Advanced Group Motor Installation and Panel System Techniques

Rockwell Automation
Allen-Bradley

Table of Contents

Background

The use of Group Motor Installation has become very popular with panel designers and builders in North America. This is a result of the availability of IEC manual motor starter/ protectors which have UL and CSA group installation ratings. The group rating itself was awarded because of the built-in short-circuit trip mechanism in these IEC manual starters. In some cases, these starters provide a measure of actual short-circuit protection for the individual motor circuit in a group which is well above the North American minimum requirements for a motor branch circuit.

These IEC manual starters meet UL508 and CSA C22.2 No. 14. The design and construction of the short-circuit protection in these starters is not based on UL or CSA circuit breaker requirements, and therefore **these starters do not qualify as branch circuit breakers in North America.** (They do qualify outside of North America, however.) This means that an upstream set of **fuses or a circuit breaker is always required** with these manual starters. The big advantage is that the upstream fuses or circuit breaker selected for the group can be rated high enough to prevent nuisance tripping, while the IEC manual starter protects the individual motor circuit. This "group fuse rating" is most useful in reducing panel size by the elimination of individual motor circuit fuses or circuit breakers. In fact, it is possible to halve the size of a motor control panel by group installation with as few as four motor circuits.

The rules for group motor installation are found in NFPA 70, the US National Electrical Code: Article 430-53. Article 430-53a is concerned with motors not over 1 HP and group limitations of 20 or 15A total running current. Article 430-53b is concerned with situations in which the protective devices selected properly for the smallest motor can also protect an additional motor or motors without nuisance tripping. For most industrial situations governed by the NEC however, Article 430-53c and d apply, and further discussion will assume conformance to Article 430-53c and d.

(NFPA 79, the National Standard for Industrial Machinery also permits grouping of motors with the major difference from the NEC of limiting the rating of group fuses or circuit breakers based on wire sizes. NFPA 79 includes a table showing wire size versus maximum fuse or circuit breaker for determining the size of the motor group.)

National Electrical Code Article 430-53c says that more than one motor may be protected by a single set of fuses or circuit breaker if the controller and overload device are listed for group installation. This code article is over 50 years old. Historically, the controller and overload device listed for group installation was the NEMA manual starter in NEMA 1, 4, or 12 enclosures. This starter/enclosure combination is often called a "loom switch" because of its past popularity in textile plants. The enclosure is required because these starters have no individual short-circuit protection. If a short-circuit occurs, the rugged enclosure contains any flame and debris caused by the action of short-circuit current on the motor starter.

The arrival of IEC manual motor starters in the mid 1980s changed the nature of "Group Motor Installation." These starters, with built-in short-circuit protection were given UL/CSA Group Motor Installation ratings. The built-in short-circuit protection of these starters is recognized in the lack of an individual enclosure requirement and in their very high fuse ratings. A 1200A back up fuse rating on a 25A starter is typical.

The Limits of Group Installation

Group installation is still considered a compromise by UL and CSA, even when used with IEC manual motor starters. For example: UL 508-47.3.1 permits greater damage in a group motor installation than in a single motor installation. It allows disintegration of the contacts and burn out of the current element. However, all IEC Manual Starters are not alike, and **Allen-Bradley's Bulletin 140 and Bulletin 190 starters can be selected to provide IEC Type 2 coordination in group installation.**

Group motor installation has great potential for savings **without compromising protection** if the IEC manual starters are selected for **Type 2 Coordination**. Type 2 is an IEC 947-4-1 designation indicating that under short-circuit conditions, the contactor or starter shall cause no danger to persons or installation and shall be suitable for further use. Such a rating is achieved by a complete test program.

The Allen-Bradley IEC manual motor starters and magnetic contactor combinations provide Type 2 Coordination as shown in Table 1 and Table 2.

This means that in the event of a short-circuit in one of the motor starter circuits, that motor starter/contactor assembly will be reusable following removal of the short-circuit condition. This is an indication of the high level of individual motor circuit protection provided by the Allen-Bradley Bulletin 140 IEC manual starter, since the group fuses are sized for the group load and provide little protection for the individual motor circuits.

