

## Application Data

Original Instructions



**Allen-Bradley**

by ROCKWELL AUTOMATION

# ArmorStart 24V DC Control Power Design

Bulletins 281E/ES/GS, 284E/ES/GS, 290, 291, 294

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## Introduction

The ArmorStart® distributed motor controllers are integrated, pre-engineered motor controllers with models for full-voltage applications and variable-frequency AC drive applications. The ArmorStart family was developed to improve productivity and reduce installation and commissioning cost, by allowing you to mount your motor control near the motor. There are two preferred series in the ArmorStart product family: ArmorStart LT and ArmorStart ST motor controllers.

ArmorStart LT motor controllers (Bulletins 290, 291 and 294) are applied in general material-handling conveyance applications that require no more than a 2 Hp V/Hz drive or 5 Hp starter. ArmorStart ST motor controllers (Bulletin 281E, 281ES, 281GS, 284E, 284ES, and 284GS) are versatile and can be used across many applications in multiple industries. ArmorStart ST motor controllers have a wider horsepower range and include sensorless vector control (SVC) for the variable-frequency drive (VFD) variant. The VFD variant ranges up to 5 Hp and the direct-on-line (DOL) starter variant ranges up to 10 Hp.



ArmorStart LT Controller



ArmorStart ST Controller

The ArmorStart distributed motor controllers with EtherNet/IP™ require a 24V DC power supply for auxiliary power (also known as control power). The auxiliary power supply provides power to the discrete I/O, electromagnetic (EM) brake control, and functional safety. Auxiliary power allows connectivity and communication to the device for setup and commissioning when 3-phase power is not available for the DOL starter variant. For ArmorStart VFD variants, which include Bulletin numbers 284 and 294, 3-phase power is required to have access to the configuration. Without the 3-phase power, the VFD inside of the unit does not power up, and the parameters of the VFD are not available. Basic requirements for reliable 24V DC control systems start by using robust and sufficiently sized power supply units with a properly configured wiring scheme.

This publication focuses on how to select, size, and design a 24V DC power supply system to meet application requirements. Wire, cable sizing, and layout guidance are also provided in the documentation. See [In-panel Solution on page 4](#) and [On-Machine Solution on page 4](#) for recommended Allen-Bradley® power supply solutions.

## Calculation Guide

A companion publication is available for calculating the current capacity for the power supplies used on the ArmorStart controllers. See ArmorStart 24V DC Auxiliary Power Calculation Reference Data, publication [280-RD001A-EN-P](#).

# ArmorStart LT and ArmorStart ST Auxiliary Power

This section describes the auxiliary power requirements for ArmorStart LT and ArmorStart ST controllers.

## ArmorStart LT Distributed Motor Controllers

The ArmorStart LT motor controller accepts a 24V DC, Class 2 input power supply for auxiliary power. The auxiliary power is divided into two types: switched and unswitched power.

The unswitched auxiliary power provides power to the communication board and the inputs. The switched auxiliary power provides power to the outputs (discrete outputs, EM brake contactor) and the enable input. Removing the switched power but maintaining the unswitched power, disables the ArmorStart LT controller. The enable input and the outputs are off but the connection to the network via the communication board is maintained and the data coming from the discrete inputs (sensor information and/or field input status) is available.

The auxiliary power terminal connections are labeled A1, A2, and A3. Switched power is identified as (+A1)(-A2). Unswitched power is identified as (+A3)(-A2).

### 24V DC Auxiliary Power

- A1 = Switched +V
- A2 = Common for both switched and unswitched (-V)
- A3 = Unswitched +V

As an option, the ArmorStart LT controller can be supplied with an internal power supply (IPS) that is sourced from the line side of 3-phase power. If you chose the IPS option, the external auxiliary power is not required.

## ArmorStart ST Distributed Motor Controllers

The ArmorStart ST motor controller integrates standard motor control with functional safety by using either a hardwired connection or a networked-based safety solution. External 24V DC auxiliary power is required for ArmorStart ST controllers because an IPS option is not available. The auxiliary power structure for the ArmorStart ST controllers is similar to the ArmorStart LT controllers, with both switched and unswitched types of power. For the ArmorStart ST controllers, additional auxiliary power is required to support the safety processor, safety I/O, and safety contactor functionality.

Switched auxiliary power (A1/A2) provides power to the outputs, contactor coil, and VFD enable. Unswitched auxiliary power (A3/A2) provides power to the inputs, communications, and electronic control module.

The auxiliary power terminal connections are labeled A1, A2, and A3. Switched power is identified as (+A1)(-A2). Unswitched power is identified as (+A3)(-A2).

### 24V DC Auxiliary Power

- A1 = Switched +V
- A2 = Common for both switched and unswitched (-V)
- A3 = Unswitched +V

## Removing Switched or Unswitched Auxiliary Power

When switched auxiliary power is removed or when the local disconnect is turned OFF for ArmorStart LT or ST controllers, the outputs turn off and power is removed from the motor output connector. This does not inhibit communication or input status.

