



INSTALLATION GUIDE

EF-785 POWER DISTRIBUTION AND SAFETY CONTROL CENTER

VERSION 1.42 / AUGUST 26, 2005

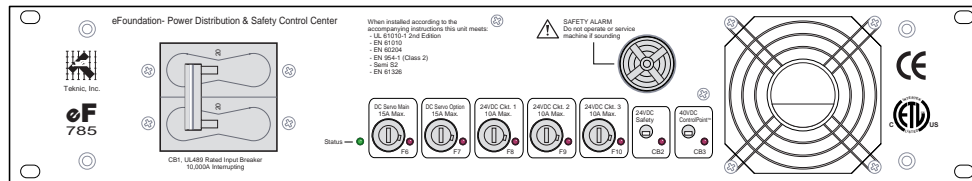
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eF-785 OVERVIEW

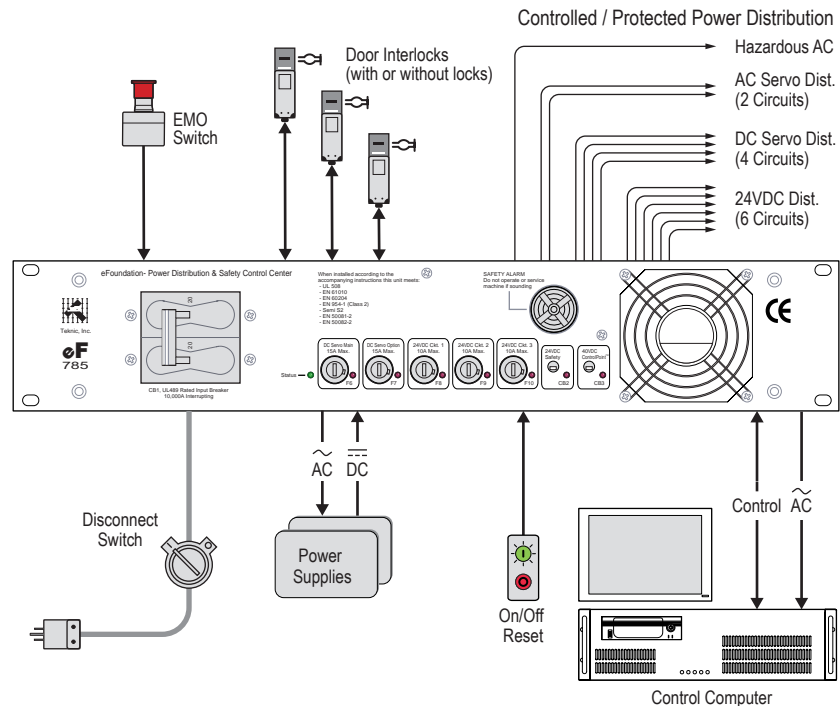
The eF-785 is Teknic's patented power distribution and safety control center, for use in OEM automated machinery. The "eF" designation stands for "Electrical Foundation", an appropriate description as the eF-785 consolidates nearly all of the required safety, power management and distribution functions required in an automated machine into one easy-to-integrate box.



eF-785 Power Distribution and Safety Center (front panel pictured)

Experienced machine designers know that successfully complying with the myriad of complicated, often ambiguous compliance standards, means spending laborious hours working on the electrical distribution, control, and safety circuits *before compliance testing can even begin*. Purchase the eF-785, and most of that work is already done. The eF-785 provides all of the critical "foundation" functions you need in a pre-tested, value priced, off-the-shelf assembly. Though these functions do not, typically, provide the OEM with a huge *differential* advantage, the eF-785, properly implemented, will reduce your engineering burden, assure that safety and compliance standards are met with a minimum of hassle, and speed your product to market.

Time after time our field engineers have come back to report a product rollout hampered or delayed by oversights and last minute testing and rework of these critical circuits. As a direct result of these observations, Teknic set out to build a better solution for our OEM customers. The eF-785 is that solution. It's the all-in-one answer to your machine's power distribution, safety and control requirements. It's economical, easy to integrate, and can greatly improve your machine production time. Why reinvent the wheel when you can join a growing number of customers who call the eF-785 *Compliance in a Box™*.



eF-785 Simplified Context Diagram

As shown in the context diagram above, the eF-785 manages a number of critical functions in your machine including:

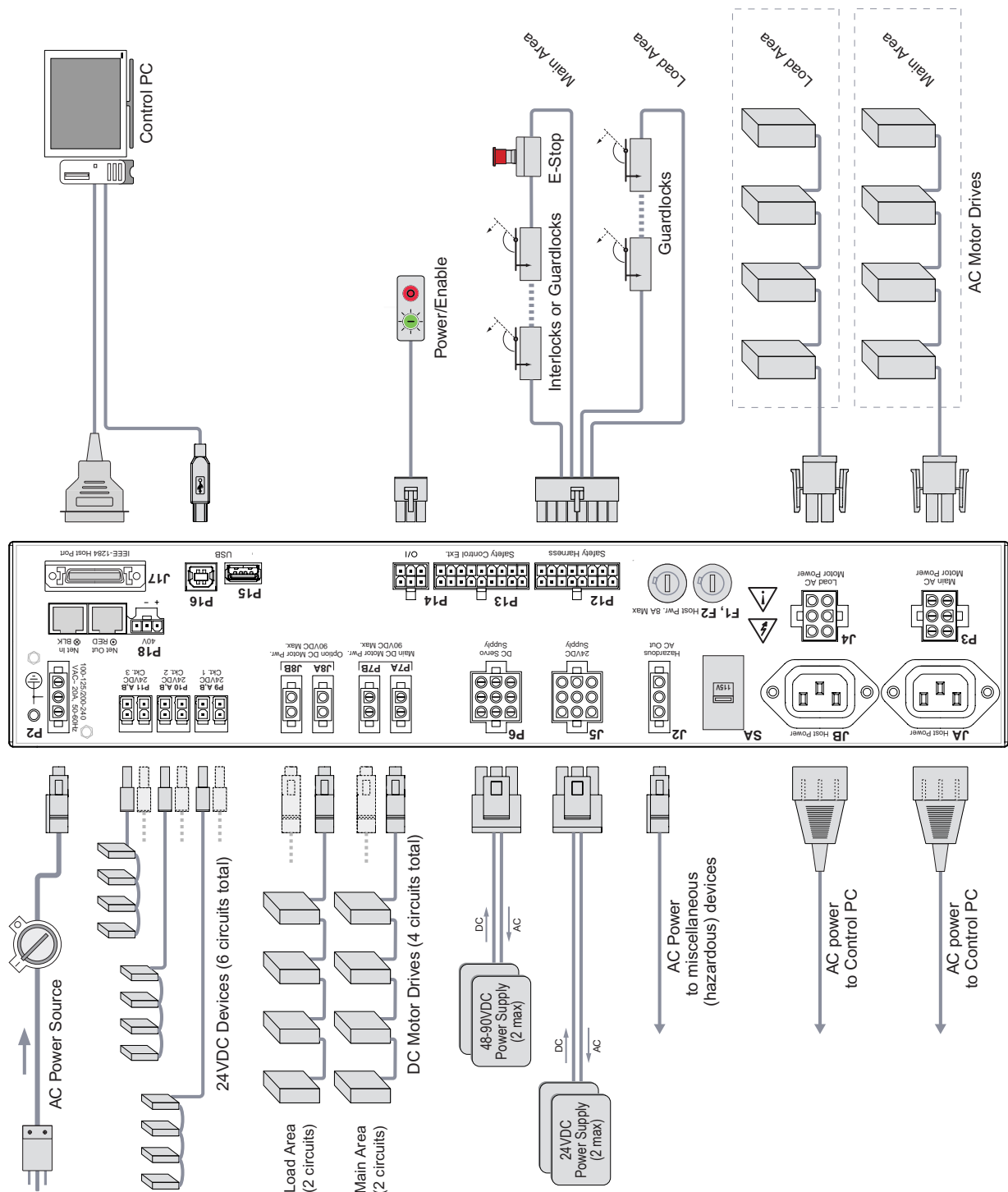
- Power control
- Power sequencing
- Safety disconnect
- Over-current protection
- Safety guard lock control/interlocks
- Regenerated power dissipation
- Conducted EMI filtering

In fact, creating a complete machine power system based on the eF-785 requires only a comparatively small amount of work. And, if you follow the installation instructions in this manual, your machine's power control system will meet US, European and world standards for electrical and machine safety, including EN 954-1, EN 60204, EN 61010 and Semiconductor safety standards SEMI S8 and S2.

The eF-785 can easily manage the power control requirements of a "two-area" (segmented) machine. This type of machine features a Main Area and an operator accessible Load/Unload Area, each under separate control. The eF-785 allows a machine operator to safely disable hazardous power to the Load/Unload Area while the Main Area of the machine continues core processing operations. Your customers will appreciate the greater machine throughput this affords them.

The eF-785's power-disconnect and safety control is fully compliant with EN-954-1 (required for compliance with the CE Machinery Directive). This hazardous power-disconnect is fully single fault tolerant to component and machine wiring faults and is monitored to detect any

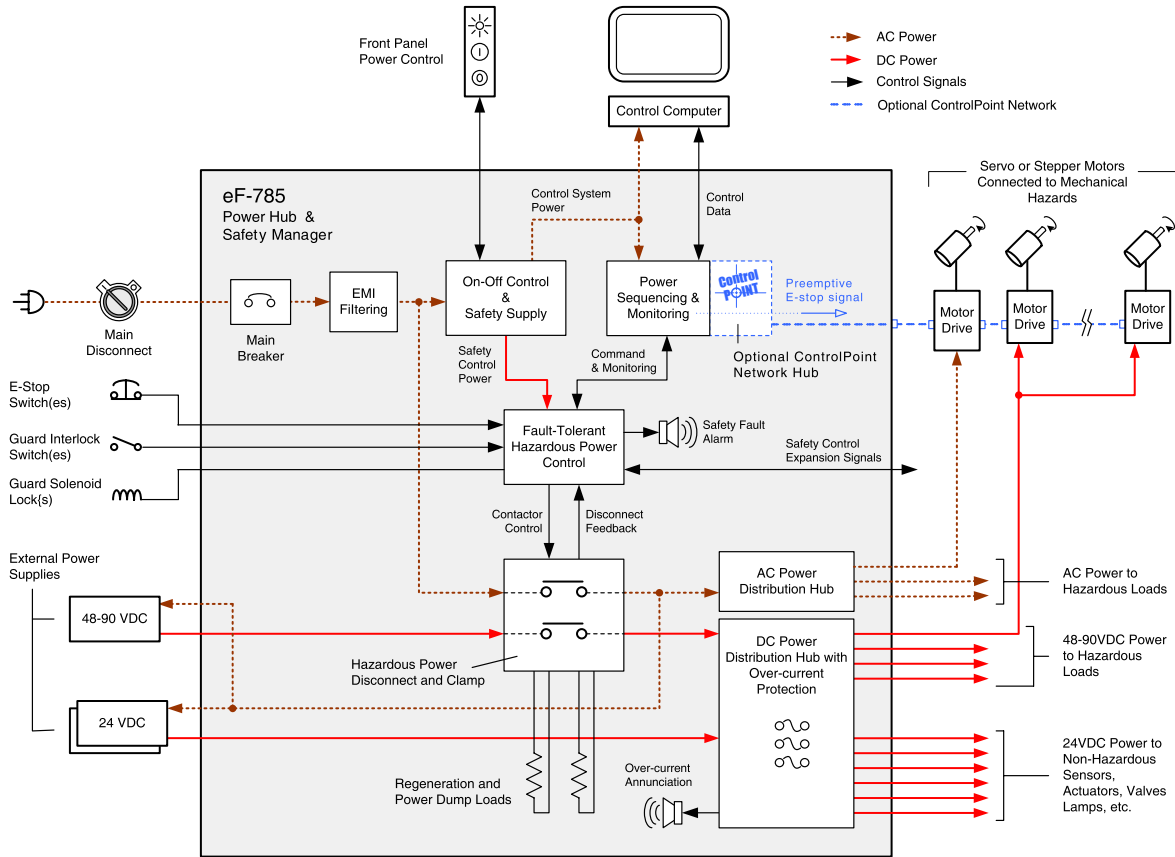
single fault. You won't need any additional safety control components (safety relays or controllers) when using the eF-785.



Hooking up the eF-785

...Plus, if you need to control more than 4KVA of power, use 3-phase power, or if your machine has other hazards you'd like the eF-785 to manage, you can extend the system's capabilities by utilizing the eF-785's safety control and feedback signals. These signals are readily available on the rear panel connector, P13. Learn how to do this in the *Extending the System* section of the manual.

Another handy feature, the Soft Shutdown, allows the operator to power up the control computer from the machine's front panel On/Off switch and automatically shut off power to the machine after the control computer has completed its shutdown process.



Safety and Compliance highlights in the eF-785

EF-785 BENEFITS

- Significantly reduces electrical system design, integration and debug effort, reducing time to market
- Eases wiring requirements, lowering total machine costs
- Integrates numerous functions in one compact enclosure, supporting a smaller machine footprint
- Speeds compliance inspection and testing of a machine for:
 - **EMC** (electromagnetic compatibility),
 - **Machine Safety** (mechanical hazards)
 - **Electrical Safety** (shock and fire hazards)

- Significantly reduces the risk of failure during machine testing, making your product launch more predictable
- Features a monitoring function to help pinpoint wiring errors in the safety control system during integration and assembly
- Allows for controlled motor stopping during an Emergency Stop, minimizing wear and tear on the machine
- Virtually eliminates intermittent connections within e-stop switches and contactors via proprietary wiring

EF-785 SAFETY FEATURES

SEGMENTED MACHINE SUPPORT

The eF-785 can be configured so that AC power to mechanical hazards is controlled independently in two different functional areas of a machine. This means that an operator can easily power down the mechanical hazards in one part of a machine (Load Area) while the Main Area of the machine continues to process material, samples, etc, allowing an operator to feed and retrieve material from the machine while it continues to do useful work. This can result in a significant, demonstrable throughput advantage on many automated machines.

GUARD-LOCK CONTROL

The eF-785 has specific outputs that control any installed guard-locks that open guard doors when hazardous power is removed from a given machine area. These guard-locks are controlled by user software *and* electromagnetic logic control. To open guardlocks, two things must occur: 1) the user software must issue an “open guardlock” request and 2) removal of hazardous power must be confirmed by the electromagnetic logic control.

AUTOMATIC SAFETY SYSTEM CHECKOUT

The monitoring systems within the eF-785 perform several functions: they monitor the e-stop and interlock switches (and wiring) for faults, continuously check the contactors for the proper electromagnetic status of the hazardous power and guard-lock power. In the event that the monitoring system detects any errors during operation, it reinforces the removal of power (which is enforced by the electromagnetic logic control) and reports the errors to the host computer.

The eF-785 has two important safety diagnostic functions. One function forces the user to perform a safety test of the e-stop and interlock switches at each power-up cycle. Periodic checking of these switches is required by EN 954-1 and this mechanism makes the procedure automatic. This function removes the requirement for writing and enforcing periodic inspection procedures and attaching placards or writing custom software to instruct operators. This function can be disabled during machine development.

The eF-785 firmware also maintains data on the complete state of the safety control system just before and after a fault is detected. This information can help pinpoint the fault to a few possible failures, speeding up root cause identification.

CONTROLLED STOPPING FUNCTION (CONTROLPOINT™ ONLY)

The eF-785 can act as a network hub for connecting Teknic's open ControlPoint™ networked motion and I/O control nodes. These nodes can control servomotor or stepper motor axes. When using the eF-785 with ControlPoint™ components in charge of the motion control, controlled stopping of the motion axes within a machine can be automatically initiated by the eF-785 when a safety shutdown occurs. This, combined with the eF-785's hazardous power disconnect delay function, forces the axes to a smooth controlled stop (in the fraction of the second before power removal) during an E-Stop, interlock open and most other safety shutdown events. This typically saves the material in process, reduces wear and tear on the machine, and generally increases the perceived quality of the machine by the customer.

INTEGRATION STEPS AT A GLANCE

Create a complete power & safety system for your machine using the eF-785 by following these simple steps:

1. Complete a risk assessment of your machine hazards, and then select guard-locks or interlocks for guarded areas.
2. Select the eF-785 configuration options that fit your machine requirements.
3. Mount the eF-785.
4. Select and connect the external 24VDC power supplies and devices to the eF-785. Example cables are shown in Appendix C of this manual.
5. Select and connect the external DC motor power supplies and DC motors to the eF-785. Example cables are shown in Appendix C of this manual.
6. Connect AC powered servo drives. Example cables are shown in Appendix C of this manual.
7. Connect any other AC loads.
8. Connect incoming AC power, and if required, an incoming power disconnect switch.
9. Connect the embedded control computer to the eF-785 using off-the-shelf cables (modular power cord, USB cable, IEEE-1284 cable).
10. Mount the machine's on-off switch(es) and connect them to the eF-785. An example cable including recommended switches is shown in Appendix C of this manual.
11. Mount the safety system components (e-stop switches, interlock switches and/or guard locks) and connect them to the eF-785. You will find recommended devices for all of these components in this manual.
12. *Optional:* Connect Teknic ControlPoint™ motion and I/O components via standard Category 5 patch cables.

This manual contains all of the instructions you'll need to complete each of these tasks quickly with a minimum of research, while meeting all of the required safety standards.

Within the manual you'll find many detailed drawings, illustrations and schematics created with you, the OEM Machine Manufacturer, in mind. Our objective is to provide you with all of the information you need to successfully visualize, integrate and install the eF-785 in your machine. To that end we've included a complete set of cable drawings, each with a comprehensive bill of materials. Additionally, we've researched, tested and recommended a number of critical components including switches, interlocks and guard-locks.

INTEGRATION STEPS

STEP 1: COMPLETE A RISK ASSESSMENT AND SELECT GUARD-LOCKS OR INTERLOCKS FOR GUARDED AREAS

EN1050 RISK ASSESSMENT

For each risk in your machine you must perform a risk assessment according to the EN 1050 standard. Naturally, you should acquire a copy of the EN 1050 standard and follow it to accomplish this. The results of this risk assessment will help you determine the appropriate level of safety control system required per EN 954-1 (levels B, 1, 2, 3 or 4) for each hazard. The eF-785 can meet levels B,1,2, and 3. Therefore, in order to use the eF-785 as a “stand-alone” safety control center, none of the hazards in your machine can exceed EN 954-1 level 3 requirements.¹

SELECT GUARD-LOCKS OR INTERLOCKS (FOR EACH GUARDED HAZARD)

IMPORTANT: You should read **Appendix A of this manual: “Meeting the EU Machinery Directive for CE Compliance”** to ensure your machine meets certain requirements. If your machine meets the assumptions described in Appendix A, you can follow the rules below for selecting between interlock switches (which simply indicate the open/closed state of a guard) and guard-lock switches (which are interlock switches with physical solenoid-driven locking devices):

You can use interlock switches (without locks) on guards in the Main area of your machine when:

- a. The hazards are such that the EN 954-1 assessment concludes that they require a level B, 1, or 2 safety control system,

or

- b. when the guards are clearly marked as containing hazards behind them and the guard can only be opened with a tool or key.

Guard-locks must be used if the hazards are such that the EN 954-1 assessment concludes that they require a level 3 safety control system. Guard-locks may be required in some areas while only interlocks may be required in others. See Appendix A for more details.

In the Load area of your machine, guard-locks (interlock switches with power-off locks) must always be used, regardless of the types of hazards.

If you are unsure where to use guard-locks vs. interlocks you can safely elect to use guard-locks in all positions as they offer superior safety qualities. This will provide you with an additional method of control over user access, often advantageous for other operational reasons.

¹ It's usually possible to extend the eF-785 with external components to meet EN-954 level 4 compliance but that topic is beyond the scope of this manual. It's often easier to reduce the hazards in the machine to lower the required level of the safety control system, by eliminating pinch points, having mechanical interlocks with guards, etc.

STEP 2: SELECT EF-785 CONFIGURATION OPTIONS

Now it's time to specify your eF-785. For this task you should know a few things:

1. Your machine's operational and power requirements
2. The definitions of a few key terms used in this section
3. The available options from which to choose
4. How to "build" a valid eF-785 part number

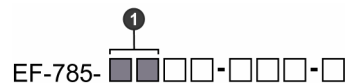
Assuming that your machine requirements are known, we will proceed into an explanation of the definitions, available options, and how those options are expressed as a part number. The objective here is to give you the information necessary to understand, specify, and order the eF-785 that will best meet your project requirements.

DEFINITIONS

Please read the following definitions before proceeding:

Segmented Machine	A machine that has more than one work processing area. A segmented machine is one that is designed to allow an operator to safely load or unload raw or finished product in one (Load) area while main processing activities continue undisturbed in another (Main) area under separate power and safety control.
Main Area	The main functional area of an automated machine. The Main Area is typically where the core processing work of the machine is performed. All machines have a Main Area; whereas, segmented machines may have both a Main and a Load area.
Load Area	A specific section of a segmented machine, separate from the Main Area. The Load Area is typically a secondary area of a segmented machine such as an operator Load/unload access area. It is often advantageous from both a machine throughput and safety standpoint to operate the Load Area under separate power and safety control from the Main Area. The eF-785 is designed to support this.

1 POWER CONTROL OPTIONS



The eF-785 offers you several options as to how you distribute power to AC and DC servo or stepper motor drives in your automated machine. Not only can you power multiple AC and/or DC motor drives simultaneously through the eF-785, but you can control the flow of power to these drives in two separate areas of your machine (Main and Load Area) under separate safety and power control. This flexibility provides you with an easy way to create a segmented machine (defined on the previous page) that offers several advantages in terms of safety and throughput to your end user.

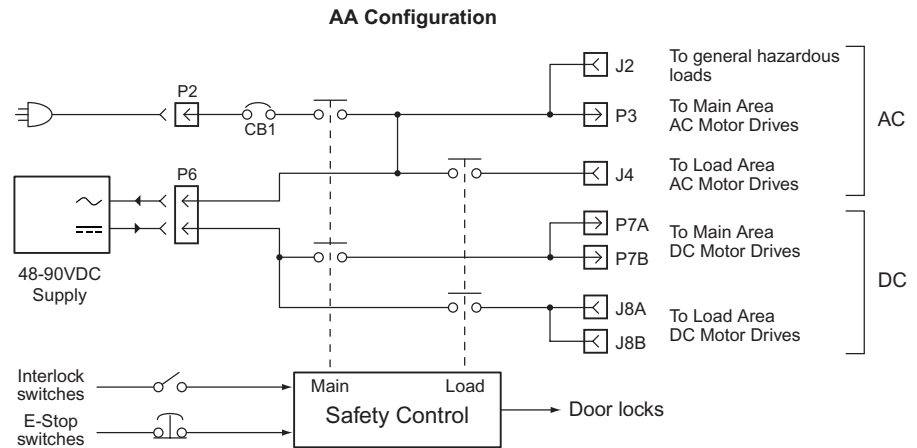
In this section we will describe the available power control options for the eF-785, illustrating each with a small schematic diagram. Below is a brief table summarizing the available options and the appropriate code to use when ordering.

eF-785 Motor Drive Power Options

	Main Area	Load Area	Option Code
Single-area Machine	DC powered drives	None	DN
	AC or [AC <i>and</i> DC] powered drives	None	AN
Segmented Machine	DC powered drives	DC powered drives	DD
	AC or [AC <i>and</i> DC] powered drives	DC powered drives	AD
	AC or [AC <i>and</i> DC] powered drives	AC or [AC <i>and</i> DC] powered drives	AA

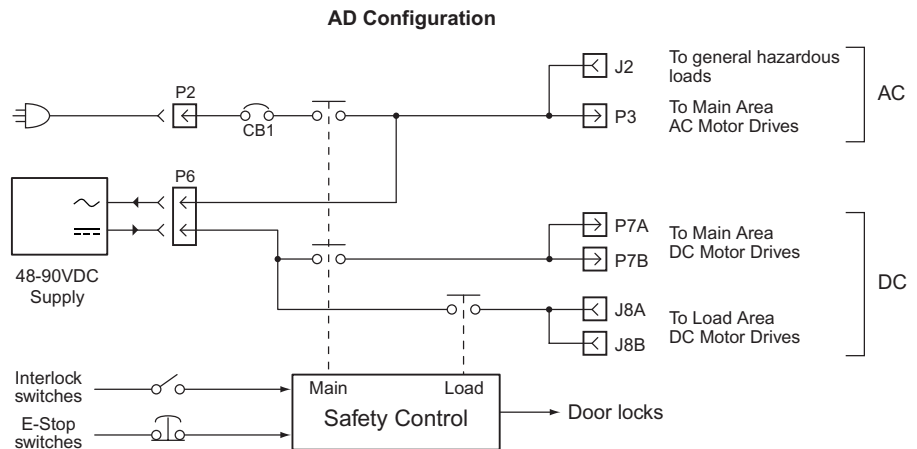
AA- This is the most versatile of the 5 power control options. The AA model leaves all of your design options open. It supports both AC and DC powered motor drives in the Main Area, and both AC and DC powered motor drives in the Load Area. Example part number:

EF-785-AAxx-xxx-x



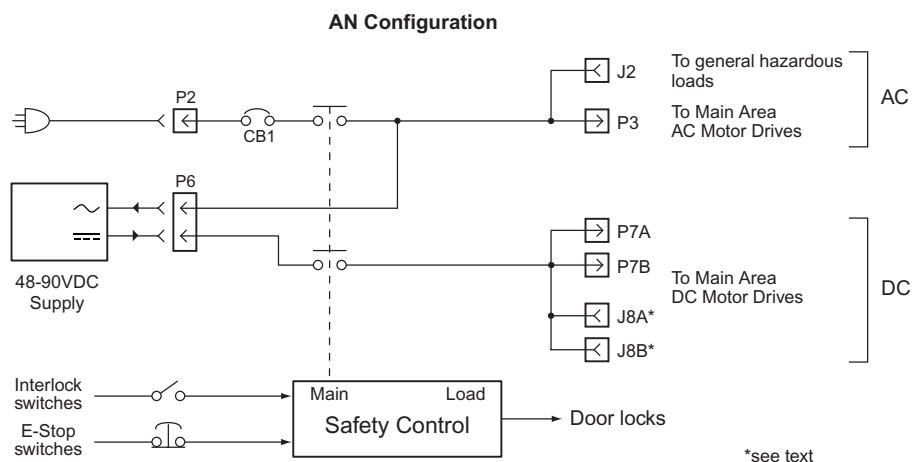
Simplified power flow schematic-AA

AD- The AD model supports AC and DC powered motor drives in the Main Area, and DC powered motor drives in the Load Area. Example part number: **EF-785-ADxx-xxx-x**.