Table 1
Bulletin 140 Series C Type 2 Coordination

Max. Available Current: 50kA Max. Voltage: 480V ❶		
Bulletin 140-MN-	**Bulletin 100-**	**Max. Amp.**
0016	A09	9
0025	A09	9
0040	A09	9
0063	A09	9
0100	A09	9
0160	A09	9
0250	A09	9
0400	A09	9
0630	A12	12
1000	A18	18
1600 + Bulletin 140-CL2	A24	24
2000 + Bulletin 140-CL2	A24	24
2500 + Bulletin 140-CL2	A24	24

Table 2
Bulletin 190 Type 2 Coordination

	Max. Available Current
Bulletin 190-MN + Bulletin 190-P + Bulletin 190-A40 Integrated Starter ❶ (requires upstream fuses or circuit breaker)	100kA at 240V 65kA at 480V 42kA at 600V
Bulletin 190-CPS40 + 190-P Coordinated Protected Starter	

❶ Maximum rating of fuses or circuit breaker to be sized in accordance with applicable codes and standards.

Application of Group Installation

The following is a method of applying group motor installation with IEC manual starters and magnetic contactors. Each individual motor circuit must have a Bulletin 140-MN or a Bulletin 190-MN + appropriate 190-P Trip Unit. Contactors are not required for group installation, but are required for remote motor control, and therefore, used for almost all group applications. The appropriate contactors for use with Bulletin 140 are Bulletin 100 IEC contactors, Bulletin 500 NEMA contactors or Bulletin 509 NEMA starters for customers who prefer eutectic overload or require Class 20 overload protection. The appropriate contactors for use with Bulletin 190 are Bulletin 190–A40 or Bulletin 500 NEMA contactors.

1. List motors of the group in descending order of motor nameplate full load current.
2. Select disconnect means.
   a. Sum all locked rotor currents of motors that can be started simultaneously using NEC Table 430-151.
   b. Add to that value all the full load currents of any other motors or loads that can be operating at the same time as the motors that start simultaneously, using tables 430-148,149,and 150 as apply.
   c. Use the total current from a. and b. above to get an equivalent horsepower value from Table 430-151. That value is the size of the disconnect means in horsepower. (NEC 430-110.)
3. Select fuse or circuit breaker protection: Select fuse or circuit breaker size for the largest motor (per NEC Table 430-152) and add that ampere value to the total of the full load currents of the rest of the motors. The final value is the fuse or circuit breaker size required. (NEC 430-53c)
4. Select wire: Ampacity of wire feeding a group of motors is the sum of the full load current ratings of all the motors plus 25% of the full load current of the highest rated motor in the group. (NEC 430-24)
5. **Note that the code states that no wire to the motor shall have an ampacity less than one third the ampacity of the branch circuit conductors. (NEC 430-53d)** The branch circuit conductors can be defined as the conductors on the load side of the fuse block or circuit breaker. This requirement actually defines the size of the group of motors. For example, if the wire from the fuses or circuit breaker is AWG #4 at 85 ampacity, the smallest wire you can use to the motors is AWG#10 at 35 ampacity. (NEC Table 310-16 for 75° C wire) The Bulletin 140-A09 or A12 contactors will not accept #10 wire. Also, #10 wire may be larger than desired for small motors. The solution is to divide the motors into two groups or more, as required to stay within desired wire sizes.

Group motor installations requires a series of steps and a number of calculations for proper application, as shown above. It is well worth the effort for fuse or circuit breaker elimination and space savings. Equally rewarding are the benefits of commoning links, adapter plates, and connector kits: all labor and time-saving devices that go with the Bulletin 140 IEC Manual Motor Starter and Protector. But there is also a labor and time saving device for the design of a group installation.

Electronic Selection Guide

The Electronic Selection Guide is a computer disc available for group motor panel design. It is in Windows™[1] format, and easy to use. One starts with a menu of parameters such as: Bulletin 140 or Bulletin 190 starters?, grouping to NEC or NFPA79?, Type 1 or Type 2 Coordination? After selecting the parameters, one starts by adding motors. As motors are added, short-circuit protection and wire sizes are indicated. These increase as the number of motors grows. When limits are reached the user is prompted, for example, to increase wire size, or to add a new set of fuses or circuit breaker, thus starting a new group.

Both a diagram of the installation you have designed and a report are provided, including a bill of materials, motor data, wire sizes, and recommended accessories.

The Electronic Selection Guide is Catalog Number 140-SG1.

Panel System

The Bulletin 140 Panel System consists of component carrying modules that can be mounted and electrically fed from bus bar, or used as convenient workbench assembled and interwired modules, applied to a standard panel by use of **Screw Modules**. There are four basic modules used to support and feed electrical components such as motor starters, fuse blocks and circuit breakers:

1. **Adapter Plates** which snap on bus bar for support and in many cases, electrical feed. DIN rail is supplied on most **Adapter Plates**.
2. **Device Adapter Plates** which snap on either **Bus Bar Modules** or **Screw Modules** for the support of electrical components on bus bar or standard panels respectively. DIN rail is supplied on most **Device Adapter Plates**.

