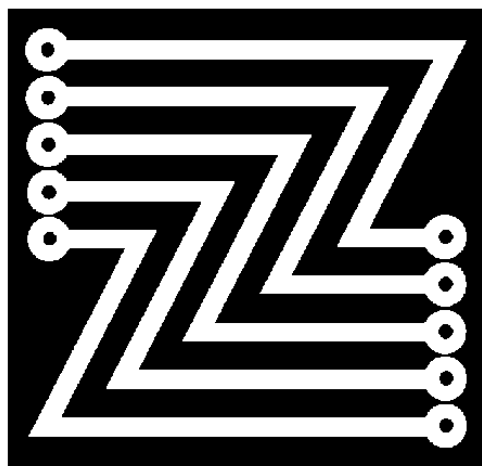


MSC-3

Instruction Manual



ZENER

MSC-3 User's Manual

ZENER TECHNOLOGY AND QUALITY ASSURANCE

Since 1978 Zener Electric has supplied many thousands of AC drives to industry. These drives have been installed into numerous applications resulting in a wealth of in house experience. The Zener MSC-3 AC variable speed controller is the culmination of this experience, modern technology and industrial application requirements. The Zener Quality Assurance program ensures that every MSC-3 manufactured has proven to operate correctly in the production test bay before dispatch.

MSC-3 PRODUCT WARRANTY

Zener Electric warranty the MSC-3 against defective workmanship and materials for a period of 24 months from the date of dispatch. Such defects will be rectified free of charge for both labour and material, at Zener Electric's premises subject to:

1. Zener Electric's customer raising an order upon Zener for service and/or repairs, subject to a warranty claim. The order is to state particulars of the model and serial number, the date of original purchase and invoice/delivery docket number.
2. All damage resulting from incorrect installation or use other than in accordance with the instruction manuals issued by Zener Electric is excluded from this warranty.
3. The Warranty being rendered invalid if the product is misused or if any unauthorised alteration, modification or substitution of any part of the product be made or the serial number of the product is defaced or altered.
4. The cost of transportation (both ways) is to be met by the owner if it's necessary to return the product, or any part of it, to Zener Electric's premises.
5. A charge being accepted by the owner for travelling time and expenses incurred in connection with warranty service at the user's site as requested by the owner.
6. If the product was not purchased from Zener Electric directly, then a warranty claim must be lodged with the original supplier in the first instance. Repairs will not be effected by Zener Electric unless approved by the original supplier. Goods not of our own manufacture incorporated in our supply or sold by us, carry their maker's warranty only.
7. Goods returned for claim under warranty will be accepted on the condition that should the claim be rejected then all costs, including inspection, will be charged to the customer's account.
8. Zener Electric is not liable for any consequential loss.

SAFETY

Your MSC-3 must be applied, installed and operated in a safe manner. It is the responsibility of the user to ensure compliance with all regulations and practices covering the installation and wiring of your MSC-3. The instruction manual should be completely read and understood before attempting to connect or operate the MSC-3. Only skilled personnel should install this equipment.

THE CONTENTS OF THIS MANUAL ARE SUBJECT TO CHANGE WITHOUT NOTICE

MSC-3 User's Manual

Contents

WARNING.....	3
RECEIVING.....	3
SOFTWARE.....	3
MSC-3 MECHANICAL INSTALLATION DIAGRAM.....	4
3 PHASE MSC-3 ELECTRICAL INSTALLATION DIAGRAM.....	7
SINGLE PHASE MSC-3 ELECTRICAL INSTALLATION.....	8
INDUSTRIAL TERMINALS TYPICAL CONNECTION DIAGRAM – CONFIG 1.....	9
HVAC TERMINALS TYPICAL CONNECTION DIAGRAM – CONFIG 3.....	10
QUICK SETUP FOR CONFIG 1.....	11
QUICK SETUP FOR CONFIG 3.....	13
QUICK SETUP FOR CONFIG 4.....	15
MSC-3 START UP.....	17
MSC-3 RUN MODE.....	17
MSC-3 MENU MODE.....	19
CONTROL CONSOLE MENU.....	19
A00 DISPLAY.....	19
A01 RUN VARIABLE.....	19
A02 RUN SCALE.....	19
A03 RUN UNITS.....	19
A04 MENU PROTECT.....	20
A05 SET CTL DEFS.....	20
B00 MOTOR.....	20
B01 MOTOR VOLTS.....	20
B02 MOTOR AMPS.....	20
B03 MOTOR HZ.....	20
B04 MOTOR RPM.....	20
C00 PERFORMANCE.....	21
C01 MIN HZ.....	21
C02 MAX HZ.....	21
C03 RAMP.....	21
C04 ACCEL TIME.....	22
C05 DECEL TIME.....	22
C06 S TIME.....	22
C07 FLUX PLUS %.....	22
C08 HI SPD FLUX+.....	22
C09 SLIP COMP.....	23
C11 AUDIBLE FREQ.....	23
D00 PROTECTION.....	24
D01 CURRENT LIM.....	24
D02 I ² T.....	24
D02 I ² T.....	24
D03 I ² T ZERO HZ.....	24
D04 I ² T CNR HZ.....	25
D05 REVERSE.....	25
D08 DC INPUT.....	25
E00 STOP/START.....	25
E01 STOPPING.....	25
E06 DYNAMIC BRK.....	25
E07 AUTO RESTART.....	26
E08 A/RS ALLOWED.....	26
E09 A/R CLR TIME.....	26
E10 RESET BY PF.....	26
F00 REFERENCES.....	27
F01 REMOTE.....	27
F02 LOCAL.....	27
F03 ESO.....	27
F04 JOGFWD.....	27
F05 JOGREV.....	27
SPEED REFERENCES.....	28
R00 AN1.....	28
MSC3 ANALOG INPUT SCALING.....	28
R01 REF AT 0%.....	29
R02 REF AT 100%.....	29
R03 PRESET.....	29
R04 MOTORIZD POT.....	29
R07 CONSOLE REF.....	29

MSC-3 User's Manual

G00 INPUT/OUTPUT	30
STANDARD TERMINAL CONFIGURATIONS.....	30
G02 CONFIG 1 INDUSTRIAL.....	30
G03 CONFIG 2 VSC2000.....	31
G04 CONFIG 3 HVAC.....	31
G05 CONFIG 4	31
G06 CONFIG 5	31
G07 CONFIG 6	32
G08 CONFIG 7	32
G09 CONFIG 8	32
G10 ENABLE/RESET	32
G11 DIG IN1	33
G12 DIG IN2	33
G13 DIG IN3.....	33
G14 DIG IN4.....	33
CONTROL TERMINAL FUNCTIONS	34
G15 RELAY1.....	36
G16 RELAY2.....	36
RELAY OUTPUT FUNCTIONS	36
DISPLAY MESSAGES	37
MSC-3 TROUBLE SHOOTING GUIDE.....	38
YOUR MSC-3 SETUP NOTES	41
MSC-3 SPECIFICATIONS.....	42
MSC-3 OUTPUT CURRENT SPECIFICATIONS.....	44
APPENDIX A - MSC-3 CHARACTER SET.....	45

MSC-3 User's Manual

Warning

Please note the following:

Your MSC-3 must be applied, installed and operated in a safe manner in accordance with all local rules and regulations.

The MSC-3 is intended for use only in fixed wiring applications. It is not intended for use on a flexible supply cable.

The MSC-3 contains a substantial EMC line filter and as a result it is unsuitable for use on earth leakage protected circuits.

The MSC-3 contains capacitors that take greater than one minute to discharge below 50Vdc. The voltage across these capacitors should be measured before any work is carried out inside the enclosure.

The MSC-3 contains high energy circuits that may be hazardous. Do not operate the MSC-3 with the door or enclosure open.

Receiving

Inspect the MSC-3 for any shipping damage. If any damage is found, report it to the carrier immediately. Access the inside of the controller and visually check for any damage.