When unswitched auxiliary power is removed, ArmorStart LT or ST controllers turn off with no further control of the motor. There is no communication or I/O activity while the unit powers down.

# In-panel versus On-Machine considerations

You can choose either an in-panel or On-Machine™ solution to feed 24V DC for ArmorStart auxiliary power. Both solutions have their own advantages and limitations. You must consider the application and plant floor layout, component and installation cost, footprint, environment, standard certification, flexibility, and scalability when you select the solution.



On-Machine Power Supply



In-panel Power Supply

## In-panel Solution

The in-panel solution uses one or more switched-mode power supplies (SMPS) installed on the back panel of an enclosure. In this solution, each enclosure has an electrical safety rating that is designated by a [UL](#) mark. The enclosures also have an environmental IP rating or NEMA classification, which designates it to be indoor or outdoor, waterproof or water-resistant, suitable for hazardous conditions, dustproof, or explosion proof. Because the SMPS is installed inside the enclosure, you can select a lower environmental rating, higher power density, and lower-cost SMPS. The panel feeds multiple motor controllers, so there is a certain required distance between the power supply and the motor controllers. Because of the line loss, voltage drops increase with wiring length. Output voltage at the motor controller must be higher than the threshold to maintain normal operation. As a result, you must carefully design the maximum wiring length and wiring layout; this could require additional power supplies and cables.

For the in-panel solution, Rockwell Automation offers the Allen-Bradley® Bulletin 1606-XLS, -XLE, and -XLP power supplies that meet most global single- and three-phase application requirements. With top-of-the-line efficiency, Bulletin 1606 power supplies help reduce costs and energy consumption. These compact power supplies are designed and manufactured to accept wide ranges of both AC and DC input voltages and are tested to meet global safety standards.

## On-Machine Solution

The On-Machine SMPS is mounted directly to the machine structure. In this solution, the SMPS must be designed and rated equivalent to or higher than what the application environment requires. This solution can minimize voltage drop because the power supply is placed closer to the load. Because of the mounting location, you must consider and evaluate the shock and vibration rating. You can apply this solution where panel space is limited or where the power supply is too far away from the motor controller. The flexibility and scalability of this solution can reduce installation time.

The Allen-Bradley Bulletin 1607-XT ArmorPower™ On-Machine power supplies from Rockwell Automation are the ideal solution for On-Machine applications. Available in 50 W and 100 W models, these IP67 power supplies address a growing trend in the industrial automation marketplace for on-machine and factory floor installations in which the traditional enclosure has been eliminated. ArmorPower power supplies are resistant to harsh environmental conditions. All models are vacuum encapsulated in potting material that helps provide maximum resistance to shock, vibration, and humidity.

# Power Supply Electrical Certification Considerations

This section describes electrical certification ratings for auxiliary power supplies.

## PELV and SELV Ratings

To comply with the CE Low Voltage Directive (LVD), all external 24V DC auxiliary power supply connections to the ArmorStart safety version must meet IEC 61800-5-2 Annex e Table E.1 requirements for supply stability with the following:

- Safety Extra Low Voltage (SELV) supply rated
- Protected Extra Low Voltage (PELV) supply rated

The International Electrotechnical Commission (IEC) is an international standards organization that sets safety standards for electrotechnology. IEC defines an extra low voltage (ELV) supply device or circuit, as one in which the [electrical potential](#) between conductor or electrical conductor and 60V DC does not exceed 25V AC rms or 60V DC ripple-free, whether between conductors or to earth.

SELV systems are defined as electrical systems in which the voltage cannot exceed the value of ELV under normal conditions and under single fault conditions, including earth faults in other electric circuits. An SELV circuit must have electrical protective separation from all circuits other than SELV and PELV, and simple separation from other SELV systems, from PELV systems, and from earth ground.

PELV systems are defined as electrical systems in which the voltage cannot exceed the value of ELV under normal conditions and under single fault conditions, except earth faults in other electric circuits. In contrast to an SELV circuit, a PELV circuit can have a protective earth ground connection.

## NEC Class 2

If the devices (sensors) connected to the ArmorStart input connections require NEC Class 2 power to operate, the auxiliary power connections of this equipment must be powered by a Class 2 source.

The “National Electrical Code” (NFPA 70) defines special requirements for safe, low voltage circuits as Class 2 circuits. To eliminate electric shock hazard, NEC Class 2 circuits have a maximum voltage limit that is essentially the same as what is defined in IEC 60950-1. The difference is that to eliminate fire hazard, the maximum power potential of NEC class 2 circuits is limited to 100VA. Because of the 100VA maximum capability requirement, power sources that meet Class 2 requirements generally have lower current capability than non-Class 2 power sources.

NEC does not consider using a higher current-capable power source, fused for 100VA, to be an acceptable Class 2 power source. All power supplies with an output that is rated at 100VA or less are not necessarily Class 2 power supplies. UL has specific tests when certifying a Class 2 power source.

