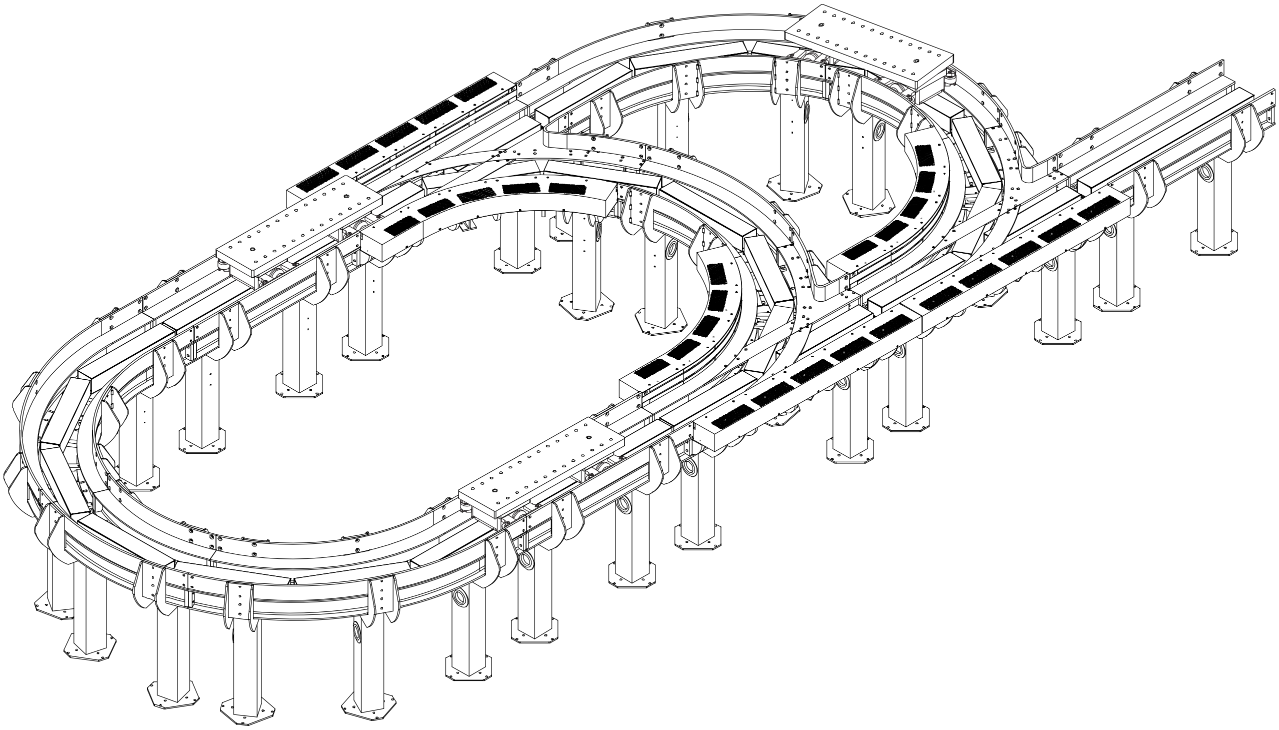
MagneMotion

A Rockwell Automation Company

QuickStick 100
User Manual



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MagneMotion
A Rockwell Automation Company

MagneMotion, Inc.
A Rockwell Automation Company
139 Barnum Road
Devens, MA 01434
USA
Phone: +1 978-757-9100
Fax: +1 978-757-9200
www.rockwellautomation.com

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Contents

Figures 11

Tables 13

Changes
- Overview 15
  - Rev. A 15
  - Rev. B 15
  - Rev. C 16
  - Rev. D 17
  - Ver. 05 18
  - Ver. 06 18
  - Rev. G 18

About This Manual
- Overview 21
  - Purpose 21
  - Audience 21
  - Prerequisites 21
- MagneMotion Documentation 22
  - Manual Conventions 22
  - Notes, Safety Notices, and Symbols 23
    - Notes 23
    - Safety Notices 23
  - Manual Structure 24
  - Related Documentation 25
- Contact Information 26

1 Introduction
- Overview 27
- QuickStick 100 Transport System Overview 28
  - QS 100 Transport System Components 29
- Transport System Overview 30
- Transport System Software Overview 31
- Getting Started with the QuickStick 100 Transport System 33

2 Safety

Overview....35
Regulatory Compliance....36
    EU RoHS and EU WEEE Compliance....36
    Equipment Regulatory Guidelines....37
Safety Considerations....38
    Personnel Safety Guidelines....38
    Equipment Safety Guidelines....39
    QuickStick 100 Transport System Hazard Locations....40
Symbol Identification....41
Label Identification and Location....43
    Motors....43
    Magnet Arrays....44
    Electronics....46
Mechanical Hazards....47
Electrical Hazards....49
Magnetic Hazards....50
    Handling Magnet Arrays....51
    Shipping Magnet Arrays....52
Recycling and Disposal Information....53
    QuickStick 100 Transport System....53
    Motors....53
    Magnet Arrays....53
    Power Supplies....54
    Packaging....54

3 Design Guidelines

Overview....55
Transport System Layout....56
    Transport System Overview....56
    Motors, Switches, and Vehicles....57
    Paths....58
    Nodes....59
    Node Controllers....60
    Additional Connections....61
Transport System Design....62
    Overview....62
    Design Guidelines....62
    Motors....63
        Available Thrust....65
        Required Thrust....66
        Motor Gap....66
        Downstream Gap....67
        Motor Cogging....67
        Motors on a Curve....68
        Motor Controllers....69
    Electrical Wiring....69

Power Wiring 69
Signal Wiring 70
Ground 71
Magnet Arrays 73
Magnet Array Length and Attractive Force 73
Magnet Array Width 74
Magnet Array Use 74
Standard Magnet Arrays 74
Vehicles 78
Vehicle Gap 80
Single Array Vehicle 80
Dual Array Vehicle 81
Vehicle Design 82
Mounting Magnet Arrays to Vehicles 83
Guideways 84
Guideway Design 84
Guideway and Support Materials 85
Motor Mounts 85
Motor Mounting Methods 86
Guideway Examples 88
Transport System Configuration 91
Straight Track Configuration 91
Curve Track Configuration 92
Switch Configuration 93
Moving Path Configuration 94

4 Specifications and Site Requirements

Overview 95
Mechanical Specifications 96
1000 Millimeter Motor 96
500 Millimeter Motor 97
Magnet Array, Standard Potted 98
Magnet Array, Standard Covered 100
QS 100 Power Supply 102
Electrical Specifications 103
QS 100 Motors 103
Motor Power Cable 106
QS 100 Power Supply 107
Control Cable 110
Communications 111
Ethernet Connection 111
TCP/IP Communication – Host Controller to HLC 111
EtherNet/IP Communication – Host Controller to HLC 112
RS-232 Serial Interface Connection 112
RS-422 Serial Interface Connection 112
Node Controller to Motor 112
Motor to Motor 114

    Sync Connection 114
  Site Requirements 115
    Environment 115
      Motors 115
      QS 100 Power Supply 115
      Magnet Arrays, Potted and Covered 115
      Derating at High Altitude 115
    Lighting, Site 115
    Floor Space and Loading 116
    Facilities 116
    Service Access 116

5 Installation

  Overview 117
  Unpacking and Inspection 118
    Unpacking and Moving 119
      Required Tools and Equipment 119
      Unpacking and Moving Instructions 119
  Transport System Installation 121
    Installing Hardware 121
      Required Tools and Materials 121
      Installation Overview 122
    System Installation 124
      Assembling the Guideway 124
      Leveling the Transport System 124
      Securing the Transport System 124
      Mounting the Motors 124
    Installing Electronics 126
      Installing Electronics on the Transport System 126
    Connecting Motors and Electronics 127
      Motor Communications 127
      Digital I/O 131
      Installing Motor Power Cables 132
    Magnet Array Installation 134
    Vehicle Installation 136
  Facilities Connections 137
    Network Connections 137
    Electrical Connections 138
      E-stop Circuit 139
      Interlock Circuit 139
      Light Stack Circuit 140
      General Purpose Digital I/O 140
      Node Electronics 140
  Software 141
    Software Overview 141
    Software Configuration 141
      Node Controller Software Installation 142

    - Motor Software Installation 142
- Check-out and Power-up 143
  - System Check-out 143
    - Mechanical Checks 143
    - Facility Checks 143
    - Pre-operation Checks 143
  - System Power-up 144
- System Testing 147

6 Operation

- Overview 149
- Theory of Operation 150
  - QuickStick 100 Transport System Advantages 150
  - Motion Control 151
  - Motor Topology 151
  - Motor Operation 152
    - Motor Cogging 153
  - Motor Blocks 154
    - Block Acquisition 154
    - Block Ownership 155
    - Block Release 155
  - Anti-Collision 155
    - Safe Stopping Distance 156
    - Thrust Limitations 156
    - In Queue 157
    - Vehicle Length Through Curves and Switches 158
  - Locating Vehicles During Startup 158
    - Moving Vehicles by Hand 159
  - Electrical System 161
    - Power Regenerated by a Vehicle 161
    - Power Management Within the QS 100 Motor 161
    - Power-Related Warnings and Faults 161
    - Power Related Warnings and Faults 164
    - Power Related Fault Resolution 166
  - Node Controllers 168
    - Node Controller Communications 168
- Controls and Indicators 169
  - Track Display 169
  - Synchronization 170
  - E-stops 171
  - Interlocks 171
  - Light Stacks 172
  - FastStop 172
  - Digital I/O 172
- Transport System Simulation 173
  - Configuring a Simulation 173
  - Running a Simulation 175

Stopping a Simulation....177
Return the System to Normal Operation....177
Transport System Operation....179
Power-up....179
Normal Running....179
Safe Shut-down....180

7 Maintenance

Overview....181
Preventive Maintenance....182
Cleaning....183
Wear Surface Maintenance....183
Cable Connection Inspection....184
Hardware Inspection....184
Cleaning Magnet Arrays....184
Transfer Log Files....185
Troubleshooting....186
Initial Troubleshooting....186
Power-Related Troubleshooting....187
Node Controller Troubleshooting....190
Communication Troubleshooting....191
Motion Control Troubleshooting....192
Light Stack Troubleshooting....193
Contact ICT Customer Support....194
Repair....195
Replacing Motors....196
Remove the Existing Motor....196
Install the New Motor....197
Programming Motors....198
Separating Magnet Arrays....199
Ordering Parts....200
Shipping....201
Packing Procedure....202
Shipping Components....203

Appendix

Overview....205
Data for Transport System Design Calculations....206
Thrust Force Data....207
Attractive Force Data....209
Determining Thrust Force....211
Determining Attractive Force....212
File Maintenance....213
Backup Files....213
Creating Backup Files....213
Restoring from Backup Files....213

Additional Documentation....214
  Release Notes....214
  Upgrade Procedure....214
Transport System Limits....215

Glossary.... 217

Index.... 225

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Figures

1-1 Detailed View of QuickStick 100 Transport System Components 29
1-2 Simplified View of the QuickStick 100 Transport System Components 30
1-3 Simplified View of Transport System Software Relationships 31

2-1 Locations of Hazardous Points on the QuickStick 100 Transport System 40
2-2 Locations of Labels on the QuickStick 100 Motors 43
2-3 Locations of Labels on the QuickStick 100 Standard Potted Magnet Arrays 44
2-4 Locations of Labels on the QuickStick 100 Standard Covered Magnet Arrays 45
2-5 Locations of Labels on the QuickStick 100 Power Supply 46

3-1 Sample QS 100 Transport System Layout Showing Motors 57
3-2 Sample QS 100 Transport System Layout Showing Paths 58
3-3 Sample QS 100 Transport System Layout Showing Nodes 59
3-4 Sample QS 100 Transport System Layout Showing Node Controllers 60
3-5 Sample QS 100 Transport System Layout Showing Additional Connections 61
3-6 QuickStick 100 System, Single Array Vehicle 62
3-7 Available Thrust Examples 66
3-8 Motor Gaps 67
3-9 Motors on Curves 68
3-10 System Wiring Block Diagram 72
3-11 Standard Potted Magnet Array, 5 Cycles, 11 Poles 75
3-12 Standard Covered Magnet Array, 5 Cycles, 11 Poles 76
3-13 Mounting Two Covered Magnet Arrays End-To-End 77
3-14 Typical Vehicle on Guideway 78
3-15 Magnet Array to Motor Alignment 79
3-16 Vehicle Gap 80
3-17 Single Array Vehicle Configuration 81
3-18 Dual Array Vehicle Configuration 81
3-19 Magnet Array Mounting 83
3-20 QuickStick 100 Transport System, Guideway Detail 84
3-21 Motor Mounting to Flat Surface 86
3-22 Motor Mounting Using Brackets 87
3-23 Guideway Example #1 88
3-24 Guideway Example #2 89
3-25 Guideway Example #3 90
3-26 Straight Track Configuration 91
3-27 Curve Track Configuration 92

3-28 Switch Configuration 93
3-29 Moving Path Configuration 94

4-1 1000 Millimeter Motor Mechanical Drawing 96
4-2 500 Millimeter Motor Mechanical Drawing 97
4-3 Standard ‘F’ Potted Magnet Array Mechanical Drawing 98
4-4 Standard ‘F’ Covered Magnet Array Mechanical Drawing 100
4-5 QS 100 Power Supply Mechanical Drawing 102
4-6 Motor Electrical Connections 104
4-7 Motor Power Drop Cable 106
4-8 QS 100 Power Supply Electrical Connections 108
4-9 QS 100 Power Supply Control and Monitoring Cable 110
4-10 RS-422 Cables 113

5-1 Simplified Representation of RS-422 Motor Connections 127
5-2 Simplified Representation of RS-422 Motor Connections in a Merge Switch 128
5-3 RS-422 Communication Connections 129
5-4 Power Connections 132
5-5 Network Cable Connections 137

6-1 Linear Synchronous Motor Derived From Rotary Motor 150
6-2 Representation of Stationary Vehicles Per Motor Block 152
6-3 Representation of Moving Vehicles Per Motor Block 152
6-4 Representation of Block Ownership by Vehicle 155
6-5 Vehicle Motion Profile 156
6-6 Vehicle Movement Profile Showing Thrust Limitations 157
6-7 Power Cycle Timing 162
6-8 Individual Block Current vs. Internal Propulsion Bus Voltage 163
6-9 Power Dissipation Per Block vs. Internal Propulsion Bus Voltage 163
6-10 Power Dissipation by 10 Ohm Resistor vs. Internal Propulsion Bus Voltage 164
6-11 The Graphics Window 169
6-12 Transport System Wiring Diagram with Synchronization 170

A-1 Thrust Force vs. Magnet Array Cycles, Standard Magnet Array 208
A-2 Thrust Force vs. Vehicle Gap, Standard Magnet Array 208
A-3 Attractive Force Data Curves, Standard Magnet Array 210

Tables

2-1 Regulatory Information 36
2-2 Hazard Alert Symbol Identification 41
2-3 Mandatory Action Symbol Identification 42
2-4 Prohibited Action Symbol Identification 42
2-5 Labels Used on the QuickStick 100 Motors 43
2-6 Labels Used on the QuickStick 100 Standard Potted Magnet Arrays 44
2-7 Labels Used on the QuickStick 100 Standard Covered Magnet Arrays 45
2-8 Labels Used on the QuickStick 100 Power Supply 46

3-1 Motor Assignments 58
3-2 Motor Blocks 64
3-3 Thrust and Attractive Force, Standard Magnet Array 64

4-1 Standard Potted Magnet Array Lengths and Weights 99
4-2 Standard Covered Magnet Array Lengths and Weights 101
4-3 QuickStick 100 Motor Power Requirements 103
4-4 Motor Connections 104
4-5 RS-422 Pinouts 104
4-6 Power Connector Pinout 105
4-7 Sync Connector Pinout 105
4-8 Motor Power Drop Cable Pinouts 106
4-9 QS 100 Power Supply Connections 108
4-10 QS 100 Power Supply Indicators (per PS Module) 108
4-11 QS 100 Power Supply DC Power Pinout 108
4-12 QS 100 Power Supply Control and Monitoring Pinout 109
4-13 QS 100 Power Supply Control and Monitoring Cable Pinouts 110
4-14 RS-422 Cable Pinouts 113

5-1 Packing Checklist Reference 118
5-2 Startup Indicators 145

6-1 Propulsion Voltage Range 164
6-2 Simulated Operation Differences 175

7-1 QuickStick 100 Transport System Preventive Maintenance Schedule 182
7-2 Initial Troubleshooting 186
7-3 Power-Related Troubleshooting 187

7-4 Node Controller Related Troubleshooting 190
7-5 Communication-Related Troubleshooting 191
7-6 Motion Control Related Troubleshooting 192
7-7 Light Stack Related Troubleshooting 193
7-8 QuickStick 100 Transport System Repair Procedures 195

A-1 Thrust Force Data, Standard Magnet Array 207
A-2 Attractive Force Data, Standard Magnet Array 209
A-3 MagneMotion Transport System Limits 215
A-4 MagneMotion Transport System Motion Limits 215

Changes

Overview

This manual is changed as required to keep it accurate and up-to-date to provide the most complete documentation possible for the QuickStick® 100 transport system. This section provides a brief description of each change.

NOTE: Distribution of this manual and all addendums and attachments is not controlled. To identify the current revision, contact ICT Customer Support.

Rev. A

Initial release.

Rev. B

Added the following:

- In *Chapter 2, Safety*, added UL Registered Component, *EU RoHS and EU WEEE Compliance*, and *Symbol Identification* information.
- In *Chapter 4, Specifications and Site Requirements*, added information on the *QS 100 Power Supply*.
- In *Chapter 7, Maintenance*, added *Wear Surface Maintenance*, *Replacing Motors*, and *Programming Motors* procedures.
- In the *Appendix*, added information about *File Maintenance*.

Updated the following:

- Updated all figures to QS 100 only. Updated product specifications. Updated software descriptions and figures.
- In *Chapter 2, Safety*, updated *Safety Considerations* and *Recycling and Disposal Information*.
- In *Chapter 3, Design Guidelines*, updated the *Transport System Layout*, *Transport System Design*, and *Transport System Configuration* sections to focus on QS 100.
- In *Chapter 4, Specifications and Site Requirements*, updated pinouts of *RS-422 Cables*. Updated Digital I/O Equivalent Circuits.

- In *Chapter 5, Installation*, updated the *Check-out and Power-up* and *System Testing* procedures.
- In *Chapter 6, Operation*, updated the *Theory of Operation*, to include more details on *Motor Topology* and *Block Acquisition*.
- In the *Appendix*, updated the tables and charts for *Thrust Force Data* and *Attractive Force Data*. Updated the *Transport System Limits* information.
- Updated the *Glossary*.

Removed the following:

- Removed all references to QuickStick High Thrust, which has a separate manual (990000496).
- Removed all references to the standard node controller, which has been replaced by the NC-12 node controller. Support for the standard node controller, including software, spare parts, technical support, and service continues to be available.
- Removed references to unsupported node types (Turntable and Host Switch).
- Removed unused RS-232 communication support.

Rev. C

Added the following:

- In *Chapter 2, Safety*, added *Handling Magnet Arrays*.
- In *Chapter 3, Design Guidelines*, added *Motor Cogging*, *Electrical Wiring*, and *Magnet Array Use*.
- In *Chapter 4, Specifications and Site Requirements*, added exposed materials identification to the *Mechanical Specifications*. Added the operating voltage range for the motors to the *Electrical Specifications* and added a note about the PTC (positive temperature coefficient) resistor that is used in the motors.
- In *Chapter 5, Installation*, added rack mounting for the NC-12 to Mounting NC-12 Node Controllers. Added cable sizing and grounding to *Installing Motor Power Cables*.
- In *Chapter 6, Operation*, added descriptions of *Motor Cogging*, *Safe Stopping Distance*, *Moving Vehicles by Hand*, and the *Electrical System* to the *Theory of Operation* section. Added *Transport System Simulation*.
- In *Chapter 7, Maintenance*, added *Cleaning Magnet Arrays*. Added *Light Stack Troubleshooting*. Added *Separating Magnet Arrays*.

Updated the following:

- In *Chapter 3, Design Guidelines*, clarified the description of the Gateway Node. Corrected motor thrust per magnet array cycle to 15.9 N at 4.0 A stator current. Updated *Vehicles* figures to show the static brush that is used for grounding vehicles.
- Moved the Magnet Array Types information from *Chapter 4, Specifications and Site Requirements* to *Chapter 3, Design Guidelines*.

- In *Chapter 4, Specifications and Site Requirements*, changed the *Power Connector Pinout* to reflect proper use. Updated the *Motor Power Cable* to the current cable design. Corrected the NC-12 Node Controller input power to 22–30V DC. Updated the Digital I/O Connection description.Corrected the temperature range for the magnet arrays.
- In *Chapter 5, Installation*, updated *Magnet Array Installation*.
- In *Chapter 6, Operation*, moved *QuickStick 100 Transport System Advantages* forward in the *Theory of Operation*. Updated the descriptions of *In Queue* and *Vehicle Length Through Curves and Switches*.
- In *Chapter 7, Maintenance*, updated all troubleshooting tables.
- In the *Appendix*, updated the *Data for Transport System Design Calculations*. Corrected the thrust spec in the *Transport System Limits*.

Removed the following:

- In the *Appendix*, removed HLC VM Slaves per Master reference from the *Transport System Limits*.

Rev. D

Added the following:

- Added information about Overtravel and Moving Path nodes.
- In *Chapter 3, Design Guidelines*, added description of *Magnet Array Use*.

Updated the following:

- In *Chapter 1, Introduction*, updated the *Simplified View of Transport System Software Relationships*.
- In *Chapter 2, Safety*, corrected the locations of labels on the QuickStick 100 High Flux Magnet Arrays.
- In *Chapter 3, Design Guidelines*, corrected description of *Ground* for NC LITE and SYNC IT modules. Moved figure from *Transport System Design Overview* to *Guideway Design*.
- In *Chapter 4, Specifications and Site Requirements*, updated the *Site Requirements* to show the environmental requirements for each component.
- In the *Appendix*, updated thrust equations to provide results in both N and Lb. Updated QSHT velocity in the *Transport System Limits*.

Removed the following:

- In *Chapter 6, Operation*, removed all references to Merge and Diverge Nodes from *Configuring a Simulation*.

Ver. 05

Added the following:

- Support for *Stainless Steel Covered Magnet Arrays*, including mounting requirements.
- Added Ingress Protection identification for all components.
- Added the *Back Cover*.

Updated the following:

- Changed the revision from alpha (Rev. D) to numeric (Ver. 05).
- Changed logo to Rockwell Automation Company version.
- Trademark and copyright information.
- Titles for all referenced manuals.
- Updated the *Glossary*.

Removed the following:

- All references to the High Flux magnet array, which is no longer available. Support for the High Flux magnet array, including technical support and service continues to be available.

Ver. 06

Added the following:

- In *Chapter 2, Safety*, added motors and packaging to *Recycling and Disposal Information*.
- In *Chapter 3, Design Guidelines*, added Figure 3-19, *Magnet Array Mounting*.
- In *Chapter 4, Specifications and Site Requirements*, added data for the NC-12 Node Controller, M12 Ethernet. Added note about limiting the cycling of the propulsion power for the motors. Added operating temperature *Derating at High Altitude*.
- In *Chapter 6, Operation*, added information on *Block Release* and on *Soft Start*.

Updated the following:

- In the *Appendix*, updated the *Transport System Limits*.

Removed the following:

- In *Chapter 4, Specifications and Site Requirements*, removed all references to shipping temperatures for all components.

Rev. G

Added the following:

- Added information on the NC-E node controller.

- In *Chapter 1, Introduction*, added description of the NC-E node controller. Added descriptions of Restricted Parameter files and MICS files.
- In *Chapter 2, Safety*, added the *Loose Material Hazard* caution.
- In *Chapter 3, Design Guidelines*, added information about mounting two covered magnet arrays end-to-end.
- In *Chapter 5, Installation*, added caution about acceptable depth for the motor mounting bolts.
- In *Chapter 6, Operation*, added a description of *Block Ownership*. Added an overview of the *Node Controllers*. Detailed information is in the *Node Controller Hardware User Manual*.

Updated the following:

- Changed the revision from numeric (Ver. 07) to alpha (Rev. G).
- Changed all Customer Support references from MagneMotion to ICT.
- Updated the structure of the changes descriptions.
- In *Chapter 1, Introduction*, updated the *Simplified View of Transport System Software Relationships* figure.
- In *Chapter 2, Safety*, updated the *Recycling and Disposal Information*.
- In *Chapter 3, Design Guidelines*, updated Thrust *Force*. Updated the *Available Thrust Examples*.
- In *Chapter 4, Specifications and Site Requirements*, updated the motor *Mechanical Specifications* to include maximum acceptable depth for the mounting bolts and shock and vibration specs. Updated the *Communications* section to better describe connections to the node controllers.
- In *Chapter 5, Installation*, updated the *Motor Communications* figures.
- In *Chapter 6, Operation*, corrected the *Soft Start* timing. Expanded the *Transport System Simulation* section.
- In *Chapter 7, Maintenance*, updated the Power and Motion Control troubleshooting tables.
- In the *Appendix*, corrected the formula for *Determining Attractive Force*. Updated the *Transport System Limits*.
- Updated the *Glossary*.

Removed the following:

- Removed all labeling, recycling, mechanical specifications, electrical specifications, digital I/O specs, environmental specifications, and installation procedures for the node controllers and Ethernet switch. This information is now in the *Node Controller Hardware User Manual*.
- In *Chapter 3, Design Guidelines*, removed track configuration for Shuttle node, which is replaced by the Moving Path node.
- In *Chapter 6, Operation*, removed detailed information about *E-stops*, *Interlocks*, *Light Stacks*, *FastStop*, and *Digital I/O*. This information is now in the *Node Controller Hardware User Manual*.

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About This Manual

Overview

This section provides information about the use of this manual, including the manual structure, related documentation, format conventions, and safety conventions.

Purpose

This manual explains how to install, operate, and maintain the QuickStick® 100 (QS 100) transport system. This manual also provides information about basic troubleshooting.

Use this manual in combination with the other manuals and documentation that accompanies the transport system to design, install, configure, test, and operate a QS 100 transport system. MagneMotion offers instructor-led training classes that provide additional instruction in the installation, configuration, testing, and operation of a QS 100 transport system.

Audience

This manual is intended for all users of QuickStick 100 transport systems and provides information on how to install, configure, and operate the QS 100 transport system.

Prerequisites

The information and procedures that are provided in this manual assume the following:

- Basic familiarity with general-purpose computers and with the Windows® operating system, web browsers, and terminal emulators.
- Complete design specifications, including the physical layout of the transport system, are available.
- All personnel who configure, operate, or service the transport system are properly trained.

MagneMotion Documentation

The documentation that is provided with the QuickStick 100 components includes this manual, which provides complete documentation for the installation, operation, and use of the QS 100 components as a transport system. Other manuals in the document set, which are listed in the *Related Documentation* section, support configuration and operation of the transport system.

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

Manual Conventions

The following conventions are used throughout this manual:

- Bulleted lists provide information in no specific order, they are not procedural steps.
- Numbered lists provide procedural steps or hierarchical information.
- Keyboard keys and key combinations (pressing multiple keys at a time) are shown enclosed in angle brackets. Examples: <F2>, <Enter>, <Ctrl>, <Ctrl-x>.
- Dialog box titles or headers are shown in bold type, capitalized exactly as they appear in the software. Example: the **Open XML Configuration File** dialog box.
- Responses to user actions are shown in italics. Example: *Motion on all specified paths is enabled.*
- Selectable menu choices, option titles, function titles, and area or field titles in dialog boxes are shown in bold type and are capitalized exactly as they appear in the software. Examples: **Add to End...**, **Paths**, **Path Details**, **OK**.
- **Dialog Box** – A window that solicits a user response.
- **Click** or **Left-click** – Press and release the left mouse button[*].
- **Right-click** – Press and release the right mouse button.
- **Double-click** – Press and release the left mouse button twice in quick succession.
- **Control-click** – Hold down <Ctrl> and press and release the left mouse button.
- **Click-and-hold** – Press down the left mouse button and hold it down while moving the mouse.
- **Select** – Highlight a menu item with the mouse or the tab or arrow keys.
- **Code Samples** – Shown in monospaced text. Example: `Paths`.

---

[*] Mouse usage terms assume typical 'right-hand' mouse configuration.

- **Data Entry** – There are several conventions for data entry:
  - **Exact** – The text is shown in single quotes. Example: Enter the name ‘Origin’ in the text field.
  - **Variable** – The text is shown in italics. Example: Save the file as *file_name*.xml.
- **Numbers** – All numbers are assumed to be decimal unless otherwise noted and use the US number format; that is, one thousand = 1,000.00. Non-decimal numbers (binary or hexadecimal) are explicitly stated.
  - **Binary** – Followed by $_2$, for example, $1100\ 0001\ 0101_2$, $1111\ 1111\ 1111\ 1111_2$.
  - **Hex** – Preceded by 0x, for example, 0xC15, 0xFFFF.
- **Measurements** – All measurements are SI (International System of Units). The format for dual dimensions is *SI_units* [*English_units*]; for example, 250 mm [9.8 in].
- Text in blue is a hyperlink. These links are active when viewing the manual as a PDF. Select a hyperlink to change the manual view to the page of the item referenced. In some cases, the item that is referenced is on the same page, so no change in the view occurs.

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.

NOTE: A note provides additional or explanatory information.

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 41* 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, will 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.

NOTICE

Notice indicates practices that are not related to personal injury that could result in equipment or property damage.

Manual Structure

This manual contains the following chapters:

- *Introduction*: Provides an overview of the QuickStick 100 components and their use in a transport system. The QS 100 motors are used to provide fast, precise motion, positioning, and tracking of medium loads.
- *Safety*: Identifies safety concerns and requirements for the QuickStick 100 components and the personnel operating and servicing the QS 100 motors and the transport system where they are installed.
- *Design Guidelines*: Provides guidelines for designing a QuickStick 100 transport system.
- *Specifications and Site Requirements*: Provides specifications and the requirements for installation of the QuickStick 100 components as a transport system.
- *Installation*: Provides complete installation procedures for the QS 100 components.

- *Operation*: Provides complete operation directions for the QS 100 components as part of a transport system.
- *Maintenance*: Provides maintenance schedules and procedures for the QS 100 components.
- *Appendix*: Provides additional information that is related to QS 100 transport systems.
- *Glossary*: A list of terms and definitions that are used in this manual and for the transport system and its components.
- *Index*: A cross-reference to this manual organized by subject.

Related Documentation

Before configuring or running the QuickStick 100 components, consult the following documentation:

- *QuickStick Configurator User Manual*, 990000559.
- *Node Controller Interface User Manual*, 990000377.
- *NCHost TCP Interface Utility User Manual*, 990000562.
- *Host Controller TCP/IP Communication Protocol User Manual*, 990000436.
  Host Controller EtherNet/IP Communication Protocol User Manual, 990000437.
  or
  Mitsubishi PLC TCP/IP Library User Manual, 990000628.
- *QuickStick 100 User Manual*, 990000460 (this manual).
- *Node Controller Hardware User Manual*, 10004903067.
- *LSM Synchronization Option User Manual*, 990000447.
- *Virtual Scope Utility User Manual*, 990000759.

NOTE: Distribution of this manual and all addendums and attachments are not controlled. Changes to the document set or the software can be made at any time. To identify the current revisions or to obtain a current version, contact ICT Customer Support.

Contact Information

Main Office

MagneMotion, Inc.
A Rockwell Automation Company
139 Barnum Road
Devens, MA 01434
USA
Phone: +1 978-757-9100
Fax: +1 978-757-9200

Customer Support

+1 978-757-9102
ICTSupport@ra.rockwell.com

Introduction 1

Overview

This chapter provides an overview of the QuickStick® 100 (QS 100) component hardware and software. It includes an overview of the basic tasks that are used to install and use the QS 100 components in a transport system.

Use this manual to install, test, and debug the QS 100 components in a transport system. Some procedures can vary based on the transport system configuration, communications, and other variables.

This manual supports:

- QuickStick 100 transport systems.

Included in this chapter are overviews of:

- The QuickStick 100 components in a transport system.
- The transport system components.
- The transport system software.
- Getting started with a QuickStick 100 transport system.

QuickStick 100 Transport System Overview

The QuickStick 100 (QS 100) is an intelligent transport system that provides fast, precise motion, and positioning and tracking of medium loads in a transport system. The QS 100 transport system is a configuration of linear synchronous motors 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 QS 100 transport system consists of the following components:

- QuickStick 100 motors.
- User-designed and supplied vehicles with QuickStick 100 Magnet Arrays.
- Node controllers.
- Power supplies.
- Paths and nodes.
- User-supplied host controller.
- User-designed and supplied guideway and track system.

Using proven linear synchronous motor (LSM) and control technology from MagneMotion, QuickStick 100 transport systems offer a superior alternative to conventional belt and chain conveyors for OEM/in-machine applications and for demanding product conveyance requirements.

- QuickStick 100 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 built into the motor.
  - Servo repeatability at any position: ± 0.5 mm [0.02 in.] (dependent on the size of the gap between the motor and the vehicle-mounted magnet array). Repeatability can vary based on the PID settings that are used and track and vehicle design/structure, 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 through the use of user-designed vehicles with magnet arrays that are attached to the surface closest to the motor.
  - Up to five vehicles in queue or in motion per meter* (150 mm [5.9 in] vehicle length).
  - Speeds up to 2.5 m/s [5.6 mph] and acceleration up to 9.8 m/s^2 [1.0 *g*].
  - QuickStick 100 motors are capable of moving payloads up to 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).
- Configuration and simulation software tools simplify transport system design and optimization.

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* 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.

- Designed for use in cleanrooms and IP54 environments (motors and magnet arrays only).
- Less wear and tear – no belts, chains, gears, or external sensors required – few moving parts means less maintenance.
- Standard industrial communication protocols, PC or 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.

QS 100 Transport System Components

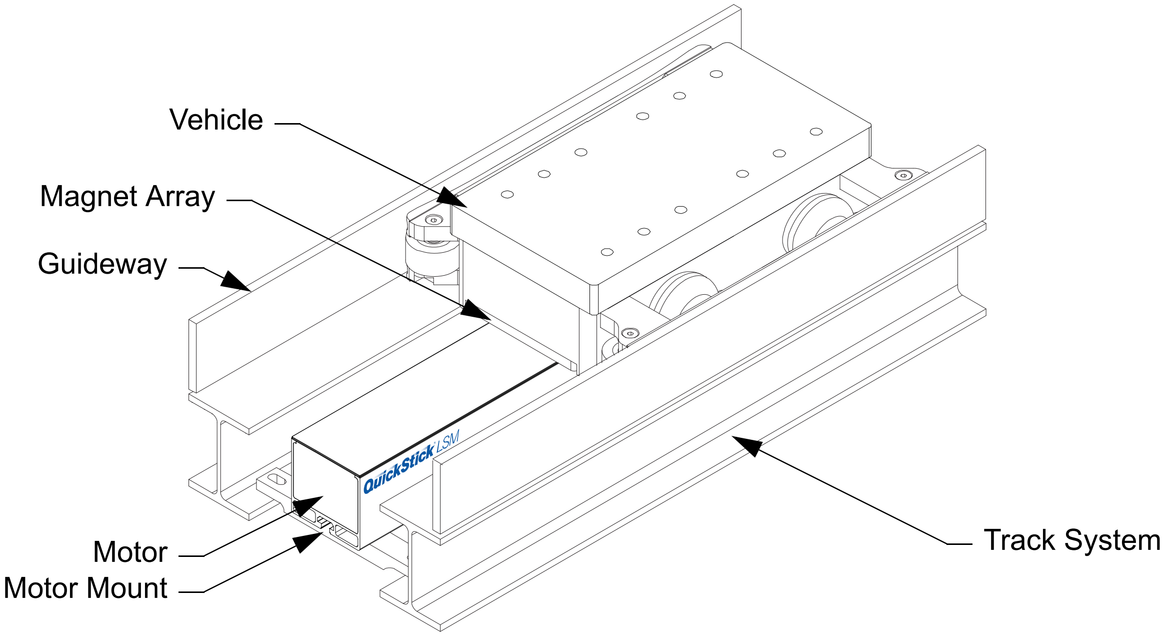


Figure 1-1: Detailed View of QuickStick 100 Transport System Components

- **Track System** – The components that physically support and move vehicles, this includes the support structure, the guideway, one or more QuickStick® 100 motors, and mounting hardware.
- **Guideway** – Used to make sure that the vehicles are maintained in the proper relationship to the motors.
    - **Straight and Curve** – Motors placed end-to-end to provide a continuous path of motion.
    - **Switch** – (not shown) 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 QuickStick 100 linear synchronous motor (LSM).
- **Motor Mount** – Used to mount the motor to the guideway.
- **Vehicle with Magnet Array** – Carries the payload through the QS 100 transport system as directed. The magnet array is mounted to the vehicle and interacts with the motors, which moves the vehicle.

Transport System Overview

This section identifies the components of a QuickStick 100 transport system as shown in Figure 1-2 and described after the figure.

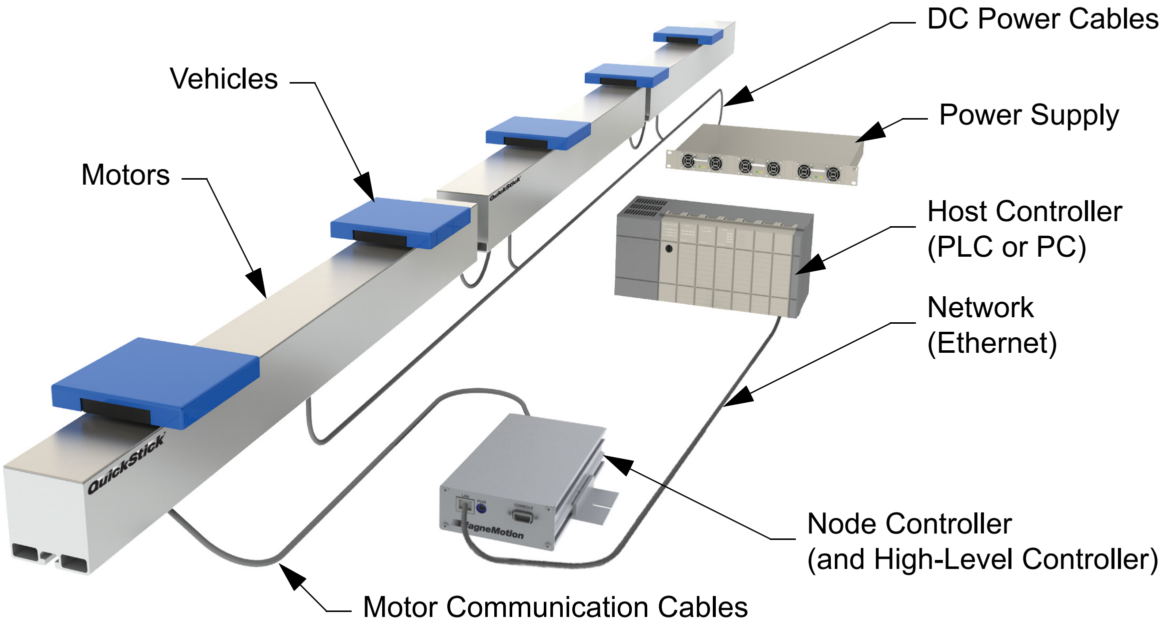


Figure 1-2: Simplified View of the QuickStick 100 Transport System Components

- **DC Power Cables and Communication Cables** – Distributes DC power to the motors and carries communications between the components of the transport system.
- **High-Level Controller** (HLC) – Software application that is enabled on one node controller. This application handles all communication with the user-supplied host controller and directs communication as appropriate to individual node controllers.
- **Host Controller** – Provides user control and monitoring of the QuickStick 100 transport system. User-supplied, it can be either PC-based or a PLC.
- **Motor** – Refers to the QuickStick 100 linear synchronous motor (LSM).
- **Network** – Ethernet network providing communications (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. Three types of node controllers are available:
  - **NC-E** (not shown) – Provides one active network port, four digital inputs, and four digital outputs. For Ethernet enabled motors only.
  - **NC-12** (not shown) – Provides one network port, two RS-232 ports, 12 RS-422 ports, 16 digital inputs, and 16 digital outputs.
  - **NC LITE** – Provides one network port and four RS-422 ports.
- **Power Supply** – Provides DC power to the motors.
- **Vehicle with Magnet Array** – Carries a payload through the QS 100 transport system as directed. The magnet array is mounted to the vehicle and interacts with the motors, which move each vehicle independently.

Transport System Software Overview

Several software applications are used to configure, test, and administer a QuickStick 100 transport system as shown in Figure 1-3 and described after the figure. See *Related Documentation* on page 25 for the reference manuals for these applications.

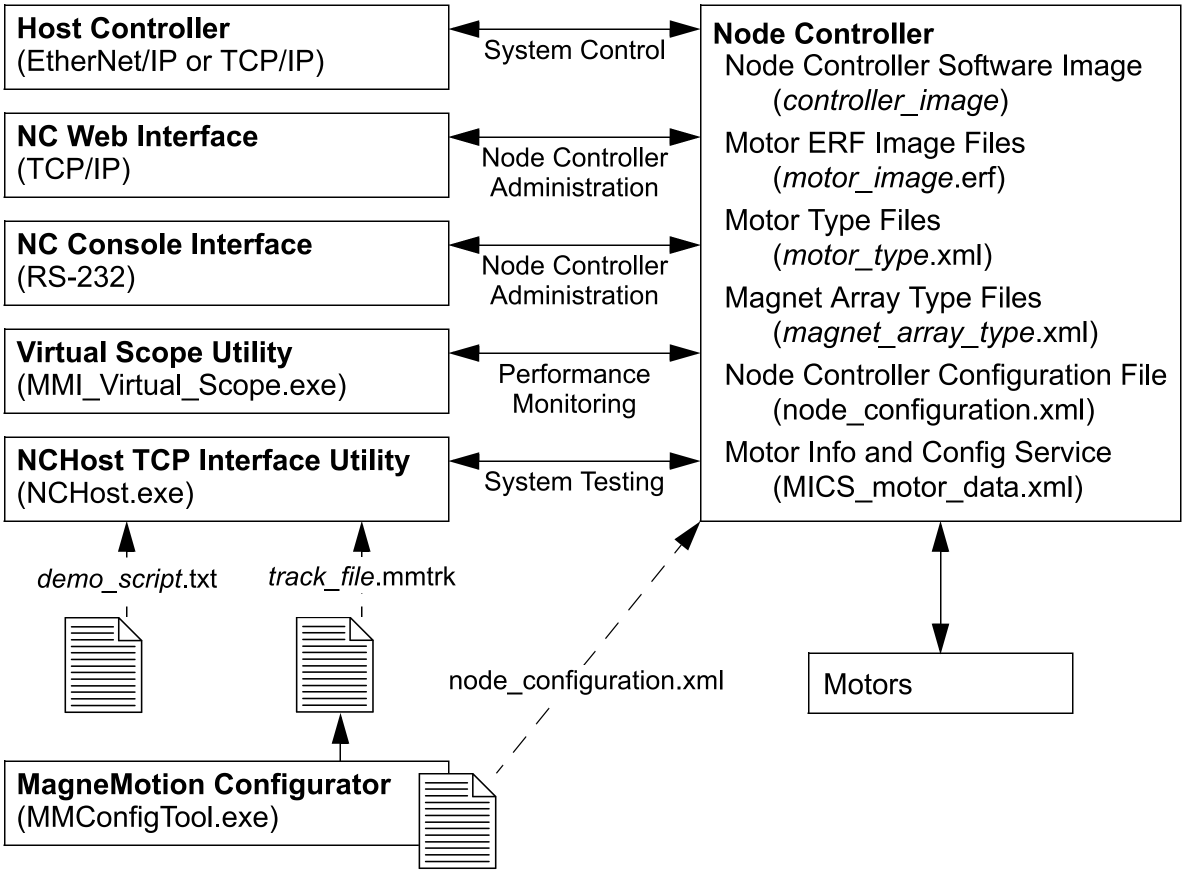


Figure 1-3: Simplified View of Transport System Software Relationships

- **NC Web Interface** – A web-based software application that is supplied by MagneMotion, resident on the node controllers, for administration of the parts of the transport system.
- **NC Console Interface** – A serial communication software application that is supplied by MagneMotion, resident on the node controllers, for administration of the node controller.
- **NCHost TCP Interface Utility** – A Windows® software application that is supplied by MagneMotion to move vehicles for test or demonstration purposes. This application supports system testing without the host controller to verify that vehicles move correctly before integrating a transport system into a production environment.
- **QuickStick Configurator** (Configurator) – A Windows software application that is supplied by MagneMotion to create or change the Node Controller Configuration File.

- **Virtual Scope Utility** – A Windows software application that is supplied by MagneMotion to monitor and record the change of motor performance parameters. These parameters are displayed as waveforms to analyze the performance of the motors.
- **Demo Script** – A text file (*demo_script*.txt) uploaded to the NCHost TCP Interface Utility to move vehicles on the transport system for test or demonstration purposes.
- **Node Controller Software Image File** (IMG file) – The software file for the node controllers (controller_image), includes the node controller and HLC applications. The Node Controller Software Image file is uploaded to all node controllers in the transport system.
- **Motor ERF Image Files** (ERF file) – The software files for the MagneMotion motors (*motor_image*.erf). The Motor ERF Image files are uploaded to all node controllers in the transport system and then programmed into all motors.
- **Restricted Parameters Files** – XML files (*restricted_parameters*.xml) that provide access to restricted configuration elements for specific transport systems. The Restricted Parameters file is uploaded to HLC. Contact ICT Customer Support for the development of a custom Restricted Parameters file for a specific transport system.
- **MagneMotion Information and Configuration Service (MICS) Files** – XML files (*MICS_motor_data*.xml) that contains the network topology parameters for the transport system when using Ethernet communication with the motors. The file includes the MAC address of each motor and the location of each motor on a Path. The MICS file is uploaded to all node controllers in the transport system.
- **Motor Type Files** – XML files (*motor_type*.xml) that contain basic information about the specific QuickStick motor types being used. The Motor Type files are uploaded to all node controllers in the transport system.
- **Magnet Array Type Files** – XML files (*magnet_array_type*.xml) that contain basic information about the specific MagneMotion magnet array type that is used on the vehicles in the QuickStick 100 transport system. The Magnet Array Type file is uploaded to all node controllers in the transport system.
- **Node Controller Configuration File** (Configuration file) – An XML file (node_configuration.xml) that contains all parameters for the components in the transport system. The Node Controller Configuration File is uploaded to all node controllers in the transport system.
- **Track File** – A text file (*track_file*.mmtrk) that contains graphical path and motor information about the transport system. The Track file is used by the NCHost TCP Interface Utility to provide a graphical representation of the transport system to monitor system operation. Contact ICT Customer Support for the development of a Track file for QuickStick 100 transport systems.

NOTICE

Modifications to the Image or Type files could cause improper operation of the transport system.