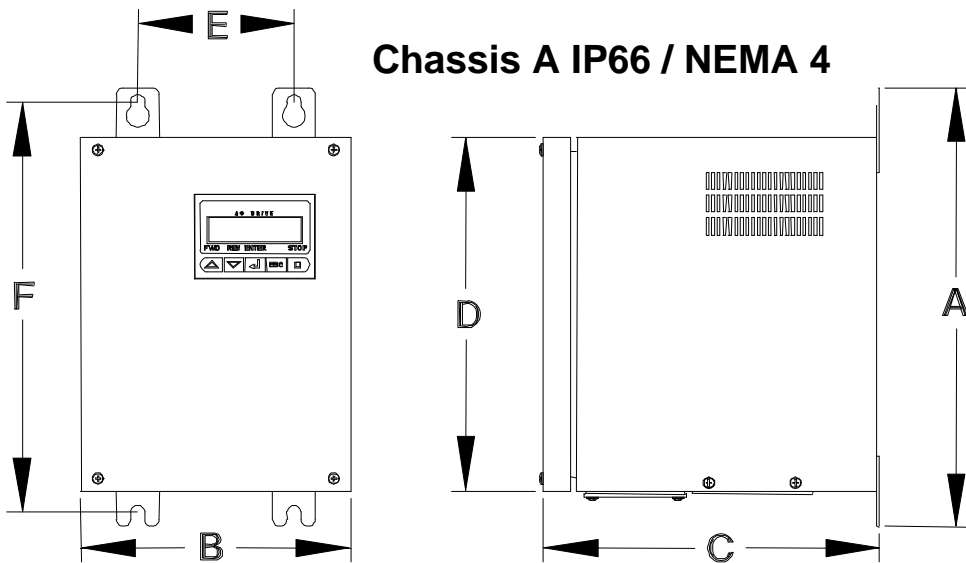
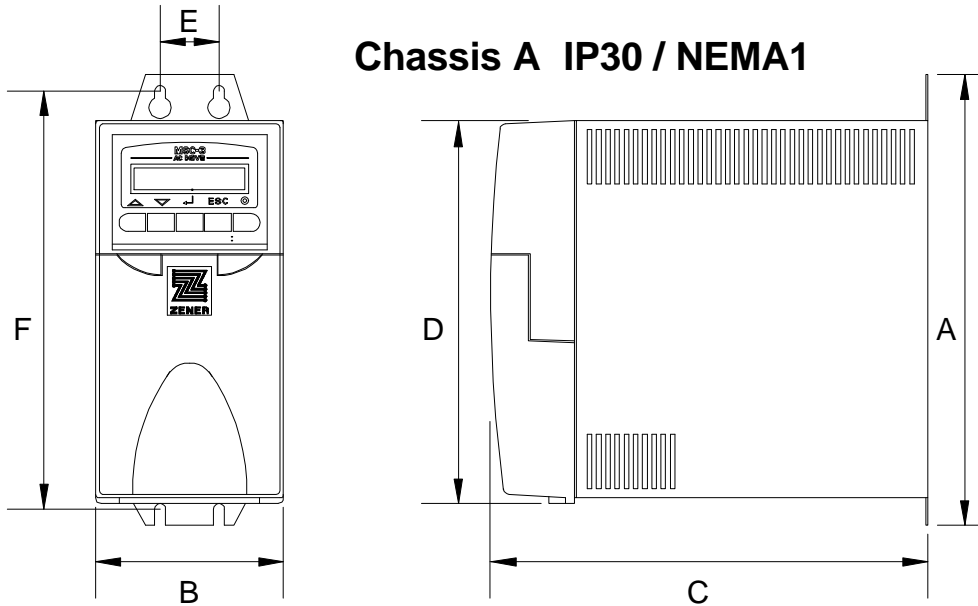
Do not attempt to operate the MSC-3 if any obvious damage exists.

After the initial inspection, the MSC-3 can be repacked and stored in a clean, dry location until it is required for use. DO NOT store this equipment in an area where the ambient temperature will fall below -20°C (-4°F) or rise above 70°C (158°F). DO NOT store this equipment in areas of high condensation or corrosive atmosphere. Proper storage is necessary to ensure satisfactory controller start up and performance.

Software

This manual applies to MSC-3 software revision 1.38. The software revision is displayed briefly at power up.

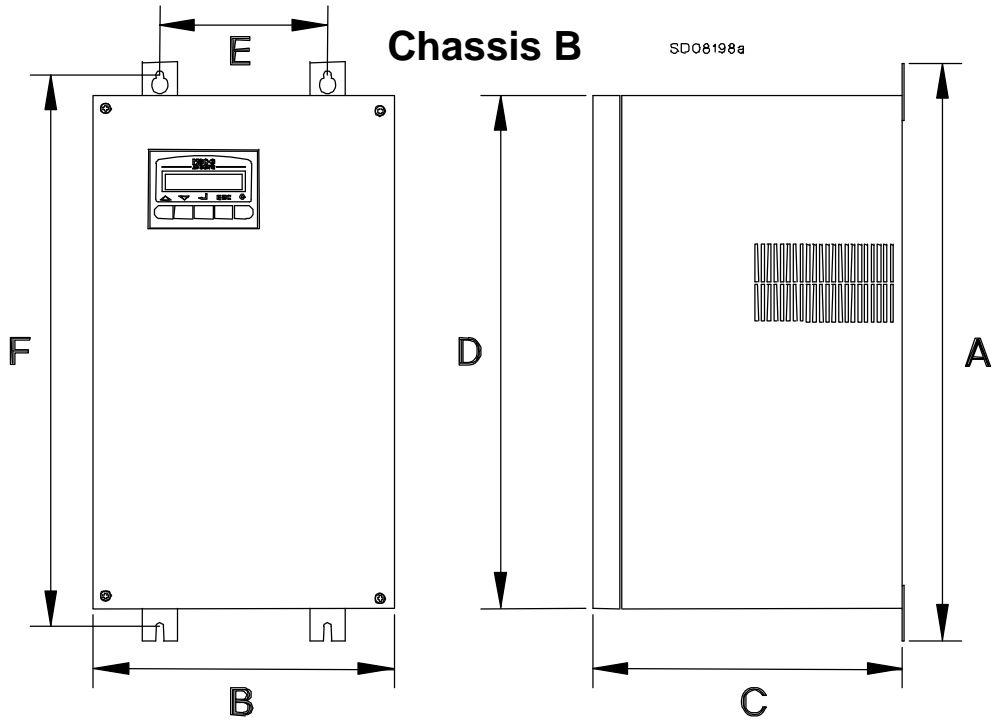
MSC-3 Mechanical Installation Diagram



11399-01

- Mounting holes are 6 mm (0.25") diameter.
- Packaging sizes:
IP30
 280 x 300 x 184 mm, 11.0 x 11.8 x 7.5 in
 add: 0.5kg, 1.1lbs
IP66
 330 x 387 x 380 mm, 13.0 x 15.2 x 15.0 in
 add: 1.4kg, 3.1lbs
- Allow 50mm above, below and either side of the enclosure for ventilation.

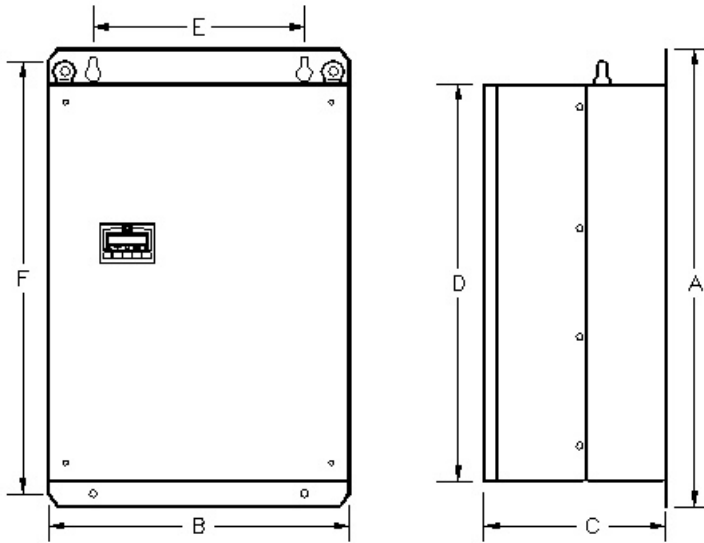
MSC-3 User's Manual



- Mounting holes are 6 mm (0.25") diameter.
- Packaging sizes:
IP30 and IP66
 540 x 400 x 360 mm, 21.3 x 15.7 x 14.2 in
 add: 2.7kg, 6.0 lbs
- Allow 75 mm above, below and either side of the enclosure for ventilation.

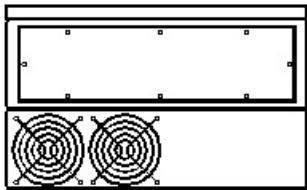
Dimensions	Chassis A				Chassis B			
	IP30		IP66		IP30		IP66	
	mm	in	mm	in	mm	in	mm	in
A	248	9.8	310	12.2	459	18.1	459	18.1
B	102	4.0	190	7.5	234	9.2	234	9.2
C	237	9.3	236	9.3	243	9.6	243	9.6
D	208	8.2	250	9.8	400	15.8	400	15.8
E	32	1.3	108	4.3	130	5.1	130	5.1
F	230	9.1	287	11.3	436	17.1	436	17.1
Weight (without Choke)	3.5kg	7.7lbs	5.7kg	12.5lbs	15 – 30 Amp models – 17.4kg/38.3lbs 40 Amp models – 18kg/40lbs			
DC Bus choke weight	3.7kg	8.1lbs	2.9kg	6.4lbs	15 – 30 Amp models – 5.5kg/12lbs 40 Amp models – 6.8kg/15lbs			
DC Bus Choke adds 72mm (2.8") to dimension C in Chassis A, IP30 only. DC Bus choke must be used with MSC-3Jxx (600VAC) models								

Chassis C



Dimensions		
	mm	inch
A	715	28.1
B	470	18.5
C	290	11.4
D	620	24.4
E	330	13.0
F	667	26.7

Dimensions for the IP 30 and IP66 chassis' are identical.



Chassis C

Drive Weights		
Drive	kg	lbs
x55	42	92
x82	44	97
x109	46	101
x140	50	110

DC Bus Choke weighs 20kg (44lbs) on top of above weights.

