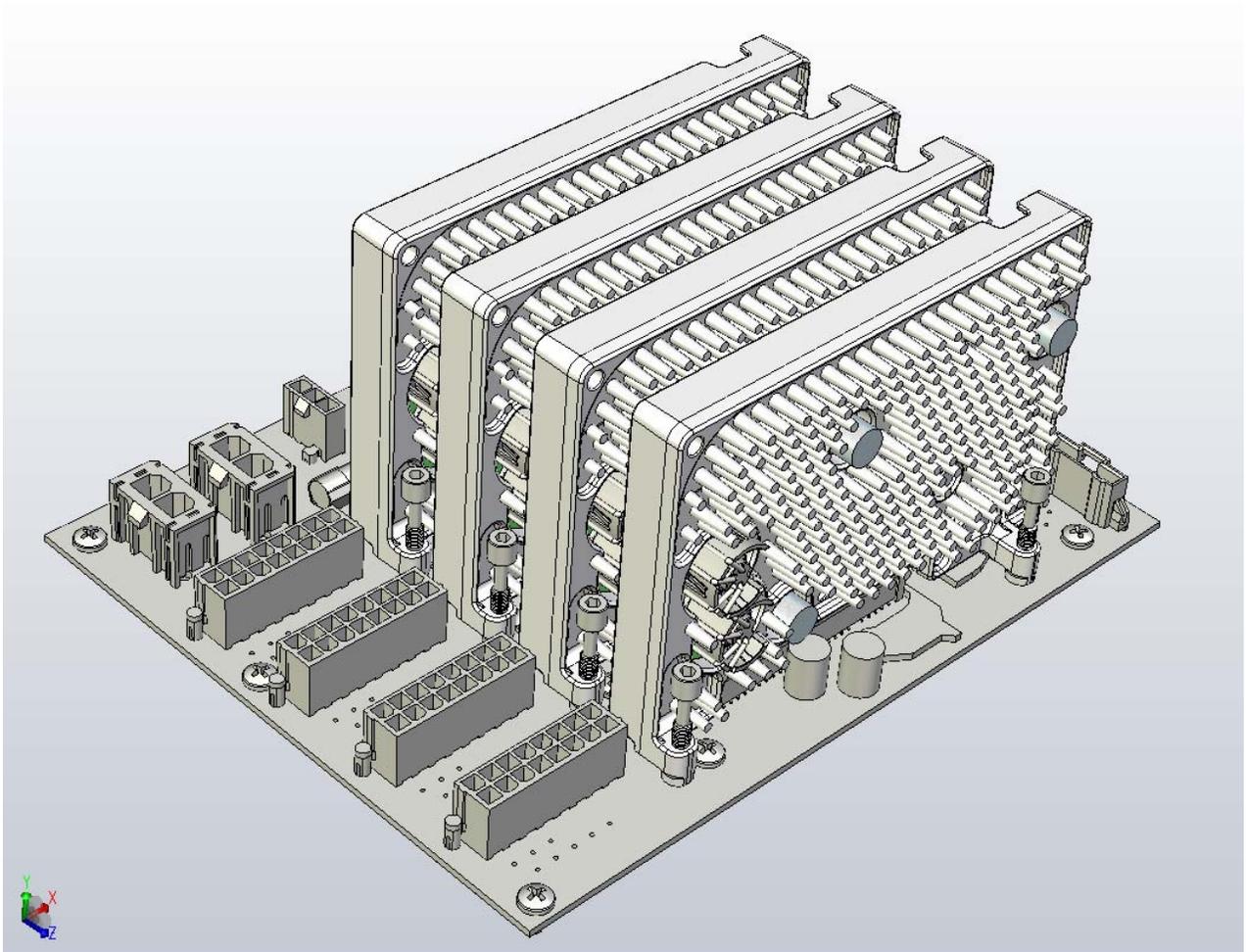




MERIDIAN ISC BOARD-MOUNT HARDWARE REFERENCE MANUAL

MODELS ISC-M255, -M295, -M355, -M375

VERSION 2.4 / JUNE 9, 2021



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INTRODUCTION

Thank you for choosing the Meridian Integrated Servo Controller (ISC). The Meridian ISC incorporates a high-fidelity servo drive, integral motion controller and local I/O. This combination results in a high-performance machine control solution that integrates the motion trajectory generator with the servo controller in an easily extensible system architecture.

Each Meridian ISC features a dedicated, high-speed digital signal processor (DSP) and onboard technology that supports the seamless integration of position, velocity, and torque loops. The unit's DSP monitors the real-time state of the position/velocity compensator, motor magnetic field, amplifier output voltages, limit switch inputs, RMS motor current, and more. This high speed data stream provides the foundation upon which the Meridian ISC produces state-of-the art motion.

The Meridian ISC is the result of Teknic's 20+ year history of hardware, software, and firmware development. That—combined with rapid advancements in DSP technology—provide the systems designer with several important benefits, including:

- The ISC's high servo bandwidth ensures fast settling times, excellent tracking performance, ultra-smooth motion and tight velocity control for even the most demanding applications
- Our wide power class and form factor options maximize selection flexibility by allowing the machine designer to select the most appropriate model based on specific power requirements, size constraints, integration needs with other devices and budgetary goals
- Powerful and fully-integrated software prototyping tools enable the machine designer to quickly start electro-mechanical integration without the need for purpose-built software code resulting in faster time-to-market

The Meridian ISC has the flexibility to control permanent magnet rotary and linear servomotors, voice coils, galvos, and most actuators on the market. Additionally, ISC units can be integrated together in an open control system architecture that leverages scalability and ease of development. The resulting solution provides excellent motion and I/O performance and outstanding overall value without the restrictions of proprietary systems.

SAFETY

GENERAL PRECAUTIONARY STATEMENT

Always follow appropriate safety precautions when installing and commissioning ISC units and motors. Equipment should be designed and utilized to prevent personnel from coming into contact with moving parts and electrical contacts that could potentially cause injury or death. Read all cautions, warnings and notes before attempting to operate or service motion control devices. Follow all applicable codes and standards when using this equipment. Failure to apply this equipment as described may impair or neutralize protections built into the product.

SYMBOLS USED IN THIS MANUAL

The following symbols and conventions are used on the equipment and in this manual. Please read all equipment labels and manuals before attempting to use Meridian ISC units.

Caution, risk of danger



Identifies information about practices or circumstances that can lead to equipment damage, personal injury, or loss of life.

Shock hazard



Identifies presence of hazardous electrical voltages and currents.

Protective earth terminal



Indicates points that must be connected to a reliable earth system for safety compliance. Protective earth connections should never be omitted.



Earth ground terminal



Frame or chassis terminal (shield)



Direct current

Note



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

Tip



Identifies additional information that may be helpful in supporting certain applications.

MECHANICAL INSTALLATION

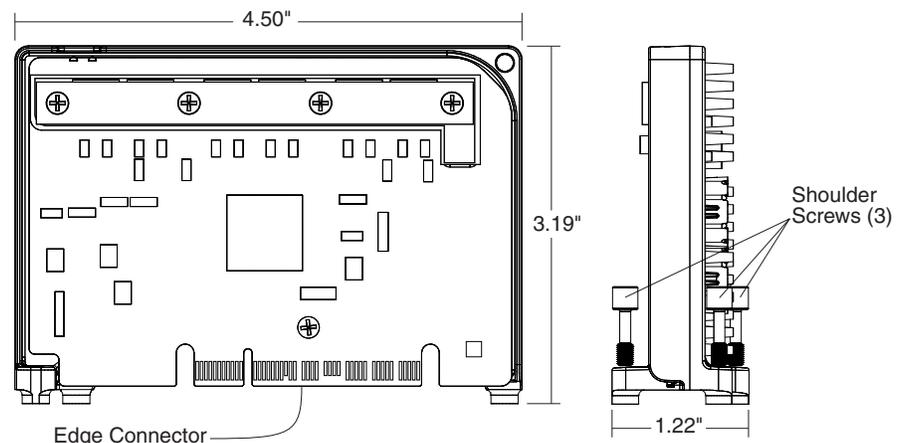
OVERVIEW

The Meridian system offers the OEM machine builder the option to deeply integrate servo drive/controllers into their custom printed wiring board architecture by using the ISC-M2x5 and ISC-M3x5 backplane mountable products. These plug-in Meridian ICS modules offer the designer a compact, fully integrated control and power package that consume minimum board space. Up to 2kW of peak power (model dependent) can be provided to the servo motor using only four square inches of board area while requiring a minimum of external components.

This document describes the electrical signals, typical interface circuits and mechanical specifications of the ISC-M2x5 and ISC-M3x5 backplane mountable products. These products are interchangeable in the same socket so that the OEM can select the most appropriate model to optimize cost vs. performance without having to change the backplane design.

Also described in this document is the BP-4, an evaluation product that allows you to test the ISC-M2x5 and ISC-M3x5 products before you design your own backplane. This manual includes several illustrations showing these backplane modules installed on the BP-4 for demonstration purposes. Your backplane board design possibilities (i.e., connector choices, number of axes, circuit configurations, etc.) are limitless.

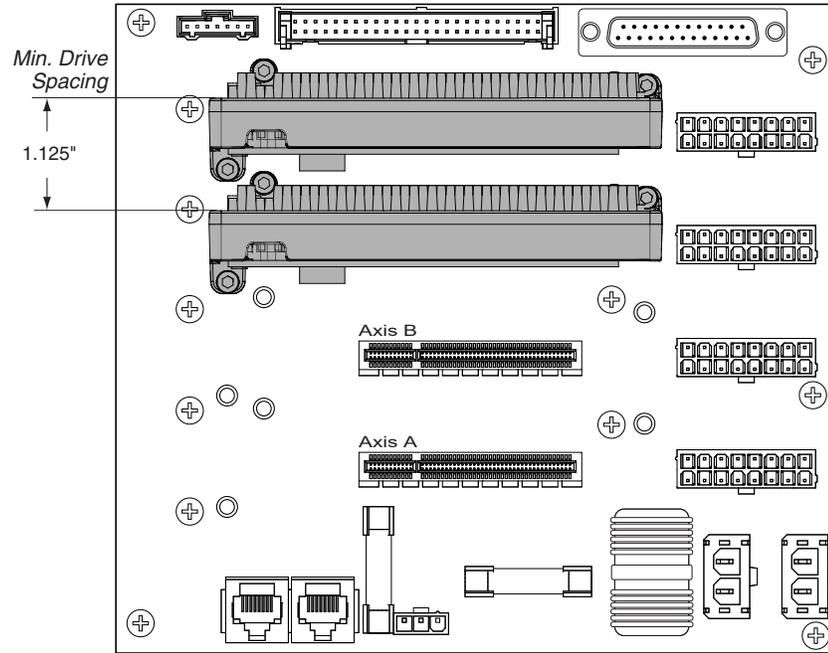
BASIC DIMENSIONS



Meridian ISC-M2xx/M3xx

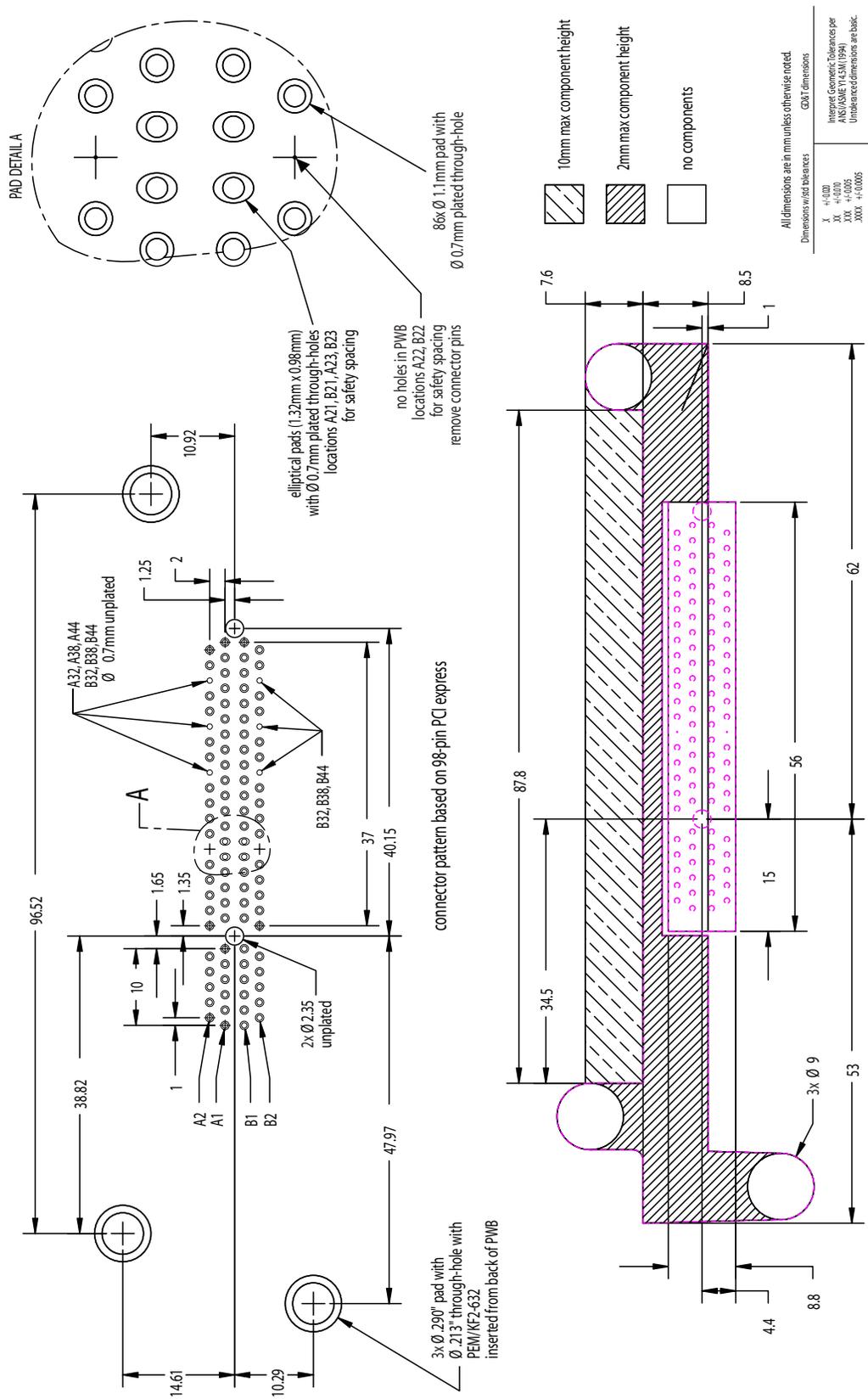
MINIMUM SPACING REQUIREMENT

The Meridian ISC must be placed a minimum of 1.125" (on center) from adjacent units.