Getting Started with the QuickStick 100 Transport System

Use this manual as a guide and reference when installing or servicing the QuickStick 100 motors in a transport system. Follow the steps in this section to get the entire transport system operational quickly with the aid of the other MagneMotion manuals (see *Related Documentation* on page 25).

NOTE: Make sure that all components and complete design specifications, including the physical layout of the transport system, are available before starting to install or test the QS 100 transport system.

To get started quickly with the transport system:

1. Save the files and folders from the QS 100 transport system software package to a folder on a computer for user access.

   NOTE: The minimum requirements for running MagneMotion software applications are a general-purpose computer (PC) running Microsoft® Windows® 7 with .NET 4.0, an Ethernet port (web interface), and an RS-232 port (console interface).

2. Install the components of the QS 100 transport system as described in the following sections of this manual:

   A. Prepare the facility for the installation:

   - *Safety Considerations on page 38*.
   - *Design Guidelines on page 55*.
   - *Site Requirements* on page 115.

   B. Prepare the components for installation and install:

   - *Unpacking and Inspection* on page 118.
   - *Transport System Installation* on page 121.

3. Install the MagneMotion Configurator on a computer for user access (see *Software Configuration* on page 141 and the *QuickStick Configurator User Manual*).

   - Create the Node Controller Configuration File (node_configuration.xml) to define the components and operating parameters of the transport system.

4. Verify that the installation is complete and the system is ready for use:

   - *System Check-out* on page 143.
   - *System Power-up* on page 144.

5. Set the node controller IP addresses and specify the node controller to be used as the HLC. Upload the configuration, image, and type files to each node controller (see

Node Controller Software Installation on page 142 and the *Node Controller Interface User Manual*).

6. Program the motors using the Motor ERF Image files (see *Motor Software Installation* on page 142, the *Node Controller Interface User Manual*, and the *NCHost TCP Interface Utility User Manual*).

7. Test and debug the transport system by using the NCHost TCP Interface Utility and Demo Scripts (see *Check-out and Power-up* on page 143 and the *NCHost TCP Interface Utility User Manual*). NCHost provides an easy method to verify proper operation and make adjustments such as refining the control loop tuning.

   NOTE: The NCHost TCP Interface Utility is for test and verification trials only. The host controller must be used to control the QS 100 transport system after verification of functionality.

8. Configure the host controller (either a general-purpose computer or PLC) to control the QS 100 transport system as required to meet the material movement needs of the facility where the system is installed. See:

   - *Transport System Operation* on page 179.
   - *Safe Shut-down* on page 180.

   When using TCP/IP communication with a PC, see the *Host Controller TCP/IP Communication Protocol User Manual*. When using TCP/IP communication with a Mitsubishi PLC, see the *Mitsubishi PLC TCP/IP Library User Manual*. When using EtherNet/IP communication with a PLC, see the *Host Controller EtherNet/IP Communication Protocol User Manual*.

Safety 2

Overview

This chapter describes safety guidelines for the QuickStick® 100 components and their use in a transport system. All personnel that are involved in the installation, operation, or maintenance of the QS 100 components and the transport system must be familiar with the safety precautions that are outlined in this chapter.

NOTE: These safety recommendations are basic guidelines. If the facility where the QuickStick 100 components are installed has additional safety guidelines, they must be followed as well, along with the applicable local and national safety codes.

If any additional safety-related upgrades or newly identified hazards that are associated with the QuickStick 100 components are identified, the ICT Customer Support group notifies the owner of record.

Included in this chapter are:

- Regulatory compliance information.
- Personnel and equipment safety guidelines.
- Symbol identification.
- Label identification and locations.
- Identification of mechanical, electrical, and magnetic hazards.
- Recycling and disposal information.

Regulatory Compliance

The QuickStick 100 components are CE-compliant. To determine if a specific component is CE-compliant, check for the CE marking on the component. If necessary, request the official Declaration of Conformity (DoC) from MagneMotion.

The QuickStick 100 components are UL Recognized in Canada and the United States. To determine if a specific component is UL Recognized, check for the UL Recognized Mark on the component. Some examples of the Mark may not display the ‘C’ and ‘US’.

Other sections of this manual may include additional regulatory information. These components comply with the regulations from the organizations that are indicated in Table 2-1.

Table 2-1: Regulatory Information

Organization	Regulations
CE (Conformité Européenne) – The European safety requirements	• Machinery Directive • Low Voltage Directive • EMC Directive
UL	• 61010-1

NOTICE

It is the responsibility of the end user/third party integrator to make sure that the installed QuickStick 100 transport system complies with the appropriate facility, local, and national regulations.

EU RoHS and EU WEEE Compliance

MagneMotion® products are considered parts of a large-scale fixed installation and as a large-scale stationary industrial tool for purposes of the European Union RoHS and WEEE Directives and are therefore exempt from mandatory compliance. The CE Marking on the DoC excludes reference to the RoHS Directive for that reason.

However, MagneMotion has taken voluntary steps to make sure that its products comply with the requirements of EU RoHS and WEEE.

Equipment Regulatory Guidelines

The following regulatory guidelines are provided to aid in the use and service of the QS 100 components in a transport system.

- ICT Customer Support issues Technical Advisories to notify the owners of record of any field retrofits.
- Contact ICT Customer Support for information regarding repair and maintenance service policies, both during the production of the QS 100 components and after production is discontinued.
- Any user-caused damage during integration of the QuickStick 100 components into their equipment is the responsibility of the user.
- Responsibility for work that MagneMotion authorized technicians perform or for equipment that the owner of record transports or resells, is determined on a case-by-case basis by ICT Customer Support.
- Any parts being returned to MagneMotion must be packaged according to the instructions provided in the *Packing Procedure* on page 202.
- MagneMotion provides training for the QuickStick 100 components as integrated into a transport system. Any personnel that are performing service procedures on the QS 100 components must be properly qualified and trained. Damage that results from improperly performing a procedure or not following cautions is not covered under warranty or service agreements.

Safety Considerations

Personnel Safety Guidelines

QuickStick 100 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 (see *Mechanical Hazards* on page 47, *Electrical Hazards* on page 49, and *Magnetic Hazards* on page 50).

- Personnel operating or servicing the QuickStick 100 transport system must be properly trained.
- Be aware of the hazardous points of the QuickStick 100 transport system as described in this chapter.
- High-strength Neodymium Iron Boron magnets are used with the QS 100 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 100 motors, ferrous material, or another magnet array to avoid injury from strong magnetic attractive forces.
    - Vehicles and magnet arrays not on the QuickStick 100 transport system must be secured individually in isolated packaging.
- Moving mechanisms have no obstruction sensors and can cause personal injury.
- Know the location of the following:
    - Fire extinguisher.
    - First Aid Station.
    - Emergency eyewash and/or shower.
    - Emergency exit.
- The following safety equipment, used according to the instructions provided by the manufacturer, must be donned before installing, testing, or servicing the QS 100 transport system:
    - Eye protection
      Breaking material can produce flying shards. When running a setup or test procedure, always wear protective eyewear to guard against possible eye injuries.
    - Foot protection
      Always wear shoes with protective toes to help protect feet from falling tools or parts.

- Observe the facility guidelines that are related to loose clothing while working around or operating the QS 100 transport system.
- It may be recommended that the use of hazardous materials, such as cleaning fluids, be used during routine maintenance procedures. Read and understand the hazardous materials policies for the facility and the SDS (provided by the manufacturer) for each substance.
- Whenever power is applied, the possibility of automatic motion of the vehicles or user-supplied equipment in the QS 100 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 100 motors and related components are properly decontaminated before performing any service by following the decontamination procedures at the facility. Follow all facility, local, and national procedures for the disposal of any hazardous materials.
- Ergonomic hazards can exist with certain installation or service operations that are related to the QS 100 transport system.

Equipment Safety Guidelines

The following safety considerations are provided to aid in the placement and use of the QuickStick 100 transport system.

- If hazardous materials are to be present, proper safety precautions must be observed. Make sure that all materials that are used are compatible with the materials from which the QS 100 components are fabricated.
- If the QS 100 transport system is to be installed in an earthquake prone environment, install the equipment accordingly.
- The QS 100 components are not provided with an Emergency Off (EMO) circuit. The facility where the system is installed is responsible for an EMO circuit (see *E-stops* on page 171 for more information).
- Do not place the power and communication cables for the QS 100 transport system where they could cause a trip hazard.
- Do not place the QS 100 transport system in a location where it could be subject to physical damage.
- Make sure that all electrical connections to the QS 100 components are made in accordance with the appropriate facility, local, and national regulations.
- Make sure that the QS 100 components receive proper airflow for cooling.
- Do not remove safety labels or equipment identification labels.
- Turn OFF power before inserting or removing the power cables.

- Use of the QS 100 components for any purpose other than as a linear transport system is not recommended and can damage the QS 100 components or the equipment they are connected to.
- Always operate the QS 100 transport system with appropriate barriers in place to help prevent contact with moving objects by personnel.
- Do not install or operate the QS 100 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.

QuickStick 100 Transport System Hazard Locations

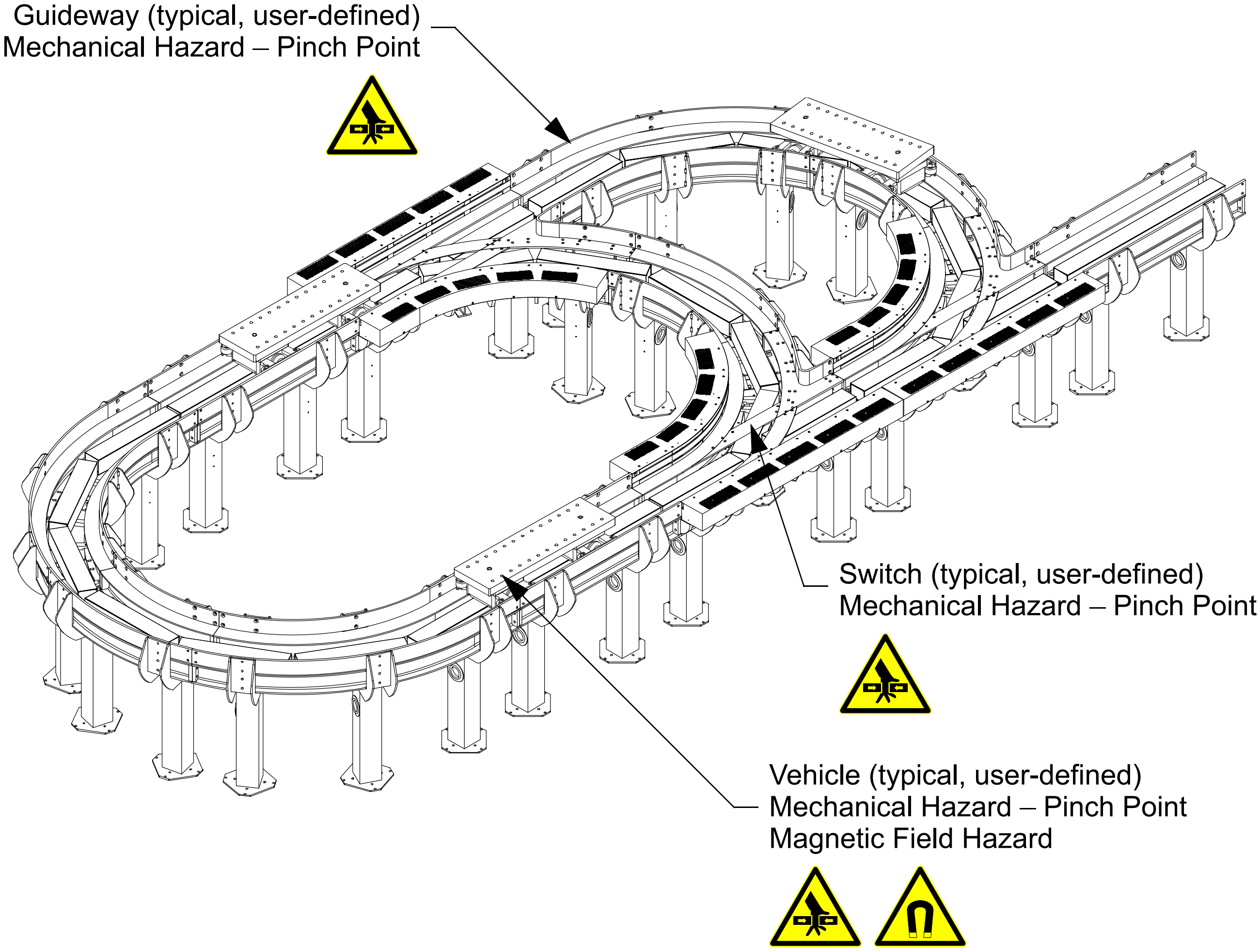


Figure 2-1: Locations of Hazardous Points on the QuickStick 100 Transport System

Symbol Identification

Symbols are used in this manual and on the MagneMotion 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 2-2: Hazard Alert Symbol Identification

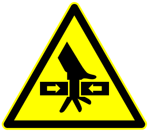
Symbol	Description
	**General Hazard Alert** – Indicates that failure to follow recommended procedures can result in unsafe conditions, which could cause injury or equipment damage.
	**Lifting Hazard** – Indicates that the specified object is heavy or awkward to handle. Personnel must use lifting aids 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 2-3: 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 2-4: 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.

Label Identification and Location

Safety labels and identification labels are placed on those QuickStick 100 components that require them. These labels provide operators and service personnel with hazard identification and information about the QS 100 components at the point of use. This section describes each label, identifies its location, and for safety labels gives instructions on how to avoid the hazard.

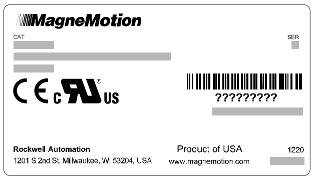
NOTE: Label images are representational only. Actual label includes all appropriate regulatory symbols and can differ in appearance.

Label placement can cause labels to be visible only during maintenance operations.

The following tables list the labels that are affixed to the QS 100 components. The figure after each table shows the location of each label that is identified in the table. To replace a lost or damaged label, contact MagneMotion and refer to its name.

Motors

Table 2-5: Labels Used on the QuickStick 100 Motors

	Product Information Label Qty: 1 Location: On the end of the motor

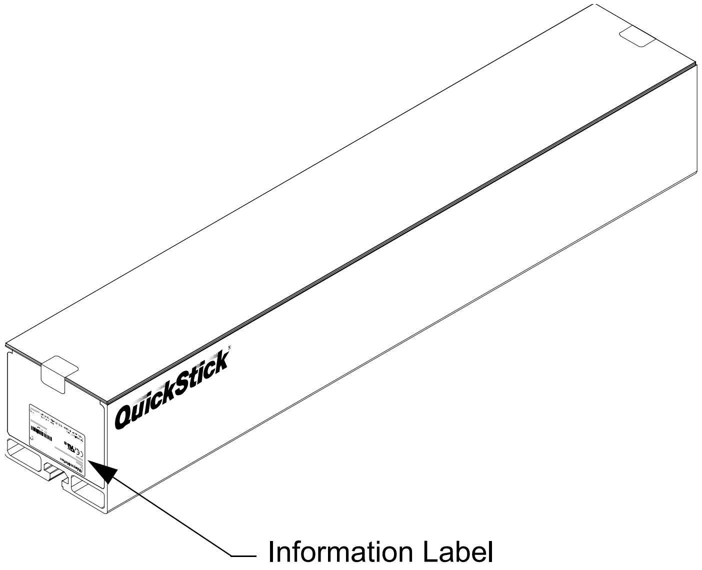
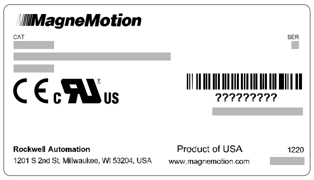


Figure 2-2: Locations of Labels on the QuickStick 100 Motors

Magnet Arrays

Table 2-6: Labels Used on the QuickStick 100 Standard Potted Magnet Arrays

	Product Information Label Qty: 1 Location: On the mounting surface of the magnet array
	Magnet Hazard Label Qty: 1 Location: On the mounting surface of the magnet array Hazard Type: Magnetic field Possible injuries: Pinch between magnet arrays, danger to medical implants and other electronics

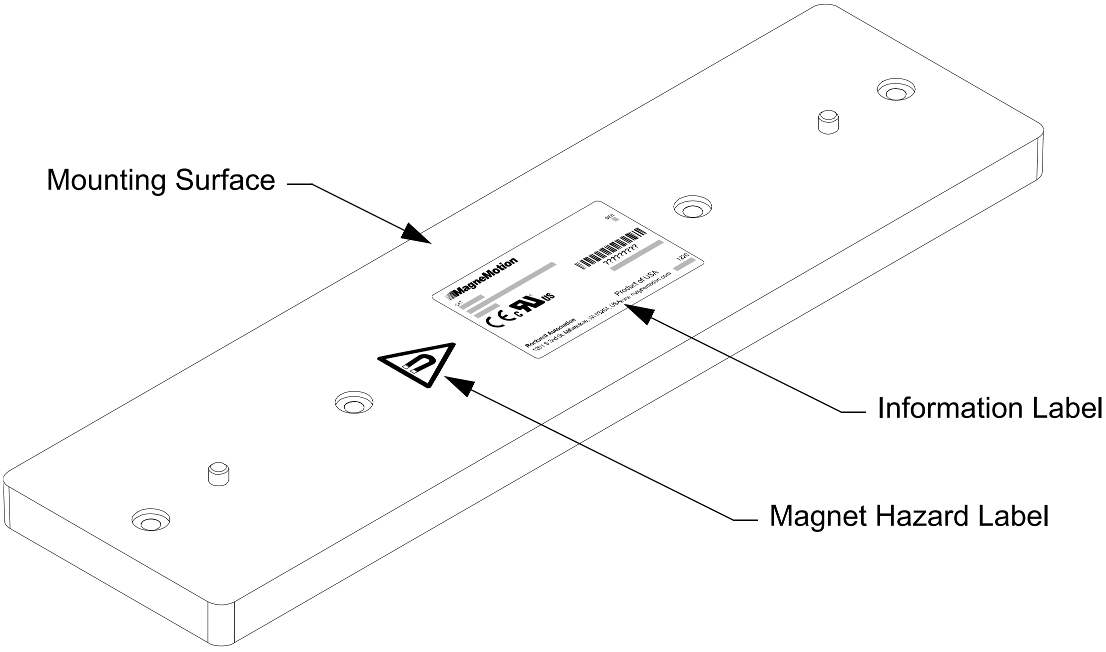
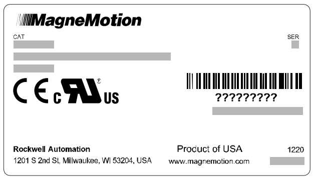


Figure 2-3: Locations of Labels on the QuickStick 100 Standard Potted Magnet Arrays

Table 2-7: Labels Used on the QuickStick 100 Standard Covered Magnet Arrays

	Product Information Label Qty: 1 Location: On the mounting surface of the magnet array
	Magnet Hazard Label Qty: 1 Location: On the mounting surface of the magnet array Hazard Type: Magnetic field Possible injuries: Pinch between magnet arrays, danger to medical implants and other electronics

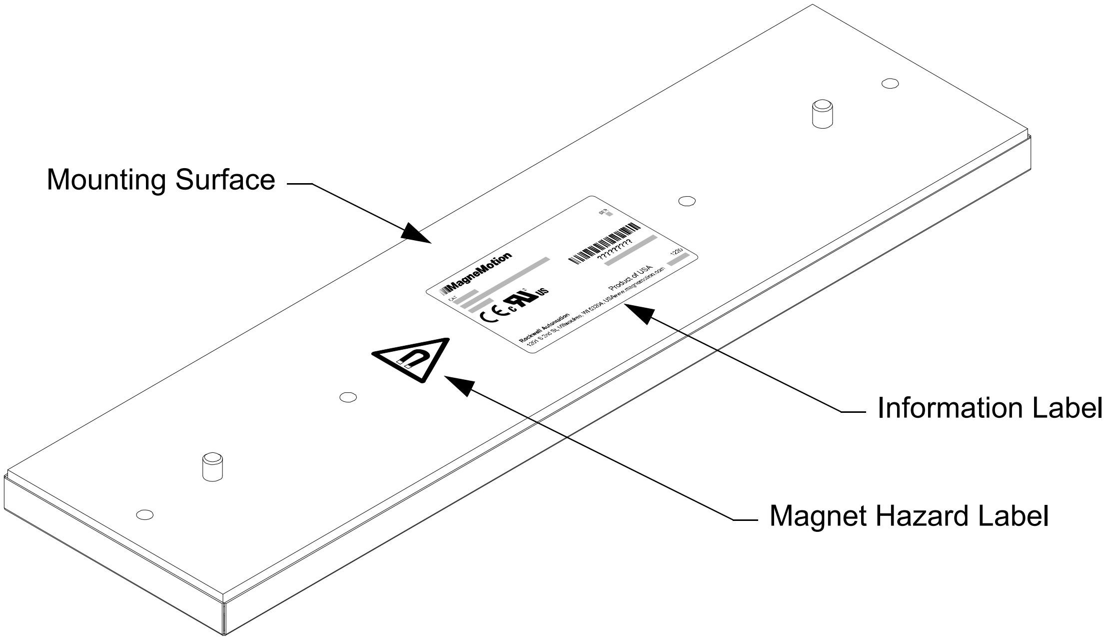
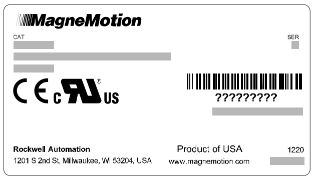


Figure 2-4: Locations of Labels on the QuickStick 100 Standard Covered Magnet Arrays

Electronics

Table 2-8: Labels Used on the QuickStick 100 Power Supply

	Product Information Label Qty: 1 Location: On the bottom of the power supply housing

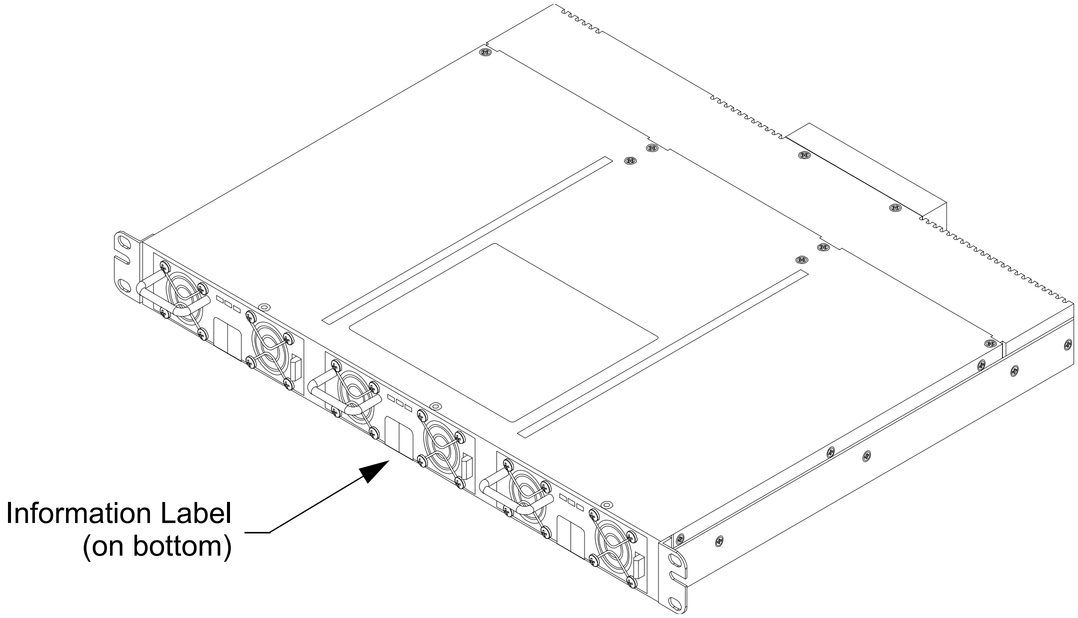


Figure 2-5: Locations of Labels on the QuickStick 100 Power Supply

Mechanical Hazards

The QuickStick 100 transport system is a complex electromechanical system. Only personnel with the proper training should install, operate, or service the QuickStick 100 transport system.

All facilities to the QS 100 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 100 components are being used.

⚠ **WARNING**

Crush Hazard

Moving mechanisms have no obstruction sensors.

Do not operate the QuickStick 100 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 QuickStick 100 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 QuickStick 100 motors can weigh as much as 13.2 kg [29.1 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 QuickStick 100 components.

Electrical Hazards

The QuickStick 100 components are classified as low voltage devices, no additional safety precautions are required.

The 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 100 components are being used.

⚠ WARNING

Electrical Hazard

All electrical power to the QuickStick 100 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 QuickStick 100 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.

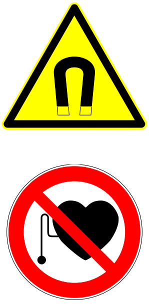
NOTICE

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 QuickStick 100 transport system uses high strength Neodymium Iron Boron (NdFeB) magnets in the magnet arrays that are attached to the vehicles. The proper precautions for using high strength magnets must be observed.

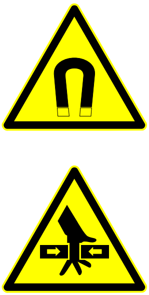


⚠ WARNING

Magnetic Field Hazard

Strong magnets in use.

To avoid severe injury, people with pacemakers and other medical electronic implants 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 QuickStick 100 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.

NOTICE

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 or internal medical devices must use caution when handling the magnet arrays as the magnetic fields can affect the operation of these devices. These individuals must consult their physician and the manufacturer of their medical device to determine its susceptibility to static magnetic fields before handling the magnet arrays and to determine the safe distance from the arrays, or if they must not handle the arrays.
- **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 that are used with the MagneMotion linear motors are very strong. The magnet arrays have a very high attractive force to each other 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 very 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 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 MagneMotion 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 flamma-

ble 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 MagneMotion magnet arrays must only be used for propulsion with a MagneMotion 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.

Shipping Magnet Arrays

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

Recycling and Disposal Information

Information regarding disposal and recycling are provided in this section. At the end of its life, the modules of the QuickStick 100 transport system must be collected separately from any unsorted municipal waste and disposed of as described in this section.

QuickStick 100 Transport System

No hazardous materials, other than the materials identified in this section, are used in the Quick Stick 100 components. The following items require special handling for disposal or recycling.

Motors

The motors contain the following materials and must be disposed of by following all facility, local, and national procedures for the disposal of electronic equipment:

- Aluminum alloy with chromate over cadmium plating.
- Stainless steel.
- Rubber.
- Nickel plated brass.
- Circuit board with connectors and semiconductors.
- Royalcast® 3101 epoxy.

Magnet Arrays

The magnet arrays (attached to the vehicles as the motor secondary) contain Neodymium Iron Boron (NdFeB) magnets and must be disposed of by following all facility, local, and national procedures for the disposal of hazardous materials. Follow all safety procedures for the handling of high strength magnets (see *Magnetic Hazards*). All strong permanent magnets must be demagnetized before disposal. The magnet arrays contain the following materials:

- Neodymium Iron Boron (NdFeB) magnets.
- Stainless Steel or Oxy-Cast 607 epoxy.
- 316L/316L #2 Stainless Steel.

Power Supplies

The power supplies contain the following materials and must be disposed of by following all facility, local, and national procedures for the disposal or recycling of electronic equipment:

- Anodized Aluminum.
- Circuit board with connectors and semiconductors.
- Zinc-plated Low Carbon Steel Screws.

Packaging

The packaging for the QuickStick 100 motors and components contains the following materials. If the packaging is not being saved, it must be disposed of by following all facility, local, and national procedures for the disposal of packaging material:

- Cardboard.
- Polyethylene Foam.

Design Guidelines 3

Overview

This chapter provides guidelines for designing a QuickStick® 100 transport system.

Included in this chapter are:

- Design guidelines for laying out the QuickStick100 transport system and creating interfaces to the system.
- Design guidelines for using QuickStick 100 motors and magnet arrays.
- Guidelines for electrical wiring.
- Design guidelines for the vehicles and guideways.
- Guidelines for motor mounting.
- Guidelines for transport system configuration.

Transport System Layout

Before installing a QuickStick 100 transport system, a transport system layout must be created that defines the following:

- Type and location of all motors (all motors provide bidirectional motion) and switching mechanisms.
- The number of vehicles on the transport system.
- Locations of all interfaces to other equipment in the facility.
- All paths and the direction of forward motion (downstream).
- All nodes and the type of the nodes.
- All node controllers, their type, and connections.
- Identification of the node controller that is assigned as the high-level controller (HLC).
- Additional connections such as motor communications, power, 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. It is also used as a reference when connecting the components of the transport system and defining the elements of the Node Controller Configuration File (see the *QuickStick Configurator User Manual*). See Table A-3 on page 215 for a list of system limits.

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 Overview

The QuickStick 100 components consist of a set of basic building-blocks that provides an easy to assemble and implement transport system. The modular nature of the QS 100 components makes it easy to implement layout or control changes. An example of how the basic building-blocks are used is provided in the following sections:

- *Motors, Switches, and Vehicles* on page 57
- *Paths* on page 58
- *Nodes* on page 59
- *Node Controllers* on page 60
- *Additional Connections* on page 61

Motors, Switches, and Vehicles

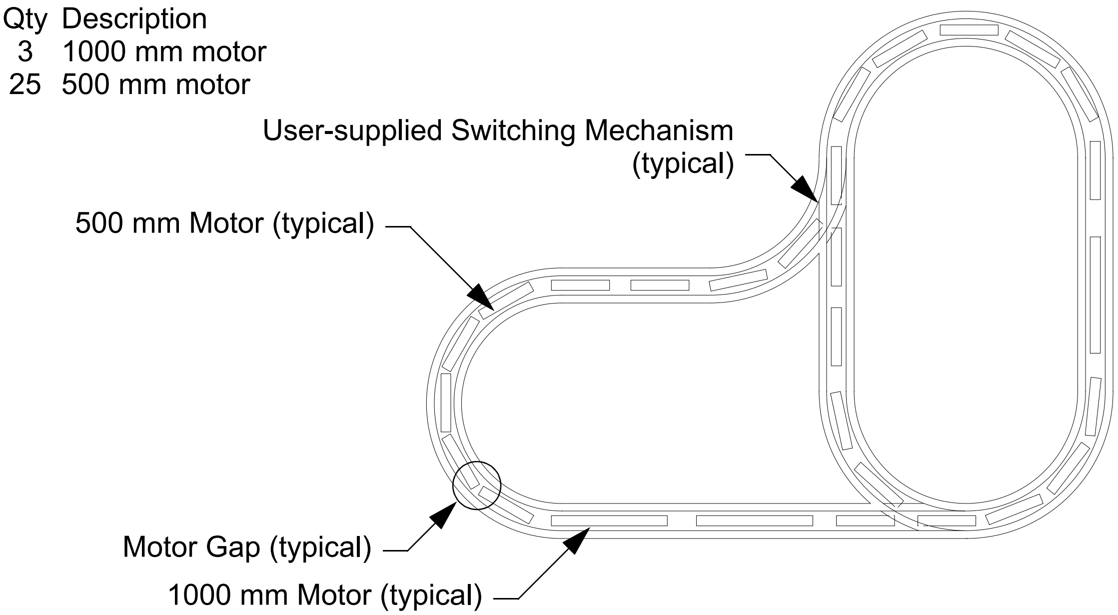
The transport system layout is a plan view layout of the QS 100 transport system. This drawing identifies each motor and switching mechanism (if necessary) in the transport system (see Figure 3-1 for an example). The drawing also includes how they are physically located, the space between each motor, and any interfaces to other equipment in the facility.

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 (see *Paths* on page 58).

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

Vehicles are user-designed independent platforms with integral magnet arrays that are used on QuickStick 100 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 ID to each vehicle at startup, which is retained until the transport system is restarted, the vehicle is removed 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.

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



Qty	Description
3	1000 mm motor
25	500 mm motor

Figure 3-1: Sample QS 100 Transport System Layout Showing Motors

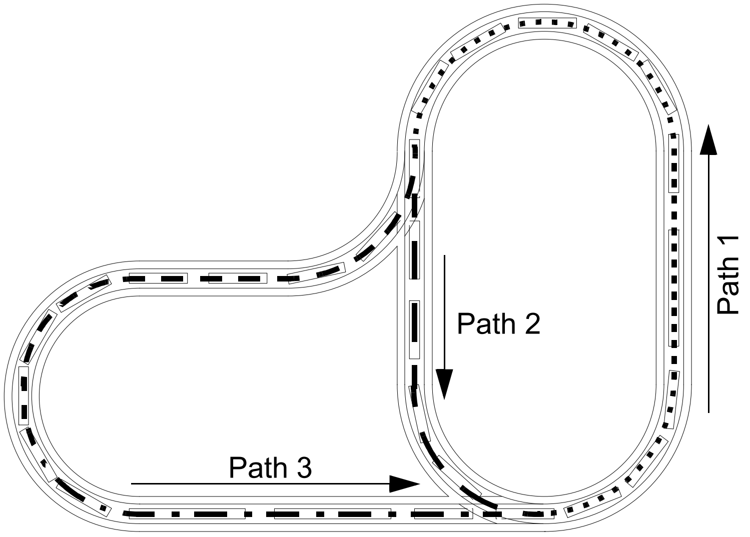
Paths

Once all motors have been identified on the QS 100 transport system layout, the individual paths must be defined (see Figure 3-2 for an example). Path definition includes identifying all motors on the path and the direction of forward (downstream) motion.

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. See the *QuickStick Configurator User Manual* for a detailed description of paths.

Qty	Description
3	1000 mm motor
25	500 mm motor
3	Paths



NOTE: Arrows indicate direction of forward motion.

Figure 3-2: Sample QS 100 Transport System Layout Showing Paths

Table 3-1: Motor Assignments

Path	Motors
1	11–500 mm, 1–1000 mm
2	4–500 mm
3	10–500 mm, 2–1000 mm

Nodes

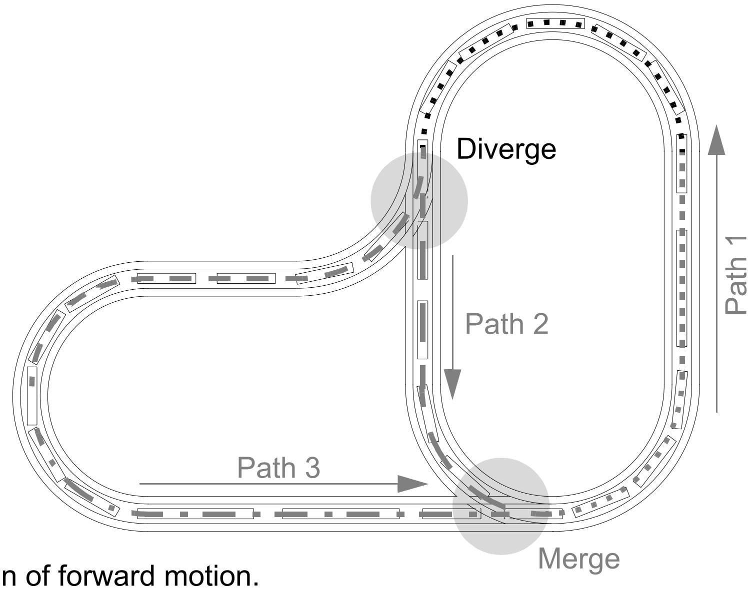
Once all paths have been identified on the QS 100 transport system layout, the nodes that connect those paths must be defined (see Figure 3-3 for an example). Node definition includes identifying the type of node being used.

Nodes define the beginning of all paths and the connections between paths. See the *QuickStick Configurator User Manual* for a detailed description of nodes and all node types. The QS 100 transport system supports the following node types:

- **Simple Node** – Defines the beginning of a path (that is, there is no other path that is connected at this point).
- **Relay Node** – Connects the end of a path to the beginning of a path.
- **Terminus Node** – Defines the start or end of a path where vehicles move to or from the QuickStick 100 transport system.
- **Gateway Node** – Connects a path in one Control Group in a transport system to a path in another Control Group within the same transport system.
- **Merge Node** – Connects the ends of two paths to the beginning of another path.
- **Diverge Node** – Connects the end of one path to the beginning of two other paths.
- **Shuttle Node** – Connects the ends of multiple paths to the beginning of other paths using a linear indexer constructed of QS 100 motors.
- **Moving Path Node** – Connects the ends of multiple paths to the beginning of other paths using a Host-controlled mechanism.

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

Qty	Description
3	1000 mm motor
25	500 mm motor
3	Paths
2	Nodes 1 Diverge 1 Merge



NOTE: Arrows indicate direction of forward motion.

Figure 3-3: Sample QS 100 Transport System Layout Showing Nodes

Node Controllers

Once all paths and nodes have been identified on the QS 100 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 3-4 shows an NC-12 node controller with RS-422 motor communication being used).

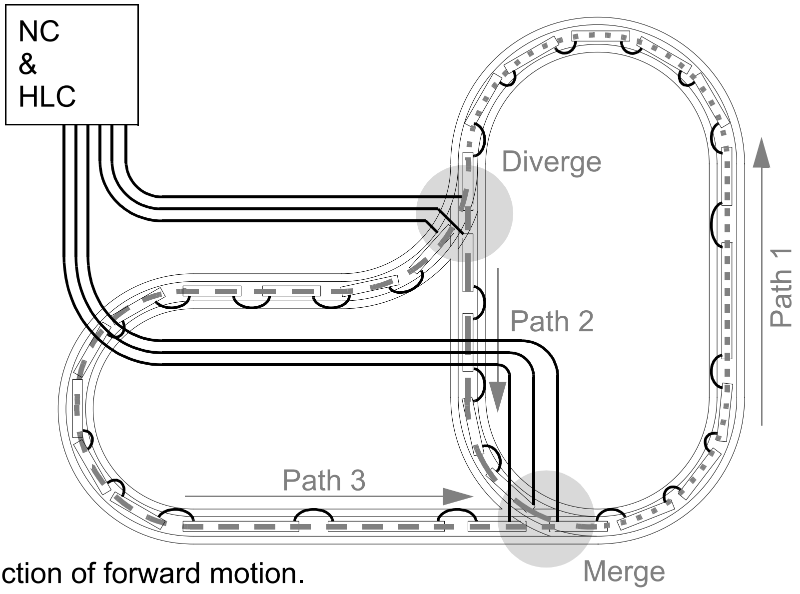
Node controllers coordinate all motor operations and communicate with the high-level controller (HLC). In all QS 100 transport systems, one node controller is designated as the HLC. The HLC manages the communication between all node controllers in the transport system and the host controller. The node controller types that the QS 100 transport system supports are:

- **NC-E Node Controller** – Node controller with one active network port, four digital inputs, and four digital outputs. This node controller can support multiple nodes (for example, Merge, Diverge, and Relay) and additional functions (for example, E-stop and interlocks).
- **NC-12 Node Controller** – Node controller with one network port, 12 RS-422 ports, two RS-232 ports, 16 digital inputs, and 16 digital outputs. This node controller can support multiple nodes (for example, Merge, Diverge, and Relay) and additional functions (for example, E-stop and interlocks).
- **NC LITE Node Controller** – Node controller with one network port and four RS-422 ports. This node controller typically supports one node (for example, Merge). However, some configurations of nodes allow the node controller to support multiple nodes (for example, Simple and Relay).

Motor Communications – Identifies the communication connections between motors on the same path and between motors at path ends and the node controllers.

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

Qty	Description
3	1000 mm motor
25	500 mm motor
3	Paths
2	Nodes 1 Diverge 1 Merge
1	Node Controller (NC)



NOTE: Arrows indicate direction of forward motion.

Figure 3-4: Sample QS 100 Transport System Layout Showing Node Controllers

Additional Connections

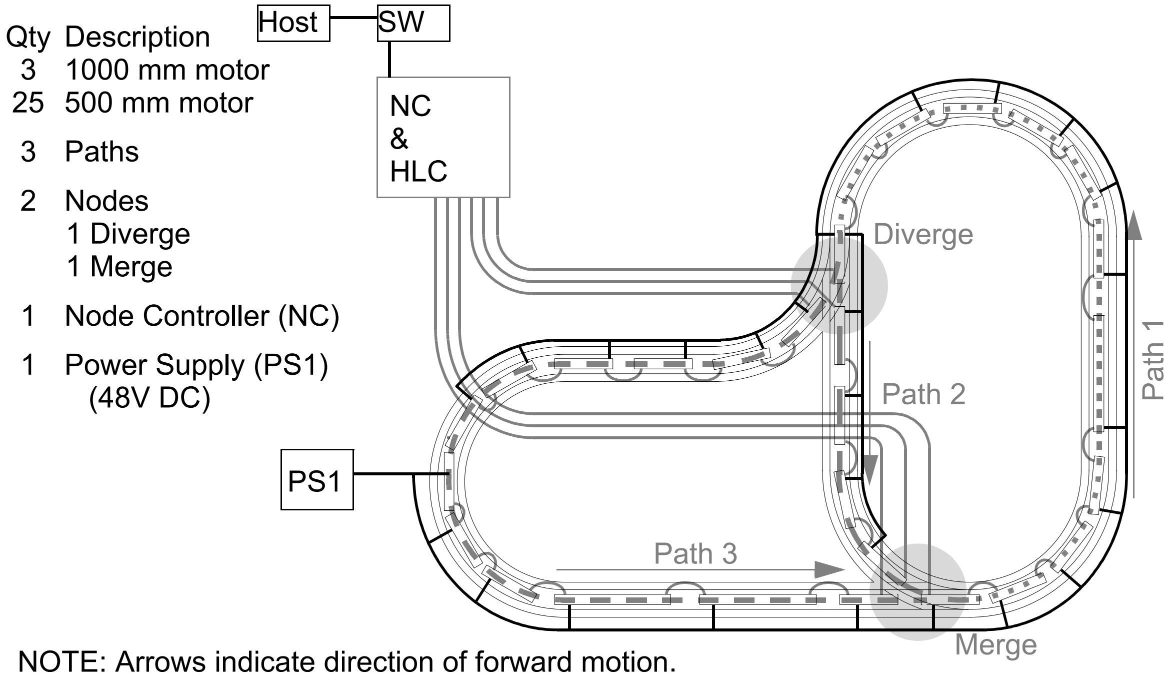
The remaining components and connections must be defined on the QS 100 transport system layout. The components include power supplies for the motors and network switches for communication with the node controllers and host controller (see Figure 3-5 for an example). If node controllers with digital I/O are being used, E-stop buttons, interlocks, and light stacks can be configured and their locations identified.

Power Supplies – DC power supplies providing +48V DC are required for powering the QuickStick 100 motors. See Table 4-3 on page 103 for power supply sizing.

Network 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.

Power Wiring – Identifies the power connections between motors that are connected to the same power supply.



NOTE: Arrows indicate direction of forward motion.

Figure 3-5: Sample QS 100 Transport System Layout Showing Additional Connections

Transport System Design

Overview

This section describes some of the basic considerations for designing a track system for a QuickStick 100 transport system. The track system includes the guideway, the guideway supports, the QS 100 motors, the vehicles with magnet arrays, and the mechanism for mounting the motors to the guideway (see *Transport System Layout* on page 56 for layout guidelines).

One advantage of the QuickStick 100 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 control software makes sure that the minimum distance between vehicles when not moving is 6 mm [0.24 in] (see *Motor Topology* on page 151).

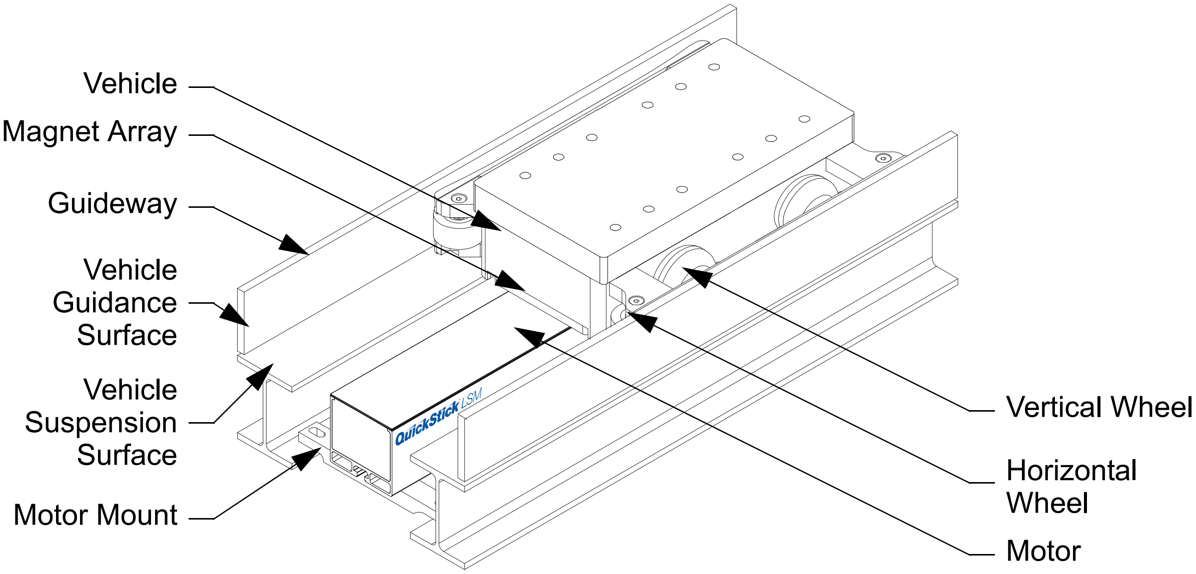


Figure 3-6: QuickStick 100 System, Single Array Vehicle

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 QuickStick 100 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 QuickStick 100 motors is constant (assuming the Vehicle Gap is maintained) regardless of the power that is applied to the motors (see *Determining Attractive Force* on page 212).
- The Vehicle Gap (distance between magnet array and motor, see Figure 3-16) must be maintained throughout the system.

- Keep the Downstream Gap (distance between motors, see Figure 3-8) as small as possible to make sure that there is enough thrust to move the vehicle over the gap.
- Do not locate process stations such that the center of the magnet array would be 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.
- 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 QuickStick 100 motors can be mounted in any orientation: right side up, sideways, upside down, and vertically. QS 100 motors have a required direction, with an upstream end and a downstream end (see *Mechanical Specifications* on page 96 for identification). The QuickStick 100 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 QuickStick 100 motors is from upstream to downstream, however vehicles can move backwards (downstream to upstream) if necessary.

NOTE: 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 QuickStick 100 transport system, review the following information:

- Application for the QuickStick 100 system.
- Desired throughput.
- Maximum payload.
- Total transport length.

- Transport topography.
- Move time.
- Vehicle length.

Once these characteristics are known, identify additional requirements:

- Accommodations for vehicles less than 0.5 meters [19.7 inches] in length.
- Accommodations for track length and topology.
    - See Figure 4-1 on page 96 and Figure 4-2 on page 97 for QuickStick 100 motor mechanical drawings.
    - See Figure 4-3 on page 98 and Figure 4-4 on page 100 for QS 100 magnet array mechanical drawings.
- Perform the calculations as shown in *Determining Thrust Force* on page 211 to determine the optimal thrust force, Vehicle Gap, and magnet array size.
- The QuickStick 100 transport system allows only one vehicle at a time on a motor block (see Table 3-2). Each block is a discrete motor primary section of multiple coils within the motor that is energized over its whole length.