600V drives must have a bus choke

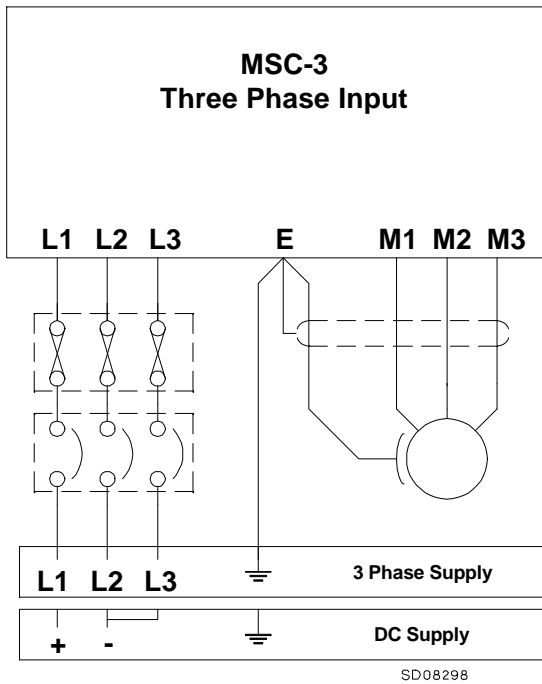
- Mounting Holes are 12mm (0.47") diameter
- Packaging size IP30 and IP66:
520 x 750 x 440mm (20.5 x 29.5 x 17.3 inches)
add 10kg (22lbs)
- Allow 100mm above, below and either side of the enclosure for ventilation.

IMPORTANT NOTES FOR ALL CHASSIS SIZES

- The MSC-3 must be mounted in a vibration free location.
- Mount the MSC-3 vertically, away from heat radiating sources.
- Do not mount the MSC-3 in direct sunlight or on hot surfaces.
- If the MSC-3 is mounted inside another enclosure, the total heat dissipation must be allowed for.
- Remove gland plate before drilling cable holes.
- Do not allow metal shavings or any other conductive material to enter the enclosure or damage may result.
- Dimension tolerance is $\pm 1.0\text{mm}$ ($\pm 0.04''$).
- DC Bus choke is mandatory with MSC-3Jxx (600VAC) models
- The optional DC Bus choke is fitted inside the MSC-3 in all models except Chassis A, IP30. For these models, the DC bus choke is located in an additional enclosure fitted to the rear face of the MSC-3. The wiring between the MSC-3 and the choke is internal.

MSC-3 User's Manual

3 Phase MSC-3 Electrical Installation Diagram.



IMPORTANT

1. Either fuses or a circuit breaker should be connected as shown. Fast semiconductor fuses are not required.
2. UL compliant installations must use UL listed fuses as per the table below.
3. Cable sizes should be selected according to local wiring rules using the currents given in the table below.
4. For complete motor thermal protection microtherms or thermistors should be installed in the motor winding.
5. For compliance with EMC standards, the motor wiring and ground conductor must be enclosed in a continuous metallic sheath or conduit, which has good contact to both the motor and inverter chassis. The sheath should contain only the wiring from one inverter and its associated motor cables. No other conductors may be included.

Fuse and Circuit Breaker Ratings For All 3 Phase MSC-3

Model Numbers	Chassis Size	Maximum RMS Input Current (A)	Recommended Fuse or C/B Rating (A)	UL Class Fuse for UL compliant installation (A)
MSC-3*3	A	4.1	10	10A, Class J
MSC-3*5	A	6.9	10	10A, Class J
MSC-3*7	A	9.6	16	15A, Class J
MSC-3*11	A	15.1	20	20A, Class J
MSC-3*15	B	22.5	32	30A, Class T
MSC-3*20	B	30.4	40	40A, Class T
MSC-3*23	B	33.0	40	40A, Class T
MSC-3*30	B	43.1	63	60A, Class T
MSC-3*40	B	55.0	63	60A, Class T
MSC-3*55	C	78.0	100	100A, Class T
MSC-3*82	C	108.0	125	125A, Class T
MSC-3*109	C	148.0	160	175A, Class T
MSC-3*140	C	179.0	200	200A, Class T

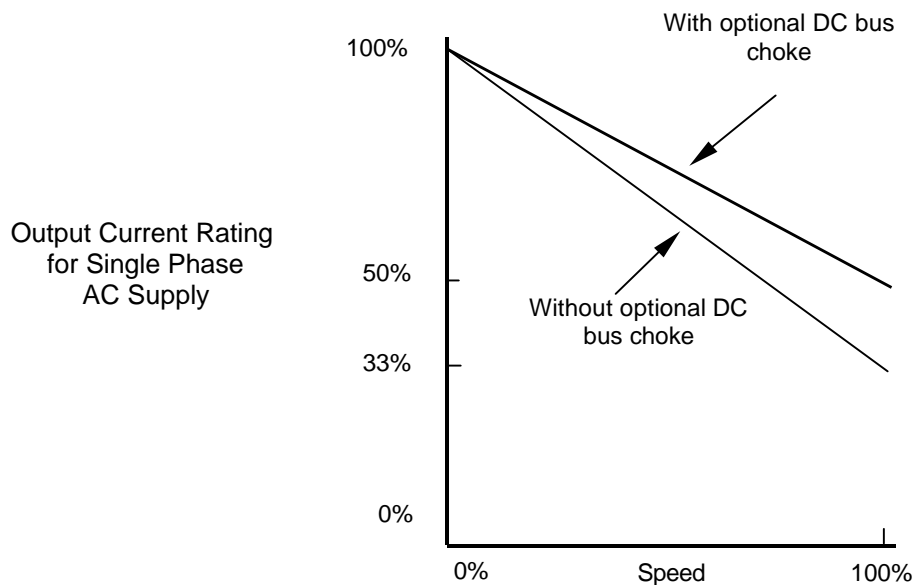
* is any 3 phase MSC, either MSC-3R, MSC-3L or MSC-3J

To operate the MSC-3 from a DC supply multiply these currents by 1.35

Single Phase MSC-3 Electrical Installation

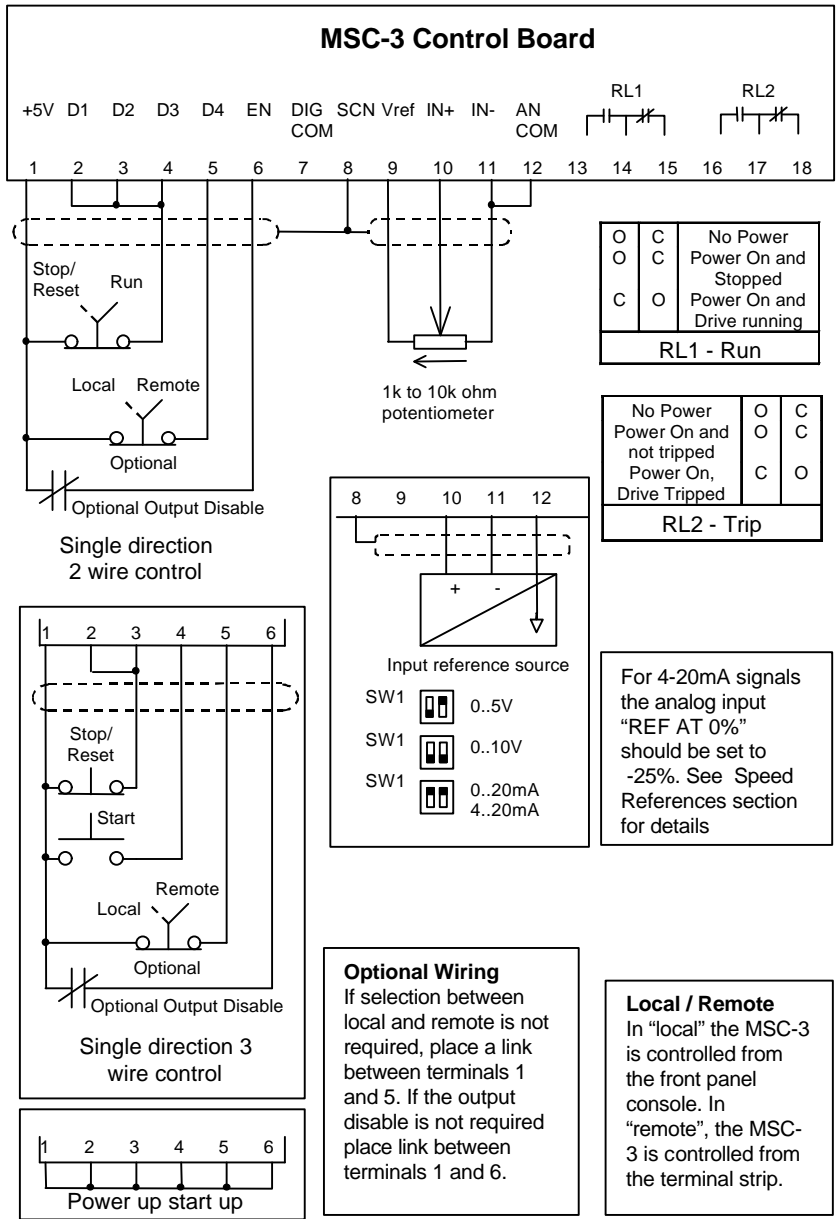
Any model MSC-3 can be operated from a single phase supply. The constraints on single phase operation are as follows:

- The single phase supply voltage must be within the 3 phase supply voltage limits for the MSC-3 model to be used. For example, use an MSC-3Lxx model for a 240VAC single phase supply or a MSC-3Rxx model for a 480VAC single phase supply.
- A standard 3 phase motor of a voltage rating appropriate to the MSC-3 model should be used. See the specifications section of this manual for output voltages.
- If the optional DC bus choke is fitted to an MSC-3 powered from a single phase supply, the maximum available output voltage will decrease to 95% of the RMS input voltage. This means that the available motor torque at full speed will be reduced to approximately 90% of the motor rated torque. This is simply a consequence of operating the motor at lower than rated voltage. This de-rating does not apply if the optional DC bus choke is not fitted. De-rating can also be avoided if the single phase input voltage is 1.05 times the rated motor voltage.
- The MSC-3 is unsuitable for use with single phase motors.
- Terminals L2 and L3 should be connected together and the single phase supply should be connected to L1 and L2. In all other respects the connections are the same as for a 3 phase supply.
- The continuous output current rating is reduced from the values stated for 3 phase supply operation according to the graph below.