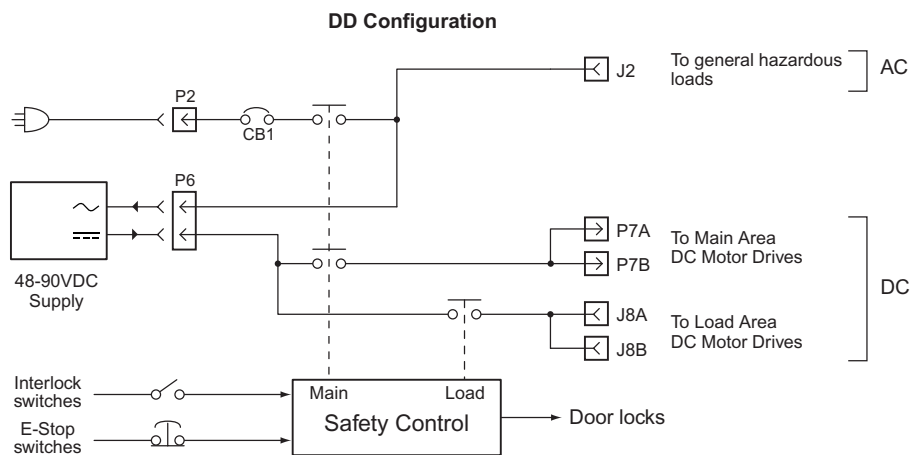
Simplified power flow schematic-AD

AN- The AN configuration supports AC and DC powered motor drives in the Main Area, but no Load Area drives. In the AN configuration, the J8 circuits, normally reserved for Load Area functionality, may be used as additional Main Area circuits. Example part number: **EF-785-ANxx-xxx-x**.



Simplified power flow schematic-AN

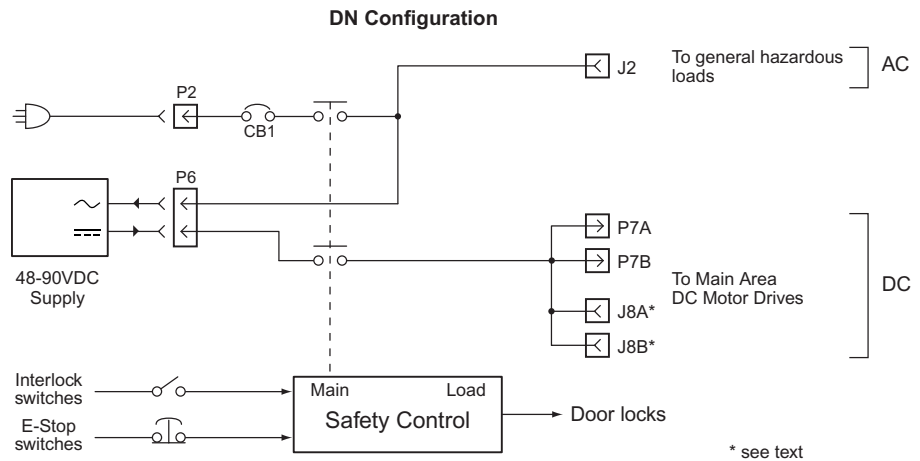
DD- The DD configuration supports DC powered motor drives in the Main area and DC powered motor drives in the Load area. Example part number **EF-785-DDxx-xxx-x**.



Simplified power flow schematic-DD

DN- The DN configuration supports DC powered motor drives in the Main Area only, but no Load Area. In the DN configuration, the J8 circuits, normally reserved for Load area functionality, may be used as additional Main Area circuits. Example part number:

EF-785-DNxx-xxx-x.



Simplified power flow schematic-DN

PURCHASING A UNIT FOR DEVELOPMENT

For the purposes of machine design and development, Teknic recommends that you initially order the **AA** configuration. This leaves your design options open (the **AA** configuration can do the work of any of the other four power configurations). Once your machine design is stable, order only the options you need.

2 EMI FILTERING OPTIONS

EF-785-

The eF-785 offers two available EMI filtering options, two-stage (**D**) and four-stage (**Q**).

TWO-STAGE (DUAL) FILTERING

The basic level of EMI filtering offered for the eF-785 is two-stage (**D**ual) filtering indicated by the letter **D** in the position shown above. The 2-stage option is standard in configurations where only DC powered motor drives are present in the machine (i.e. power control configurations DD or DN). This (lesser) magnitude of filtering is usually sufficient for machines in which there are no AC powered motor drives present.

FOUR-STAGE (QUAD) FILTERING

Quad or four-stage filtering is specified by the letter **Q**. Four-stage filtering comes standard on all eF-785s configured for AC powered motor drives (i.e. power configurations AA, AD, and AN). With this level of filtering, your machine can meet EN 50081-2 and EN 50082-2 for emissions and susceptibility without individual line filters for each servo drive (typically a notable cost savings).

Optionally, 4-stage filtering may be added as an upgrade to DC motor drive configurations if additional EMI filtering is required.

3 CP NETWORK HUB OPTIONS

EF-785- ☐☐☐☒-☐☐☐☐

Using ControlPoint™ components can greatly simplify wiring complexity, reduce integration effort, and decrease the number of assemblies in your machine. Ultimately this will save money and help reduce errors in design and implementation. ControlPoint™ also provides a controlled shutdown function for all connected motor drives when an E-Stop is detected or door interlocks are opened. This works seamlessly with the optional eF-785 Power-Off Delay to provide very controlled machine shutdowns.

This position of the eF-785 part number indicates the presence (C) or absence (X) of the optional Teknic ControlPoint™ network hub and integrated 40V network power supply. If you are currently using Teknic's ControlPoint™ components, you'll quickly realize the benefits of incorporating the CP network hub and 40V network power supply into your eF-785.

If your design does not include the ControlPoint™ hub with 40VDC network power supply, order your eF-785 with an X in the indicated position. With or without ControlPoint™ options, the eF-785 provides excellent power distribution and safety control functionality.

4 POWER-OFF DELAY OPTIONS (MAIN)

EF-785- ☐☐☐☐☒-☐☐☐☐

The eF-785 offers you some options as to how quickly hazardous power is removed from the Main Area of your machine. Q: When can this option be valuable? A: In cases where the sudden removal of power from a motor axis could cause significant (read expensive) damage to the machine, its payload, or both.

The safety guidelines outlined by EN 954-1 allow for a power-off delay as long as certain criteria are met, and the eF-785 meets these guidelines. The delay should be selected to allow for a controlled stop of the relevant motor axes in the event of an E-stop event. The delay can also be independently configured for the Load/Unload Area, if the machine is segmented. Available options and codes are listed below.

N No Delay Required

F Fast Delay (150mS) - For smaller axes or axes where high rates of deceleration are tolerable.

S Slow Delay (450mS) - For larger axes or axes where more time is required to complete a controlled removal of power.

5 POWER-OFF-DELAY OPTIONS (LOAD) EF-785-

The power-off-delay in the Load Area is configured in the same way as described in the Main Area. If there is no Load Area select code **X** in the F-785 part number where indicated.

- N** No delay required
- F** *Fast* delay (150 mS) - For smaller axes or axes where high rates of deceleration are tolerable.
- S** *Slow* Delay (450mS) - For larger axes or axes where more testtime is required.
- X** Not applicable. No Load Area designated.

6 SUPPLEMENTARY OPTIONS EF-785-

CONFIGURING SUPPLEMENTARY OPTIONS

The Soft Shutdown and Post E-Stop Enable features comprise the eF-785 Supplementary Options. Each of these two options is factory preconfigured to your specification, but can be reconfigured by repositioning one or two hardware jumpers. Below is a list of the 4 possible Supplementary Option configurations available with the eF-785.

- B** Host Soft Shutdown disabled; Post E-Stop Enable bypassed
- C** Host Soft Shutdown enabled; Post E-Stop Enable bypassed
- D** Host Soft Shutdown disabled; Post E-Stop Enable required
- E** Host Soft Shutdown enabled; Post E-Stop Enable required

SOFT SHUTDOWN FEATURE

The soft shutdown feature allows you to power off your machine by shutting down the host computer. This feature is user configurable by installing (or removing) an internal hardware jumper. See the appendix for details.

Example scenario of a system with Soft Shutdown enabled:

Power up with Soft Shutdown enabled - An operator initiates the machine power-up cycle by pressing the machine's front panel "on" button (which is wired into the eF-785). The machine powers up and the eF-785 sends AC power to the host computer which then powers up as well. Immediately, the PC sends a signal, via USB connection, to the eF-785, creating a feedback loop. And, as long as the USB signal is present at the eF-785's USB port, the system remains powered. Note: to use this feature, the BIOS on the control PC must be configured to power up the PC when AC power is detected.

Power down with Soft Shutdown enabled – When the operator powers down the host PC, the USB signal to the eF-785 turns off. When the eF-785 no longer detects the USB signal, it shuts down the entire machine.

Note: When Soft Shutdown is enabled, pulling the USB cord out of the eF-785 will have the same effect as turning the eF-785 off via the power switch.

Follow these steps to provide Soft Shutdown functionality in your machine

- 1) Select one of the two options that feature host Soft Shutdown enabled (see the *Configuring Supplementary Options* section below).
- 2) Configure the host PC BIOS to power up the PC when AC power is present.
- 3) Connect the PC to the eF-785 with a standard USB cable.

POST E-STOP ENABLE FUNCTION

The Post E-Stop Enable function is an extra layer of protection that serves to provide independent confirmation from the operator that it is safe to resume normal machine operation after an Emergency Stop (E-Stop) has occurred.

Consider a typical machine that has several E-Stop buttons on it. When the machine operator observes that a dangerous condition exists, he would actuate (i.e. “hit”) the nearest E-Stop button on the machine, terminating machine operations as a result. When the Post E-Stop Enable function in the eF-785 is functional, the operator must reset the E-Stop button to its normal ‘run’ position, *and then press the machine’s On/Enable button* in order for the machine to resume normal operations. Note: The operator should always follow safe machine operating procedures and return to a safe operating position prior to any machine restart. If operation were to *immediately* resume after an E-Stop button was restored to the ‘run’ position, an undesirable, potentially dangerous operational condition could occur. Always know and follow your machine’s safe operation guidelines.

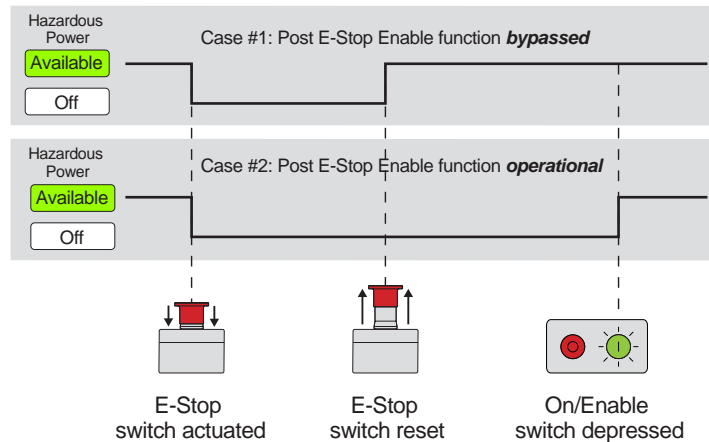
Having the Post E-Stop Enable feature enabled is especially important in cases where it is possible for an operator (or parts of an operator) to be inside a machine while the interlocks are closed.

For general safety and compliance requirements, Teknic recommends that you configure your eF-785 with the Post E-Stop Enable feature activated (options **D** and **E**).

The Post E-Stop Enable feature satisfies the ‘Manual Reset’ step required by EN 954-1. As previously stated, the machine safety design engineer should perform a complete safety assessment prior to selling machines with this function disabled. ***Read EN 954-1 carefully to decide if your machine can operate with the Post E-Stop Enable function bypassed.***

During the engineering design and development phases, the Post E-stop Enable function can be inconvenient. By disabling the Post E-Stop Enable function, machine operation can resume immediately after an actuated E-Stop button has been restored to its normal “Run” position, assuming that the system software is configured to allow this and the

internal hardware jumpers are set correctly. Refer to the appendix for instructions on how to defeat the Post E-Stop Enable function.



Hazardous power availability vs. E-Stop switch status

7 FIRMWARE REVISION

EF-785- - - ⁷

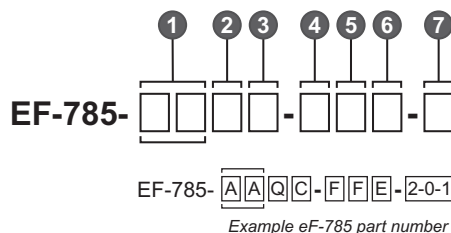
The final position of the eF-785 part number contains the firmware revision of the embedded Teknic ControlPoint™ network hub (NC-540). The firmware revision will appear as three numbers separated by hyphens (e.g. 2-0-0 or 2-10-3). This is not typically a user-specified option.

EXAMPLE EF-785 PART NUMBER

Example Part Number: **EF-785-AAQC-FFE-2-0-1**

- | | |
|--------------|---|
| AA | AC and DC drives in Main and Load Areas |
| Q | Quad EMI Filtering installed |
| C | CP network hub and 40 VDC network power supply installed |
| F | “Fast” Main Area power-off delay (150mS) |
| F | “Fast” Load Area power-off delay (150mS) |
| E | Host Soft Shutdown enabled <i>and</i> Post E-Stop Enable required |
| 2-0-1 | Embedded firmware is revision 2.0.1 |

SUMMARY IF THE EF-785 PART NUMBER



1 Power Control Options

- DN** DC powered servo or stepper drives/motors in Main Area only
- DD** DC powered servo or stepper drives/motors in Main and Load Areas
- AN** AC and DC powered servo or stepper drives/motors in Main Area
- AD** AC and DC powered servo or stepper drives/motors in Main Area and DC powered servo or stepper drives/motors in Load Area
- AA** AC and DC powered servo or stepper drives/motors in Main and Load Areas

2 EMI Filtering Options

- D** Dual EMI filter; use with DC-only configurations
- Q** Quad EMI filter; use with AC configurations

3 ControlPoint Network Hub Options

- C** CP network hub and 40VDC supply included
- X** Power and Safety functions only

4 Power-off Delay options (Main Area)

- N** None. Power is turned off with no delay
- F** Fast. Power is turned off within 150 ms
- S** Slow. Power is turned off within 450 ms

5 Power-off Delay options (Load Area)

- N** None. Power is turned off with no delay
- F** Fast. Power is turned off within 150 ms
- S** Slow. Power is turned off within 450 ms
- X** Not applicable (no Load Area)

6 Supplementary Options

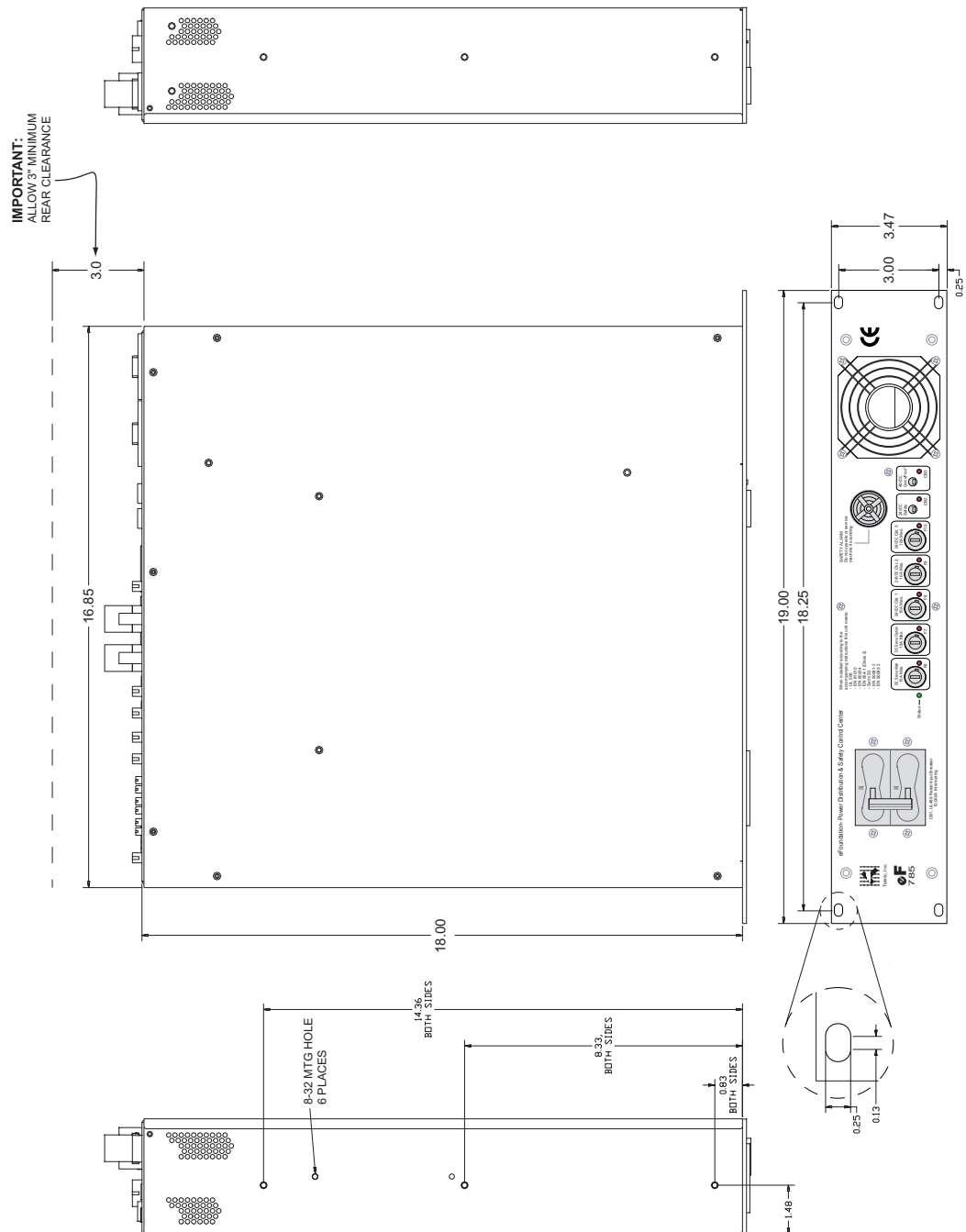
- B** Host software shutdown disabled; post E-Stop Enable bypassed
- C** Host software shutdown enabled; post E-Stop Enable bypassed
- D** Host software shutdown disabled; post E-Stop Enable required
- E** Host software shutdown enabled; post E-Stop Enable required

7 Firmware revision - The unit's firmware revision. Typically appearing in the form x-x-x. An example firmware revision might be "2-2-1" or "3-12-2" (without quotation marks)

STEP 3: MOUNT THE EF-785

This section describes how to properly mount the eF-785 to your machine. It includes the unit's physical dimensions, mounting hole specifications, minimum clearances, and recommended spatial orientations.

IMPORTANT MOUNTING DIMENSIONS

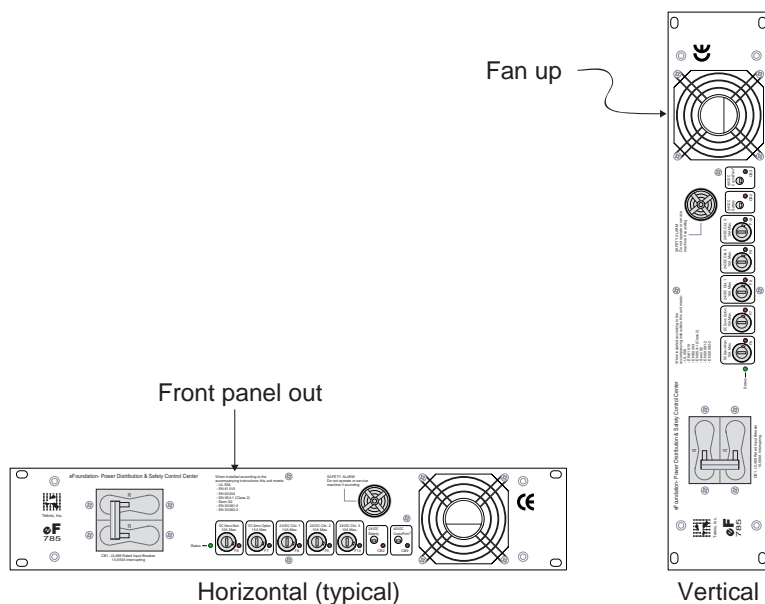


EF-785 physical dimensions and mounting specifications

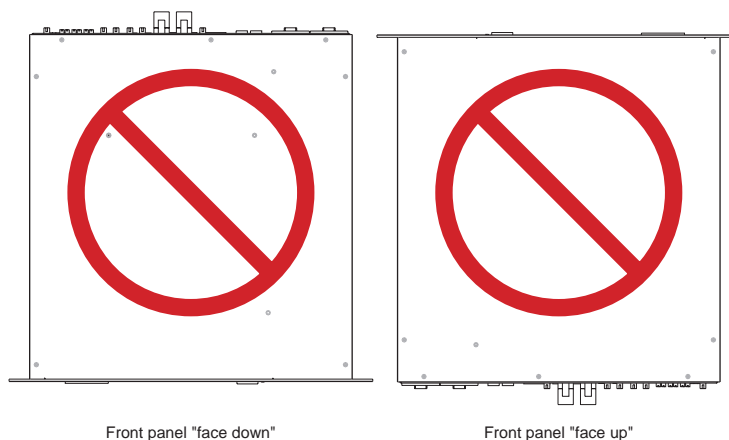
MOUNTING ORIENTATION

Always mount the eF-785 in one of the orientations shown below. Customers typically mount the unit horizontally, but it can be mounted vertically as well. If a vertical mount is chosen, the fan should be “up” to assure proper ventilation and cooling action (see diagram).

Never mount the eF-785 such that the front panel faces directly down or up. Refer to the “Unacceptable Mounting Orientation” diagram below.



Recommended mounting orientations



Unacceptable mounting orientations

COOLING

Regardless of the mounting orientation you select, always be sure that the exhaust fan is clear of obstructions that could interfere with its

cooling effectiveness. For proper cooling, the unit should be positioned such that the ambient air being drawn through it is **40° C (104°F) or less**. Often, the bottom of a machine offers the coolest ambient air temperatures.

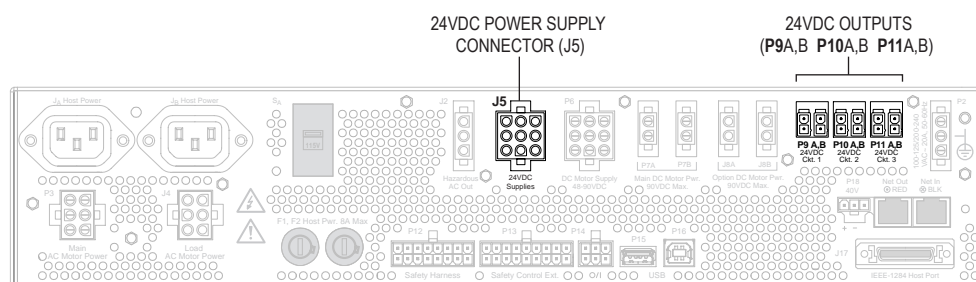
RACK SLIDES

If you plan to rack mount your eF-785, Teknic recommends the Accuride model c 2807-20 rack drawer slides. This model is compatible with the thread inserts on the side panel of the eF-785.

STEP 4: SET UP THE 24VDC POWER DISTRIBUTION

The eF-785 features a configurable 24VDC distribution system designed to manage power control to a wide range of low voltage devices including:

- Solenoids
- Solenoid valves
- Contactors
- Relays
- Indicator lamps
- Through-beam sensors
- Small stepper drives
- Proximity Sensors
- Slotted optical sensors
- Signal conditioning modules
- Gas valves
- Buzzers
- Hall Effect sensors
- Many others



24VDC Distribution Connectors

SELECTING THE POWER SUPPLIES

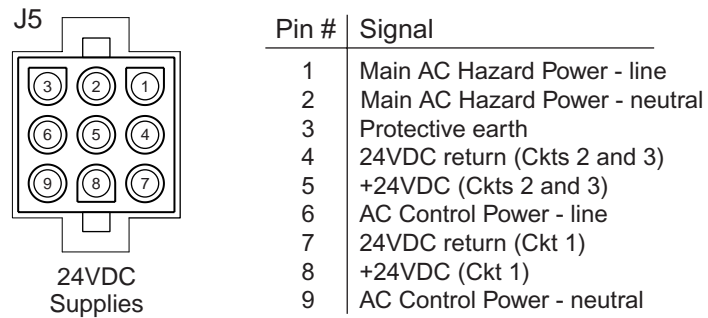
Your 24VDC power distribution requirements will help you determine which power supply (or supplies) and wiring harness to select. You can integrate 1 or 2 supplies depending on your machine's specific requirements.

There are a few considerations to keep in mind when selecting the 24VDC supply/supplies to be used with the eF-785. The supply you choose should, at a minimum have:

- Internal protective fusing
- A nominal voltage range of 12-41VDC
- Output current not to exceed 20A Maximum

CONNECTING 24VDC POWER SUPPLIES (J5)

The 24VDC supplies are connected to the 24VDC Supply connector J5 (see figure below), located on the rear panel of the eF-785. This connector not only serves to provide two different control modes for AC line voltage to power the supplies (described below), it also receives the 24VDC power back from the supplies for fusing and external distribution.



J5 24VDC power supply connector

AC CONTROL POWER

We refer to the first “type” of AC power as AC Control Power. This simply means that AC line voltage is always available at the 24VDC supply connector when machine power is on, regardless of the state of the E-stop or interlock switches. AC Control Power is typically used to supply a 24VDC supply that will be powering sensors and non-hazardous actuators throughout the machine. This type of power will remain on even after a safety event (E-Stop) in the machine has occurred.