Table 3-2: Motor Blocks

Motor Type	Block Length	No. Blocks
QS 100, 1000 mm	96 mm	10
QS 100, 500 mm	96 mm	5

- The magnetic attractive force present per magnet cycle and the required thrust must be accounted for with the QuickStick 100 motors (see Table 3-3). Complete tables for thrust and attractive force are available in *Data for Transport System Design Calculations* on page 206.

Table 3-3: Thrust and Attractive Force, Standard Magnet Array[*]

	Force
Thrust per cycle @ 4 A stator current[†]	16.3 N/cycle
Attractive force per cycle	58.8 N/cycle

[*] Applies to both potted and covered magnet array versions.

[†] 3 mm Vehicle Gap.

Available Thrust

Several variables determine the thrust available from the QS 100 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 3-8.

The effect of the first two variables, the number of cycles of magnet array and the Vehicle Gap are shown best in *Data for Transport System Design Calculations* on page 206. Equations that use all of these variables are provided in *Determining Thrust Force* on page 211.

At the nominal Vehicle Gap of 3 mm [0.12 in] (gap between the magnet array and the top of the QuickStick 100 motor) the QS 100 motors provide approximately 16.3 N thrust per magnet array cycle at 4 A stator current (see Table 3-3). 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 81), 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 the loss of thrust in the gaps between the motors must be accounted for (see Figure 3-7).

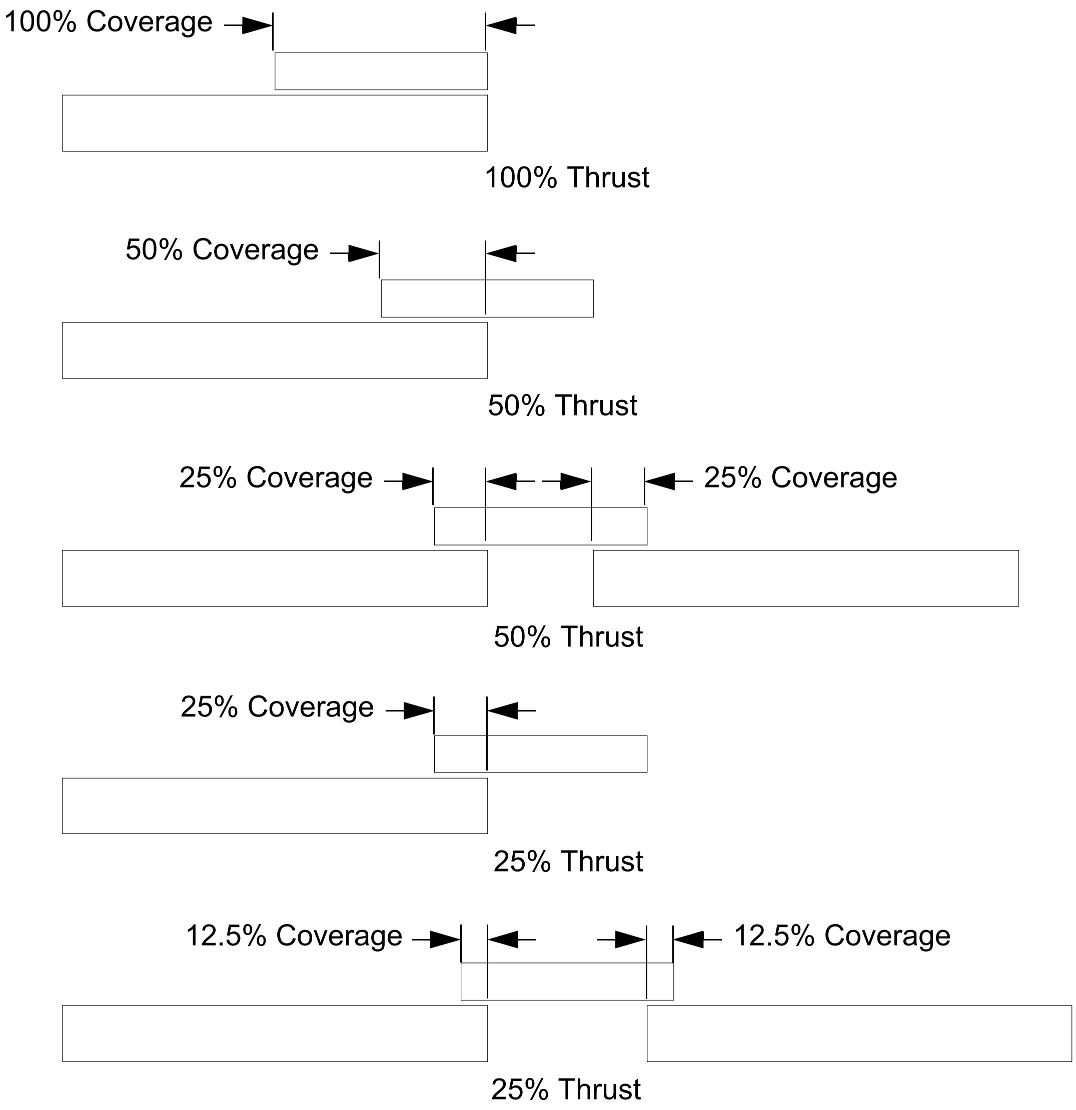


Figure 3-7: Available Thrust Examples

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 QuickStick 100 motors installed in a transport system, there is always a space (Motor Gap) between motors, as shown in Figure 3-8. The minimum space is 2 mm (for thermal expansion) and a typical space is 22 mm, which places 1 m QuickStick 100 motors on a 1 meter pitch.

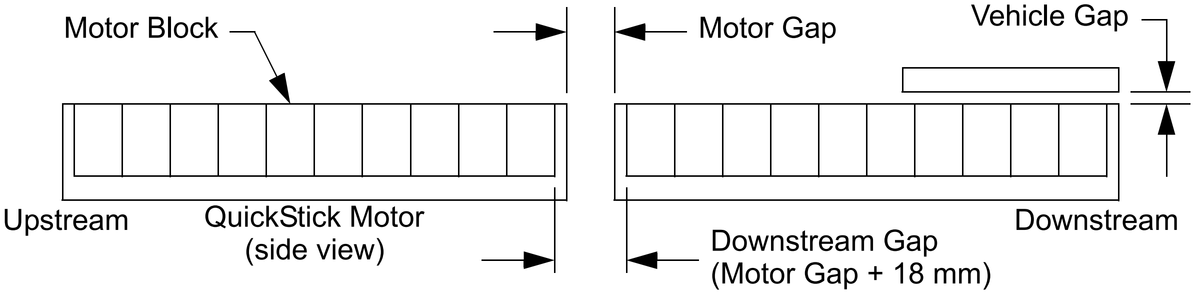


Figure 3-8: Motor Gaps

Downstream Gap

An additional measurement between 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 3-8). The Downstream Gap is equivalent to the Motor Gap plus 18 mm.

NOTE: It is recommended that the maximum Downstream Gap between motors is 10% of the magnet array length. When a dual-array vehicle is used, the maximum Downstream Gap is 10% of the length of one of the arrays. Larger gaps are possible, but cause greater loss of thrust. Contact ICT Customer Support for additional information.

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.

NOTE: The QuickStick 100 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, 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 QuickStick 100 motors in the transport system. This gap value is important when considering the motor blocks that a vehicle owns (see *Block Acquisition* on page 154). 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).

Motor Cogging

Any cogging between the QS 100 motor and the 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 (see *Motor Cogging* on page 153). Any cogging does not affect the positioning accuracy of the motor.

Cogging can be minimized by the following methods:

- Placing QuickStick 100 motors at the optimal pitch on the transport system (see *Downstream Gap*).
- Maximizing the Vehicle Gap between the motor and the magnet array.
- Providing external damping between the vehicle and the payload.

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. This defines by default the Downstream Gap (Motor Gap + 18 mm).

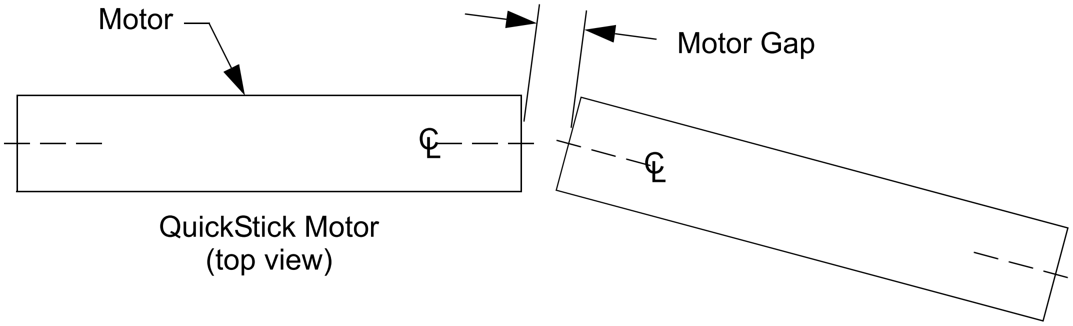


Figure 3-9: Motors on Curves

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 3-15). 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 81) 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 MagneMotion) 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 *QuickStick Configurator User Manual*).

NOTE: If **On Curve** is selected for a motor and MagneMotion has not supplied a unique version of software with the correction table, the vehicles may not move properly and the system does not perform as expected.

Motor Controllers

The motor controller for each QuickStick 100 motor is located inside the QS 100 motor. Each QS 100 motor has one motor controller, also referred to as the master.

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 vehicle position. The motor controllers communicate with each other and a node controller via RS-422 serial communication.

Electrical Wiring

The QS 100 motors are designed to operate at a nominal +48V DC. 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 seen 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 100 system schematic is provided in Figure 3-10. Any part numbers that are shown are for reference only and are subject to change.

The acceptable voltage range for the QS 100 motors is between +43V DC and +53V DC, with a nominal voltage of +48V DC. 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 100 transport system, a means of internally consuming regenerated power within a QS 100 motor is incorporated as a product feature (see *Electrical System* on page 161).

The QS 100 motors are enabled when the internal propulsion bus rises above +43V DC. Until this voltage is reached, the motor reports an under-voltage 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 +41V DC during operation, the motor reports an under-voltage fault and all inverters within the motor are disabled. Normal operation resumes once the internal propulsion bus rises back up to +43V DC. If the internal bus voltage rises above +59V DC during operation, the motor reports an over-voltage fault and all inverters within the motor are disabled. Normal operation resumes once the internal propulsion bus falls below +57V DC. 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 (see *Electrical System* on page 161). 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 100 system is a number of junction boxes (shown in Figure 3-10) 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 (+48V DC) 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 10 W of power per motor (see Table 4-3 on page 103). If only propulsion power is supplied to the motors, connection to logic power is automatically made within the motor.

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 QuickStick 100 transport system is required to make sure of proper operation and to minimize electrical safety issues.

- The bodies of the motors are grounded through the PE connection on the power connector.
- The NC LITE and SYNC IT modules are not grounded through their power connections. The cases of these modules must be grounded to an electrical safety ground (PE) through their mounting features.
- The NC-12 is grounded through the GND stud on the node controller.
- The NC-E is grounded through the power connection.
- 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).

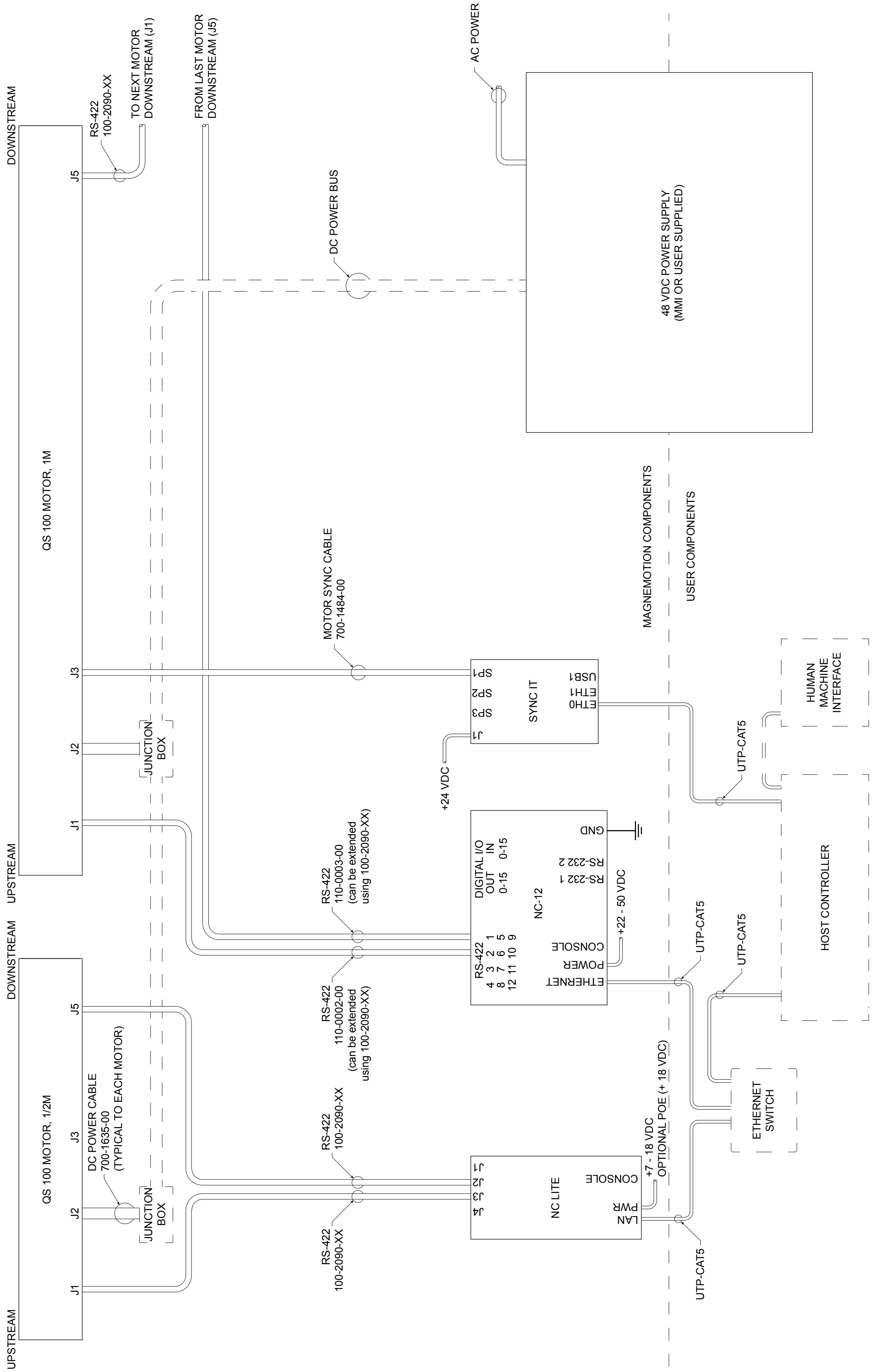


Figure 3-10: System Wiring Block Diagram

Magnet Arrays

The amount of linear thrust that a QS 100 motor provides is primarily a function of magnet array length.

Magnet Array Length and Attractive Force

There is a strong magnetic attractive force present between the magnet array and the QuickStick 100 motor. This force is an important consideration in designing the support structure for the QuickStick 100 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 Figure A-3 on page 210.

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, side-by-side or 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 3-11 and Figure 3-12.
- 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 3-11 and Figure 3-12.
- For QS 100 magnet arrays the cycle length is always 48 mm.

The smallest magnet array available for use with QS 100 motors is 3 cycles (150 mm [5.9 in]). With a 3 cycle magnet array the recommended maximum Motor Gap (distance between motors) is 15 mm (see *Downstream Gap* on page 67).

NOTE: 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 and South-oriented poles in the magnet array. The number of poles is always an odd number (see Figure 3-11) 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 arrays are used in applications where the array does not need to be wider than the motor. These applications are typically when QS 100 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 QS 100 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 QuickStick 100 magnet arrays are intended for use as the QS 100 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, see *Cleaning Magnet Arrays* on page 184.

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 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.

Available Magnet Arrays

The magnet arrays are available in different styles, widths, and lengths (see *Magnet Array, Standard Potted* on page 98 and *Magnet Array, Standard Covered* on page 100).

Standard Magnet Arrays

The standard magnet array for the QS 100 motors is an arrangement of alternating North oriented and South oriented neodymium iron boron (NdFeB) permanent magnets placed perpendicular to the direction of motion. These magnet arrays are available in an epoxy potted version and in a stainless steel covered version that is replacing the epoxy potted version. The stainless steel covered arrays are fully backwards compatible with the potted arrays and provide a one-for-one replacement for the potted arrays. Both magnet array styles 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 3-11 and Figure 3-12.

Epoxy Potted Magnet Arrays

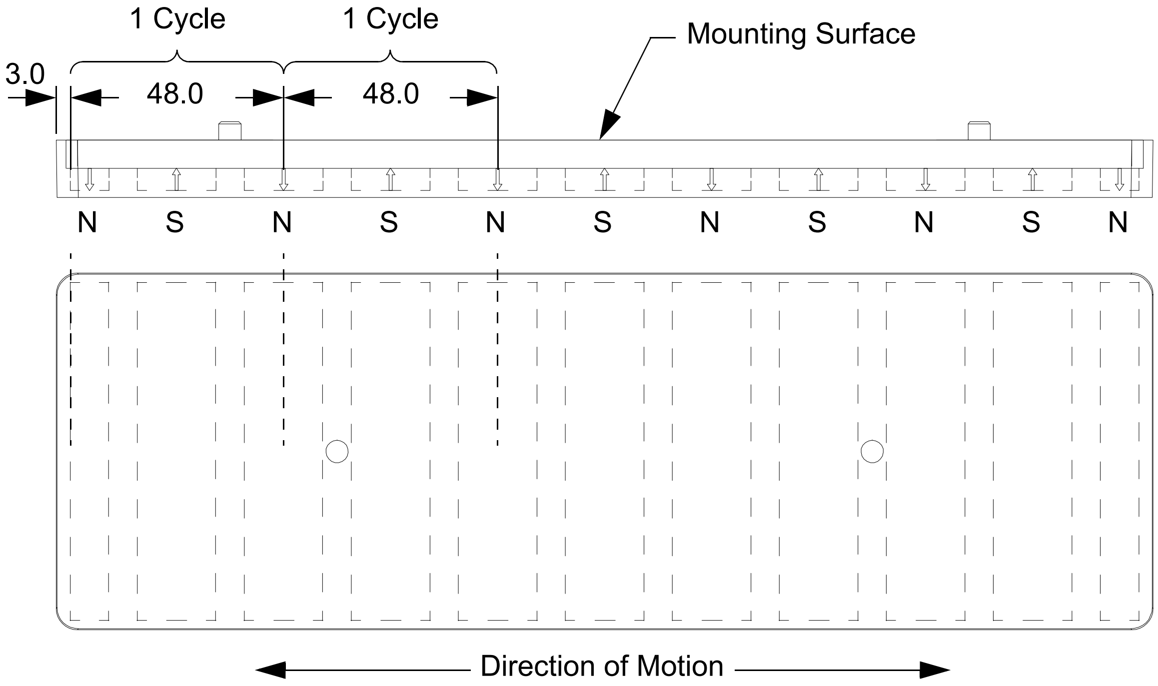


Figure 3-11: Standard Potted Magnet Array, 5 Cycles, 11 Poles

NOTICE

Even though the magnet arrays are potted in epoxy the magnets can still be damaged and are subject to corrosion if damaged.

The potted arrays cannot be placed end-to-end to create longer arrays since the potting on one array interferes with the potting on the other array.

Physical Length

The physical length of the standard potted 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 potted magnet array is:

$$MagnetArrayLength = (Cycles \times 48) + 6 \text{ mm}$$

Where:

MagnetArrayLength is the length of the array, in millimeters.

Cycles is the number of whole cycles in the array.

6 mm is the additional length of the epoxy protecting the magnets.

Stainless Steel Covered Magnet Arrays

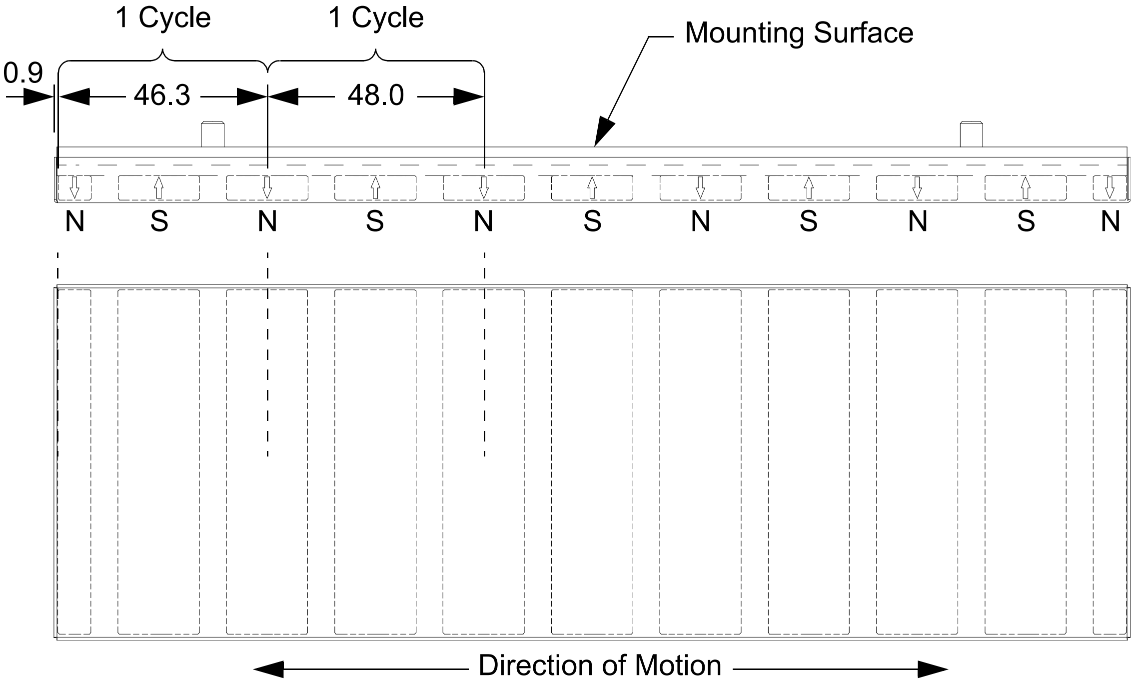


Figure 3-12: Standard Covered Magnet Array, 5 Cycles, 11 Poles

NOTICE

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 as shown in Figure 3-13.

The dowel pin holes for the magnet array pins must be 72.00 mm apart from each other (as shown in Figure 3-13) to make sure the cycle length remains constant. This set the correct physical gap between the magnet arrays and is true for any mix of magnet array lengths. Contact ICT Customer Support for mounting detail drawings.

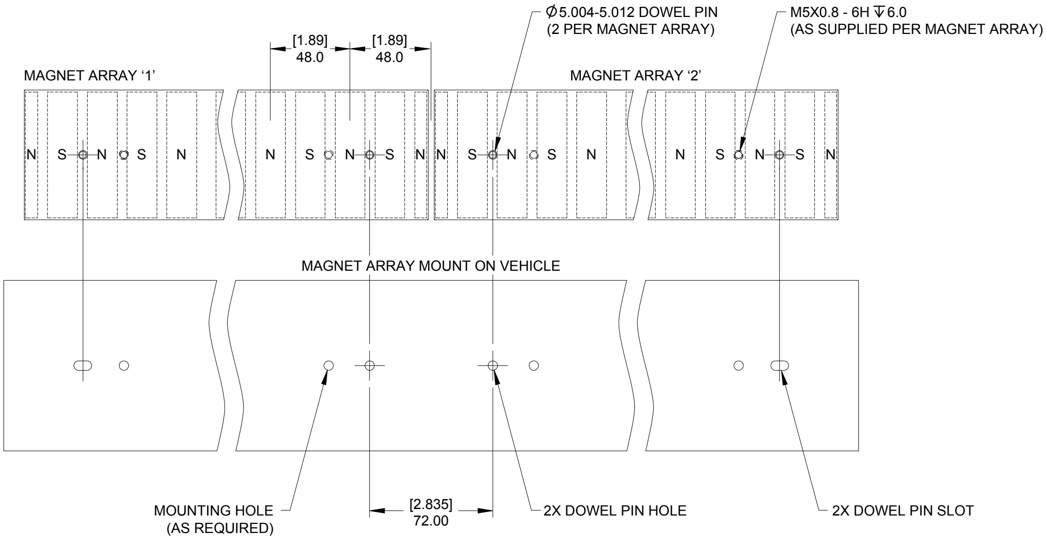


Figure 3-13: Mounting Two Covered Magnet Arrays End-To-End

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:

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

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.

Vehicles

Vehicles carry payloads through the QS 100 transport system as directed. A high-strength magnet array, described in *Magnet Arrays* on page 73, is mounted to the surface of the vehicle closest to the 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 QuickStick 100 motor. There are several design elements that must be met:

- The vehicle supports the magnet array and its placement in the guideway must make sure that the Vehicle Gap, see Figure 3-16, is maintained throughout the system.
- 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 3-14.
- The vehicle platform must be at least as long, and preferably longer than the magnet array.
- 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.

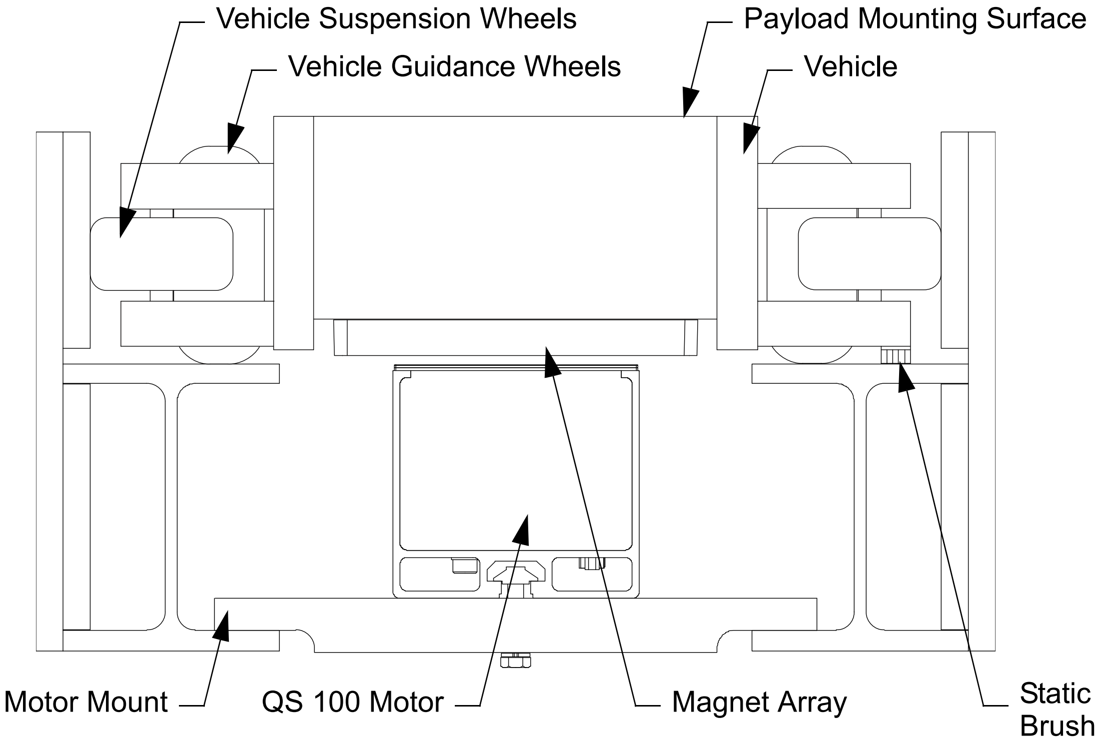


Figure 3-14: Typical Vehicle on Guideway

Various materials can be used to construct the vehicles in a QuickStick 100 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. They also maintain a consistent space between the magnet array that is attached to the vehicle and the QS 100 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.

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 3-15.

Single Magnet Array Misaligned
with Respect to Motors in a Curve

Dual Magnet Array Aligned with
Respect to Motors in a Curve

Figure 3-15: Magnet Array to Motor Alignment

Vehicle Gap

The Vehicle Gap, which is shown in Figure 3-16, is the distance that is maintained between the magnet array and the QS 100 motor. This gap must be maintained throughout the transport system to make sure that the vehicle operates consistently (the larger the gap the longer the magnet array must be to achieve the same thrust). See Table A-1 on page 207 for vehicle thrust data.

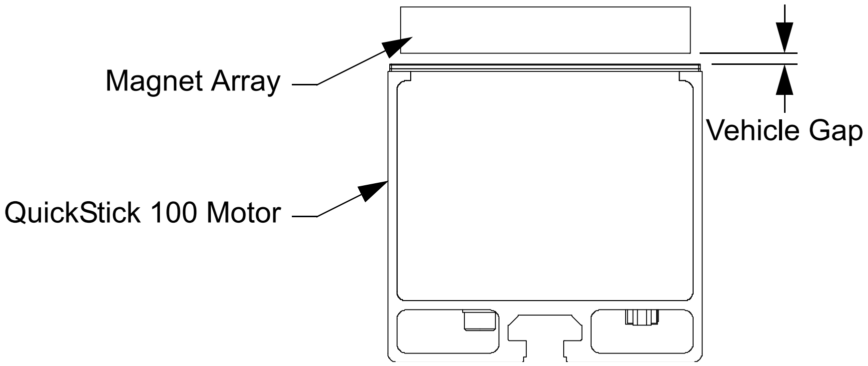


Figure 3-16: Vehicle Gap

The suspension surfaces on which the vehicles move are typically held as flat as is reasonable to maintain consistency in the Vehicle Gap. Allowing greater variability in the Vehicle Gap helps to minimize the guideway and vehicle costs to meet the thrust requirements (see *Determining Thrust Force* on page 211). 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.

NOTE: 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 QS 100 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 ICT Customer Support for additional information.

- Minimum Vehicle Gap is 1 mm.
- Nominal Vehicle Gap is 3 mm for typical industrial applications.
- Maximum Vehicle Gap is 9 mm.

Single Array Vehicle

Vehicles with single magnet arrays are typically used in QuickStick 100 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 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 short or wider than the motor.

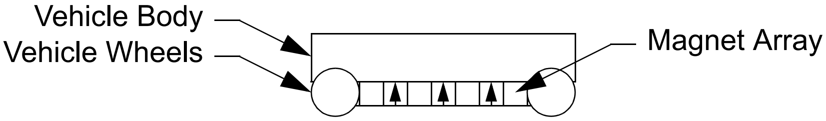


Figure 3-17: Single Array Vehicle Configuration

Dual Array Vehicle

Vehicles with two magnet arrays are typically used in QuickStick 100 transport systems where the guideway includes curves or large distances between 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 3-15), 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 needs to be longer than a standard single magnet array.
- The magnet array is typically wider than the motors.
- The guideway uses small radius curves.

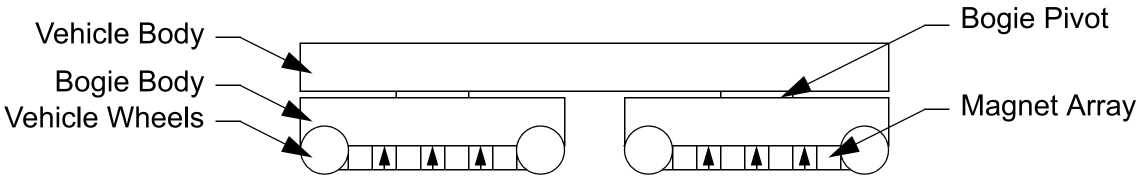


Figure 3-18: Dual Array Vehicle Configuration

Vehicle Design

When designing vehicles for use with the QuickStick 100 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.
- 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.
- 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 creates 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.

Mounting Magnet Arrays to Vehicles

Magnet arrays are provided with locating features to provide consistent mounting to the vehicles and threaded holes for attachment. Arrays must be attached using stainless steel hardware that fully engages the threads in all magnet array mounting holes as shown in Figure 3-19.

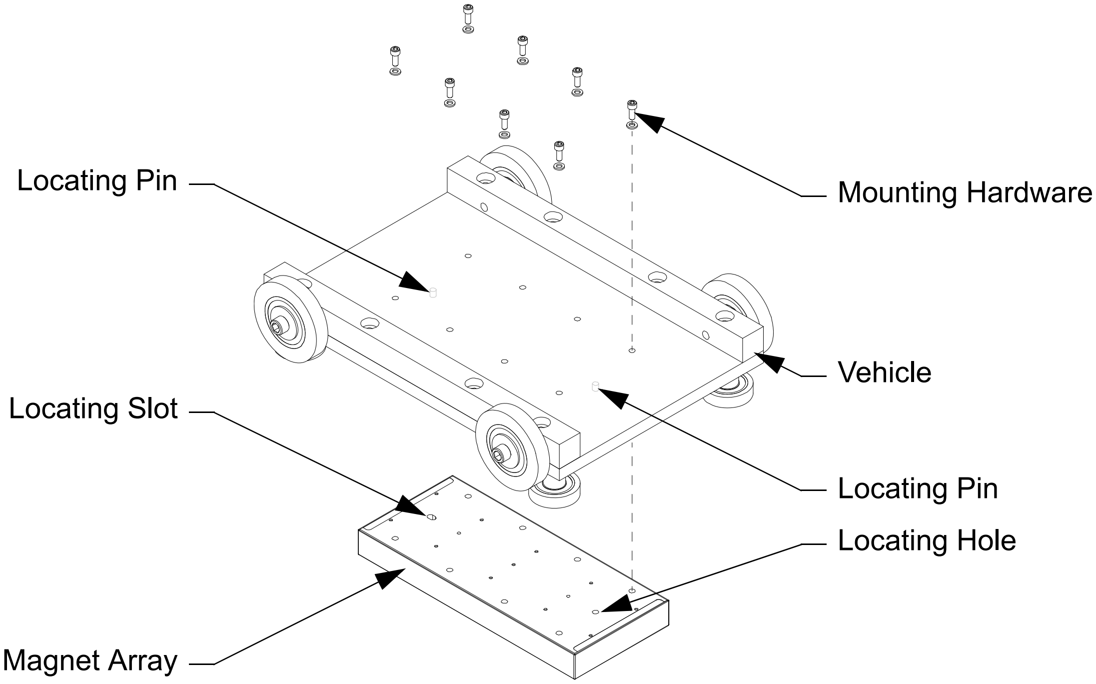


Figure 3-19: Magnet Array Mounting

Guideways

As with any conveyance technology, vehicle motion imparts dynamic loads on the guideway system. Make sure that the guideway is adequately secured to a rigid, permanent structure, such as the equipment the guideway is associated with or the floor, wall, or ceiling, which can reduce vibrations and other stresses on the system.

Guideway Design

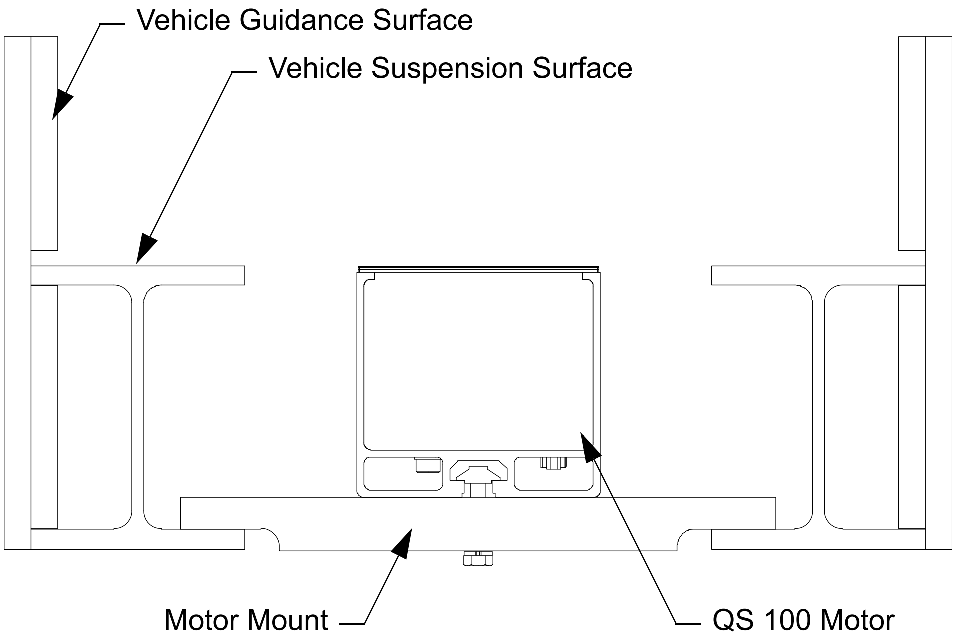


Figure 3-20: QuickStick 100 Transport System, Guideway Detail

Basic guideway design guidelines and considerations:

- The guideway can have any orientation in relation to the motors and vehicles as long as the 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 3-8).
- The guideway must hold the motors and support the vehicles to make sure that the Vehicle Gap (see Figure 3-16) 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 payload, vehicle mass, and motor mass must be within the limits of the guideway.
- The guideway must provide features to allow the vehicle to maintain its position on the guideway (see Figure 3-20).
- The guideway must provide proper grounding to provide static dissipation.

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 QuickStick 100 motors provide mounting features on the bottom, which provides for a simple mounting scheme (see *Mechanical Specifications* on page 96). The following guidelines are provided for designing the motor mounts.

- 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.
- Design the mounts to make sure that the motor is securely fastened and cannot move.

Motor Mounting Methods

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

- When attaching directly to the track or mounting plate as shown in Figure 3-21, 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.

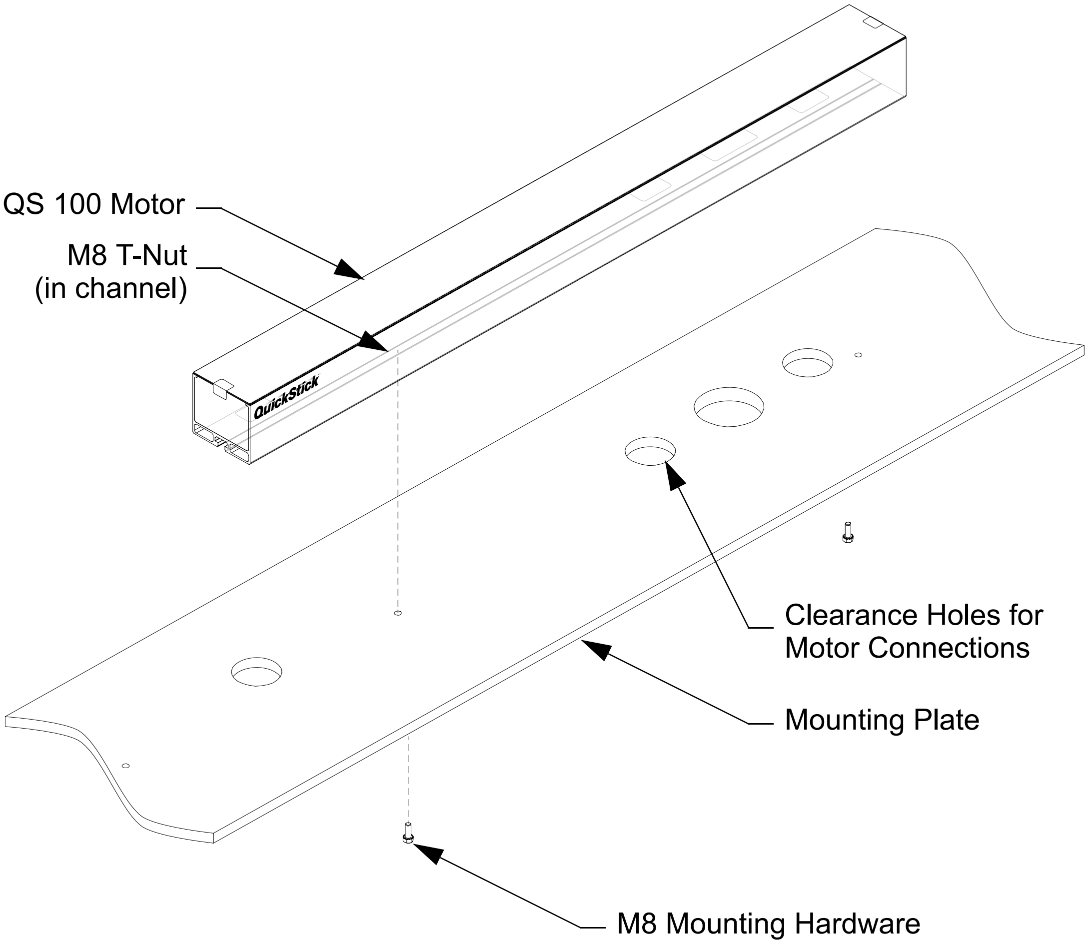


Figure 3-21: Motor Mounting to Flat Surface

- When attaching mounting brackets to the motors and securing the brackets to the track as shown in Figure 3-22, 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.

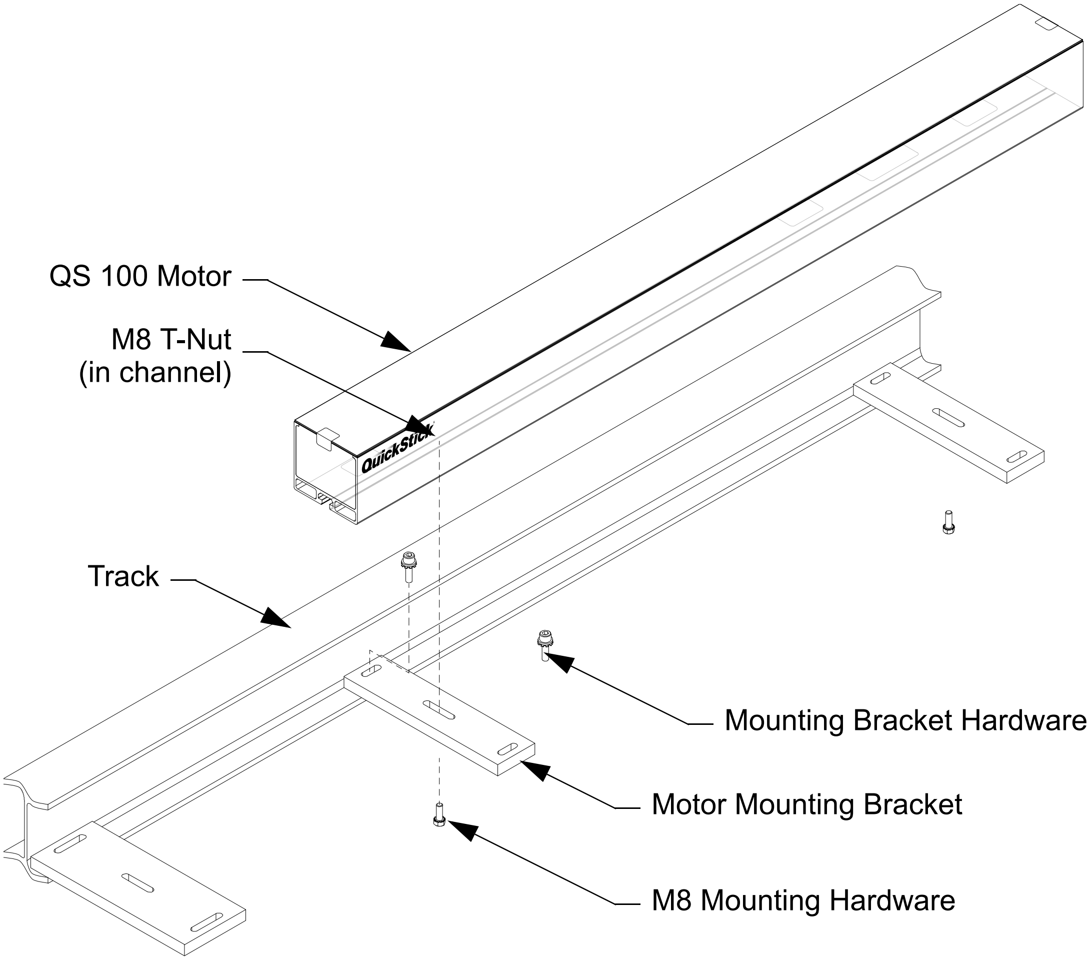


Figure 3-22: Motor Mounting Using Brackets

When using either of the mounting methods shown.

1. Loosely mount the motors to the motor mounting surface. The motor mounts should allow the motors a small amount of movement relative to each other.

   NOTE: The upstream end of the motor is the end where the power connector is located (see Figure 4-1 on page 96 and Figure 4-2 on page 97).

2. Make sure that there is consistent spacing between the motors.

3. Make sure that the top surfaces of all motors are coplanar to each other.

4. Treating each motor to motor interface as a separate operation, tighten the motor mounts. See *Mounting the Motors* on page 124 for details of the mounting procedure.

Guideway Examples

Figure 3-23 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.