Meridian boards shown on BP-4 evaluation backplane board

COMPONENT LAYOUT DETAIL



NOTES ON EMI AND GROUNDING

Electromagnetic Interference (EMI) can affect the quality and integrity of digital signals used in servo systems. One key EMI suppression tactic is to provide a low impedance RF return path between the motor case and the backplane motor connector. Be aware that not all third-party motors and cables provide high quality noise immunity.

When using a third-party motor with your Meridian ISC unit, verify that the following conditions exist:

- The motor phase shield is bonded to the motor case.
- The motor phase shield is terminated at the motor cable connector. See Appendix C for Meridian connector and pin designations.
- The motor extension cable (if used) carries the phase shield (uninterrupted) all the way back to the drive.
- The motor phase shield does not contact or mix with the encoder/commutation signal shield at any point.
- Additionally, to lessen the potential for ground loops:
 - The DC bus (24-90VDC) power supply should be connected to protective earth (PE) ground at only one point on the machine frame.
 - The communications power supply (24-42VDC) should be connected to the system only through the CON-MOD component as this component provides isolation and filtering.
 - The logic power supply (+5VDC) should only be connected at the backplane and must not be connected to chassis ground at any point.
 - No signal ground or I/O ground (i.e., on P9 or P10) should be connected to chassis ground at any point.



Note: If you are using the Teknic 4-axis backplane (BP-4) the Meridian's protective earth connection is made through four mounting holes on the board. These holes are located between the Meridian Interface connectors (J3-J6) and the Motor connectors (P3-P6). Connect these mounting holes to chassis ground ensuring direct metal to metal (unpainted) contact.

ELECTRICAL INSTALLATION

Many time-saving and cost-saving details are presented in the schematic fragments and text that follow. Please read this entire section, as well as the “Golden Rules of Installation”, before integrating Meridian ISC units into your machine.

OVERVIEW: ELECTRICAL ISOLATION & GROUNDING

In order to prevent ground loops in Meridian ISC systems, the control ground, power circuits, and chassis are electrically isolated from each other.

All logic-level signals are electrically isolated from the Meridian ISC's DC power input and motor output circuits, as well as from the Meridian ISC's chassis (case ground). This design feature ensures that your control signals will not be compromised due to induced currents from the motor, power supply, or PWM return path. You can also daisy-chain the power wiring to multiple Meridian ISCs. This simplifies wiring requirements while simultaneously reducing cost and increasing system reliability.



Note: Always maintain separation between isolated control ground and power ground. See the “Golden Rules of Installation” for more details.

GROUNDING & SHIELDING RULES

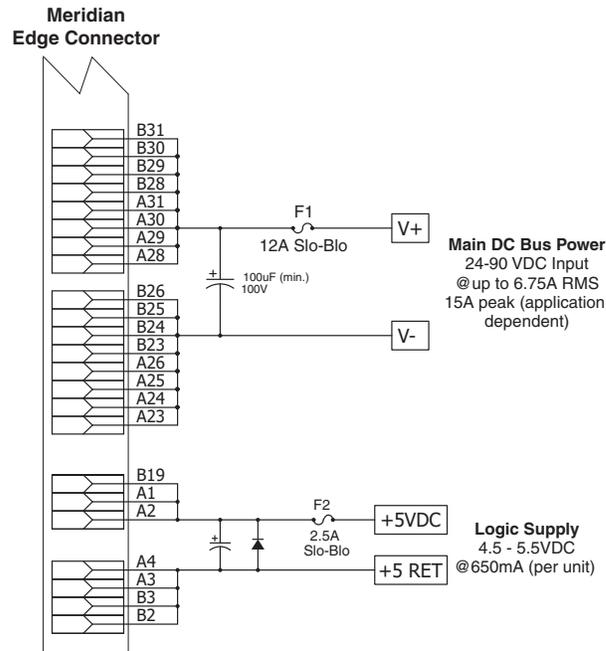
In order to meet EMC emissions specification EN-61000-6-4, and EMC immunity specification EN-61000-6-2, as well as EMC electrical safety specification EN-61010, the following rules must be followed:

1. The ISC's Protective Earth (PE) Ground must be connected to the machine's safety ground. On the BP-4 backplane, the Meridian PE ground can be connected to any of the 4 mounting screws located between the Drive Connector and motor connectors..
2. The motor phase cable must be shielded. The shield must be connected to the motor case (on the motor end) and to the CHASSIS pin on the ISC's motor connector (see Appendix C). The shield lead length at both ends of the cable should be as short as possible with a 2.0" maximum length.
3. The encoder and commutation sensor (Hall) cable must be separately shielded from the motor phase cable (even though the motor and encoder shields connect to the ISC's chassis) in order to prevent motor PWM noise from traveling through the encoder shield. The motor and encoder shields **must not** touch at any point. The shield for the encoder cable must be left unconnected at the motor end (don't connect it to the motor's case).



Note: In scenarios where the motor is isolated from proper ground return paths (as when bench testing) temporary measures should be taken to comply with safety grounding requirements. Failure to do so can result in mechanical and electrical hazards.

POWER SUPPLY REQUIREMENTS



MAIN DC BUS POWER SUPPLY (24-90 VDC)

The Meridian ISC requires an external 24-90 VDC power supply that can deliver high peak currents. Teknic recommends a "bulk" unregulated power supply—basically a transformer, rectifier, and large capacitor—for this purpose. To support high current requirements, the DC Bus input current requirements vary depending on the nature of the application, number of axes, motor size, etc. See Appendix E or your Teknic support team for information on sizing a power supply.



The problem with switching power supplies

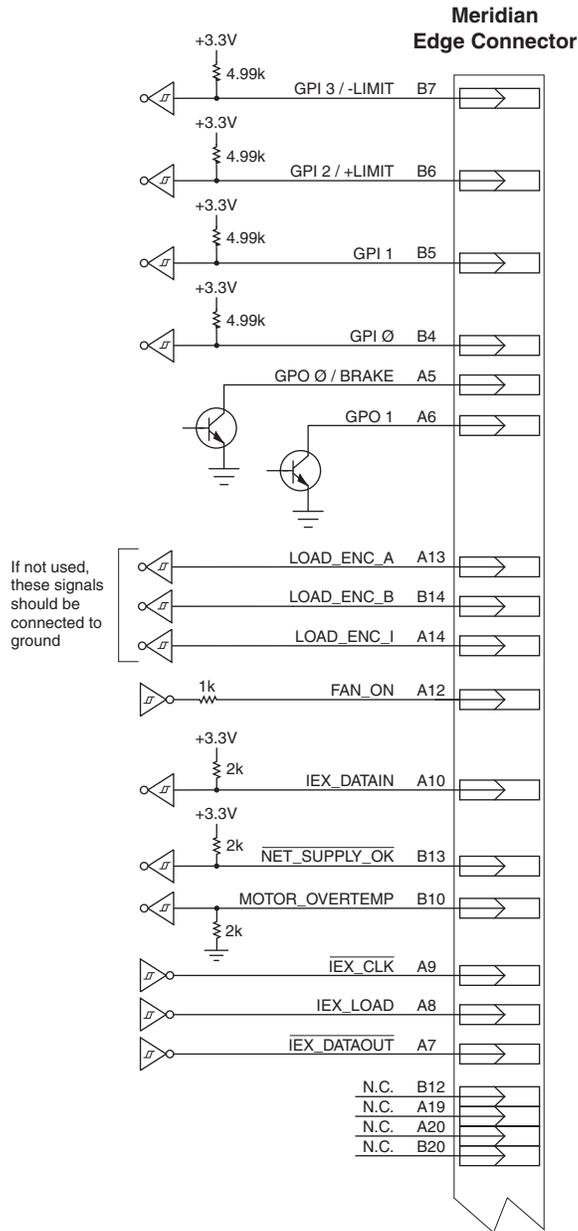
Switching power supplies are poorly suited to servo applications because switchers usually have the same peak and continuous-current ratings, forcing you to purchase a large, but under-worked power supply just to meet peak current requirements. Additionally, most switchers are not designed to accept the regenerated energy that a decelerating motor pumps back into a power supply. This can cause a switching supply to power cycle, shutdown, or even fail in some instances.

LOGIC POWER SUPPLY (5VDC NOMINAL)

The Meridian ISC requires 4.4-5.5 VDC @ 650mA. See diagram above.

INPUT/OUTPUT SIGNALS

The Meridian I/O signals are shown below. The schematic fragments (left side of the edge connector) represent the relevant Meridian ISC internal circuits for each I/O line.



Meridian I/O Signals with internal schematic fragments

LIMIT SWITCH WIRING

The Meridian ISC unit has two specific general purpose inputs that can be configured as limit switch inputs. Normally closed (NC) switches are wired between the limit inputs and GND. Alternately, the limit switch

inputs can be driven low by an open collector output or TTL-level output limit switch.

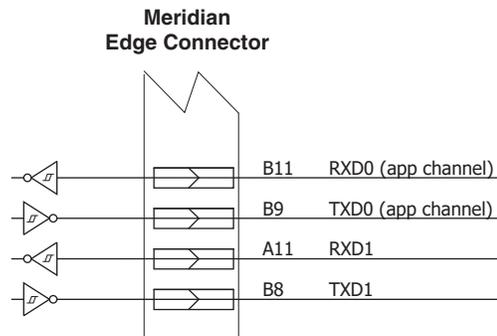
The most popular limit switches are optical interrupt switches such as the Omron SX series.



Note: Never ground the limit switch signals to the machine chassis; i.e. do not use the machine chassis as the return path for the limit switch signals.

COMMUNICATION SIGNALS

Meridian ISC units communicate to the host computer (and/or diagnostic computer) via RS-232 serial communications in a ring-style architecture. Each ISC is equipped with two communications channels, one for the main host application and another for diagnostic purposes. Communications in to and out of each unit are provided by the Meridian board edge connector on the pins described below.

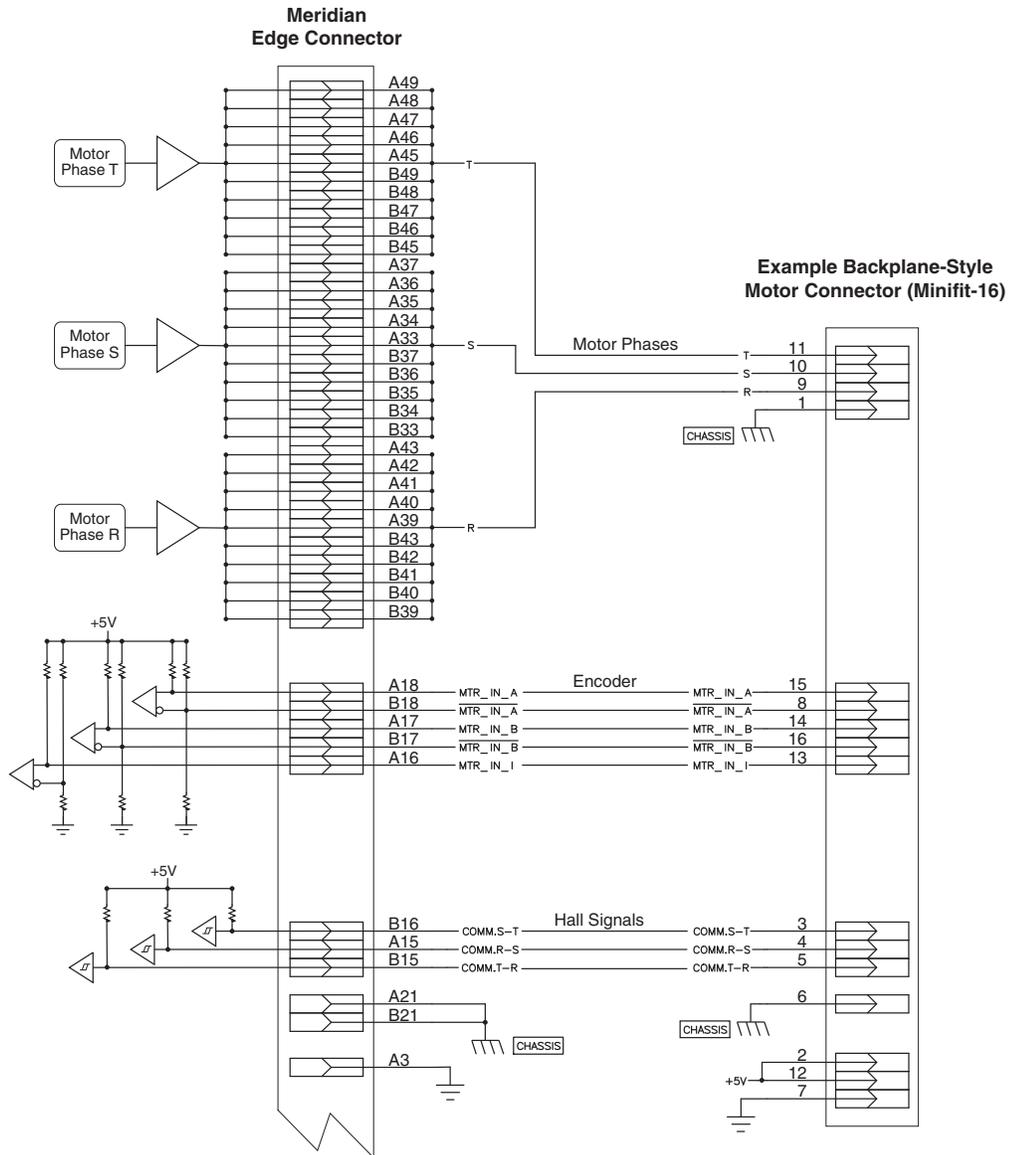


Meridian Communication signals

MOTOR SIGNALS

OVERVIEW

This section discusses Meridian ISC motor signals (with example schematic fragments) plus abbreviated coverage of motor cable construction and third-party motor wiring.