MAIN AC (HAZARD) POWER

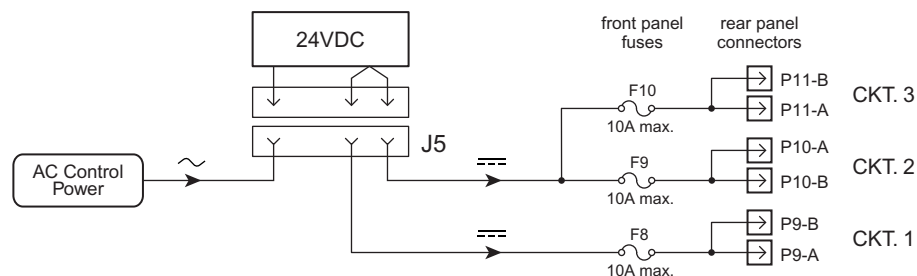
We refer to the second “type” of AC power available to an external 24VDC supply as Main AC Power. This means that power to the 24VDC supplies is on only when hazardous power in the Main area of the machine is on. Main AC Power is removed after a safety event (E-Stop) has occurred. Although 24V is not considered hazardous (when fused at or below 10A), it is often desirable to have some or all of it turn off when a safety event occurs e.g. in order to turn off solenoid valves such that pneumatics will exhaust to release pressure in mechanisms, for removing power to low power stepper motor drives², etc.

There are four 24VDC wiring configurations available depending on your project requirements. Please refer to the following schematic fragments for details.

² Note that although the eF-785 can remove AC power to externally connected 24VDC supplies, it does not provide any means for quick-discharge of the connected supplies once AC power is removed. This is usually not an issue if a switching supply is used for the 24V, which is common, the 24VDC will usually drop very quickly, in less than a few hundred milliseconds.

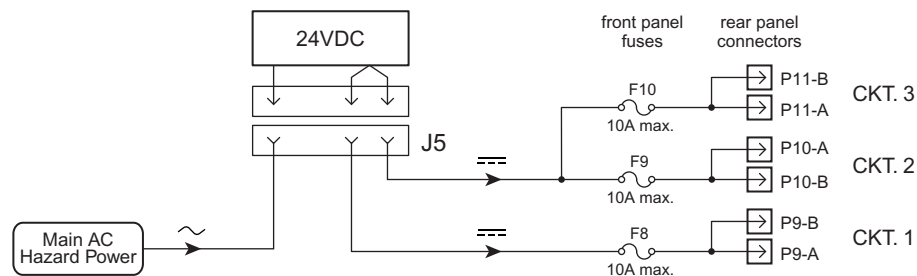
CONFIGURATION OPTIONS FOR SINGLE OR DUAL 24VDC SUPPLIES

- A. A single 24VDC power supply that is on continuously whenever AC Control Power is on.



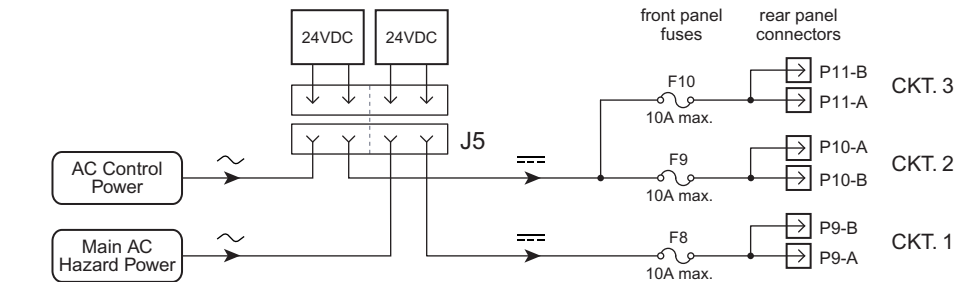
Single 24VDC supply-configuration A

- B. A single 24VDC power supply that is on only when Main AC Hazard Power is on. Power to these circuits would be cut in the event of an E-Stop or interlock breach. See figure B below.

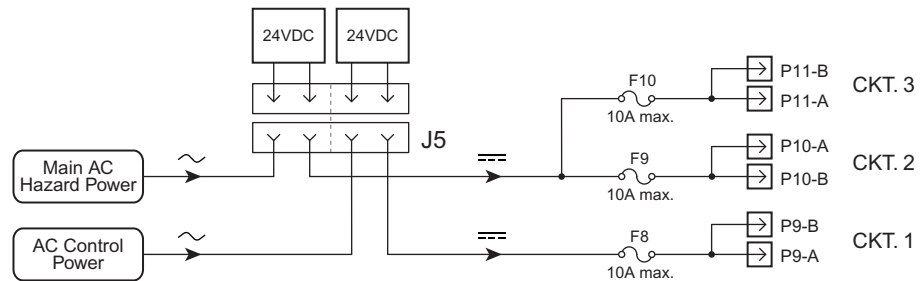


Single 24VDC supply-configuration B

- C. Two power supplies where one supply is on continuously when AC Control Power is present (circuits 2 and 3), and the other supply is on only when Hazardous Power is present in the Main Area (circuit 1). See schematic below.
- D. Two power supplies where one supply is on continuously when AC Control Power is present (circuit 1), and the other supply is on only when Hazardous Power is present in the Main Area (circuit 2 and 3). See schematic below.



Configuration C



Configuration D

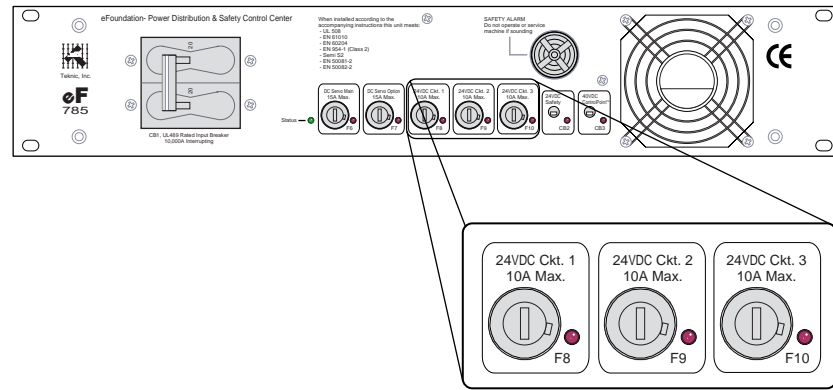
Dual 24VDC supply configurations C and D

Design Note: Use 14 AWG wire with a temperature rating of 90°C or greater or 12AWG when fabricating AC wiring to any connected 24V power supply. 12 AWG or larger wire if it has insulation rated at or above 70 degrees C). Note: Your 24VDC supplies should have an internal fuse or other current limiting device to protect against catastrophic failure of the supply itself (this is typical of most commercially available drives).

Refer to Appendix C for a typical cable diagram for connecting the 24VDC supply to the eF-785.

CONNECTING 24VDC LOADS (P9-P11)

There are 3 circuits for the distribution of 24VDC power which are rated up to 10A each, for a total of 30A. Each 24V-distribution circuit includes two distribution connectors on the rear panel: P9A-P9B, P10A-P10B and P11A-P11B. Each of these three 24V circuits has its own dedicated front panel fuse (F8, F9, and F10, respectively.) Each fuse has a dedicated a blown fuse indicator LED.

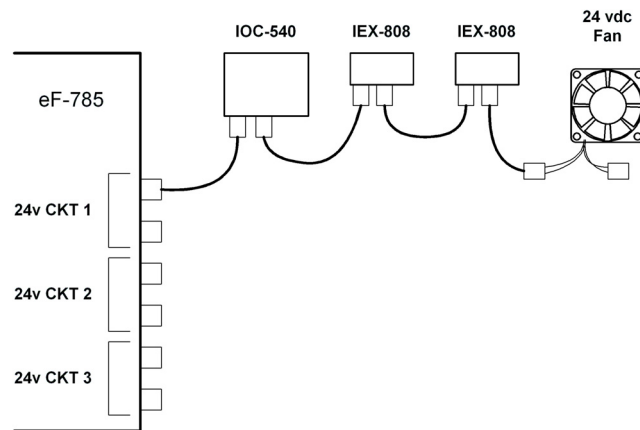


24VDC fuses on EF-785 front panel

WIRING TOPOLOGIES

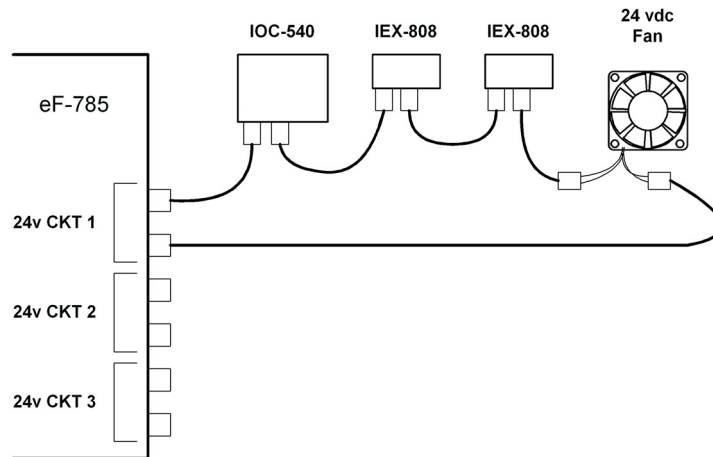
There are three ways in which to distribute 24VDC power to loads in your machine, and each topology has its own pros and cons. The following is a brief description of each wiring method.

- Daisy-chained** 24VDC power from the eF-785 is connected to the first load in the chain; power from the first load is connected to the second load, and so on. This is the simplest wiring topology available, but does not have the redundancy and lower resistance that the Daisy-chained loop topology offers.



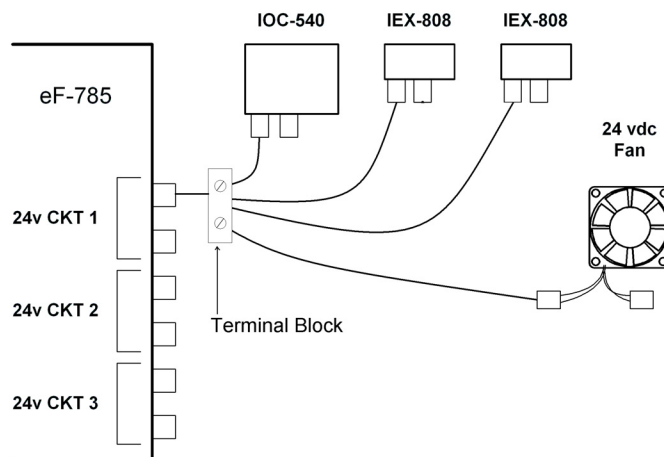
Daisy-chained wiring topology

- Daisy-chained loop** This topology is similar to the daisy-chained wiring described above, the difference being that the “last” load in the chain is connected back to the eF-785. This type of wiring offers the advantages of not only being redundant should one of the cables delivering power to the loads become open or intermittent, but addition of another power-carrying cable supplying the loads lowers supply-to-load resistance (and subsequently the I^2R power loss in the cabling). This parallel power path provides improved machine performance and reliability.



Daisy-chained loop wiring topology

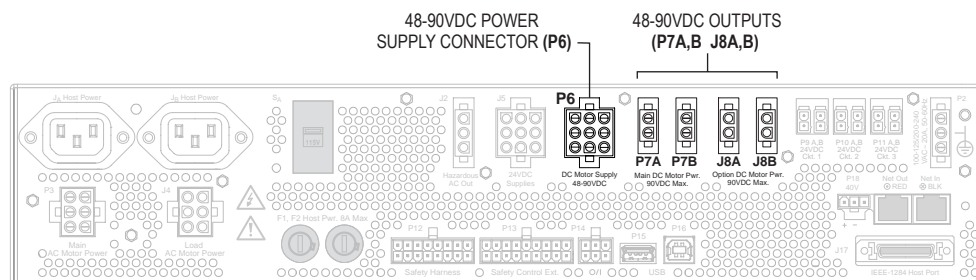
- Central star** This wiring method may be required when the 24V circuits within the powered devices are electrically connected to the chassis or other control circuits to reduce noise. The central star distribution method will prevent ground loops in the machine from occurring. In this method, each load is wired individually to the eF-785 by using a terminal block or distribution panel to bring power to each load separately.



Central star wiring topology

STEP 5: SET UP DC MOTOR POWER DISTRIBUTION 48-90VDC

The eF-785 simplifies power distribution to DC powered motor drives. Connector P6, on the rear panel of the eF-785, provides switched Main AC power to the DC power supply, and connects the DC output of the supply back to the eF-785. Though we often refer to this as the “75VDC Power Distribution” in the manual, the permissible voltage range for this supply is 48-90VDC.



48-90VDC Power Distribution Connectors

SELECTING THE POWER SUPPLIES

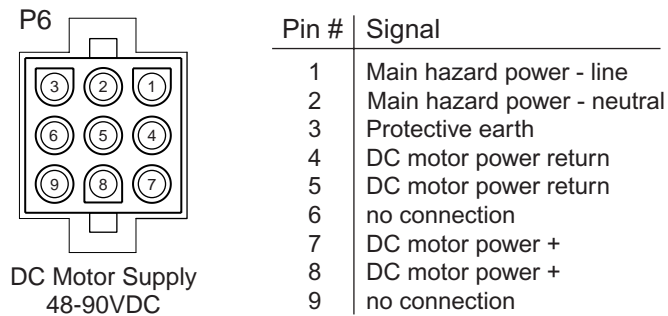
For most applications, Teknic recommends a bulk linear power supply with a large capacitive output filter (to accept regenerated power from the motor drives). Also, since servo and stepper motor drives have high peak current demands, the supply should support a high peak current rating above the continuous RMS rating. Teknic manufactures a bulk DC supply of this type (part number SSt-EMF75). The SSt-EMF75 is a bulk DC power supply featuring a large (47,000 μ F) output capacitor bank that also offers a resistive power clamp for regenerated drive power. A cable for connecting this supply is shown in Appendix C. If you are using non-Teknic drives, contact the drive manufacturer for guidance on power supply selection.

Use switching power supplies only if their outputs are paralleled with a large capacitor and the supply is oversized to handle the peak current demands. Note: *this is typically not an economical choice.*

CONNECTING DC MOTOR POWER SUPPLIES (P6)

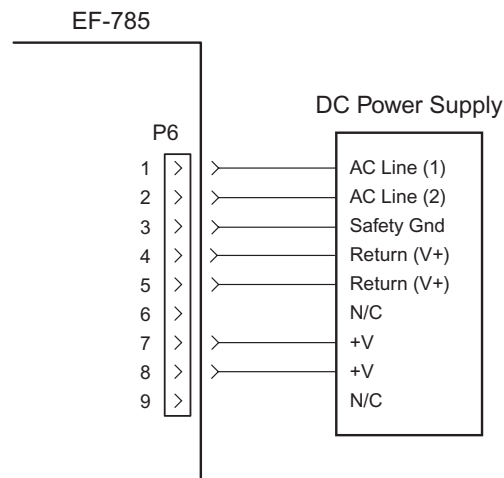
WIRING THE POWER SUPPLY

Since the DC Motor Supply connector, P6, not only provides switched AC power out to the power supply, but also receives the DC power back into the eF-785, wiring between the power supply and the eF-785 can be accomplished by using a point-to-point harness. AC wiring to any connected DC motor power supply should be fabricated with 14AWG wire with a temperature rating of 90 degrees C or greater, and all the wiring should be rated for 300 v to maintain proper isolation. 12AWG or larger wire can also be used if it has insulation rated at or above 70 degrees C.



DC motor supply connector P6

Any connected DC motor supply should have an internal fuse or other current limiting device to protect against catastrophic failure of the supply itself. The negative (return) lead of the power supply should *not* be connected to safety ground at the power supply. This connection is made internally in the eF-785, and to avoid any ground loops, should not be done externally.

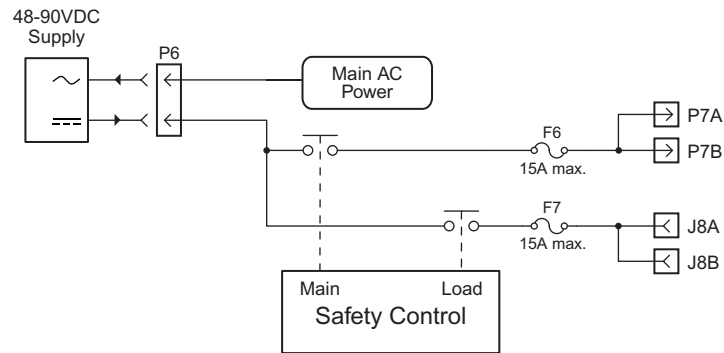


Connecting a DC power supply for the 48-90V motor drives

The connector that mates to P6 is a Tyco Electronics (AMP) MATE-N-LOK™ Style connector part number 1-480706-0 and female crimp sockets part number 350550-3.

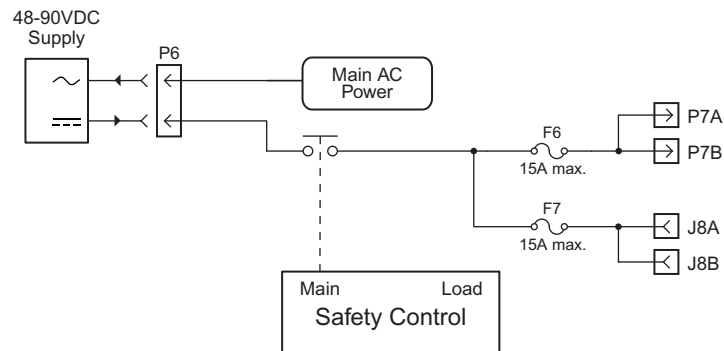
CONNECTING THE LOADS (DC MOTOR DRIVES) (P7A, P7B, J8A, J8B)

The eF-785 can manage power for any DC powered stepper or servo drive from 48VDC up to 90VDC. The DC motor power is split into two separately switched circuits (referred to as Main and Load) and is protected with time-delay fuses located on the eF-785 front panel. Each circuit is separately fused at 15A maximum (F6 and F7) yielding a total of 30A available for DC motor power. Each fuse has a dedicated blown fuse indicator LED on the eF-785 front panel.



DC motor power distribution and fusing for AA, AD, DD

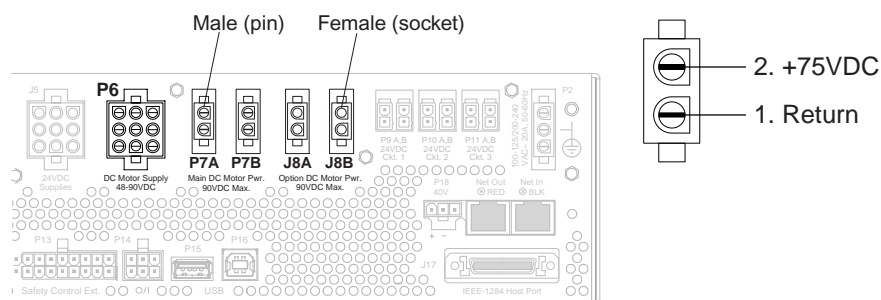
In a segmented machine (AA, AD, DD configurations) P7A and P7B distribute Main Area DC motor power, and J8A and J8B distribute Load Area DC motor power. In a non-segmented machine (AN, DN configurations) all of these connectors are used to distribute Main Area DC motor power throughout the machine. The J8A and J8B connectors become additional Main Area motor power connectors (although they are keyed differently from P7A and P7B (see below)).



DC motor power distribution and fusing for AN and DN configurations

Switched and over-current protected DC servo power is available at the rear panel connectors P7A, B (Main Area) and J8A, B (Load Area) for distribution into the machine. Note: At minimum, use 16AWG with wire with insulation rated at 90° C to supply power to DC motors on these circuits. Refer to Appendix C for cable drawings.

The Main DC motor power connectors (P7A, B) are keyed differently than the Load DC motor power connectors (J8A, B) to prevent incorrect connections during installation of the eF-785. See illustration below.



DC motor power distribution connector detail

DC Power Cable Part Descriptions	Manufacturer & Part Number
Plastic Connector Housing	AMP, 1-480698-0
Main DC, (Female crimp sockets)	AMP, 350550-3
Option DC, (Male crimp pins)	AMP, 350547-3

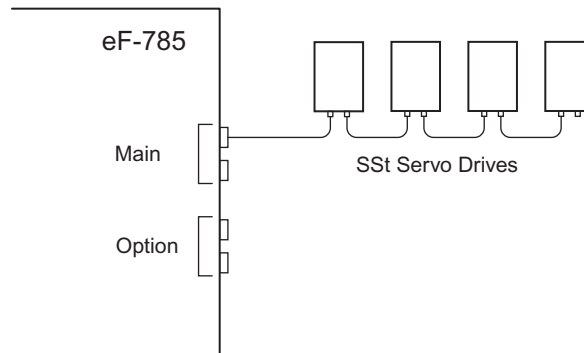
See Appendix C for further drawings that show examples of DC power cables to interconnect the eF-785 and Teknic servo drives.

WIRING TOPOLOGIES: CONNECTING TEKNIC SERVO DRIVES (ISC-1000, ISC-1700, SST-1000, SST-1500)

There are three methods by which you can distribute DC power to servo or stepper motor drives in your machine.

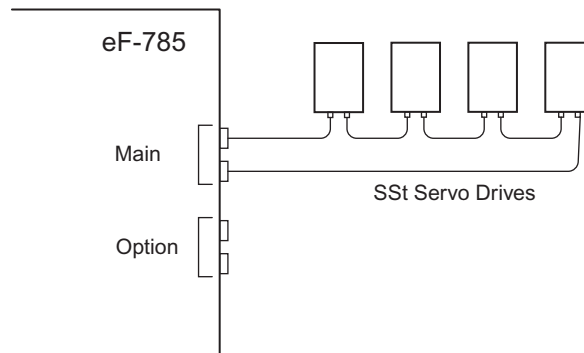
If you are using *Teknic* servo drives in your machine, you can take advantage of our unique *dual power connector* design to create a power distribution “daisy chain” that offers reduced complexity, lower cost, and superior noise immunity for your servo power distribution system. By daisy-chaining your Teknic drives (see below) no extra terminal blocks, distribution panels or fuses are required, and, because the DC bus power is isolated from all of the control circuits in our drives, no ground loop noise is created.

- **Daisy-chained** DC servo power from the eF-785 is connected to the first servo drive in the chain; power from the first drive is then connected to the second drive, and so on. The last drive in the chain does not have a redundant connection back to the eF-785. This is the simplest wiring topology available, but does not have the redundancy and lower resistance that the Daisy-chained loop topology (described below) offers. This wiring scheme requires that the drive’s power circuits are isolated from the machine chassis and any control circuits connected to them (e.g. Teknic ControlPoint™ and SSt products).



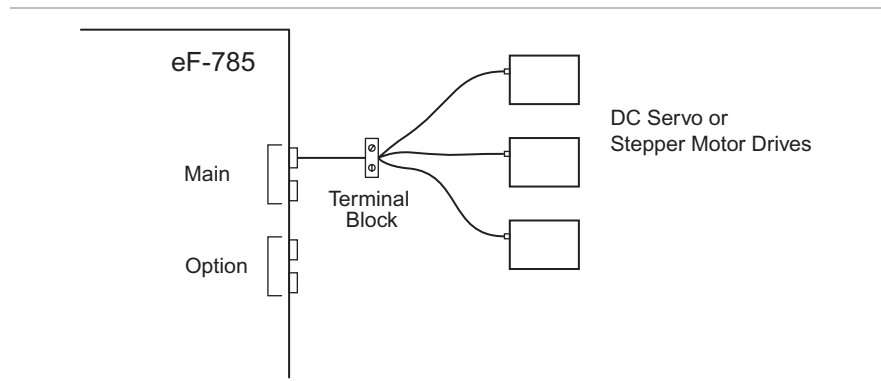
Daisy-chained wiring topology

- Daisy-chained loop** This topology is only slightly different from the daisy-chained wiring described previously. In the loop version, the “last” drive in the chain is connected back to the eF-785. The daisy chain loop offers the advantages of redundancy and improved performance. Should any *one* of the cables delivering power to the drives become open or intermittent, the drives will continue to receive power and therefore continue to operate. Also, with the additional cable supplying the drives, supply-to-load resistance is reduced and, subsequently, the I^2R power loss in the cabling is reduced. This parallel power path provides improved machine performance and reliability. As with the daisy-chained wiring method described previously, the drive’s power circuits should be isolated from the machine chassis and any control circuits connected to them.



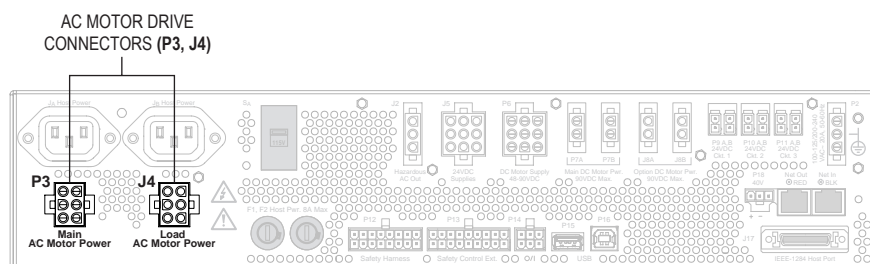
Daisy-chained loop wiring topology

- Central star** If you are connecting motor drives other than Teknic’s, and they don’t have electrical isolation between DC bus power and the control circuitry, then you need to use this method of wiring in order to prevent ground loops from occurring in the machine. Each drive is wired individually to the eF-785 by using a terminal block or distribution panel to bring power to each drive separately.



Central star wiring topology

STEP 6: CONNECT AC POWERED MOTOR DRIVES (P3, J4)



AC Powered Motor Drive Connectors

The AC Motor Power connectors P3 (Main) and J4 (Load) provide switched hazardous AC power to the Main and Load/Unload Areas of the machine. The motor power connectors have different sex terminals to help prevent accidental cross connection.



P3 and J4 pin designations

P3 supplies power for the Main area, while J4 supplies power for the Load/Unload area (when the dual area control option is installed). These connectors also provide connections for the DC bus and regeneration control circuits that are provided on most AC powered motor drives. For specific details on wiring AC motor drives, see the diagram under the “Wiring Configuration” section below.