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

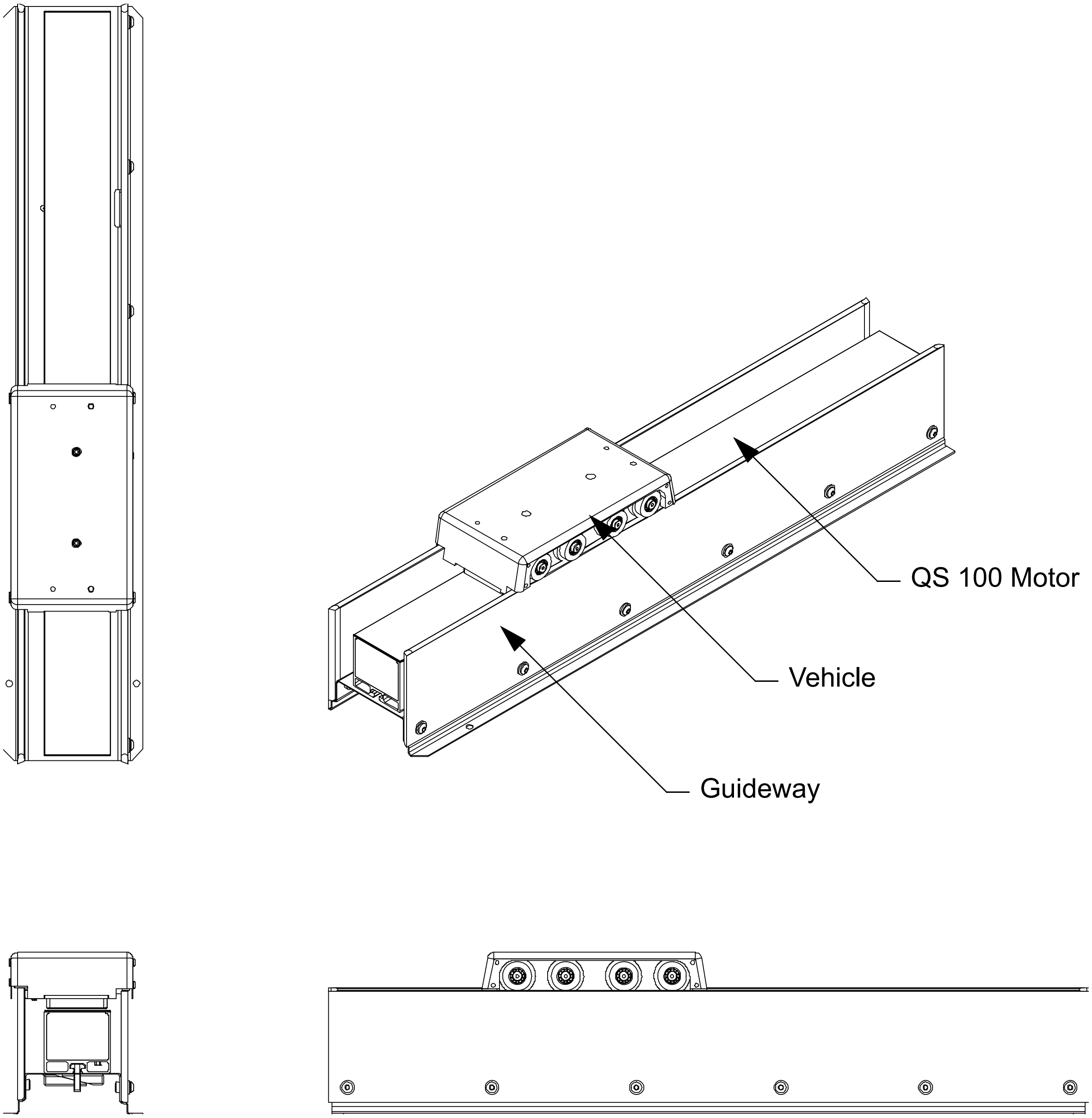


Figure 3-23: Guideway Example #1

Figure 3-24 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 magnet array in the correct relationship to the motors. This guideway can be used in any orientation as the vehicles are captive.

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

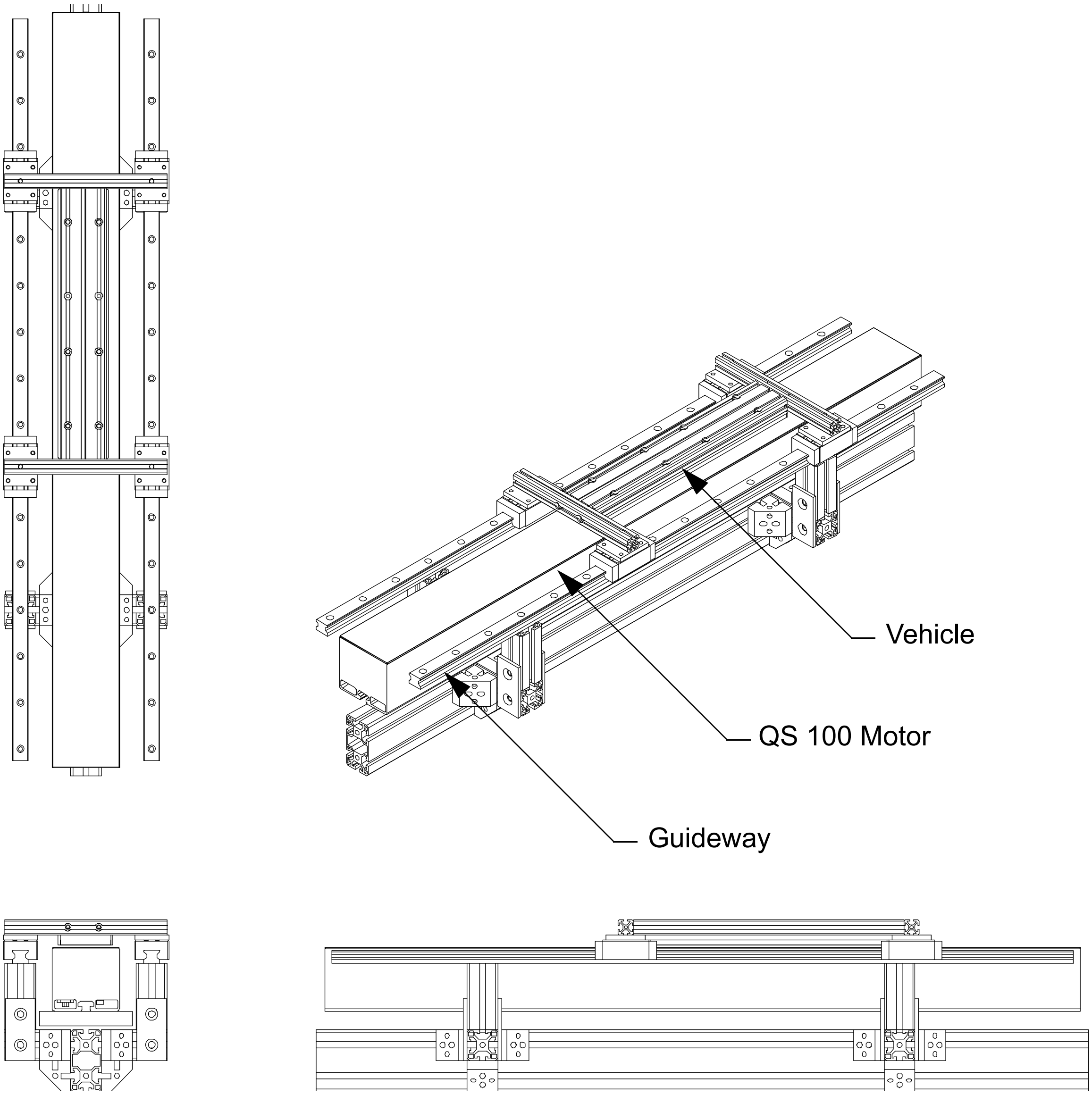


Figure 3-24: Guideway Example #2

Figure 3-25 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 magnet array in the correct relationship to the motors.

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

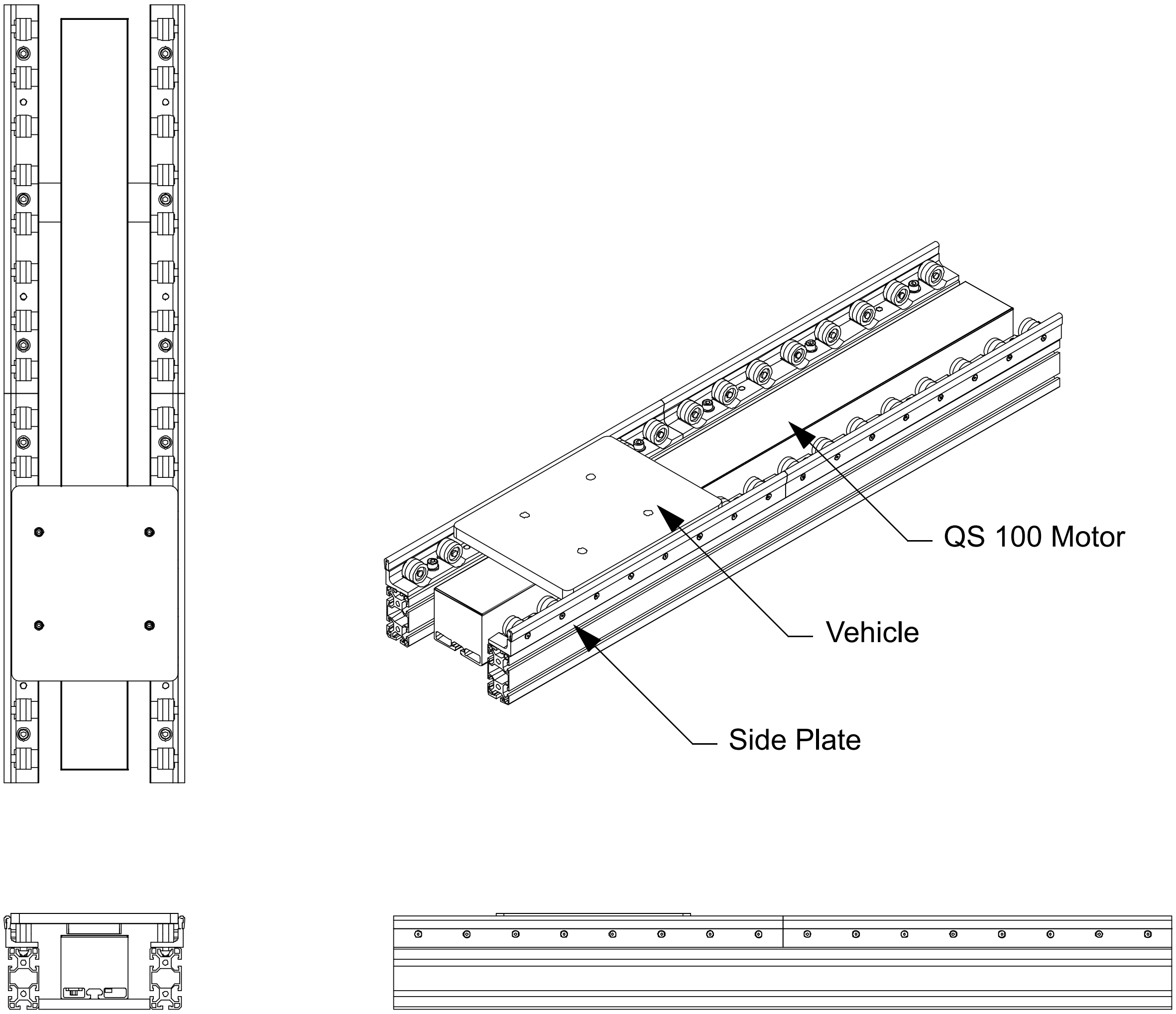


Figure 3-25: Guideway Example #3

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 3-20.

Straight Track Configuration

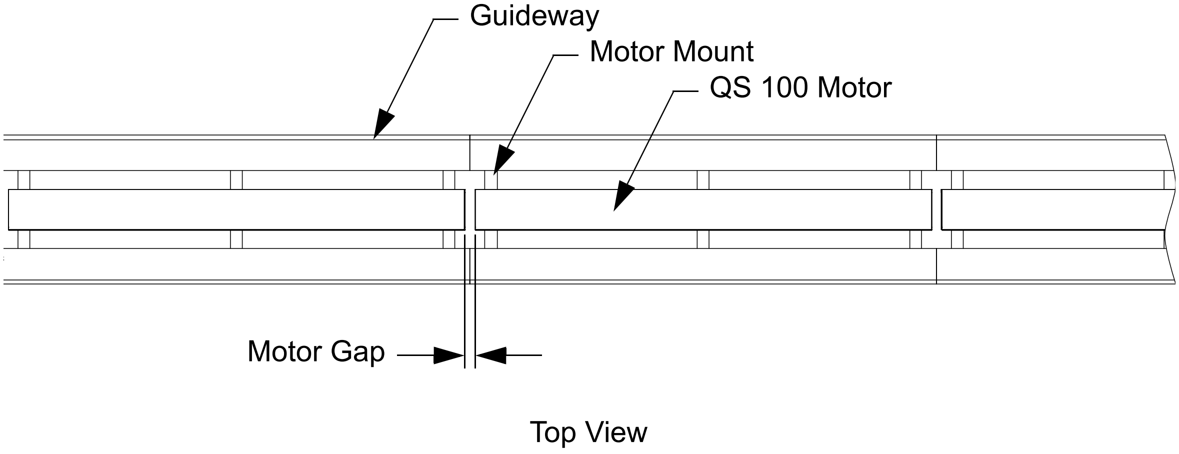


Figure 3-26: Straight Track Configuration

- 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.

NOTE: Different size gaps between motors must be identified in the Node Controller Configuration File (see the *QuickStick Configurator User Manual*).

Curve Track Configuration

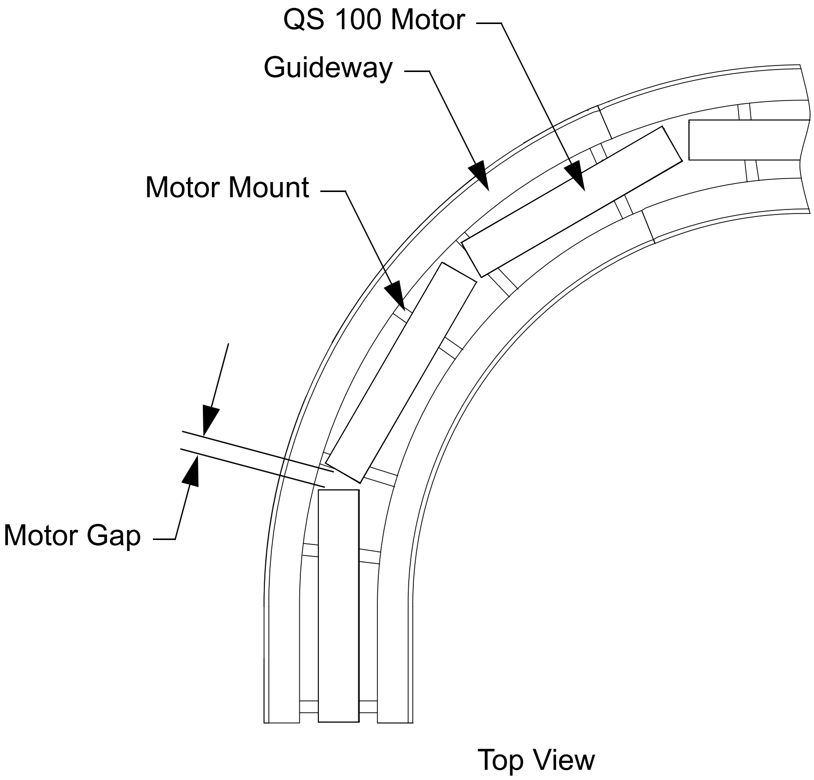


Figure 3-27: Curve Track Configuration

- 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 3-15, *Magnet Array to Motor Alignment*, on page 79).
- Motors may need to be configured as being **On Curve** in the Node Controller Configuration File.
- Keep the Motor Gaps consistent over the length of the curve in the guideway.

  NOTE: Different size gaps between motors must be identified in the Node Controller Configuration File (see the *QuickStick Configurator User Manual*).

Switch Configuration

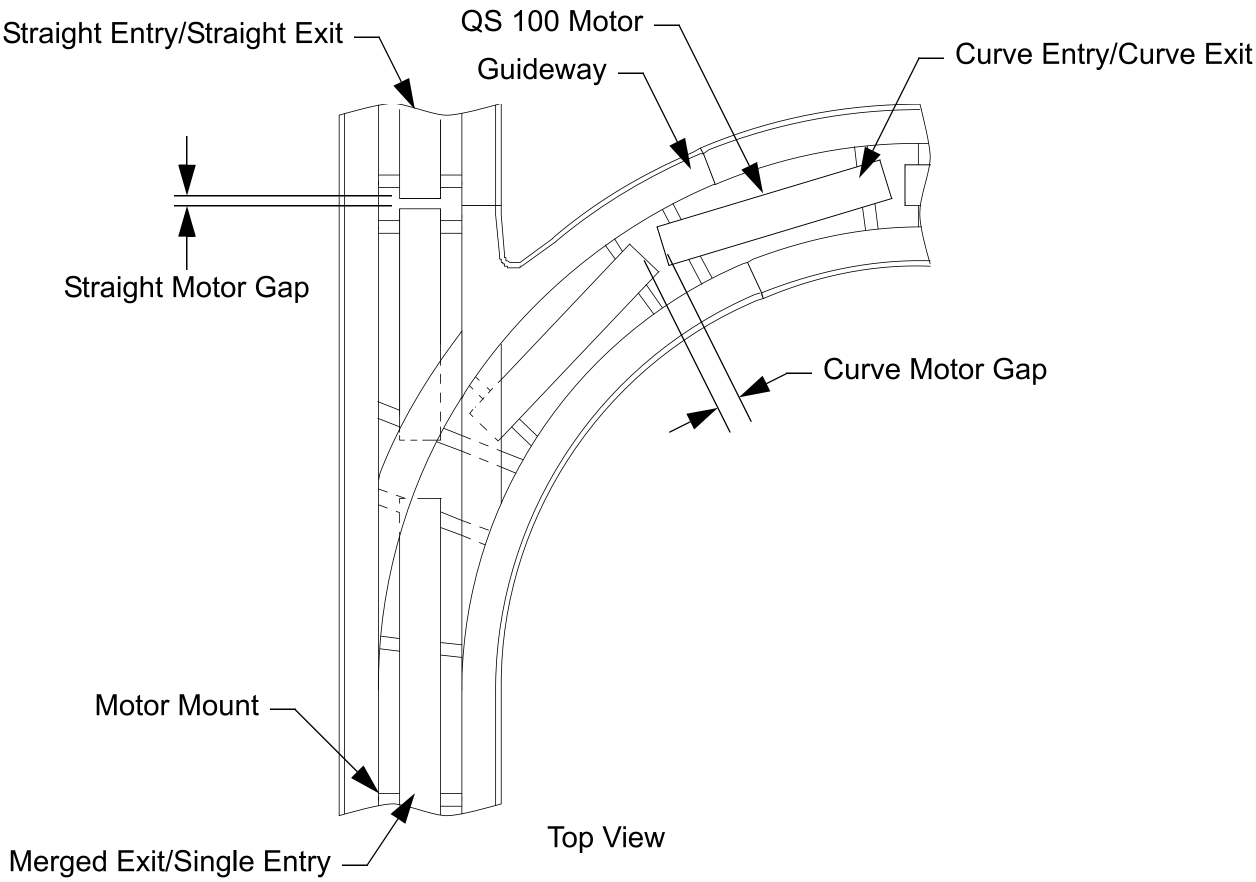


Figure 3-28: Switch Configuration

- Node types at switch: Merge, Diverge.
- 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 3-15, *Magnet Array to Motor Alignment*, on page 79).
- 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.

  NOTE: Different size gaps between motors must be identified in the Node Controller Configuration File (see the *QuickStick Configurator User Manual*).

Moving Path Configuration

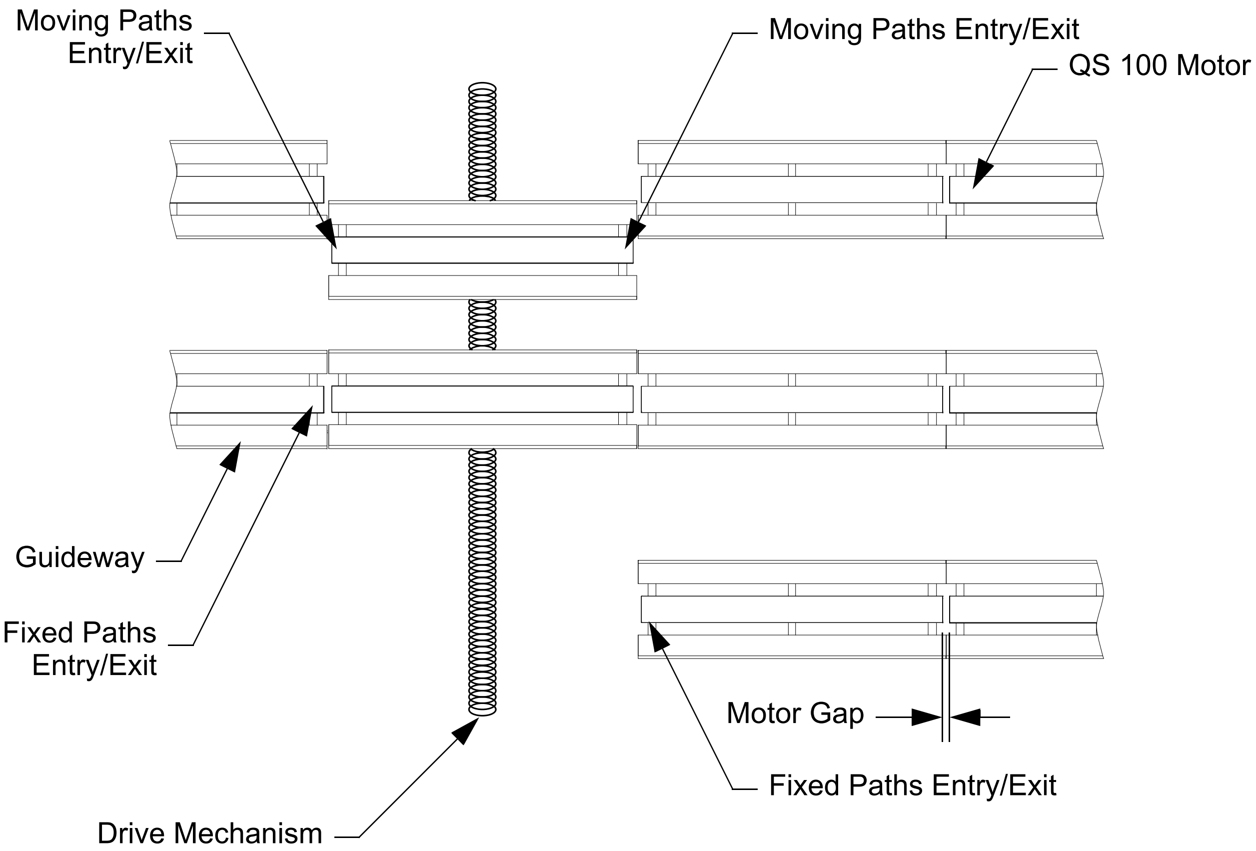


Figure 3-29: Moving Path Configuration

- Node type: Moving Path.
- Provides multiple entries and exits (maximum of 12). The example that is shown in Figure 3-29 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.
- QuickStick 100 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 guideway.

  NOTE: Different size gaps between motors must be identified in the Node Controller Configuration File (see the *QuickStick Configurator User Manual*).

Specifications and Site Requirements 4

Overview

This chapter describes specifications for the QuickStick® 100 transport system components and the requirements for installation.

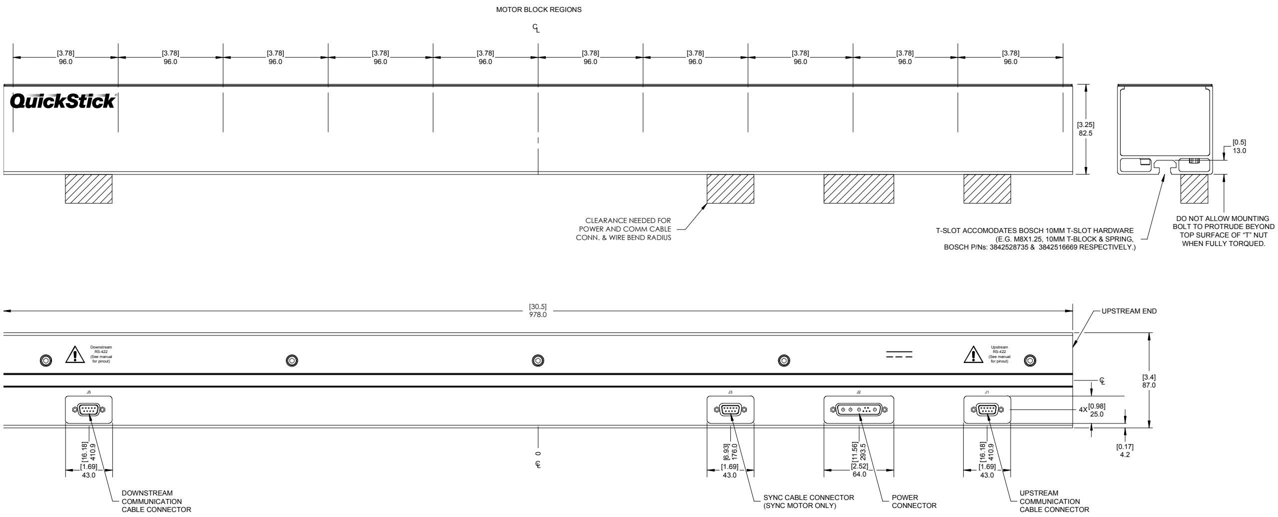
Included in this chapter are:

- Mechanical specifications for all QuickStick 100 components, including dimensions.
- Electrical specifications for power and communications, including connector pinouts.
- Site requirements, including environmental and service access.

Mechanical Specifications

All drawings within this manual are generic and do not reflect specific configurations of the QuickStick 100 components. To obtain current drawings, contact ICT Customer Support.

1000 Millimeter Motor



Weight: 13.2 kg [29.1 lb]

All Dimensions in Millimeters [Inches]

Figure 4-1: 1000 Millimeter Motor Mechanical Drawing

NOTE: The exclusion zones that are shown are for the QS 100 motor only. Additional exclusion zones may be required based on the design of the vehicle and the material being transported.

Ingress Protection Rating: Designed for IP54 (IEC 60529).

Vibration Rating: 10–500 Hz. @ 2 *g*.

Shock Rating: 15 *g*.

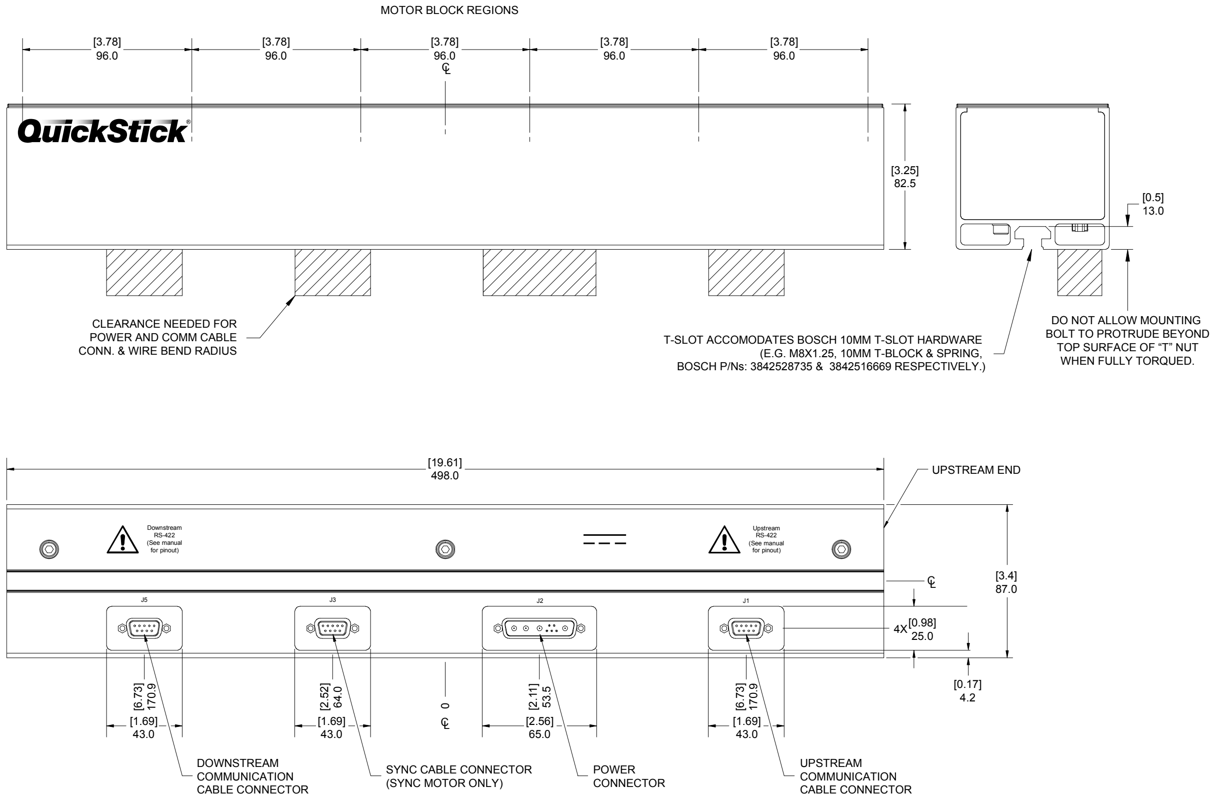
See *QS 100 Motors* on page 103 for the electrical specifications.

Contact ICT Customer Support for current detail drawings.

Exposed Materials

- Aluminum 6063-T6.
- 304 Stainless Steel.
- TGIC powder coat.
- VHB conformable foam with acrylic adhesive.
- The motor has exposed D-style connectors and must not be located where harsh conditions exist.

500 Millimeter Motor



Weight: 6.6 kg [14.6 lb]

All Dimensions in Millimeters [Inches]

Figure 4-2: 500 Millimeter Motor Mechanical Drawing

NOTE: The exclusion zones that are shown are for the QS 100 motor only. Additional exclusion zones may be required based on the design of the vehicle and the material that the motor is moving.

Ingress Protection Rating: Designed for IP54 (IEC 60529).

Vibration Rating: 10–500 Hz. @ 2 *g*.

Shock Rating: 15 *g*.

See *QS 100 Motors* on page 103 for the electrical specifications.

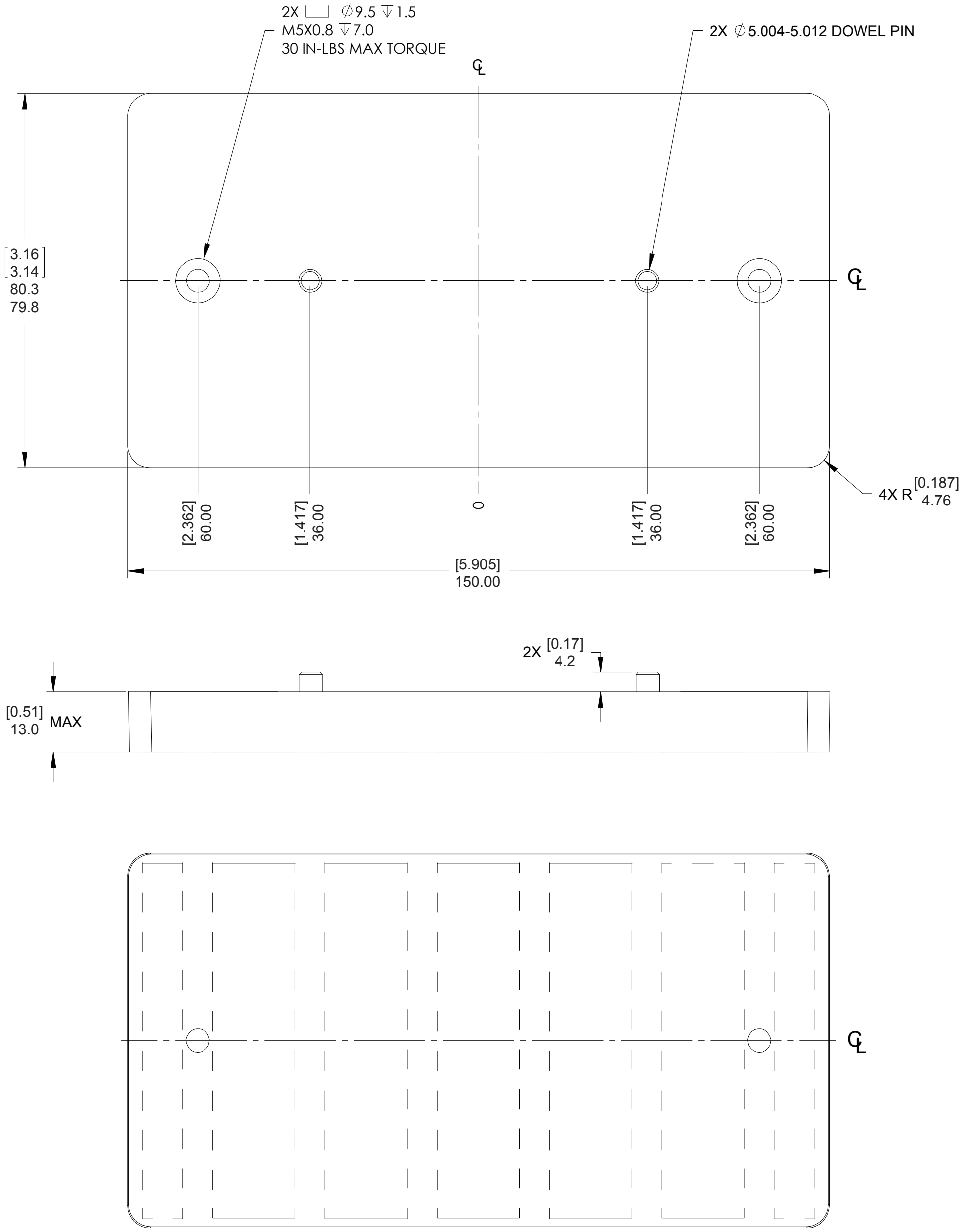
Contact ICT Customer Support for current detail drawings.

Exposed Materials

- Aluminum 6063-T6.
- 304 Stainless Steel.
- TGIC powder coat.
- VHB conformable foam with acrylic adhesive.
- The motor has exposed D-style connectors and must not be located where harsh conditions exist.

Magnet Array, Standard Potted

Potted magnet arrays (see *Standard Magnet Arrays* on page 74) are available in two widths (80.0 mm [3.2 in] ('F') and 130.8 mm [5.2 in] ('E')). Both widths are available in lengths from 3 cycles to 20 cycles (see Table 4-1). Figure 4-3 shows an 80 mm wide 3 cycle array for reference. The quantity and locations of the mounting holes vary based on the size of the array.



Weight: see Table 4-1

All Dimensions in Millimeters [Inches]

Figure 4-3: Standard 'F' Potted Magnet Array Mechanical Drawing

NOTE: Contact ICT Customer Support for current detail drawings.

Designed for IP65 (IEC 60529).

Table 4-1: Standard Potted Magnet Array Lengths and Weights

		80.0 mm [3.2 in] Wide ('F')	**130.8 mm [5.2 in] Wide[*] ('E')**
Cycles	**Length**	**Weight**	**Weight**
3	150.0 mm [5.90 in]	0.9 kg [2.0 lb]	1.5 kg [3.3 lb]
4	198.0 mm [7.79 in]	1.2 kg [2.6 lb]	2.0 kg [4.4 lb]
5	246.0 mm [9.68 in]	1.6 kg [3.5 lb]	2.6 kg [5.7 lb]
6	294.0 mm [11.57 in]	1.9 kg [4.2 lb]	3.1 kg [6.8 lb]
7	342.0 mm [13.46 in]	2.2 kg [4.9 lb]	3. kg [7.9 lb]
8	390.0 mm [15.35 in]	2.5 kg [5.5 lb]	4.1 kg [9.0 lb]
9	438.0 mm [17.24 in]	2.8 kg [6.2 lb]	4.6 kg [10.1 lb]
10	486.0 mm [19.13 in]	3.1 kg [6.8 lb]	5.1 kg [11.2 lb]
11	534.0 mm [21.02 in]	3.4 kg [7.5 lb]	5.6 kg [12.3 lb]
12	582.0 mm [22.91 in]	3.7 kg [8.2 lb]	6.1 kg [13.4 lb]
13	630.0 mm [24.80 in]	4.0 kg [8.8 lb]	6.6 kg [14.6 lb]
14	678.0 mm [26.69 in]	4.3 kg [9.5 lb]	7.1 kg [15.7 lb]
15	726.0 mm [28.58 in]	4.7 kg [10.4 lb]	7.7 kg [17.0 lb]
16	774.0 mm [30.47 in]	5.0 kg [11.0 lb]	8.2 kg [18.1 lb]
17	822.0 mm [32.36 in]	5.3 kg [11.7 lb]	8.7 kg [19.2 lb]
18	870.0 mm [34.25 in]	5.6 kg [12.3 lb]	9.2 kg [20.3 lb]
19	918.0 mm [36.14 in]	5.9 kg [13.0 lb]	9.7 kg [21.4 lb]
20	966.0 mm [38.03 in]	6.2 kg [13.7 lb]	10.2 kg [22.5 lb]

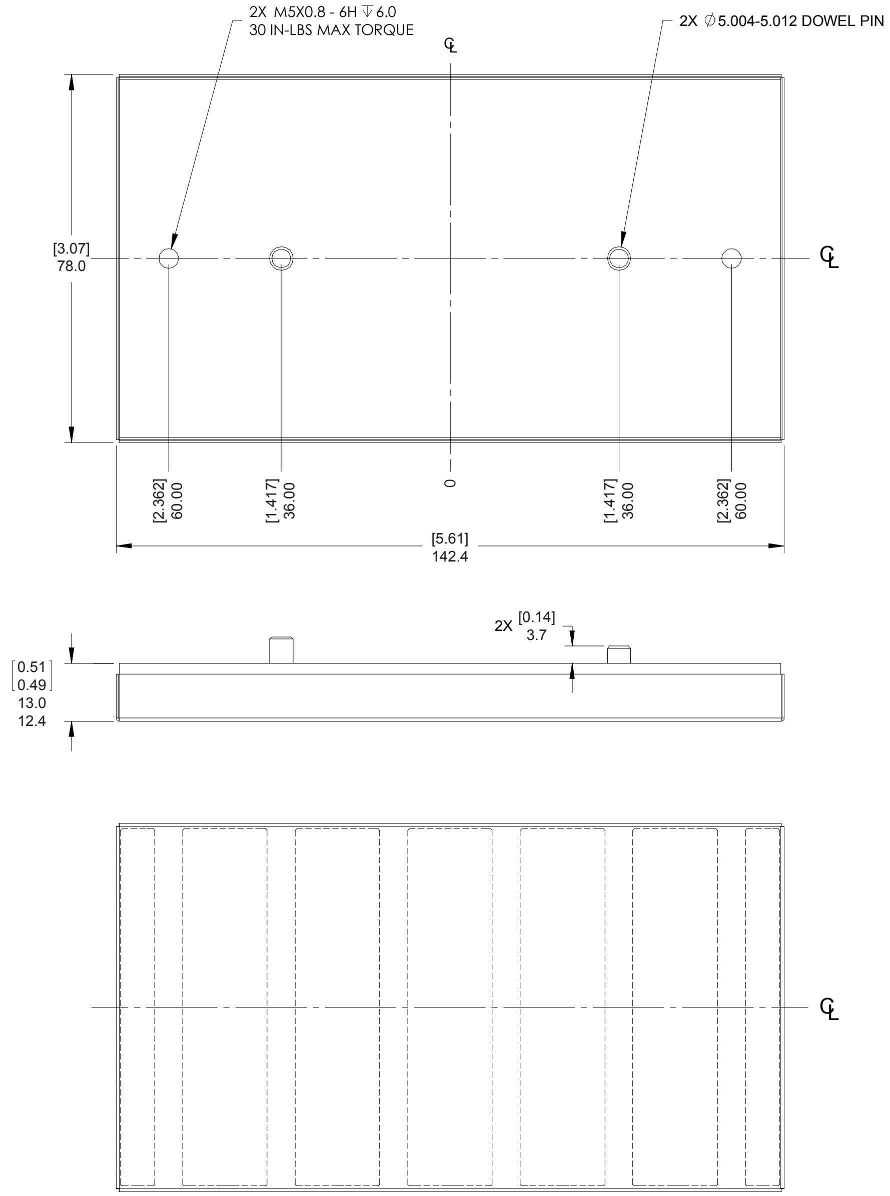
[*] Wide magnet arrays are typically used when QS 100 motors are arranged in a curve to provide better motor coverage (see *Magnet Array Length and Attractive Force* on page 73).

Exposed Materials

- Low Carbon Steel.
- Hardened Steel.
- Nd-Fe-B magnets with Ni-Cu-Epoxy coating.
- Oxy-Cast 607.

Magnet Array, Standard Covered

Stainless steel covered magnet arrays (see *Standard Magnet Arrays* on page 74) are available in two widths (78.0 mm [3.1 in] (‘F’) and 128.6 mm [5.1 in] (‘E’)). Both widths are available in lengths from 3 cycles to 20 cycles (see Table 4-2). Figure 4-4 shows a 78 mm wide 3 cycle array for reference. The quantity and locations of the mounting holes vary based on the size of the array.



Weight: see Table 4-2

All Dimensions in Millimeters [Inches]

Figure 4-4: Standard ‘F’ Covered Magnet Array Mechanical Drawing

NOTE: This magnet array package is fully backwards compatible with the potted arrays and is a one-for-one replacement for the potted arrays.

Contact ICT Customer Support for current detail drawings.

Designed for IP50 (IEC 60529).

Table 4-2: Standard Covered Magnet Array Lengths and Weights

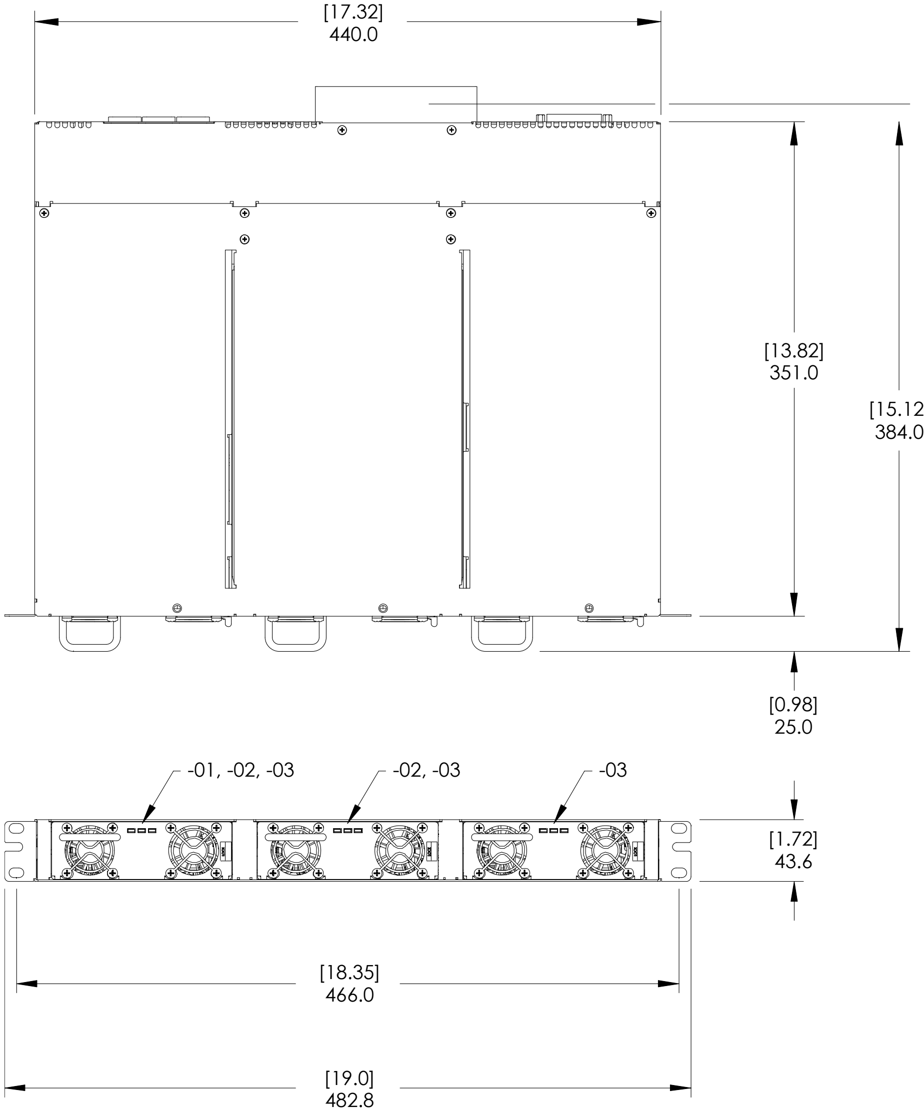
		78.0 mm [3.1 in] Wide ('F')	128.6 mm [5.1 in] Wide* ('E')
Cycles	**Length**	**Weight**	**Weight**
3	142.5 mm [5.6 in]	0.9 kg [2.1 lb]	1.5 kg [3.4 lb]
4	190.5 mm [7.5 in]	1.2 kg [2.7 lb]	2.0 kg [4.5 lb]
5	238.5 mm [9.4 in]	1.6 kg [3.4 lb]	2.5 kg [5.6 lb]
6	286.5 mm [11.3 in]	1.9 kg [4.1 lb]	3.1 kg [6.7 lb]
7	334.5 mm [13.2 in]	2.2 kg [4.8 lb]	3.6 kg [7.9 lb]
8	382.5 mm [15.1 in]	2.5 kg [5.5 lb]	4.1 kg [9.0 lb]
9	430.5 mm [16.9 in]	2.8 kg [6.2 lb]	4.6 kg [10.1 lb]
10	478.5 mm [18.8 in]	3.1 kg [6.9 lb]	5.1 kg [11.2 lb]
15	718.5 mm [28.3 in]	4.7 kg [10.3 lb]	7.6 kg [16.8 lb]
20	958.5 mm [37.7 in]	6.2 kg [13.7 lb]	10.2 kg [22.4 lb]

* Wide magnet arrays are typically used when QS 100 motors are arranged in a curve to provide better motor coverage (see *Magnet Array Length and Attractive Force* on page 73).

Exposed Materials

- Low Carbon Steel.
- Hardened Steel.
- Nd-Fe-B magnets with Ni-Cu-Ni coating.
- Stainless Steel.

QS 100 Power Supply



Weight: -01: 5.7 kg [12.6 lb]
-02: 7.7 kg [17.0 lb]
-03: 9.7 kg [21.4 lb]

All Dimensions in Millimeters [Inches]

Figure 4-5: QS 100 Power Supply Mechanical Drawing

NOTE: All vents must be clear for unobstructed airflow.

Designed for mounting in a standard 19 in electronics rack.

Ingress Protection Rating: IP10.

See *QS 100 Power Supply* on page 107 for the electrical specifications.

Contact ICT Customer Support for current detail drawings.

Exposed Materials

The power supply provides openings for airflow and must not be located where harsh conditions exist.

Electrical Specifications

QS 100 Motors

- **1000 mm** – 48V DC ±10%, 2 A typical, 5 A max
  See *1000 Millimeter Motor* on page 96 for the mechanical drawing.
- **500 mm** – 48V DC ±10%, 1 A typical, 2.5 A max
  See *500 Millimeter Motor* on page 97 for the mechanical drawing.

Table 4-3: QuickStick 100 Motor Power Requirements

Component	Maximum Power
QS 100 Motor, 500 mm – Control power	5 W
QS 100 Motor, 1000 mm – Control power	10 W
Vehicle – Propulsion power	Variable*

* The propulsion power for the motor is fused at 15 A. The motor draws maximum power when the vehicle is moving at maximum acceleration or velocity. Contact ICT Customer Support for help with determining the correct power supply size based on the motor application and size of the magnet array.

NOTE: The motors draw additional power when the vehicle is moving or accelerating (see Table 4-3). 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.

The propulsion power input (J2) uses a PTC (positive temperature coefficient) resistor to limit inrush current upon application of power. The PTC is only used for inrush current limiting and is bypassed in normal operation. Limit cycling of the propulsion power to 30 seconds between each turn on and 10 seconds between turn off and turn on (power cycle). Additionally, make sure the Soft Start Not Complete bit in the motor fault data is clear before turning on propulsion power to make sure that the soft start circuit has reset.

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.

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.

NOTICE

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.

NOTICE

Any user-supplied power supply must be NRTL/ATL approved.