# Power Supply Capacity Sizing

The 24V DC system can either use one 24V DC SMPS or two separate 24V DC SMPS for ArmorStart switched (A1/A2) and unswitched (A3/A2) auxiliary power. If one 24V DC SMPS is used in the system, the SMPS must be sized for the total current  $I_{total}$ . If two separate 24V DC SMPS are used for A1/A2 and A3/A2 respectively, one 24V DC SMPS must be sized for  $I_{A1}$  and the other one must be sized for  $I_{A3}$ . See [Inrush Current](#) for definitions of  $I_{total}$ ,  $I_{A1}$ , and  $I_{A3}$ . An amperage buffer (at least 5%) is recommended for SMPS selection.

## Inrush Current

During power-up, high inrush current occurs for a short period or for several line cycles. The power supply must be able to support the instant power demand when multiple ArmorStart motor controllers are turned on simultaneously. For supplies without this capacity, we recommend applying unswitched power (A3/A2) first and after a 2...4 second delay, apply switched power. If auxiliary power falls below a minimum threshold, there is a higher risk of communications issues or device faults.

## Current Capacity Calculation

Use the following formulas to calculate the current that is used for sizing the SMPS or see ArmorStart 24V DC Auxiliary Power Calculation Reference Data, publication [280-RD001A-EN-P](#).

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**IMPORTANT** When using the ArmorStart 24V DC Auxiliary Power Calculation spreadsheet, you must assume responsibility for the accuracy of your entry values.

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## Total Current

Total auxiliary power current includes inrush current for ArmorStart devices that starts simultaneously and it includes steady state current for devices on operation mode, electromechanical (EM) brake current, safety contactor current (if applicable), and discrete I/O and safety I/O current (if applicable).

The following formula calculates the 24V DC power supply total current (switched  $I_{A1}$  and unswitched  $I_{A3}$ ) required for an ArmorStart system:

- $I_{total} = I_{A1} + I_{A3}$
- $I_{A1} = I_{inrush\_A1} + I_{steady\_A1} + I_{EB} + I_{safety\_A1\_total} + I_{out}$
- $I_{A3} = I_{inrush\_A3} + I_{steady\_A3} + I_{safety\_A3\_total} + I_{in}$

## Inrush Current

Inrush current is calculated as follows:

- $I_{inrush\_A1} = N * I_{inrush\_A1\_LT} + M * I_{inrush\_A1\_ST}$
- $I_{inrush\_A3} = N * I_{inrush\_A3\_LT} + M * I_{inrush\_A3\_ST}$

Where:

N is the maximum number of ArmorStart LT controllers that are commanded to start simultaneously

M is the maximum number of ArmorStart ST controllers that are commanded to start simultaneously

All inrush current can be found in [Table 1 on page 7](#).

## Steady-state Current

Steady-state current is calculated as follows:

- $I_{steady\_A1} = (L-N) * I_{steady\_A1\_LT} + (K-M) * I_{steady\_A1\_ST}$
- $I_{steady\_A3} = (L-N) * I_{steady\_A3\_LT} + (K-M) * I_{steady\_A3\_ST}$

Where:

L is the total number of ArmorStart LT. (L-N) is the number of ArmorStart LT controllers at steady state (already running or idle).

K is the total number of ArmorStart ST. (K-M) is the number of ArmorStart ST controllers at steady state (already running or idle).

All steady state current can be found in [Table 1 on page 7](#).

## Safety Contactor Current

Safety contactor currents  $I_{safety\_A1}$  and  $I_{safety\_A3}$  are calculated as follows:

- $I_{safety\_A1\_total} = H * I_{safety\_A1} + J * I_{safety\_A1} * 2$
- $I_{safety\_A3\_total} = H * I_{safety\_A3} + J * I_{safety\_A3} * 2$

Where:

H is the number of ArmorStart ST safety version starters.

J is the number of ArmorStart ST safety version VFDs.

$I_{safety\_A1}$  is the safety contactor current that is drawn from A1.

$I_{safety\_A3}$  is the safety contactor current that is drawn from A3.

$I_{safety\_A1\_total}$  is the total sum of safety contactor current that is drawn from A1.

$I_{safety\_A3\_total}$  is the total sum of safety contactor current that is drawn from A3.

The “\*2” factor accounts for the ArmorStart ST Safety VFD having two safety contactors added. The ArmorStart ST Safety starter has only one safety contactor added. For details, see Chapter 3 of ArmorStart ST Motor Controller User Manual, publication [280ES-UM001](#), or ArmorStart ST Motor Controller with Integrated Safety User Manual, publication [280ES-UM002](#).

All current consumption for the safety contactor can be found in [Table 1 on page 7](#).

## Total Current for Inputs and Outputs

ArmorStart LT and ST controllers provide different discrete I/O options and the ArmorStart ST safety version also provides a safety I/O option. Inputs are sourced from A3/A2 auxiliary power. Outputs are sourced from A1/A2 auxiliary power. Therefore, the total current need for inputs and outputs can be calculated as follows:

- $I_{out} = P * I_{DO} + R * I_{SO}$
- $I_{in} = Q * I_{DI} + S * I_{SI}$

Where:

P is the total number of discrete outputs.