The eF-785 automatically discharges any DC power stored within the drives when the hazardous power is interrupted to those drives. 25 ohm resistors within the eF-785 dissipate the power that is typically generated during load deceleration. Thus, the issues presented by the implementation of regenerative power resistors, such as thermal and shock hazard protection, overload protection, and custom guarding, are eliminated. Additionally, these resistors are fan-cooled in a dedicated plenum protected by automatically resetting fuses. Over-current protection for these circuits is provided by the main front panel circuit breaker, CB1.

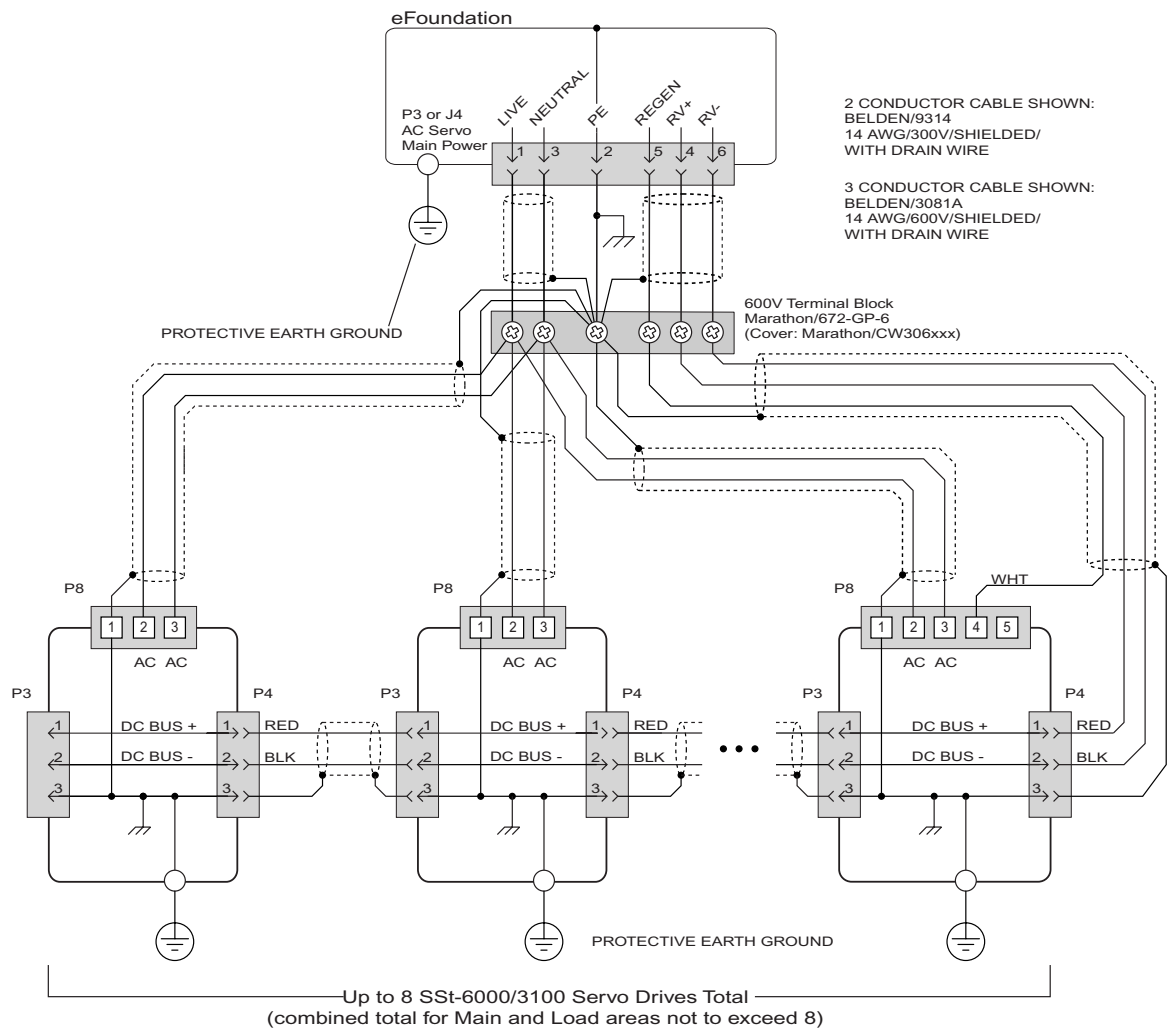
Most AC powered motor drives provide these connections and are compatible with the internal 25-Ohm regeneration resistors. Contact Teknic for specifics on connecting 3rd party servo drives to these circuits. Over-current protection for these circuits is provided by the main front panel circuit breaker, CB1.

By using a 6-position, 600V terminal block, AC servo drive power can be distributed to multiple servo drives with ease. Whether there are multiple servo drives or only one, it is important to keep the Hazardous DC voltages and regen in a separate shielded cable due to noise generated

by these lines. It is also important to keep all of the AC servo power (running between the eF-785 and the drives) in its own shielded cable.

A combined maximum of number of eight SSt-6000/3100 AC servo drives may be connected to the eF-785. This combined total number of AC servo drives is the total sum of AC servo drives in both the Main and Load areas that are to have their AC power managed by the eF-785. If you are using non-Teknic drives, contact Teknic for the maximum number of drives that can be used.

WIRING CONFIGURATIONS

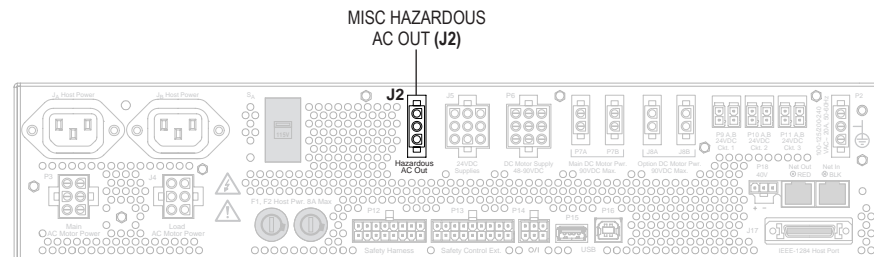


Connecting SSt-6000/3100 drives to the eF-785. (Note: 2 circuits are required for Main and Load areas if AC servos are used on both.)

STEP 7: CONNECTING OTHER MISCELLANEOUS AC LOADS (J2)

AC power is also available for miscellaneous hazardous loads on connector J2. This is switched with other Main area AC power which means that power will be removed from the circuit if an E-Stop event occurs.

The maximum current that can be drawn from J2 is 20A. This circuit is protected by the main front panel circuit breaker, CB1.



Hazardous AC Out Connector

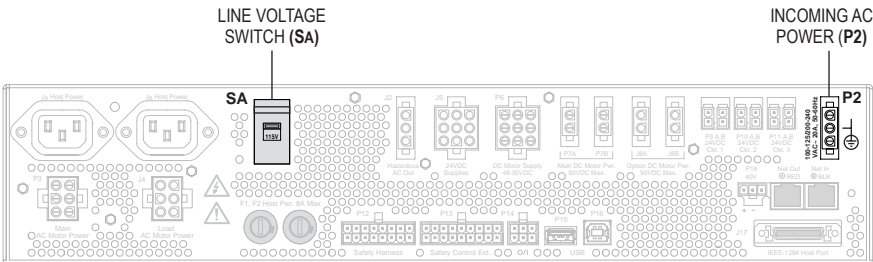
Fabricate all wiring from this connector with 14AWG wire with a temperature rating of 90 degrees C or greater. 12AWG or larger wire can also be used provided that it has insulation rated at or above 70 degrees C.

Any device connected to J2 that is rated below 20A should have either an internal fuse (preferred) or an external current limiting device. This will help protect the device in the event of a catastrophic failure of the device itself.

STEP 8: CONNECT INCOMING AC POWER

INCOMING POWER (P2)

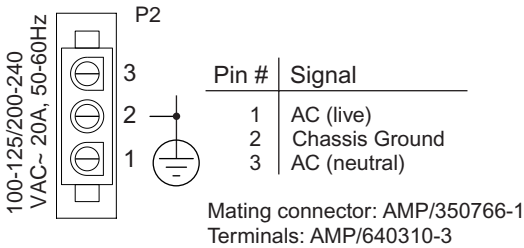
Incoming AC power to the eF-785 is supplied through connector P2. The eF-785 can be powered directly from a 115 or 230 nominal VAC single-phase source. Input voltage is selected by setting the line voltage switch S_A, located on the rear panel, to either the 115V or 230V setting.³ Incoming power is protected by an internal UL-489 rated, 20A circuit breaker.



Incoming AC Power components

The line cord should be a 12AWG (2.05mm) cable with international color codes. Recommended cordage is Alpha/1918, International Configurations/1601312 or Olflex/1600119. Refer to the Appendix for a drawing of a line cord assembly with a recommended cord grip.

The eF-785 can be extended to control 3-phase power while maintaining safety compliance. Contact Teknic for details or see the 3-Phase Power Control section in this manual.



AC input power connector P2

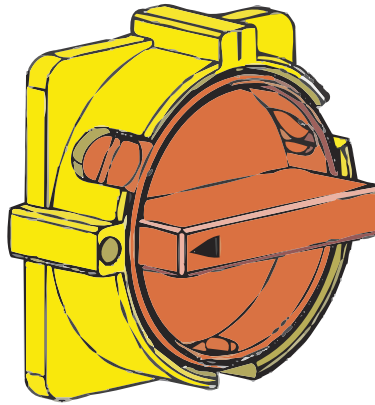
ADD A POWER DISCONNECT SWITCH (IF REQUIRED)

If your machine is wired directly to facility power (i.e. not connected to the AC power with a plug) EN 60204-1 section 5.3 requires that a positive disconnect switch be provided for maintenance personnel. If, on the

³ Note that all external supplies connected to the eF-785 must independently be configured for 115VAC or 230VAC operation consistent with the incoming power source.

other hand, the machine has a plug and cord for AC input power, the plug must offer sufficient breaking capacity for the load presented by the machine. Some machine designers use a power disconnect switch even when power is supplied via a plug.

EN 60204-1 section 5.3.4 states that the recommended height for locating the disconnect is from 0.6 m (23.63 inches) to 1.7 m (66.92 inches) above the floor. Altech/KU340N switch is an economical option for this switch and is pictured below with the Altech/OKA 0.V Y/R handle.

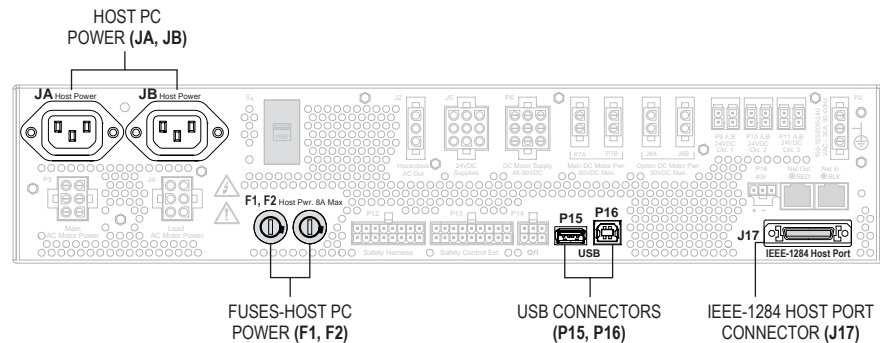


***A typical positive disconnect/lock-out switch
(Altech/KU340N switch with Altech/OKA 0.V Y/R
handle shown)***

STEP 9: CONNECT THE EMBEDDED CONTROL COMPUTER

Connect the host computer, display, and peripherals to the Host Power receptacles J_A and J_B (pictured below) using an IEC detachable cord set.

Connect the host PC's parallel port to the eF-785's IEEE-1284 Host Port (J17) using an IEEE-1284 compliant printer cable.



Host Computer Connectors and Fuses

CPU, DISPLAY AND PERIPHERAL POWER (JA, JB)

The eF-785 has two universal IEC 60320 Type C-13 power outlets which supply power to the host PC, display and any other peripherals, up to 8A max. A suitable IEC 60320 detachable cord set must have a Type C-14 plug (on the eF-785 end) and a Type C-13 connector (on the Host PC or display end). *Note: These cords should be marked as indicated below.*



Example Warning Label

The fuses for these outlets are also located on the rear panel of the eF-785; see fuse-holders F1 and F2 in above illustration. AC power is present at these two outlets as soon as the eF-785 has been turned on via the Power/Enable switch. Power is disconnected from the outlets when the machine's 'OFF' button is pressed.

If you require more than 2 outlets, it is permissible to use a universal power plug-strip to add more. Suggested products include Tripp-Lite's rack-mount AC power distribution unit (p/n PDU12IEC) or International Configuration's line of IEC 60320 multiple outlet strips. Each circuit is rated for 8A max.

HOST CONTROL CONNECTIONS

IEEE-1284 (J17)

The host PC communicates with the eF-785 via a parallel port connection to J17 on the rear panel of the eF-785 (see illustration above). An IEEE-1284 compliant printer cable such as Belkin/F2A045-06 or

Belkin/F2A045-10 is all you need to connect. **Important:** *this cable must not exceed 10 feet (3 meters) in length.*

USB CONNECTIONS (P15, P16)

Two USB connectors (one Type A and one Type B) are provided on the rear panel of the eF-785. These USB connectors provide only a pass-through connection and are necessary only if the Soft Shutdown feature is enabled.

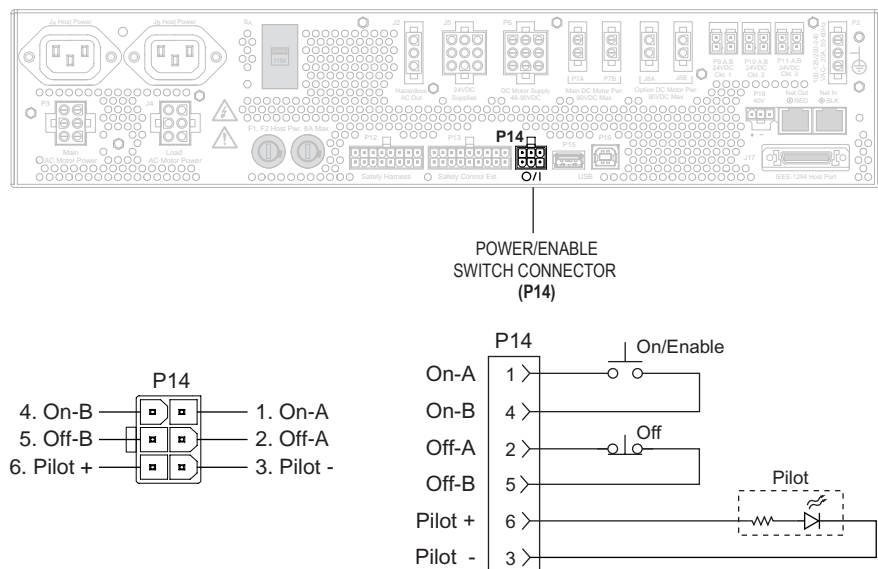
STEP 10: MOUNT AND CONNECT THE POWER/ENABLE SWITCH(ES)

POWER/ENABLE CIRCUITS (P14)

The eF-785's power controls provide a means with which to turn on and off machine power as well as a visual indication that the machine is powered (via the pilot lamp). The On/Enable switch also allows the operator to reset the eF-785 after an E-Stop event has occurred (when the post E-Stop Enable feature is enabled). *Note: Your machine's On-Off switch and pilot lamp should be mounted in an area that is both viewable by and readily accessible to the operator.*

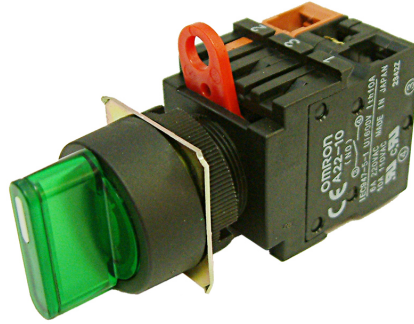
The machine's On/Enable switch requires only a momentary normally open (NO) switch, and, if equipped with an integrated 24VDC pilot lamp or LED, makes the use of a separate machine "on" pilot lamp unnecessary. Similarly, the machine's "off" switch should be a momentary, normally closed (NC) switch.

The pilot lamp circuit in the eF-785 can be used with incandescent lamps that consume 1 Watt or less. All voltages within this circuit are low voltage and are "touch safe".



P14 Connector and Typical Power/Enable switch schematic

An alternative to having separate On and Off switches is to use a combination rotary switch that combines the On/Reset switch, Off switch, and pilot lamp. Using a combination switch such as this not only allows you to provide front panel controls using only one component, but also the front panel wiring harness from P14 on the eF-785 to this switch can be wired with one straight point-to-point cable. Teknic recommends a 22 mm rotary switch such as the Omron/A22W-3AG-24A-11.



Combination Power/Enable switch with integrated pilot lamp (Omron/A22W-3AG-24A-11)

The On/Enable and Off switches must be labeled using the appropriate IEC on and off symbols, \bigcirc /I.

As previously discussed, the eF-785 also supports automatic “actuation” of the Off button from the control computer. This feature, known as the Soft Shutdown, works by connecting the control computer to P16 on the eF-785 via a standard USB cable. When the control computer is shut down, the 5V from the USB port is removed. The eF-785 immediately detects the USB voltage change of state from +5v to 0V and turns off AC Control Power. Since this (Soft Shutdown) event is essentially the same thing as manually pressing the off switch, the pilot lamp will turn off as well, providing a visual cue that power has been removed.

STEP 11: MOUNT AND CONNECT THE SAFETY CONTROL COMPONENTS

SELECTING EXTERNAL SAFETY DEVICES

E-STOP SWITCHES

E-Stop switch selection requirements

- The switch must be a DPST type switch, with normally closed, and positively guided contacts. (refer to EN 60204-1 section 10.7.2, EN 60947-5-1 Annexes K and L, EN 292-2 section 3.5, and EN 418 section 4.1.2)
- The switch must latch (once actuated) and be released by a separate action, such as by pulling or by using a key. (refer to EN 60204-1 section 10.7.2, EN 418 section 4.1.11, and EN 60947-5-1-1 section 7.1.4.5)
- The switch must be colored red, and the area immediately around the switch must be yellow. (refer to EN 60204-1 section 10.7.4 and EN 418 section 4.4.3)

Mounting the E-Stop switches

- The E-Stop switches must be mounted in readily accessible, ergonomic locations and be within close reach of the operator's normal operating position. (refer to EN 60204-1 sections 10.1.2, 10.7.1 and EN 418 section 4.4.2)
- The E-Stop switches must be mounted so that they are not less than 0.6 m above the servicing level of the machine (typically the floor). (refer to EN 60204-1 section 10.1.2)

Recommended E-Stop Switch (consists of 3 separate parts)

Omron/A22E-M-01 (40mm dia. head SPST-NC E-Stop switch)
Digikey/Z1504-ND

Omron/A22-01 (SPST-NC 10 Amp contact block) Digikey/Z1547-ND

Omron/A22Z-3466-1 (60mm dia. yellow E-Stop plate)
Digikey/Z1555-ND



Recommended E-Stop Switch (part number listed above)

INTERLOCK SWITCHES

Interlock switch selection considerations

- The switch must be a DPST type switch, with normally closed, and positively guided contacts. (refer to EN 1088, EN292-1 section 3.22.4, and EN 292-2 section 3.5)

Mounting the interlock switches

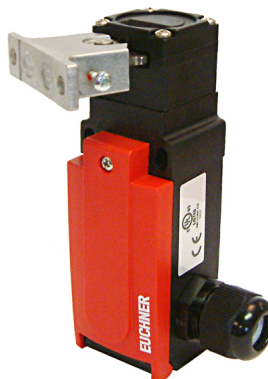
- The interlock switch must be mounted in such a way that prevents the actuator key from being latched into the interlock switch while the gate/guard is in the open position (i.e. bypassing the interlocking system).
- The actuator key should be mounted to the gate/guard using tamper-resistant hardware/screws.
- Refer to EN 1088 for information regarding selection and mounting of interlock switches.

Suggested Interlock Switch (consists of 3 separate parts)

Euchner/GP1-538HA-M (interlock switch with 2 NC force-guided contacts)

Euchner/059 440 (metal hinged latch actuator key)

Euchner/M20CGP (cable entry gland nut)



Suggested Euchner Interlock Switch

GUARD-LOCKS

Guard-lock selection considerations

- The switch must be a DPST type switch, with normally closed, and positively guided contacts. (refer to EN 1088, EN292-1 section 3.22.5, and EN 292-2 section 3.5)
- The guard-lock must operate in such a way that the actuator key is locked when inserted into the guard-lock when no power is applied, and the actuator key may only be removed when power is applied to the device. (refer to EN 1088 section 4.2.2)

Mounting the Guard-locks

- The guard-lock must be mounted in such a way that prevents the actuator key from being latched into the guard-lock while the gate/guard is in the open position (i.e. bypassing the interlocking/guard-locking system).

- The actuator key should be mounted to the gate/guard using tamper-resistant hardware/screws.
- Refer to EN 1088 for information regarding selection and mounting of guard-locks.

Suggested Guard-lock (consists of 3 separate parts)

Euchner/TP3-2131A024M (guard locking interlock switch with 2 NC force-guided contacts, spring lock and solenoid unlock)

Euchner/O59 440 (metal hinged latch actuator key)

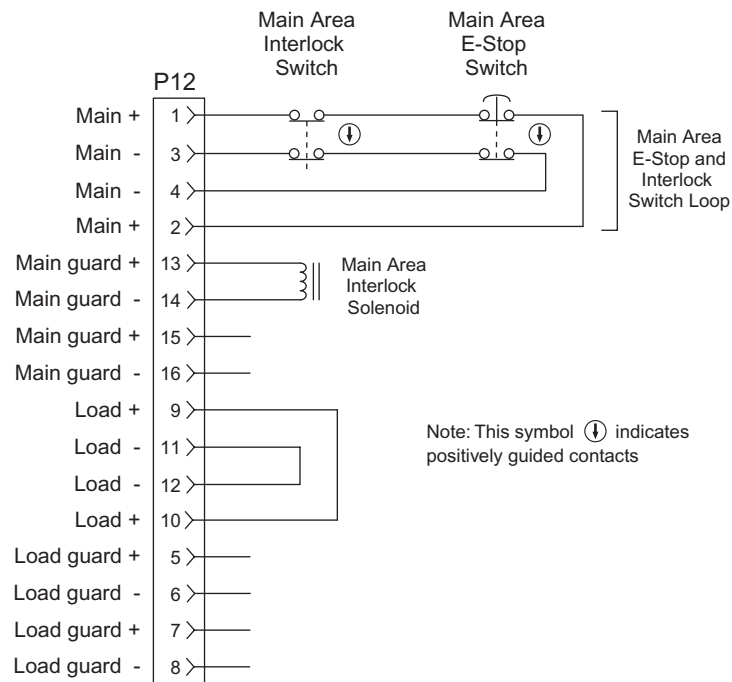
Euchner/M20CGP (cable entry gland nut)



Suggested Euchner Guard-lock

SAFETY HARNESS FOR NON-SEGMENTED MACHINE (P12)

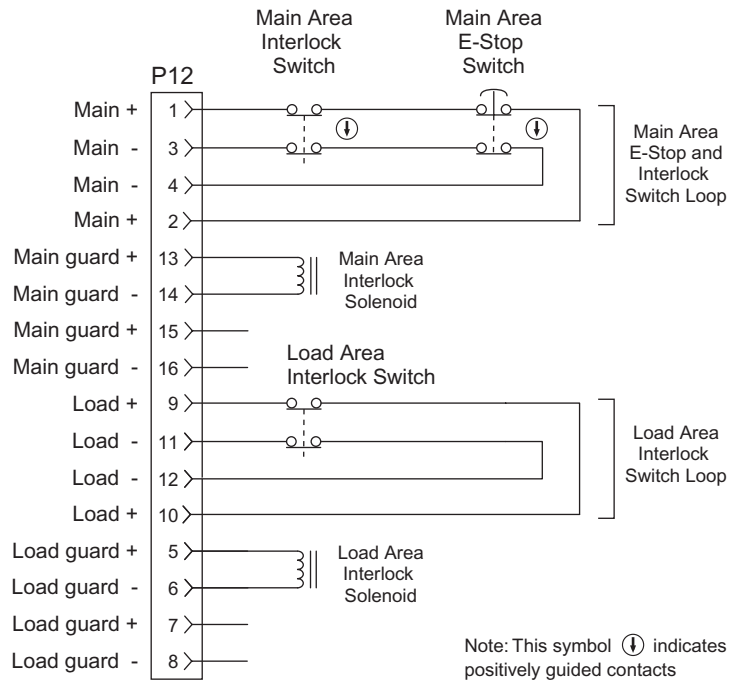
The safety harness for a non-segmented machine is quite simple (see schematic below) featuring two redundant loops through all of the interlock switches and E-stop switches. To minimize the opportunity for wiring shorts the harness typically daisy chains through each switch and a separate cable is used to power the interlock solenoids.