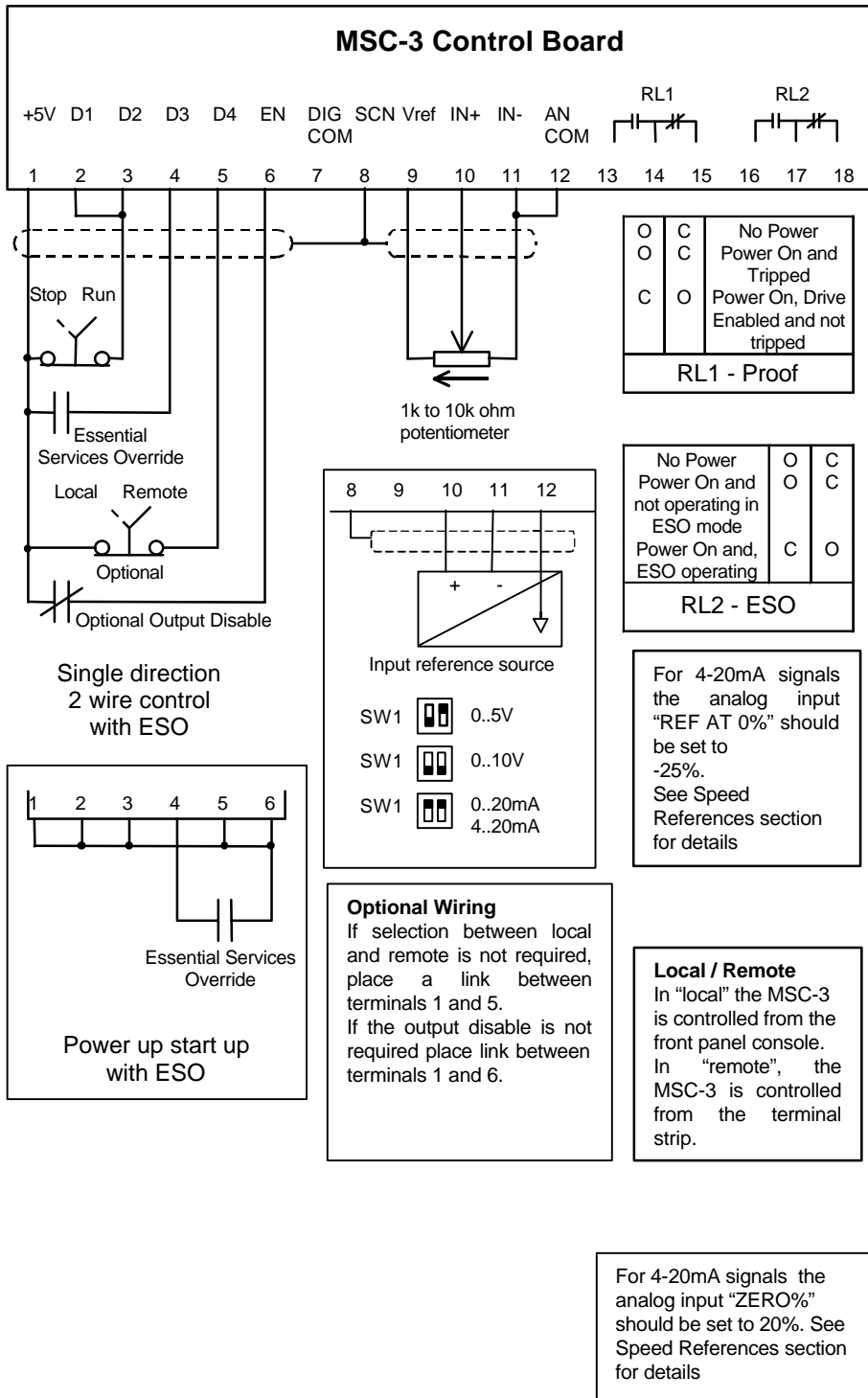


MSC-3 User's Manual

Industrial Terminals Typical Connection Diagram – Config 1



HVAC Terminals Typical Connection Diagram – Config 3



MSC-3 User's Manual

Quick Setup for Config 1.

Features

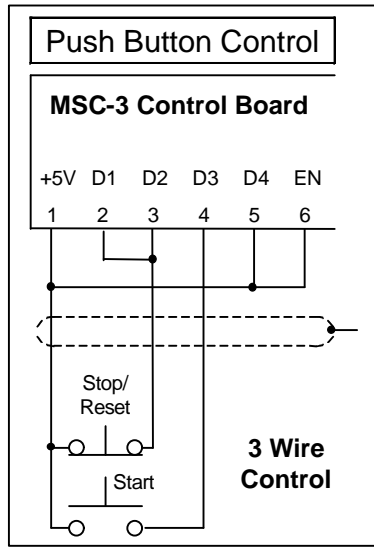
Forward Operation

Select between Local and Remote

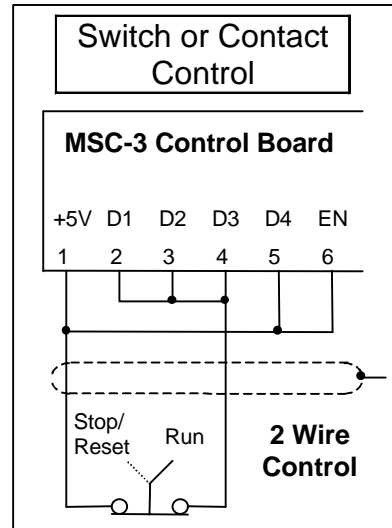
This terminal configuration gives single direction control from the terminal strip. This uses the MSC-3 default terminal configuration, Config 1.

STEP 1. Wire your supply into the L1, L2, L3 and Earth terminals. Wire your motor into the M1, M2, M3 and Earth terminals. See page 7 of the instruction manual for recommended fuse or circuit breaker ratings.

STEP 2. Choose your control method from one of the following. Connect your control wiring as shown.

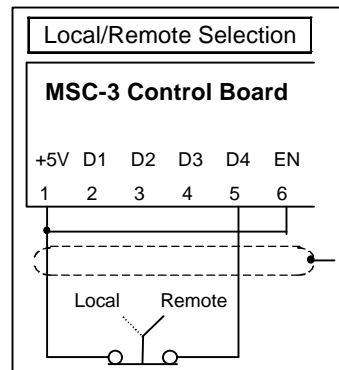
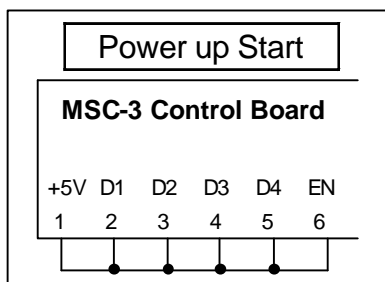


OR



OR

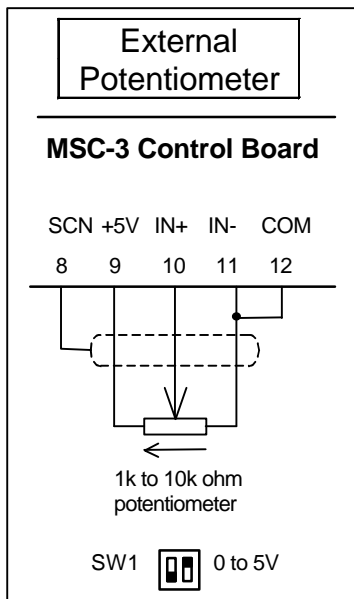
OR



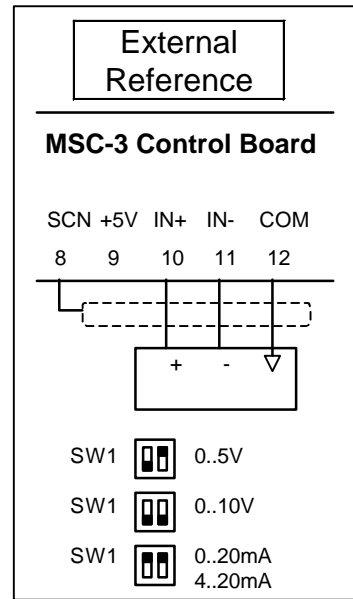
The Local/Remote Selection can be used on any of the above circuits. Wire terminals 5 and 6 as shown.

MSC-3 User's Manual

STEP 3. Choose your speed reference and connect it as shown.