NOTICE

Hot-plugging of either power source to the motors is not recommended.

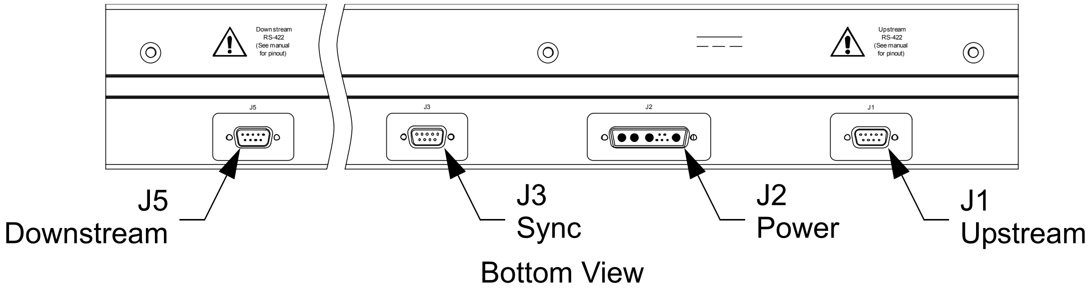
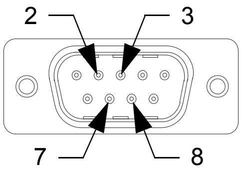


Figure 4-6: Motor Electrical Connections

Table 4-4: Motor Connections

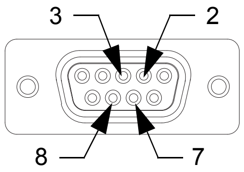
Label	Description	Connector Type
J1	RS-422, Upstream communications	DE-9, Female
J2	Power, +43–55.5V DC, +48V DC nominal 1000 mm motor – 2 A, 5 A max 500 mm motor – 1 A, 2.5 A max	DB-9W4, Male
J3	External Synchronization	DE-9, Female
J5	RS-422, Downstream communications	DE-9, Male

Table 4-5: RS-422 Pinouts



J5 – DE-9, Male (Downstream)

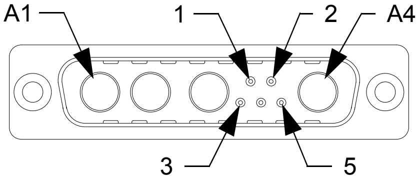
—	1
TxD-	2
RxD+	3
—	4
—	5
—	6
TxD+	7
RxD-	8
—	9



J1 – DE-9, Female (Upstream)

—	1
RxD-	2
TxD+	3
—	4
—	5
—	6
RxD+	7
TxD-	8
—	9

Table 4-6: Power Connector Pinout

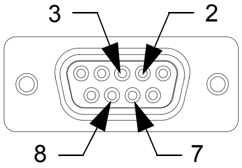


J2 – DB-9W4, Male

GND (PE)	A1
+48V DC Logic	A2
+48V DC Propulsion	A3
48V DC Return	A4
—	1
+48V DC Logic	2*
—	3
48V DC Logic Return	4*
GND (PE)	5*

* Pins 2, 4, and 5 provide connections for Logic power. For existing installations, there is no need to change the power wiring. However, for new designs it is recommended that all power connections to the motor be made to Pins A1–A4 only.

Table 4-7: Sync Connector Pinout



J3 – DE-9, Female

Signal	Pin	I/O	Max Voltage
—	1	—	—
SIMO	2	Input	3.3 V
SOMI	3	Output	3.3 V
RESET	4	Output	3.3 V
—	5	—	—
—	6	—	—
CLK	7	Input	3.3 V
STE	8	Input	3.3 V
GND	9	—	3.3 V

Motor Power Cable

The QS 100 Motor is supplied with a 2 meter, unterminated, power drop cable, which is shown in Figure 4-7, which provides power to the motor. Contact MagneMotion for replacement cables. This cable connects the motor power to a nearby junction box. When installing, the cable must be cut to length to minimize the voltage drop between the motor and the junction box as specified in *Cable Use*. Each wire in the cable is color-coded for identification.

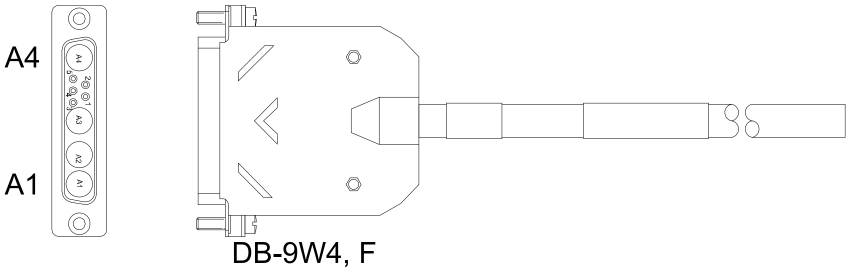
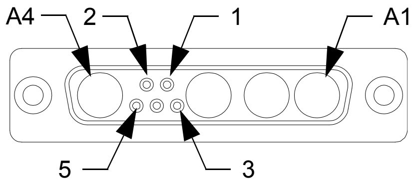


Figure 4-7: Motor Power Drop Cable

Table 4-8: Motor Power Drop Cable Pinouts

	Wire Gauge	**Individual Terminals**	 **DB-9W4, Female**
GND (PE)	16 AWG	Grn	A1
+48V DC Logic	16 AWG	Wht	A2
+48V DC Propulsion	16 AWG	Red	A3
48V DC Return	16 AWG	Blk	A4
no connection	—	—	1
no connection	—	—	2
no connection	—	—	3
no connection	—	—	4
no connection	—	—	5

Cable Use

1. Cut the supplied cable to length.
2. Strip the ends of the individual wires (approx. 1/2 in).
3. Connect +48V DC Logic, +48V DC Propulsion, and 48V DC Return to the Power Bus in a junction box.
4. Connect GND (PE) to the Ground stud in the same junction box.
5. Make sure that all junction boxes are connected to PE.

QS 100 Power Supply

85–265V AC, 47–63 Hz. Inrush current < 40 A per power supply module. The QS 100 Power Supply can contain up to three 1 kW power supply modules. See *QS 100 Power Supply* on page 102 for the mechanical drawing.

⚠ **CAUTION**

High Voltage Hazard

85–265V AC, 1 kW per power supply module.

AC power must be disconnected before servicing.

The actual power being drawn depends upon operations being performed, however all power wiring must be sized to carry the full load.

NOTE: A readily accessible third-party approved branch circuit overcurrent protection device that is rated at 20 A must be installed for each QS 100 Power Supply.

Each QS 100 Power Supply provides up to 3 kW DC for powering the QuickStick motors. The number of power supplies that are required for a specific QuickStick configuration can be determined from Table 4-3 where the maximum power consumption for each component within the QuickStick transport system is identified.

NOTICE

The QS 100 Power Supply uses internal NRTL/ATL approved power supplies. If a user-supplied power supply is used in its place, it must be NRTL/ATL approved.

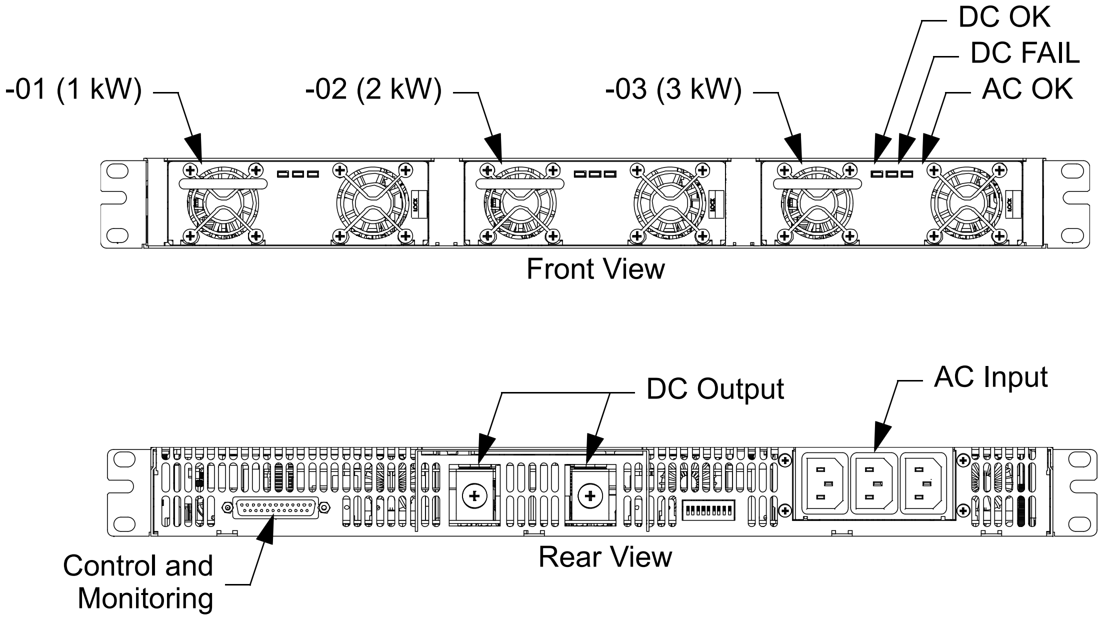


Figure 4-8: QS 100 Power Supply Electrical Connections

Table 4-9: QS 100 Power Supply Connections

Label	Description	Connector Type
AC Input	85–265V AC, 47–63 Hz	IEC 320, Female
DC Output	Motor power: 48V DC ±1%, 1–3 kW	M6 Screw Terminals
Control and Monitoring	Power supply control and monitoring (see the documentation from the manufacturer)	DB-25, Female

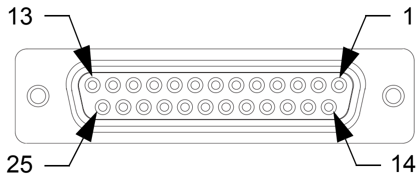
Table 4-10: QS 100 Power Supply Indicators (per PS Module)

Label	Description	Indicator Type
DC OK	ON – Indicates that output voltage is > 80% of rated value	Green Light
DC FAIL	ON – Indicates that output voltage is < 80% of rated value	Red Light
AC OK	ON – Indicates that input voltage is > 85 V rms	Green Light

Table 4-11: QS 100 Power Supply DC Power Pinout

	Individual Terminals
+48V DC	**V+**
RTN	**V-**

Table 4-12: QS 100 Power Supply Control and Monitoring Pinout



DB-25, Female

V_TRIM_B	1
TEMP_ALARM_B	2
DC_OK_B	3
TEMP_ALARM_A	4
ON/OFF_A	5
DC_OK_A	6
V_TRIM_A	7
+12V_AUX	8
CS	9
V_TRIM_C	10
SIGNAL_RETURN	11
DC_OK_C	12
+SENSE	13
AC_FAIL_B	14
ON/OFF_B	15
AC_FAIL_A	16
NC	17
NC	18
NC	19
SCL	20
SDA	21
-SENSE	22
TEMP_ALARM_C	23
AC_FAIL_C	24
ON/OFF_C	25

Control Cable

The QS 100 Power Supply is supplied with a control cable, which provides basic ON/OFF control of the power supply. Contact MagneMotion for replacement cables. The control cable plugs directly into the power supply.

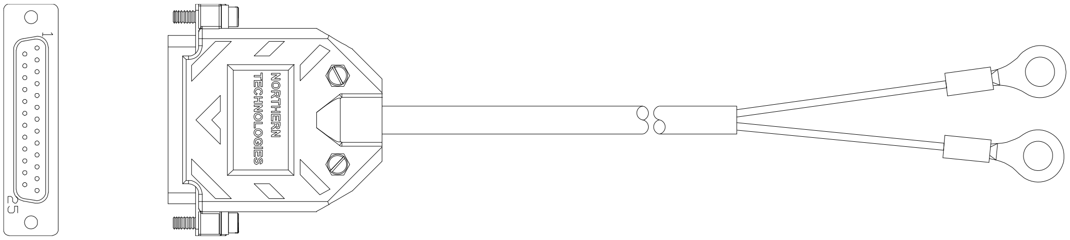
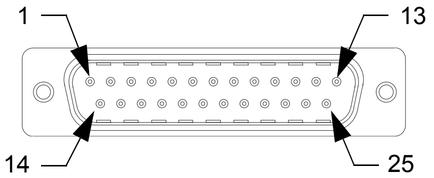


Figure 4-9: QS 100 Power Supply Control and Monitoring Cable

Table 4-13: QS 100 Power Supply Control and Monitoring Cable Pinouts



Individual Terminals	DB-25, Male
+V DC	13
-V DC	22
Internally Shorted	5, 11, 15, 25

AC Power Cable

The QS 100 Power Supply is supplied with a power cable. Contact MagneMotion for replacement cables. The AC power cable plugs directly into the power supply.

⚠ CAUTION

There is a potential shock hazard if the power supply chassis and cover are not connected to an electrical safety ground via the safety ground in the AC input connector.

Communications

Ethernet Connection

The NC LITE node controller supports Ethernet connections of 10/100 Mb/s (auto-negotiation supported). The NC-12 node controller supports Ethernet connections of 10/100/1000 Mb/s (auto-negotiation supported). Network communication allows connecting a number of different devices to a factory controller using one communications cable, which simplifies wiring. Each device that is connected to the network has a unique network device address. Individual devices only receive communications through the network that are addressed to that device.

The Ethernet connection that is provided by the node controllers supports both MagneMotion proprietary TCP/IP and EtherNet/IP™ communication protocols. Typically, TCP/IP is used by PC-based host controllers and EtherNet/IP is used by PLC-based host controllers. The node controllers always use TCP/IP for communication between node controllers. When the host controller is unavailable, a general-purpose computer with a communications application such as PuTTY© (a free SSH and telnet client for Windows) or a host simulator such as NCHost, can be connected to the transport system network for communication with the HLC.

NOTE: While both TCP/IP and EtherNet/IP use the same hardware for communication, the communication protocol itself is different. This difference allows both protocols to run on the same network simultaneously without interfering with each other.

For the 700-1482-00 NC-12 and the NC LITE the Ethernet cables that are used are standard network cable (UTP-Cat5) with an RJ45 connector. This cable plugs into the ETHERNET port on the NC-12 and the LAN port on the NC LITE. See the *Node Controller Hardware User Manual* for the locations of these connections.

For the 700-1573-00 NC-12, the Ethernet cables that are used are standard network cable (UTP-Cat5) with a 4-pin M12 Eurofast connector that plugs into the ETH port on the NC-12. See the *Node Controller Hardware User Manual* for the location of this connection.

NOTE: To establish a direct communications link from a PC to any node controller using Ethernet, a standard Ethernet cable can be used (auto-MDIX is supported).

TCP/IP Communication – Host Controller to HLC

TCP/IP communication is supported for use when the host controller is PC-based or for some PLCs that use TCP/IP. TCP/IP communication allows the host controller to communicate with the high-level controller (HLC) as described in the *Host Controller TCP/IP Communication Protocol User Manual* and the *Mitsubishi PLC TCP/IP Library User Manual*. TCP/IP communication is also used between the node controllers and the node controller that is designated as the HLC.

There is one Host control connection and four Host status connections on the HLC. If a second Host attempts to connect to the Host control TCP/IP port, it causes the first Host to be disconnected. If a fifth connection to the status TCP/IP port is attempted, it causes the first status connection to be disconnected.

The connection to all node controllers uses standard Ethernet network wiring. If multiple node controllers are connected to the same network, the IP address of each additional node controller must be changed to a unique address to avoid IP conflicts. The TCP/IP address that is used on the node controllers must be configured as specified in the *Node Controller Interface User Manual*.

EtherNet/IP Communication – Host Controller to HLC

EtherNet/IP communication is supported for use when the host controller is PLC-based. EtherNet/IP communication allows the host controller to communicate with the HLC as described in the *Host Controller EtherNet/IP Communication Protocol User Manual*.

The connection from the host controller to the node controller that is configured as the HLC uses standard Ethernet network wiring. The EtherNet/IP address that is used on the node controller that is configured as the HLC must be configured as specified in the *Node Controller Interface User Manual*.

RS-232 Serial Interface Connection

RS-232 serial communication on the NC-12 node controller is not used with QuickStick 100 transport systems.

RS-422 Serial Interface Connection

Node Controller to Motor

RS-422 serial communication is used to connect the NC-12 and NC LITE node controllers to the motors and switches in a daisy chain with a 4-wire cable. See Figure 4-10 for cable identification and Table 4-14 for cable pinouts. See Figure 4-6 the locations of these connections on the motors. See the *Node Controller Hardware User Manual* for the locations of these connections on the node controllers. There is no need to construct any of the cables as all cabling is supplied with the transport system. Contact MagneMotion for additional or replacement cables.

When using an NC LITE, the RS-422 cables for upstream communications connect to the node controller with a 9-pin female ‘D’ connector at any of the odd numbered RS-422 ports. When using an NC-12, the RS-422 cables for upstream communications connect to the node controller with a 4-pin female M8 connector at any of the RS-422 ports. These cables connect to the first QS 100 motor on the path with a 9-pin male ‘D’ connector on the end of the cable that plugs into the upstream communication port.

When using an NC LITE, the RS-422 cables for downstream communications connect to the node controller with a 9-pin male ‘D’ connector at any of the even numbered RS-422 ports.

When using an NC-12, the RS-422 cables for downstream communications connect to the node controller with a 4-pin female M8 connector at any of the RS-422 ports. These cables connect to the last QS 100 motor on the path with a 9-pin female ‘D’ connector on the end of the cable that plugs into the downstream communication port.

It is recommended that the upstream connection to the NC LITE node controller is always made to an odd numbered (male DE-9) RS-422 port and the downstream connection is always made to an even numbered (female DE-9) RS-422 port. However, a custom crossover gender changer can be used to connect an RS-422 DE-9 connector of the wrong gender to any port on the NC LITE node controller.

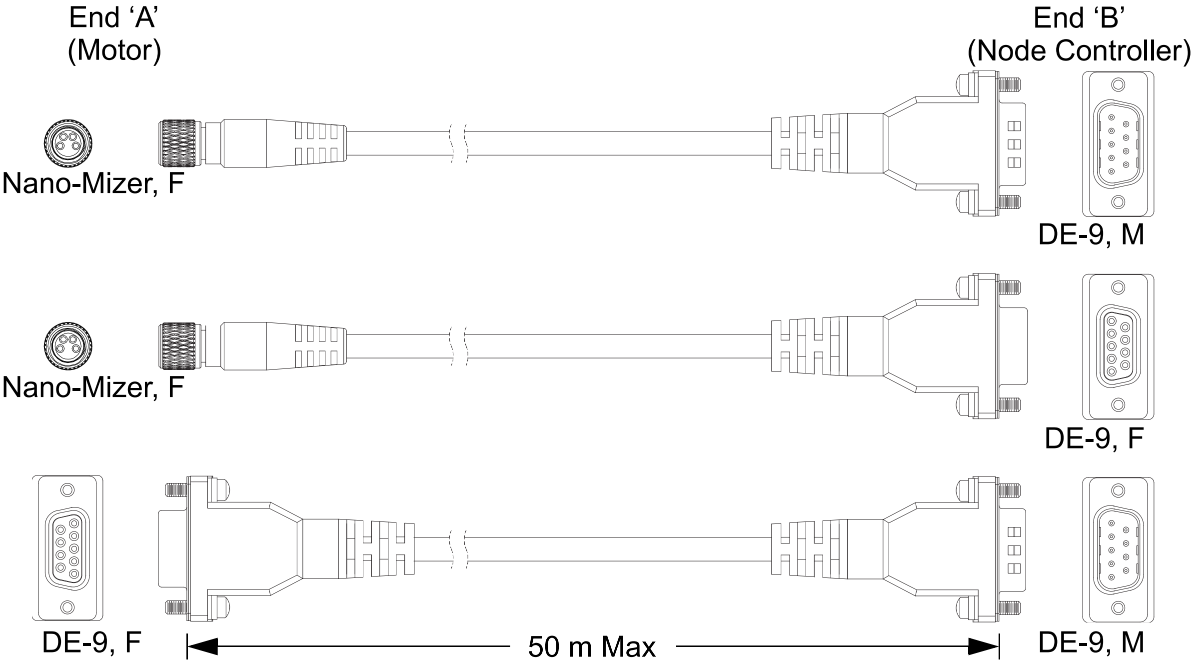
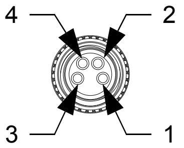
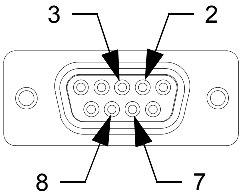
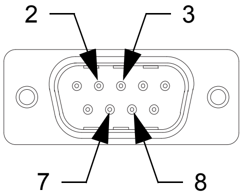
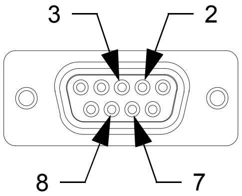


Figure 4-10: RS-422 Cables

Table 4-14: RS-422 Cable Pinouts

	 **M8 Nano-Mizer, 4-Pin, Female**	 **DE-9, Female**		 **DE-9, Male**	 **DE-9, Female**
	End ‘A			**End ‘B’**	
RxD+	1	7	**TxD+**	3	7
RxD-	2	2	**TxD-**	8	2
TxD+	3	3	**RxD+**	7	3
TxD-	4	8	**RxD-**	2	8

Motor to Motor

An RS-422 daisy chain cable is used to connect the downstream end of one motor to the upstream end of the next motor in the path. This cable is a standard pin-to-pin straight through cable with a 9-pin female ‘D’ connector on one end and a 9-pin male ‘D’ connector on the other end. The female DE-9 connector plugs into the downstream communication port on the motor and the male ‘D’ connector plugs into the upstream communication port on the next motor.

Sync Connection

The optional Sync connection provides a method to connect a motor directly to the host controller to allow the controller to synchronize the positioning of vehicles on the motor with an external mechanism. See the *LSM Synchronization Option User Manual* for cable and connection details. There is no need to construct the sync cables as all cabling is supplied with the transport system. Contact MagneMotion for additional or replacement cables.

Site Requirements

Environment

Motors

Temperature:

Operating: 0° C to 50° C [32° F to 122° F]
Storage: -18° C to 50° C [0° F to 122° F]

Humidity:

85% Maximum (relative, noncondensing)

QS 100 Power Supply

Temperature:

Operating: 0° C to 50° C [32° F to 122° F]
Storage: -18° C to 50° C [0° F to 122° F]

Humidity:

85% Maximum (relative, noncondensing)

Magnet Arrays, Potted and Covered

Temperature:

Operating: 0° C to 50° C [32° F to 122° F]
Storage: -18° C to 60° C [0° F to 140° F]

Humidity:

85% Maximum (relative, noncondensing)

Derating at High Altitude

When operating in a high altitude environment with lower air pressure, the operating temperature range must be derated compared to that of sea level.

Lighting, Site

No special lighting is required for proper operation of the QuickStick 100 transport system. Maintenance can require a user-supplied service lamp (for example, a flashlight).

Floor Space and Loading

The site for the QuickStick 100 transport system must meet the minimum space requirements that are defined after developing the layout as defined in *Transport System Layout* on page 56. Reference the *Mechanical Specifications* on page 96 to make sure that there is proper clearance for installation, operation, and servicing of the QS 100 motors and other components. The dimensions that are given are for the QS 100 motors and other components only. The user must make sure that there is adequate space for operation and service around the equipment that is based on their needs and any vehicle overhang.

Facilities

The user is responsible for providing the facilities that are specified in *Electrical Specifications* on page 103 to support proper operation of the QuickStick 100 motors and other components. See *Facilities Connections on page 137* for the connection of all facilities to the QS 100 transport system.

The facility is responsible for the main disconnect device between the QuickStick 100 transport system and the power source, making sure it complies with the appropriate facility, local, and national electrical codes. Service to the QuickStick 100 transport system must have the appropriate circuit breaker rating.

Service Access

The QuickStick 100 transport system requires adequate space for service access and for proper operation. The typical service space that is required for the QS 100 motors is shown in Figure 4-1 and Figure 4-2 and for the power supplies in Figure 4-5. See the *Node Controller Hardware User Manual* for the service space required for the node controllers. See the *LSM Synchronization Option User Manual* for the service space required for the SYNC IT Controller.

Make sure that installation of the QuickStick 100 transport system is such that it provides access to items required for service after installation, such as power and communication connections.

NOTE: The Exclusion Zones that are shown are for the QuickStick 100 transport system components only. Additional exclusion zones may be required based on the design of the vehicle and the material that the QuickStick 100 transport system is moving.

Installation 5

Overview

This chapter provides complete installation procedures for the QuickStick® 100 components that are used in a transport system.

Included in this chapter are:

- Unpacking and inspection of the QuickStick 100 transport system components.
- QuickStick 100 component installation including: hardware installation, facilities connections, and software installation and configuration.
- Initial power-up and check-out.
- Transport system testing using demo scripts.

Unpacking and Inspection

The QuickStick 100 transport system components are shipped in separate packages. Open each package carefully following the steps that are provided in *Unpacking and Moving* on page 119; inspect and verify the contents against the shipping documents. Report any damage immediately to the shipper and to MagneMotion.

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

NOTE: The number and contents of the shipping packages depends on the items purchased. See the shipping documents for the exact contents. The checklist in Table 5-1 is provided for reference only.

Table 5-1: Packing Checklist Reference

Package	Contents
QuickStick 100 Motors	QuickStick linear synchronous motors.
Magnet Arrays	Magnet arrays to be attached to the vehicles for use as the LSM secondary to move material on the transport system.
Node Controllers	MagneMotion node controllers for managing the nodes in the transport system.
Power Supplies	Power supplies to provide DC logic and motor power to the QS 100 motors.
Installation Kit	• Miscellaneous hardware. • Cables. • User Manuals, drawings, and so on.

Unpacking and Moving

Required Tools and Equipment

- Open-end Wrench, Adjustable.
- Metric Hex wrenches.

Unpacking and Moving Instructions

The QuickStick 100 components arrive from the factory ready for installation. The information required to install these components is provided in *Transport System Installation* on page 121.

⚠ WARNING

Strong Magnets

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 QuickStick 100 motors, ferrous material, or another magnet array.
- Magnet arrays or vehicles not being used must be secured individually in isolated packaging.

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.

⚠ CAUTION

Heavy Lift Hazard

The QuickStick 100 motors can weigh as much as 13.2 kg [29.1 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 QuickStick 100 components.

Save all shipping packaging for possible future use. If any of the QuickStick 100 components are shipped, the original shipping packaging must be used. If the original packaging has become lost or damaged, contact MagneMotion for replacements.

1. Upon receiving the packages, visually verify that the packaging is not damaged. Inform the freight carrier and MagneMotion of any inspection discrepancy.

2. Open each shipping package and verify the contents against the shipping documents.

3. Carefully inspect the QuickStick 100 components and all additional items for signs of shipping damage.

4. Move all items to their destination (see *Transport System Installation* on page 121).

Transport System Installation

The QuickStick 100 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 QuickStick 100 components provides access to items required for service after installation, such as connection panels. Once properly located, the QS 100 transport system must be leveled and secured to the floor or other rigid mounting points to help prevent any movement.

Installing Hardware

To install the motors on user-supplied supports, make sure that the supports are properly prepared to receive the motors (see *Mechanical Specifications* on page 96). Install the motors (see *Mounting the Motors* on page 124) and make any adjustments necessary to account for the custom supports.

NOTE: Any bolts with plastic caps have been pre-tightened at the factory to the appropriate torque specification and do not need to be tightened during installation.

When performing any of the following procedures, adhere to and follow all safety warnings and instructions.

Required Tools and Materials

- Metric Hex wrench set.
- Torque wrench (0.9–26 N•m [8–230 in•lb] range) with metric and Torx bits.
- Soft jaw pliers.
- Screwdriver, Small flat blade.
- Screwdriver, Phillips.
- 12” Machinist Square.
- Laser level, rotary.
- Digital Multimeter.
- Loctite 243, Thread locker Anaerobic Adhesive, Blue.

Installation Overview

The following sequence provides an overview of the installation of the QuickStick 100 motors and other QS 100 components on user equipment or a custom track system.

NOTICE

Make sure that the equipment or track system where the QuickStick 100 motors are mounted and the motor mounting surfaces are properly grounded to safety ground (earth).

1. Assemble a section of the track, including guideway, motor mounts, and stand (see *Assembling the Guideway* on page 124 and *Vehicle Installation* on page 136).
2. Prepare and level the equipment where the motors are going to be mounted (see *Leveling the Transport System* on page 124).
3. Secure the track to the floor or other equipment as required (see *Securing the Transport System* on page 124).
4. Install the motors, make sure that the motor bodies are collinear to each other and the tops of all motors are coplanar to each other. Tighten the motor mounting bolts (see *Mounting the Motors* on page 124).

   NOTE: Make sure that the tip of the mounting bolt does not protrude beyond the t-nut to prevent damage to the motor housing.

   Make sure that there is sufficient space around the motor mounting surface for all connectors and for the bend radius of all cables.
5. Install the power supplies, node controllers, network switches, and cables (see *Installing Electronics* on page 126).
6. Install magnet arrays on the vehicles and install the vehicles on the system (see *Vehicle Installation* on page 136).

   NOTE: Install vehicles on captive closed loop systems before closing the loop to eliminate the need to remove a section of the guideway.
7. Make all communication, network, and power connections (see *Facilities Connections* on page 137).
8. Assemble the next section of the system following Step 1 through Step 7 and connect it to the previously installed section verifying that both sections are in the same plane and level to each other.
9. Continue assembling and installing sections of the track until the system is complete.

10. Create the Node Controller Configuration File (see *Software* on page 141).

11. Power up the system and check all operating features, safety features, and connections (see *Check-out and Power-up* on page 143) and install the software (see *System Power-up* on page 144).

System Installation

Assembling 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.

NOTE: Before completing a closed guideway, add the vehicles by sliding them onto a section of guideway that has been installed (see *Vehicle Installation* on page 136).

Leveling 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, and so on).

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.

Securing the Transport System

Secure the QuickStick 100 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.

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

Mounting the Motors

The motors must be attached to the motor mounts on the guideway (see Figure 3-20 on page 84 for an overview). Make sure that all motors are flat and level once mounted.

1. Locate all QS 100 motors (if not already installed) by placing the bottom of the motor on the motor mounts installed on the guideway. Secure the motor using M8 bolts and M8 split lock washers through the motor mount to the M8 T-Blocks and finger tighten.

   NOTE: Locking features such as thread locker or lock washers must be used.

Make sure that there is sufficient space around the motor mounting surface for all connectors and for the bend radius of all cables.

2. Adjust the position of all motors to make sure that the motors are collinear to each other and the space between motor bodies is consistent with the system layout.

3. Make sure that the tops of all motors are coplanar to each other (adjust the motor mounts as required).

4. Tighten all QS 100 motor mounting hardware (typically 25 N•m [18 ft•lb] max).

   NOTE: Make sure that the tip of the mounting bolt does not protrude beyond the t-nut to prevent damage to the motor housing. See the engineering drawings for the locations, depths, and torques for all mounting features.

5. Verify that all motors are properly mounted and the Motor Gap between all motors is identified and recorded. Make sure that the top surfaces of all motors are coplanar to each other, all vehicle guides are collinear, and all motor mounting bolts are tightened.

   NOTE: The Motor Gap must be entered for the motors in the Node Controller Configuration File. If all motors on a path have the same Motor Gap, it can be entered once in the Motor Defaults before defining the individual motors on the path (see the *QuickStick Configurator User Manual*).

Installing Electronics

The electronics for the QS 100 transport system can be attached to the transport system stands or positioned elsewhere in the facility in an appropriate location.

NOTICE

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

Installing Electronics on the Transport System

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

Mounting Node Controllers

Locate the node controllers close to the nodes 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 *Node Controller Hardware User Manual* are maintained.

Mounting Network Switches

Locate the network switches close to the node controllers they are responsible for to minimize the length of all wiring. The switch can be mounted to the same bracket used for the NC LITE and can be oriented in any direction required.

Mounting Network Switch Power Supplies

If the Network Switches are powered using the remote power supply (instead of using PoE), locate the power supply on the transport system stand close to the switch it is powering to minimize the length of all wiring. The power supply can be oriented in any direction required.

Connecting Motors and Electronics

The QuickStick 100 transport system uses daisy chained communication with all motors in the transport system. All motors in a specific path are chained together. The upstream end of each chain is always connected to a node controller. The downstream end of a chain is only connected to a node controller if it terminates in a node. Power and communication cables must be run such that they are shielded from damage and can be easily accessed for service.

The following procedure provides the information that is required to make all motor connections as shown in Figure 4-6. Connections to the node controllers are detailed in the *Node Controller Hardware User Manual*.

NOTICE

Never connect or disconnect the power lines while power is applied to the QuickStick 100 transport system as damage to internal components can result.

NOTICE

The NC LITE only supports the custom 18V DC Power over Ethernet (PoE) used by MagneMotion. Never connect the NC LITE to a standard PoE network as damage to internal components can result.

The NC-E and NC-12 node controllers and the MM LITE motors do not support Power over Ethernet (PoE). Never connect these components to a powered Ethernet network as damage to internal components can result.

Motor Communications

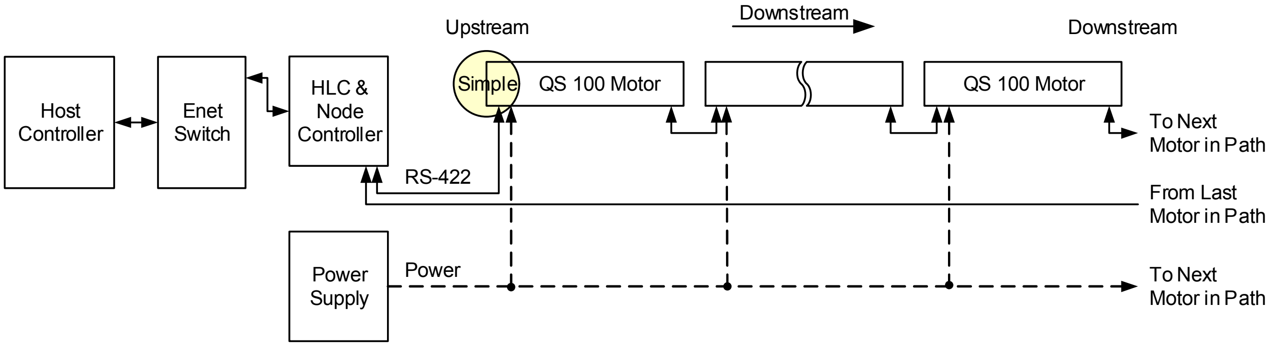


Figure 5-1: Simplified Representation of RS-422 Motor Connections

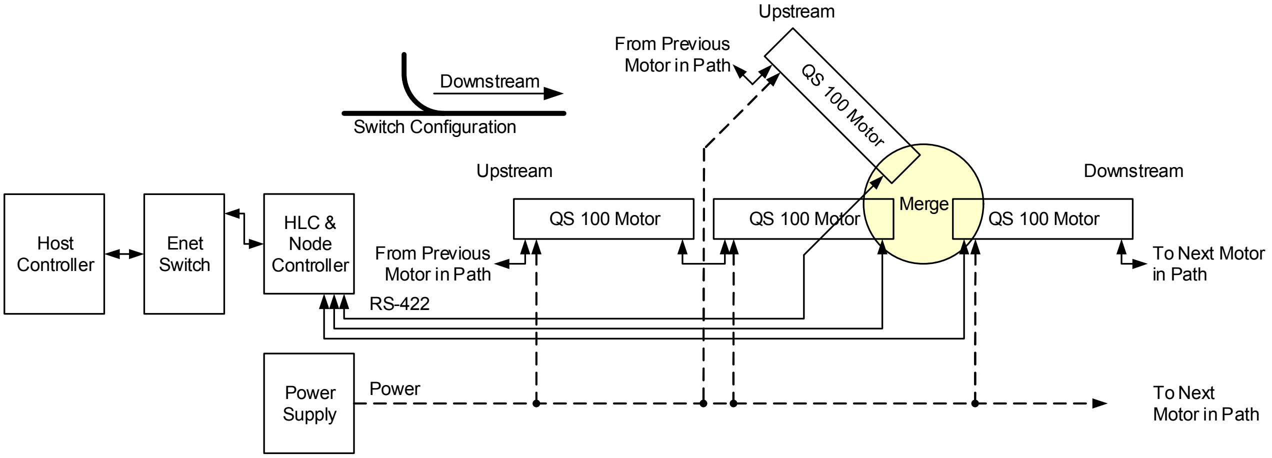


Figure 5-2: Simplified Representation of RS-422 Motor Connections in a Merge Switch

Installing Motor Communication Cables

See Figure 4-6 on page 104 for the communication connection locations on the QS 100 motors and the *Node Controller Hardware User Manual* for the communication connection locations on the node controllers. See Figure 5-1 and Figure 5-2 for simplified diagrams of the wiring and Figure 5-3 for a detailed example.

When connecting the motors to the node controllers, both ends of a path do not need to connect to the same node controller. However, all connections to the motors at the ends of all paths that meet in a node must be made to the same node controller. See the *QuickStick Configurator User Manual* for more information about nodes and paths.

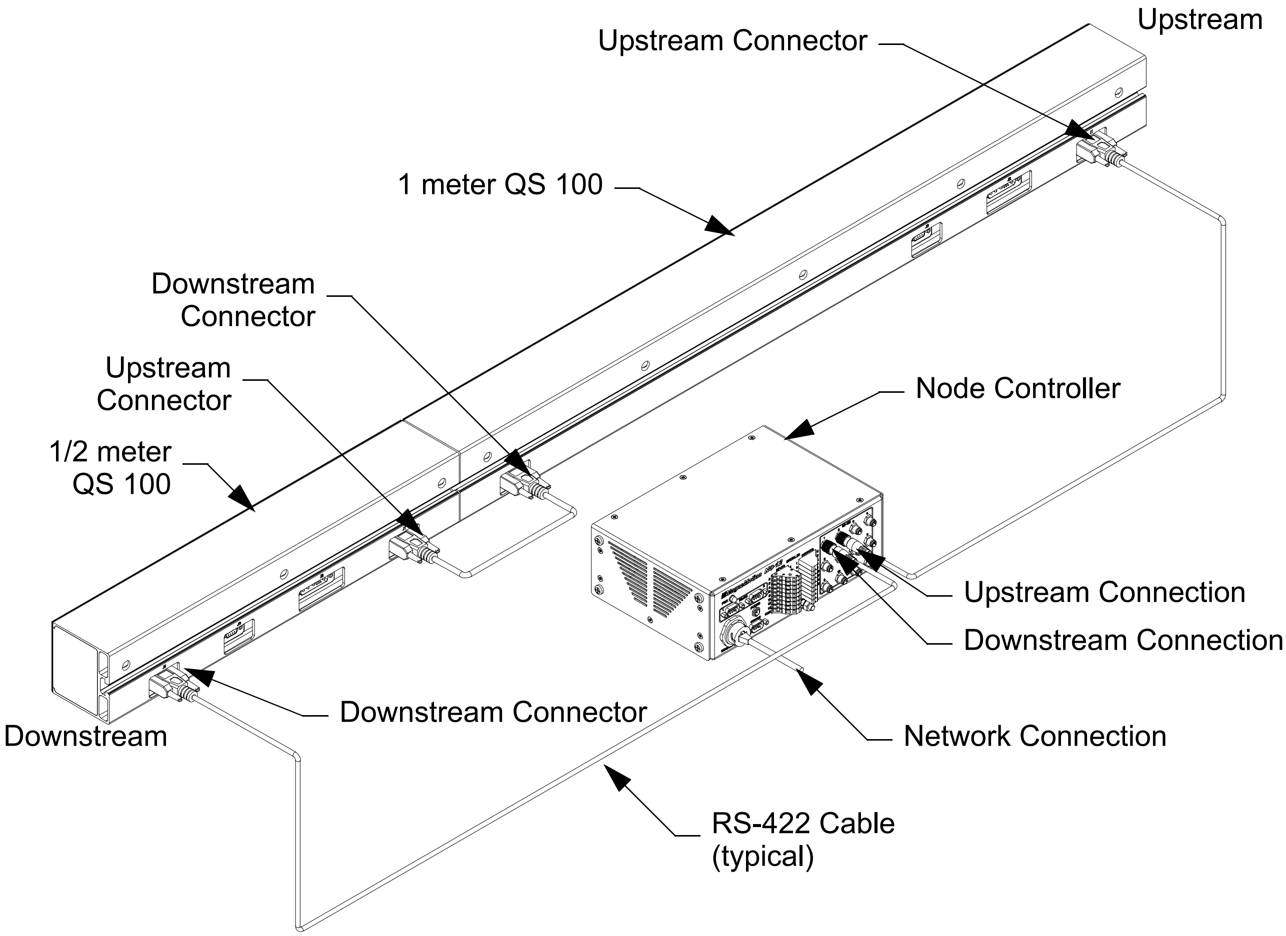


Figure 5-3: RS-422 Communication Connections

1. Connect an external communication cable from an RS-422 connector on the node controller to the communication connector at the upstream end of the first motor in a path (as defined in the transport system layout drawing). Route the cable so it is shielded from damage and can be easily accessed for service (see Figure 5-3).
    - For an NC-12 node controller, connect to any RS-422 port, finger tighten only.
    - For an NC LITE, typically connect to either J1 or J3, use a small screwdriver to tighten the connector – do not overtighten.

      NOTE: When using an NC LITE, a custom cross-over gender changer can be used when connecting the upstream end of a path to one of the even (downstream) ports.
    - Record the node controller IP address from the transport system layout and the Port number from the node controller for entry into the Node Controller Configuration File.

2. Connect a communication cable from the communication connector at the downstream end of the motor to the communication connector at the upstream end of the

next motor in the path. Use a small screwdriver to tighten the connector – do not overtighten. Route the cable so it is shielded from damage and can be easily accessed for service.

3. Continue to connect the remaining motors in the path with the communication cables.

4. Connect an external communication cable from the communication connector at the downstream end of the last motor in the path to an RS-422 connector on the node controller if that path ends at a node (for example, Relay Node, switch, or Terminus Node). Route the cable so it is shielded from damage and can be easily accessed for service.
   - For an NC-12 node controller, connect to any RS-422 port, finger tighten only.
   - For an NC LITE, typically connect to either J2 or J4, use a small screwdriver to tighten the connector – do not overtighten.

     NOTE: When using an NC LITE, a custom cross-over gender changer can be used when connecting the downstream end of a path to one of the odd (upstream) ports on the node controller.
   - Record the node controller IP address from the transport system layout and the Port number from the node controller for entry into the Node Controller Configuration File.

5. Repeat Step 1 through Step 4 for each path in the QS 100 transport system.

   NOTE: The motors at the ends of all paths that are connected in the same node must be connected to the same node controller.

6. Bundle and dress all cables (use nylon cable-ties) as required to keep all cable routing clean.

7. See *Facilities Connections* on page 137 for external communication connections.

Network Communications

See the *Node Controller Hardware User Manual* for the network connection locations on the node controllers. See Figure 5-5 for a simplified diagram of the network wiring.

NOTE: Make sure that the network for the transport system is a dedicated, separate subnet to minimize any unrelated network traffic.

1. Connect a Category 5 (Cat 5) cable for network communication to the node controller.
   - For an NC-12 node controller, connect from a dedicated standard network switch to ETHERNET (auto-MDIX and auto-negotiation are supported). Route the cable so it is shielded from damage and can be easily accessed for service.

     NOTICE

     The NC-12 node controller does not support Power over Ethernet (PoE). Never connect these node controllers to a PoE network as damage to internal components can result.

   - For an NC LITE node controller, connect from a network switch to LAN (auto-MDIX and auto-negotiation are supported). Route the cable so it is shielded from damage and can be easily accessed for service.
     - When supplying power to the NC LITE through PoE, connect from a dedicated network switch with 18V DC PoE.
     - When supplying power directly to the NC LITE, connect from a dedicated standard network switch.
2. Bundle and dress all cables (use nylon cable-ties) as required to keep all cable routing clean.
3. See *Facilities Connections* on page 137 for external network connections.

Digital I/O

If node controllers with digital I/O are being used, wiring for discrete digital inputs and outputs can be connected to the node controllers and used for E-stops, interlocks, light stacks, and general-purpose I/O. See the *Node Controller Hardware User Manual* for the digital I/O connection locations and wiring diagrams.

Installing Motor Power Cables

See Figure 4-6 on page 104 for the power connection locations on the QS 100 motors in the QuickStick 100 transport system. See Figure 5-1 and Figure 5-2 for simplified diagrams of the wiring. Figure 5-4 shows the power connections being made to the bottom of the motor.

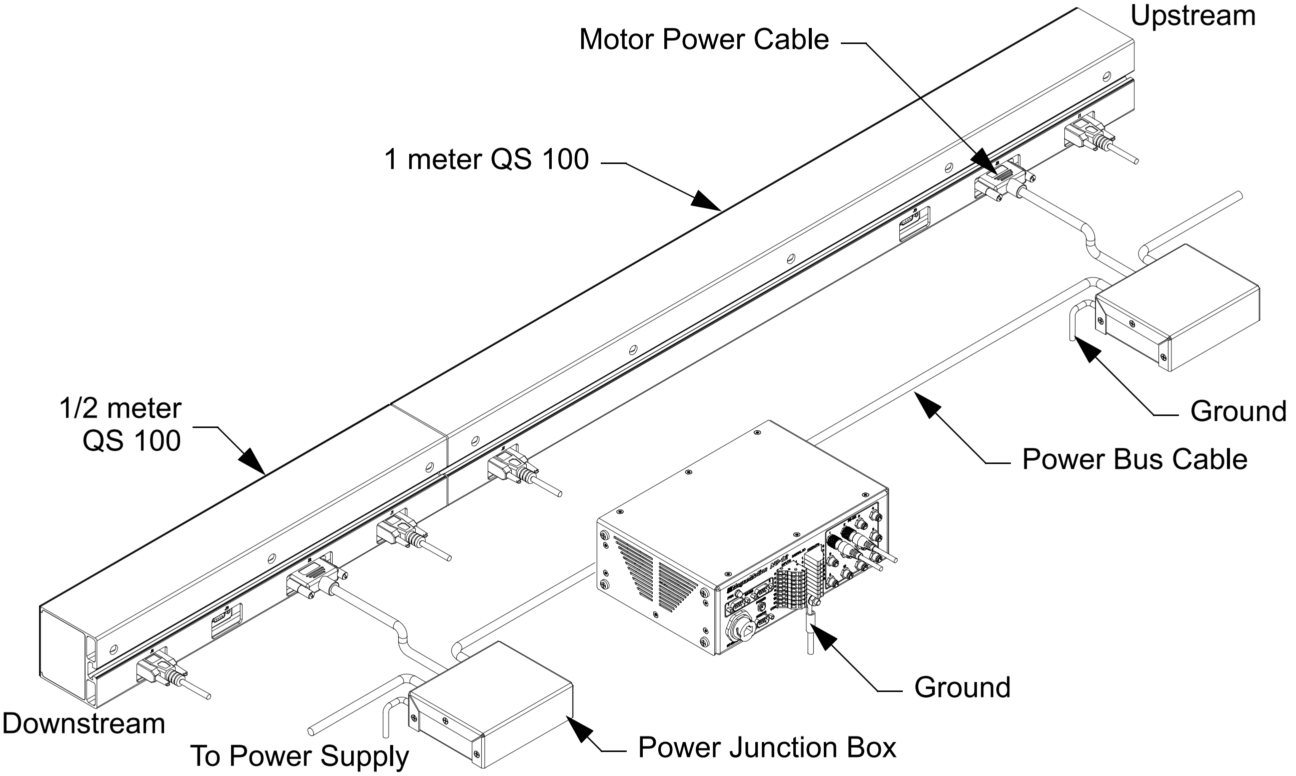


Figure 5-4: Power Connections

NOTICE

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 137). See *Electrical Wiring* on page 69 to make sure that all power wiring is properly sized. See Table 4-3 on page 103 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.