Typical non-segmented safety harness

SAFETY HARNESS FOR SEGMENTED MACHINE (P12)

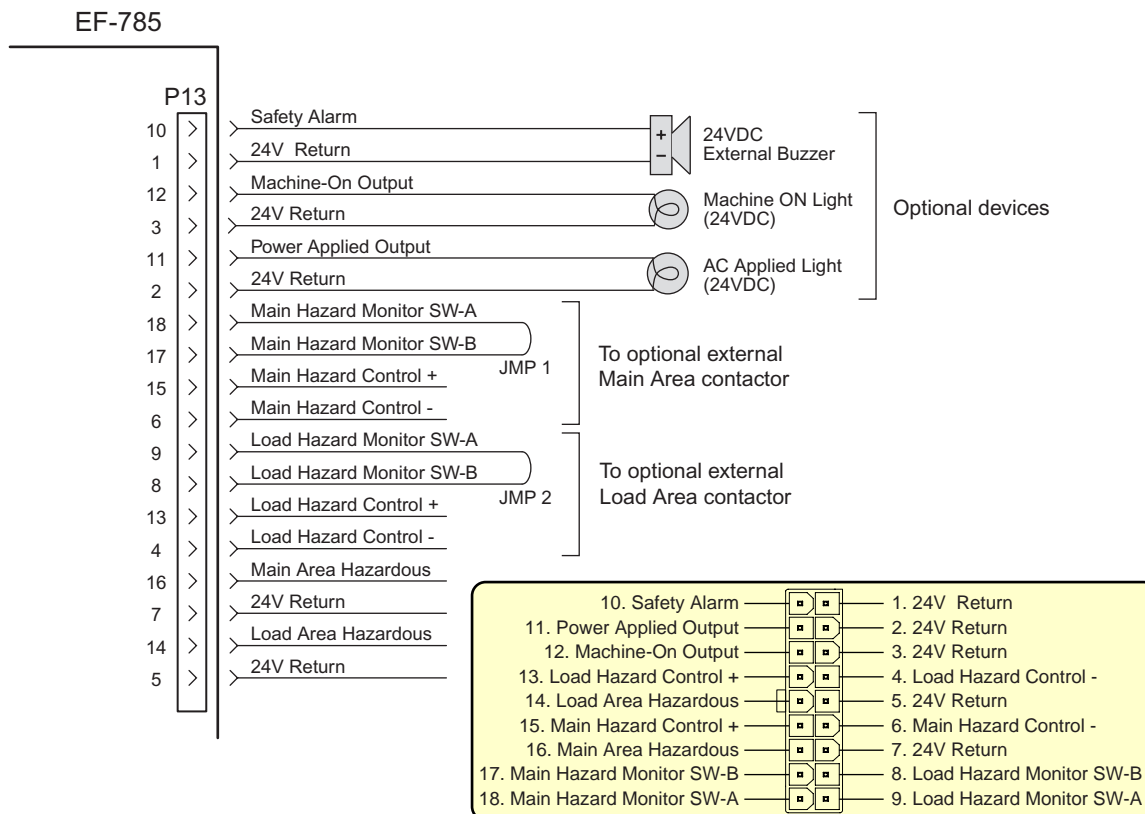
The safety harness for a segmented machine is very similar in structure to the non-segmented machine safety harness shown above. Essentially, this harness is a dual version of the non-segmented harness with the only difference being that the E-stop switches are not wired into the Load Area interlock switch loop.



Typical safety harness for segmented machine

AUXILIARY SAFETY CONNECTOR (P13)

The P13 connector on the eF-785 provides the ability to connect and control additional contactors in the Main and Option (or Load/Unload) Areas. The connector also allows external status indicators and alarms to be connected.



Auxiliary Safety Connector P13 with sample schematic
(Usually only jumpers Jmp1 & Jmp2 are required)

<u>Auxiliary Safety Connector Part Descriptions</u>	<u>Manufacturer & Part Number</u>
Connector Housing, 18 pin, Minifit	Molex, 39-01-2180
Female crimp socket contacts, 22-28 AWG wire	Molex, 39-00-0047

IMPORTANT NOTE: When external contactors are not used, the Main Safe and Load Safe monitoring signals must be jumped to allow the eF-785 to operate. The two jumpers required are:

Jmp1 Jumper wire P13 pin 8 to 9 for Load safe.

Jmp2 Jumper wire p13 pin 17 to 18 for Main safe.

(An example jumper is shown in Appendix C of this manual.)

SAFETY SYSTEM POWER CONSIDERATIONS (P12, P13, P14)

All safety control circuits are powered by a dedicated, high reliability 24VDC supply internal to the eF-785. This supply is used to power the safety control relay logic circuits, internal (and external) control

contactors, the On/Off front panel, and any connected guard-lock solenoid coils. The CB2 circuit breaker located on the front panel protects these circuits. CB2 has a dedicated tripped-indicator LED.

If you are powering external guard-locks or other devices such as lamps, external safety management contactors, etc, you must select devices such that ***the total power drawn from the 24VDC supply (available at connectors P12, P13 and P14) is less than the power budget shown in the table below.*** Exceeding this power budget will cause CB2 to trip.

eF-785 Model	Total Allowable External Component Power Draw	I _{MAX} (mA)
DN	38.5 Watts	1604
DD	30.2 Watts	1258
AN	30.2 Watts	1258
AD	30.2 Watts	1258
AA	22.0 Watts	916

Allowable power available from the safety supply

If the eF-785 is to be powered from a low AC line voltage (i.e. below 105VAC or 210VAC) the allowable external power draw figures in the above table must be derated by 5%.

RUNNING A MACHINE WITH THE eF-785

POWERING UP

To power up the machine, the operator presses the machine's front panel On/Enable switch. Once machine power is on, the machine's pilot lamp (if used) will illuminate. If the attached host computer's BIOS is configured to wake upon detection of AC power, the host PC will then begin to power and boot-up, bringing machine power under the control of the host PC. If the eF-785 has been configured with the soft-shutdown feature enabled, one of the host PC's USB ports must be connected to the eF-785 (to either P15 or P16) in order for the machine to latch into the power-on state.

SAFETY ALARM CHECK

The function of the eF-785's front panel safety alarm is to alert the operator to a potentially dangerous fault in the safety system or the machine. Periodically checking the safety alarm function is accomplished by pressing and holding the machine's On/Enable switch for approximately 2 seconds. The operator should then hear the eF-785's front panel alarm sound while the button is being held, as well as any external safety alarm that may be connected to P13. The safety alarm should stop sounding after the operator releases the On/Enable switch. The safety alarm check can only be performed while the machine is idle (i.e. no hazardous power being requested in any area(s) of the machine).

RECOVERING AFTER AN E-STOP EVENT

After any of the machine's E-Stop buttons have been actuated (i.e. the switch has been pressed down and "latched") any unsafe or hazardous conditions in the machine must be cleared. Once the machine operator has closed any open guards/gates and returned to a safe operating position, the E-Stop button may be reset by un-latching it (typically by pulling up on the button head, or by twisting it in the direction indicated on the button head).

At this point, in machines where the post E-Stop enable feature is required (the most common scenario), the operator must momentarily press the machine's On/Enable button in order for the eF-785 to recover from the E-Stop event. Once this has been done, any power requests from the host PC will result in hazardous power being turned on to those areas requesting power.

Important Safety Note: When an eF-785 has been configured to have the Post E-Stop Enable bypassed, hazardous power may be re-applied as soon as the E-Stop button is reset.

SHUTTING DOWN

At the end of operations, there are two ways to shut down the machine:

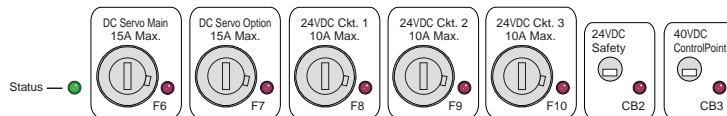
- **Soft Shutdown disabled** To shut down the machine, the operator must shut down the host PC, and then press the machine's front panel Off switch.

- **Soft Shutdown enabled** When the Soft Shutdown feature is enabled, the operator needs only to start a shutdown sequence on the host PC. The eF-785 will then power off automatically when the host PC turns off, thereby removing power from the machine.

FINDING AND REPLACING A BLOWN FUSE

DC POWER OVER-CURRENT ALARM

All DC power circuits managed by the eF-785 are protected against over-current events by front panel fuses or circuit breakers. This includes not only DC Motor Supply power and 24VDC sensor/actuator power, but also the 24VDC internally supplied safety power and 40VDC ControlPoint™ network hub power. Each of these seven circuits has its own “fuse-blown” LED indicator. In addition to the open/tripped indicator LEDs on each circuit, if any of these devices should open or trip, an annunciator will emit a high-pitched continuous tone to alert the operator to the over-current event. Unless power is removed from the unit, the tone will sound until the fuse is replaced.



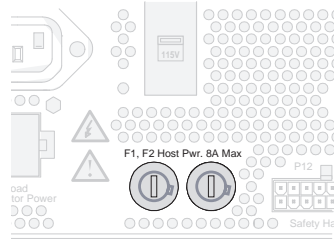
Front panel fuses and circuit breakers

FUSE	CIRCUIT PROTECTED	REAR PANEL CONNECTOR	I _{MAX}	MFG./PART#
F6	Main DC Motor Power	P7A, B	15	Bussmann/MDA-15
F7	Option DC Motor Power	J8A, B	15	Bussmann/MDA-15
F8	24VDC Ckt. 1	P9A, B	10	Bussmann/MDA-10
F9	24VDC Ckt. 2	P10A, B	10	Bussmann/MDA-10
F10	24VDC Ckt. 3	P11A, B	10	Bussmann/MDA-10

Recommended DC power replacement fuses

AC CONTROL POWER CIRCUIT PROTECTION

The AC voltage available at the Host Power connectors JA and JB, the 24VDC Supplies connector (J5, pins 6 and 9), and the 40VDC net power's AC side are all protected by the rear panel fuses F1 and F2. The fuses used in F1 and F2 can not be rated for more than 8 Amps. A suggested time-delay fuse is Bussmann/MDA-8.



AC Control Power rear panel fuses (F1 and F2)

EXTENDING THE SYSTEM

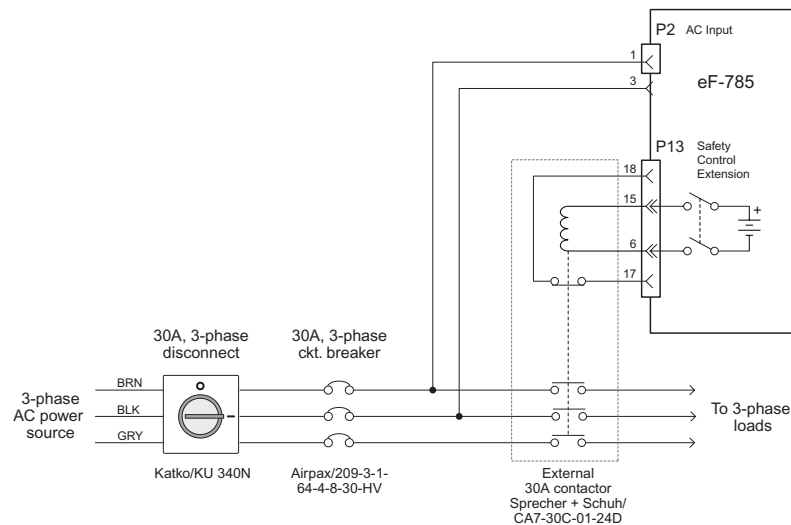
CONTROLLING EXTERNAL HAZARDOUS ENERGY

The eF-785 may also be used to control and monitor an alternate power supply or a redundant disconnect. Circuits are provided at P13 to control the flow of external hazardous energy along with circuits for monitoring the disconnect of that energy in compliance with EN 954-1.

In order to comply with EN 954-1, a redundant means of disconnecting power must be used with a high reliability means of verifying that hazardous power has been removed⁴. In this context, “hazardous power” can be electrical, hydraulic, pneumatic, chemical, etc. The most common example of this application is the use of 3-phase AC power (see diagram below).

EXAMPLE: 3-PHASE POWER CONTROL

In this example, 3-phase AC power is switched along with other Main area power. In order for the eF-785 to be able to control and monitor the switching of 3-phase AC power, an external 3-phase contactor must be used. This contactor must be of the type that has three normally open contacts for switching power as well as one normally closed contact that monitors the state of the power contacts. The NC contact must be guaranteed to be open if any of the NO contacts weld closed (per EN 60947-5-1 Annex L). These contacts provide feedback to the eF-785 that the hazardous power has been removed from the connected 3-phase load(s). These feedback contacts must be positively-guided per EN 50205. This means that the feedback contacts must remain open if any power contact welds closed, even after power is removed from the contactor’s coil.



3-Phase Power Control

⁴ Assumes that the 3-phase power is used in a machine that is consistent with the assumptions discussed in Appendix A.

APPENDIX A: MEETING THE EU MACHINERY DIRECTIVE FOR CE COMPLIANCE

WHAT IS THE MACHINERY DIRECTIVE (AND WHY IS IT IMPORTANT EVEN OUTSIDE OF THE EU)

All machinery with mechanical hazards that is to be sold to the European Union must meet the requirements of the CE Machinery Directive (Directive 98/37/EC). The CE Machinery Directive is similar to (and in most cases a superset of) the American National Standards Institute (ANSI) machine specific standards for safety, (e.g. ANSI B11.19-1990 “Machine Tools, Safeguarding”). In the U.S., the Occupational Safety & Health Administration (OSHA) states: “OSHA encourages employers to abide by the more current industry consensus standards [such as the CE Machinery Directive] since those standards are more likely to be abreast of the state of the art than an applicable OSHA standard may be.”

Further, several industry groups reference the CE Machinery Directive and specifically the safety control system standard: EN 954-1 “Safety of machinery - Safety-related parts of control systems...” in their machine safety standards. (For example, the Semiconductor industries consortium (SEMI) calls out EN 954-1 as a normative reference in their S2 safety standard “Facility Standards & Safety Guidelines for Semiconductor Manufacturing Equipment”). Most Asian countries either recognize the CE mark as sufficient, or have drafted safety standards that strongly reflect (and in some instances mimic) the CE Machinery Directive and the supporting EN standards.

In short, the CE Machinery Directive and the EN standards that support it have become the de-facto world standard suite for machinery safety because, as standards go, these are well thought out, comprehensive and conservative.

Even if you don't intend to sell equipment in Europe, meeting the CE Machinery Directive requirements is a well understood way to keep the machine operators safe. (and may put your company in a more legally defensible position against lawsuits resulting from machine misuse).

Because of its comprehensive, conservative nature, meeting the CE Machinery Directive is surprisingly complicated. First, the mechanical hazards must be evaluated to understand what level of safety control system is necessary using EN 1050 “Safety of machinery. Principles for risk assessment”. The result of the EN 1050 risk assessment then dictates the level of fault tolerance and monitoring required in the safety control system as outlined in EN 954-1. To simplify the discussions in this manual, we have assumed that we are working with a typical servo motor or high power stepper motor driven machine. In nearly all of these machines there is a likelihood of significant irreversible bodily injury or death caused by moving mechanics (basically, this is defined as anything more severe than a bruise or sprain). This then requires that the safety control system meet EN 954-1 Level 2 or 3 combined with requirements on guarding the hazards. (Under certain instances, if the risk is high enough and the frequency of exposure is also high, Level 4 may be required, but this is not very common.) Once you have determined what level of safety control system you require, then EN 954-1 dictates what

you need to do to provide the required level of protection. Typical safety control systems for level 2, 3 or 4 are constructed using safety control “relays”⁵, positively-driven E-Stop switches, interlock switches, guard-lock switches⁶, and contactors with positively-driven feedback contacts, all wired together by the machine builder to interrupt power to the mechanical hazards. (The requirements for all of these devices are each called out by various other EN standards.) There is then a procedure described in ISO 13849-2 which details how to do an FMEA (Failure Mode Effects Analysis) to prove that your system is fault tolerant. Then the system must be tested to make sure that the monitoring of the safety system will report errors when they occur to fully meet the requirements. The requirements become more difficult and expensive to comply with if you want to allow for a controlled stop before removing hazardous power and/or if you want to construct a two area (Main + Load/Unload) machine.

All of the above sounds like a lot of work, hassle and expense- and it is. To make things even more frustrating, meeting these important requirements rarely, if ever makes your machine more attractive to your customers at the time of sale. It slows time-to-market and increases development cost without providing any *differentiating* market value. Basically, all machinery vendors are forced to mark their machines as compliant, so customers don’t perceive any difference.

Sometimes engineers take shortcuts when designing their safety control system by not reading, or partially ignoring, any or all of the EN standards referenced by the CE Machinery Directive, hoping that the test lab does not catch any errors or omissions. Unfortunately, this can often result in significant rework and delay of product launch when the test lab discovers insufficient compliance. If you’re “lucky” enough to pass a machinery safety compliance inspection despite having errors and/or omissions then, of course, there is a real liability issue. Clearly, taking “shortcuts” is not advisable.

Light at the end of a short tunnel...

Fortunately, the eF-785 is pre-engineered to remove nearly all of this work from your project plan. All you have to do is to assess whether you need a level 2 or 3 safety control system based upon your risk assessment. If you need a level 3 system, install the eF-785 with guard-locks on any movable guards (i.e. protective doors or covers). If you require a level 2 system, install the eF-785 with interlock switches on any Main area moveable guards, and guard locking switches on any moveable guards in the Load area. That’s it.

The safety review and certification of the eF-785 to EN 954-1 explicitly included an FMEA of a safety control system constructed as detailed in this manual to make sure the installation instructions, when followed, would result in a safety control system compliant with the standards. So, if you install the eF-785 according to these instructions, using the recommended 3rd party components, your machine will be compliant.

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- ⁵ Safety control “relays” are control circuits constructed of multiple relays with special positively guided contacts, electrically cross-coupled and packaged together to perform fail-safe control and monitoring functions. These “relays” typically cost \$200-\$1,000USD depending on the safety level required and the required complexity of the control system (systems that allow time for a controlled stop and/or control multiple areas cost increasingly more).
- ⁶ Guard-lock switches are interlock switches that also have a fail safe solenoid latch to lock the guard (door) they are monitoring in a closed position.

This assumes that certain basic safety requirements (guarding etc.) are met. See list below for details.

Teknic created a list of basic assumptions about a hypothetical machine that features the eF-785 Power Distribution and Safety Control Center. These assumptions (and a test setup consistent with them) were used in the FMEA and fault testing to assure that the eF-785 meets the requirements of EN-954-1 and EN 1050. The objective of this section is to make it clear how to use the eF-785 while complying with requirements EN 954-1 and EN 1050.

Your machine must comply with all of the applicable assumptions in order to meet the CE machine safety requirements:

1. All hazards in the machine must be internal, behind frame members, covers (skins), and inaccessible to the user. The user must be protected from accessing them by movable guards that are monitored and/or locked by the eF-785.
2. All hazards must be supervised and powered by the eF-785 and made harmless by the removal of hazard power from the given area.
3. Fixed and moveable guards for hazards must be designed and installed in accordance with EN 953.
4. If the machine is segmented (designed with separate Main and Load/unload Areas) any operation or failure of the Main Area can't cause a hazard (electrical or mechanical) to exist in the Load/unload Area by virtue of the construction of the machine.
5. All interlocks with guard-locking must have their unlock solenoid under the direct control of the eF-785 using the separate and specific outputs for the Main and Load areas.
6. The machine's moveable guards must employ interlock switches with guard-locking wherever the operator enters the hazard area of the machine at a medium frequency (e.g. a typical Load/Unload Area guard).
7. The machine's moveable guards must employ interlock switches wherever the operator enters that hazard area at a low frequency of access and opening the guard to access the area requires the use of a tool. Each guard must be marked appropriately to indicate the presence of a hazard behind it.
8. The machine's moveable guards must employ interlock switches with guard-locking in the Load/unload Area, regardless of frequency of access or whether access requires the use of a tool or not.
9. For areas behind guards that are accessed at a medium frequency, the size and or construction of these areas must not permit a person to get inside and close the guard.
10. Under *any* control system, failure hazards must not protrude beyond the machine perimeter exposing themselves to the operator or other personnel. Appropriate measures must be taken in the construction of the machine to ensure this, including, but not limited to, a strong frame, appropriately rated bearings, bumpers, shock absorbers and strong covers (if required). Guards must not be relied upon as part of the system that constrains these hazards from protruding beyond the

machine perimeter. Guards must be used only to limit personnel access to hazards within the machine.

11. The human possibility of avoidance or limiting harm (e.g. reflex, agility, possibility of escape) for all hazards associated with this machine can be impossible. (EN 1050 7.2.3.3)
12. Hazards in this machine are to a person or several persons and where the highest consequence may be serious (non-reversible) injury or death. (EN 1050 7.2.2)
13. The E-Stop switches, interlocks with and without guard-locking and any external power disconnect contactors must meet the required standards :

EN 418	E-Stop equipment, functional aspects
EN 60947-5-1	E-Stop and interlock switch contact block requirements
EN 60947-5-5	E-Stop actuator requirements
EN 1088	Interlocking devices for guards
EN 60947-4-1	Electromechanical contactors

14. The E-Stop switch (or switches) must be placed where they are readily accessible by machine operators as per EN 292-2 Section 3.6.
15. Power to devices from circuits connected to J_A and J_B and pins 6 & 9 on J₅ must be protected from being touched by personnel, i.e. these circuits are not accessible (as per EN 61010-1) within the machine. These devices must require that a tool is used to access any hazardous circuits or hazardous mechanical elements. The cables which supply power to devices within the machine from J_A and J_B and pins 6 & 9 on J₅ should be clearly marked with the shock hazard international symbol. There should be marking on cables and components powered from this power source, which states that the circuit is live and not interrupted by safety interlock. An example of acceptable marking is shown below.



Example label

16. Hazards that might exist in a machine, but that are not rendered safe when electrical power is removed may include, but are not limited to: chemical hazards, nuclear radiation, potential energy (from springs, elevated loads, pressurized fluids and/or pressurized gases), explosive materials, sharp edges, impalement hazards, etc. are beyond the scope of this document. These hazards can likely be controlled and monitored by a safety control system based upon the eF-785, however, no attempt has been made to consider them herein.
17. The machine must pass (or be able to pass) EN61010-1.
18. All accessible metal parts must be bonded to protective earth.

19. Ambient Operating conditions must be in the range of 0°-40° Celsius.
20. The machine must not be hand held.
21. The machinery must not be for use in explosive environments.
22. The machine must meet or exceeds all current international standards for human factors engineering and ergonomics.
23. The machine must not be a vehicle, and once installed must not be mobile.
24. The machine must not used for underground work.
25. The machine must not move or lift people.
26. The machine must be designed with a low center of gravity and the mounting of the machine must prevent any hazardous motion, movement, or turnover.
27. Software must not have the ability to override the electromechanical safety logic within the eF-785.

WARNING:

To the best of our knowledge, at the time of the writing of this manual the guidelines described herein meet the following EN standards:

- EN 954-1
- EN 60204-1
- EN 61010-1
- SEMI S8
- SEMI S2

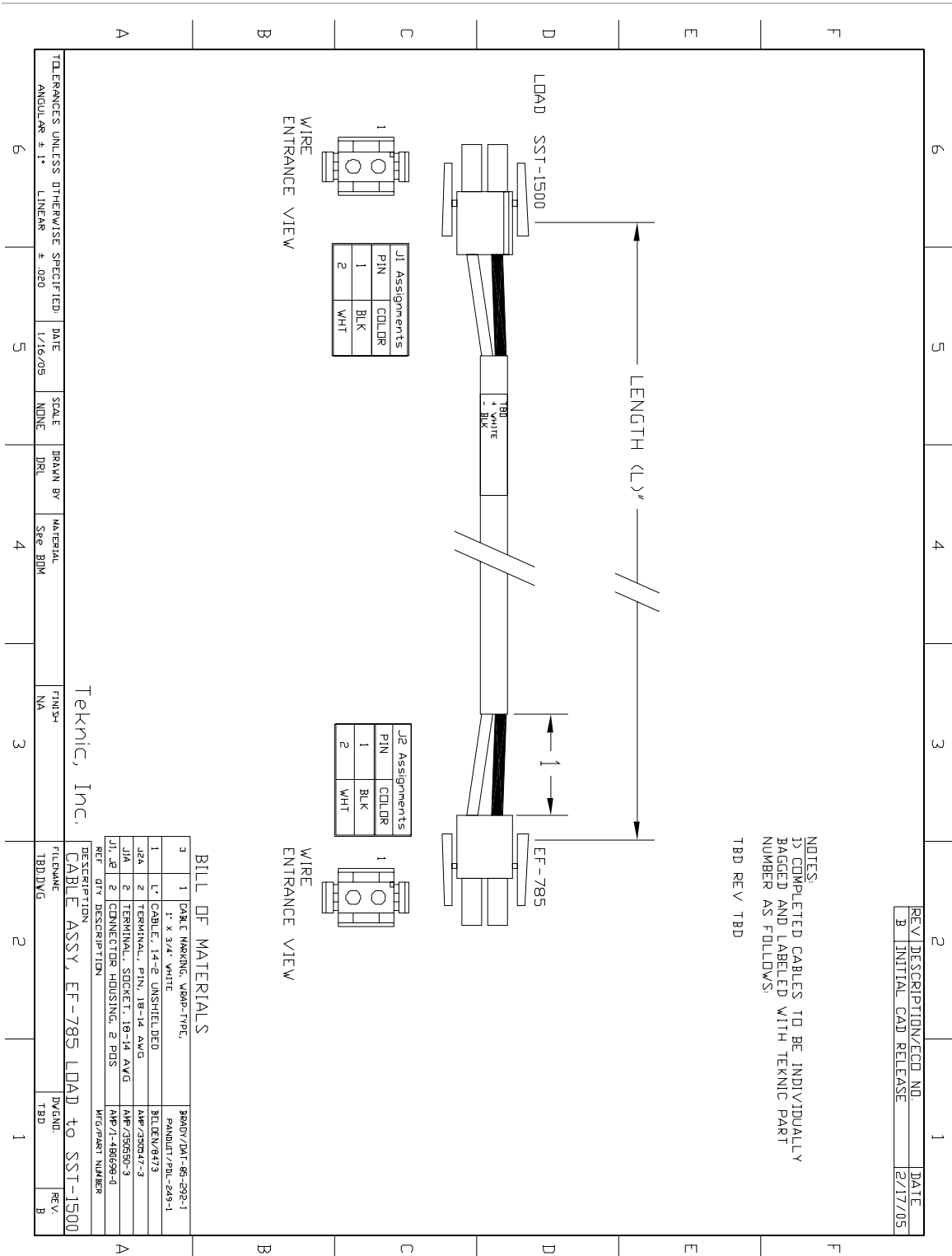
These guidelines are no substitute for a proper evaluation of risks and a careful review of the appropriateness of the safety system. In fact, meeting the EN standards and the Machinery Directive may be insufficient to protect personnel and property.

The user of the eF-785 must perform a careful, exhaustive Failure Mode Effects Analysis (FMEA) for their machine safety system and decide if the level of protection is appropriate. Teknic can furnish you with an FMEA for the eF-785 that has been provided to us by a third party testing laboratory which you can use to help you prepare this; however, the responsibility for the entire safety control system's design in your machine is your responsibility. Teknic does not warrant that installation of the eF-785 in your machine according to these instructions will prevent accidents, injuries or deaths.