OR



OR

Preset Speed.
Operation at a fixed speed

Console Reference.
Use the Up and Down arrows on the front panel to control the speed.

To use either the **Preset Speed** or the **Console Reference** select REMOTE from the REFERENCES menu. Use the arrows to display the options. Press Enter when the one you require is displayed.

Set SW1 as shown. If a **4 to 20mA** reference is to be used, select REMOTE from the REFERENCES menu. AN1 should be displayed. Press Enter. Set the REF AT 0% to -25%. Press Enter.

- STEP 4.** Setup your motor parameters in the MOTOR menu using the motor nameplate information.
- STEP 5.** From the PERFORMANCE menu setup your MIN and MAX speeds and your RAMP times.
- STEP 6.** From the PROTECTION menu setup your current limit and I²t currents.

MSC-3 User's Manual

Quick Setup for Config 3.

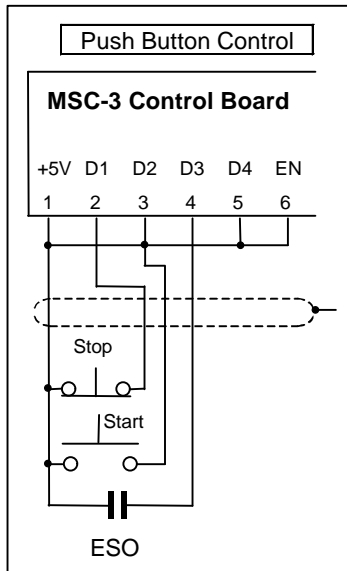
Features

Forward Operation

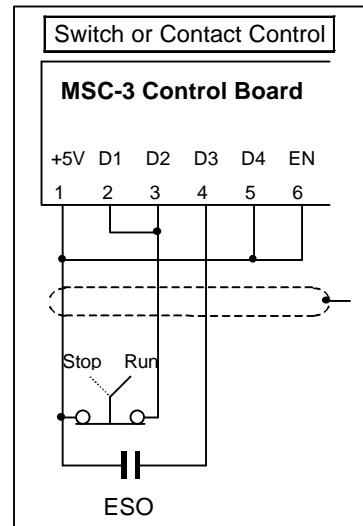
Hand/Off/Auto Operation

STEP 1. Wire your supply into the L1, L2, L3 and Earth terminals. Wire your motor into the M1, M2, M3 and Earth terminals. See page 7 of the instruction manual for recommended fuse or circuit breaker ratings.

STEP 2. Choose your control method from one of the following. Connect your control wiring as shown. Do not connect the wire into terminal 6 yet.

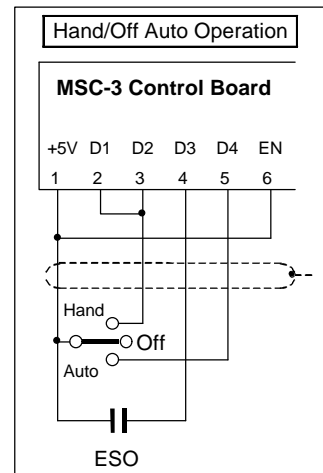
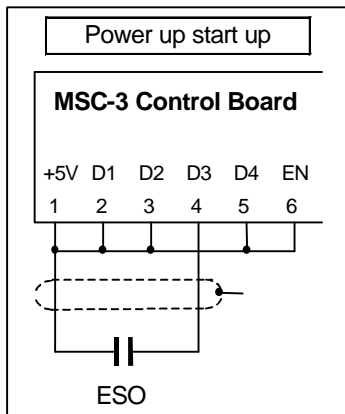


OR



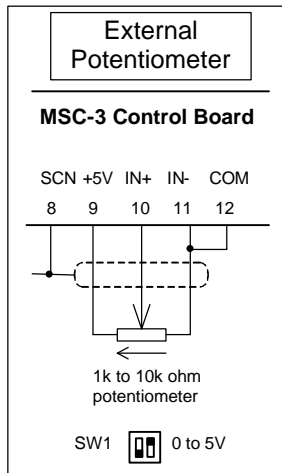
OR

OR

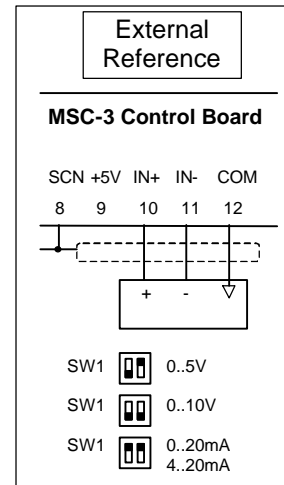


MSC-3 User's Manual

STEP 3. Choose your speed reference and connect it as shown



OR



OR

OR

Preset Speed.
Operation at a fixed speed

Console Reference.
Use the Up and Down arrows on the front panel to control the speed.

To use either the **Preset Speed** or the **Console Reference** select REMOTE from the REFERENCES menu. Use the arrows to display the options. Press Enter when the one you require is displayed.

Set SW1 as shown. If a **4 to 20mA** reference is to be used, select REMOTE from the REFERENCES menu. AN1 should be displayed. Press Enter. Set the REF AT 0% to -25%. Press Enter.

- STEP 4.** From the INPUT/OUTPUT menu select Terminal CFG. Use the up and down arrows until CONFIG 3 is displayed. Press ENTER. Now connect the wire to terminal 6.
- STEP 5.** Setup your motor parameters in the MOTOR menu using the motor nameplate information.
- STEP 6.** From the PERFORMANCE menu setup your MIN and MAX speeds and your RAMP times.
- STEP 7.** From the PROTECTION menu setup your current limit and I^2t currents.

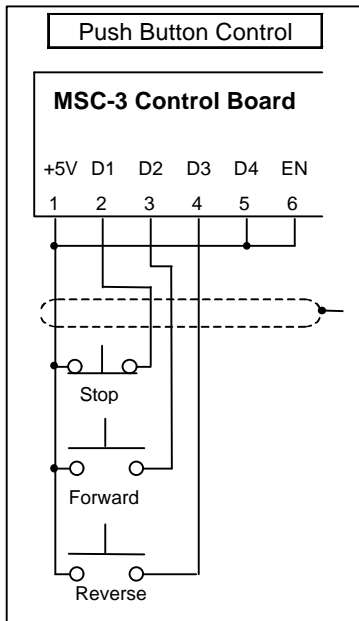
MSC-3 User's Manual

Quick Setup for Config 4.

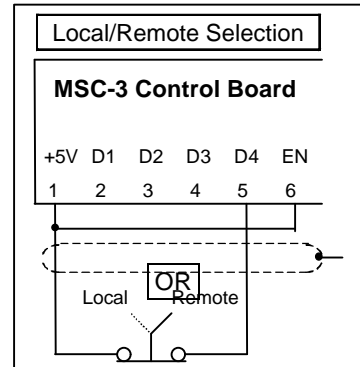
Features	Select between Local and Remote
Forward Operation	Reverse Operation

STEP 1. Wire your supply into the L1, L2, L3 and Earth terminals. Wire your motor into the M1, M2, M3 and Earth terminals. See page 7 of the instruction manual for recommended fuse or circuit breaker ratings.

STEP 2. Choose your control method from one of the following. Connect your control wiring as shown. Do not connect the wire into terminal 6 yet.

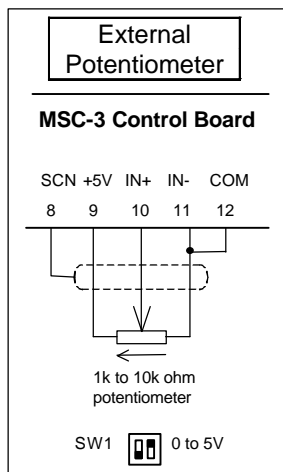


OR

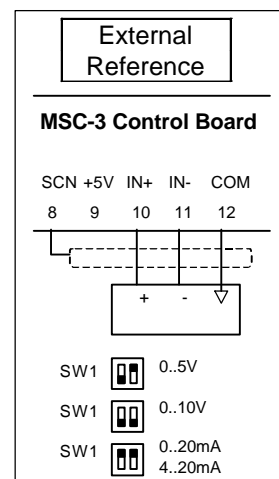


If Local/Remote Selection is required wire terminals 5 and 6 as shown.

STEP 3. Choose your speed reference and connect it as shown.



OR



OR

OR

Preset Speed.
Operation at a fixed speed

Console Reference.
Use the Up and Down arrows on the front panel to control the speed.

To use either the **Preset Speed** or the **Console Reference** select REMOTE from the REFERENCES menu. Use the arrows to display the options. Press Enter when the one you require is displayed.

MSC-3 User's Manual

Set SW1 as shown. If a **4 to 20mA** reference is to be used select REMOTE from the REFERENCES menu. AN1 should be displayed. Press Enter. Set the REF AT 0% to -25%. Press Enter.