Q is the total number of discrete inputs.

R is the total number of safety outputs.

S is the total number of safety inputs.

Discrete input, discrete output, safety input, and safety output current consumption are shown in [Table 1 on page 7](#).

**Table 1 - ArmorStart Current Consumption**

Attributes	ArmorStart ST (Bulletins 281E/ES/GS, 284E/ES/GS)		ArmorStart LT (Bulletins 290, 291, 294)	
	A1/A2 [A]	A3/A2 [A]	A1/A2 [A]	A3/A2 [A]
Inrush Current	1.09	0.3	0.45	0.45
Steady-state Current	0.23	0.3	0.125	0.15
EM Brake (VFD - Bulletins 284 and 294 only)	0.125	—	0.125	—
Discrete Input	—	0.05	—	0.05
Discrete Output	0.5	—	0.5	—
Safety Contactor	0.125	0.002	—	—
Safety Input (Bulletins 281ES/GS, 284 ES/GS only)	0	0.002	—	—
Safety Output (Bulletins 281ES/GS, 284 ES/GS only)	1	0	0	0

## Application Examples

Examples of current calculations are listed here. Values that are taken from [Table 1 on page 7](#) are shown in red text.

### EXAMPLE: Current Example 1 – ArmorStart ST controllers

There are ten ArmorStart ST units on a conveyor line, three of them are 281E starters and the remaining seven units are 284E VFDs. They start sequentially by group. Three units start simultaneously before all units are in operation mode. All ArmorStart ST VFDs come equipped with EM brakes, but only five of them use the EM brakes. There are two discrete inputs and one discrete output used per unit. Calculate the auxiliary power supply per the following equations:

$$I_{A1} = I_{inrush\_A1} + I_{steady\_A1} + I_{EB} + I_{out} \rightarrow 3 * 1.09 + 7 * 0.23 + 5 * 0.125 + 1 * 10 * 0.5 = 10.51 \text{ A}$$

$$I_{A3} = I_{inrush\_A3} + I_{steady\_A3} + I_{in} \rightarrow 3 * 0.3 + 7 * 0.3 + 2 * 10 * 0.05 = 4 \text{ A}$$

$$I_{total} = I_{A1} + I_{A3} \rightarrow 10.51 + 4 = 14.51 \text{ A}$$

### EXAMPLE: Current Example 2 – ArmorStart LT controllers

Ten ArmorStart LT VFDs are installed on a conveyor line. Five ArmorStart LT VFDs start simultaneously each time before all units are in operation mode. Two ArmorStart LT VFDs are installed with EM brake options. 15 discrete inputs and 8 discrete outputs are set up and used in this conveyor line. Auxiliary power supply can be calculated as follows:

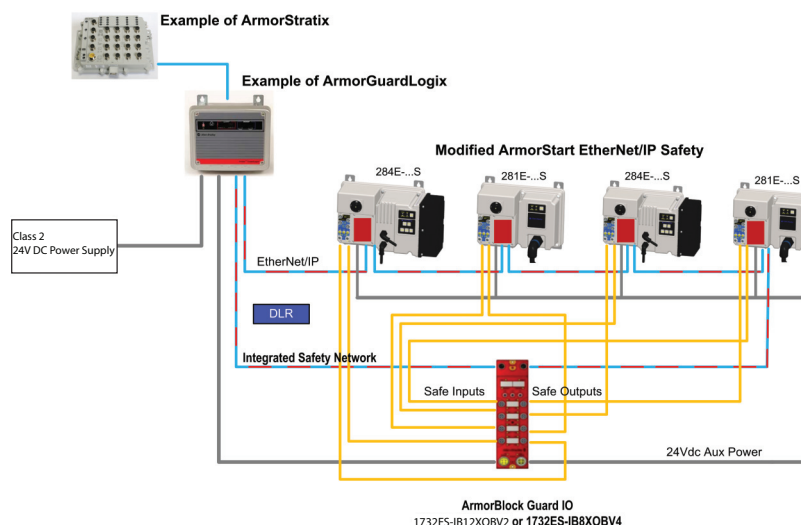
$$I_{A1} = I_{inrush\_A1} + I_{steady\_A1} + I_{EB} + I_{out} \rightarrow 5 * 0.45 + 5 * 0.125 + 2 * 0.125 + 8 * 0.5 = 7.13 \text{ A}$$

$$I_{A3} = I_{inrush\_A3} + I_{steady\_A3} + I_{in} \rightarrow 5 * 0.45 + 5 * 0.15 + 15 * 0.05 = 3.75 \text{ A}$$

$$I_{total} = I_{A1} + I_{A3} \rightarrow 7.13 + 3.75 = 10.88 \text{ A}$$

ArmorStart LT requires NEC class 2 power supply. The circuit limits to 100VA, which means the current limits to 4.167 A for the 24V DC power supply. In this example, two power supplies are required for switched power A1 and one power supply is required for unswitched power A3.