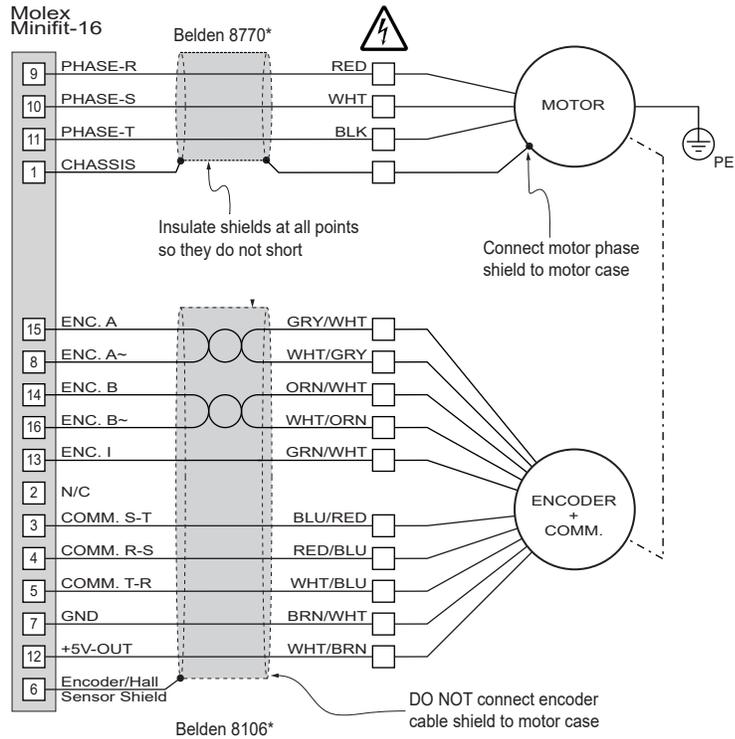


Meridian Motor Signals

THIRD-PARTY MOTOR SIGNALS

The section below provides some basic details, schematics and guidelines to follow when connecting a third party (non-Teknic) motor to a Meridian ISC unit.

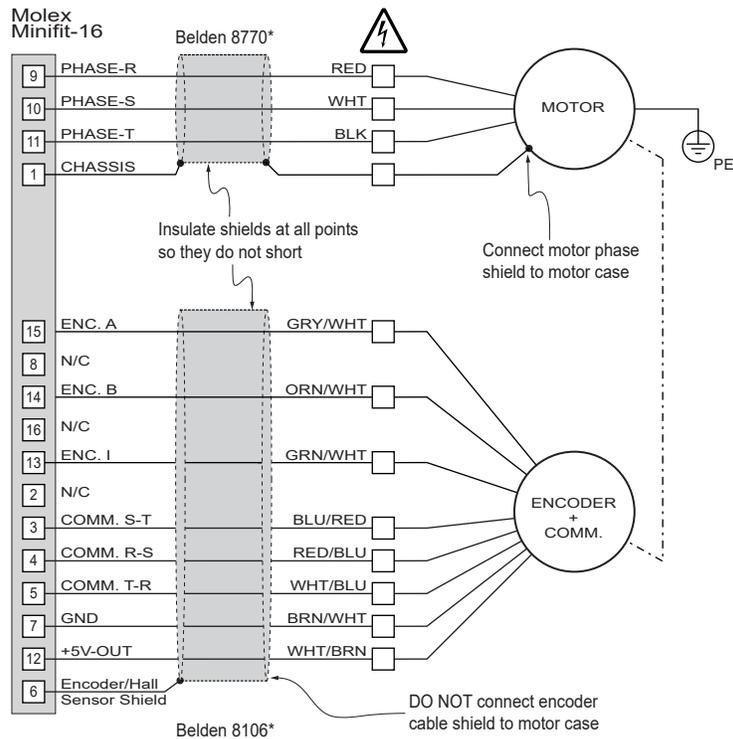
Differential Encoder



* Cable stock shown is not for use in high-flex applications.

Differential motor connections

Single-ended Encoder



* Cable stock shown is not for use in high-flex applications.

Single-ended encoder connections

Sources are specified for the connectors and the raw cable required in the diagrams below and in Appendix C (connector reference). The Belden cable products listed are economical yet have excellent electrical properties. They are a good choice for *non-flex* applications, but not appropriate for high-flex applications. Several manufacturers, including Igus® and Olflex®, manufacture cable stock specifically designed for and lab tested to withstand long-term cyclical flexing. Your Teknic Application Engineer can recommend an appropriate cable stock for your project requirements.



Note: Teknic motor pigtails (the 16” cable with connector that exits the motor housing) are not high flex rated. Always strain relieve the motor pigtail to prevent repetitive flexing.



Tip: Teknic OEMs frequently wire third-party motors to run with Teknic servo drives. This can seem like a tricky process as there is no industry standard naming convention for motor phases, commutation sensor signals, and encoder signals. Your applications engineer can often help determine how to wire a non-Teknic motor to a Teknic servo product.

GUIDELINES FOR MOTOR CABLE CONSTRUCTION

Motor cables for Meridian ISCs should be constructed according to the following:

1. Motor phase leads should be kept as short as possible after they exit the cable shield, preferably under 2”.
2. The motor phase cable shield termination should be kept short at both ends, preferably under 2”.
3. Use 16AWG or larger shielded cable for the motor phases.
4. Use low capacitance, shielded twisted pair cable for the encoder and commutation sensor signals, if possible.
5. Commutation sensor signals (Hall sensors) should be run in the encoder cable and NOT in the motor phase cable.
6. The shield on the motor phase cable must not come in contact with the shield of the encoder cable at any point. Cover exposed shield and drain wires with heat shrink tubing at termination points to prevent this. Failure to isolate these shields can result in loss of logic signal integrity and spurious failures and shutdowns.
7. Connect the motor phase cable shield to the motor case.
8. DO NOT connect the encoder cable shield to the motor case.

Warning: When connecting and disconnecting motors from Meridian ISC units:



1. Always remove power from the ISC unit before connecting or disconnecting a motor from the drive.
2. Verify that the proper motor configuration file is loaded into the ISC unit before enabling the unit. This is particularly important if the configuration file currently loaded in the drive is unknown, or if you have connected a different type of motor to the Meridian.
3. Always reset the ISC unit after connecting or reconnecting a motor to it.

MERIDIAN FEATURES, TIPS, AND TRICKS

INTRODUCTION

Meridian ISC units incorporate highly flexible firmware features intended to help you:

- Achieve your machine goals for less
- Improve machine performance without increasing cost
- Simplify and speed up the production process

Thoughtful design and implementation of one or more of these features can yield significant cost savings and give your machine a competitive advantage.

This section is focused on the Meridian features specifically designed to lower cost and improve machine robustness. The objective here is to provide you with a working understanding of these features so you understand what they are, how they work, and how they can add value to your application. Along the way we will provide explanations, tips and tricks to help you get the highest level of performance out of your Meridian ISC units. Teknic support specialists are available to provide design analysis, detailed application notes, and technical support to help you implement the features discussed in this section.



Tip: In general, once a Meridian feature is properly configured, the work is done. Duplicating these settings on subsequent (production) machines is simply a matter of loading the motor configuration file. In most cases the engineering is simplified and production effort is reduced.

FEATURE: LIMIT SWITCH HOMING

Typical reasons for use

- Eliminates dedicated homing sensors and related wiring
- Eliminates motor mechanical alignment
- Lowers cost
- Simplifies homing (eliminates controller routines)
- Improves homing repeatability

Description

Limit Switch Homing is a simple, inexpensive method for homing an axis with excellent precision and repeatability—without dedicated homing sensors, software, and ongoing maintenance costs. The setup involves changing one setting in the Meridian ISC and simply driving the axis into a limit switch at moderate speed, and then moving the axis a fixed distance away from the limit to the desired home position. The Meridian firmware manages the necessary logic, leaving you with a straightforward software implementation.

Universal benefits

- Enables the use of lower cost indexers that lack encoder feedback inputs, even in machines that require state-of-the-art performance
- Allows for full-torque braking in the event a limit is accidentally triggered

vs. home sensors

- Reduces part count by eliminating dedicated home sensors and related harnessing
- Reduces software development time

vs. encoder index homing

- Eliminates the hardware and software to process encoder signals for the homing operation
- Eliminates software offset calibrations
- Reduces software development time

Use example

Scenario: You have a linear motor axis with a full stroke travel equal to 200,000 encoder counts and you want to use Limit Switch Homing to precisely home the axis. The machine has just powered up and the axis must now execute a homing routine before it can enter “operate” mode.

1. The machine control software commands the axis to move toward the limit switch at a “safe” speed. In this case, a move of greater than 200,000 counts (e.g. 201,000 counts) will guarantee that the axis will engage the limit switch regardless of its current position.
2. The axis trips the limit switch causing the Meridian to immediately stop motor motion and actively servo to the location where the limit switch was triggered. Note: optical limit switches generally provide the best performance in this type of application.
3. The currently executing motion command is cancelled and the physical location - where the limit switch was triggered - becomes the new commanded position.
4. The machine control software then commands the axis to move away from the limit to its home reference position. The axis is precisely homed, often repeatable to within one encoder count.

FEATURE: HARD STOP HOMING (SENSORLESS HOMING)**Typical reasons for use**

- Home without sensors, switches or cables
- Eliminate sensor or motor alignment
- Achieve lowest possible cost of homing
- Simplify homing procedure
- For use when low cost and high reliability are paramount

Description

Hard Stop Homing is a simple yet elegant firmware-based method for homing an axis with excellent precision and repeatability—with no sensors. The implementation involves changing three settings in the Meridian ISC, testing the results, and refining the relationship in the three drive settings (which is typically about a ten minute, one-time effort).

Once the Hard Stop Homing settings are satisfactory, simply drive the axis into a hard stop at a “safe” speed. There is no stalling, no motor noise and no physical jumping. The axis clamps to the hard stop, the algorithm is engaged, and a user defined torque rollback is engaged in a time-controlled manner yielding very repeatable positioning. At that point, a command is issued to move the axis a fixed distance away from the hard stop to the home position, completing the homing routine.

Benefits

- Yields homing results that are precise and repeatable—often to within one encoder count
- Eliminates the cost, wiring, assembly time, maintenance and failure points of limit and home sensors
- Enables the use of lower cost controllers—specifically those that lack encoder feedback inputs—even in machines that require state-of-the-art performance
- Eliminates hardware/software that processes encoder signals for the homing operation
- Eliminates the need for mechanical alignment of home switches
- Reduces software development time by simplifying control software
- Reduces calibration efforts during the manufacturing process (sensor alignment, index mark alignment, and/or software offsets are eliminated)

Use example

The user in this example is running a linear motor axis with a full stroke travel of 100,000 encoder counts and wants to use Hardstop Homing to precisely home his axis. In this scenario, the machine has just powered-up and the user wants to home the machine for a new job. The following sequence of events would occur:

1. The machine control software commands the axis to move toward the hard stop at a “safe” speed. In this case, a move of greater than 100,000 counts (e.g. 101,000) will guarantee contact with the hard stop.
2. The axis approaches and makes contact with the hard stop. Axis motion stops. Note: steps 3-6 occur in a fraction of a second.
3. Servo error grows and the Meridian ISC (still holding position against the hard stop) responds by increasing force to the motor in an attempt to drive the motor to the commanded position.
4. When torque/force reaches a user-defined maximum level (e.g. 80% of total torque/force) the unit’s HardStop Torque/Force Foldback algorithm is triggered.

5. The torque/force holding the axis against the hard stop automatically relaxes to a user-settable holding force over a user-defined time period. For example, the holding force can be programmed to relax from 80% to 10% over a period of 100mS.
6. The Meridian position register is reset, effectively making the current position (still snug against the hard stop) the new commanded position.
7. The machine control software then commands the axis to move away from the hard stop to a known reference position. The axis is precisely homed with positioning performance often repeatable to one encoder count.

FEATURE: VARIABLE LOAD AND INERTIA MATCHING TECHNOLOGY™

Typical reasons for use

- Eliminates production tuning, even with notable machine to machine variation
- Allows for high inertial mismatch enabling the use of smaller, less costly motors
- Allows for variable load weights without retuning with virtually no change in performance
- Compensates for mechanical wear over time, providing consistent performance over the life of equipment
- Controls overshoot, even with high integrator gains

Description

Inertia Matching Technology or IMT is a powerful adaptive control technique developed by Teknic to reduce or eliminate the overshoot and instability problems caused by variable loads and/or high load to motor inertia differences (a.k.a. inertia mismatch). The IMT neutralizes the impact of load weight variation, machine to machine variability, high load to motor inertia ratios on machine performance, and mitigates the effects of long term mechanical component wear.

In essence, this dynamic algorithm looks at all aspects of position and velocity performance and dynamically adjusts the gains on the fly to proactively adjust for predicted errors in either motion domain. The result is short-term performance otherwise realized with only with much larger (and more costly) servomotors, as well as long-term system compensation that even oversized motors can't match.

Benefits

- Reduces or eliminates overshoot induced by high integrator settings
- Adjusts servo gains dynamically to account for varying loads and machine to machine mechanical variation
- Improves settling times
- Enables the reuse of motor tuning files in production – eliminates the need to individually tune each axis as a production

machine is built. This effectively makes the unit a “black box” to production.

IMT Background

Of course the ideal (read: not realistic) servo axis would have a well-balanced, fixed load with a perfect 1:1 match between the motor inertia and reflected load inertia. It is well understood that maximum power transfer between motor shaft and load occurs when motor and load inertia are equal. Unfortunately, in the real world of design constraints, cost targets, and performance requirements, it is not practical (or possible for that matter) to build the “ideal” system. In developing Inertia Matching Technology, Teknic engineers first examined the problems associated with variable loads and inertia mismatch. The two main problems were identified as:

1. The excitation of low frequency resonances that effectively limit the usable gain of the servo system. Resonance control torque filtering is often used to mitigate this problem, either directly (with a digital low-pass filter) or indirectly (by adjusting the response of the torque controller).
2. Overshoot and system instability causing serious tuning and performance problems, unless the gains—especially the integrator gain— are set well below their useful ranges. This is especially true for axes with compliant or “lossy” mechanics. This problem has challenged servo system designers and users for years. Here’s some background on how this problem typically manifests itself:

In a servo system, the function of the integrator is to drive steady-state position error to zero. In theory, the higher the integrator gain, the faster the position/velocity error is driven to zero and the greater the dynamic stiffness of the axis. In general, this is desirable behavior. However, prior to the introduction of IMT, servo designers who used integrator gain aggressively would always see axis overshoot in response to disturbances. This is due to the very nature of the integrator (i.e. the higher the integrator gain, the larger the overshoot). They would also find that by lowering the integrator gain - although they would lower the amplitude of the overshoot - they would increase the duration of overshoot and therefore the time to settle. So, an axis with less than perfect mechanics and/or significant inertia mismatch would very likely experience overshoot or stability problems unless the gains were drastically reduced.