1. Connect the power cable to the terminals on the power supply.
   - Make sure that the power supply is properly grounded.
   - Make sure that the power cables are sized for the full load of all motors downstream from the connection.

2. Run the power cable from the power supply to the junction box at the first motor in the path. Route the cable so it is shielded from damage and can be easily accessed for service.
    - Make sure that the junction box is properly grounded.

3. Run a power cable from the junction box (see *Motor Power Cable* on page 106) to J2 on the motor, use a small screwdriver to tighten the connector – do not overtighten. Route the cable so it is shielded from damage and can be easily accessed for service.
    - Connect +48V DC Logic, +48V DC Propulsion, and 48V DC Return to the Power Bus in the junction box.
    - Connect GND (PE) to GND (PE) in the junction box.

4. Run a power cable from the junction box to the junction box at the next motor in the path. Route the cable so it is shielded from damage and can be easily accessed for service.
    - Make sure that the junction box is properly grounded.

5. Repeat Step 3 and Step 4 for each motor in the power chain.

    NOTE: It is not necessary to connect all motors on a path to the same power supply or to connect a power supply to only one path.

6. Make sure that all NC LITE node controllers are mounted to grounded surfaces.

7. Connect the Ground stud on all NC-12 node controllers to GND (PE).

8. Bundle and dress all power cables (use nylon cable-ties) as required to keep all cable routing clean.

9. See *Facilities Connections* on page 137 for external power connections.

Magnet Array Installation

⚠ WARNING

Strong Magnets

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 QuickStick 100 motors, ferrous material, or another magnet array.
- Magnet arrays or vehicles not being used must be secured individually in isolated packaging.

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.

The magnet arrays are supplied with threaded holes and locating pins for attaching the array to the mounting surface of the vehicle. The number and location of the mounting holes depends on the size and type of the magnet array. See the MagneMotion Interface Control Drawing for the magnet array, which includes the mounting hole locations and torques. Mount the magnet arrays to the vehicles as defined by the design of the vehicle, see an example in Figure 3-19 on page 83.

NOTE: 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 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.

Mounting A Single Array

When installing one magnet array on one vehicle:

1. Work on only one vehicle at a time.

2. Make sure that the vehicle is secured to a work surface that is clear of any magnet arrays or ferrous material.

3. Move only one magnet array at a time and make sure that the magnet array stays as far away from all other magnets and any ferrous material as possible.

4. Locate the magnet array on the vehicle using the locating features on the magnet array as defined by the design of the vehicle.

5. Secure the magnet array to the vehicle using all provided mounting holes.

6. Once the array is secured to the vehicle, install the vehicle on the guideway.

Mounting Multiple Arrays

When installing multiple magnet arrays on one vehicle:

1. Work on only one vehicle at a time.

2. Make sure that the vehicle is secured to a work surface that is clear of any magnet arrays or ferrous material.

3. Place the first magnet array as described in *Mounting A Single Array*.

4. Cover the installed magnet array with non-ferrous material (for example, wood) thick enough to shield the attractive force from the magnet array (use a tool such as a steel screwdriver to test).

5. Bring each additional magnet array to the vehicle from the opposite direction of the installed magnet arrays.

   NOTE: When a magnet array is being installed butted up against the existing magnet array, the existing magnet array repels that magnet array. Being repelled can cause the magnet array to attempt to twist away from the existing magnet array.

6. Locate the magnet array on the vehicle with the locating features on the magnet array.

7. Secure each additional magnet array to the vehicle as defined by the design of the vehicle.

8. Once all arrays are secured to the vehicle, install the vehicle on the track.

Vehicle Installation

WARNING

Strong Magnets

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 QuickStick 100 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 QuickStick 100 transport system is installed.

NOTE: 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.

Facilities Connections

The standard configuration of the QuickStick 100 transport system requires user-supplied electrical power and communication connections. See the *Electrical Specifications* on page 103 for descriptions and specifications of all required facilities.

Network Connections

The QuickStick 100 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 PoE connections to the node controllers as shown in Figure 5-5. See Figure 5-1 and Figure 5-2 for motor and network connections.

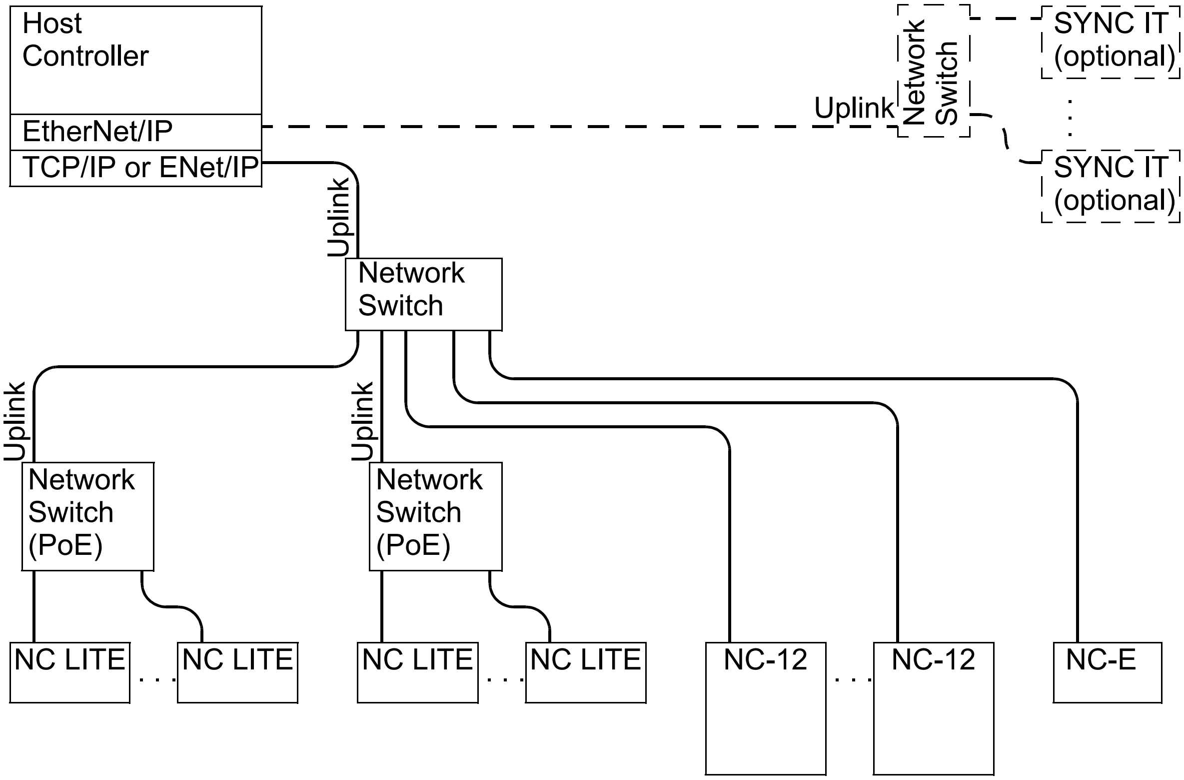


Figure 5-5: Network Cable Connections

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 5-5.

NOTICE

The Ethernet cable that connects a PoE switch to the host controller or other switches must connect to the Uplink port. Connecting to other ports can damage the switches or other devices that are connected to the switches.

NOTE: When using multiple network switches to connect all node controllers, use one switch as a master and connect all other switches to it as shown in Figure 5-5.

When using multiple MagneMotion PoE network switches, connect the Uplink from each switch to a master switch as shown in Figure 5-5, do not daisy chain the PoE switches.

When using the optional SYNC IT controllers, use a switch that is dedicated to those controllers connected directly to the EtherNet/IP™ port on the PLC dedicated to synchronization as shown in Figure 5-5.

2. Connect a CAT 5 cable for network communication from the switch to each node controller, the *Node Controller Hardware User Manual* for the connection locations.

Electrical Connections

Electrical power is connected to the QuickStick 100 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 *Electrical Specifications* on page 103 for electrical requirements. Make sure that all electrical connections are for the appropriate voltage and power rating.

NOTICE

Do not turn on facility power until all installation procedures have been completed.

1. Connect power to each NC-12:

NOTICE

The NC-12 node controller does not support Power over Ethernet (PoE). Never connect these node controllers to a powered Ethernet network as damage to internal components can result.

- 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. Then, connect the DC power cable to the power connector on each NC-12 node controller.

2. Connect power to each NC LITE:
    - When supplying Power over Ethernet to the NC LITE, make sure that the Ethernet connection goes to a +18V DC PoE enabled switch. Plug the switch power supply into the power distribution from the main power disconnect for the facility. Then, connect the cable from the switch power supply to the switch.
    - When supplying power directly to the NC LITE, plug the power supply into the power distribution from the main power disconnect for the facility. Then, connect the cable from the NC LITE power supply to the NC LITE.
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.

E-stop Circuit

The QuickStick 100 transport system can use digital I/O, provided through a node controller, for monitoring and control of local options such as an E-stop. The optional E-stop circuit is the responsibility of the user and requires a user-supplied E-stop button and DC power supply for the digital input. See the *Node Controller Hardware User Manual* for the digital I/O equivalent circuits. See the *QuickStick Configurator User Manual* for information on configuring an E-stop.

⚠ CAUTION

High Voltage Hazard

The E-stop is not the same as an EMO (Emergency Off), which removes power to the Quick Stick 100 transport system.

Interlock Circuit

The QuickStick 100 transport system can use digital I/O, provided through a node controller, for monitoring and control of local options such as interlocks. The optional interlock circuit is the responsibility of the user and requires a user-supplied +3–24 VDC power supply for the digital input. See the *Node Controller Hardware User Manual* for the digital I/O equivalent circuits. See the *QuickStick Configurator User Manual* for information on configuring an interlock.

Light Stack Circuit

The QuickStick 100 transport system can use digital I/O, provided through a node controller, for monitoring and control of local options such as a light stack. The optional light stack circuit is the responsibility of the user and requires a user-supplied 3-color light stack and +5–35 VDC power supply (sized for the light stack) for the digital outputs. See the *Node Controller Hardware User Manual* for the digital I/O equivalent circuits. See the *QuickStick Configurator User Manual* for information on configuring a light stack.

General Purpose Digital I/O

The QuickStick 100 transport system can use digital I/O, provided through a node controller, to allow the host controller to monitor and control digital inputs and outputs, respectively. See the *Node Controller Hardware User Manual* for the digital I/O equivalent circuits. See the *Host Controller TCP/IP Communication Protocol User Manual* or the *Host Controller EtherNet/IP Communication Protocol User Manual* for the command details on performing these operations.

Node Electronics

The Merge and Diverge Nodes in the QuickStick 100 transport system rely on external devices to provide the switching. This switching mechanism can be controlled through the digital I/O, provided through a node controller.

For Merge and Diverge Nodes that use digital I/O, control and status signals are used for each switch position. See the *QuickStick Configurator User Manual* for information on configuring these nodes.

Software

The QuickStick 100 transport system requires user creation of the Node Controller Configuration File and creation of host controller software to direct vehicle movement for the particular application and to monitor transport system performance. MagneMotion provides software tools to simplify the creation of the Node Controller Configuration File, for system testing, and for system monitoring. See *Transport System Software Overview* on page 31 for identification and descriptions of all software components.

Software Overview

Node controllers that are supplied with the QuickStick 100 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 *Node Controller Interface User Manual* for details.

All QuickStick 100 motors ship with just a basic software image installed. This image is used for testing during manufacturing and must not be used to run the motors as part of a 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.

Upgrades to the software can be uploaded through the network communication link. See the Upgrade Procedure in the Release Notes supplied with the software upgrade.

NOTE: Specific builds of the MagneMotion software may not implement all features that are described in this manual. See the Release Notes that are provided with the software for additional information.

All software running on the QuickStick 100 transport system must be part of the same release. See the Release Notes that are provided with the software for additional information.

Only qualified MagneMotion personnel or personnel that are directed by MagneMotion should make alterations or changes to the software.

Software Configuration

Create the Node Controller Configuration File (node_configuration.xml) with the Configurator to define the components of the transport system and their relationship to each other. See *Design Guidelines* on page 55 and the *QuickStick Configurator User Manual* for more details. The Node Controller Configuration File must then be uploaded to each node controller in the transport system before using the system. See the *Node Controller Interface User Manual* for details.

Configure the host controller to control the transport system. See the *Host Controller TCP/IP Communication Protocol User Manual*, the *Host Controller EtherNet/IP Communication Protocol User Manual*, or the *Mitsubishi PLC TCP/IP Library User Manual* depending on the host controller type.

Node Controller Software Installation

1. Upload the node controller image files to each node controller with the node controller web interface. See the *Node Controller Interface User Manual* for details.

   NOTE: Activate the image and reboot the node controller for the changes to take effect.

2. Upload the configuration files through the node controller web interface to each node controller. See the *Node Controller Interface User Manual* for details.

   NOTE: Restart the node controller for the changes to take effect.

Motor Software Installation

1. Upload the Motor ERF Image files (*motor_image*.erf) to each node controller with the node controller web interface and program the motor masters and slaves. See *Programming Motors* on page 198 and the *Node Controller Interface User Manual* for details.

   NOTE: Restart the node controller for the changes to take effect.

2. Reset the paths where the motors were programmed (for example, use the NCHost TCP Interface Utility, see the *NCHost TCP Interface Utility User Manual* for details).

Check-out and Power-up

System Check-out

Before the QuickStick 100 transport system is started for the first time, or after servicing the transport system, it is necessary to check all operating and safety features.

The following startup procedure is used to apply power to the QuickStick 100 transport system in an orderly manner to make sure that all components are in known states. This procedure is used to prepare the transport system for full operation.

Mechanical Checks

- Verify that all shipping brackets have been removed.
- Make sure that all QuickStick 100 components are properly and securely installed in the facility.
- Make sure that all hardware is secure.
- If the optional E-stop circuit is being used, make sure that the button is functional.
- Manually move a vehicle through the entire QS 100 transport system to verify free vehicle motion (no binding).

Facility Checks

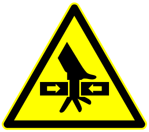
- Make sure that all facilities meet, or exceed, the requirements as described in the *Electrical Specifications* on page 103 and *Site Requirements* on page 115.
- Make sure that all system power and communication connections have been completed.
- Check all cables. Verify that the connectors are fully seated and screws/locks are secured to make sure of good continuity.
- Verify that all cables are routed so they are shielded from damage and can be easily accessed for service and are away from any travel areas.
- Inspect all cables for restricting bend radii, excessive tension, or physical damage.

Pre-operation Checks

- Make sure that there are no obstructions in the travel path of the vehicles.

System Power-up

After the QuickStick 100 transport system has been installed, all connections must be checked. Then, an initial power-up must be performed before proceeding any further with the installation process. This section describes the procedure for the initial installation check-out.



⚠ WARNING

Crush Hazard

Moving mechanisms (vehicles) have no obstruction sensors.

Do not operate the QuickStick 100 transport system 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

Whenever power is applied, the possibility of automatic movement of the vehicles on the QuickStick 100 transport system exists, which could result in personal injury.

1. Make sure that all installation procedures that are previously described in this chapter have been completed.
2. Make sure that the system is properly grounded.
3. Connect the QuickStick 100 transport system to the electrical services for the facility. Make sure that the power remains off.

⚠ CAUTION

High Voltage Hazard

Each motor can draw 48V DC @ 5 A maximum. Make sure the AC circuit suppling power to the power supplies for the motors is properly sized and properly protected.

4. Perform a Ground Continuity check from the surfaces of the QuickStick 100 transport system to a known good ground.

5. Apply power to the QuickStick 100 transport system.

⚠ WARNING

Automatic Movement

The host controller is responsible for all QS 100 transport system motion. It is the responsibility of the user to initiate a safe startup of all QS 100 components.

Do not attempt to operate the QuickStick 100 transport system until all setup procedures that are described in this chapter have been completed.

The indicators on the components of the QuickStick 100 transport system light as shown in Table 5-2.

Table 5-2: Startup Indicators

Component	Indicator	Status
Node Controller, NC-12	Power	On (green)
Node Controller, NC-E	⏻ (Power)	On (blue)
QS 100 Power Supply	AC OK	On (green)
	DC OK	On (green)

6. If power-up was successful, the QuickStick 100 transport system is ready to accept commands. If however, the power-up sequence was unsuccessful, see *Troubleshooting* on page 186.

7. Create the Node Controller Configuration File for the transport system (see *Software Configuration* on page 141 and to the *QuickStick Configurator User Manual*).

8. Set the IP address for each node controller. See the *Node Controller Interface User Manual* for more details. If EtherNet/IP is being used, see the *QuickStick Configurator User Manual* for additional configuration information.

9. Configure one node controller as the HLC. See the *Node Controller Interface User Manual* for more details.

10. Upload the configuration, image, and type files to each node controller (see the *Node Controller Interface User Manual*).

11. Program the masters and slaves for the motors. See the *Node Controller Interface User Manual* for details.

12. Review the log files for each node controller to make sure that the system has been programmed and configured properly (see the *Node Controller Interface User Manual*).

System Testing

Test the QuickStick 100 transport system to verify proper operation of all nodes, paths, and vehicles. Testing can be accomplished using the MagneMotion NCHost application to move vehicles without the host controller to verify proper operation before integrating a transport system into a production environment. Create Demo Scripts to perform repetitive testing throughout the transport system (see the *NCHost TCP Interface Utility User Manual* for details). If any problems are encountered, see *Troubleshooting* on page 186.

⚠ WARNING

Crush Hazard

Moving mechanisms have no obstruction sensors.

Do not operate the QuickStick 100 transport system without barriers in place or personal injury could result in the squeezing or compression of fingers, hands, or other body parts between moving mechanisms.

1. Make sure that the transport system is fully configured.

2. Make sure that the Node Controller Configuration File is fully defined and has been uploaded to all node controllers (see the *Node Controller Interface User Manual*).

3. Make sure that the web interface for each node controller shows a status of running/valid (see the *Node Controller Interface User Manual*).

4. Issue a Restart Services command for each node controller (see the *Node Controller Interface User Manual*).

5. Issue a Reset command for all paths (see the *Node Controller Interface User Manual*).

   All motors on the paths in the transport system are reset.

6. Issue a Startup command to all paths (see the *Node Controller Interface User Manual*).

   Motion on all paths is enabled, all vehicles on the paths are identified and located, and the paths become operational.

⚠ WARNING

Crush Hazard

The vehicles move during the startup sequence.

7. Verify that the host controller has identified all vehicles in the transport system (see the *NCHost TCP Interface Utility User Manual*).

8. Move vehicles individually or create a Demo Script for repetitive testing (see the *NCHost TCP Interface Utility User Manual*).

9. Monitor transport system operation with the NCHost TCP Interface Utility.

Operation 6

Overview

This chapter provides an overview of operation for the QuickStick® 100 transport system. The operation of the QS 100 transport system is covered for both normal conditions and emergency conditions.

Included in this chapter are:

- Theory of operation of the MagneMotion® linear synchronous motors and the QuickStick 100 transport system.
- Controls and indicators that are provided on the system.
- Simulation of QS 100 transport system operation.
- Operational startup and safe shut-down.

Theory of Operation

The QuickStick 100 is a new approach to linear synchronous motor (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 100 transport system can achieve various acceleration and velocity profiles while moving a wide range of payloads with high precision.

The QuickStick 100 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 6-1. The motor primary is a series of coils that generate a magnetic field within the QuickStick 100 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 100 motors also use the magnets on the vehicle to track the position of the vehicle over the motor.

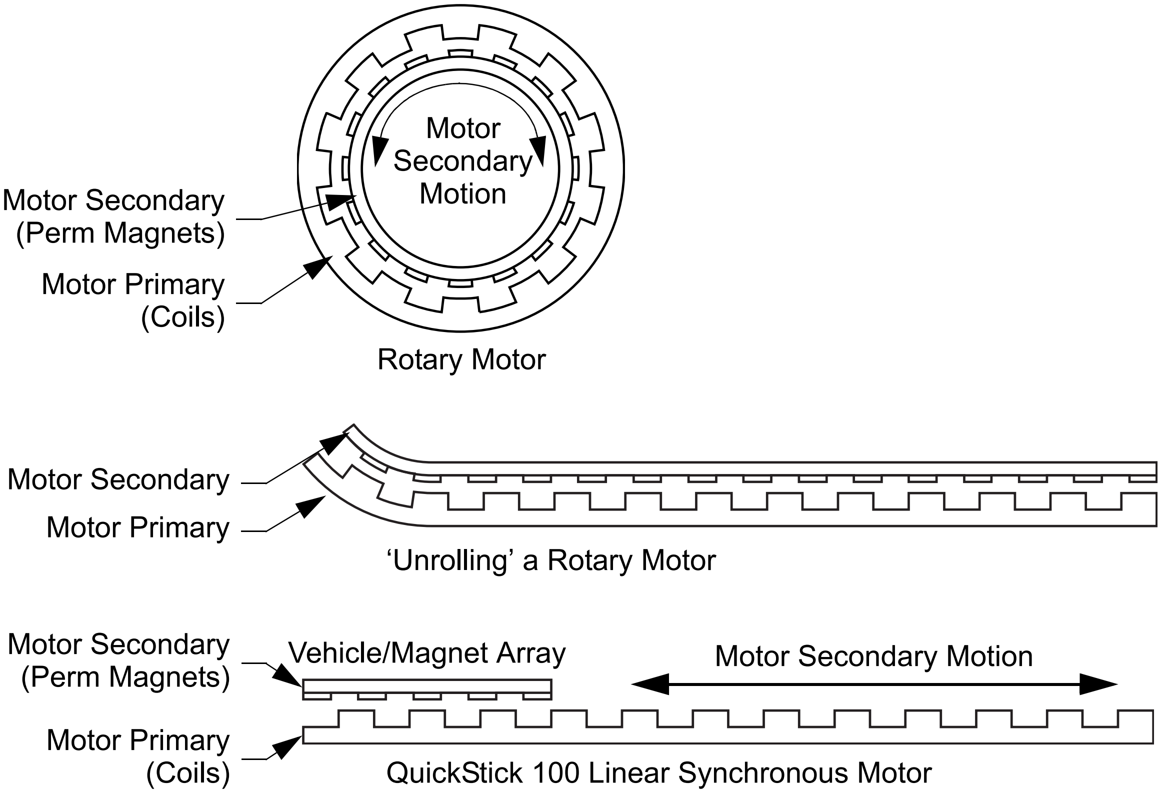


Figure 6-1: Linear Synchronous Motor Derived From Rotary Motor

QuickStick 100 Transport System Advantages

An advantage of the QuickStick 100 transport system is that the motor secondary (vehicle) is not connected or tethered to the motor primary. This configuration allows the vehicle to travel further and faster than connection cables allow. Another advantage is unlimited travel length. The result is a propulsion solution with excellent reliability that is efficient, quiet, and clean.

The QS 100 transport system also provides high reliability because it does not require frequent replacement of power transmission parts.

A summary of QuickStick 100 transport system benefits includes:

- Less maintenance than conventional belt conveyors.
- No moving parts within the motor modules.
- Passive vehicles that do not require batteries, wires, or power.
- Bidirectional motion.
- Variable guideway system layout including curves and horizontal or vertical guideways.
- Anti-collision feature.
- Automated move profiles.
- Independent vehicle motion.

Motion Control

The QuickStick 100 transport system provides an integrated transport system for material movement along one axis. Motors are linked together in paths that define the individual motion routes. The host controller can then direct the motion and position of the vehicles anywhere along the length of the path. Vehicles can also be moved from one path to another as long as there is a connection between the paths (either direct or through one or more other paths) through a node (or multiple nodes).

The design and operation of the QuickStick 100 transport system uses a minimum of moving parts to minimize maintenance requirements. Position sensors in all motors make sure that there is accurate tracking and positioning of all vehicles in the transport system.

Motor Topology

Each QuickStick 100 motor is constructed as a series of blocks (see Table 3-2 on page 64 and Figure 6-2 and Figure 6-3). Each block is a discrete motor primary section within the motor consisting of multiple coils that is energized as required. Varying the magnetic force within a block and its neighbors causes the vehicle to move in the desired direction and provides precise positioning of the vehicles.

The control software makes sure that the minimum distance between vehicles at the extreme ends of adjacent motor blocks is 6 mm [0.26 in] when not moving. However, this dimension is variable depending upon the vehicle edge location relative to the block boundary. This feature allows having a magnet array (vehicle) right justified in the first block of a QuickStick 100 motor with a second magnet array (vehicle) left justified in the second block of the QuickStick 100 motor. The anti-collision feature in the QuickStick 100 motors keeps two vehicles from occupying the same motor block.

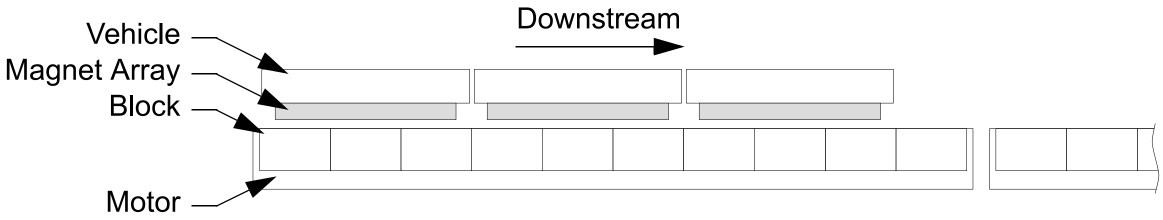


Figure 6-2: Representation of Stationary Vehicles Per Motor Block

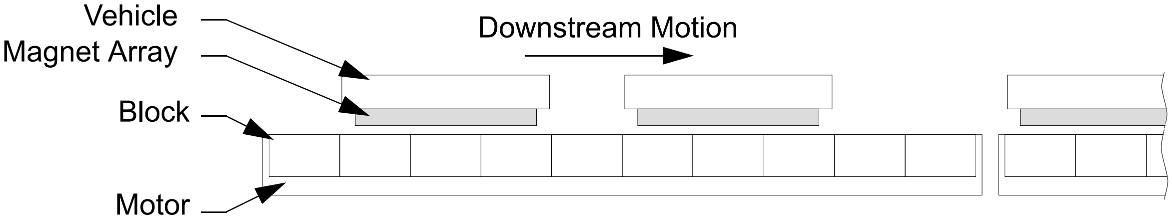


Figure 6-3: Representation of Moving Vehicles Per Motor Block

Motor Operation

The QuickStick 100 motors provide asynchronous control of vehicles on the transport system as directed by the host controller. This control method minimizes the load on the host controller with the node controllers and motors performing all routing and vehicle control operations (positioning, acceleration, deceleration, and collision avoidance) as described in the following sequence.

1. The host controller generates an asynchronous motion order to move a vehicle to a specific location and sends it to the high-level controller (HLC) using either a position or station command. Locations are always defined from the beginning of a path.

   For example, the Order is to move Vehicle #1 to a Position 1.5 m on path 1 (P_{dest}) at a maximum speed of 0.5 m/s (V_{max}), and acceleration/deceleration of 1 m/s^2 (A_{max}).

2. The HLC routes the order to the appropriate node controller.

3. The node controller generates a motion order and sends it to the appropriate vehicle master (motor controller for the motor where the vehicle is located).

4. The vehicle master generates a motion profile that is based on the order. Every update period (~1 ms) a new position, velocity, and acceleration setpoint (P_{set}, V_{set}, and A_{set}) are calculated.

   - As the vehicle moves, the master acquires empty blocks ahead of the vehicle that the vehicle can move into based on the current motion order for the vehicle. A ‘block’ is defined as an independently controlled set of coils (see Table 3-2 on page 64 for details), no two vehicles are allowed to occupy the same block.

- The vehicle master uses the position of the most recently acquired block farthest from the vehicle as an interim destination (target) to calculate the next profile setpoint (P_{set}, V_{set}, and A_{set}).
- The vehicle master handles all collision avoidance to make sure brick-wall headway is maintained between vehicles.

5. The vehicle master uses the profile setpoints as inputs to control the vehicle position.

   During the move, vehicle data such as actual position, velocity, and interim destination are sent back to the node controller, typically every 100–200 ms. This data provides the host controller some level of feedback as to where the vehicle is located.

6. The vehicle master continues to generate updated motion profiles that are based on the order and vehicle control continues based on the new profile setpoints. This updating continues until the vehicle is handed off to the next vehicle master or it reaches its destination.

   The vehicle master hands-off vehicle control to the motor controller in the next motor as the vehicle moves across motor boundaries. The new master ‘picks up’ where the old one left off for profile generation. The new master is now responsible to continue the closed-loop control of the vehicle.

7. The motion order is finished when the vehicle position is equal to the ordered destination.

Motor Cogging

Brushless Permanent Magnet (BPM) motors that are iron core-based inherently exhibit cogging forces. In traditional BPM motors, these cogging forces are felt when turning the shaft of the motor and are periodic in nature. The periodicity in this case would be expressed in degrees and the magnitude and direction of this cogging force would vary as a function of shaft position.

Linear motors, such as the QuickStick 100 motors from MagneMotion that use an iron core to maximize thrust (equivalent to torque in a traditional rotary motor) also exhibit cogging forces. The main difference between rotary motors and linear motors is that in linear motors these forces are periodic as a function of distance versus angle. In the linear motor, these forces tend to pull the vehicle forward or backward at specified intervals along the motor.

The QS 100 motors are designed to minimize cogging as the vehicles travel over the motor. Vehicles are subjected to slightly greater cogging as they travel from motor to motor. The frequency of these cogging forces is directly proportional to vehicle speed. Cogging forces are below 5% of the available thrust that is provided by the motors and do not appreciably impact the acceleration and speed capabilities of the motors. However, cogging can lead to perceptible low-level vibrations whose frequency are related to vehicle speed. These small vibrations have a typical frequency range of 0 Hz (at zero speed) to 30 Hz (at high vehicle speeds).

For general transport and conveyance applications, cogging effects are not observable or perceptible if the vehicle, track, and payload design do not exhibit a sharp resonance within the 0–30 Hz range. However, for payloads susceptible to vibration, these cogging effects can have an impact and require special attention to suppress them. See *Motor Cogging* on page 67 for installation methods to minimize cogging.

Motor Blocks

A motor block is a discrete motor section within each QuickStick 100 motor as shown in Figure 6-2 and Figure 6-3. Each block is a set of independently controlled copper windings that are driven by one inverter, with multiple blocks creating the motor primary (stator). Each of the copper windings has an iron core, which creates an attractive force between the magnet array and motor even when the motor is not powered.

Block Acquisition

The master controller for each motor takes ownership of vehicles when they enter the motor or are identified during startup and maintains that ownership the entire time the vehicle is on the motor. Ownership includes identification of the final destination, maximum acceleration, and maximum velocity as defined in the current motion order and determination of the interim destination for the vehicle and current acceleration and velocity setpoints.

The master makes sure that the vehicle has acquired sufficient empty blocks ahead of the vehicle in the direction of motion to maintain brick-wall headway with the current motion profile. The vehicle is said to own these blocks until they are released. Headway is maintained by communicating with the motors ahead of the vehicle to make sure that sufficient blocks can be acquired to define new interim destinations.

- The vehicle master uses the position of the most recently acquired block farthest from the vehicle as an interim destination (target) to calculate the next profile setpoint (P_{set}, V_{set}, and A_{set}).
- A new interim destination (target) block is only granted if the block has not been allocated to another vehicle (that is, permission is granted for only one vehicle per motor block).
- A new target is requested only immediately before the vehicle must start slowing down for its current target to minimize the number of committed blocks and to make sure brick-wall headway is maintained.
- Permission to enter a motor block is only granted after the previous vehicle has exited the block and released ownership.
- Each vehicle is controlled in such a manner that it is always able to stop in the last motor block it was granted permission to enter.

Block Ownership

The minimum distance two vehicles can be from each other is 6 mm, since the end of each vehicle maintains a space of 3 mm from the end of the owned motor block in the direction of motion for anti-collision. This minimum distance is based on the length of the vehicle, not the magnet array. Figure 6-4 shows that when any portion of a vehicle is over a motor block, the vehicle owns that whole block. The vehicle positions in Figure 6-4 show that the vehicles could be closer together, but vehicle separation is based on the length of the configured payload or vehicle and block ownership, not the length of the magnet array.

When vehicles are placed in queue, they get as close to their commanded position as possible without violating the block boundaries as shown in Figure 6-4. When trying to create stations that put vehicle next to each other, the vehicle positions and the space that a vehicle occupies in a motor block must be considered, as shown in Figure 6-4.

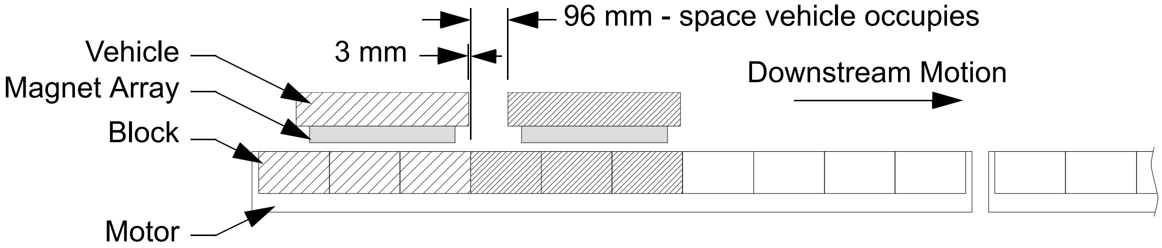


Figure 6-4: Representation of Block Ownership by Vehicle

Block Release

The master controller for each motor releases ownership of blocks once the vehicle exits the block and is at least 3 mm away from that block. Block ownership is also released if the vehicle is deleted.

Anti-Collision

The QuickStick 100 transport system allows only one vehicle per motor block. This block allocation is the basic rule on which the anti-collision feature of the QS 100 transport system controls is founded. Since two vehicles are not allowed to be in the same motor block, they cannot collide. This block allocation affects how many vehicles can fit on a motor or path.

Also, the magnet arrays on the vehicles have a slight repulsive force that causes them to passively separate from each other a short distance when they are manually pushed together and not being servoed (actively controlled). The distance they passively separate varies based on vehicle and guideway conditions (including friction).

The vehicles can be commanded to a tighter spacing but this spacing requires constantly driving the motor to force them together. They can be commanded to a pitch where they are practically in contact with each other but if this constant, close position condition is held too long the motors reach a thermal limit and shut down. This tight spacing can be done on occasion but it cannot be a standard part of a process.

Safe Stopping Distance

Standard vehicle control makes sure that vehicles always have a safe stopping distance (brick-wall headway). Figure 6-5 shows acceleration, velocity, and position versus time for the standard vehicle motion profile. Permission for vehicle motion is granted as required for the vehicle to maintain its motion profile (solid heavy line) and provide brick-wall headway (dashed heavy line) based on the current velocity and commanded acceleration of the vehicle. The brick-wall headway distance can be found by dividing the square of the current velocity of a vehicle by twice its acceleration ($V^2/2a$).

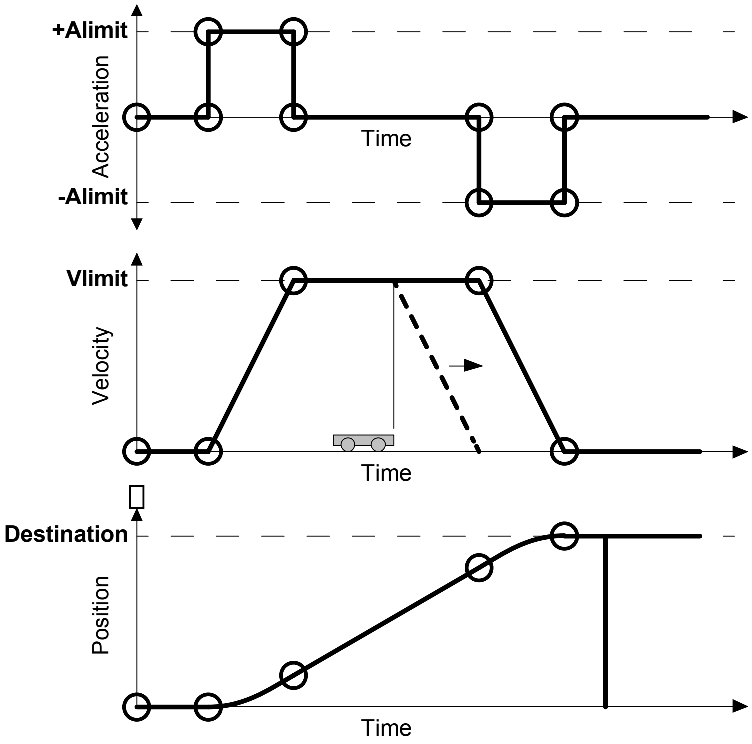


Figure 6-5: Vehicle Motion Profile

Thrust Limitations

When a vehicle is commanded with a higher acceleration rate than the motor can provide, the vehicle falls behind its ideal move profile while accelerating. Figure 6-6 shows both the ideal move profile (solid line) and the degraded move profile (dashed line).

In addition, and more critically, the vehicle is not able to decelerate at the specified rate and overshoots its destination as shown by the dashed line in Figure 6-6. This behavior can result in vehicles colliding with other vehicles or switch components, or loss of control of a vehicle as it exits the area where it has permission to move. Thus, it is important to avoid commanding a move with an acceleration that is higher than the deceleration capability of the system.

The precise deceleration capability depends on vehicle mass (including payload), center of gravity location, speed, and track geometry. Furthermore, the thrust capability of the motors are reduced in proximity to the gaps between motors.

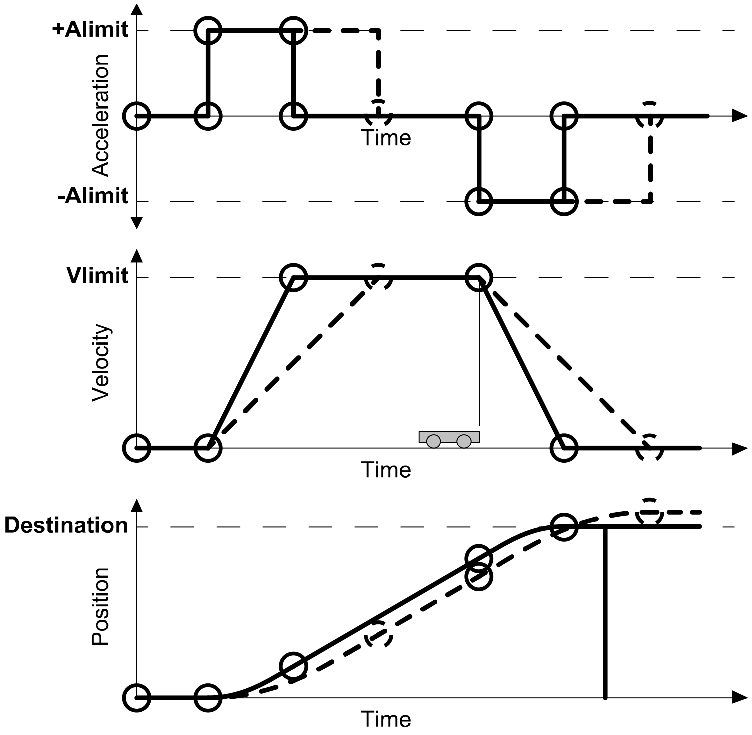


Figure 6-6: Vehicle Movement Profile Showing Thrust Limitations

In Queue

Typically, vehicles queue up while in route to a particular destination when another vehicle obstructs the route. Obstructions are normal occurrences, jams are not. While in queue, the vehicles can be as close together as permitted by the system. The amount of space in between the carriers that are mounted on the vehicles depends on the defined length of the vehicle. All vehicles in the queue report being obstructed.

An obstruction indicates that something that the system knows about is keeping the vehicle from completing its current motion order. This obstruction could be another vehicle, a node not ready for a vehicle, or a path that is suspended or has not completed startup. Once the obstruction clears (that is the obstructing vehicle moves, the node becomes ready, or the path becomes available) the obstructed vehicle is free to complete its order.

A jam indicates that there is no known obstruction keeping the vehicle from moving, but the vehicle is not moving towards its destination. This lack of progress is typically due to an unknown obstruction (something having fallen onto the track) or friction within the system that cannot be overcome. Once the jam has been cleared, typically by outside intervention, the vehicle is free to complete its order and any vehicles it has obstructed are free to complete their orders. Other causes of a vehicle being unable to move that are considered a jam are:

- A vehicle is commanded to move with a velocity of zero.
- A vehicle is commanded to move with an effective PID set equal to zero.

Vehicle Length Through Curves and Switches

The width of the vehicles is not defined in the Node Controller Configuration File. To make sure that multiple vehicles can move on curved sections of the transport system without colliding, the vehicle length must be defined longer than it actually is to account for the width of the vehicle in a curve. The value of the defined length must be calculated using basic trigonometry, see the *QuickStick Configurator User Manual*.

Locating Vehicles During Startup

The node controller scans for the magnet array on the vehicles starting from the upstream end of a path and scanning towards the downstream end of the path. When the node controller detects a magnet array (vehicle), it attempts to locate it precisely by moving the vehicle into the adjacent motor block in the downstream direction to determine its position (using the sensors in the next motor block). If the node controller is able to move the vehicle, it assigns the vehicle a Vehicle ID. If another vehicle occupies the adjacent motor block (or there are no more motor blocks downstream), it looks to the next detected vehicle and tries to move it. The node controller continues scanning for vehicles until it locates a new one, or it tries to move an already located vehicle to make room to locate a new vehicle if there is additional room to move the already located vehicle that is in the way.

If the node controller scans to the end of the path, and it was unable to move any detected new vehicles into a downstream motor block or it is unable to move existing vehicles for room, it switches directions and begins scanning in the upstream direction from the downstream end of the path. The node controller assigns a vehicle ID to the next vehicle it can move into an adjacent upstream motor block to determine its position.

NOTE: There must be at least one motor block free per path for startup to succeed.

The node controller continues to scan back and forth in the downstream and upstream directions until all vehicles detected have been assigned a vehicle ID. This scanning could take several seconds to several minutes depending on how many vehicles are on a path. If the node controller scans in the downstream direction and then scans in the upstream direction of a path without being able to move any vehicles, startup fails for that path. This failure could be due to either due to no space to move a detected vehicle or a jammed vehicle.

Once a vehicle ID is assigned, it remains with that vehicle until the vehicle is removed from the QuickStick 100 transport system, the vehicle is deleted, or a Reset is issued for the path. Vehicles are removed via a Terminus Node or deleted with a Delete Vehicle command.

Moving Vehicles by Hand

Only move vehicles on the QuickStick 100 transport system using the QS 100 motors in the system. If there is an event that requires moving the vehicles by hand, the guidelines that are provided here must be followed.

⚠ WARNING

Crush Hazard

Moving mechanisms have no obstruction sensors.

Do not attempt to move any vehicles manually while propulsion power is supplied to the transport system or personal injury could result in the squeezing or compression of fingers or other body parts between moving mechanisms.

⚠ CAUTION

Electrical Hazard

Moving vehicles by hand produces eddy currents in the stators of the motors where the vehicle is being moved, which puts power on the propulsion bus.

If both propulsion power and logic power to the transport system are removed, there is no tracking of vehicles being provided. Once power is restored the transport system must be restarted, which detects all vehicles at their current locations.

If propulsion power to the transport system is removed while logic power is maintained and a vehicle is moved manually on the motor, the transport system tracks its position. If the center of the magnet array on the vehicle crosses a motor boundary (moves off the end of a motor), it creates an Unlocated Vehicle Fault. Vehicles that have crossed a motor boundary are said to have lost their signal (Vehicle Signal = 0) when monitoring the vehicle status through the Host Communication Protocols (see either the *Host Controller TCP/IP Communication Protocol User Manual*, the *Host Controller EtherNet/IP Communication Protocol User Manual*, or the *Mitsubishi PLC TCP/IP Library User Manual*).

A vehicle that has been manually moved, bumped, or dislodged, and lost its signal, is able to reacquire its signal when it is manually relocated to within approximately 25 mm of its original position as measured from the center of the magnet array in a vehicle or the mid-point between arrays in a tandem vehicle. When propulsion power returns, the vehicle is not able to move unless it had been returned to the same section of the motor where it was located when the power was shut off. In this case, the vehicle is shown as having signal (Vehicle Signal = 1) but it also shows as Suspect. Vehicles that are identified as Suspect require a restart of the path where they are located to clear the Suspect bit. In some cases, the vehicle can be commanded, but it continues to show as Suspect.

NOTE: The vehicle IDs for all vehicles on a path that is reset are not maintained. That is, a vehicle can be assigned a vehicle ID different from the ID it had before the path was reset.

If both propulsion power and logic power are maintained and a vehicle is moved manually, the motor resists motion of the vehicle. Once the vehicle is released, it snaps back to its original position if it has not been moved vary far (less than 25 mm) unless the center of the magnet array on the vehicle crossed a motor boundary.

Vehicles that have been moved too far can be recovered by deleting the moved vehicles and restarting the section of the transport system where they are located to detect them.

Electrical System

The QS 100 motors are designed to operate at a nominal +48V DC. The inverters that power the individual blocks within the motor are enabled when the internal propulsion bus for the motor rises above +43V DC, which allows normal motor operation and are shut down if the voltage falls below +41V DC. The inverters in the motor are also shut down when the internal propulsion bus reaches +59V DC to help protect internal circuitry and are enabled when the voltage falls below +57V DC. The logic circuits in the motor are designed to operate at a nominal +48V DC, but start to function once the logic bus rises above +40V DC, which allows reporting of all motor warnings and faults.

Voltage drops in the power distribution system when the motors consume power while moving vehicles and voltage increases during regeneration events lead to fluctuations in the voltage seen at the motor power terminals. Under normal operating conditions, these fluctuations are minimal and can be ignored. The power supplies and wiring for the system must be designed to minimize these fluctuations (see *Electrical Wiring* on page 69).

Power Regenerated by a Vehicle

When a vehicle slows to a stop, the mechanical energy of the vehicle is converted to electrical energy, which is applied to the internal propulsion bus of the motor. This energy must then be dissipated to avoid raising the voltage of the bus beyond the acceptable limit of +57V DC.

Power is provided to the motor 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 a number of factors, but a conservative estimate is that the net effective regeneration power is about 75% of the acceleration power. As the vehicle slows down under constant deceleration, the regeneration power drops linearly with speed.