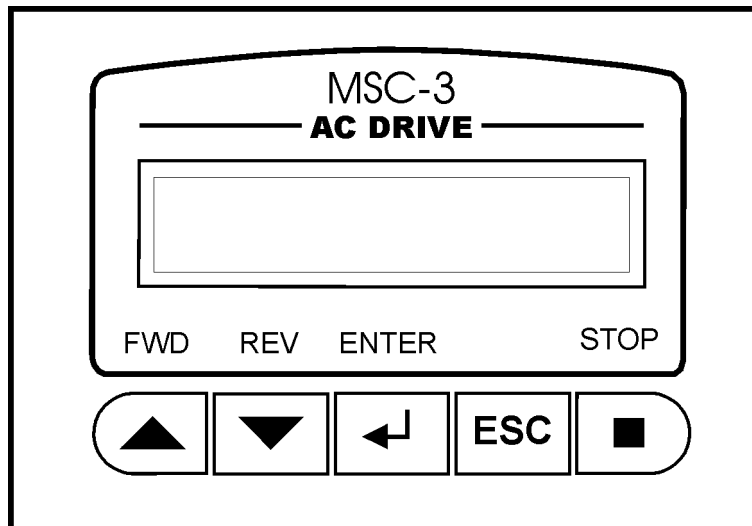
- STEP 4.** From the INPUT/OUTPUT menu select Terminal CFG. Use the up and down arrows until CONFIG 4 is displayed. Press ENTER. Connect the wire to terminal 6 now.
- STEP 5.** Setup your motor parameters in the MOTOR menu using the motor nameplate information.
- STEP 6.** From the PERFORMANCE menu setup your MIN and MAX speeds and your RAMP times.
- STEP 7.** From the PROTECTION menu setup your current limit and I^2t currents.
- STEP 8.** From the PROTECTION menu enable the REVERSE direction.

MSC-3 User's Manual

MSC-3 Start up

Connect the input and motor wiring in accordance with the Electrical Installation Diagram. Select the terminal configuration you require from the table on page 30. Connect the control wiring according to the appropriate Control Wiring Diagram or follow a quick setup. The MSC-3 is now ready to run. Before applying power ensure that rotation of the motor shaft will not cause injury or damage.

After applying power it is recommended that you at least go through the MOTOR, PERFORMANCE and the INPUT/OUTPUT menus to set up the MSC-3 before running the motor to prevent any unexpected motor operation. The MSC-3 is supplied with a link between the En terminal and the +5V terminal which is all that is required to run the MSC-3 from the console. A connection between these two terminals must always be made for the motor to run.



The five pushbuttons and display form a console through which drive features and settings are altered to suit the application. When the MSC-3 is first powered up, the start banner is displayed for approximately 2 seconds. An example of the start banner is shown below. It displays the drive size, software version and the temperature of the MSC-3 hardware. While the banner is displayed the internal fan is switched on to verify its operation. If the fan is not required it will then be turned off.

```

                R11
          V1.38   23°C

```

MSC-3 Run mode

Once the start banner is removed the display is set in the **Run Mode**. The top line contains the run variable. The second line contains the speed reference and the drive status. An example of the Run Mode display is shown below:

```

          25.0 Hz
          50.0 FWD

```

The example shows that the desired output speed is 50 Hz and the motor is rotating at 25 Hz in the forward direction as indicated by the status.

To start the drive, select a direction by pressing either of the run buttons: ▲ FWD or ▼ REV button. Use the ▲ FWD button to increase the speed reference and the ▼ REV button to decrease it. The motor should rotate up to the desired speed. If it does not, refer to the Trouble Shooting Guide at the end of this manual.

If the motor shaft spins in the wrong direction remove the input power, wait for the MSC-3 to discharge and swap any two motor phase wires. Re-apply input power and select a direction by pressing ▲ FWD or ▼ REV.

MSC-3 User's Manual

Operation and access to the Run Mode and Menu Mode is done with the console push buttons. The action of each push button changes with the mode of operation and the state of the drive. The following table describes how the console push buttons affect the drive control.

Console Push Button operations

Console Mode	Motor Running	Motor Stopped
Menu mode used for entering setup information.	<ul style="list-style-type: none"> Pressing STOP will stop the motor Pressing ▲ or ▼ will either select another menu item or adjust a setting Pressing ↵ will select the displayed menu item or accept the value being adjusted. Pressing ESC will abort value adjustment or the current menu. If the current menu is the top of the menu tree, the console changes mode to the Run Display mode 	<ul style="list-style-type: none"> Pressing STOP will not reset trip conditions to allow trip messages to be viewed after exiting menu mode Pressing ▲ or ▼ will either select another menu item or adjust a setting Pressing ↵ will select the displayed menu item or accept the value being adjusted. Pressing ESC will abort value adjustment or the current menu. If the current menu is the top of the menu tree, the console changes mode to the Run Display mode
Run Display mode -when the CONSOLE REF <u>is</u> the active speed source	<ul style="list-style-type: none"> Pressing STOP will stop the motor Pressing ▲ or ▼ will either increase or decrease the motor speed Pressing ↵ will have no effect Pressing ESC will abort the Run Display mode and the console changes to the Menu mode 	<ul style="list-style-type: none"> Pressing STOP will reset any trip condition If no trip is present, pressing ▲ or ▼ will either start the motor running forward or reverse (internally latched). If a trip is present, ▲ and ▼ adjust the speed reference without running the motor. Pressing ↵ will have no effect Pressing ESC will abort the Run Display mode and the console changes to the Menu mode
Run Display mode -when the CONSOLE REF <u>is not</u> the active speed source	<ul style="list-style-type: none"> Pressing STOP will stop the motor Pressing ▲, ▼ or ↵ will have no effect Pressing ESC will abort the Run Display mode and the console changes to the Menu mode 	<ul style="list-style-type: none"> Pressing STOP will reset any trip condition. Pressing ▲, ▼ or ↵ will have no effect. Pressing ESC will abort the Run Display mode and the console changes to the Menu mode.

MSC-3 Menu mode

The Menu mode is entered from the Run mode by pressing the ESC push button (pressing ESC again will return to Run mode). Use the ▲ and ▼ push buttons to display each menu item. To enter the menu press the ↵ push button. This action will either display another menu or display a setting ready for adjustment.

Control Console Menu

A00 DISPLAY

This menu allows selection of run variables and in the case of output frequency adjustment of its display format and units. It also provides a restore factory defaults function.

A01 RUN VARIABLE

A single run variable is selected from this menu for display on the run screen.

- **V01** Hz Output frequency
- **V02** rpm Motor speed
- **V03** % Load Relative motor load
- **V04** Amps Drive output current
- **V05** Volts DC DC link voltage
- **V06** kW Drive output power
- **V07** Volts AC Drive output voltage
- **V08** °C Power circuit temperature (Celsius)
- **V09** °F Power circuit temperature (Fahrenheit)
- **V10** I²t used Motor thermal overload level

A02 RUN SCALE

Default Value: 50.0

The default run variable is output frequency in Hz. This is the only run variable that may be re-scaled. It can be changed to any number from 1.0 to 9999 (or 999.9 with one decimal place).

With A02 RUN SCALE displayed on the top line, press enter and the run scale value is displayed ready for edit. Use the up and down push buttons to adjust each individual digit. Press Enter to move to the next digit. To abandon the adjustment at any time, press the ESC push button.

Once the last digit has been adjusted, press Enter. The value remains on the display and is waiting for decimal point assignment. Use the up and down push buttons to shift the decimal point and Enter to accept the position.

Press ESC to return to A00 DISPLAY.

A03 RUN UNITS

Default Value: Hz

The MSC-3 is able to display the output frequency in user defined units. The default setting is Hz, but it can be changed, so that the display will show user preferred units. For example, mtr/min, Cans/hr or anything else up to 8 characters. The output frequency is the only run variable whose units can be changed. The available characters are found in Appendix A

With A03 RUN UNITS displayed on the top line press Enter and the existing run units are displayed on the second line. Use the up and down push buttons to select a different character.

When the desired character is displayed, press Enter and the next character may now be adjusted. Repeat this seven more times. Changes to the run units can be abandoned at any point by pressing the ESC push button.

When the eighth character is selected, pressing Enter will accept the new units setting.

A04 Menu Protect

The feature protects the entire menu mode with a code so that settings and configurations are protected from unauthorized changes. After you enable this feature, return to the Run Screen. The next time anyone presses ESC to enter the Menu mode the following message will appear:

A07 Enter Code
0

Use the up and down buttons to adjust the code value to the number **1470**. Press Enter to accept. If entered correctly, the familiar menu mode will be displayed. If the correct code is not entered you are returned back to the run screen.

A05 SET CTL DEFS

This menu allows the factory default parameters to be reinstalled. **The MSC-3 must be disabled before you can restore the defaults.** Pressing the Enter button will cause the message **A06 CHECK WIRING** to be displayed. This is intended as a warning and an opportunity to confirm that terminal wiring is suited to the default settings, otherwise unexpected drive operation may result.

Pressing the ENTER button again will cause the defaults to be loaded.

B00 MOTOR

This menu allows you to enter motor nameplate information. Press the Enter button to view and modify Motor Volts, Motor Amps, Motor Hz and Motor rpm.

B01 MOTOR VOLTS

Default value: 230, 240, 415, 460 or 575 V (depends on model)

Range: 200..900 V

Use the up or down push buttons to adjust this setting to the motor nameplate voltage. Press Enter when finished and the motor nameplate current is displayed or ESC to abort the adjustment

B02 MOTOR AMPS

Default value: drive nominal current

Range: 18 to 137% of drive overload current listed in the MSC-3 Output Current Specifications table on page 44.