APPENDIX B: SPECIFICATIONS

Operating Environment	0-40° C, 0-90% humidity
Input power	100-120/ 200-240VAC 50/60Hz (selectable), up to 20A RMS (4KVA@200VAC)
Input Power ranges	115 range: 100-126 Vrms, 50-60Hz 230 range: 198-240 Vrms, 50-60Hz
Input circuit breaker	UL489 rated 20A magnetic-hydraulic breaker with 10kA-interrupt capacity
240 VAC power management capacity	4KVA in three circuits: <ul style="list-style-type: none"> • Non-hazardous load circuits (PC power) • Load/Unload Area hazardous circuits • Main Area hazardous circuits
75VDC management capacity	1500W RMS, (20A) in two fused circuits
24VDC management capacity	480W, (20A) in three fused circuits
40VDC output	150 W (3.6A) internal supply (for ControlPoint™ devices, overload protected)
EMI filtering	Consistent with meeting EN61326
Regeneration load capacity	150W RMS
Cooling	Fan cooled
Safety Control Functions	Support for one or two area control (Load/Unload Area and Main Area) fully monitored and EN954 compliant to Category 3. Supports E-stop switches, door interlock switches and solenoid guard locks. Includes audible alarm to warn of safety breach.
Dimensions	Width: 16.875 inches (42.87 cm) Height: 3.48 inches (8.84 cm) Depth: 18.188 inches (46.2 cm)
Rack mount information	2 rack units tall 19 inch rack mount front panel Side hole pattern for mounting
Weight	28 lbs (12.7Kg)

48–90VDC LOAD AREA TO SST (J8A, J8B)



The drawing shows a cable assembly with a length dimension of $\langle L \rangle$ inches. The cable has a diameter of 1 inch. The assembly includes a connector housing and a cable jacket. The drawing is labeled with dimensions and part numbers.

WIRE ENTRANCE VIEW

J2 Assignments	
PIN	COLOR
1	BLK
2	WHT

WIRE ENTRANCE VIEW

J2 Assignments	
PIN	COLOR
1	BLK
2	WHT

BILL OF MATERIALS

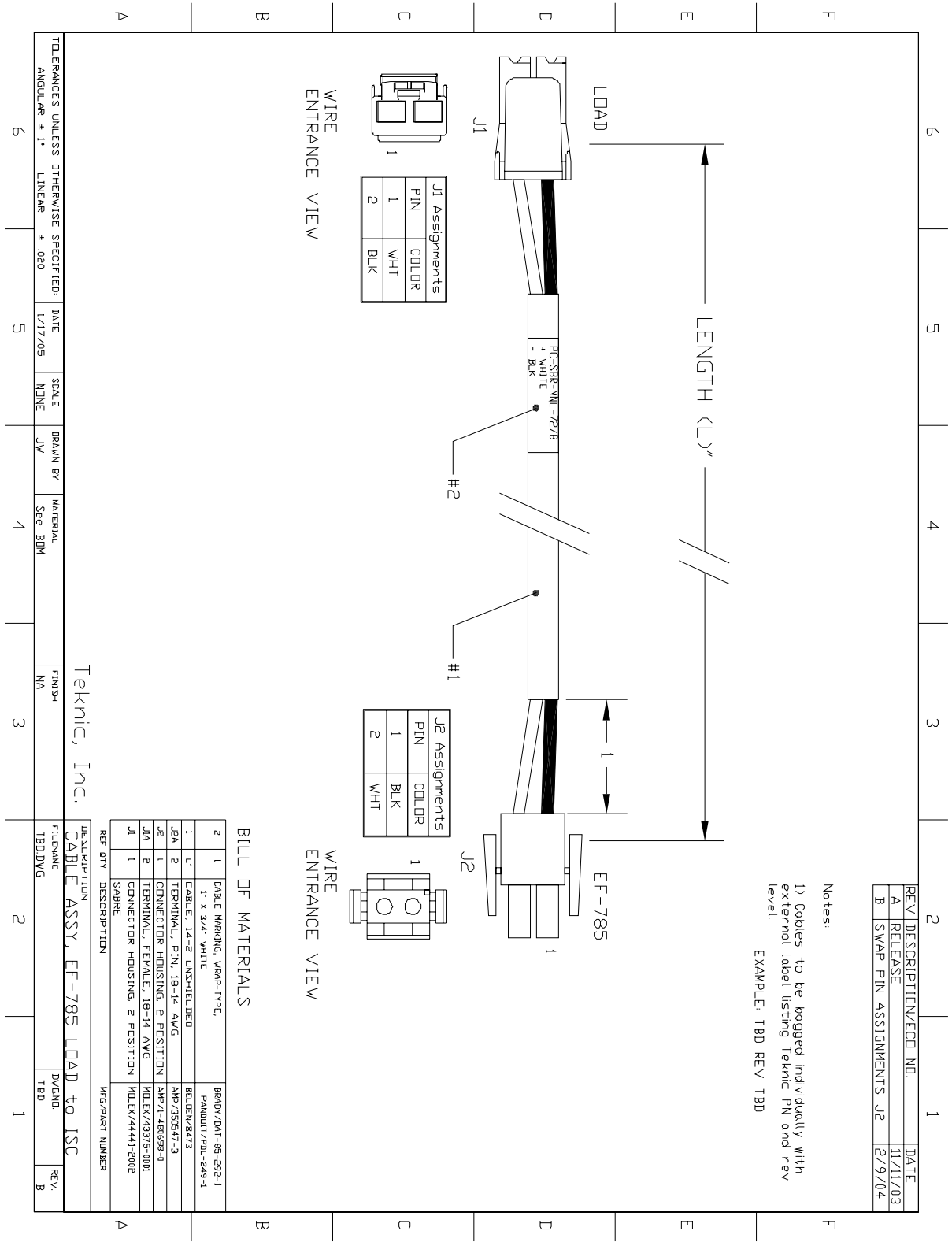
QTY	DESCRIPTION	REF. QTY	DESCRIPTION
4	1" X 3/4" WHITE CABLE MARKING, WRAP-TYPE	1	360/104T-80-292-1
1	1" CABLE, 14-2 UNSHIELDED	1	PANDUIT/PDL-249-1
1	TERMINAL, SOCKET, 18-14 AWG	1	BELEN/8473
1	CONNECTOR HOUSING, 2 POS	1	AMP/250550-3
1		1	AMP/1-48069-0

NOTES:

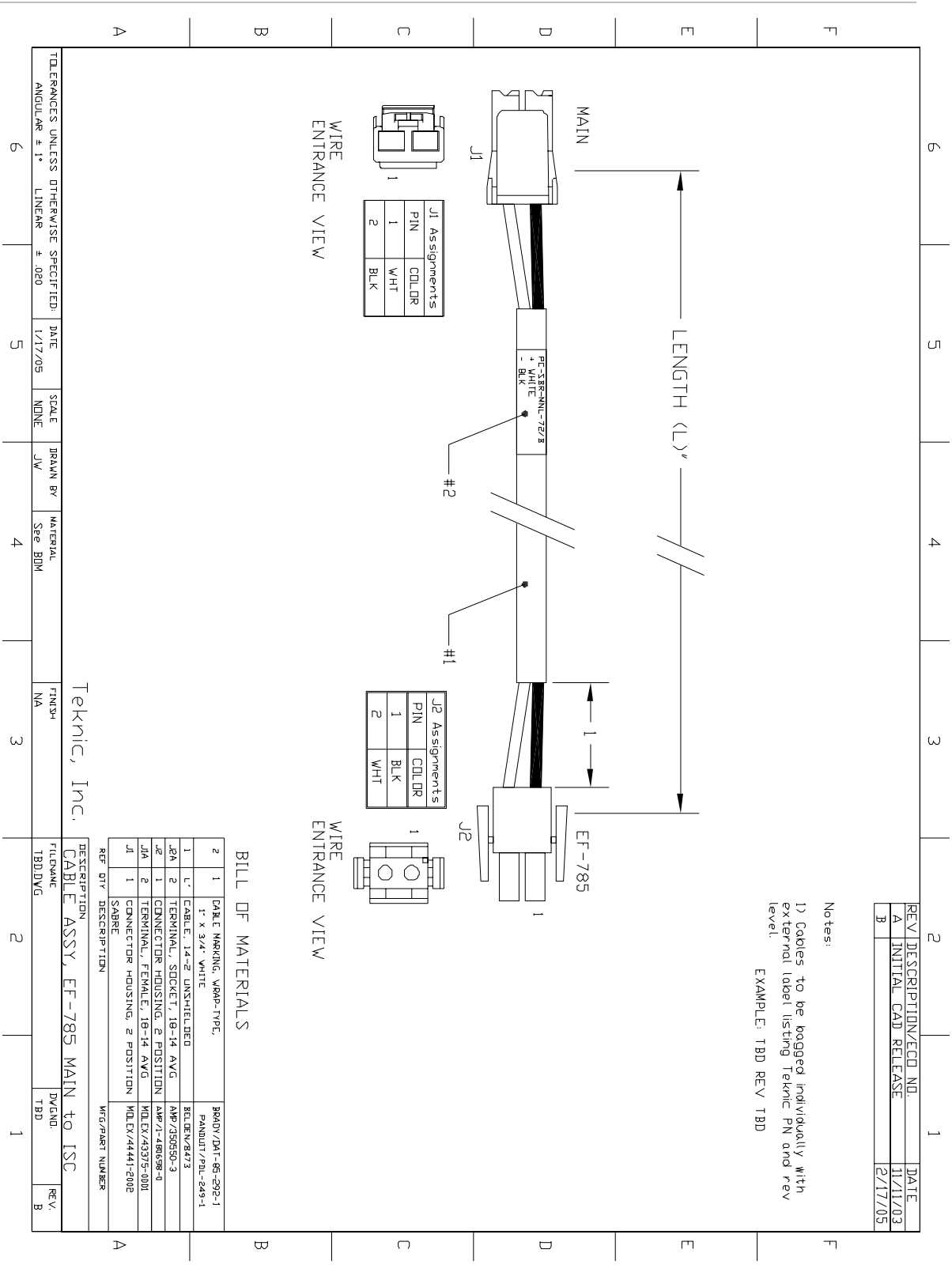
- COMPLETED CABLES TO BE INDIVIDUALLY BAGGED AND LABELED WITH TEKNIC PART NUMBER AS FOLLOWS:

TBD REV TBD

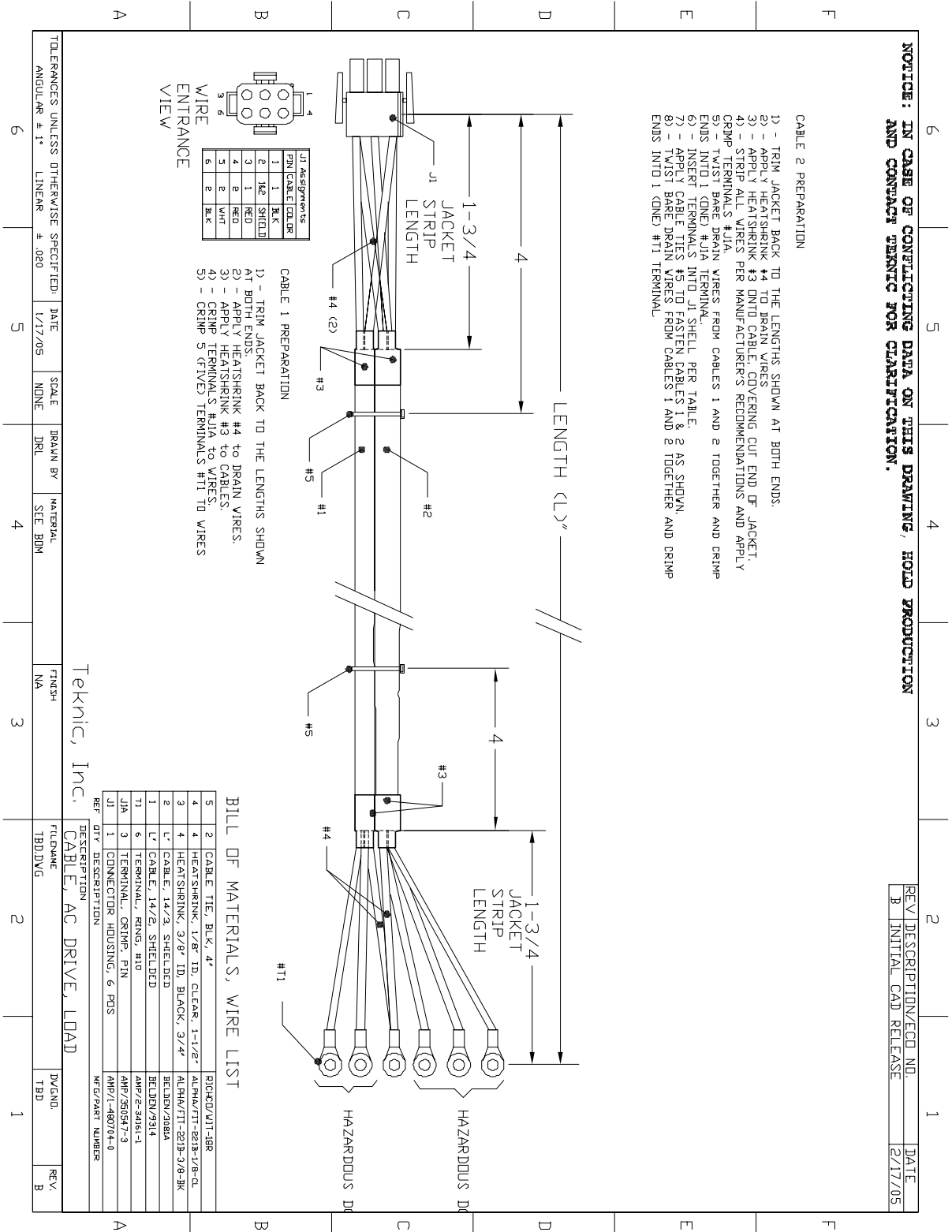
48-90VDC LOAD AREA TO ISC (J8A, J8B)



48-90 VDC MAIN AREA TO ISC / SST-ISC (P7A, P7B)



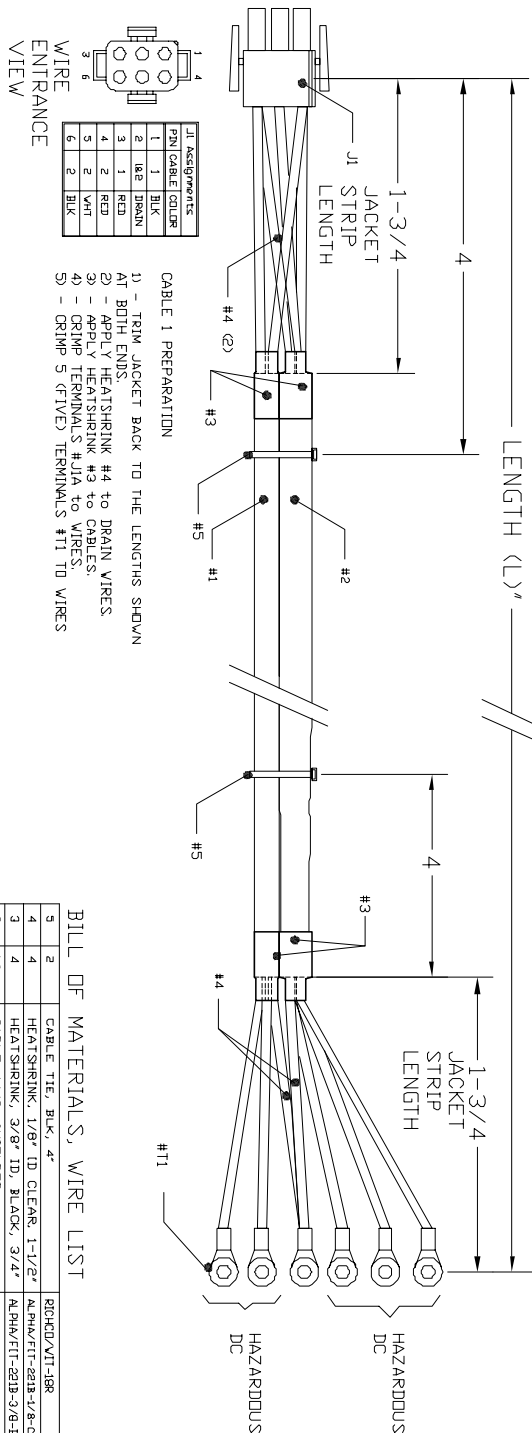
AC SERVO POWER CABLE, LOAD AREA (J4)



NOTICE: IN CASE OF CONFLICTING DATA ON THIS DRAWING, HOLD PRODUCTION AND CONTACT TERNIC FOR CLARIFICATION.

REV	DESCRIPTION/ECO NO.	DATE
B	INITIAL CAD RELEASE	2/17/05

- 1) - TRIM JACKET BACK TO THE LENGTH SHOWN AT BOTH ENDS.
- 2) - APPLY HEATSHRINK #3 TO DRAIN WIRES
- 3) - APPLY HEATSHRINK #4 TO CABLE, COVERING CUT END OF JACKET.
- 4) - STRIP 1/2" OF JACKET FROM CABLE, LEAVING 1/2" OF JACKET ON CABLE.
- 5) - STRIP 1/2" OF JACKET FROM MANUFACTURER'S RECOMMENDATIONS AND APPLY CRIMP TERMINAL #1.
- 6) - TWIST BRAIN WIRES FROM CABLES 1 AND 2 TOGETHER AND CRIMP ENDS INTO 1 ONE# 9/16 TERMINAL.
- 7) - INSURE TERMINALS INTO J1 FASTEN PER TABLE.
- 8) - APPLY CABLE TIES #3 TO SPACER CABLES 1 & 2 AS SHOWN.
- 9) - TWIST BRAIN WIRES FROM CABLES 1 AND 2 TOGETHER AND CRIMP ENDS INTO 1 ONE# 1/16 TERMINAL.



J1 Assignments		
PIN	CABLE	COLOR
1	1	BLK
2	1&2	DRN
3	1	RED
4	2	RED
5	2	WHT
6	2	BLK

CABLE 1 PREPARATION

- 1) - TRIM JACKET BACK TO THE LENGTHS SHOWN AT BOTH ENDS.
- 2) - APPLY HEATSHRINK #4 TO DRAIN WIRES
- 3) - APPLY HEATSHRINK #3 TO CABLES
- 4) - CRIMP TERMINALS #11A TO WIRES
- 5) - CRIMP 5 (FIVE) TERMINALS #11 TO WIRES

BILL OF MATERIALS, WIRE LIST	
1	ETCHED/VTI-16R
2	CABLE TIE, 1/8", 4"
3	HEATSHRINK, 1/8", ID CLEAR, 1-1/2"
4	ALPHA/MTI-2213-1/8-CL
5	HEATSHRINK, 3/8" ID, BLACK, 3/4"
6	ALPHA/MTI-2213-3/8-BK
7	CABLE, 14/2, SHIELDED
8	BECDEN/3514
9	CABLE, 14/2, SHIELDED
10	AMP-2-2461-1
11	TERMINAL, RING, #10
12	AMP/35051-3
13	TERMINAL, CRIMP, SOCKET
14	AMP/1-48070-4D
15	CONNECTOR HOUSING, 6 POS
16	AMP/1-48070-4D
17	DESCRPTION
18	QTY

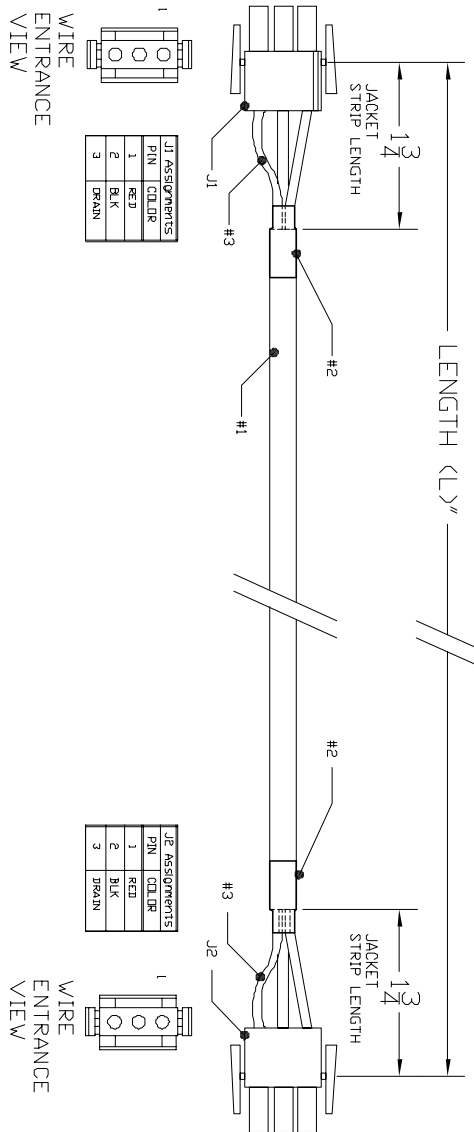
Teknic, Inc.

CABLE, AC DRIVE, MAIN

TOLERANCES UNLESS OTHERWISE SPECIFIED:	DATE	SCALE	DRAWN BY	MATERIAL	FINISH	FILENAME	DWGNO.	REV.
ANGULAR $\pm 1^\circ$ LINEAR $\pm .020$	1/17/05	NONE	DRL	S/E BDM	NA	TBD\DWG	TBD	B
6	5		4		3	2		1

NOTICE: IN CASE OF CONFLICTING DATA ON THIS DRAWING, HOLD PRODUCTION AND CONTACT TECHNICAL FOR CLARIFICATION.

REV	DESCRIPTION/ECD NO.	DATE
B	INITIAL CAD RELEASE	2/17/05



CABLE PROCEDURE

- 1) - STRIP JACKET EACH END
- 2) - APPLY HEATSHRINK (#3) TO EACH DRAIN WIRE CAPTURING HEATSHRINK #2
- 3) - APPLY HEATSHRINK (#2) TO EACH CABLE END
- 4) - STRIP WIRES AND APPLY TERMINALS (REF J4), CAPTURING HEATSHRINK ON DRAIN WIRES.
- 5) - INSERT TERMINALS PER TABLES.

Teknic, Inc.

ITEM	QTY	DESCRIPTION	MP/ PART NUMBER
3	2	HEATSHRINK, 1/8" ID, CLEAR, 1-1/2"	ALPHA/TTI-223-B-V-B-CL
2	2	HEATSHRINK, 3/8", 1D, BLACK, 3/4"	ALPHA/TTI-223-B-V-B-3K
1	1	CABLE, 14/2, SHIELED, 600V	BELEN/9343
14	2	TERMINAL, CRIMP, SOCKET	AMP/350356-3
17, 22	2	CONNECTOR HOUSING, 3 PDS	AMP/148070-04

TOLERANCES UNLESS OTHERWISE SPECIFIED:		DATE	SCALE	DRAWN BY	MATERIAL	FINISH	FILENAME	DWGNO.	REV.
ANGULAR $\pm 1^\circ$	LINEAR $\pm .020$	1/17/05	NONE	DRL	SEE BOM	NA	TBD\DWG	TBD	B

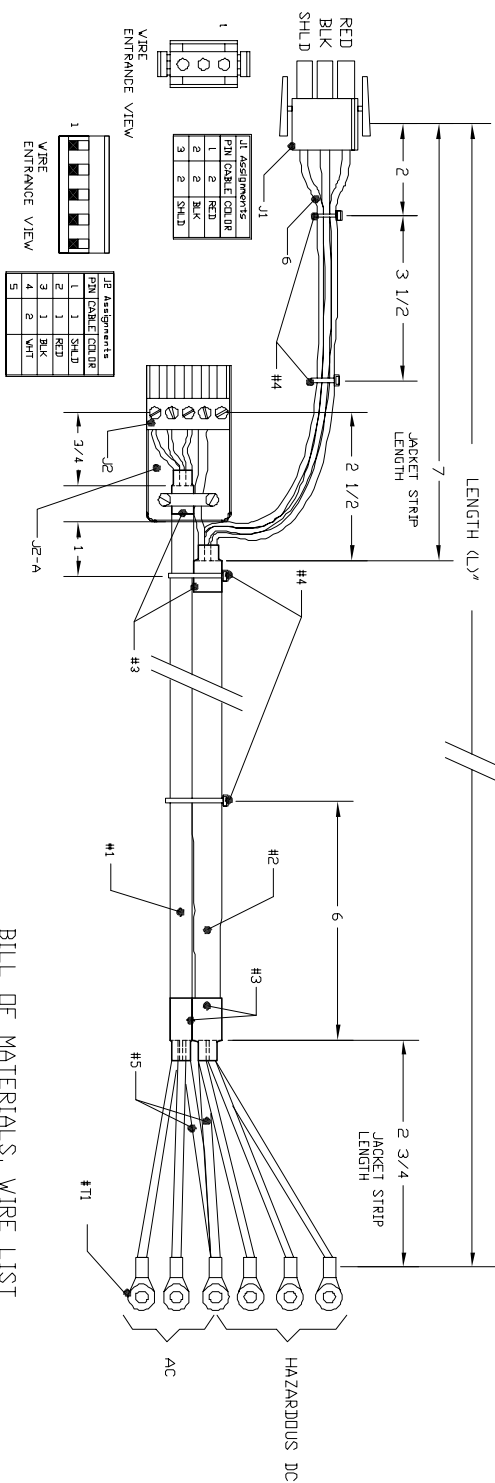
1	2	3	4	5	6
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NOTICE: IN CASE OF CONFLICTING DATA ON THIS DRAWING, HOLD PRODUCTION AND CONTACT TECNIG FOR CLARIFICATION.

REV	DESCRIPTION/ECD NO.	DATE
B	RELEASE	2/17/05
C	CORRECTED J1 & J2 TABLES	5/2/05

11) - APPLY TWO CABLE TIES #4 TO REMAINING WIRES OF CABLE 2 BETWEEN JACKET END AND CONNECTOR J1 AS SHOWN.