The Historical Approach to Integrator Overshoot

Historical approaches to integrator induced overshoot include:

- Turning off the integrator until the very end of a move
- Limiting the maximum value of the integrator
- Setting a tolerance band within which the integrator functions

The main issue is that none of these techniques really solve the root problem; in fact, they often cause significant reductions in performance.

The most common, although now dated, approach to dealing with overshoot and inertia mismatch is to specify an oversized motor, keep the

primary feedback gains at moderate levels, and use very little or no integrator gain. Using this (literally brute force) approach, the motor sees so little of the reflected load inertia that it responds more like an unloaded motor (which requires little or no integrator gain to maintain positional accuracy). Some obvious drawbacks to this approach include:

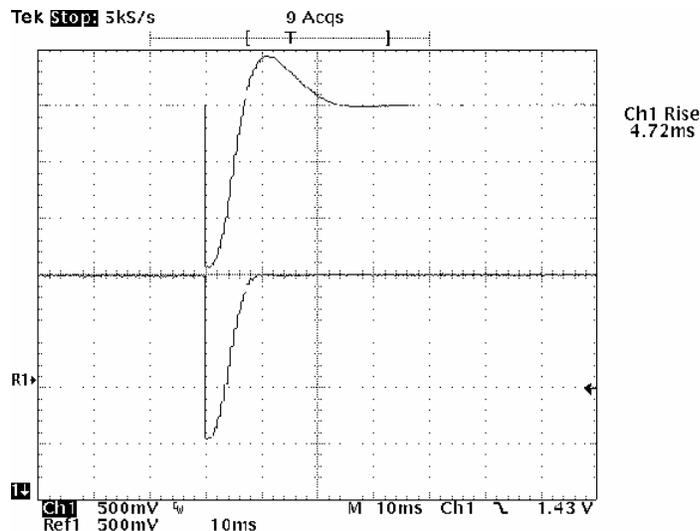
1. Larger motors are expensive. They drive up the machine cost, drive down profit, or both.
2. In many space-sensitive applications, an oversized motor is physically too large to satisfy critical design objectives.

Despite the drawbacks, the success of this “supersize it” approach has led to various questionable inertia-matching rules of thumb favored by servo system salesmen. These salesmen know that if they can sell the customer on oversized motors—instead of addressing the underlying problem—they will receive fewer support calls and take home larger commission checks from the sale of unnecessarily large and expensive systems. It’s a win-win situation for them.

Operation

Inertia Matching Technology is a standard feature on all Meridian ISC units. It is one of the main tuning gains (K_{nv}) set during axis tuning sessions. The IMT continuously works to eliminate overshoot caused by large disturbances while maintaining high dynamic stiffness.

The scope shots below display the response of a Meridian servo system to an instantaneous [step] change in commanded position. The top trace is a well-tuned Meridian system with a reasonable integrator value and no IMT. The lower trace, to those with servo experience, might look as if the integrator gain has been set to zero—in fact, it was increased by forty percent. The difference: IMT was turned on this time. Notice that the response is actually faster with no overshoot.



Servo response without IMT (top) and with IMT (bottom)

FEATURE: RAS FOR VIBRATION DAMPING AND ENHANCED SMOOTHNESS

Typical reasons for use

- Improves tracking performance
- Reduces mechanical system wear (on items such as gearboxes and screws)
- Lowers motor and drive RMS (which provides more engineering margin or permits the use of smaller motors)
- Allows elegant use of lower frequency pulse output rate indexers (common among software based CNC controllers) or controllers that “burst” pulses

Description

RAS works by automatically fitting a modified, high-order rational spline to the velocity command before it is passed to the position/velocity compensator. The duration of the RAS spline segment on the incoming profile is configurable.

Benefits

- Reduces wear on machine mechanics
- Lowers acoustical noise
- Causes less jostling of the load
- Minimizes ringing of the mechanism at the end of moves – this is especially important for trapezoidal motion profiles with linear acceleration ramps
- Improves tracking accuracy
- Reduces settling time
- Smooths the torque signature resulting in cooler running motors. Some users even downsize to a smaller, less expensive motor as a result of using RAS

Operation

The RAS function effectively interpolates the velocity profile and its derivatives at a high degree of resolution, providing extremely smooth inputs to the position/velocity compensator. These inputs, used in acceleration and velocity feed-forward calculations, allow the feed-forward gains to be turned up to optimum levels without creating the acoustical noise and torque chatter from which other digital servo drives suffer – the very reason why their use of feed-forward gains is limited to inadequate levels. (See the following screen captures).

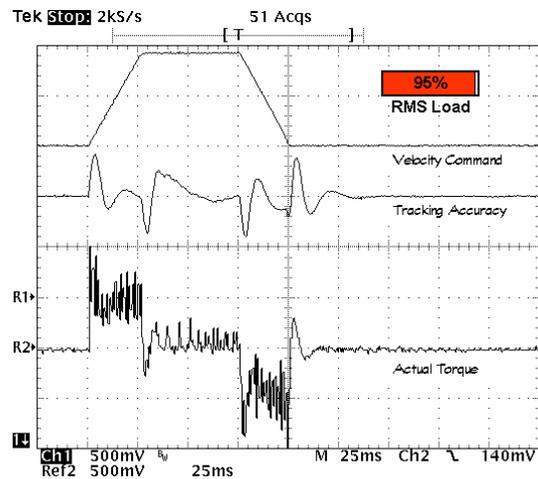


Figure 1: Commanded velocity, tracking error, and actual torque used without RAS

This scope shot (Fig.1) shows the commanded velocity (top: 3000RPM/div), tracking accuracy (center: 2 degrees/div) and the actual torque used (bottom: 25% of max torque/div) without the RAS engaged. Notice that the torque required during this move has significant “chatter”. With 200 ms of dwell between moves, reciprocating this move required 95% of the motor’s RMS capability.

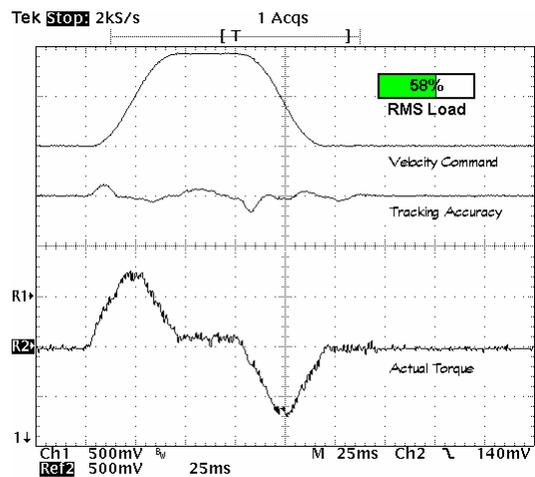


Figure 2: Same motion profile with RAS applied

The effect of the RAS on the same move’s tracking accuracy and torque usage is dramatic. Notice the freedom from “torque chatter” when the RAS is engaged—this is one reason why the RAS makes motion so quiet. Also, the RMS load on the motor was reduced by 37%!

FEATURE: CONTROL SERVO HUNTING WITH ENHANCED ANTI-HUNT

Description

A common problem faced by automated machine builders and servo users in general is the performance and perception problems associated

with servo hunting. Because the Meridian is a high performance, inherently “quiet” servo product, the chances of encountering a true servo hunting problem is low, but under certain circumstances, hunting-like behaviors can occur. The Meridian ISC’s Enhanced Anti-Hunt feature is a convenient, configurable feature that effectively reduces or eliminates the undesirable hum, buzz and micro motion caused by servo hunting.

Benefits

- Reduces axis acoustical noise during dwell
- Increases perceived smoothness of axis motion
- Allows for the use of high gain settings and high stiffness without typical servo jitter or hunting (so you don’t need to sacrifice performance during motion to get the motor to sit still during dwell)
- No loss of accuracy is incurred when using Enhanced Anti-Hunt

Background

It is worth noting that a well-tuned Meridian ISC unit/motor system that is stiffly coupled to its load will not hunt. Servo hunting behaviors tend to occur in systems where the load weight and axis friction are relatively high and where there is backlash present (think inexpensive gearbox). When an axis that is nominally tuned to move a heavy load is commanded to stand still, the load and friction components change dramatically in a micro sense (mainly due to backlash in the gearing). Even a few arc-seconds of low friction “free motion” in the gearbox can cause buzzing and vibration as the drive actively seeks to maintain motor position within the relatively low friction confines of the gearbox’s backlash zone. This means that, during dwell when the load is essentially motionless, the motor may dither back and forth about the target encoder position.

In some applications—micro-probing of silicon wafers for example—hunting can easily disrupt sensitive probing operations. For other applications, such as CNC routers, imaging devices, and printers, hunting generally has no noticeable impact on machine performance or output, but the telltale buzz or hum from the servo motors can be perceived as a quality issue. In either case, it can be viewed as a negative by the end user or prospective customer. Enhanced Anti-Hunt can resolve this.

Operation

Appropriate settings for this feature (including when not to use it) depend entirely on the motion requirements and objectives of the application. The exact appropriate setting for an axis on your machine is determined empirically and typically takes about 5 to 10 minutes. Consult your Teknic Applications Engineer for more information on the appropriate uses and settings for Enhanced Anti-Hunt.

FEATURE: PRECISION TORQUE/FORCE CONTROL FOR CLAMPING OR INSERTION

Description

There are many applications that require the ability to reduce torque (force) during a move. One example: an axis that must rapidly transport

a part to a receiving socket and then reduce torque to properly insert the part into the socket and then hold the part in the socket with an exacting amount of force – all in the same profiled move. The Meridian's Torque/Force Foldback feature can help you do this easily and inexpensively.

The setting for the amount of torque applied during a Torque/Force Foldback event can be pre-set as part of the base configuration or you can change the torque/force setting on the fly to the current desired level.

Benefits

- Uncomplicated software implementation
- Eliminates the need for expensive load cells or other force feedback devices
- Torque/Force limiting is directionally sensitive – you can set the Meridian to limit torque in either direction (or both)

Use example

A part is being rapidly decelerated as it approaches a test insertion dock. As it is being decelerated, the machine control software sets torque/force foldback in the positive direction to “active”. So full power is still available to decelerate the load (negative direction) but it will not crush the part into the fixture (positive direction). As the part starts to insert into the dock, the velocity is now low. However, the part is commanded to go a small distance beyond the full contact zone and the part would otherwise get crushed. However, the Meridian takes over and once torque has built up to the user-specified level, the unit will continue to apply that exact amount of force on the part and no more. (The amount of force is typically the right amount of force to make proper contact for an accurate electrical test.) Thus load cells aren't needed and a precise amount of force is applied – even with parts of varying thickness. Moreover, when you start to pull away from the dock, full power is available in the retract direction – so throughput is maximized.

FEATURE: GLOBAL TORQUE (FORCE) LIMITING

Description

Meridian ISC units include an easy-to-set global torque (force) limit. This feature allows you to specify the maximum (never to be exceeded) motor shaft torque (force for linear motors) for a given drive/motor combination.

Benefits

- Can reduce or eliminate accidental damage to sensitive mechanical components
- May enhance human safety by limiting torque/force to maximum necessary levels. Warning: even limited torque or force can be hazardous to humans. Never put body parts in the path of an active motion axis.

Common use example

An OEM has a NEMA 23 servomotor that can produce 300 oz-in of peak torque when paired with the selected drive. A smaller NEMA 17 servomotor costs more money and is less robust, but the mechanics are

only rated for 150 oz-in. We can set the Global Torque Limit to 50%, so torque at the shaft will be limited to 150 oz-in (50% of 300 oz-in). So we can use the less costly, more robust motor without causing risk to the mechanics. Note: in this use case, if more than 150 oz-in. of torque is needed to follow the command, the unit will be in a “torque saturation” state and may possibly issue a tracking error safety shutdown. However, the mechanical components will not be exposed to stresses beyond their rating.

FEATURE: REMOTE MACHINE TUNING AND SUPPORT

Description

One of the most versatile and convenient features supported by the Meridian ISC unit is the real time integrated software oscilloscope, or Soft Scope. The Soft Scope emulates the capabilities of a full-blown hardware storage oscilloscope from within the ISC configuration software, so it's ready to go whenever your PC is connected to a Meridian ISC and the software is running. Once you're connected, the Soft Scope can display (in real time) over 15 diagnostic servo waveforms including commanded velocity, actual torque, and tracking error vs. time.

The Soft Scope comes with many hardware oscilloscope features including adjustable cursors, adjustable time base, adjustable range, real-time display, two storage channels, four trigger modes, multiple trigger sources and positions. But the real value of this technology is that it lets you work collaboratively with a Teknic Applications Engineer from virtually anywhere in the world. As long as you have an internet connection, a Teknic engineer can work with you online – seeing exactly what you see. Anyone who's ever had to interpret oscilloscope images over the phone or wait for data to compile between each move will appreciate the speed and ease of the Soft Scope.

Benefits

- Enables remote support by Teknic Support Engineers
- Allows OEMs to support their machines in the field, regardless of location
- Useful for diagnosing not only the servo, but mechanical and electrical systems as well
- Allows you to easily capture, save, and compare benchmark machine performance data points
- Eliminates the need for an external oscilloscope
- Contains a full suite of scope controls that operate in real time, offering the convenience of an on-board scope but the speed and power of hardware scopes

FEATURE: BRAKE SOLUTIONS

ROTARY INLINE BRAKES (HARDWARE BRAKES)

If your rotary motor application requires failsafe stopping power, an inline rotary brake may be the solution. Teknic can help you specify and

integrate a brake into your rotary motor application. Your Teknic Applications Engineer will work with you to analyze braking requirements, create a brake specification, recommend a brake manufacturer and model, and support the integration of that brake into your machine.