### EXAMPLE: Current Example 3 – ArmorStart ST controllers with hardwired safety



Four ArmorStart ST motor controllers are installed on a conveyor line, two 284E VFDs and two 281E starters. All of them start simultaneously. All ArmorStart VFDs use EM brakes. Two discrete inputs and one discrete output are used in each 284E VFD. One discrete input is used in each 281E starter.

This conveyor line uses a hardwired safety solution. ArmorStart ST controllers can be combined with a Catalog Number 1732ES-IB12XOBV2 or 1732ES-IB8XOBV4 safety I/O module to form a subsystem that is part of the overall machine stop function. In this example, one 1732ES-IB8XOBV4 safety I/O module is connected to all four ArmorStart units. For ArmorStart hardwired safety controllers, the safety I/O power consumption is included in the safety contactor.



$$I_{A1} = I_{inrush\_A1} + I_{EB} + I_{out} + I_{safety\_A1\_total} \rightarrow 4 * 1.09 + 2 * 0.125 + 2 * 0.5 + (2 * 2 + 2 * 1) * 0.125 = 6.36 \text{ A}$$

$$I_{A3} = I_{inrush\_A3} + I_{in} + I_{safety\_A3\_total} \rightarrow 4 * 0.3 + (2 * 2 + 2 * 1) * 0.05 + (2 * 2 + 2 * 1) * 0.002 = 1.512 \text{ A}$$

$$I_{total} = I_{A1} + I_{A3} \rightarrow 6.61 + 1.512 = 7.872 \text{ A}$$

Safety I/O module 1732ES-IB8X0BV4 requires a 24V DC power current of 0.11 A.

#### Current Example 4 – ArmorStart ST controllers with integrated safety

Three ArmorStart ST 284ES VFDs with integrated safety units are in a conveyor line. All of them start simultaneously and they all use EM brakes. Two discrete inputs and one discrete output are used in each 284ES VFD. Each unit uses one dual-channel safety input and one bipolar safety output.

$$I_{A1} = I_{inrush\_A1} + I_{EB} + I_{out} + I_{safety\_A1\_total} \rightarrow 3 * 1.09 + 3 * 0.125 + 3 * 0.5 + 3 * 1 + (3 * 2) * 0.125 = 8.90 \text{ A}$$

$$I_{A3} = I_{inrush\_A3} + I_{in} + I_{safety\_A3\_total} \rightarrow 3 * 0.3 + (3 * 2) * 0.05 + (2 * 3) * 0.002 + (2 * 3) * 0.002 = 1.22 \text{ A}$$

$$I_{total} = I_{A1} + I_{A3} \rightarrow 8.90 + 1.22 = 10.12 \text{ A}$$

## Impact of Cable Length and Wire Size

The maximum distance that an ArmorStart can be located from a nominal 24V DC supply is determined by the inrush current requirements of the ArmorStart distributed motor controllers. [Table 2 on page 9](#) gives the maximum distance from the power source that a single ArmorStart can be placed.

In systems with multiple ArmorStart controllers where more than one unit is commanded to start simultaneously, provisions must be made to account for maximum inrush current. The DC power supply and distribution system must have sufficient capacity and the wire gauge of sufficient size, to handle the maximum current required.

**Table 2 - Maximum Distances between ArmorStart controllers and power supplies**

Wire Gauge [AWG]	Cross Section Area [mm <sup>2</sup> ]	Maximum Distance [m (ft)]
18	0.83	24 (79)
16	1.31	38 (125)
14	2.08	62 (205)
12	3.31	100 (325)
10	5.26	158 (520)

The total capacity of the system also includes any additional loads that are connected to the ArmorStart I/O outputs. The maximum distance can still be used if each of the ArmorStart that is commanded to start simultaneously, is wired directly back to the DC power supply, or if a 100 ms delay occurs between consecutive starts when ArmorStart controllers are daisy-chain connected.

When more than one ArmorStart controller is commanded to pick up simultaneously, the length of each wire segment in the system must be multiplied by the number of units that can simultaneously pick up through that section of wire. This calculation represents the equivalent starting distance. The sum of the equivalent starting distances must be less than the maximum distance allowed for the selected gauge.