Use the up or down push buttons to adjust this setting to the motor nameplate current in amps. Press Enter when finished and the motor frequency is displayed or ESC to abort the adjustment.

Entering the Nameplate Current of your motor determines the operation points for the Flux Plus and Slip Comp features. This setting is not used to limit the output current of the MSC-3. Refer to D01 CURRENT LIMIT for that particular feature.

B03 MOTOR Hz

Default value: 50 or 60 Hz

Range: 30..200 Hz

Use the up or down push buttons to adjust this setting to the motor nameplate frequency (Hz). Press Enter when finished or ESC to abort the adjustment. This setting does not affect the minimum or the maximum frequency output of the MSC-3. Refer to C01 MIN Hz and C02 MAX Hz for those features.

B04 MOTOR RPM

Default value: 1465 or 1765 rpm

Range: 500..60 times the Motor Hz entered previously, in rpm

Use the up or down push buttons to adjust this setting to the motor nameplate speed (rpm). 60 times the Motor Hz is the two pole speed for an unloaded motor. Press Enter when finished or ESC to abort the adjustment.

C00 PERFORMANCE

This section allows you to set the motor performance characteristics.

C01 MIN Hz

Default value: 0 Hz

Range: 0 to 195Hz

This sets the frequency that the MSC-3 will run when given a run signal. The value is entered in Hz. There must be a difference of at least 5Hz between the MIN Hz and the MAX Hz setting. For example, if MAX Hz is set to 45Hz, then the largest allowed value for MIN Hz is 40Hz. Use the up or down push buttons to adjust the MIN Hz value, press Enter to accept the value or press ESC to abort the adjustment. It is possible to use the full span of the analog input to adjust the speed reference through the remaining reduced speed range. For example: Max Hz = 50Hz and Min Hz = 20Hz, the analog input "R01 Ref at 0%" should be set to 40%. Zero at the analog input will produce a reference of 20Hz. Full span at the input will produce a reference of 50Hz.

C02 MAX Hz

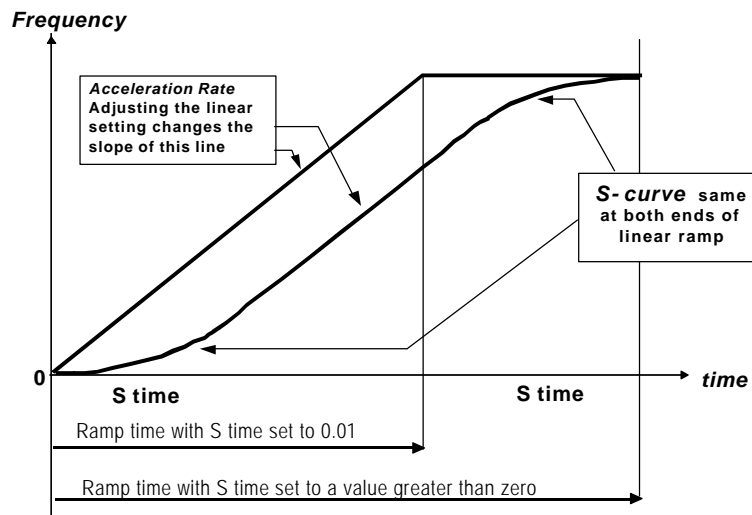
Default value: 50 or 60Hz (depends on model)

Range: 5Hz to 200Hz

This sets the frequency that the drive will run with the speed reference at maximum. There must be a difference of at least 5Hz between the MIN Hz and the MAX Hz setting. This value is scaled by the Run Scale value and so is always entered in user defined units. Use the up or down push buttons to adjust the MAX Hz value, press Enter to accept the value or press ESC to abort the adjustment.

C03 Ramp

The MSC-3 has a programmable Ramp with adjustable acceleration, deceleration and S-curve rates. Individual settings are provided for the linear and curved portions of the ramp.



When the motor accelerates, the ACCEL TIME and S TIME settings are used. When the motor decelerates, the DECEL TIME and S TIME settings are used. Press Enter to adjust these parameters.

NOTE: Alterations to any ramp parameter is not permitted while the drive is operating in ESO mode, (see page 35 for more information on ESO)

C04 ACCEL TIME

Default value: 10 sec

Range: 0.5 to 600 sec

The ACCEL TIME is the time taken for the motor to go from zero speed up to motor rated speed (assuming minimum S TIME). An MSC-3 with Motor Hz set to 50 Hz and an ACCEL TIME of 10 seconds will take 10 seconds to go from 0 Hz to 50 Hz. Use the up or down buttons to adjust the ACCEL TIME or press ESC to abort adjustment.

C05 DECEL TIME

Default value: 10 sec

Range: 0.5 to 600 sec

The DECEL TIME is the time taken for the motor to go from motor rated speed down zero speed (assuming minimum S TIME). An MSC-3 with Motor Hz set to 50 Hz and an DECEL TIME of 10 seconds will take 10 seconds to go from 50 Hz to 0 Hz. Use the up or down buttons to adjust the DECEL TIME or press ESC to abort adjustment.

C06 S TIME

Default value: 0.01 sec

Range: 0.01 to 40.00 sec

The S TIME is the time taken for the motor to reach the limit of acceleration (as set by the rated speed and the ACCEL TIME or DECEL TIME). Using the S TIME ensures smooth speed increases and decreases. The longer the S TIME, the smoother the speed transition.

The S TIME will extend the ramp time as set by the ACCEL and DECEL TIME. The ramp time is now roughly equal to the S TIME plus ACCEL TIME or DECEL TIME.

C07 Flux plus %

Default value: 25%

Range: 0 to 150% of adjustment range

The MSC-3 uses a sensorless flux vector control algorithm to control the motor operation. This control algorithm provides independent control of motor flux throughout the speed range and is highly robust against motor parameter changes. It uses the motor nameplate parameters entered in the B00 MOTOR menu as the basis for its calculations to produce the correct flux in the motor. For a motor to produce full torque it must have the correct flux applied to it. This is particularly critical at low speed. Flux Plus adjusts the motor flux estimate to provide additional control where specific adjustments to the motor torque response are required.

This feature enables an adjustment in the flux vector algorithm that can increase motor flux to produce more torque for the same motor current. The amount of extra torque produced will vary from motor to motor depending on motor size, efficiency and the operating speed.

Increase the value to produce more torque. This should be done in small steps to ensure the drive does not go into Current Limit. If the drive does go into current limit decrease the Flux Plus value slightly. This is the maximum torque that the motor can produce.

Use the up or down buttons for the adjustment. Press Enter when adjusted or ESC to abort adjustment.

C08 Hi Spd Flux+

Available Choices: H00 ENABLE

H01 DISABLE (default)

When this is disabled the flux plus decreases with increasing speed. This allows more efficient operation of the MSC-3 on loads that have a high starting torque but do not require any extra torque during normal operation. If your load requires high torque throughout the entire speed range Enable Hi Spd Flux+. Press Enter to view the setting. Use the up or down push button to enable or disable Hi Spd Flux+. Press Enter to accept the new setting or ESC to abandon.

C09 SLIP COMP

Default value: 0%

Range: 0 to 150% of slip speed

Motor slip is the difference between the shaft speed and the frequency applied to the motor (synchronous speed) and is dependent on load. Slip Comp can provide compensation for this varying slip to produce constant shaft speed under varying loads. The MSC-3 estimates the slip of the motor using the parameters entered in the MOTOR parameters menu and the motor load. A value of 100% will make the shaft speed equal the synchronous speed. Flux Plus may be used in conjunction with Slip Comp to provide increase output torque at low speeds. Press Enter then use the up and down buttons to adjust the amount of SLIP COMP. When adjusted, press Enter to accept the new setting or ESC to abort the adjustment.

C11 AUDIBLE FREQ

Available Choices:

C12	2kHz
C13	4kHz
C14	8kHz
C15	16kHz
C16	Auto select (default)

This value sets the maximum frequency that the drive uses in the creation of its PWM output voltage. This frequency is noticeable as an audible sound that the motor makes. Usually higher settings produce less audible noise but increase the switching losses which produces more heat in the drive. For most efficient operation select 2 kHz. Press Enter then use the up or down buttons to choose the AUDIBLE FREQ. Press Enter when finished to accept the choice or ESC to abort.

D00 PROTECTION

This section lets you set the motor protection features.

D01 CURRENT LIM

Default value: drive overload current.

Range: 18 to 100% of Drive Overload Current listed in MSC-3 Output Current Specifications table on page 44, entered in amps.

This sets the maximum output current of the MSC-3. If excessive load is applied to the motor, the drive will only apply this amount of current to the motor until the overload condition is removed. Current limiting is achieved by reducing the speed of the motor. The Current Limit value cannot be set higher than the maximum output current for the drive.