CONNECTION TO THE SUBSTRATE



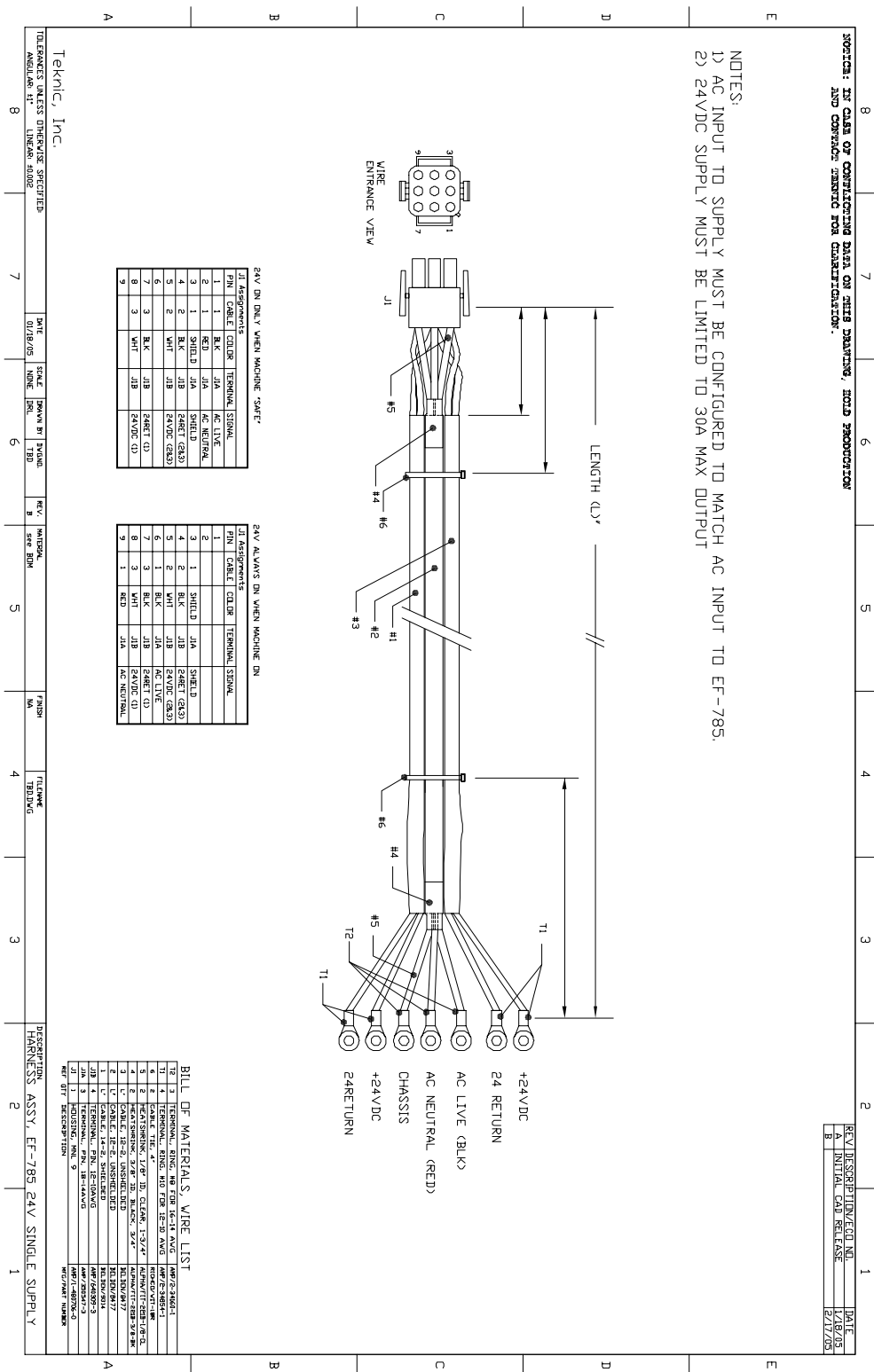
5) - ATTACH CONNECTOR JE ACCORDING TO TABLE.

REF	QTY	DESCRIPTION	MFG/PART NUMBER
6	1	HEATSHRINK, 1/8" ID, CLEAR, 6-1/2"	ALPHA/TI-223B-1/8-DL
5	2	HEATSHRINK, 1/8" ID, CLEAR, 2-1/2"	ALPHA/TI-223B-1/8-OL
4	4	CABLE TIE, BLK, 4"	RICHCO/MIT-BR
3	4	HEATSHRINK, 3/8" ID, BLACK, 3-1/4"	ALPHA/TI-223B-3/8-BK
2	1	CABLE, 14/3, SHELDED	BELDEN/7080A
1	1	CABLE, 14/4, SHELDED	BELDEN/9314
1	1	TERMINAL, RING, #10	AMP-2-3451-1
2	1	CONNECTOR, HOUSING, 5 POS	PHENIX/1809398
2	1	CONNECTOR, PLUG TERMINAL, 5 POS	PHENIX/1727038
2	1	TERMINAL, CRIMP, SOCKET	AMP/356591-3
2	1	CONNECTOR HOUSING, 3 POS	AMP/1-480700-0

DESCRIPTION	TECHNICAL SPECIFICATIONS
CABLE, AC DRIVE POWER	1. Cable Type: 3-core, 12 AWG, 100% copper conductors, 100% PVC jacket, 100% shielded.

TOLERANCES UNLESS OTHERWISE SPECIFIED	DATE	SCALE	DRAWN BY	MATERIAL	FINISH	FILENAME	DWG/NO.	REV.
ANGULAR $\pm 1^\circ$ LINEAR $\pm .020$	1/17/05	NONE	DRL	SEE BOM	NA	TBD.DWG	TBD	C
6	5		4		3	2		1

SINGLE 24VDC SUPPLY CABLE (J5)

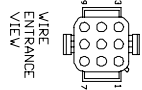


NOTICE: IN CASE OF CONFLICTING DATA ON THIS DRAWING, GOLD PRODUCTION AND CONTACT TAKE PRECEDENCE FOR CLARIFICATION.

KEY	DESCRIPTION/CD NO.	DATE
A	INITIAL CAD RELEASE	1/18/05
B		2/17/05

-

CONNECT TO SUPPLY FOR CIRCUIT 1
SUPPLY MUST BE LIMITED TO 20A MAX OUTPUT



24V CKT1 DN ONLY WHEN MACHINE 'SAFE'
24V CKT2&3 ALWAYS DN WHEN MACHINE DN

IT Assignment 15			
PIN	CABLE	COLOR	SIGNAL
1	1	BLK	AC LIVE (S&E)
2	1	RED	AC NEUTRAL (S&E)
3	1&2	DRN	SHIELD
4	4	BLK	24VDC (G&D)
5	4	WHT	24VDC (G&D)
6	2	BLK	AC LIVE (DN)
7	3	BLK	24VDC (G)
8	3	WHT	24VDC (G)
9	2	RED	AC NEUTRAL (DN)

24V CKT1 ALWAYS ON WHEN MACHINE ON
24V CKT2&3 ON ONLY WHEN MACHINE 'SAFE'

J1 Assignments		
PIN	CABLE	COLOR SIGNAL
1	2	BLK AC LIVE (SMT)
2	2	RED AC NEUTRAL (SMT)
3	1&2	BRN SHIELD
4	4	BLK GNDT (2&3)
5	4	GRNDC (2&3)
6	1	BLK AC LIVE (GND)
7	3	BLK GNDT (1)
8	3	WHT GRNDC (1)
9	1	RED AC NEUTRAL (GND)

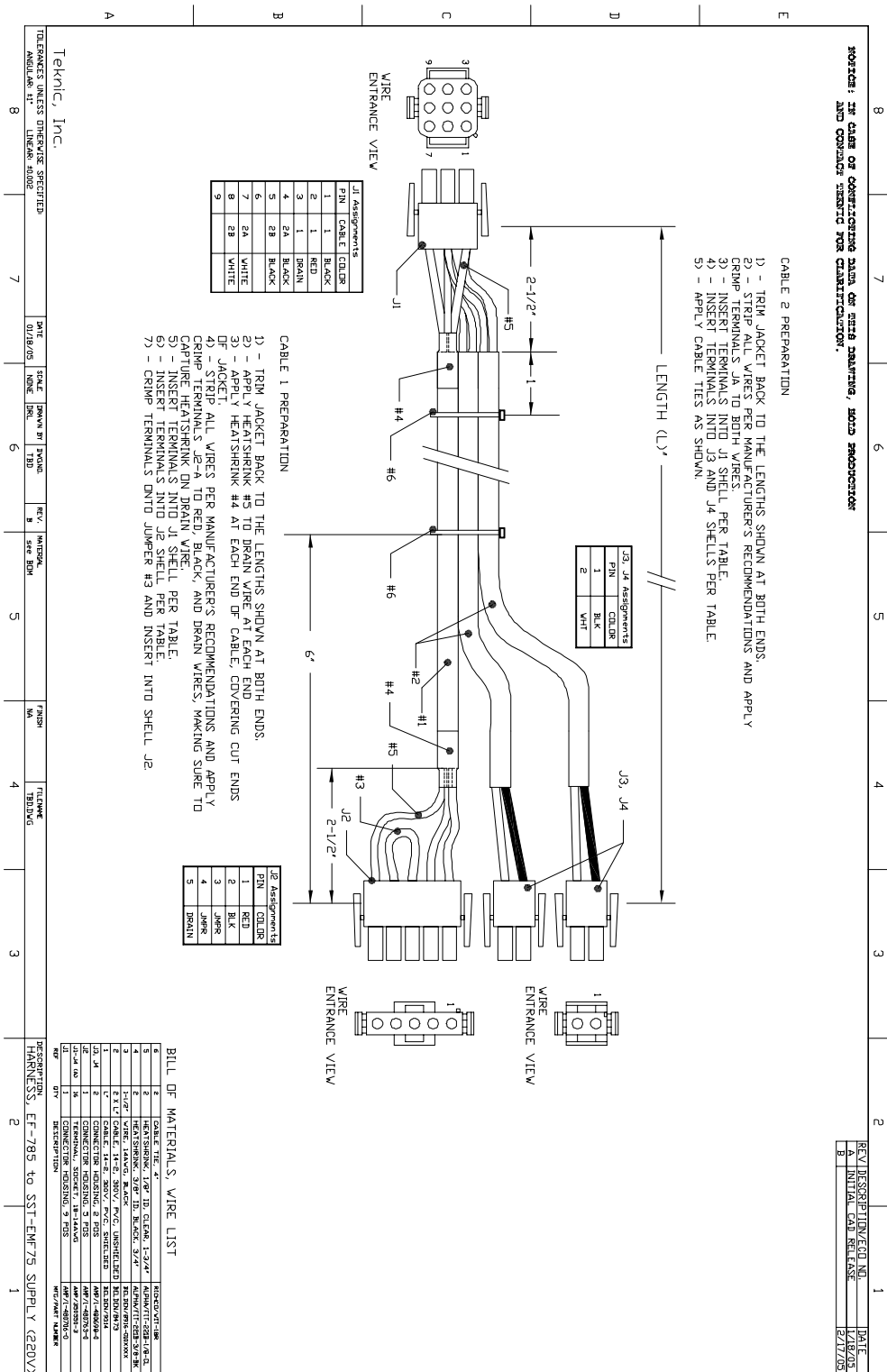
TI	16	TERMINAL	STNG	NO	FOR	16-14	AVG	4
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[illegible]

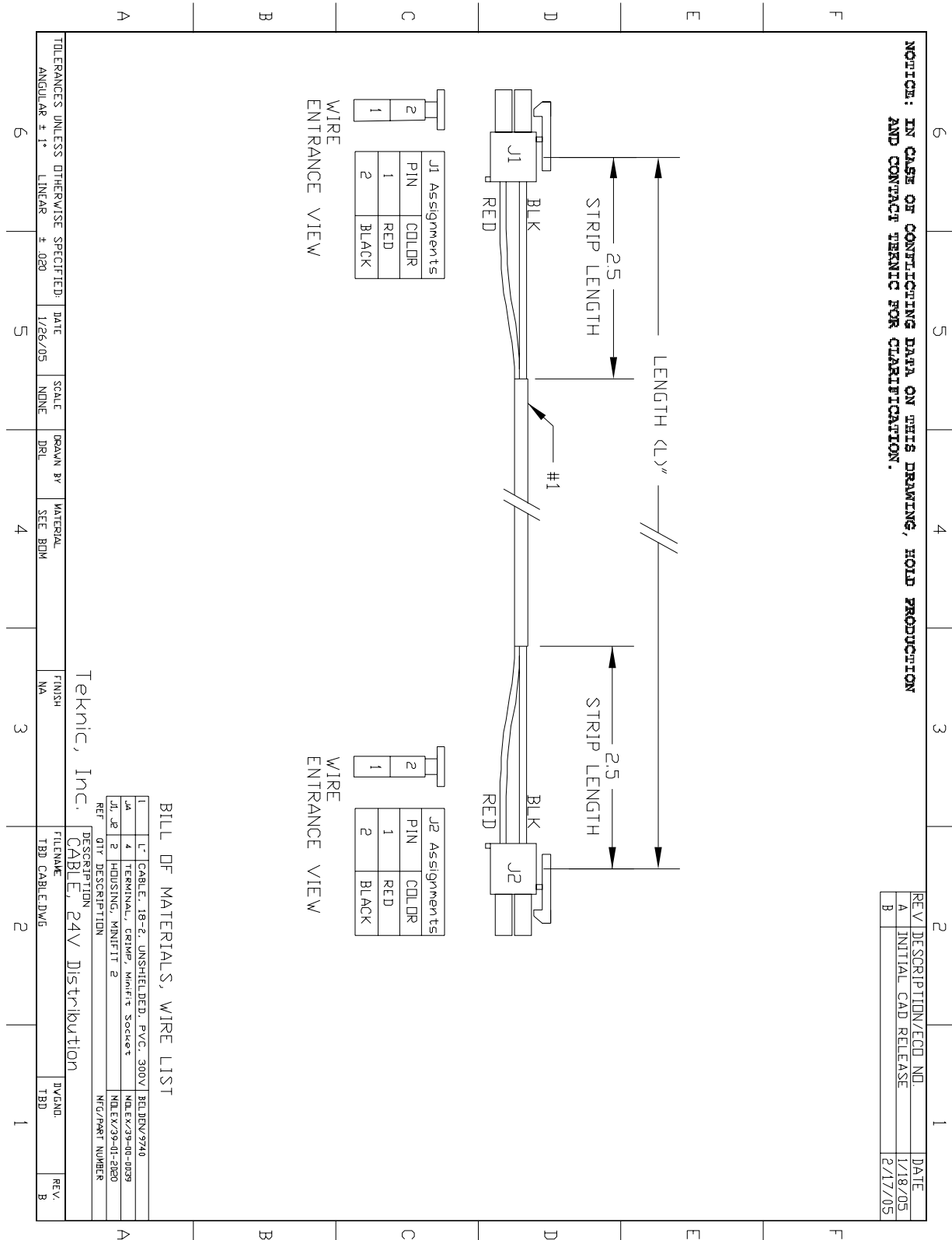
Teknic, Inc.

[illegible]

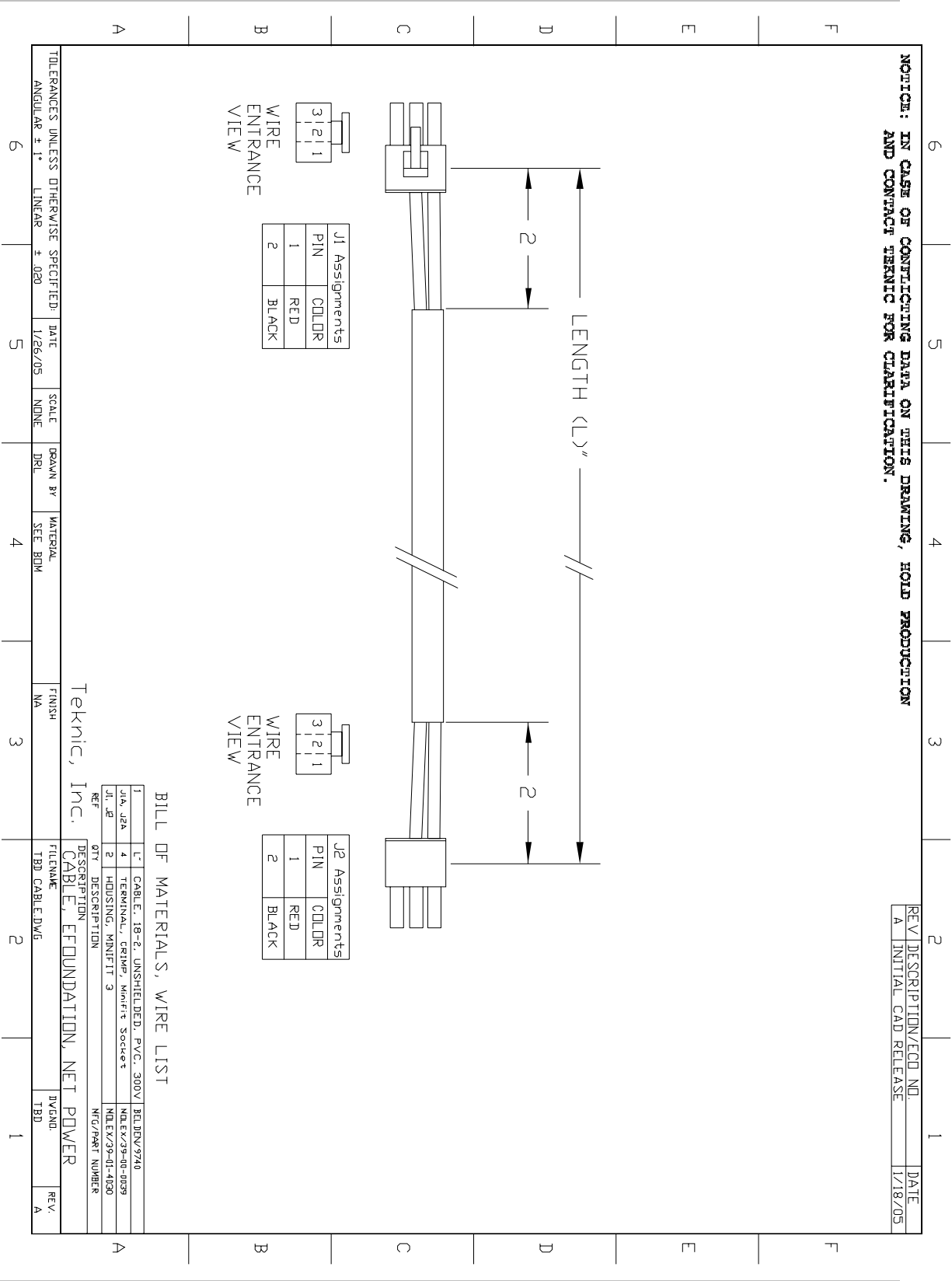
70 – 90VDC SUPPLY CABLE – SST-EMF75 (P6)



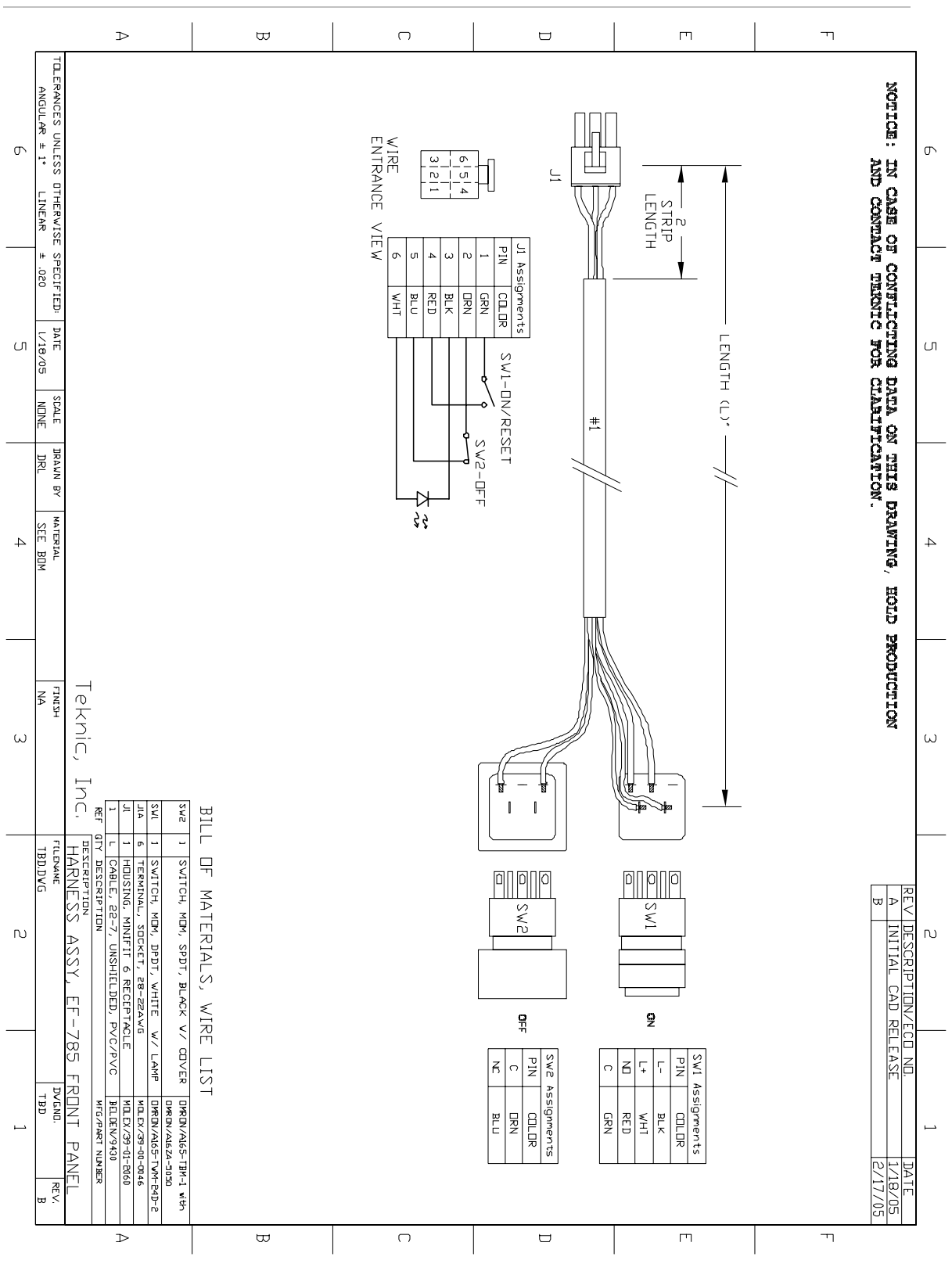
FAX (585)784-7460 VOICE (585)784-7454



40VDC POWER TAP DISTRIBUTION CABLE (P18)



FRONT PANEL HARNESS POWER/ENABLE CIRCUITS (P14)



REV DESCRIPTION/ECO NO.		DATE
A	INITIAL CAD DRAWING RELEASE	1/18/05
B		2/17/05

6	5	4	3	2	1
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TOLERANCES UNLESS OTHERWISE SPECIFIED:					
ANGULAR ± 1°	LINEAR ± .020	DATE 1/17/05	SCALE NONE	DRAWN BY TDT	MATERIAL SPE BOM
Teknic, Inc.			FINISH N/A		
DESCRIPTION SW DEVELOPMENT SAFETY JUMPER					
FILDRWG TBDDWG					
DIVCND TBD					
REV. B					

CAUTION:
DO NOT INSTALL IN A MACHINE THAT HAS
MECHANICAL HAZARDS ATTACHED TO
MOTORS.

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
----	----	----	----	----	----	----	---	---	---	---	---	---	---	---	---

BILL OF MATERIALS		
QTY	DESCRIPTION	REF. PART NUMBER
4	JUMPER, 24 AWG, R/L, 1 1/2"	BE-LBN/9984-0000 CR EQ
8	TERMINAL, SOCKET, 28-22AWG	WLE/V/39-00-0047
1	HOUSING, MINIFT-16 RECEPTACLE	WLE/V/39-01-2160

[illegible]

NOTICE: IN CASE OF CONFLICTING DATA ON THIS DRAWING, HOLD PRODUCTION AND CONTACT TECNIP FOR CLARIFICATION.

REV	DESCRIPTION/ECD NO.	DATE
A	INITIAL CAD RELEASE	1/18/05

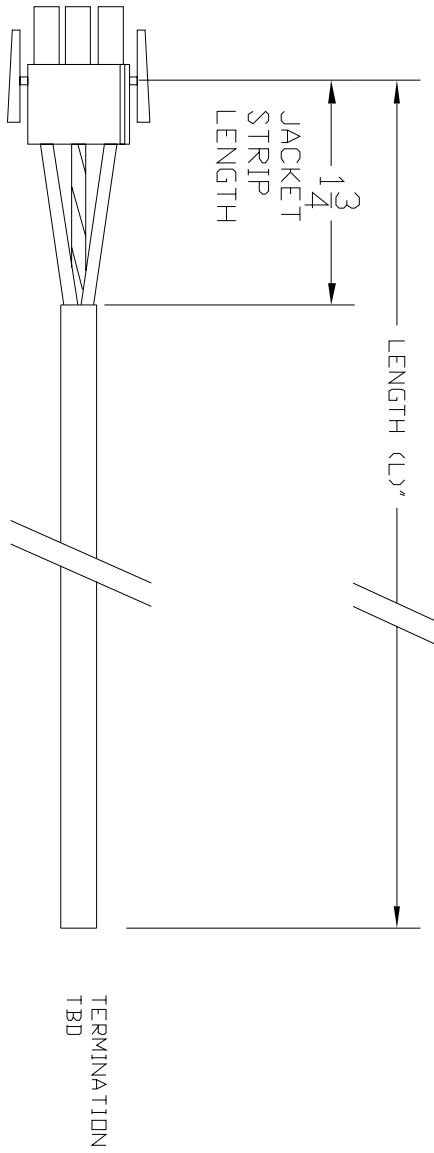


Diagram of a 3-pin connector. The table below lists the J1 Assignments:

J1 Assignments	
PIN	COLOR
1	BRN
2	GRN/YEL
3	BLU

WIRE
ENTRANCE VIEW

REF	QTY	DESCRIPTION	
1	L*	CABLE, 12-3, UNSHIELD, 450V	ALPHA/SIB, RS DLF/LX(60019)
JM	3	TERMINAL, CRIMP, SOCKET	NIL CON IG&A DMS/(603)2
RT	1	CONNECTOR HOUSING, 3 POS	AMP/6430-3
			AMP/1-48070-0
			MFG/PART NUMBER

DESCRIPTION	TECHNIC, INC.
CABLE, FOUNDATION, AC INPUT	

REV.	DATE	SCALE	DRAWN BY	MATERIAL	FINISH	FILE NAME	DWG NO.	REV.
A	1/17/05	NONE	DRL	SEE BOM	NA	TBD.DWG	TBD	

#	LINE#	=	DATE	TIME	DIR	SLE	BUM	NA	IBUD	IBD
5			1/11/05	NINE						
6						4		3	2	1

APPENDIX D: FIELD MODIFIABLE OPTIONS

This section provides a brief review of the two “Supplementary Options”, Host Soft Shutdown, and Post E-stop Enable, and describes how to change these options, by setting the appropriate eF-785 internal jumpers.