Selecting an inline brake

In general rotary inline brakes should be:

- Failsafe, i.e. engage when main power is interrupted
- Installed to the output shaft of the motor, and not of a gearbox
- Have the lowest practical inertia

Brake tip

Most brakes do not produce as much clamping torque as the motor's peak driving torque, so always avoid actively driving the motor with the brake engaged.

BACK EMF BRAKES (ELECTRICAL ASSIST MOTOR BRAKING)

If power is removed from the ISC *during axis motion*, the spinning motor acts as a generator. If you electrically “clamp” that induced energy, the motor will decelerate more quickly than if just coasting to a stop. The exact stopping distance depends on the motor's back EMF, mechanics, load weight, and velocity at which power was lost.

There are two ways to create an electrical assist brake:

1. Clamp the DC bus
2. Short the three motor phases together.

Please contact your Teknic Application Engineer for relay recommendations and assistance if you wish to use phase clamping.

FEATURE: THIRD PARTY MOTOR SUPPORT

Many servo motor and drive manufacturers (somewhat understandably) discourage their customers from using competing motor solutions by designing their products with proprietary connectors, hardware, software, and feedback devices. Unfortunately, this tactic often limits their customers' choices to just a few motors in their line that come close enough to meeting the application requirements.

With this in mind, Teknic designed the Meridian ISC to be cross-compatible with motors from most major manufacturers (and many smaller ones, too). Simply stated, this gives our customers greater design flexibility. Though we'd like to sell you Teknic servomotors, the fact is if the linear motor, brushless motor, brush motor, galvo, or voice coil solution for your application isn't made by Teknic, Meridian servos can almost always drive them (and often with better results than the motor manufacturer's own drive product).

Benefits

- Open-standard for motor control without proprietary roadblocks to prevent you from using other motors

- Teknic supports the widest range of third-party motor solutions
- Easily manage motor changes without extensive, costly rewiring
- Teknic Engineers are trained to assist you with simulations, selection and installation of third-party motor solutions. In fact, the growing motor library contains several thousand third party motors already simulated with Meridian ISCs

FEATURE: DIGITAL ENCODER NOISE FILTERING

Description

The Meridian ISC offers user-settable digital filters for the encoder signals. These custom-designed algorithms remove unwanted noise frequencies while allowing the desired signals to pass. Combined with the galvanic isolation between power stage and logic stage (common to all Meridian ISCs) digital filtering allows for the use of standard, off-the-shelf encoders with no extra electronics (ferrite beads, chokes, capacitors, etc.). This is true even in environments with high levels of electromagnetic interference (EMI), such as those with plasma cutters in close proximity. Once properly set, the filters load as part of the drive's motor configuration file and become invisible to production personnel and machine owners alike.

Benefits

- Meridian digital filtering removes unwanted noise, allowing robust performance in electrically noisy environments
- Eliminates the need for traditional add-on filter methods, such as capacitors, ferrite beads, chokes, etc. that increase cost and manufacturing effort while having some negative side-effects (such as attenuation of control signals)
- User definable
- Except in plasma or other similarly noisy applications, digital filtering is rarely needed (mainly because the units are fully isolated). Machines that normally do not need this filtering will benefit from an enhanced level of robustness as the filter will intercede if an unexpected event—the loss of a ground connection during operation—happens. In such a case, the machine will keep running while the control system is alerted to the fact that the Meridian's digital filtering has activated and that maintenance or repair may be necessary.

Operation

In a nutshell, after the noise and actual encoder pulse stream is evaluated, the proper filter is selected. Once it is set, the filter becomes part of the configuration file and all future machines will have the filters automatically set via the unit's motor configuration file. It takes about 15 to 20 minutes to evaluate the prototype machine's process noise. Contact Teknic for a procedure to evaluate the typical noise frequencies and filter settings for your prototype machine.

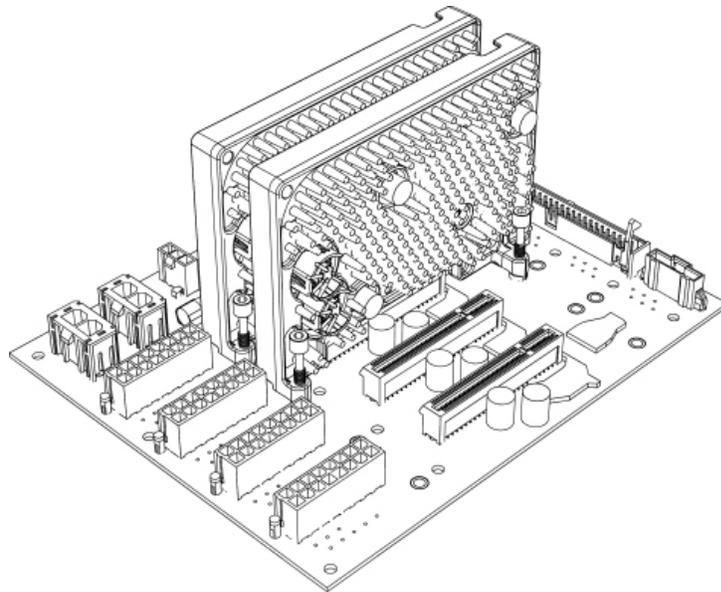
4-AXIS BACKPLANE BOARD (BP-4)

INTRODUCTION

The 4-Axis Backplane (BP-4) was designed as the development and demonstration platform for the board-mount Meridian ISC, and serves as the design roadmap for similar multi-axis backplane-style boards. Fully detailed fabrication plans and schematics are available to qualified Teknic OEM customers.

This section includes a discussion of the following BP-4 topics:

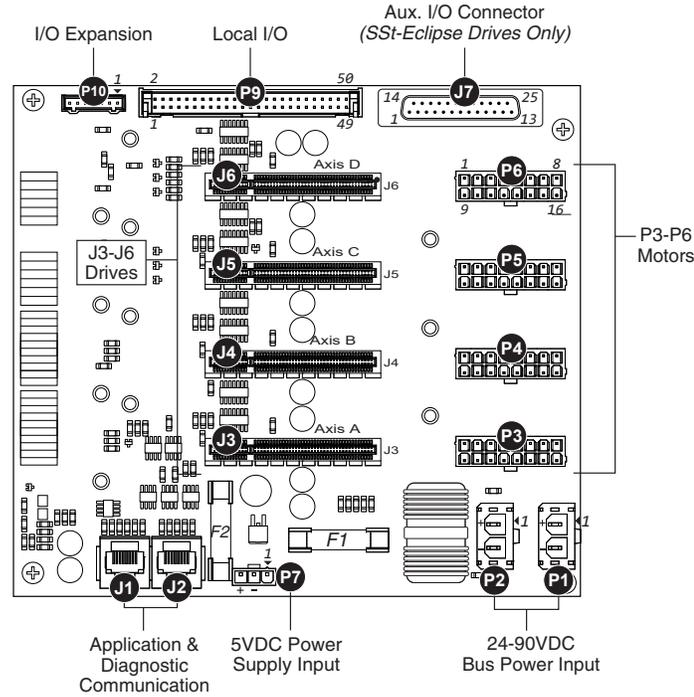
- Connector reference and pinout information
- Mating connector information
- How to install a Meridian ISC in the BP-4
- Fuse information
- Input power requirements
- Expanded discussion of I/O and other selected circuits



BP-4 (shown with two Meridian ISC units installed)

BP-4 BACKPLANE CONNECTORS

The diagram and table below detail the location, part numbers, and mating connector information for the BP-4.

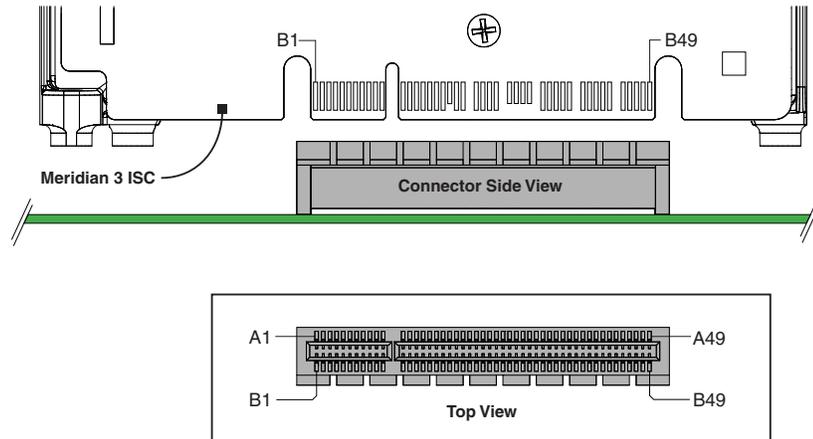


BP-4 connector map (above) and connector mating information (table below)

Ref.	Function	Teknic PN	Mfg. PN	Conn. Description	Mating Conn.	Contacts
J1	Comm.	1101125	Kycon/GD-PNS-88	8 pos. PWB vert. mt, gold female contacts	RJ-45 (typ.)	N/A
J2	Comm.	1101125	Kycon/GD-PNS-88	8 pos. PWB vert. mt, gold female contacts	RJ-45 (typ.)	N/A
J3	Meridian - A	1106329	FCI/11018783-10202TLF	98 pos. PWB vert. mt, PCI Express	Meridian board	N/A
J4	Meridian - B	1106329	FCI/11018783-10202TLF	98 pos. PWB vert. mt, PCI Express	Meridian board	N/A
J5	Meridian - C	1106329	FCI/11018783-10202TLF	98 pos. PWB vert. mt, PCI Express	Meridian board	N/A
J6	Meridian - D	1106329	FCI/11008783-10202TLF	98 pos. PWB vert. mt, PCI Express	Meridian board	N/A
P1	24-90 VDC In	1106142	Molex/43160-2102	2 pos. PWB vert. mt, male contacts	Molex/44441-2002	Molex/43375-1001 (14-18 AWG)
P2	24-90 VDC In	1106142	Molex/43160-2102	2 pos. PWB vert. mt, male contacts	Molex/44441-2002	Molex/43375-1001 (14-18 AWG)
P3	Motor-A	1106138	Molex/15-24-7160	16 pos. PWB vert. mt, tin male contacts	Molex/39-01-2160	Molex/39-00-0047 (24 AWG) Molex/39-00-0077 (16 AWG)
P4	Motor-B	1106138	Molex/15-24-7160	16 pos. PWB vert. mt, tin male contacts	Molex/39-01-2160	Molex/39-00-0047 (24 AWG) Molex/39-00-0077 (16 AWG)
P5	Motor-C	1106138	Molex/15-24-7160	16 pos. PWB vert. mt, tin male contacts	Molex/39-01-2160	Molex/39-00-0047 (24 AWG) Molex/39-00-0077 (16 AWG)
P6	Motor-D	1106138	Molex/15-24-7160	16 pos. PWB vert. mt, tin male contacts	Molex/39-01-2160	Molex/39-00-0047 (24 AWG) Molex/39-00-0077 (16 AWG)
P7	5VDC Input	1101147	Molex/39303035	3 pos. PWB rt. ang. mt, tin male contacts	Molex/39-01-4030	Molex/39-00-0046
P9	Local I/O	1101059	AMP/1-1761606-5	50 pos. PWB vert. mt, pins, tin	AMP/1-102387-0	AMP/102548-3 (22-26 AWG) Molex/16-02-0097 (24-30 AWG)
P10	I/O Expansion	1103925	Molex/70555-0006	7 pos. PWB rt angle mt, tin male contacts	Molex/50-57-9407	Molex/16-02-0103 (22-24 AWG)
F1	Fuse, 15A	1100911	Bussmann/MDA-15-R	fuse, 3AB, 15A, TIME DELAY (T), ceramic, 250 V		
F2	Fuse, 2.5A	1100912	Bussmann/MDQ-2-1/2	fuse, 3AB, 2.5A double time delay (TT), ceramic, 250V		

BP-4 EDGE CONNECTOR (J3, J4, J5, J6)

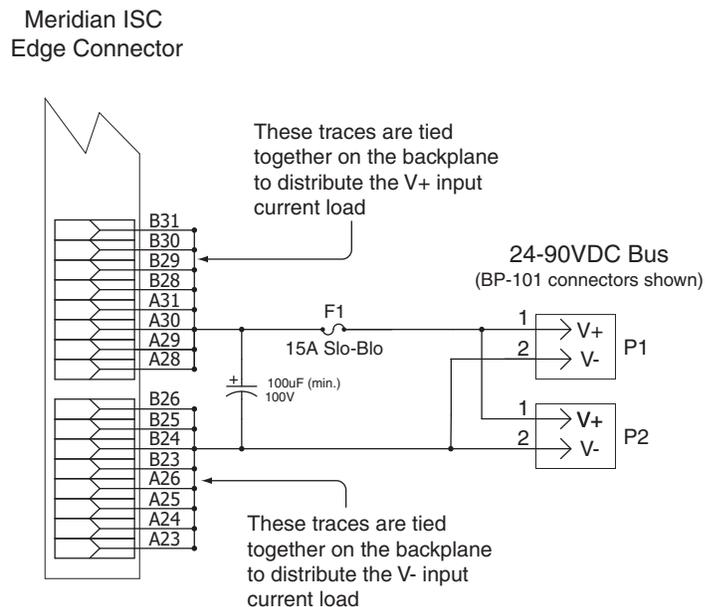
All Meridian ISC signals pass through a 98 pin, PCI Express-style connector keyed to prevent reverse installation.