Power Management Within the QS 100 Motor

To supplement any external power management schemes that are applied to a QuickStick 100 transport system, several means of internally consuming regenerated power within a QS 100 motor are incorporated to help protect the motor and help minimize voltage increases. These include both *Block Level Power Management*, where excess power is dissipated through unused motor blocks and *Motor Level Power Management*, where excess power is dissipated through an internal resistive load.

Power-Related Warnings and Faults

The power distribution system experiences voltage drops when the motors draw power to move vehicles and voltages increases during regeneration events when vehicles slow down. These fluctuations can lead to the motor issuing warnings and faults and can cause motor shutdown.

Soft Start

If the PTC used to limit inrush current heats up and goes into a high-resistance state, it does not allow the propulsion bus to power up. To keep from overheating the internal soft start resistor, the time between each successive turn on of the propulsion power must be a minimum of 30 seconds and a minimum of 10 seconds between turn off and turn on (power cycle) as shown in Figure 6-7.

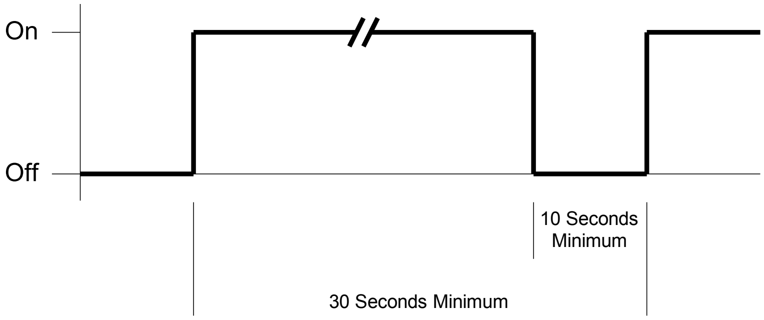


Figure 6-7: Power Cycle Timing

To make sure that the soft start circuit resets for the next turn on:

- Wait a minimum of 30 seconds from turn on to turn on.
- Wait a minimum of 10 seconds from turn off to turn on.
- Wait for the Soft Start Not Complete bit in the motor fault data to be clear before turning the propulsion power back on. See either the *Host Controller TCP/IP Communication Protocol User Manual*, the *Host Controller EtherNet/IP Communication Protocol User Manual*, or the *Mitsubishi PLC TCP/IP Library User Manual*.

Block Level Power Management

When the internal propulsion bus reaches +51.5V DC, current begins to ramp in the coils of blocks that are available to allow the motor to absorb and dissipate unused power due to regeneration within itself or coming from other motors that are connected to a commonly shared +48V DC power supply effectively. A coil block is defined as available and is used to dissipate power within a motor if its neighboring blocks (upstream and downstream) do not have any part of a magnet array over them. A neighboring block can be within another motor as would be the case for the first and last blocks within a given motor.

The current in these available blocks ramps linearly to 5 A over a 2 volt range from +51.5V DC to +53.5V DC. The coil current remains constant at 5 A for voltages above +55V DC and drops to zero for voltages above +59V DC since all inverters are turned off. This behavior is shown in Figure 6-8.

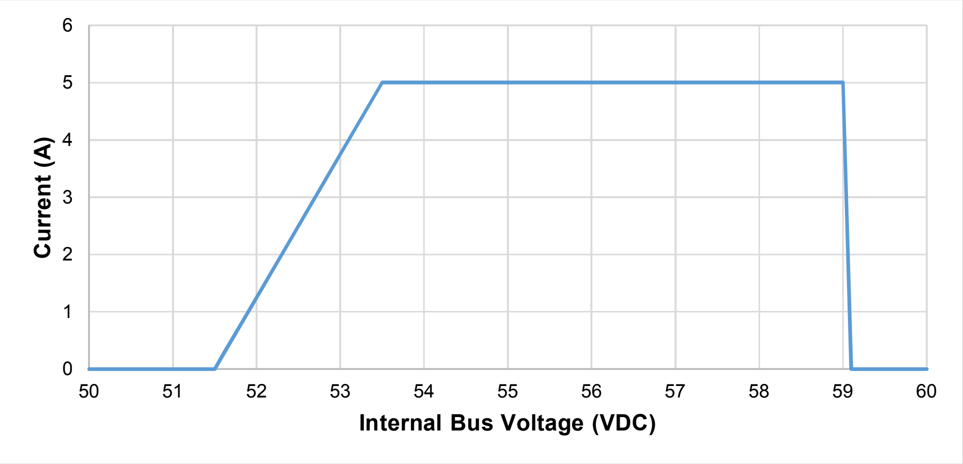


Figure 6-8: Individual Block Current vs. Internal Propulsion Bus Voltage

With a nominal block coil resistance of 1.9 Ohms, the dissipated power is 47.5 W per block when the 5 A current level is reached and remains at this level up to +59V DC. The dissipated power vs. the internal propulsion bus voltage is shown in Figure 6-9.

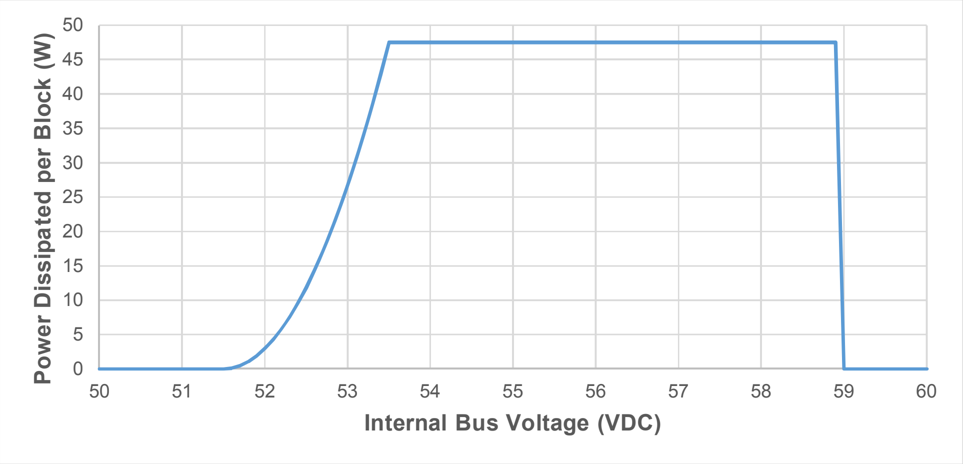


Figure 6-9: Power Dissipation Per Block vs. Internal Propulsion Bus Voltage

Motor Level Power Management

When the + 48V DC internal propulsion voltage rises above +58.9V DC, a 10 Ohm resistor within the motor is automatically switched across the +48V DC propulsion and +48 V return lines. This internal load remains active for voltages higher than this voltage and is removed when the voltage goes below +56.9V DC. The power dissipated by this load, which is shown in Figure 6-10 (the blue line shows power increasing and the orange line shows power decreasing), is additive to any power dissipated by the coils in the blocks as previously described.

Under normal use conditions, this resistor is never activated or relied upon to absorb regeneration power. This resistor is meant to handle anomalous high voltage transients that might otherwise lead to a catastrophic voltage induced motor failure only.

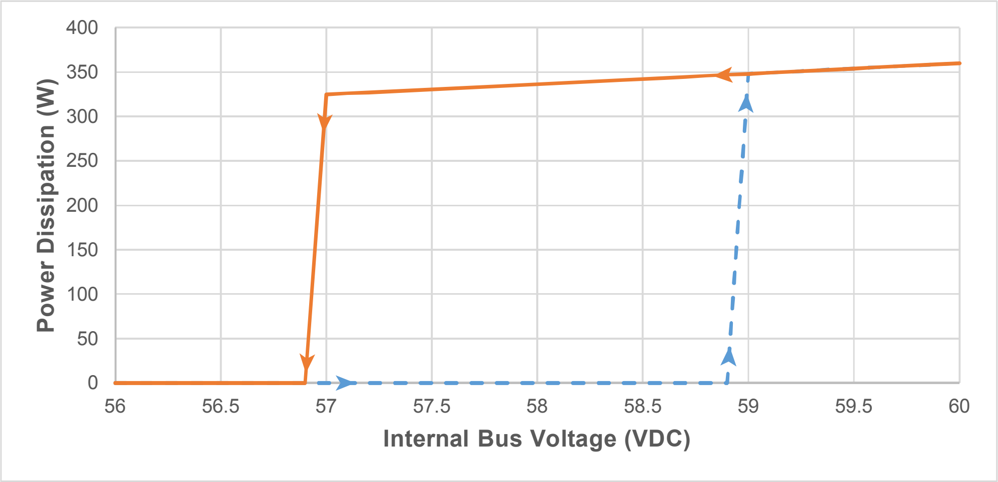


Figure 6-10: Power Dissipation by 10 Ohm Resistor vs. Internal Propulsion Bus Voltage

Power Related Warnings and Faults

Fluctuations in the voltage that is seen at the motor power terminals are due to voltage drops when the QS 100 motors consume power while moving vehicles and voltage increases during regeneration events.

These fluctuations can lead to the motor issuing warnings and faults and can cause motor shutdown as shown in Table 6-1.

Table 6-1: Propulsion Voltage Range

Voltage (VDC)	Event	Status
41	Soft Start Not Complete Fault Triggered.	Voltage Too Low Motor operation suspended
41	Under-voltage Fault Triggered, Inverters disabled.	
42.5	Under-voltage Warning Triggered.	
43	Minimum recommended Operating Voltage.	Operating Range
51.5	Blocks begin dissipating power.	
53.5	Blocks reach maximum power dissipation.	
56.5	Maximum Recommended Operating Voltage.	
57	Over-voltage Warning Triggered.	Voltage Too High Motor operation suspended
59	Over-voltage Fault Triggered, Inverters disabled.	

🟩	Motor in normal operating condition.
🟨	Motor in warning condition – continues to control vehicles.
🟥	Motor in fault condition – does not control vehicles (motion is undefined).

Soft Start Not Complete Fault

Upon initial power up, when the internal propulsion bus in the motor is below +43V DC, the motor reports a soft start not complete fault to the HLC. The HLC reports this fault to the host controller as a soft start not complete fault (see either the *Host Controller TCP/IP Communication Protocol User Manual*, the *Host Controller EtherNet/IP Communication Protocol User Manual*, or the *Mitsubishi PLC TCP/IP Library User Manual*) and the motor does not allow vehicle motion to occur. Once +43V DC is reached, the motor supports vehicle motion and the soft start fault message self-clears.

If the internal propulsion bus voltage drops below +41V DC during operation, the motor reports a soft start not complete fault through the HLC to the host controller. When this fault is reported, all inverters within the motor are disabled, and any vehicles in motion over the motor are no longer under active control and as such their motion is undefined. Normal operation resumes once the internal propulsion bus rises back up to +43V DC.

Under-voltage Fault

Upon initial power-up, when the internal propulsion bus in the motor is below +41V DC, the motor reports an under-voltage fault to the HLC. Once this fault clears, it only reappears if the internal propulsion bus voltage drops below +41V DC. The HLC reports this fault to the host controller as an under-voltage fault (see either the *Host Controller TCP/IP Communication Protocol User Manual*, the *Host Controller EtherNet/IP Communication Protocol User Manual*, or the *Mitsubishi PLC TCP/IP Library User Manual*). This fault self-clears when the internal propulsion bus voltage rises above +43V DC.

If the internal propulsion bus voltage drops below +41V DC during operation, the motor reports an under-voltage fault through the HLC to the host controller. When this fault is reported, all inverters within the motor are disabled, and any vehicles in motion over the motor are no longer be under active control and as such their motion is undefined. Normal operation resumes once the internal propulsion bus rises back up to +43V DC.

This fault is likely due to excessive +48V DC power cable and +48V DC return cable resistance from the power source to the motor.

Under-voltage Warning

When the internal propulsion bus in the motor drops below +42.5V DC, the motor reports an under-voltage warning to the HLC. This warning is logged in the HLC Log when the Log Level for Faults is set to the Warning level (see the *Node Controller Interface User Manual*). This warning is not sent to the host controller. When the voltage rises back up to +43V DC this fault self-clears. There is no voltage filtering associated with this warning since the intent is to capture minimum voltage excursions. Upon initial system power-up, this fault is present and persists until the propulsion bus reaches +43V DC.

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. A properly designed system never exhibits this alarm following system power-up.

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 *Power Related Fault Resolution*.

Over-voltage Warning

When the motor detects instantaneous voltage in excess of +57V DC on its internal propulsion bus, the motor reports an over-voltage warning to the HLC. This warning is logged in the HLC Log when the Log Level for Faults is set to the Warning level (see the *Node Controller Interface User Manual*). This warning is not sent to the host controller. When the propulsion bus voltage drops back below +56.5V DC this fault self-clears.

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 *Power Related Fault Resolution*.

Over-voltage Fault

When the internal propulsion bus in the motor rises above +59V DC, the motor reports an over-voltage fault to the HLC. The HLC reports this fault to the host controller as an over-voltage fault (see either the *Host Controller TCP/IP Communication Protocol User Manual*, the *Host Controller EtherNet/IP Communication Protocol User Manual*, or the *Mitsubishi PLC TCP/IP Library User Manual*). When this fault is reported, all inverters within the motor are disabled, and any vehicles in motion over the motor are no longer under active control and as such their motion is undefined. This fault self-clears and normal operation resumes once the internal propulsion bus voltage falls below +57V DC. To avoid issuing an over-voltage fault to the host controller due to spurious noise, the internal propulsion bus that is used to trigger this event is filtered.

Based on the specific system wiring and vehicle activity, it is possible for regenerated power resulting from vehicle decelerations to cause the internal propulsion bus voltage to rise to excessive levels. To help protect against this, protective features guard against operating conditions that could damage the motor. Since the source of such a condition is due to regeneration effects associated with active braking or deceleration of a vehicle (loaded or unloaded), a means (among others) of eliminating such regenerated power is to shut down the inverters in the motor.

Power Related Fault Resolution

The power-related error messages and the associated faults persist until the voltage of the internal propulsion bus in the motor is between +42.5V and +57V DC. Once the voltage is within the operating range, the system attempts to resume active control of the vehicle. There are several possible solutions available to eliminate faults of these types.

- Reduce the cable resistance between the power supply and the motors if a voltage drop in these cables leads to under voltage on motors accelerating vehicles.

- Reduce the cable resistance between motors that share a common +48V DC power supply if a voltage drop in these cables leads to under voltage on motors accelerating vehicles or excessive voltage on motors undergoing regeneration.
- Reduce the maximum speeds and/or maximum accelerations to reduce the amount of power that is drawn and the regenerated power flowing back into the system.
- Reduce the number of vehicles accelerating on motors that are connected to the same common +48V DC power supply.
- Split the power bus into smaller sections and install additional power supplies.
- Increase the spacing between vehicles on motors sharing a common +48V DC power supply to increase the number of blocks available to absorb power during regeneration.
- Connect more motors to a common +48V DC power supply to increase the number of blocks available to absorb regenerated power.

If all of these resolution paths have been explored and excessive voltage problems still persist, add an active voltage clamp across the +48V DC power supply local to the power supply or to the motors that are exhibiting this issue. The clamping voltage should be above +51V DC but kept as low as possible.

Node Controllers

The MagneMotion node controller is used to monitor vehicles and control the motors and other components of a QuickStick 100 transport system based on the commands from the host controller. The node controller also provides status information to the host controller. There can be multiple node controllers in a transport system, each responsible for a subset of the transport system. Each node controller is connected to the local area network (LAN) for the transport system. Providing all communications to the node controllers through a LAN allows the node controllers to be located near the motors they are controlling, which minimizes the length of all cabling.

Each node controller is responsible for coordinating vehicle movement through the nodes that are assigned to it and along the paths that are connected to those nodes. The node controllers are also used to program the motors on the paths that are connected to the nodes assigned to it.

One node controller in the transport system also functions as the high-level controller (HLC). The HLC provides one point of contact for all communications with the host controller through either TCP/IP or EtherNet/IP™. The HLC distributes any commands or requests that are received to the appropriate node controller through the LAN using TCP/IP and passes any messages from the node controllers to the host controller. The HLC also assigns vehicle IDs and tracks vehicle movement from node controller to node controller to make sure vehicle IDs are maintained.

NOTE: All TCP communications is unicast. Additionally, do not connect the node controllers to a network with large amounts of broadcast traffic as this extra traffic could impact node controller communication.

Node Controller Communications

All node controllers constantly communicate with the node controller configured as the HLC through a LAN. Additionally, the node controller designated as the HLC communicates with the host controller through the same network.

All node controllers have the same IP address when they leave the factory. Individual node controllers with the same IP address cannot be distinguished on a network and must not be connected to the network until their IP address is set to a unique address that matches the addressing structure of the network for the transport system (see the *Node Controller Interface User Manual*).

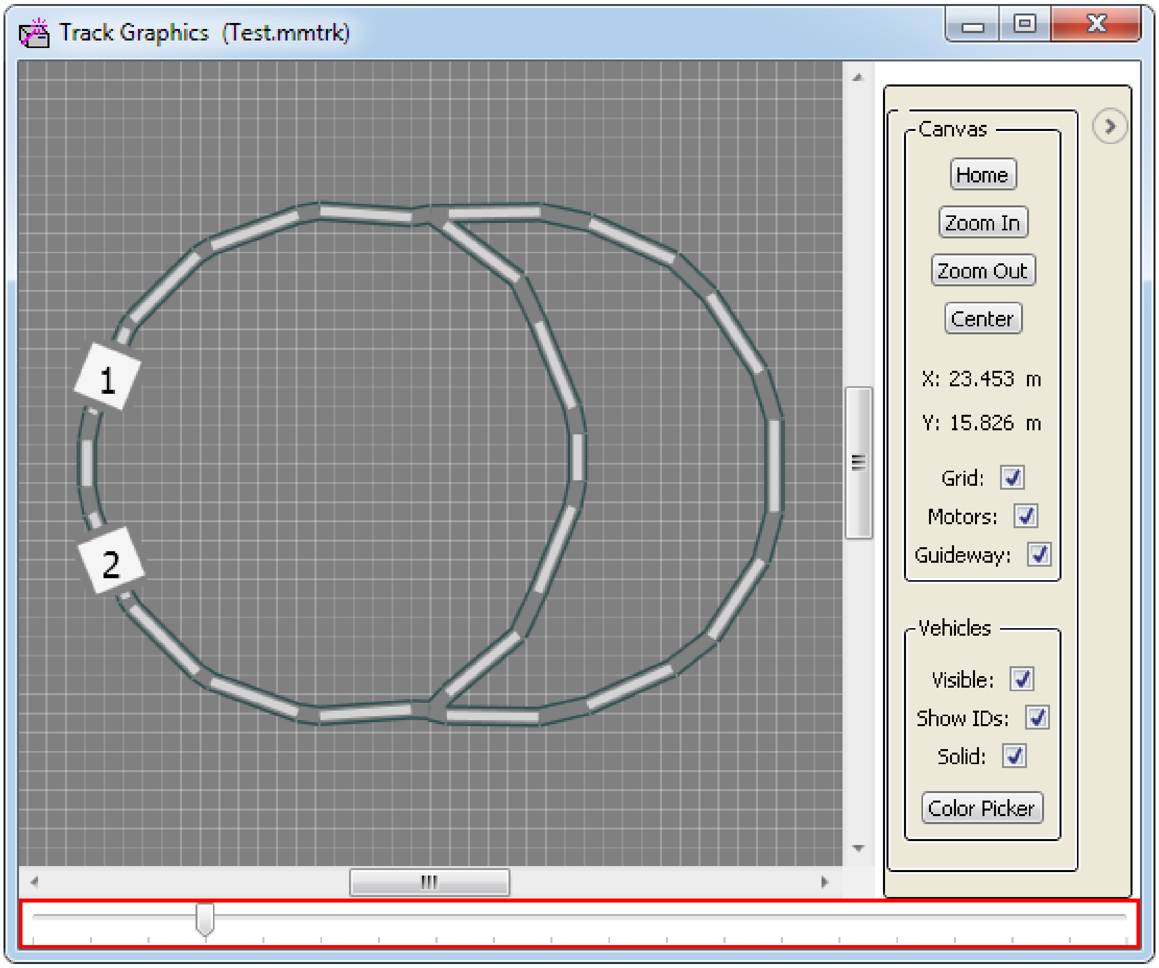
See the *Node Controller Hardware User Manual* for mechanical dimensions, detailed connector identification and pinouts, and procedures for mounting and connecting the node controllers to the transport system.

Controls and Indicators

The control application on the host controller must provide any needed controls or indicators that are related to transport system operation. Additional controls and indicators can be configured as described in this section. The controls and indicators of the QuickStick 100 components are identified in the *Electrical Specifications* on page 103.

Track Display

The NCHost TCP Interface Utility can be used to display the Graphics Window, which is shown in Figure 6-11. The Graphics Window shows the transport system layout and all vehicles in the transport system for real-time monitoring of transport system operation. This display can only be used if there is a Track file for the specific configuration (created by MagneMotion). See the *NCHost TCP Interface Utility User Manual* to use the Graphics Window.



X: 23.453 m

Y: 15.826 m

Grid: ☑

Motors: ☑

Guideway: ☑

Visible: ☑

Show IDs: ☑

Solid: ☑

Figure 6-11: The Graphics Window

Synchronization

The Synchronization option for the QuickStick 100 transport system provides the ability for the end user to more accurately control the motion of individual vehicles within a specified zone. More elaborate motion profiles can be implemented, such as jerk control. Synchronization also allows co-ordinating vehicle motion to that of an external moving element (for example, robot, filler). Only use the Sync option with those motors that are in a location where vehicle motion must be synchronized with an external mechanism.

In normal asynchronous operation, the node controllers route the orders from the Host to the motors and the motors control the profiles (position, velocity, and acceleration) for the vehicles. All asynchronous control is handled through the RS-422 interface from the node controller to the motors.

In synchronous operation the profile (position, velocity, and acceleration) generation for individual vehicles is the responsibility of the host controller, which generates profiles for all vehicles in the synchronization region. This profile requires that the host controller is in charge of collision avoidance. Once the vehicle leaves the sync region, the MagneMotion control system picks up profile generation and collision avoidance functions. The vehicle IDs assigned to the vehicles by the transport system are preserved across non-Sync and Sync regions.

For synchronization, a SYNC IT controller is required for every three motors that are being synchronized as shown in Figure 6-12. See the *LSM Synchronization Option User Manual* for configuration and operation details to use the Sync option with the QuickStick 100 transport system.

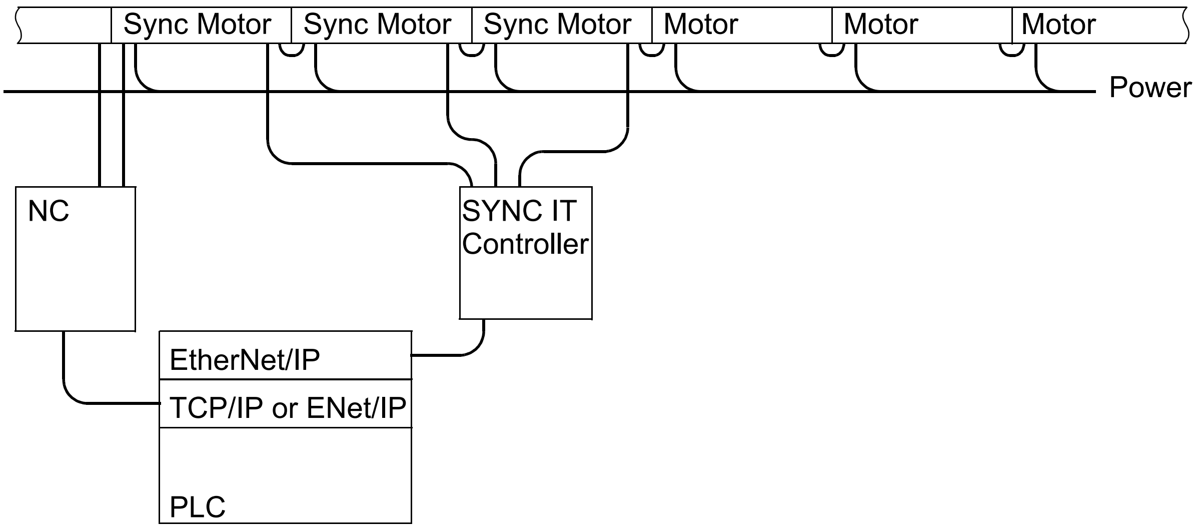


Figure 6-12: Transport System Wiring Diagram with Synchronization

E-stops

When using a node controller with digital I/O, the node controller can be connected directly to an E-stop circuit. An E-stop is a user-supplied button (typically locking) that an operator can press if an emergency situation arises to halt all motion on the specified paths. When the node controller detects that the E-stop button is activated, it commands all paths that are associated with that E-stop to suspend vehicle motion. All motors on those paths suspend vehicle target requests and permissions and all vehicles come to a controlled stop and are held in position by the motors. Stopping time for each vehicle is dependent on the load on the vehicle and the acceleration setting of the current motion command for the vehicle. See the *Node Controller Hardware User Manual* for additional details and equivalent circuits.

NOTE: Motion cannot resume until the button is released and the host controller issues a Resume command to the paths associated with the E-stop.

⚠ CAUTION

Electrical Hazard

The E-stop only executes the actions that are described, it is not the same as an EMO (Emergency Off), which removes power to the transport system.

Interlocks

When using a node controller with digital I/O, the node controller can be connected directly to an interlock circuit. An interlock is a user-installed circuit that another piece of equipment in the facility activates to halt all motion on the specified paths temporarily. When the node controller detects that the interlock circuit is activated, it commands all paths that are associated with that interlock to suspend vehicle motion. All motors on those paths suspend vehicle target requests and permissions and all vehicles come to a controlled stop and are held in position by the motors. Stopping time for each vehicle is dependent on the load on the vehicle and the acceleration setting of the current motion command for the vehicle. See the *Node Controller Hardware User Manual* for additional details and equivalent circuits.

⚠ WARNING

Automatic Movement Hazard

When the interlock is cleared, automatic movement of the vehicles on the QuickStick 100 transport system resumes, which could result in personal injury.

Light Stacks

When using a node controller with digital I/O, the node controller can be connected directly to a light stack. A light stack is a user-installed visual signal that is used to provide transport system status. The QuickStick 100 transport system supports standard three color light stacks (typically green, yellow, and red). The light stack can be used to monitor the status of any, or all, paths on the node controller where it is connected. See the *Node Controller Hardware User Manual* for additional details and equivalent circuits. See the *QuickStick Configurator User Manual* to configure the QS 100 transport system to use a light stack.

FastStop

The host controller can send a FastStop command to the node controller, on a per-path basis. This command suspends all motion on the specified paths. Vehicles immediately decelerate with maximum thrust opposing their motion. Previously commanded motion does not resume until a Resume Motion command is received. The control loop is still enabled while motion is suspended holding all vehicles in place. See the *Host Controller TCP/IP Communication Protocol User Manual* or the *Host Controller EtherNet/IP Communication Protocol User Manual* for details on the use of the FastStop command.

Digital I/O

When using a node controller with digital I/O, digital inputs and outputs can be monitored and controlled, respectively. These circuits can be wired directly to the digital I/O terminals on the node controller. The host controller can then issue commands to set the value of the digital outputs, or read the value of the digital inputs. See the *Node Controller Hardware User Manual* for additional details and equivalent circuits. See the *Host Controller TCP/IP Communication Protocol User Manual* or the *Host Controller EtherNet/IP Communication Protocol User Manual* for details on the use of the digital I/O commands.

Transport System Simulation

The QuickStick 100 transport system can be simulated to verify proper configuration of all nodes and paths and proper motion of commanded vehicles within the transport system. Simulations can be useful to test and observe system behavior without physically moving vehicles on the transport system. To run a simulation, the system must be fully defined in a Node Controller Configuration File (see the *QuickStick Configurator User Manual*) and that file must be loaded onto the node controller being used for simulation (see the *Node Controller Interface User Manual*).

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 Interface Utility). The simulated transport system cannot exceed the limits of a physical transport system as described in *Transport System Limits* on page 215.

Configuring a Simulation

1. Configure a node controller to run in Simulation Mode.
    A. Run the node controller web interface (see the *Node Controller Interface User Manual*).
    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**.

        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. Download the Node Controller Configuration File from the node controller. If a Node Controller Configuration File does not exist, see the *QuickStick Configurator User Manual* 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.

   NOTE: 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 *QuickStick Configurator User Manual*).

   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.

      1. In the Configuration Tree, open the **Paths** list.

      2. Select the path where the simulated vehicle is initially located.

      3. Right-click on **Simulated Vehicles** and select **Add to End** to add a simulated vehicle.

      4. Select the simulated vehicle just added and specify its starting location on the path.

      5. Repeat Step 2 through Step 4 for each vehicle to be added.

   D. For Merge and Diverge nodes, specify the **Simulated Move Time** for the switching mechanism to accurately simulate switching. This time is the actual amount of time it takes the switching mechanism to move from one position to the other position.

      1. In the Configuration Tree, open the **Nodes** list.

      2. Select either a Merge or Diverge node.

      3. In the **Simulated Move Time** field, enter the amount of time it takes for the switch mechanism to change directions.

      4. Repeat Step 2 through Step 3 for each Merge/Diverge node in the configuration.

   E. 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 *Node Controller Interface User Manual*).
    B. Make sure that the latest version of the motor type files is installed and upload new files if necessary (see the *Node Controller Interface User Manual*).
    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 6-2.

Table 6-2: 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 Advanced Parameters are not simulated.
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. • Shuttle Nodes are not simulated. • Overtravel Nodes are not simulated. • Moving Path Nodes are not simulated.
Paths	All paths must be defined.	All paths must be defined.
Stations	All stations must be defined.	All stations must be defined.

Table 6-2: Simulated Operation Differences (Continued)

Feature	Physical Operation	Simulated Operation
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.	• Single Vehicle Areas are not simulated. • 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. • SYNC IT is not simulated. • Jams are not simulated. • E-stops are not simulated. • Interlocks are not simulated. • Traffic lights are not simulated. • Wide vehicles are not simulated.

1. Connect to the node controller to run the simulation.
   - Use the NCHost TCP Interface Utility to run the system manually (see the *NCHost TCP Interface Utility User Manual*).
   - 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.

   NOTE: 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 Interface Utility to move vehicles individually or create a Demo Script for repetitive testing (see the *NCHost TCP Interface Utility User Manual*).
    - Use the host controller application to run the system as planned for production.

      All QS 100 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.

   NOTE: 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 Interface Utility to move vehicles individually or create a Demo Script for repetitive testing (see the *NCHost TCP Interface Utility User Manual*).
   - Use the host controller application to run the system as required.

     All QS 100 transport system elements move as directed.

Transport System Operation

Power-up

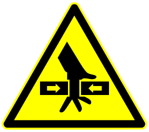
The QuickStick 100 transport system is started by applying power as previously specified (see *Check-out and Power-up* on page 143). Once the system completes startup, the QS 100 components are ready to operate. If the host controller is in control of the QS 100 transport system, the system accepts commands from the host controller through the network connection.

NOTICE

All switch settings, communication connections, and power connections must be made before power is applied.

Normal Running

During normal operation, the host controller controls the QuickStick 100 transport system. The user must determine the exact usage of the QS 100 transport system. See the *Host Controller TCP/IP Communication Protocol User Manual* or the *Mitsubishi PLC TCP/IP Library User Manual* for details of each command to use TCP/IP communication. See the *Host Controller EtherNet/IP Communication Protocol User Manual* for details of each user-defined tag and the PLC interface to use EtherNet/IP communication.



⚠ WARNING

Crush Hazard

Moving mechanisms (vehicles) have no obstruction sensors.

Do not operate the QuickStick 100 transport system without barriers in place or personal injury could result in the squeezing or compression of fingers, hands, or other body parts between moving mechanisms.

Safe Shut-down

The following shut-down procedure is used to remove power from the QuickStick 100 transport system in an orderly manner and place the components in known safe conditions. This procedure is used to prepare the components for removal, replacement, or maintenance.

⚠ **CAUTION**

Electrical Hazard

The shut-down procedure is used in the normal shut-down of the QuickStick 100 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.

The QuickStick 100 transport system requires no special shut-down procedures. When shutting down the host controller, the QS 100 components must be shut down first.

1. All material transfers must be completed (move all material to the appropriate locations).
2. Command all vehicles to known positions.
3. Issue a Suspend Motion command for all paths.

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

   The HLC clears all vehicle records.
5. Turn off all power to the motors.
6. Turn off power to the node controllers.
7. Turn off power to the host controller.
8. Turn off the main power disconnect for the QuickStick 100 transport system.

NOTE: This procedure only shuts down facilities to the QuickStick 100 motors, their subsystems, and the host controller. Any user equipment remains powered up.

Maintenance 7

Overview

This chapter provides maintenance schedules and procedures for the QuickStick® 100 components. Only trained, qualified personnel should perform maintenance or troubleshooting on the QS 100 transport system. MagneMotion® provides training in the troubleshooting and repair of the QS 100 transport system.

Included in this chapter are:

- Preventive maintenance procedures.
- Troubleshooting procedures.
- Contacting ICT Customer Support.
- Basic repair procedures.
- Component shipping procedures.

Preventive Maintenance

The motors, node controllers, and power supplies in the QuickStick 100 transport system are self-contained components that are designed for use in a clean, inert environment, and require no maintenance other than that described here. Any deviation from this basic environment can affect the maintenance requirements, contact ICT Customer Support for additional information. See *Troubleshooting* on page 186 if any problems are detected.

Table 7-1: QuickStick 100 Transport System Preventive Maintenance Schedule

Component	**Maintenance Action**	**Frequency**[*]	**Page #**
QS 100 Transport System	*Cleaning*	3 months or as required	183
	Wear Surface Maintenance	3 months or as required	183
	Cable Connection Inspection	3 months or as required	184
	Hardware Inspection	3 months or as required	184
	Cleaning Magnet Arrays	3 months or as required	184
Node Controllers	*Transfer Log Files*	3 months or as required	185

[*] The specified frequency is based on a certified clean, inert environment. Adjust the facility Preventative Maintenance Schedule to account for any deviations from this environment.

Cleaning

General cleaning of the QuickStick 100 transport system consists of cleaning the transport system surfaces as described.

Required Tools and Equipment

- Disposable gloves.
- Microfiber cleaning cloth.
- Deionized water.
- Isopropyl alcohol (optional).

Procedure

1. Stop all motion on the sections of the QS 100 transport system to be cleaned.
2. While wearing gloves, clean all exposed transport system surfaces and cables with a clean microfiber cloth slightly dampened with deionized water or isopropyl alcohol. Wipe in the direction of the grain on all surfaces that have a grain.
3. Make sure that all components are dry.
4. Resume motion on the sections of the QS 100 transport system that were stopped.

Wear Surface Maintenance

The vehicles that are used on the QS 100 transport system may need to be rotated to make sure that there is even wear on the wheels. This is especially true for vehicles that are used in a transport system where all motion is in one direction, for bogies in a tandem vehicle configuration, or for vehicles that have a cantilevered load.

NOTE: Rotating vehicles is only done for vehicles where the magnet array is centered on the vehicle. For vehicles where the magnet array is not centered, the design of the vehicle will determine if it is possible to rotate the vehicle.

1. Stop all motion on the QS 100 transport system.
2. Remove the vehicles from the QS 100 transport system.
3. Rotate the vehicles 180°.
4. Replace the vehicles on the QS 100 transport system.

Cable Connection Inspection

1. Stop all motion on the sections of the QS 100 transport system to be inspected.
2. Verify that all cable connectors are fully seated and screws/locks are secured to achieve good continuity.
3. Inspect all cables for restricting bend radii, excessive tension, or physical damage.
4. Return the QS 100 transport system to normal operation.

Hardware Inspection

1. Stop all motion on the sections of the QS 100 transport system to be inspected.
2. Turn off all QS 100 transport system components with accessible power controls.
3. Make sure that all motor stand hardware is secure.
4. Make sure that all guideway mounting hardware is secure.
5. Make sure that all motor mounting hardware is secure.
6. Make sure that all vehicle grounding materials (for example, static brushes) are secure and functioning properly.
7. Make sure that all vehicle hardware, especially the hardware securing the magnet array, is secure.
8. Make sure that the Vehicle Gap (distance between the magnet array on the vehicle and the motor) is within tolerance for all vehicles on all motors.
9. Return the QS 100 transport system to normal operation.

Cleaning Magnet Arrays

The magnet arrays attract ferrous particles from the air and surrounding surfaces. These particles accumulate and appear as small “hairs” on the surface of the array.

- Use adhesive tape to capture the ferrous particles on the magnet arrays.
- To combat accumulated debris, keep magnet arrays not being used in their original container.
- 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 contact-

ing the array. The mounting must secure the array with a suitable form of gasketing to 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.

Transfer Log Files

Review the log files for each node controller and the HLC periodically to look for unexpected messages.

Log files can be transferred from the node controller or SysLog server to a CD or external USB device so they can be archived or e-mailed to ICT Customer Support, see the *Node Controller Interface User Manual*.

Troubleshooting

This section describes the common difficulties that are encountered with the QuickStick 100 transport system and software components.

For assistance, see *Contact ICT Customer Support* on page 194.

Initial Troubleshooting

This section covers the initial determination of the problem area within the QuickStick 100 transport system and provides direction to the second step of the troubleshooting process. If a specific problem is suspected, see that problem in Table 7-2. If the problem has not been identified, review each of the symptoms that are identified in Table 7-2 to help determine the problem area.

Table 7-2: Initial Troubleshooting

Symptom	Possible Problem Area
Power lights do not turn on.	See *Power-Related Troubleshooting* on page 187
Motors report power-related faults.	
Vehicles do not seem to move as fast as when the QS 100 transport system was initially installed.	See *Power-Related Troubleshooting* on page 187
	See *Motion Control Troubleshooting* on page 192
Node controller logs do not indicate correct time.	See *Node Controller Troubleshooting* on page 190
QS 100 transport system does not respond to the host controller.	See *Communication Troubleshooting* on page 191
	See *Motion Control Troubleshooting* on page 192
Vehicles producing excessive noise.	See *Motion Control Troubleshooting* on page 192
The light stack does not function as expected.	See *Light Stack Troubleshooting* on page 193

Power-Related Troubleshooting

This section covers the determination of power-related problems within the QuickStick 100 transport system.

Table 7-3: Power-Related Troubleshooting

Symptom	Problem Description	Corrective Action
Lights on power supplies do not turn on.	No power or incorrect power being supplied.	Verify that the cable from the facility power is fully seated and secured.
		Verify that the facility power to the QS 100 transport system is the correct power rating.
	Power supply main fuses are blown.	Replace fuses and determine the cause to minimize the chance of recurrence.
Motors do not move the vehicles at full speed.	Power supply is not providing full power.	Verify that the power supply air filter is not dirty. Clean or replace if necessary.
		Verify that power supply vents are not obstructed.
	Transport system motion control issues.	Review *Motion Control Troubleshooting* on page 192.
One or more motors do not operate.	Power or communication to the affected motors is lost or intermittent.	Verify that the cables to the affected motor are fully seated and secured.
	Power supply is not providing full power.	Verify that the power supply for the affected motor is operating properly.
		Verify the output voltage from the power supply.
		Verify that the power supply fuses are not blown. Replace if necessary and determine the cause to help prevent recurrence.

Table 7-3: Power-Related Troubleshooting (Continued)

Symptom	Problem Description	Corrective Action
Motor reports ‘Not in operational mode’.	All motors currently enter this state for 100 ms, and then automatically exit. This state allows sampled A/D inputs and observers settle before using this data. There is no lockout of behavior that is based on this fault, this fault is informational only.	Wait 100 ms after reset or power on before sending any commands to the motor.
After power cycling the +48V DC propulsion power line multiple times, the motor does not clear the under-voltage fault.	The PTC used to limit inrush current eventually heats up enough that it goes to a high-resistance state. This state does not allow the motor controller to power up enough to clear the under-voltage fault.	Turn off the +48V DC power supply for a few minutes to allow the PTC to cool down sufficiently to allow proper resumption of operation upon reapplication of the power source. Make sure that there is a minimum of 30 seconds between turn on cycles and 10 seconds between turn off and turn on (power cycle). Additionally, monitor the Soft Start bit to make sure it is off before turning the propulsion power back on.
The motor reports an under-voltage fault.	Power being supplied to the motor is below +41V DC. See *Under-voltage Fault* on page 165.	Verify the voltage output from the power supply.
		Verify the voltage at the motor.
		Verify that all power wiring is sufficient to carry all loads and deliver the proper power to the motors.
		Reduce power cable resistance between motors that share a common +48V DC power supply.
		The fault clears once the power bus rises above +43V DC.
The motor reports a Soft Start not complete fault.	The internal power bus for the motor is below +41V DC.	The fault clears once the power bus rises above +43V DC.

Table 7-3: Power-Related Troubleshooting (Continued)

Symptom	Problem Description	Corrective Action
The motor reports an over-voltage fault.	Power being supplied to the motor is above +59V DC. See *Over-voltage Fault* on page 166.	The fault clears once the power bus drops below +57V DC.
		Verify the voltage output from the power supply.
		Verify the voltage at the motor.
		Reduce power cable resistance between motors that share a common +48V DC power supply.
		Reduce maximum speed and/or maximum acceleration to reduce the amount of regenerated power that flows back into the system.
		Increase the spacing between vehicles on motors that share a common +48V DC power supply.
		Connect more motors to a common +48V DC power supply to increase the number of blocks available to absorb regenerated power.

Node Controller Troubleshooting

This section covers the determination of problems within the node controllers.

Table 7-4: Node Controller Related Troubleshooting

Symptom	Problem Description	Corrective Action
Node controller logs do not indicate the correct time.	The battery for the clock in the node controller has lost its charge.	Manually correct the time each time the node controller is powered up or return the node controller to MagneMotion for repair.
		Use the node controller web interface **Set Clock** function to set the time (see the *Node Controller Interface User Manual*).

Communication Troubleshooting

This section covers the determination of communication-related problems within the QuickStick 100 transport system.

Table 7-5: Communication-Related Troubleshooting

Symptom	Problem Description	Corrective Action
QS 100 motors are powered but there is no response to the host controller.	Communication to the affected motors is lost or intermittent.	Verify that all communication cables are fully seated and secure.
		Check for proper connection and continuity of all connections.
		Check communication to the host controller.
		Make sure that logic power is enabled.
	Host controller application issue.	Verify that the host controller is correctly configured.
		Verify that the host application software is correctly written.
Intermittent Communication with the host controller.	Communication is lost or intermittent.	Make sure that all network cables are properly seated.
QS 100 motors respond to the host controller but the motors do not operate.	Power to the affected motors is lost or intermittent.	Make sure that power cables to all motors are properly seated.
		Make sure that propulsion power is enabled.
	E-stop or interlock circuit is activated.	Make sure that any E-stops or interlocks that are configured for the paths where the motors are located are in the operate state.

Motion Control Troubleshooting

This section covers the determination of motion-related problems within the QuickStick 100 transport system.

Table 7-6: Motion Control Related Troubleshooting

Symptom	Problem Description	Corrective Action
Material slips while the vehicles are in motion.	Vehicle is not designed to carry that specific material.	Make sure that the vehicle design is correct.
	Vehicle is not holding the material securely.	Make sure that all material contact surfaces are clean.
	Motion configuration issue.	Make sure that the vehicle acceleration is correct.
		Make sure that the vehicle speed is correct.
		Make sure that the PID values are correct.
Vehicles do not move smoothly or movement is noisy.	Debris on the guideway.	Make sure that the guideways and motors are clean.
	Misalignment of sections of the guideway.	Make sure that the joints between guideway sections are properly secured and co-planar.
	Power or communication to the affected motors is lost or intermittent.	Make sure that the power and communication cables to all motors are properly seated.
	Motion configuration issue.	Make sure that the PID values are correct.
	Excessive noise when the vehicle moves from section to section of the guideway.	Make sure that the motors are properly mounted and the transition from one section of guideway to the next is smooth (sections must be at the same height).
Vehicles are loosing thrust.	Misalignment or wear of sections of the guideway.	Make sure that the Vehicle Gap is consistent at all locations on the guideway.
		Make sure that the vehicle and/or track wear is within tolerance.
	Thrust is lost when the vehicle moves from motor to motor.	Make sure that the Downstream Gap does not exceed 10% of the magnet array length.

Light Stack Troubleshooting

This section covers the determination of light stack-related problems within the QuickStick 100 transport system.

Table 7-7: Light Stack Related Troubleshooting

Symptom	Problem Description	Corrective Action
Lights do not turn on.	Power to the light stack is lost or intermittent.	Make sure that all wiring to the light stack is properly seated.
		Verify voltage output from the power supply.
	Light stack is not wired properly.	Make sure that all connections to the light stack are properly wired (see *Light Stacks* on page 172).
		Make sure that the bits specified in the Node Controller Configuration File are the bits connected to the light stack.
	Light stack is not configured properly.	Make sure that the light stack is configured to monitor the appropriate paths and/or nodes.
Yellow light does not turn off.	Light indicates one or more faults.	Review the log file to determine the fault (see the *Node Controller Interface User Manual*).
Red light does not turn off.	Light indicates that vehicles are stopped.	Send a move vehicle command to any vehicle on the paths or nodes that the light stack monitors.
	Light indicates that vehicles are stopped even though there is motion.	Verify that the light stack is properly wired.

Contact ICT Customer Support

To help you receive the most value from the Rockwell Automation Independent Cart Technology (ICT) Support Specialists, have the following information ready before contacting ICT Customer Support.

1. Download and save the node controller and HLC logs.
2. Record the serial numbers from the motors and node controllers.
3. Provide the location of the QuickStick 100 transport system.
4. Provide the name of the person to contact, email address, and telephone number.
5. List any error codes that are received during the failure.
6. Prepare a detailed description of the events before the error.
   - How long has the equipment been in operation?
   - Was any work done on the equipment before the error?
   - What command was the equipment performing when the error occurred?
   - List all actions that were taken after the error occurred. What were the results of those actions?
   - Is there any other information that can assist our Specialist?
7. Contact ICT Customer Support:

Main Office

MagneMotion, Inc.
A Rockwell Automation Company
139 Barnum Road
Devens, MA 01434
USA
Phone: +1 978-757-9100
Fax: +1 978-757-9200

Customer Support

+1 978-757-9102
ICTSupport@ra.rockwell.com

Repair

If a component of the QuickStick 100 transport system malfunctions, see *Troubleshooting* on page 186 in this manual for diagnostic procedures. If these procedures are not adequate to determine the source of the problem, see *Contact ICT Customer Support* on page 194. Once the failed unit has been identified, a replacement unit can be ordered and installed as directed in *Installation* on page 117.

NOTE: The components of the QuickStick 100 transport system are designed for easy replacement. Motors, controllers, and other modules do not contain any user serviceable parts.

NOTICE

Only a qualified service representative can service the components of the QuickStick 100 transport system. Any attempt to open the transport system modules by anyone other than a qualified MagneMotion service representative voids the warranty.