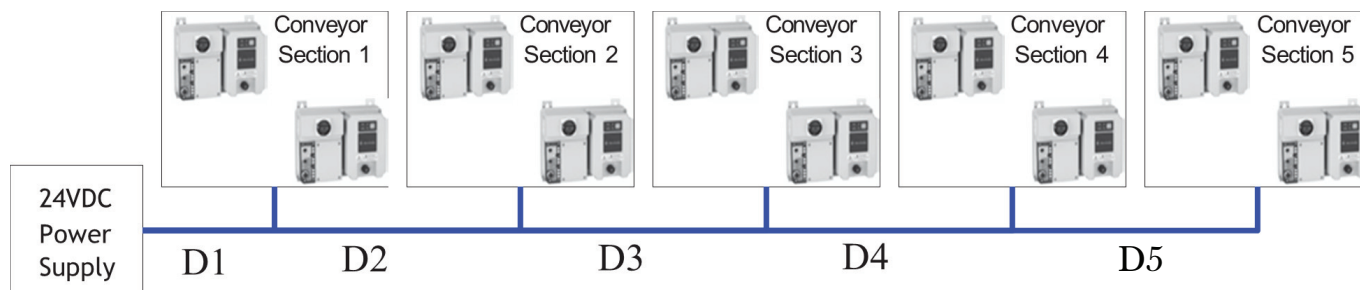
## Application Examples

Some examples of wiring calculations are shown here.

### Wiring Example 1 – Conveyor Line Configuration

Five sections of conveyor are to be wired up. Each section of conveyor has a conveyor motor and a diverter motor. Assume that they are 50 ft apart. The conveyor motors can be started in sequence, but it is possible that all five of the diverter motors could start simultaneously. All controllers are Bulletin 280 ArmorStart units with the Hand-Off-Auto (HOA) keypad. Assume that the conveyor motors are sequenced on and are running before the diverters start.

**Figure 1 – One Run Conveyor Wiring Example**



Calculate the effective wire lengths.

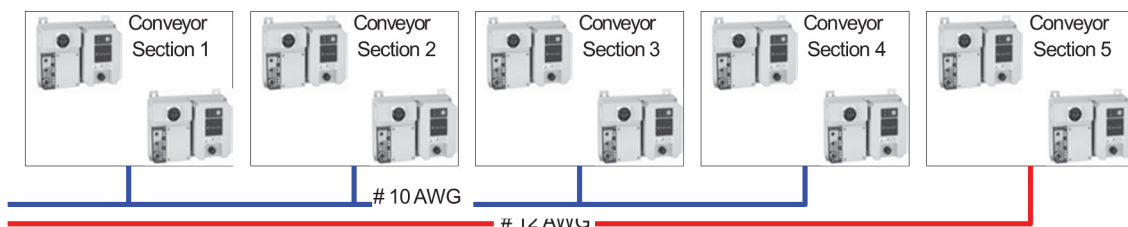
	Distance 1	Distance 2	Distance 3	Distance 4	Distance 5	Equivalent Distance
Run 1	+15 m (50 ft) * 5	+15 m (50 ft) * 4	+15 m (50 ft) * 3	+15 m (50 ft) * 2	+15 m (50 ft) * 1	= 229 m (750 ft)

Based on this calculation, there is no wire gauge that can be taken 228.6 m (750 ft), so the fifth section is required to have its own run.

### Wiring Example 2 – Conveyor Line Configuration with separate power feed

Example 1 is recalculated with section 5 having its own power feed:

**Figure 2 – Two Run Conveyor Wiring Example**



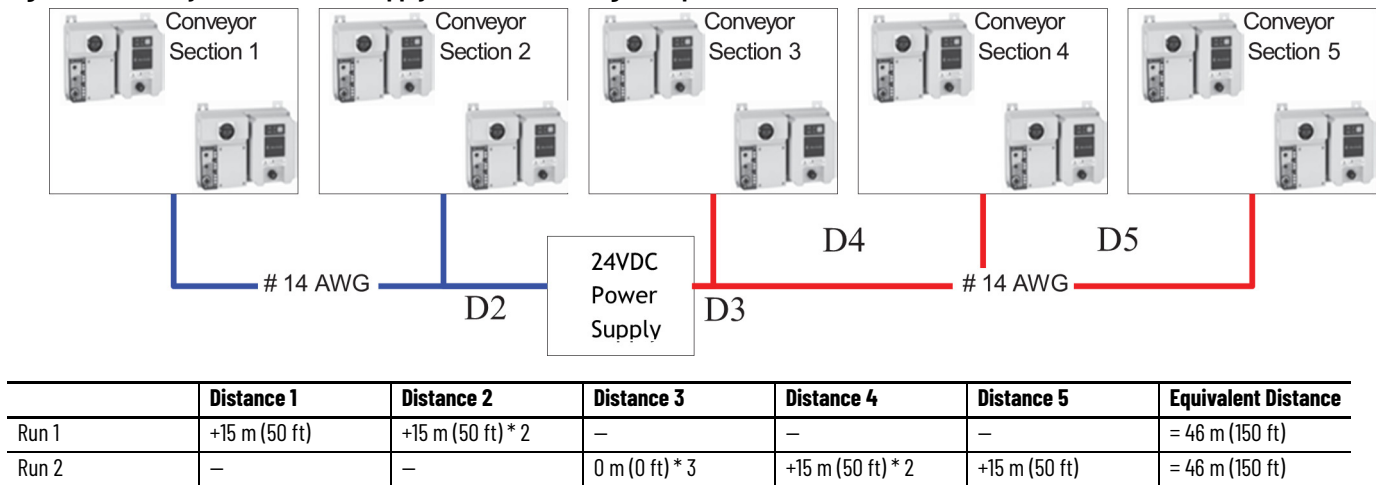
	Distance 1	Distance 2	Distance 3	Distance 4	Distance 5	Equivalent Distance
Run 1	+15 m (50 ft) * 4	+15 m (50 ft) * 3	+15 m (50 ft) * 2	+15 m (50 ft) * 1	—	= 152 m (500 ft)
Run 2	+15 m (50 ft)	+15 m (50 ft)	+15 m (50 ft)	+15 m (50 ft)	+15 m (50 ft)	= 76 m (250 ft)