HOST SOFT SHUTDOWN

When *enabled*, the Soft Shutdown feature allows you to power off your machine by shutting down the host computer. When Soft Shutdown is *disabled*, you must power down the host PC and the eF-785 separately. See the Supplementary Options section for more details.

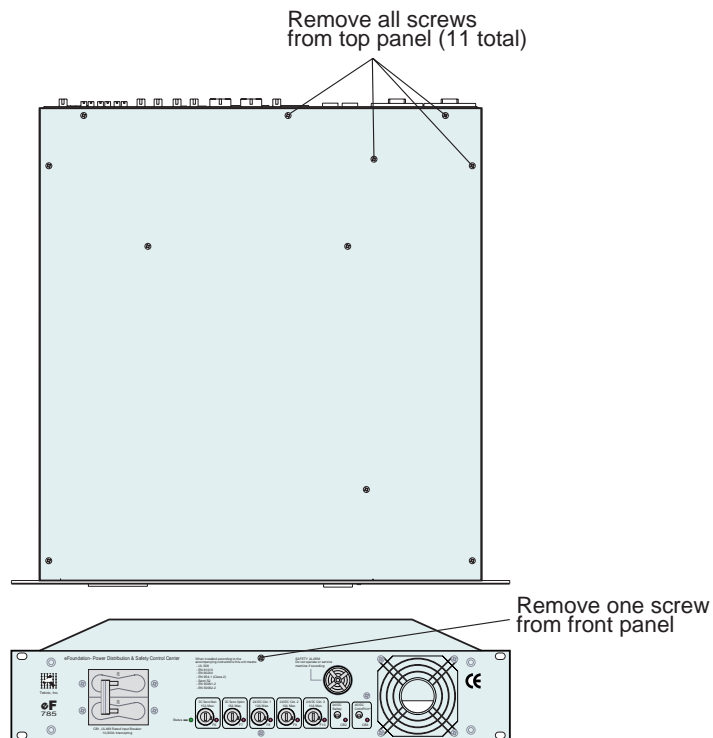
POST E-STOP ENABLE

When *enabled*, the Post E-Stop Enable feature requires that the operator not only reset the e-stop switch, but also press the on/enable button to restore hazardous power availability to the machine after an Emergency Stop (E-Stop) has occurred. When this feature is *disabled*, hazardous power can become available as soon as the E-Stop button is reset to its normal operating position. See the Supplementary Options section for more details.

CHANGING THE JUMPER SETTINGS

Step 1: Remove all power from the eF-785.

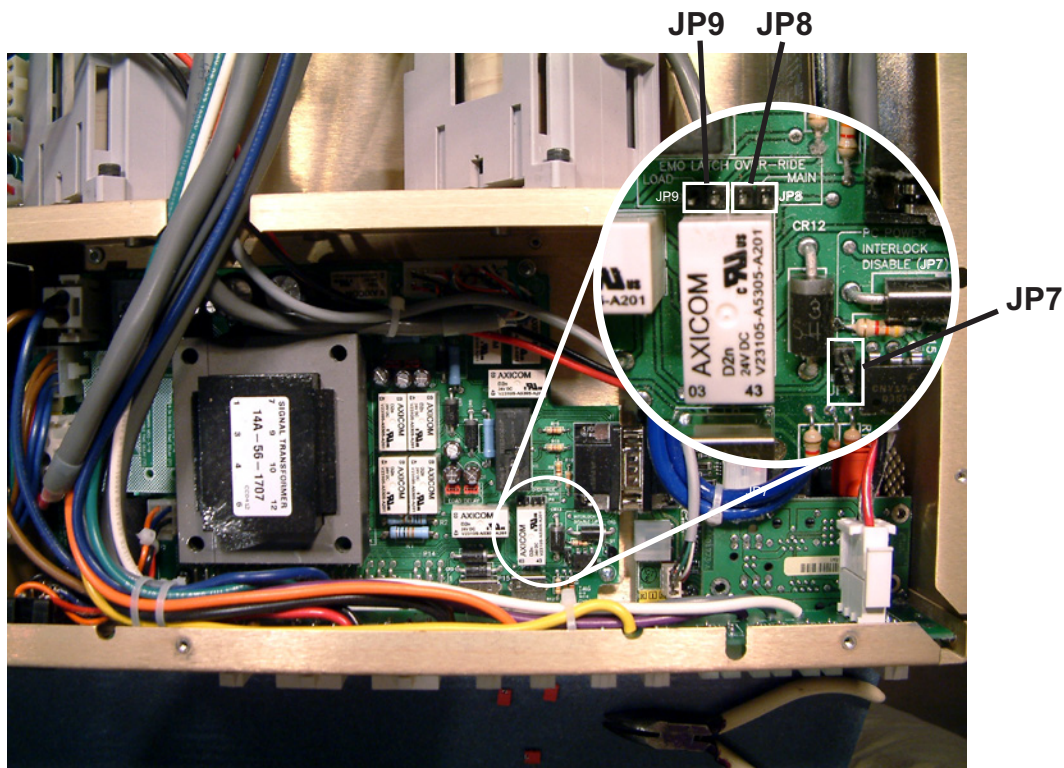
Step 2: Remove the top access panel. Refer to diagram below.



Screw locations on top and front panels of eF-785

Step3: Locate the jumper positions of interest

JP7, JP8, and JP9 are located near each other on the board next to the rear panel of the eF-785. Refer to the photo illustration below.

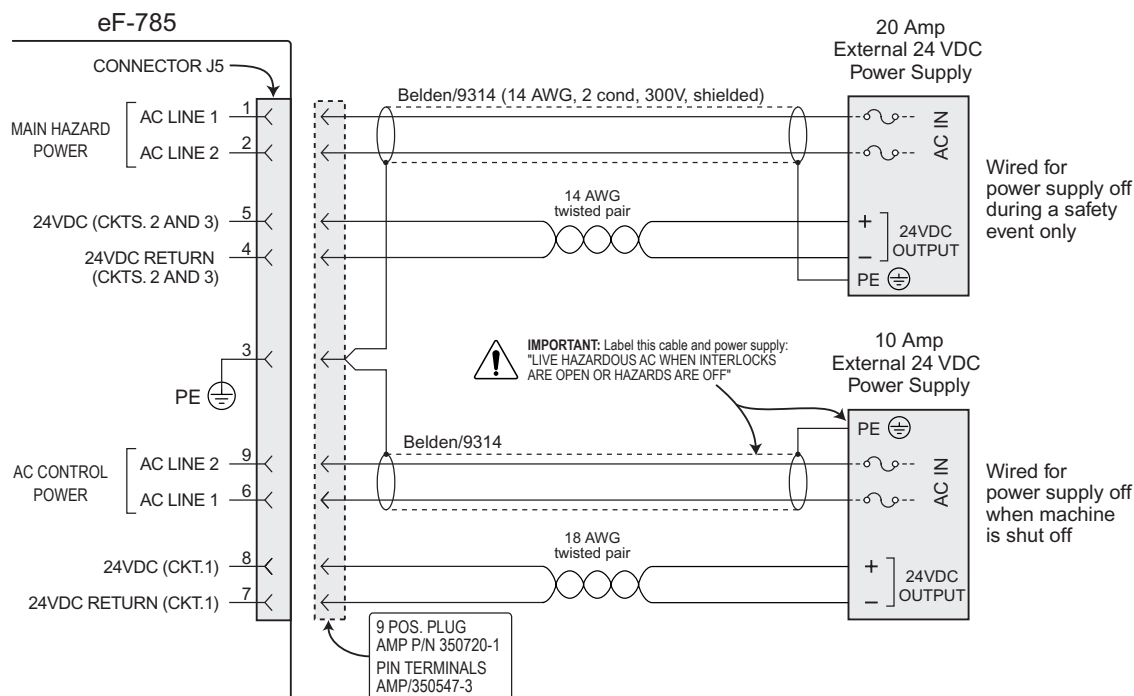
**Jumper locations for JP7, JP8, and JP9**

Step 4: Set jumpers . Refer to the table below.

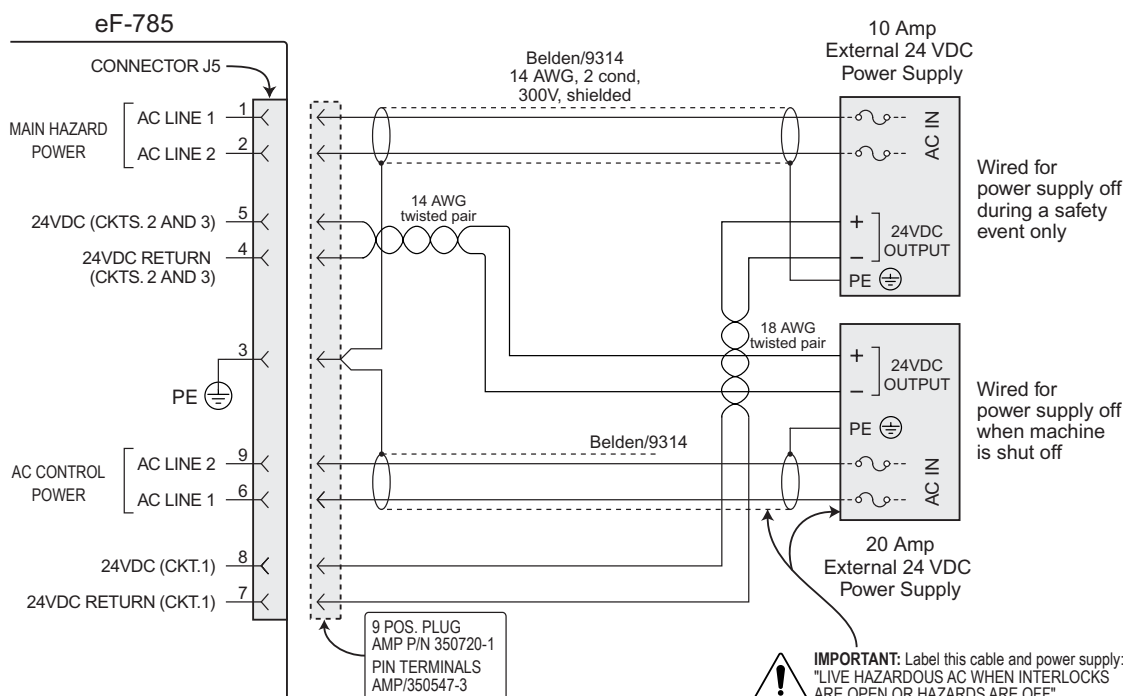
Feature	Enabled	Disabled
Host Soft Shutdown	JP7 open	JP7 installed
Post E-Stop Enable	JP8, JP9 open	JP8, JP9 installed

Jumper Configuration Table

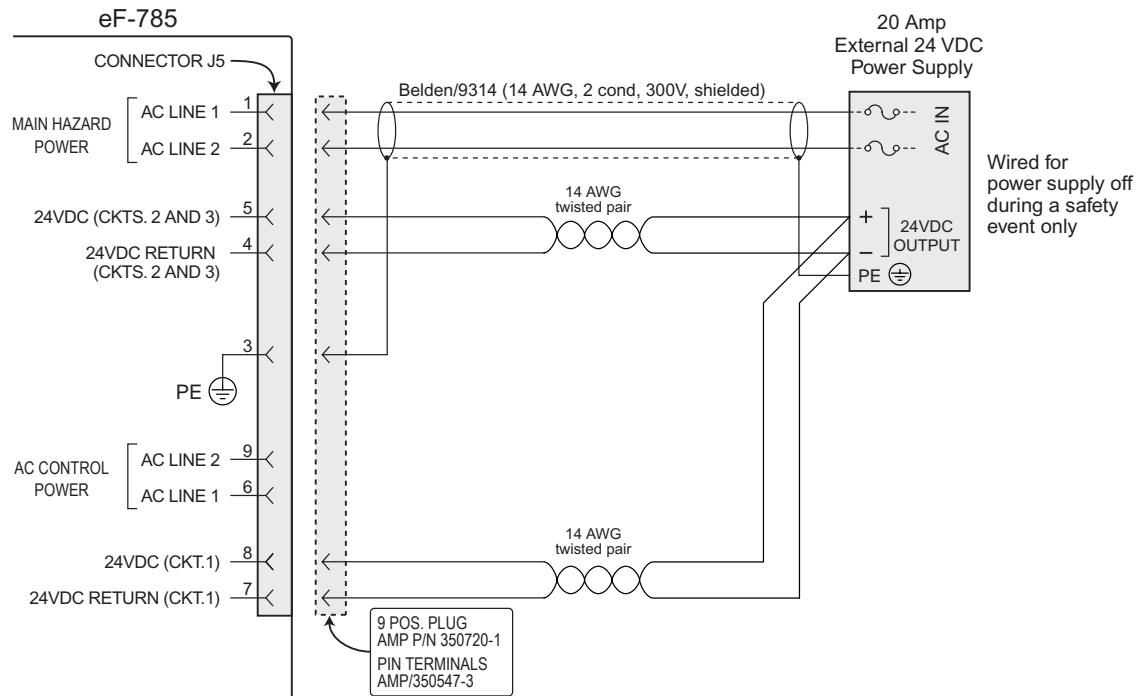
APPENDIX E: 24VDC SUPPLY WIRING



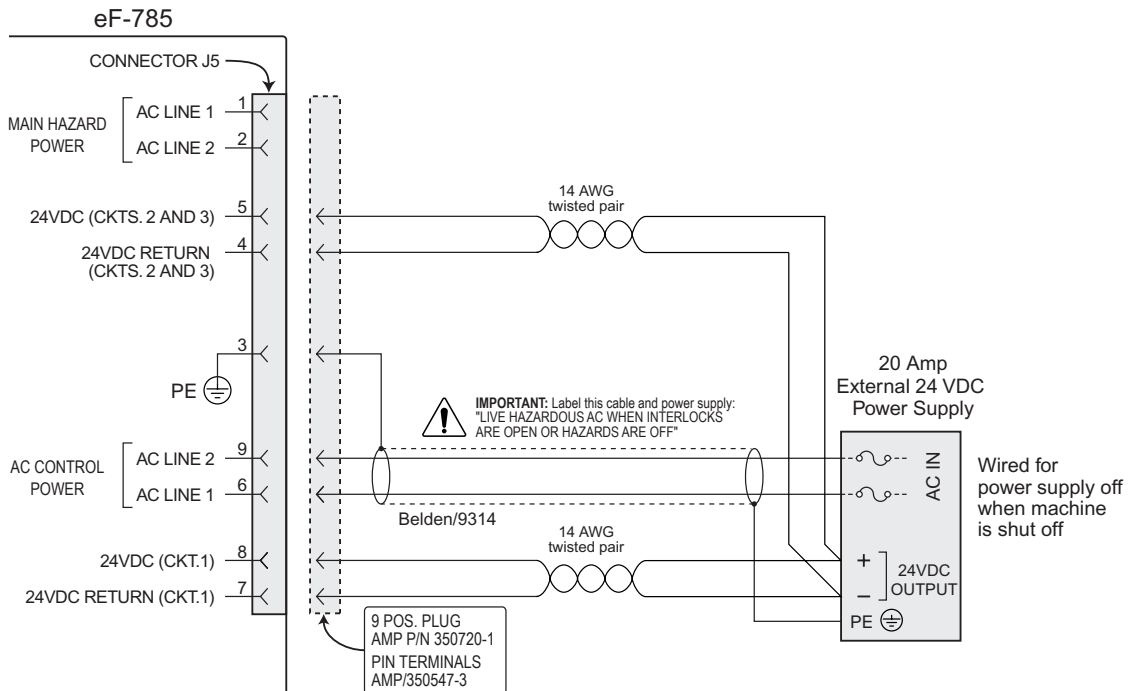
24VDC Supply Connections for 20A supply feeding 24VDC Circuits 2 and 3 (power supply off during a safety event), and 10A supply feeding 24VDC Circuit 1 (power supply off when machine is shut-off)



24VDC Supply Connections for 10A supply feeding 24VDC Circuit 1 (power supply off during a safety event), and 20A supply feeding 24VDC Circuits 2 & 3 (power supply off when machine is shut-off)



24VDC Supply Connections for 30A supply feeding 24VDC Circuits 1, 2, & 3 (power supply off during a safety event)



24VDC Supply Connections for 30A supply feeding 24VDC Circuits 1, 2, & 3 (power supply off when machine is shut-off)

APPENDIX F: SAFETY STANDARDS REFERENCE

SAFETY STANDARDS REFERENCED IN THIS MANUAL

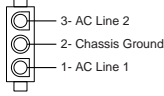
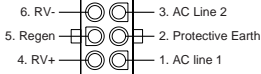
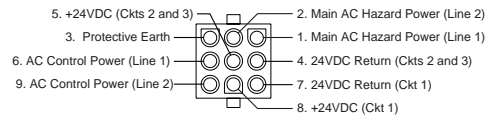
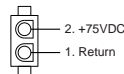
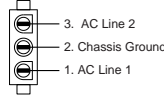
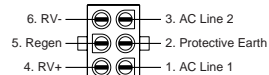
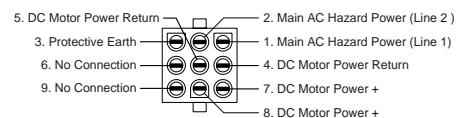
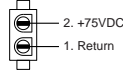
DOCUMENT NUMBER	TITLE
BS EN 1050:1997	Safety of machinery - Principles for risk assessment
BS EN 1088:1996	Safety of machinery - Interlocking devices associated with guards - Principles for design and selection
BS EN 292-1:1991	Safety of machinery - Basic concepts, general principals for design - Part 1: Basic terminology, methodology
BS EN 292:Part 2:1991	Safety of machinery - Basic concepts, general principals for design - Part 2: Technical principles and specifications
BS EN 418:1992	Safety of machinery - Emergency stop equipment, functional aspects - Principles for design
BS EN 50205:2002	Relays with forcibly guided (mechanically linked) contacts
BS EN 60204-1:1998 [IEC 60204-1:1997]	Safety of machinery - Electrical equipment of machines - Part 1: General requirements
BS EN 60947-5-1:1998	Low-voltage switchgear and controlgear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices
BS EN 61010-1:2001 [IEC 31010-1:2001]	Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements
BS EN 953:1998	Safety of machinery - Guards - General requirements for the design and construction of fixed and movable guards
BS EN 954-1:1997	Safety of machinery - Safety related parts of control systems - Part 1: General principles for design
SEMI S2-0703	Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment
SEMI S8-1103	Safety Guidelines for Ergonomics Engineering of Semiconductor Manufacturing Equipment

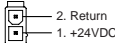
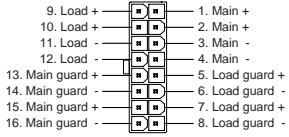
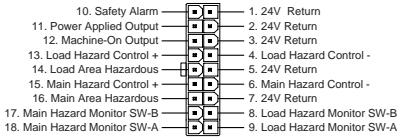
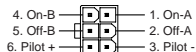
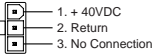
MISCELLANEOUS SAFETY STANDARDS

DOCUMENT NUMBER	TITLE
BS EN 349:1993	Safety of machinery - Minimum gaps to avoid crushing of parts of the human body
BS EN 414:2000	Safety of machinery - Rules for the drafting and presentation of safety standards
prEN 954-2	Safety of machinery - Safety related parts of control systems - Part 2: Validation
BS EN 999:1999	Safety of machinery - The positioning of protective equipment in respect of approach speeds of parts of the human body

BS EN 294:1992	Safety of machinery - Safety distances to prevent danger zones being reached by the upper limbs
BS EN 811:1997	Safety of machinery - Safety distances to prevent danger zones being reached by the lower limbs

APPENDIX G: CONNECTOR REFERENCE

J2: Misc. Hazardous AC Out 	Mating Connector AMP/1-480700-0 AWG 10 12 20-14 20-14 Terminal PN AMP/640309-3 AMP/640309-3 AMP/350547-3 AMP/350552-3 Insul Dia. .200" Max. .200" Max. .060-.130 .130-.200 Crimp Tool (manual) AMP/69710-1 (w/o die) AMP/69710-1 (w/o die) AMP/91500-1 AMP/91508-1 Crimp Die AMP/58380-2 AMP/58380-1 NA NA
J4: AC Motor Drive Power - Load 	Mating Connector AMP/1-480704-0 AWG 10 12 20-14 20-14 Terminal PN AMP/640309-3 AMP/640309-3 AMP/350547-3 AMP/350552-3 Insul Dia. .200" Max. .200" Max. .060-.130 .130-.200 Crimp Tool (manual) AMP/69710-1 (w/o die) AMP/69710-1 (w/o die) AMP/91500-1 AMP/91508-1 Crimp Die AMP/58380-2 AMP/58380-1 NA NA
J5: 24VDC Power Distribution 	Mating Connector AMP/1-480706-0 AWG 10 12 20-14 20-14 Terminal PN AMP/640309-3 AMP/640309-3 AMP/350547-3 AMP/350552-3 Insul Dia. .200" Max. .200" Max. .060-.130 .130-.200 Crimp Tool (manual) AMP/69710-1 (w/o die) AMP/69710-1 (w/o die) AMP/91500-1 AMP/91508-1 Crimp Die AMP/58380-2 AMP/58380-1 NA NA
J8A, J8B: DC Motor Power - Load 	Mating Connector AMP/1-480698-0 AWG 10 12 20-14 20-14 Terminal PN AMP/640309-3 AMP/640309-3 AMP/350547-3 AMP/350552-3 Insul Dia. .200" Max. .200" Max. .060-.130 .130-.200 Crimp Tool (manual) AMP/69710-1 (w/o die) AMP/69710-1 (w/o die) AMP/91500-1 AMP/91508-1 Crimp Die AMP/58380-2 AMP/58380-1 NA NA
P2: Incoming AC Power 	Mating Connector AMP/1-480700-0 AWG 10 12 20-14 20-14 Terminal PN AMP/640310-3 AMP/640310-3 AMP/350550-3 AMP/350551-3 Insul Dia. .200" Max. .200" Max. .060-.130 .130-.200 Crimp Tool (manual) AMP/69710-1 (w/o die) AMP/69710-1 (w/o die) AMP/91500-1 AMP/91508-1 Crimp Die AMP/58380-2 AMP/58380-1 NA NA
P3: AC Motor Drive Power - Main 	Mating Connector AMP/1-480704-0 AWG 10 12 20-14 20-14 Terminal PN AMP/640310-3 AMP/640310-3 AMP/350550-3 AMP/350551-3 Insul Dia. .200" Max. .200" Max. .060-.130 .130-.200 Crimp Tool (manual) AMP/69710-1 (w/o die) AMP/69710-1 (w/o die) AMP/91500-1 AMP/91508-1 Crimp Die AMP/58380-2 AMP/58380-1 NA NA
P6: 48-90VDC Power Supply Distribution 	Mating Connector AMP/1-480706-0 AWG 10 12 20-14 20-14 Terminal PN AMP/640310-3 AMP/640310-3 AMP/350550-3 AMP/350551-3 Insul Dia. .200" Max. .200" Max. .060-.130 .130-.200 Crimp Tool (manual) AMP/69710-1 (w/o die) AMP/69710-1 (w/o die) AMP/91500-1 AMP/91508-1 Crimp Die AMP/58380-2 AMP/58380-1 NA NA
P7A, P7B: DC Motor Power - Main 	Mating Connector AMP/1-480698-0 AWG 10 12 20-14 20-14 Terminal PN AMP/640310-3 AMP/640310-3 AMP/350550-3 AMP/350551-3 Insul Dia. .200" Max. .200" Max. .060-.130 .130-.200 Crimp Tool (manual) AMP/69710-1 (w/o die) AMP/69710-1 (w/o die) AMP/91500-1 AMP/91508-1 Crimp Die AMP/58380-2 AMP/58380-1 NA NA

P9A-B, P10A-B, P11A-B: 24VDC Outputs	Mating Connector	AWG	Terminal PN	Insul Dia.	Crimp Tool (manual)	Crimp Die
	Molex/39-01-2020	24-18	Molex/39-00-0039	.051-.122.	Molex/11-01-0197	NA
P12: Safety Control	Mating Connector	AWG	Terminal PN	Insul Dia.	Crimp Tool (manual)	Crimp Die
	Molex/39-01-2160	24-18	Molex/39-00-0039	.051-.122.	Molex/11-01-0197	NA
P13: Safety Extension	Mating Connector	AWG	Terminal PN	Insul Dia.	Crimp Tool (manual)	Crimp Die
	Molex/39-01-2180	24-18	Molex/39-00-0039	.051-.122.	Molex/11-01-0197	NA
P14: Power/Enable	Mating Connector	AWG	Terminal PN	Insul Dia.	Crimp Tool (manual)	Crimp Die
	Molex/39-01-2060	24-18	Molex/39-00-0039	.051-.122.	Molex/11-01-0197	NA
P18: 40VDC Power Distribution	Mating Connector	AWG	Terminal PN	Insul Dia.	Crimp Tool (manual)	Crimp Die
	Molex/39-01-4030	24-18	Molex/39-00-0039	.051-.122.	Molex/11-01-0197	NA

CABLE STOCK

USE	CURRENT (A) MAX.	SUGGESTED GAUGE (AWG)	SHIELDED	MAX TEMP. RATING	RECOMMENDED CABLE	RECOMMENDED FLEX CABLE
24VDC	10	18	N	70° C	Belden/82740	
40VDC	5	18	N	70° C	Belden/9740	
75VDC	15	16	N	70° C	Belden/8473	
120-240VAC	20	14	Y	90° C	Belden/9314	
120-240VAC	20	12	Y	70° C	Belden/9312	
Safety Harness	2	18	N	70° C	Belden/82740	Not recommended
300-400VDC	20	14	Y	90° C	Belden/3081A	Not recommended
Input AC power cord	20	12	N	70° C	Alpha/1918 Int'l Configurations/1601312 Olflex/1600119	Not recommended