Table 7-8: QuickStick 100 Transport System Repair Procedures

Component	Maintenance Action	Page #
QS 100 Transport System	*Replacing Motors*	196
	Programming Motors	198
	Separating Magnet Arrays	199

Replacing Motors

The QuickStick 100 motors can typically be replaced easily depending upon the location and mounting method for the motor.

Required Tools and Equipment

- Torque wrench.
- Computer with an Ethernet port and a web browser.

Remove the Existing Motor

1. Complete all material transfers (move all material to the appropriate locations) on the section of the QS 100 transport system where the motor is being replaced.

2. Command all vehicles to positions off the path where the motor is being replaced.

3. Issue a Suspend Motion command for the path where the motor is being replaced.

   All vehicles come to a controlled stop.

4. Once all motion has stopped, issue a Reset command for the path where the motor is being replaced.

   The HLC clears all vehicle records.

5. Turn off all power to the section of the QS 100 transport system where the motor is being replaced.

6. Label the power and communication connections to the motor.

7. Disconnect all connections.

8. Remove the M8 bolts that secure the motor to the motor mounts.

9. Remove the motor from the transport system.

⚠ CAUTION

Heavy Lift Hazard

The QuickStick 100 motors can weigh as much as 13.2 kg [29.1 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 QuickStick 100 components.

10. Store the motor in a secure location.

11. See *Shipping* on page 201 to return the motor to MagneMotion.

Install the New Motor

1. See *Mounting the Motors* on page 124 for detailed installation instructions.

2. Reconnect the power and communication connections to the motor (refer to the labels previously placed on the cables).

3. Restore power to the section of the QS 100 transport system where the motor was replaced.

4. Program the masters and slaves on the new motor with the current Motor image files (see *Programming Motors* on page 198).

5. Resume motion on the section of the QS 100 transport system where the motor was replaced.

Programming Motors

When a new QuickStick 100 motor is installed, either as part of a new system installation or as a replacement for an existing motor it must be programmed with the appropriate Motor ERF Image file (*motor_image*.erf).

NOTE: QuickStick 100 motors are shipped from the factory with just a basic motor software image installed. They must be programmed with the software that is supplied with the motors before use.

Required Tools and Equipment

- Computer with an Ethernet port and a web browser.
- Motor ERF Image files.

Procedure

1. Upload the Motor ERF Image files (*motor_image*.erf) to each node controller by using the node controller web interface and program the motor masters and slaves. See the *Node Controller Interface User Manual* for details.

   NOTE: Restart the node controller for the changes to take effect.

2. Reset the paths where the motors were programmed (for example, use the NCHost TCP Interface Utility, see the *NCHost TCP Interface Utility User Manual* for details).

Separating Magnet Arrays

Magnet arrays can become stuck to each other or to any ferrous materials through improper handling. It is the responsibility of the user to define and implement their own separation procedures. It can be impossible to separate large magnet arrays.

WARNING

Strong Magnets

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 QuickStick 100 motors, ferrous material, or another magnet array.
- Magnet arrays or vehicles not being used must be secured individually in isolated packaging.

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.

- Magnet arrays that become stuck to each other should only be separated by trained personnel. Returning stuck magnet arrays to MagneMotion for separation is recommended.
- Magnet arrays stuck to a surface can be removed by sliding the array to the edge of the surface it is stuck to. Then move the array so it is only in minimal contact with the edge and then lift the array away from the edge starting at one end of the array.

Ordering Parts

If new or replacement parts are needed, contact MagneMotion Sales:

Main Office

MagneMotion, Inc.
A Rockwell Automation Company
139 Barnum Road
Devens, MA 01434
USA
Phone: +1 978-757-9100
Fax: +1 978-757-9200

Sales

+1 978-757-9101
ICT-InsideSales@ra.rockwell.com

Shipping

If a QuickStick 100 component must be shipped, either for return to MagneMotion 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 100 components for shipment.

⚠ CAUTION

Electrical Hazard

Before beginning this procedure, the QuickStick 100 transport system must be shut down following the procedure that is provided in *Safe Shut-down* on page 180.

⚠ CAUTION

Heavy Lift Hazard

The QuickStick 100 motors can weigh as much as 13.2 kg [29.1 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 QuickStick 100 components.

Required Tools and Equipment

- Metric hex wrenches.
- English hex wrenches.
- Open-end wrench, adjustable.
- Fork truck or appropriate lift as required.

Packing Procedure

When any of the QuickStick 100 components are shipped, either for return to MagneMotion for service or to another location, they must be properly packaged to make sure that they arrive undamaged. The following procedure provides the correct method of handling and packaging the QuickStick 100 components for shipment.

NOTE: The original shipping packaging must be used when shipping QuickStick 100 components. If the original packaging has become lost or damaged, contact MagneMotion for replacements.

⚠ WARNING

Strong Magnets

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 QuickStick 100 motors, ferrous material, or another magnet array.
- Magnet arrays or vehicles not being used must be secured individually in isolated packaging.

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.

⚠ CAUTION

Heavy Lift Hazard

The QuickStick 100 motors can weigh as much as 13.2 kg [29.1 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 QuickStick 100 components.

1. Turn off and disconnect all power and communication connections as detailed in *Safe Shut-down* on page 180.

2. Make sure that the component has been properly decontaminated following the decontamination procedures for the facility. Follow all facility, local, and national procedures for the disposal of any hazardous materials.

3. When shipping individual components, remove all components to be shipped (see *Transport System Installation* on page 121 and reverse the sequence to remove the components) and see *Shipping Components* on page 203.

Shipping Components

1. Each component must be wrapped, bagged, and packed following standard packing procedures.

2. Use the container that the component was originally shipped in and set the component into the container and secure using the supplied packing material.

3. Close the shipping container and secure.

4. Make sure that the container is properly labeled (This End Up, Caution – Heavy, and so on) and all shipping documents are attached to the outside of the container.

⚠ CAUTION

Magnetic Field Hazard

When shipping magnet arrays, make sure that the shipping container properly isolates the magnet arrays or identifies the Magnetic Field Hazard.

5. When shipping to MagneMotion, make sure that the RMA number is clearly visible on the outside of the container.

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Appendix

Overview

The following appendices are included to provide the user with one location for additional information that is related to the QuickStick® 100 transport system.

Included in this appendix are:

- Data for QuickStick 100 transport system design calculations.
- File maintenance.
- Additional documentation.
- Transport system configuration limits.

Data for Transport System Design Calculations

The tables and curves (charts) in this appendix provide data to help in determining the optimal QuickStick 100 thrust force, Vehicle Gap, or magnet array size for a QuickStick 100 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 MagneMotion for precise values.

See *Determining Thrust Force* on page 211 for more information about using thrust and attractive forces calculations.

See *Magnet Arrays* on page 73 for magnet array type and size information.

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 *Determining Thrust Force* on page 211 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 Vehicle Gap increases, the magnetic attractive force decreases. See Table A-1, *Thrust Force Data, Standard Magnet Array*, on page 207 for more information.
- **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.

Thrust Force Data

The data that is provided in Table A-1 shows the available thrust for QS 100 motors at 4 Amps stator current with a standard (potted or covered) magnet array. This data is graphed in Figure A-1, which shows how the available thrust increases with an increase in the number of magnet array cycles. The chart also shows that as the Vehicle Gap increases, the available thrust decreases.

Table A-1: Thrust Force Data, Standard Magnet Array

Maximum Thrust (N) at 4 Amps Stator Current					
Magnet Array Length (Cycles)	**QS 100 Vehicle Gap (mm)**				
	1	**3**[*]	**5**	**7**	**9**
3	66	48	35	25	19
4	88	64	47	34	25
5	109	80	58	42	31
6	131	96	70	51	37
7	153	112	81	59	43
8	175	128	93	68	49
9	197	144	105	76	56
10	219	160	116	85	62
11	241	175	128	93	68
12	263	191	140	102	74
13	284	207	151	110	80
14	306	223	163	119	87
15	328	239	174	127	93
16	350	255	186	136	99
17	372	271	198	144	105
18	394	287	209	153	111
19	416	303	221	161	117
20	438	319	233	170	124

[*] Recommended nominal Vehicle Gap.

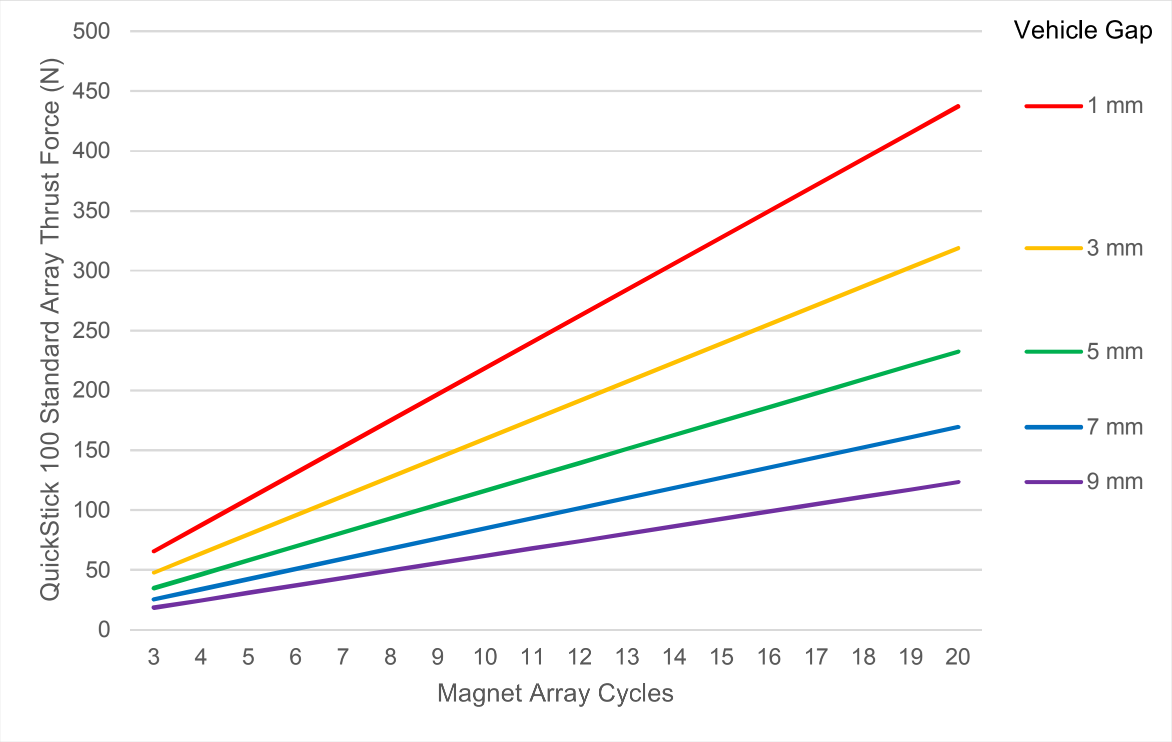

Figure A-1: Thrust Force vs. Magnet Array Cycles, Standard Magnet Array

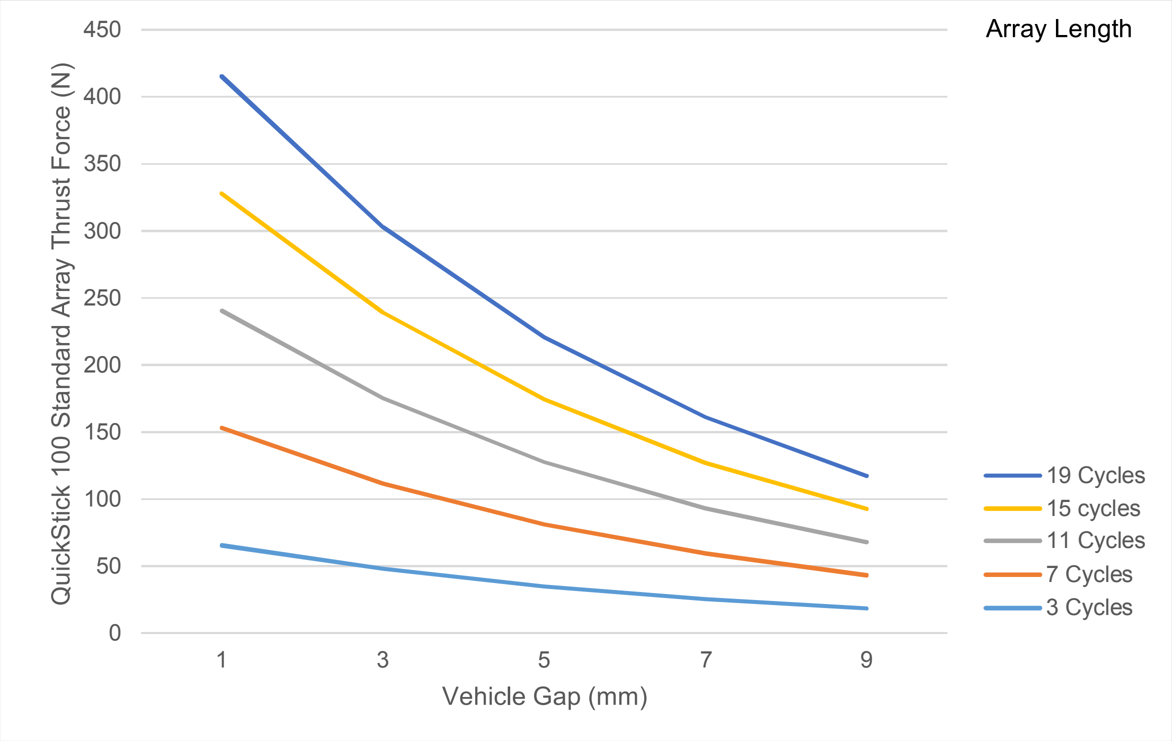

Figure A-2: Thrust Force vs. Vehicle Gap, Standard Magnet Array

Attractive Force Data

See *Determining Thrust Force* on page 211 for more information about calculating attractive force. The data that is provided in Table A-2 shows the attractive force between the QS 100 motors and a standard (potted or covered) magnet array. This data is graphed in Figure A-3, which shows how the attractive force increases with an increase in the number of magnet array cycles.

Table A-2: Attractive Force Data, Standard Magnet Array

Magnet Array Length (Cycles)	**QS 100 Vehicle Gap (mm)**				
	1	**3**[*]	**5**	**7**	**9**
3	322	176	97	53	29
4	429	235	129	71	39
5	536	294	161	89	49
6	643	353	194	106	58
7	750	412	226	124	68
8	858	471	258	142	78
9	965	529	291	159	88
10	1072	588	323	177	97
11	1179	647	355	195	107
12	1286	706	387	213	117
13	1394	765	420	230	126
14	1501	824	452	248	136
15	1608	882	484	266	146
16	1715	941	517	284	156
17	1822	1000	549	301	165
18	1930	1059	581	319	175
19	2037	1118	613	337	185
20	2144	1177	646	354	194

[*] Recommended nominal Vehicle Gap.

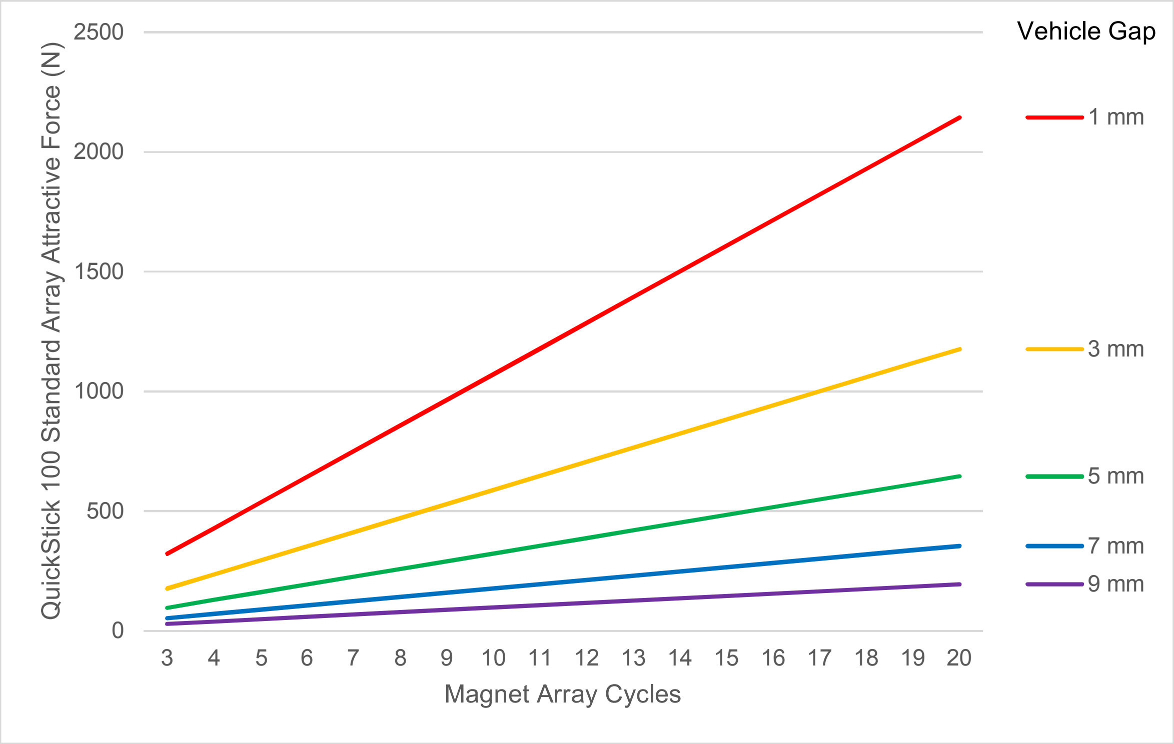

Figure A-3: Attractive Force Data Curves, Standard Magnet Array

Determining Thrust Force

The thrust obtainable from a QuickStick 100 motor is dependent on several operational parameters, including the length of 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. Thus the obtainable thrust can be impacted by ambient temperature or the duty cycle of the drive current.

Laboratory measurements of the thrust that is obtained with a QuickStick 100 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 A-1).
- 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 A-2).

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

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

$$\mathit{Thrust}\ (\mathrm{Lb}) = ((((-0.043 * I_{stator}^{2}) + (6.579 * I_{stator})) * \mathrm{EXP}^{(-0.158 * \mathit{PhysGap})}) * \mathit{NumCycles}) / 4.4482$$

Where:

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

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. This will be from 1 mm to 9 mm.

Thrust – The thrust force that is produced.

---

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

Determining Attractive Force

In addition to the thrust force produced by the QuickStick 100 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 magnet array engaged by the stators, and decreases roughly in an exponential fashion as the gap is increased (see Figure A-3). The hold-down force is nearly independent of stator current, and thus has the same value whether or not the stator is powered.

Laboratory measurements of the hold-down force that is obtained with a QuickStick 100 motor at various operational parameter values were used to derive a model that describes the hold-down force produced.

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

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

$$HDForce\ (\mathrm{Lb}) = ((144.7 * \mathrm{EXP}^{(-0.3\ *\ PhysGap)}) * NumCycles) / 4.4482$$

Where:

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

PhysGap[†] – The distance from the top of the stator to the bottom of the magnet array, in mm. This will be from 1 mm to 9 mm.

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

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

File Maintenance

Backup Files

Making regular backups of all files that have been changed is recommended. Keep copies of all original and backup files at a remote location for safety.

Creating Backup Files

Backup files are not created automatically. It is the responsibility of the user to create backups of all files by copying them to a safe location.

Restoring from Backup Files

Damaged files can be restored by copying the backup files into the appropriate locations.

Additional Documentation

Release Notes

The Release Notes that are supplied with MagneMotion software include special instructions, identification of software versions, identification of new features and enhancements, and a list of known issues. Reading this file is recommended before using the software.

Upgrade Procedure

The Upgrade Procedures that are supplied with MagneMotion software provide instructions for upgrading from one version of MagneMotion software to another. They also include the procedures for file and driver upgrades that are associated with the software.

Transport System Limits

Table A-3: MagneMotion Transport System Limits

	Path	Node Controller	System (HLC)
Motors	20/RS-422 30/Ethernet	–[†]	3,840
Node Controllers	–	–	96
Nodes	2	–[†]	256
Paths	–	–[†]	128
Stations	–	–	2048
Vehicles	50/RS-422[*] 300/Ethernet	384	5,120[‡]

[*] When using RS-422 communications with the motors, 50 vehicles maximum per path when all vehicles on the path are commanded forward (downstream).
45 vehicles maximum per path when all vehicles on the path are commanded backwards.

[†] When using RS-422 communications with the motors, limited by the number of RS-422 connections on the node controller (NC LITE up to 4 connections, NC-12 up to 12 connections).
When using Ethernet communications with the motors, limited by the node controller configuration and processor loading (NC-E up to 36 nodes, NC-12 up to 16 nodes, NC LITE up to 5 nodes), see the *Node Controller Hardware User Manual*).

[‡] 6,000 vehicles maximum when using HLC Control Groups.

Table A-4: MagneMotion Transport System Motion Limits[*]

	Acceleration	Velocity	Thrust
MagneMover® LITE	2.0 m/s^2 [0.2 *g*]	2.0 m/s [4.5 mph]	10.0 N/cycle[†]
QuickStick® 100	9.8 m/s^2 [1.0 *g*]	2.5 m/s [5.6 mph]	16.3 N/cycle[‡]
QuickStick® HT	60.0 m/s^2 [6.1 *g*]	3.5 m/s [7.8 mph]	182.0 N/cycle[§]

[*] The limits that are shown are at the typical payloads (contact ICT Customer Support for payload guidance). Use of a smaller payload may permit higher limits. Use of a larger payload may lower the limits.

[†] Thrust at 25% duty cycle, nominal Vehicle Gap is 1 mm for G3 and 1.5 mm for G4.2.

[‡] Thrust at 4.0 A stator current with a nominal Vehicle Gap of 3 mm with a standard magnet array.

[§] Thrust at 10.9 A stator current with a nominal Vehicle Gap of 12 mm with a high flux magnet array.

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Glossary

Block: See *Motor Block*.

Bogie: A structure underneath a vehicle to which a magnet array is attached. The structure is then attached to the vehicle. For vehicles that travel over curves, the attachment is through a bearing that allows independent rotation.

Brick-wall Headway: The space that is maintained between vehicles to make sure that a trailing vehicle is able to stop safely if the lead vehicle stops suddenly (‘hits a brick wall’).

Byte: An octet of data (8 bits).

Clearance Distance: The distance from a node where the trailing edge of a vehicle is considered cleared from a node.

Component: The main parts that form a MagneMotion® transport system. Also called system components, these include *Motors* and *Node Controllers*.

Configuration File: See *Node Controller Configuration File*.

Configurator: The application that is used to define and edit the basic operating parameters of the transport system that is stored in the *Node Controller Configuration File*.

Controller: A device that monitors and controls the operating conditions of the equipment being monitored. In a MagneMotion transport system, the types of controllers include the *High-Level Controller*, *Node Controller*, and *Host Controller*.

Cycle Length: Cycle Length is the distance between the centerlines of two like poles on the magnet array.

Demo Script: A text file that is used with the NCHost TCP Interface Utility for test or demonstration purposes to move vehicles on the transport system.

Design Specifications: The unique parameters for a specific MagneMotion transport system.

Downstream: The end of a motor or path as defined by the logical forward direction. Vehicles typically enter the motor or path on the *Upstream* end.

Downstream Gap: The physical distance from the end of the stator in one motor to the beginning of the stator in the next motor downstream on the same path. This distance includes the *Motor Gap*.

E-stop: See *Emergency Stop*.

Emergency Off: A user-supplied device that disconnects AC power to the transport system.

Emergency Stop:	A user-supplied circuit with a locking button that anyone can press to stop motion in the transport system. It can be wired through the digital I/O on the NC-12 *Node Controller*.
EMO:	See *Emergency Off*.
Entry Gate:	The position on a path associated with a node where the leading edge of a vehicle is considered cleared from the node.
Entry Path:	A path whose downstream end is a member of a node. A vehicle that is moving downstream enters a node on an Entry Path.
Ethernet Chain:	Ethernet chains allow devices to be connected in series with standard Ethernet cable, without the need for additional network switches. A daisy chain device has two embedded Ethernet ports that function as an Ethernet switch and an interface to the local device. This embedded switch allows information to flow to the device, or flow through the ports to other devices in the chain.
Exit Path:	A path whose upstream end is a member of a node. A vehicle that is moving downstream exits a node on an Exit Path.
Forward Direction:	The default direction of motion, from *Upstream* to *Downstream*, on a MagneMotion transport system.
Glide Puck:	A preconfigured vehicle for use on MagneMover® LITE transport systems that uses low friction skids to slide on the integral rails.
Global Directives:	The *Demo Script* commands that define the general operating characteristics for all vehicles specified. See also *Vehicle Directives*.
Ground:	The reference point in an electrical circuit from which voltages are measured. This point is typically a common return path for electric current. See also *PE*.
Guideway:	A component of the *Track System* that consists of rails or other devices in contact with the *Vehicle*, either through wheels or low friction runners on the vehicle. The guideway maintains the proper relationship between the vehicles and the motors. In the MagneMover LITE transport system, the guideway is the integral rails that are mounted on the motors.
Headway:	The space that is maintained before a vehicle to make sure that the vehicle is able to stop safely. See *Brick-wall Headway*.
Hall Effect Sensor:	A transducer that varies its output in response to changes in a magnetic field. Hall Effect Sensors (HES) are used by MagneMotion LSMs for vehicle positioning and speed detection.
High-Level Controller:	The application in a node controller that communicates with the host controller. Only one node controller per HLC Control Group runs the high-level controller application. In a transport system with only one node controller, it runs both the node controller and high-level controller applications.
HLC:	See *High-Level Controller*.
HLC Control Group:	The portion of a multi-HLC LSM transport system under control of a specific HLC.

Host Application: The software on the host controller that provides monitoring and control of the transport system.

Host Controller: The user-supplied controller for the operation of the transport system. The controller can be either a *PC-Based Controller* or a *Programmable Logic Controller*.

Host Control Session: A session between a host controller application (such as the NCHost TCP Interface Utility) and an HLC that allows control of all aspects of transport system operation. The Host Control Session also allows active monitoring of transport system status.

Host Status Session: A session between a host controller application (such as the NCHost TCP Interface Utility) and an HLC that only provides active monitoring of transport system status.

ICT: See *Independent Cart Technology*.

ID: The software labels used to identify various components of the transport system to make sure proper execution of commands involving vehicle position, vehicle destination, and transport system configuration. ID types include vehicle and path.

Independent Cart Technology: A programmable intelligent conveyor system that uses linear synchronous motors for moving multiple independently controlled vehicles.

Interlock: A user-supplied circuit that is used to stop motion in the transport system. It is wired through the digital I/O on the NC-12 *Node Controller*.

Inverter: Hardware that converts DC from the propulsion power bus to AC to energize the coils in a *Motor Block*.

Keep-out Area: A unidirectional area of a *Path*. A vehicle that is moving in the specified direction of the area is not allowed to enter the area unless it has permission from the motors to either move past or stop within the area. Once a vehicle enters the keep-out area in the specified direction, all other vehicles that are moving in the same direction must wait to enter the area until that vehicle exits.

Logic Power: The power that is used for the controllers and signals. See also, *Propulsion Power*.

LSB: Least Significant Byte.

LSM: Linear Synchronous Motor. See *MagneMover LITE* and *QuickStick*.

Master (also Master Controller): The supervisory controller for each motor, it communicates with the *Slaves* to direct *Motor Block* operation and read motor sensors, and it communicates vehicle positions and other information to the *Node Controller*. It is internal to the motor assembly on MagneMover LITE and QuickStick® 100 motors. For QuickStick HT motors the master is in the motor controller.

MagneMover LITE: A MagneMotion linear synchronous motor with integrated guideways and vehicles that enable quick, efficient conveyance of small loads.

MagneMover LITE System: A group of specific components that contribute to a *Transport System*. These components include *MagneMover LITE* motors, *Node Controllers*, *Pucks*, and other parts available from MagneMotion.

Magnet Array: The magnets that are attached to the *Vehicle*. It is the motor secondary, moved by the primary in the motor.

MM LITE™: See *MagneMover LITE*.

Motor: See *LSM*.

Motor Block: A discrete motor primary section (coil or set of coils) in a motor that can be energized independently. This section can contain only one vehicle during transport system operation.

Motor Controller: The assembly that contains the *Master* and the *Inverter* for QuickStick HT motors.

Motor Gap: The physical distance between two motors that are mounted end to end. This gap excludes the distance from the end of the stator to the end of the motor housing.

MSB: Most Significant Byte.

NC: See *Node Controller*.

Node: A junction that is defined as the beginning, end, or intersection of *Paths*. The different node types define their use: Simple, Relay, Terminus, Merge, Diverge, and so on.

Node Controller Configuration File: The XML file unique to the transport system that defines the basic operating parameters of the transport system. A copy of the Node Controller Configuration File is uploaded to each node controller in the transport system.

Node Controller: The application in a node controller that coordinates vehicle motions along a path or paths of motors. The node controller is responsible for the motors on all paths that begin at nodes that the node controller is responsible for.

There can be multiple node controllers in a transport system each responsible for a subset of the nodes within the transport system.

NRTL/ATL: Nationally Recognized Test Lab/Accredited Test Lab.

OSHA recognizes NRTL organizations in accordance with 29 CFR 1910.7 to test and certify equipment or materials (products).

Accreditation bodies evaluate ATL organizations to ISO/IEC 17025 for testing and calibration laboratories.

Path: A designation for one or more motors placed end to end, which defines a linear route for vehicle travel. A path begins at the *Upstream* end of the first motor in the series and ends at the *Downstream* end of the last motor in the series. All paths must begin at a *Node* and the beginning of a path is always the zero position for determining positions along that path.

PC-Based Controller: The user-supplied general-purpose computer that provides control and sequencing for the operation of the transport system.

PE: Protective Earth. A conductor that is provided for safety purposes (for example, against the risk of electric shock) and which also provides a conductive path to earth. See also, *Ground*.

Platooning: A set of vehicles that are moving in a convoy and being controlled together. This group of vehicles is allowed to maintain a distance between each other while in motion that is less than the *Brick-wall Headway*.

PLC: See *Programmable Logic Controller*.

Position: A specific location on a *Path*, which is measured from the beginning of that path, which is used as a vehicle destination. Position zero on any path is defined as the leading edge of the first LSM in the path.

A vehicle at a specific position has its midpoint over that location on the path.

Power Supply: The equipment that is used to convert facility AC power to the correct voltages for the transport system.

Programmable Logic Controller: The user-supplied dedicated controller consisting of Processor and I/O modules that provide control, sequencing, and safety interlock logic for the operation of the transport system.

Propulsion Power: The power that is used for vehicle motion. See also, *Logic Power*.

Protected Area: The area around a node that is defined by the entry gates and clearance distances. This area is used to make sure that vehicles do not collide with other vehicles in the node or with the mechanism that is related to the node.

Puck: A preconfigured vehicle for use on MagneMover LITE transport systems. The magnet array is mounted to the puck and interacts with the motors, which move each vehicle independently. See *Glide Puck* and *Wheeled Puck*. See also, *Vehicle*.

QS: See *QuickStick*.

QuickStick: A MagneMotion linear synchronous motor that enables quick, efficient conveyance of large loads on user-designed guideways and vehicles. QuickStick 100 (QS 100) motors move loads up to 100 kg [220 lb] per vehicle. QuickStick High Thrust (QSHT) motors move loads up to 4,500 kg [9,900 lb] per vehicle.

QuickStick System: A group of specific components that contribute to a *Transport System*. These components include *QuickStick* motors, *Node Controllers*, *Motor Controllers* (QSHT only), *Magnet Arrays*, and other parts available from MagneMotion.

Sensor Map: A snapshot of the signal state of vehicle magnet array sensors that are collected from all blocks of a motor.

Signal: Each motor contains sensors that detect the magnetic field from the magnet array. When the signal from the sensors is higher than a threshold, the signal bit for the associated sensor is set high, otherwise it is set low.

Single Vehicle Area: A unidirectional area of a *Path*. Only one vehicle that is moving in the specified direction of the area is allowed to enter the area at a time. Other vehicles on the path that are moving in the same direction as the initial vehicle in the SVA must wait to enter this area until the previous vehicle exits. This queueing allows one vehicle to move backward and forward along a portion of a path without interfering with any other vehicles.

Slave (also Slave Controller): The subordinate controllers for the motor, they communicate with the *Master* and operate the *Inverters* and position-sense hardware. They are internal to the motor assembly on MagneMover LITE and QuickStick 100 motors. For QuickStick HT motors the slaves are in the motor controller.

Station: A specific location on a *Path*, which is measured from the beginning of that path, and identified with a unique ID, used as a vehicle destination.

Stator: The stationary part of the motor over which the magnet array is moved.

Switch: The mechanical guide for positioning a vehicle through guideway sections that merge or diverge.

SYNC IT™: Provides direct control by a PLC of up to three sync-zones (motors) where the host controller generates the vehicle motion profile.

Sync Zone: An area where vehicle motion can be synchronized with other systems through direct control of the motor by the host controller.

System Component: See *Component*.

Tandem Vehicle: A vehicle that uses dual *Bogies* to provide enough thrust to carry larger loads.

Track System: The components that physically support and move vehicles. For a QuickStick transport system, the track includes a *Guideway*, one or more *QuickStick* motors, mounting hardware, and a stand system. For a MagneMover LITE transport system, the track includes the *MagneMover LITE* motors and stands.

Transport System: The components that collectively move user material. These components include the *Motors*, external *Motor Controllers* (QSHT only), *Track System*, *Node Controllers*, *Vehicles,* cables, and hardware.

Upstream: The beginning of a motor or path as defined by the logical forward direction. The upstream ends of all paths are connected to node controllers. Vehicles typically exit the motor or path on the *Downstream* end.

V-Brace: The mechanical fixture that is used to align and secure MagneMover LITE guide rail and motor sections.

Vehicle: The independently controlled moving element in a MagneMotion transport system. The vehicle consists of a platform that carries the payload and a passive magnet array to provide the necessary propulsion and position sensing. All vehicles on paths in the transport system that are connected through nodes must be the same length.

The transport system constantly monitors and controls vehicle position and velocity for the entire time the vehicle is on the transport system. All vehicles are assigned a unique ID at startup and retain that ID until the transport system is restarted or the vehicle is removed or deleted.

Vehicle Directives: The *Demo Script* commands that define the individual motion characteristics for a specific vehicle. See also *Global Directives*.

Vehicle Gap: The distance between the bottom of the magnet array that is attached to a vehicle and the top surface of a motor.

Vehicle ID Master Database: The HLC database for the assignment and tracking of Vehicle IDs in the transport system. When using *HLC Control Groups*, the Master HLC maintains this database.

Vehicle ID Slave Database: The Slave HLC database for tracking of Vehicle IDs in the HLC Control Group managed by that Slave HLC and assigned by the Master HLC. This database is only used when using *HLC Control Groups* to subdivide a transport system.

Vehicle Master: The motor controlling the vehicle.

Vehicle Signal: A motor software flag for each vehicle that is used to indicate if the vehicle is detected on the transport system.

Vehicle Spacing: The distance between two vehicles on the same path.

Wheeled Puck: A preconfigured vehicle for use on MagneMover LITE transport systems that uses low friction wheels to ride on the integral rails.

Zero Point: The position on the *Upstream* end of a *Path* that denotes the first part on which a *Vehicle* travels.

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Index

A

AC Power Requirement, QS 100 PS, 107
Attractive Force, 212

B

Backup, 213
Block Length, 64
Bogie, see *Dual Magnet Array*
Brick-wall Headway, 156

C

Cables
  AC power, 110
  design, 69
  Ethernet, 111
  motor power, 106
  power supply control, 110
  RS-422, 112
  Sync option, 114
Cleaning, 183
Communication Cables
  Ethernet, 111
  identification, 30
  installation, 128, 131
  RS-422, 112
  Sync option, 114
Computer Requirements, 33
Configuration File, *see* Node Controller Configuration File
Configurator, see *MagneMotion Configurator*
Connections
  communication, 129
  motor power, 132
  motor to motor, 127, 128
  network, 137
  network communications, 131
Connections (*Continued*)
  power, 138
  RS-422, 128, 129
Console Interface, description, 31
controller_image, see *Node Controller Software Image File*
Curve Track
  configuration, 92
  correction table, 68
Customer Support, 26, 194
Cycle Length, 73

D

DC Power Requirements
  motors, 103
  PoE, 131
Demo Script
  create, 34
  description, 32
  use for testing, 147
Demonstration Script, see *Demo Script*
Design
  guidelines, 62
  guideway, 84
  transport system, 56
  vehicles, 78, 82
Digital I/O
  Diverge Node, 140
  E-stop, 139
  interlock, 139
  light stack, 140
  Merge Node, 140
  operation, 172
  wiring, 131
Downstream
  connection, 113
  gap, 67

Dual Magnet Array
  alignment in curves, 79
  motor downstream gap, 67
  vehicle, 81

E

Equipment Safety, 39
E-stop
  connection, 139
  operation, 171
Ethernet Cable, 111
Ethernet TCP/IP
  connections, 137
  description, 111
EtherNet/IP
  configuration, 145
  connections, 137
  description, 112

F

FastStop, 172
Faults
  over-voltage, 166
  soft start, 165
  under-voltage, 165
Force
  calculate attractive force, 212
  calculate thrust, 211

G

Gap
  downstream, 67
  motor, 66
  vehicle, 80, 206
Gender Changer, 113, 129
Getting Started, 33
Grounding
  power supply, 110
  transport system, 71, 124, 126
  vehicles, 78
Guideway
  assembly, 124
  design, 62
  identification, 29
  installation, 124
  installation overview, 122
Guideway (*Continued*)
  level, 124
  materials, 85

H

Hazards
  electrical, 49
  locations on system, 40
  magnetic, 50
  mechanical, 47
High-Level Controller
  configure, 145
  identification, 30
  transport system layout, 60
Host Controller
  control connection, 111
  identification, 30
  status connection, 111
  transport system layout, 61
Humidity
  magnet array, 115
  motor, 115
  power supply, 115

I

Image Files
  motor, 32
  node controller, 32
Inspection
  cables, 184
  hardware, 184
Installation
  check-out, 143
  connections, 127
  electronics, 126
  leveling, 124
  magnet arrays, 134
  motor, 124
  network switches, 126
  node controllers, 126
  overview, 122
  power cables, 132
  software, 141
Interlock
  connection, 139
  operation, 171

Internet Protocol
  EtherNet/IP, 168
  TCP/IP, 168
IP Rating
  magnet array, 98, 100
  motor, 96, 97
  power supply, 102

J

Jam, vehicle, 157

L

Labels
  magnet arrays, 44, 45
  motors, 43
  power supply, 46
Light Stack
  connection, 140
  operation, 172
  troubleshooting, 193
Lighting, site, 115
Linear Synchronous Motor, 150
LSM, see *Linear Synchronous Motor*

M

MagneMotion
  contact, 26, 194
  ICT Customer Support, 194
  Sales, 200
MagneMotion Configurator, overview, 31
MagneMotion Information and Configuration Service File, see *MICS File*
Magnet Array
  calculating size, 206
  cycle length, 73
  description, 73
  dimensions, 98–100
  disposal, 53
  epoxy potted, 75, 98
  humidity, 115
  identification, 29, 30
  installation, 134
  IP rating, 98, 100
  labels, 44–45
  motor secondary, 150
  stainless steel covered, 76, 100
Magnet Array (*Continued*)
  temperature range, 115
Magnet Array Type File, description, 32
magnet_array_type.xml, see *Magnet Array Type File*
Maintenance
  cleaning, 183
  inspection, cables, 184
  inspection, hardware, 184
  log files, 185
  magnet arrays, 184
  transport system, 182
  wear surfaces, 183
Manual
  chapter descriptions, 24
  conventions, 22
  prerequisites, 21
  related documents, 25
  safety notices, 23
MICS File, 32
MICS.xml, see *MICS File*
MMConfigTool.exe, see *MagneMotion Configurator*
Motion
  order, 152
  profile, 152
Motor
  block, 154
  block acquisition, 154
  block length, 64
  block ownership, 155
  block release, 155
  communication connection, 129
  connections, 104
  dimensions, 1000 mm, 96
  dimensions, 500 mm, 97
  exclusion zones, 1000 mm, 96
  exclusion zones, 500 mm, 97
  gap, 66
  grounding, 71
  humidity, 115
  identification, 29
  installation, 124
  IP rating, 96, 97
  labels, 43
  mount design, 85
  mounting, 86, 124

Motor (*Continued*)
  power management, 161
  primary, 150
  programming, 198
  regenerated power, 161
  secondary, 150
  shipping, 201
  temperature range, 115
  theory of operation, 150
  thrust, 206
  transport system layout, 57
Motor ERF Image File, description, 32
Motor Mount
  design, 85
  identification, 29
  installation, 124
Motor Type File, description, 32
motor_image.erf, see *Motor Image File*
motor_type.xml, see *Motor Type File*
Moving Path, configuration, 94

N

NCHost TCP Interface Utility
  overview, 31
  using, 142, 198
NCHost.exe, see *NCHost TCP Interface Utility*
Network
  communication connections, 131
  identification, 30
  transport system layout, 61
Network Switch
  connections, 137
  mounting, 126
Node Controller
  connecting, 128
  identification, 30
  IP address, 33, 168
  NC LITE
    description, 60
    identification, 30
    RS-422 connections, 129
  NC-12
    description, 60
    identification, 30
    RS-422 connections, 129
  NC-E
    description, 60

Node Controller (*Continued*)
  NC-E (*Continued*)
    identification, 30
  overview, 168
  set IP Address, 145
  transport system layout, 60
  troubleshooting, 190
Node Controller Configuration File
  create, 33
  define, 56
  description, 32
  node controller port, 129
Node Controller Console Interface, see *Console Interface*
Node Controller Software Image File, description, 32
Node Controller Web Interface, see *Web Interface*
node_configuration.xml, *see* Node Controller Configuration File
Nodes
  connections, 128
  descriptions, 59
  transport system layout, 59
Notes, 23

O

Obstruction, vehicle, 157
Operation
  monitoring, 169
  shut down, 180
  start up, 179, 182

P

Paths
  connections, 129
  transport system layout, 58
Personnel Safety, 38
Power Cables
  AC power, 110
  connection, 138
  identification, 30
  installation, 132
  motor power, 106
Power over Ethernet Wiring Diagram, 137
Power Requirements QS 100 Motors, 103

Power Supply
    connections, 108
    dimensions, 102
    exclusion zones, 102
    humidity, 115
    identification, 30
    IP rating, 102
    labels, 46
    power, 107
    temperature range, 115
    transport system layout, 61

Q

QS 100 System
    benefits, 151
    components, 30
    description, 28
    design, 56
    installation, 121, 124
    magnet array size, 206
    service access, 116
    site lighting, 115
    software, 31
    start up, 179
    vehicle gap, 206
QuickStick 100, see *QS 100*

R

Recycling, 53
Regulatory Guidelines, 37
Repair, 195
Replacement, 195
Restricted Parameters File, 32
restricted_parameters.xml, see *Restricted Parameters File*
Roller, see *Wheel*
RS-422
    cable, 112
    connections, 128, 129
    wiring motors, 127
    wiring switches, 128

S

Safe Stopping Distance, 156
Safety
    alert types, 23
Safety (*Continued*)
    equipment, 39
    hazardous points, 40
    personnel, 38
    symbols, 41
Scope, see *Virtual Scope Utility*
Shipping, 201
Shut Down, 180
Simulation
    configure, 173
    run, 175
    stop, 177
Single Magnet Array
    alignment in curves, 79
    motor downstream gap, 67
    vehicle, 80
Software
    configuration, 141
    installation, motors, 142
    installation, node controller, 142
    programming motors, 198
    types, 31
Start Up, 179
Stations, location restrictions, 67
Straight Track, configuration, 91
Switch
    configuration, 93
    transport system layout, 57
SYNC IT Controller, 170
Synchronization Option
    connection, 114
    connection location, 104
    operation, 170
System Configurator, see *MagneMotion Configurator*

T

Tandem Vehicle, see *Dual Magnet Array*
Temperature Range
    magnet array, 115
    motor, 115
    power supply, 115
Text Files
    Demo Script, 32
    Track File, 32
Thrust Force, 211

Tools
  installation, 121
  packing, 201
  unpacking, 119
Track
  curve, 92
  design, 62
  identification, 29
  moving path, 94
  straight, 91
  switch, 93
Track File, overview, 32
track_file.mmtrk, see *Track File*
Transport System Layout
  high-level controller, 60
  host controller, 61
  motors, 57
  network, 61
  node controllers, 60
  nodes, 59
  paths, 58
  power supplies, 61
  switches, 57
Transport System, see *QS 100 System*
Troubleshooting
  communication, 191
  initial, 186
  light stack, 193
  motion, 192
  node controller, 190
  power, 187
Type Files
  magnet array, 32
  motor, 32

U

Unpacking, 119
Upstream, 113

V

Vehicle
  anti-collision, 155
  configuration, dual array, 81
  configuration, single array, 81
  design, 78, 82
  detected, 158

Vehicle (*Continued*)
  dual magnet array, 81
  gap, 80, 206
  identification, 29
  installation, 136
  jammed, 157
  locating during startup, 158
  materials, 82
  obstructed, 157
  simulated, 174
  single magnet array, 80
Virtual Scope Utility, description, 32

W

Warnings
  over-voltage, 166
  under-voltage, 165
Web Interface
  description, 31
  file upload, 142
  program motors, 142
  using, 198
Wheel Materials, 83
Wiring
  motor power, 132
  network communications, 131
  power, 69
  signal, 70
  transport system layout, 61

X

XML Files
  Magnet Array Type file, 32
  MICS file, 32
  Motor Type file, 32
  Node Controller Configuration File, 32
  Restricted Parameters file, 32

Notes:

Rockwell Automation Support

Use the following resources to access support information.

Technical Support Center	Knowledgebase Articles, How-to Videos, FAQs, Chat, User Forums, and Product Notification Updates.	https://rockwellautomation.custhelp.com/
Local Technical Support Phone Numbers	Locate the phone number for your country.	http://www.rockwellautomation.com/global/support/get-support-now.page
Direct Dial Codes	Find the Direct Dial Code for your product. Use the code to route your call directly to a technical support engineer.	http://www.rockwellautomation.com/global/support/direct-dial.page
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Rockwell Otomasyon Ticaret A.Ş., Kar Plaza İş Merkezi E Blok Kat:6 34752 İçerenköy, İstanbul, Tel: +90 (216) 5698400

www.rockwellautomation.com

Power, Control and Information Solutions Headquarters

Americas: Rockwell Automation, 1201 South Second Street, Milwaukee, WI 53204-2496 USA, Tel: (1) 414.382.2000, Fax: (1) 414.382.4444
Europe/Middle East/Africa: Rockwell Automation NV, Pegasus Park, De Kleetlaan 12a, 1831 Diegem, Belgium, Tel: (32) 2 663 0600, Fax: (32) 2 663 0640
Asia Pacific: Rockwell Automation, Level 14, Core F, Cyberport 3, 100 Cyberport Road, Hong Kong, Tel: (852) 2887 4788, Fax: (852) 2508 1846

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