Therefore, Run 1 must be 10 AWG, while Run 2 can be either 12 AWG or 10 AWG.

### Wiring Example 3 – Conveyor Line Configuration with centrally located power supply

This example is a reconfiguration of *Wiring Example 1*. It has a centrally-located power supply, see [Figure 3](#).

**Figure 3 - Centrally Located Power Supply Distribution Wiring Example**

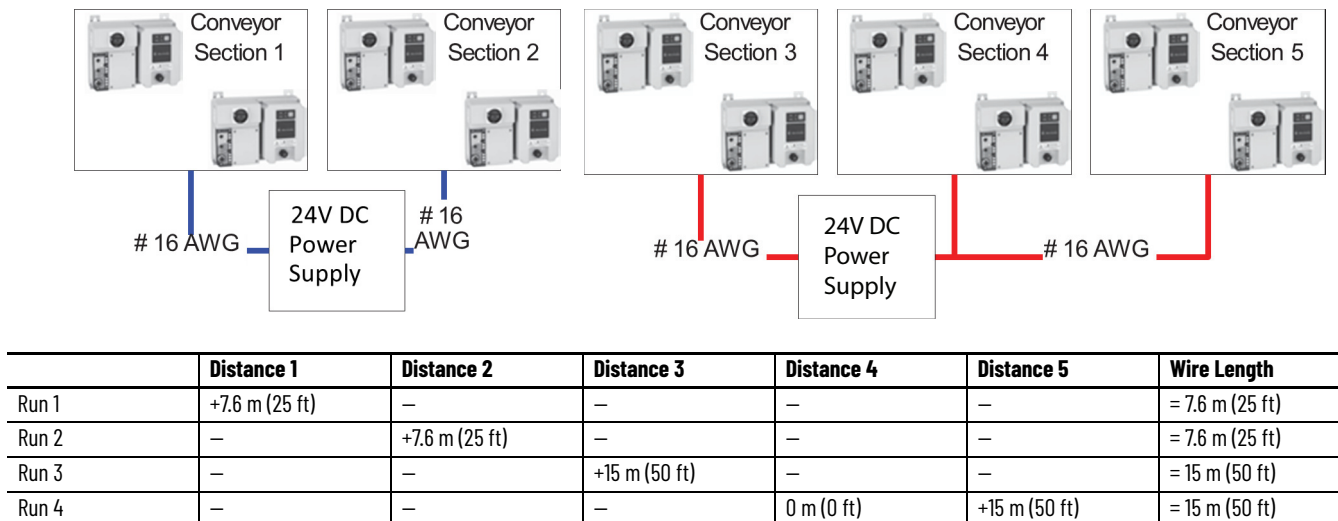


With the power supply centrally located, both runs can be 14 AWG. The controllers on section three are considered to have no length since the power supply is very close to the units.

### Wiring Example 4 – System Design Considerations When Using 16 AWG Control Wiring

The use of 16 AWG cable requires more consideration when determining the number and location of the power supplies, since it is effectively limited to 38.1 m (125 ft). Reworking example 1 using 16 AWG, shows that two power supplies are required.

**Figure 4 - 16 AWG Control Wiring Example**



## Conclusion

ArmorStart ST and ArmorStart LT controllers without internal 24V DC power supplies require external 24V DC power supplies to provide power for control, I/O, and functional safety. This application note provides a design guideline to help you determine in-panel or on-machine solutions, standard requirements, capacity calculations, and wiring layouts. This application note only applies to ArmorStart LT and ArmorStart ST products. To minimize the DC power ampacity requirements, we recommend staggering the power up (sequenced on) of the ArmorStart devices when possible.

For other devices connected to ArmorStart controllers, such as discrete or safety I/O, refer to their respective technical specifications to identify their individual power requirements. If other power supply devices, such as buffer, redundancy, DC/DC converters, and UPS products, must be added into a power supply system to help improve the reliability of the whole control system, see Designing High Availability 24V DC Systems, publication [1606-AT003](#).

## Additional Resources

These documents contain additional information concerning related products from Rockwell Automation. You can view or download publications at [rok.auto/literature](http://rok.auto/literature).