Meridian ISC mates with 98 position Drive Connector on BP-4 as shown above

DC BUS INPUT POWER CONNECTORS (P1, P2)

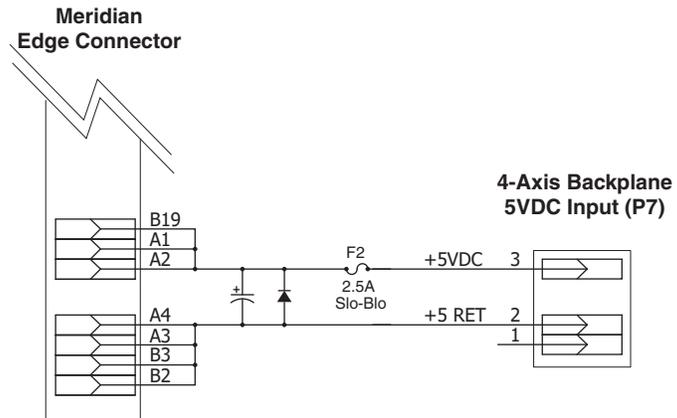
Meridian ISC units operate with DC bus voltages between 24-90 VDC. DC bus power is provided to the ISC units via two DC bus connectors on the BP-4 backplane. P1 and P2 are wired in parallel to support daisy-chained power distribution. Routing of power from P1 / P2 to the Meridian edge connector is shown below.



24-90 VDC Bus Input (P1, P2)

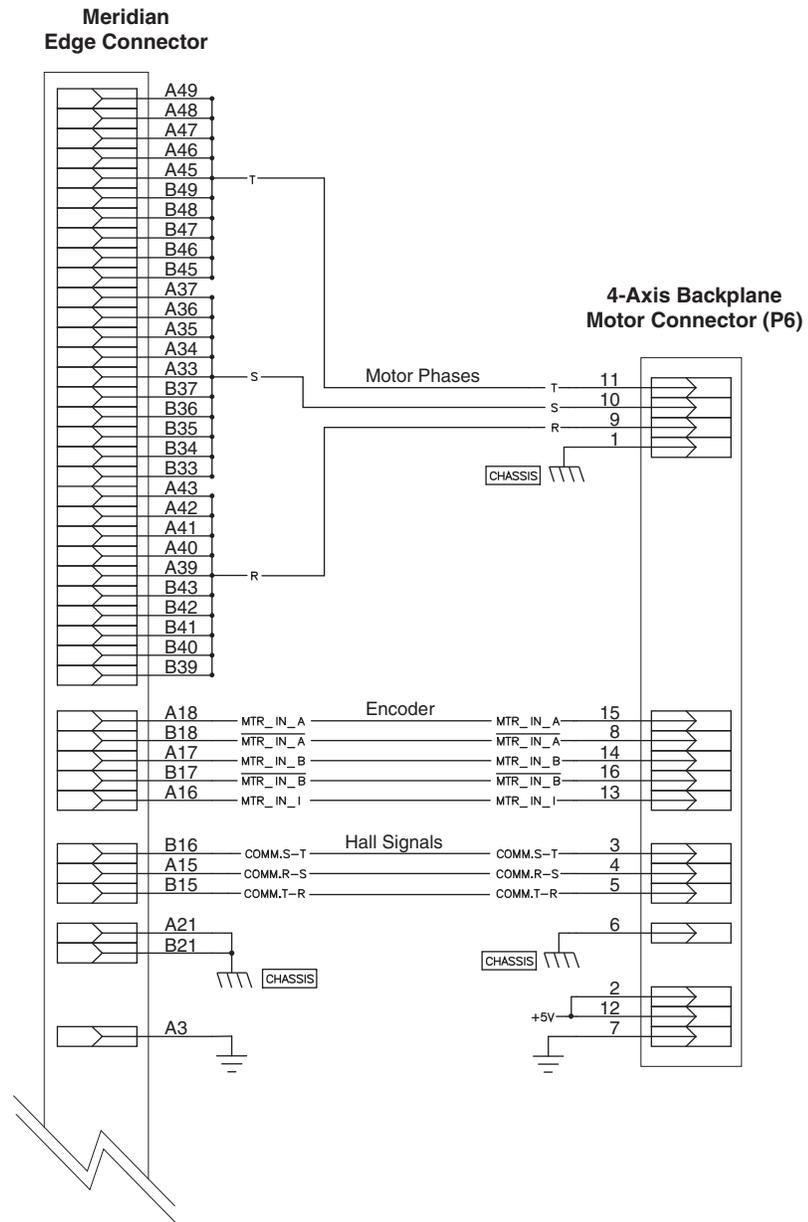
5VDC INPUT SUPPLY (P7)

Board mounted Meridian ISCs require an external +5VDC logic power supply. This power supply provides power to the Meridian ISC's DSP processor as well as all courtesy I/O in the system. The power supply circuit used on the BP-4 backplane is shown below.



5VDC Input circuitry on BP-4 (P7)

MOTOR CONNECTORS (P3, P4, P5, P6)



BP-4 Motor Connector P6

I/O CONNECTOR (P9)

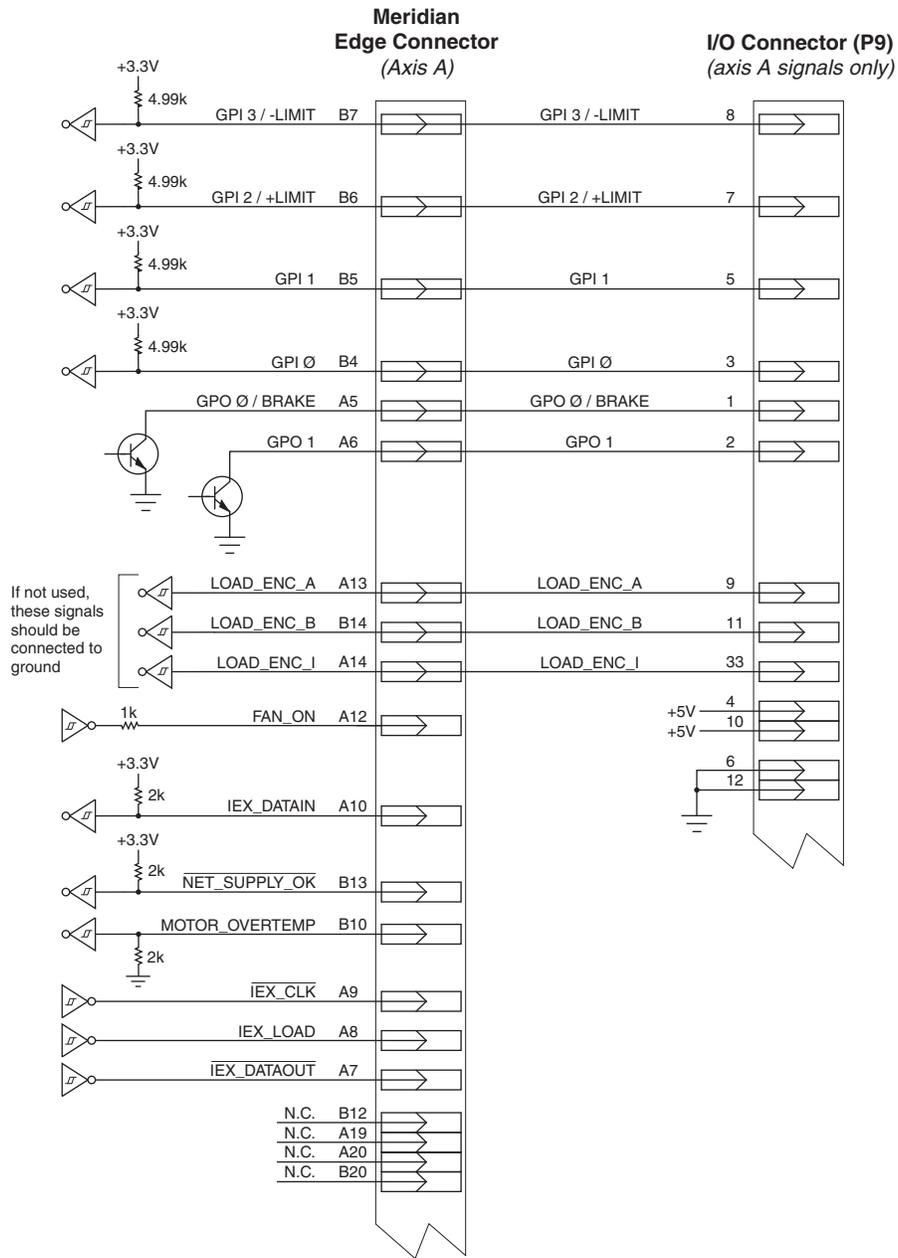
P9 is a 50-pin connector that serves as the I/O interface for all 4 axes on the BP-4. When referring to the pinout table below, note that the axis designation (A, B, C, or D) is represented by the first character in the signal name. For example, B_GPO1 is *GPO1 on axis B*. The table below is color coded by axis for greater ease of use.



Note: On the BP-4, the set of I/O signals sent to each axis is not the same in all cases. This is due to the design intent of the BP-4 as a demonstration and test backplane for the Meridian ISC “B” product line. The most notable similarities/differences:

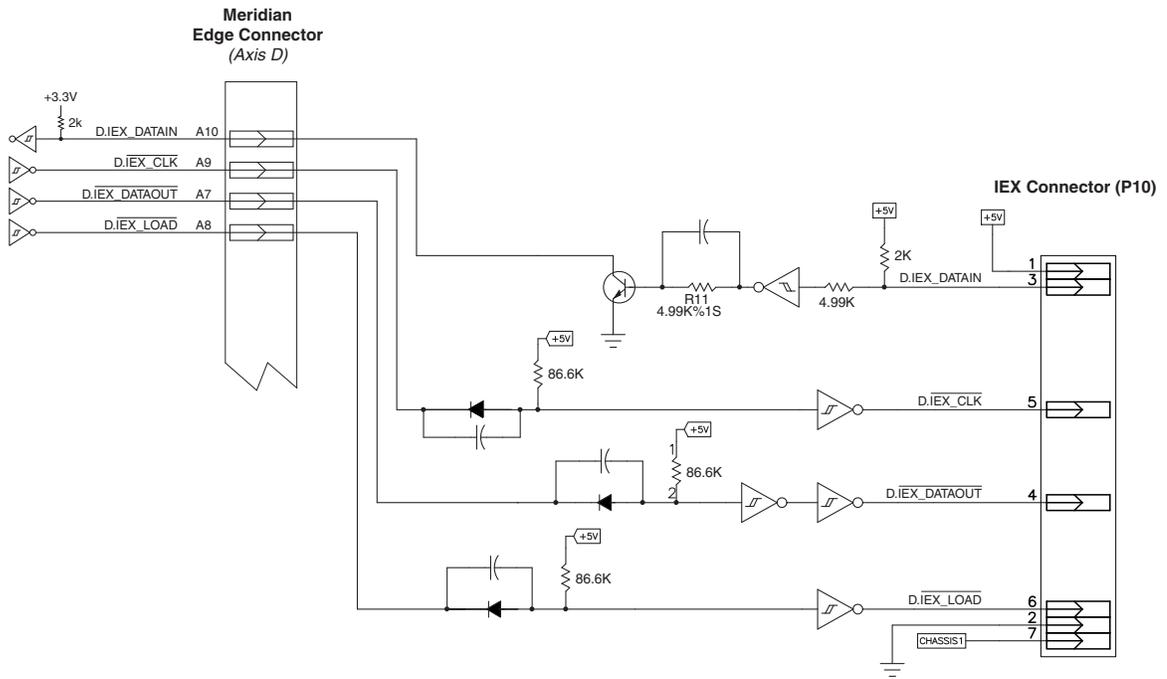
- Axis A and B use the same complement of I/O signals
- Axis C and D do not support secondary/load encoder feedback
- Axis C includes support for expanded external I/O

Pin	Signal	Pin	Signal
1	A_GPO0 /BRAKE	26	C_GPO1
2	A_GPO1	27	C_GPI0
3	A_GPI0	28	+5VDC
4	+5VDC	29	C_GPI1
5	A_GPI1	30	GND
6	GND	31	C_GPI2 /+LIMIT
7	A_GPI2 /+LIMIT	32	C_GPI3 /-LIMIT
8	A.GPI3 /-LIMIT	33	A_LOAD_ENC_I
9	A_LOAD_ENC_A	34	+5VDC
10	+5VDC	35	B_LOAD_ENC_I
11	A_LOAD_ENC_B	36	GND
12	GND	37	D_GPO0 /BRAKE
13	B_GPO0 /BRAKE	38	D_GPO1
14	B_GPO1	39	D_GPI0
15	B_GPI0	40	+5VDC
16	+5VDC	41	D_GPI1
17	B_GPI1	42	GND
18	GND	43	D_GPI2 /+LIMIT
19	B_GPI2 /+LIMIT	44	D_GPI3 /-LIMIT
20	B_GPI3 /-LIMIT	45	C_IEX_CLK.5~
21	B_LOAD_ENC_A	46	+5VDC
22	+5VDC	47	C_IEX_DATAOUT.5~
23	B_LOAD_ENC_B	48	GND
24	GND	49	C_IEX_LOAD.5~
25	C_GPO0 /BRAKE	50	C_IEX_DATAIN.5



BP-4 I/O signals for Axis A (see pinout table for complete listing)

IEX CONNECTOR (P10)