[1] *Windows is a trademark of the Microsoft Corporation.*

3. **Bus Bar Modules** which snap on bus bar, providing support and electrical feed for **Device Adapter Plates** on bus bar.

4. **Screw Modules** which support **Device Adapter Plates** on standard panels, permitting uniform drilling and spacing of diverse electrical components for best appearance with minimum drilling and layout requirements.

It should be noted that a **Device Adapter Plate** + a **Bus Bar Module** = an **Adapter Plate**. Thus, the first choice for bus bar application is the **Adapter Plate**. Stocking considerations may make it desirable to assemble **Adapter Plates** from their two components as needed.

The Bulletin 140 Panel System is useful for Group Motor Installation on bus bar using **Adapter Plates**, **Device Adapter Plates** and **Bus Bar Modules**. Two methods can be considered:

1. If the entire panel is a single group, the entire bus bar assembly can be electrically fed from the branch circuit fuses or circuit breaker selected for the motor group. The IEC manual starters for the group, Bulletin 140 + Bulletin 100 or Bulletin 190 can be fed directly from the bus bar.

2. If several groups are on the same bus bar system, the branch circuit fuses or circuit breakers for the individual groups can be fed from the bus bar. The fuses or circuit breakers will in turn, feed the groups of IEC manual starters through Commoning Links and Terminals, using the bus bar only as structural support for the individual motor starter groups. If Bulletin 140/B100 are used, it is possible to take advantage of the **Connector Clips** to lock adjacent **Device Adapter Plates** together, supporting alternate ones with **Bus Bar Modules**.

Check List for Panel System Used with Bus Bar

1. **Select bus bar type.**

   Example: 140–BB24, 20 x 5, 60mm spacing between bus bars

2. **List the components to be installed on the bus bar.**

   Example:
   (3) Bulletin 140/Bulletin 100 combinations
   (1) 3 pole 30A fuse block
   (5) Bulletin 190-CPS40,
   (1) 130VA control transformer

3. **Assign an Adapter Plate or Device Adapter Plate width to each component.**

   Example:

(3)	Bulletin 140/ Bulletin 100 combinations	(3)	@ 54mm
(1)	Three-pole 30A fuse block	(1)	@ 81mm
(5)	Bulletin 190-CPS40	(5)	@ 81mm
(1)	130VA control transformer	(2)	@ 54mm

4. **Add up the widths in millimeters required for all of the Adapter Plates or Device Adapter Plates plus Terminal Cover @ 54mm.**

   Example:
   $3 \times 54 + 1 \times 81 + 5 \times 81 + 2 \times 54 + 1 \times 54 = 810$mm

5. **Use the above total and the bus bar spacing charts[•] to determine the short-circuit current rating of the bus bar type you have chosen. If it is inadequate, consider the addition of a Bus Bar Support in the middle of the assembly to divide the support interval in half. If still inadequate, subdivide the halves of the assembly using additional Bus Bar Supports until the short-circuit rating is adequate for the application.**

   Example:
   The 810mm interval between supports is off the chart, meaning that the short-circuit rating is considered too low; but one extra support in the center of the components makes unsupported width 810/2 = 405mm which will provide approximately 45kA short-circuit current rating for 20x5mm bus bar.

[•] Charts of bus bar support interval are found in the Allen-Bradley Industrial Controls Catalog Publication A111 and Bulletin 140 Panel System brochure Publication 140-1.2.1. These charts indicate millimeters between supports versus short-circuit current in kA.

6. **Add the width of all Bus Bar Supports to the total width in number 4 above, to determine actual length of bus bar required for each pole.**

   Example:
   810mm + 3[20mm] = **870mm**. The bus bar comes in 1500mm lengths. Therefore, three pieces are required for this system.

7. **Select Bus Bar Terminals.** Determine total current of all components that could possibly be running at the same time. Choose wire size with an ampacity at least equal to the total current plus 25% of the largest motor's current [per NEC Art.430-24]. Choose the terminal which will work with 5mm bus bar and with the wire size selected above; from Industrial Control Catalog, Publication A111, page 1-339 or Publication 140–1.0.1, page 4.

   Example:
   (3), 3HP motors @4.8A each, 130VA transformer @ .27A, and (5), 20HP motors @ 27A each = 149.7A + 25% of 27A = 156.42A or 2/0 wire. (From NEC Table 310-16, 75 degree wire) Terminal is 140-V170.