Resource	Description
ArmorStart 24V DC Control Power Calculation, publication <a href="#">280-RD001</a>	Provides current capacity calculations for selecting power supplies used for ArmorStart ST and ArmorStart LT controllers.
ArmorStart ST Distributed Motor Controller Specifications Technical Data, publication <a href="#">280ES-TD001</a>	Provides product information about the ArmorStart ST Distributed Motor Controller.
ArmorStart ST Motor Controller User Manual, publication <a href="#">280ES-UM001</a>	Provides information on how to install, configure, program, and use ArmorStart ST controllers.
ArmorStart ST Motor Controller with Integrated Safety User Manual, publication <a href="#">280ES-UM002</a>	Provides information on how to install, configure, program, and use ArmorStart ST controllers with integrated safety.
ArmorStart User Manual - Bulletin 280/281, 283, 284, publication <a href="#">280-UM002</a>	Provides information on how to install, configure, program, and use ArmorStart controllers.
ArmorStart LT Distributed Motor Controller DeviceNet Version - User Manual, publication <a href="#">290D-UM001</a>	Provides information on how to install, configure, program, and use ArmorStart LT controllers with DeviceNet communications.
ArmorStart LT EtherNet/IP Version - User Manual - Bulletin 290E, 291E, 294E, publication <a href="#">290E-UM001</a>	Provides information on how to install, configure, program, and use ArmorStart LT controllers with EtherNet/IP communications.
Designing High-Availability 24VDC Systems Application Guide, publication <a href="#">1606-AT003</a>	Describes Redundancy, Buffer Modules, DC-UPSs & DC/DC Converters functions.
Power Supply Reference Manual 1606-XLE96B-2, publication <a href="#">1606-RM030</a>	Provides details about switch mode power supplies.
On-Machine Power Supply Specifications Technical Data, publication <a href="#">1607-TD001</a>	Provides product information about On-Machine power supplies.
Designing NEC Class 2 Circuits - Using Bulletin 1692 Circuit Protection White Paper, publication <a href="#">1692-WP001</a>	Explains circuit design using Bulletin 1692 circuit protection.
EtherNet/IP Network Devices User Manual, <a href="#">ENET-UM006</a>	Describes how to configure and use EtherNet/IP devices to communicate on the EtherNet/IP network.
Ethernet Reference Manual, <a href="#">ENET-RM002</a>	Describes basic Ethernet concepts, infrastructure components, and infrastructure features.
System Security Design Guidelines Reference Manual, <a href="#">SECURE-RM001</a>	Provides guidance on how to conduct security assessments, implement Rockwell Automation products in a secure system, harden the control system, manage user access, and dispose of equipment.
UL Standards Listing for Industrial Control Products, publication <a href="#">CMPNTS-SR002</a>	Assists original equipment manufacturers (OEMs) with construction of panels, to help ensure that they conform to the requirements of Underwriters Laboratories.
American Standards, Configurations, and Ratings: Introduction to Motor Circuit Design, publication <a href="#">IC-AT001</a>	Provides an overview of American motor circuit design based on methods that are outlined in the NEC.
Industrial Components Preventive Maintenance, Enclosures, and Contact Ratings Specifications, publication <a href="#">IC-TD002</a>	Provides a quick reference tool for Allen-Bradley industrial automation controls and assemblies.
Safety Guidelines for the Application, Installation, and Maintenance of Solid-state Control, publication <a href="#">SGI-1.1</a>	Designed to harmonize with NEMA Standards Publication No. ICS 1.1-1987 and provides general guidelines for the application, installation, and maintenance of solid-state control in the form of individual devices or packaged assemblies incorporating solid-state components.
Industrial Automation Wiring and Grounding Guidelines, publication <a href="#">1770-4.1</a>	Provides general guidelines for installing a Rockwell Automation industrial system.
Product Certifications website, <a href="http://rok.auto/certifications">rok.auto/certifications</a>	Provides declarations of conformity, certificates, and other certification details.

# Rockwell Automation Support

Use these resources to access support information.

<b>Technical Support Center</b>	Find help with how-to videos, FAQs, chat, user forums, Knowledgebase, and product notification updates.	<a href="http://rok.auto/support">rok.auto/support</a>
<b>Local Technical Support Phone Numbers</b>	Locate the telephone number for your country.	<a href="http://rok.auto/phonesupport">rok.auto/phonesupport</a>
<b>Technical Documentation Center</b>	Quickly access and download technical specifications, installation instructions, and user manuals.	<a href="http://rok.auto/techdocs">rok.auto/techdocs</a>
<b>Literature Library</b>	Find installation instructions, manuals, brochures, and technical data publications.	<a href="http://rok.auto/literature">rok.auto/literature</a>
<b>Product Compatibility and Download Center (PCDC)</b>	Download firmware, associated files (such as AOP, EDS, and DTM), and access product release notes.	<a href="http://rok.auto/pcdc">rok.auto/pcdc</a>

## Documentation Feedback

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Rockwell Automation maintains current product environmental compliance information on its website at [rok.auto/pec](http://rok.auto/pec).

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