IEX connector with schematic fragments

APPENDIX A: MERIDIAN ISC SPECIFICATIONS

ISC-M255-xBx Specifications		
GENERAL	Dimensions, in (mm):	4.5 (114.3) x 3.25 (82.6) x 1.22 (31.0)
	Weight, oz (g):	5.0 (142)
ENVIRONMENTAL	Temperature:	0-40°C
	Humidity:	0-90%, non-condensing
COMPLIANCE	Electrical safety:	EN 61010, UL508C
	EMI:	EN 61326
	Machine safety:	EN 954-1, with proper power control
FORCED AIR COOLING	Optional	
OUTPUT POWER	Peak Current:	16A
	Continuous Current:	4A RMS
	PWM ripple frequency:	28kHz, center balance vector type
	Conversion Efficiency:	>99%
COMPENSATOR	TSPD:	35 μ S
	Position/Velocity control:	Enhanced PIV with proprietary velocity, acceleration and jerk estimators, Inertia Matching Technology (IMT), Regressive AutoSpline (RAS) and Anti-Hunt. Provides velocity, acceleration, jerk, and friction feed-forward gains
	Torque control:	Synchronous vector with DQ decoupling, SmartSaturation, and auto calibration
ENCODER	Interface:	Primary: Single-ended or differential, user selectable
	Features:	Bad sequence detection, digital filtering adjustable from 100kHz to 40MHz
MOTOR COMPATIBILITY	Requirements:	Rotary brush or 3-phase brushless rotary/linear motor
HALL SENSOR INPUTS	Specifications:	5k Ω pull-up to +5V
	Features:	Digitally filtered; used for setting torque vector upon initialization only; drive can also operate in Hall-less mode
DEDICATED INTERFACE INPUTS/OUTPUTS	Interface:	5k Ω pull-up to +3.3VDC; digitally filtered
	Outputs:	Two (2) general purpose, open-collector outputs; an additional 32 outputs can be made available via the IEX port (ruggedized SPI interface)
	Inputs:	Four (4) general purpose, Schmitt-triggered inputs; two may be configured as dedicated limit-switch inputs; one input may be configured for high-speed encoder capture; an additional 32 inputs can be made available via the IEX port (ruggedized SPI interface)
PROTECTION & SAFETY FUNCTIONS	Drive protection:	Short circuit (phase-to-phase, phase-to-ground), over temp, over voltage, over current, protected for open windings, fused.
	Motor protection:	True RMS torque limiting, automatic speed limit, motor jam detection, over temp
	Mechanical safeguards:	Hardstop detection, limit switch servoing, adjustable tracking error limits and shutdown thresholds, adjustable torque and speed limits
	Electrical Isolation:	1.0mm (0.0394")
INPUT SUPPLY	Input voltage/current: Main DC (bus) power supply	24-90 VDC @ Up to 6.75A RMS, 15A peak (application dependent)
	Input voltage/current: 5VDC supply	4.5-5.5VDC@650mA per drive
COUNTRY OF ORIGIN	Manufactured in:	USA

ISC-M295-xBx Specifications		
GENERAL	Dimensions, in (mm):	4.5 (114.3) x 3.25 (82.6) x 1.22 (31.0)
	Weight, oz (g):	5.0 (142)
ENVIRONMENTAL	Temperature:	0-40°C
	Humidity:	0-90%, non-condensing
COMPLIANCE	Electrical safety:	EN 61010, UL508C
	EMI:	EN 61326
	Machine safety:	EN 954-1, with proper power control
FORCED AIR COOLING	Optional	
OUTPUT POWER	Peak Current:	20A
	Continuous Current:	6A RMS
	PWM ripple frequency:	28kHz, center balance vector type
	Conversion Efficiency:	>99%
COMPENSATOR	TSPD:	35 μS
	Position/Velocity control:	Enhanced PIV with proprietary velocity, acceleration and jerk estimators, Inertia Matching Technology (IMT), Regressive AutoSpline (RAS) and Anti-Hunt. Provides velocity, acceleration, jerk, and friction feed-forward gains
	Torque control:	Synchronous vector with DQ decoupling, SmartSaturation, and auto calibration
ENCODER	Interface:	Primary: Single-ended or differential, user selectable
	Features:	Bad sequence detection, digital filtering adjustable from 100kHz to 40MHz
MOTOR COMPATIBILITY	Requirements:	Rotary brush or 3-phase brushless rotary/linear motor
HALL SENSOR INPUTS	Specifications:	5kΩ pull-up to +5V
	Features:	Digitally filtered; used for setting torque vector upon initialization only; drive can also operate in Hall-less mode
DEDICATED INTERFACE INPUTS/OUTPUTS	Interface:	5kΩ pull-up to +3.3VDC; digitally filtered
	Outputs:	Two (2) general purpose, open-collector outputs; an additional 32 outputs can be made available via the IEX port (ruggedized SPI interface)
	Inputs:	Four (4) general purpose, Schmitt-triggered inputs; two may be configured as dedicated limit-switch inputs; one input may be configured for high-speed encoder capture; an additional 32 inputs can be made available via the IEX port (ruggedized SPI interface)
PROTECTION & SAFETY FUNCTIONS	Drive protection:	Short circuit (phase-to-phase, phase-to-ground), over temp, over voltage, over current, protected for open windings, fused.
	Motor protection:	True RMS torque limiting, automatic speed limit, motor jam detection, over temp
	Mechanical safeguards:	Hardstop detection, limit switch servoing, adjustable tracking error limits and shutdown thresholds, adjustable torque and speed limits
	Electrical Isolation:	1.0mm (0.0394")
INPUT SUPPLY	Input voltage/current: Main DC (bus) power supply	24-90 VDC @ Up to 6.75A RMS, 15A peak (application dependent)
	Input voltage/current: 5VDC supply	4.5-5.5VDC@650mA per drive
COUNTRY OF ORIGIN	Manufactured in:	USA

ISC-M355-xBx Specifications		
GENERAL	Dimensions, in (mm):	4.5 (114.3) x 3.25 (82.6) x 1.22 (31.0)
	Weight, oz (g):	5.0 (142)
ENVIRONMENTAL	Temperature:	0-40°C
	Humidity:	0-90%, non-condensing
COMPLIANCE	Electrical safety:	EN 61010, UL508C
	EMI:	EN 61326
	Machine safety:	EN 954-1, with proper power control
FORCED AIR COOLING	Optional	
OUTPUT POWER	Peak Current:	25A
	Continuous Current:	8A RMS
	PWM ripple frequency:	28kHz, center balance vector type
	Conversion Efficiency:	>99%
COMPENSATOR	TSPD:	35 μ S
	Position/Velocity control:	Enhanced PIV with proprietary velocity, acceleration and jerk estimators, Inertia Matching Technology (IMT), Regressive AutoSpline (RAS) and Anti-Hunt. Provides velocity, acceleration, jerk, and friction feed-forward gains
	Torque control:	Synchronous vector with DQ decoupling, SmartSaturation, and auto calibration
PRIMARY AND SECONDARY ENCODER	Interface:	Primary: Single-ended or differential, user selectable Secondary: Differential only
	Features:	Bad sequence detection, digital filtering adjustable from 100kHz to 40MHz
MOTOR COMPATIBILITY	Requirements:	Rotary brush or 3-phase brushless rotary/linear motor
HALL SENSOR INPUTS	Specifications:	5k Ω pull-up to +5V
	Features:	Digitally filtered; used for setting torque vector upon initialization only; drive can also operate in Hall-less mode
DEDICATED INTERFACE INPUTS/OUTPUTS	Interface:	5k Ω pull-up to +3.3VDC; digitally filtered
	Outputs:	Two (2) general purpose, open-collector outputs; an additional 32 outputs can be made available via the IEX port (ruggedized SPI interface)
	Inputs:	Four (4) general purpose, Schmitt-triggered inputs; two may be configured as dedicated limit-switch inputs; one input may be configured for high-speed encoder capture; an additional 32 inputs can be made available via the IEX port (ruggedized SPI interface)
PROTECTION & SAFETY FUNCTIONS	Drive protection:	Short circuit (phase-to-phase, phase-to-ground), over temp, over voltage, over current, protected for open windings, fused.
	Motor protection:	True RMS torque limiting, automatic speed limit, motor jam detection, over temp
	Mechanical safeguards:	Hardstop detection, limit switch servoing, adjustable tracking error limits and shutdown thresholds, adjustable torque and speed limits
	Electrical Isolation:	1.0mm (0.0394")
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	Weight, oz (g):	5.0 (142)
ENVIRONMENTAL	Temperature:	0-40°C
	Humidity:	0-90%, non-condensing
COMPLIANCE	Electrical safety:	EN 61010, UL508C
	EMI:	EN 61326
	Machine safety:	EN 954-1, with proper power control
FORCED AIR COOLING	Optional	
OUTPUT POWER	Peak Current:	30A
	Continuous Current:	10A RMS
	PWM ripple frequency:	28kHz, center balance vector type
	Conversion Efficiency:	>99%
COMPENSATOR	TSPD:	35 μS
	Position/Velocity control:	Enhanced PIV with proprietary velocity, acceleration and jerk estimators, Inertia Matching Technology (IMT), Regressive AutoSpline (RAS) and Anti-Hunt. Provides velocity, acceleration, jerk, and friction feed-forward gains
	Torque control:	Synchronous vector with DQ decoupling, SmartSaturation, and auto calibration
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COUNTRY OF ORIGIN	Manufactured in:	USA

APPENDIX B: GOLDEN RULES OF INSTALLATION

POWER

1. Ground the Meridian backplane (BP-4) to the machine chassis or frame using the four mounting locations positioned between the Meridian Interface connectors (J3-J6) and the motor connectors (P3-P6). Verify that the frame is connected to the machine's Protective Earth Terminal (safety ground).
2. Daisy-chain power through the Meridian ISC power connectors. "Star" power distribution is not required due to the electrical isolation barrier between power and control signals within the Meridian ISC.
3. Use 16-18 AWG gauge wire for power cables.
4. Connect the drive power return (negative lead) to the machine frame or chassis, but *only at the power supply*. Don't run the drive's power return through the machine frame or chassis.
5. As a general rule, the quiescent output voltage of the power supply (i.e. the DC bus voltage) should be no more than 85.0 VDC with all ISC units connected and disabled. If the output is higher than this, change the input or output taps on the power supply transformer to lower the voltage. **Important:** The Meridian ISC units will perform a safety shutdown if the DC bus voltage exceeds 90.0 VDC.

GROUNDING AND SHIELDING

6. Use shielded cable for all control signal connections: the motor's encoder & commutation signals, optional connections and the I/O and limit cables. The encoder and control signal cables should have low capacitance insulation. Low capacitance cable conductors are typically made from polyethylene, foamed polyethylene, Teflon[®], FEP, etc.
7. Do not connect any logic-level signal cable's shield to the machine frame or chassis at any point. Do not hook any isolated control ground to the machine frame or chassis at any location.
8. Don't ground the limit switch circuit to the machine frame or chassis.

MOTOR CABLES

9. Don't allow the encoder cable shield to touch the motor phase shield at any point.
10. Don't hook the encoder cable shield to the motor case. Leave floating.

11. Attach the motor phase shield to motor body (forcer body for linear motors). An all-Teknic system (motor, cable, and drive) does this automatically. Many third-party motors—especially linear motors—do not come with the motor phase shield attached to the motor/forcer. **Note: Failure to follow this step will result in operational problems.**
12. Use heavy gauge shielded cable for the motor phase wiring. Connect the motor phase cable's shield to pin 1 on the Meridian ISC unit's motor connector (this is tied to the drive's case ground).
13. Don't run the motor's commutation signals or thermostat signals (if any) through the motor phase cable at any point.

CABLE MAKING TOOLS & TECHNIQUES

The following guidelines will help minimize cable design and fabrication problems.

GENERAL RECOMMENDATIONS

1. Avoid cables made with hand tools.

Hand crimping tools, when properly selected and used by a skilled operator, make good crimp connections. However, since these tools are expensive, typically \$200 - \$400 each, technicians rarely have the wide variety required to make proper crimps on all of the terminal types and wire sizes they encounter. Unfortunately, it's easy to use the wrong tool and not realize it, or even more likely, to use the wrong tool and think it's "probably OK". These hand tools are awkward, cumbersome to use and often require the operator to master a certain "feel". In addition, these hand tools don't have any built-in quality assurance features.

In certain instances, you may be forced to make a hand crimped cable, for example, when you're in a hurry for a custom length. If you do, be sure that you have the *exact hand tool and die* that the terminal manufacturer recommends (see below), perform a visual inspection to ensure that the insulation is captured in the terminal's strain relief and do a pull test on each connection before inserting it into the connector.

2. Verify that your cable shop has all of the proper tools and equipment.

Use a cable shop that has automated presses for wire termination and make sure they have the proper applicator "heads" (dies) for the exact terminals used. (If they don't, consider buying applicator heads for them). It's strongly preferred that they have presses with automatic "crimp height" checking as this in-process check is the main measure of termination quality. Making this 100% check without requiring human intervention is a key advantage. If they don't have these automatic crimp-height-checking presses, make sure their general procedures include checking the crimp height on first articles and periodically during a run of cables. Under no circumstances should you accept a shop using hand tools.

3. Specify 100% electrical testing of all cables.

Specify that cables and harnesses be 100% electrically tested, preferably with resistance tests. The cable shop should have automated equipment by CableScan, DynaLab, CheckSum, or other vendors for this purpose. The fixture cost for 100% electrical testing is low, ranging from \$0-\$200 per cable assembly, and it's definitely worth it.

4. Be certain that all terminals are properly specified

Check all your terminal specifications carefully. Research all of your drawings and make certain that the terminals specified can accept the necessary wire gauges. Also, look carefully at the insulation diameter range supported by each terminal. If the insulation diameter range on the terminal is incorrect for the wire used, the individual wire strain relief will be compromised and this can lead to premature failure. Make certain

that the plating between mating terminals is the same. Using gold is great, but not if you are mating with tin. Use gold plated terminals with gold plated connectors and tin plated terminals with tin plated connectors to avoid galvanic corrosion.

5. Prepare complete pictorial drawings.

Create drawings that are pictorial in nature (i.e. visually representative of the subject). Include fabrication details such as jacket strip lengths, shield termination details, cable tie locations, marking details, etc. The more call-outs, detail views, and exploded views, the better. Visual communication is critical here. Don't leave the details to the cable shop as "best practices" vary *widely* from shop to shop. Include the complete BOM right on the drawing. Finally, make the end-to-end cable length easy to modify. This may help reduce future drawing effort if you need similar cables of varying length at some point in the future.

A NOTE ON HAND CRIMP TOOLS

When necessary, quality cables can be made with hand tools, provided that manufacturer's guidelines are faithfully adhered to. An excellent web-based resource on this subject is the Molex document [Good Crimps and How to Recognize Them](#), found in the Tech Library section of the Molex website. This collection of crimp-specific reference information includes how to identify good and bad crimps as well as best practices and specifications for crimp techniques and tooling.



Note: Though similar in appearance, each type of crimp terminal requires a specific handset and die set. Failure to use the proper tool, die set, or terminal for the job will result in poor quality terminations and premature cable harness failures.



Note: Cable failures due to poor crimp quality are the most common mode of failure for OEM machine manufacturers and their customers.