8. **Determine Adapter Plate, Device Adapter Plate and Bus Bar Module requirements.**

   Example:
   The Bulletin 140/Bulletin 100 combinations are fed as a group from the 30A, three-pole fuse block via 140-L2 Terminal and 140-L13 Commoning Links. They are 54mm wide and need DIN rails. A choice for this application is the **140-GS320 Adapter Plate.**

   For the 30A DIN rail mounting fuse block, Cat. No. **140-GS4163 Adapter Plate** will provide the support and electrical feed.

   The Five 190-CPS40s will each require one 15mm deep or two 7.5mm deep DIN rails and 63A electrical feed. Cat. No. **140-GS4163 Adapter Plates** will provide a single 15mm deep DIN rail.

   The control transformer can be mounted on two 54mm wide 140-B054 Device Adapter Plates supported by one each of a 140-S225L Bus Bar Module with feed and a 140-S20 without, held together by 140-K Connector Clips. A plate for the transformer will have to be made for mounting on the Device Adapter Plates.

Summary:

Motors	Amp.	Bulletin 140s	Bulletin 100s	Bulletin 190
3 @ 3 HP	4.8	(3) MN-0630	(3) A09	
5 @ 20 HP	27			(5) CPS 40/P320

140 Adapter Plates = 3 @ 54mm	190 Adapter Plates = 5 @ 81mm
(3) 140-GS320	(5) 140-GS4163

Fuse Block Adapter Plate = 1@ 81mm (1), 140-GS4163
Transformer Device Adapter plates = 2@ 54mm (2), 140-B054
and Bus Bar Modules 1, 140-S125L (1), 140-S20)

9. Bill of Material

Qty.	Cat. No.	Description
3	140-BB24	Bus Bar
3	140-T60	Bus Bar Supports
2	140-T60E	End Covers
3	140-V170	Terminals
1	140-BK60	Terminal Cover
3	100-A09ND3	Contactors
3	140-MN-0630	IEC Manual Starter / Protectors
3	140-N11	Connector Kits
1	140-L2	Terminal
1	140-L13	Three Unit Commoning Link
5	190-CPS40D	Coordinated Protected Starters
5	190-P320	Trip Unit
3	140-GS320	Adapter Plate for Bulletin 140-MNs
5	140-GS4163	Adapter Plate for Bulletin 190-MNs
1	140-GS4163	Adapter Plate for Fuse Block
2	140-B054	Device Adapter Plates for Transformer
1	140-S225L	Bus Bar Module with Long Leads
1	140-S20	Bus Bar Module without Leads
4	140-K	Connector Clips
1	1497-N16	Transformer
1		Three-pole Class J DIN Rail Fuse Block

Summary

A short decade ago, the multi-motor control panel was an assembly of NEMA starters individually bolted to a panel. Short-circuit protection was provided by the main SCPD with group installation using NEMA manual starters or by individual motor circuit protection (fuses or circuit breakers) with group installations using NEMA magnetic starters.

Todays multi-motor control panel can be less than half the size of its functional equivalent of ten years ago using either NEMA or IEC contactors. The starters and contactors can be snapped on DIN rail or various adapter plates. Much assembly and wiring can be done at the workbench. Much of that wiring can be in the form of commoning links and terminals eliminating a great deal of measuring, cutting, and stripping of wires. Short-circuit protection can now assure a reusable starter in addition to preventing fire or injury.

Allen–Bradley is committed to supporting you throughout each phase of the Automation Investment Life Cycle.

Allen–Bradley offers a wide range of motor protection products that will help extend the life of your motor. These products are an integral part of the automation process and the life cycle.

Justify. If your application requires motor protection, choose any one of our solutions for increased productivity. These product lines offers many protective features such as detection of overload, short circuit and ground fault conditions. Analyze the complete line of motor protection products through customer training seminars, product demonstrations and literature.

Apply. Any one of the motor protection devices may be applied based upon your application and requirements. Many of these products work together to provide increased functionality.

Install. Integrate our products with new systems as well as existing systems. Traditional and solid–state protection is available. Our panel system solution reduces wiring and installation costs.

Operate. Striving for optimum productivity and monitoring motor faults constitute pro–active approaches to this phase.

Maintain. By protecting the motor from damage, our products help reduce downtime. Product features such as diagnostics and communications capability also reduce system maintenance.

Improve. Extending the life of your motor is the main benefit of our product line. As your needs change, we change with you by increasing the effectiveness of our products and monitoring market demands. Staying focused on product line improvements results in advanced product offerings such as the SMP™ Overload Relays and the Smart Motor Manager.

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Allen-Bradley Headquarters, 1201 South Second Street, Milwaukee, WI 53204 USA, Tel: (1) 414 382-2000 Fax: (1) 414 382-4444

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