APPENDIX C: EDGE CONNECTOR SIGNALS

Pin Pos.	Signal	Pin Pos.	Signal
A1	+5VDC in	B1	BLADE_PRESENT
A2	+5VDC in	B2	GND
A3	GND	B3	GND
A4	GND	B4	GPI0
A5	GPO0/BRAKE	B5	GPI1
A6	GPO1	B6	GPI2/+LIMIT
A7	IEX_DATAOUT~	B7	GPI3/-LIMIT
A8	IEX_LOAD~	B8	TXD1
A9	IEX_CLK~	B9	TXD0
A10	IEX_DATAIN	B10	MOTOR_OVERTEMP
A11	RXD1	B11	RXD0
A12	FAN_ON	B12	NO CONNECT
A13	LOAD_ENC_A	B13	NET_SUPPLY_OK~
A14	LOAD_ENC_I	B14	LOAD_ENC_B
A15	COMM. R-S	B15	COMM. T-R
A16	MTR_IN_I	B16	COMM. S-T
A17	MTR_IN_B	B17	MTR_IN_B~
A18	MTR_IN_A	B18	MTR_IN_A~
A19	DO NOT CONNECT	B19	+5VDC in
A20	DO NOT CONNECT	B20	DO NOT CONNECT
A21	CHASSIS	B21	CHASSIS
A22	Remove Contact	B22	Remove Contact
A23	V- (24-90VDC)	B23	V- (24-90VDC)
A24	V- (24-90VDC)	B24	V- (24-90VDC)
A25	V- (24-90VDC)	B25	V- (24-90VDC)
A26	V- (24-90VDC)	B26	V- (24-90VDC)
A27	DO NOT CONNECT	B27	DO NOT CONNECT
A28	V+ (24-90VDC)	B28	V+ (24-90VDC)
A29	V+ (24-90VDC)	B29	V+ (24-90VDC)
A30	V+ (24-90VDC)	B30	V+ (24-90VDC)
A31	V+ (24-90VDC)	B31	V+ (24-90VDC)
A32	DO NOT CONNECT	B32	DO NOT CONNECT
A33	MOTOR PHASE S	B33	MOTOR PHASE S
A34	MOTOR PHASE S	B34	MOTOR PHASE S
A35	MOTOR PHASE S	B35	MOTOR PHASE S
A36	MOTOR PHASE S	B36	MOTOR PHASE S
A37	MOTOR PHASE S	B37	MOTOR PHASE S
A38	DO NOT CONNECT	B38	DO NOT CONNECT
A39	MOTOR PHASE R	B39	MOTOR PHASE R
A40	MOTOR PHASE R	B40	MOTOR PHASE R
A41	MOTOR PHASE R	B41	MOTOR PHASE R
A42	MOTOR PHASE R	B42	MOTOR PHASE R
A43	MOTOR PHASE R	B43	MOTOR PHASE R
A44	DO NOT CONNECT	B44	DO NOT CONNECT
A45	MOTOR PHASE T	B45	MOTOR PHASE T
A46	MOTOR PHASE T	B46	MOTOR PHASE T
A47	MOTOR PHASE T	B47	MOTOR PHASE T
A48	MOTOR PHASE T	B48	MOTOR PHASE T
A49	MOTOR PHASE T	B49	MOTOR PHASE T

APPENDIX D: BLINK CODES

Meridian Integrated Servo Controllers have two external status LEDs—one green, one red. If a safety shutdown occurs, the status LEDs on the unit will indicate the type of fault that has occurred. Safety shutdowns will fall into two categories:

- 1) **Safety shutdown** (most common) – The green status LED blinks to indicate an error condition. In this case, the unit is *reporting* a problem, but is not necessarily the cause of the problem. Refer to the table below for recommended actions.
- 2) **Hardware failure shutdown** – The red status LED blinks with a 50% on, 50% off blink pattern. In this case, the unit has experienced a hardware failure and must be returned for repair or replacement. Contact Teknic for warranty information and return/repair instructions.

Note: Red Status LED



During normal operation, the red status LED will pulse briefly only during power up, reset, and power down. If the red LED is on or blinking at any other time, the Meridian hardware is damaged and should be returned to Teknic for service.

Green LED	Status	Description	Troubleshooting Information
Rapid Blink	Servo power stage is enabled	The unit is actively servoing	No problem
Solid On	The unit is ready, but servo power is not enabled	The unit is not enabled and not shutdown	No problem. Enable unit to engage servo power stage.
Slow Strobe (LED mostly off)	Unit not initialized	The host computer has not yet initialized the unit	Re-initialize the system from the host computer
Toggle	Error	An error condition is active	Query the unit from the host computer to determine the error condition.
Reverse strobe (LED mostly on)	No bus power present	The main DC bus (servo power) is not present	Check DC bus power supply, contactor or fusing for problem

APPENDIX E: SIZING A POWER SUPPLY

SIZING A POWER SUPPLY

The following calculations will help you determine the power supply requirements for a Meridian ISC operating under various loading from an arbitrary supply voltage with any motor. In actual practice, these calculations may be difficult to apply due to varying duty cycles, loads and machine sequences. Often the best way to size a supply is to run your machine while measuring the RMS current between the bridge rectifier and transformer with the RMS filter in your ammeter set to 10 seconds or more. The transformer is then sized so that its RMS limit is not exceeded.

CALCULATING PEAK CURRENT REQUIREMENT

To calculate peak supply current demand from any Meridian ISC unit you need to know three things: [1] the supply voltage (V_s), [2] the phase to phase resistance of the motor (R_t), and [3] the peak shaft power (S_{pmax}) in Watts available from the motor when the Meridian ISC is supplied by V_s .

The peak current demand (I_{smax}) for brushless motors is then:

$$I_{smax} = \frac{[0.75I_p 2R_t + S_{pmax}]}{V_s},$$

where I_p is the maximum current output of the Meridian ISC.

Peak shaft power of a vector driven brushless motor is highly dependent upon the inductance of the motor, the number of motor poles, supply voltage, drive peak current and the winding resistance. It cannot, in general, be easily calculated. Worst case peak shaft power values have been pre-calculated and verified for Teknic standard motors when operated with a 75V supply and you should use these in figures your calculations. If you are using a custom motor or a different supply voltage, contact Teknic for an estimate of the peak shaft power that will be produced using a Meridian ISC.

PEAK CURRENT WHEN USING LESS THAN FULL OUTPUT

If you are planning on using the motor at a peak speed below the speed at which maximum power is produced and/or if you plan to limit the torque to some value (T_p) less than the peak rated torque (T_r), then calculate S_{pmax} and I_p as follows for use in the I_{smax} formula above:

$$S_{pmax} = \frac{T_p V_{max}}{1352}, \text{ and}$$

$$I_p = \frac{23T_p}{T_r}$$

where V_{max} is the maximum speed in RPM.

CALCULATING RMS CURRENT REQUIREMENT

The RMS current demand from the supply is dependent upon the application type. Two sets of calculations are provided below. If the application is for incremental positioning, as in a "pick and place" machine, then calculation method (1) or (1A) should be used. If the application is a continuous velocity type, such as running a conveyor, then calculation method (2) should be used¹.

1. INCREMENTAL POSITIONING APPLICATIONS

If the application is incremental positioning, then we assume that the torque is being used primarily to accelerate the motor and load from zero to a maximum speed and then to decelerate it back to zero speed again.

We can also assume that the current used to decelerate the load is not drawn from the supply (part of it is actually pumped back into the supply during deceleration). Given this assumption, the maximum RMS current demand from a Meridian ISC is:

$$I_{RMS} = \sqrt{\frac{tdc}{2} \left[\left(S_{p\max} + \frac{3}{4} I_p^2 R_t \right)^3 - \left(\frac{3}{4} I_p^2 R_t \right)^3 \right]} \quad 3V_s^2 S_{p\max}$$

where tdc is the torque duty cycle defined as:

$$tdc \equiv \frac{\text{torque on time}}{\text{torque on time} + \text{torque off time}}$$

Torque on time should not be confused with the running time of the motor. It is the time that torque is being used to accelerate or decelerate the motor and can be a small portion of the running time when trapezoidal velocity move profiles are used. (It is equivalent to the motor running time when only triangular velocity type move profiles are used.)

tdc can be a maximum of 0.15 for a Meridian ISC that uses full output torque to accelerate and decelerate the load (at this duty cycle the output current is 9A RMS which is the rated limit of the Motor connector). You should attempt to estimate tdc for your application if possible, otherwise use 0.15 as a conservative estimate if you plan to use the full output torque capability for acceleration (although this will probably cause you to over-specify your supply requirements).

1A. INCREMENTAL POSITIONING WITH REDUCED OUTPUT

If you are planning on using the motor at a peak speed below the speed at which maximum power is produced and/or if you plan to limit the torque to some value (T_p) less than the peak rated torque (T_r), then calculate $S_{p\max}$, I_p and tdc_{\max} as follows:

$$S_{p\max} = \frac{T_p V_{\max}}{1352},$$

¹ CNC cutting type applications usually are a hybrid of both incremental positioning and constant velocity applications so the higher of the two calculated RMS current figures should be used to determine the worst case maximum RMS current.

$$I_p = \frac{23T_p}{T_r}, \text{ and}$$

$$tdc_{\max} = \min \left[1, \left(\frac{9T_r}{23T_p} \right)^2 \right]$$

where V_{\max} is the maximum speed in RPM.

Now use these I_p , and $S_{p\max}$ values and your estimate of tdc to calculate I_{RMS} using the formula above. If you can't estimate tdc in your application then use the tdc_{\max} calculated above as a conservative estimate (although this will probably cause you to over-specify your supply requirements).

2. CONTINUOUS VELOCITY APPLICATIONS

If the application is for a continuous velocity application such as running a conveyor at some constant speed (V_{cont}) then we assume that the drag load (T_d) is predominant. For these applications you can calculate the RMS supply current required based upon the continuous output power as follows:

$$I_{RMS} = \frac{[0.75I_c 2R_t + S_{p\text{cont}}]}{V_s},$$

where:

$$S_{p\max} = \frac{T_p V_{\max}}{1352}, \text{ and}$$

$$I_p = \frac{23T_p}{T_r}$$

APPENDIX F: FORCED AIR COOLING

Forced air cooling may be required for certain Meridian models operating at or near continuous RMS rating for extended periods of time.

Ways to reduce the need for forced air cooling:

- Design cabinet ventilation that supports good convection cooling
- Reduce move acceleration and duty cycle
- Mount the drives where the ambient air temperature is lowest (usually close to the floor)

Tip: Care should be taken during the machine design and engineering phases to ensure that Meridian drives remain cool enough *under worst case operating conditions* to prevent protective thermal shutdowns.

IS FORCED AIR COOLING NECESSARY?

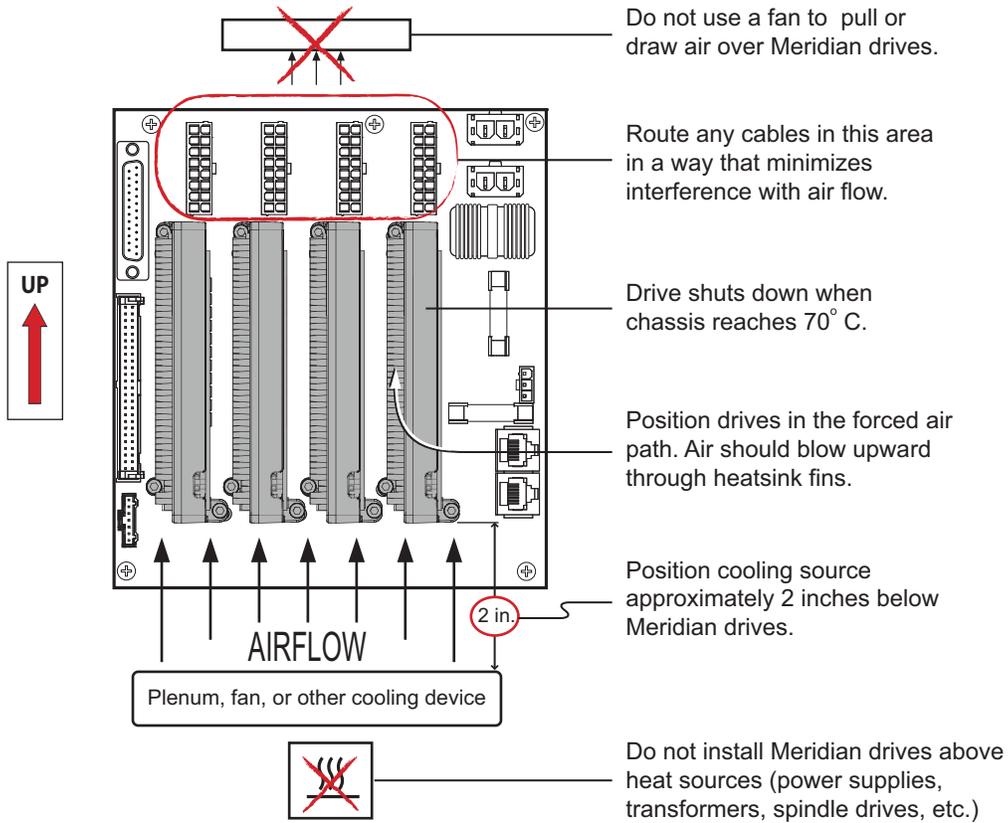
Actual cooling requirements vary from application to application due to differences in control cabinet design, local ambient temperature, and motion profiles. So it's not always clear when additional cooling is needed.

The table below shows which models are more likely to require forced air cooling. In particular, the ISC-M375, when operating at or near its peak continuous current (10A) for extended periods will likely require forced air cooling; the ISC-M355 on the other hand will likely not need forced air cooling.

Model #	Max. Continuous Current (Amps RMS)	Will forced air cooling be required when run @ Max. Continuous Current?
ISC-M375-xBx	10A (RMS)	UNLIKELY  LIKELY
ISC-M355-xBx	8A (RMS)	UNLIKELY  LIKELY
ISC-M295-xBx	6A RMS	UNLIKELY  LIKELY
ISC-M255-xBx	4A RMS	UNLIKELY  LIKELY

Note: A Meridian ISC will automatically shut down when its chassis temperature exceeds 70 C. This is a protective measure that does not indicate a failure of the device itself. The ISC will operate properly again when chassis temperature returns to the normal operating range.

MOUNTING DIAGRAM FOR FORCED AIR COOLING



Mounting orientation and direction of airflow for forced air cooling installations

Teknic Incorporated
115 Victor Heights Parkway
Victor, NY 14564

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