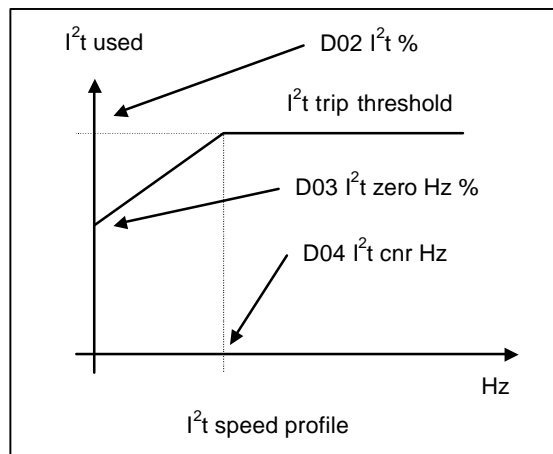
Press Enter then use the up or down buttons to adjust the CURRENT LIM. Press Enter when finished to accept the adjustment or ESC to abort.

D02 I²t

The I²t feature estimates the heating of the motor according to the motor load. When the estimated heating exceeds I²t setting, the drive will trip on I²t. For a motor running at 110% of its I²t current this will take approximately two minutes. The time to trip will shorten the further the motor current exceeds the I²t value.

If power is removed from the drive after an I²t trip, the motor should be allowed to cool down before the inverter is restarted. Motors running highly loaded at low speeds should have external cooling and an external motor thermal sensing device such as microtherms or thermistors for protection.

The I²t feature has the ability to set the trip threshold as a function of output frequency. This allows the I²t to protect motors that have reduced cooling at low speeds because they are not externally cooled. The diagram below is an example of the I²t trip threshold profile.



D02 I²t

Default value: drive nominal current

Range: 18% to 100% of drive Overload Current listed in MSC-3 Output Current Specifications table on page 44, entered in amps.

This sets the upper limit of I²t and is entered in amps. This is equivalent to the usual I²t setting. Use the up and down push buttons to adjust the D02 I²t value and press Enter to accept the value or ESC to abandon changes.

D03 I²t zero Hz

Default value: drive nominal current

Range: 18% to 100% of drive Overload Current listed in MSC-3 Output Current Specifications table on page 44, entered in amps.

MSC-3 User's Manual

This sets the trip threshold when the speed is zero (e.g. DC HOLD). This value cannot be set higher than the D02 I²t value set above. Use the up and down push buttons to adjust the D03 I²t zero Hz value and press Enter to accept the value or ESC to abandon changes.

D04 I²t cnr Hz

Default value: 10Hz

Range: 2 to 200Hz

The D04 I²t cnr Hz value sets the frequency above which the profile uses the trip threshold as set by D02 I²t. Below this frequency the I²t value is set by the slope on the I²t profile. Use the up and down push buttons to adjust the D04 I²t value and press Enter to accept the value or ESC to abandon changes.

D05 Reverse

Available Choices: H00 ENABLE
H01 DISABLE (default)

The MSC-3 is shipped with its reverse direction disabled to prevent damage to mechanical devices or hazardous equipment operation caused by the motor running backwards. Press Enter to view the setting. Use the up or down push button to enable or disable Reverse. Press Enter to accept the new setting or ESC to abandon.

D08 DC INPUT

Available Choices: H00 ENABLE
H01 DISABLE (default)

This feature allows the MSC-3 to operate from a DC Input Supply. The DC Supply voltage should be at least 1.414 times higher than the motor voltage. Press Enter to view the setting. Use the up or down push button to enable or disable DC Input. Press Enter to accept the new setting or ESC to abandon.

E00 STOP/START

This section sets the motor stopping and starting modes.

E01 STOPPING

Available Choices: E02 RAMP TO STOP (default)
E03 COAST

This controls the operation of the MSC-3 when any stop signal is given.

RAMP TO STOP means that the MSC-3 will continue to control the motor in order to bring it to a stop in the time set by the DECEL TIME and S TIME.

COAST means that the MSC-3 will stop controlling the motor and allow it to coast to a stop, just as if the power supply had been disconnected.

E06 DYNAMIC BRK

Available Choices: H00 ENABLE
H01 DISABLE (default)

Dynamic Braking provides the means for dissipating the motor regenerative energy into an external resistor. This may be required when the MSC-3 experiences regenerative currents from an overhauling load or a high inertia load that is required to decelerate rapidly. Dynamic Braking requires the dynamic braking option to be connected to the MSC-3. Please see the dynamic braking instruction manual for resistor sizing and dynamic braking application information.

Use the up or down buttons to select either Enable or Disable. Press Enter to accept the selection or ESC to abort.

E07 AUTO RESTART

Auto Restart allows the MSC-3 to automatically attempt to restart after a trip occurs. If the MSC-3 trips it will wait 10 seconds then attempt to clear the fault. If it is unsuccessful it will keep trying every ten seconds. It will do this the number of times specified in A/Rs ALLOWED. If the fault is cleared and the drive runs without tripping for the A/R CLR TIME the number of auto restarts attempted will start counting from 1 again. If the trip is cleared by any other means the fault count will start from 1 again.

Note: Alteration to any of the Auto Restart parameters is not permitted while the MSC-3 is operating in ESO mode.

E08 A/Rs ALLOWED

Default value: 0

Range: 0 to 15 restarts

This number indicates how many times the MSC-3 will attempt to restart after a trip. For the motor to run after the trip is cleared, the drive must be given a valid run command. Select 0 restarts in order to deactivate Auto Restart.

Use the up or down buttons to adjust A/Rs ALLOWED. Press Enter to accept the adjustment or ESC to abort.

E09 A/R CLR TIME

Default value: 20 min

Range: 0.1 to 20 min

If the MSC-3 operates for the A/R CLR TIME without any trips occurring the number of restarts is reset to the value of A/Rs ALLOWED. Set the A/R CLR TIME to 0.1min for infinite auto restarts.

Use the up or down buttons to adjust A/R CLR TIME. Press Enter to accept the adjustment or ESC to abort.

E10 Reset by PF

Available Choices: H00 ENABLE

H01 DISABLE (default)

Enabling this facility allows the MSC-3 to reset all trips when a momentary power failure occurs. This feature is useful in power-up start applications because trips may be cleared without any extra switch logic by turning the power off and straight back on again without waiting for the drive to completely power down.

Use the up or down buttons to select either Enable or Disable. Press Enter to accept the selection or ESC to abort.

F00 REFERENCES

This lets you set the speed references for all the MSC-3 operating modes. Various options may allow the connection of a different speed source from those listed for the standard MSC-3. When these options are fitted the extra input options will appear where the word "Options" appears in the lists below. More preset speeds or a second analog input are examples of this.

For more information on the different drive operating modes see the Control Terminal Functions on Page 34

F01 REMOTE

Default value: Analog Input 1

Other Choices: Preset
Motorized Pot
Console Ref
Options

When the drive is operating in remote mode it will take its speed reference from this source. Use the up and down push buttons to select a reference and press Enter to accept the selection or ESC to abandon.

F02 LOCAL

Default value: Console Ref

Other Choices: Analog Input 1
Preset
Motorized Pot
Options

When the drive is operating in local mode it will take its speed reference from this source. Use the up and down push buttons to select a reference and press Enter to accept the selection or ESC to abandon.

F03 ESO

Default value: Preset

Other Choices: Analog Input 1
Motorized Pot
Console Ref
Options

When the drive is operating in ESO mode it will take its speed reference from this source. Use the up and down push buttons to select a reference and press Enter to accept the selection or ESC to abandon.

If Reverse operation is required in ESO enter the desired speed as a negative value.

F04 JOGFWD

Default value: Preset

Other Choices: Analog Input 1
Motorized Pot
Console Ref
Options

When the drive is running in JOGFWD it will take its speed reference from this source. Use the up and down push buttons to select a reference and press Enter to accept the selection or ESC to abandon.

F05 JOGREV

Default value: Preset

Other Choices: Analog Input 1
Motorized Pot
Console Ref
Options

MSC-3 User's Manual

When the drive is running in JOGREV it will take its speed reference from this source. Use the up and down push buttons to select a reference and press Enter to accept the selection or ESC to abandon.

Speed References

R00 AN1

When the Analog Input is selected as a speed reference for any of the different operating modes, two parameters need to be checked. The MSC-3 will let you do this every time the analog input is selected as a reference. They are **R01 REF AT 0%** and **R02 REF AT 100%**. Use the up or down buttons to change the values (if required). Press enter to accept the value or ESC to abort.

MSC3 Analog Input Scaling

To calculate the values for REF AT 0% and REF AT 100% you need to know the following:

- Two analog input values and the speed required at each value
- The maximum speed.
- The input range, 5V, 10V or 20mA

Now use the following formulae to calculate the values for REF AT 0% and REF AT 100%

$$m = \frac{\text{highspeed} - \text{lowspeed}}{\text{max speed} \cdot (\text{highinput} - \text{lowinput})}$$

$$\text{REFAT0\%} = \left(\frac{\text{highspeed}}{\text{max speed}} - m * \text{highinput} \right) * 100$$

$$\text{REFAT100\%} = 100 * m * \text{inputrange} + \text{REFAT0\%}$$

Examples:

<p>Standard 4-20mA At 4mA input we want 0Hz and at 20mA input we want 50Hz, maximum speed 50Hz using the 0-20mA input range.</p> $m = \frac{50 - 0}{20 - 4} = 0.0625$ $\text{REFAT0\%} = \left(\frac{50}{50} - 0.0625 * 20 \right) * 100 = -25$ $\text{REFAT100\%} = 100 * 0.0625 * 20 - 25 = 100$	<p>Bipolar Input At 1V input we want 40Hz in reverse and at 4V input we want 30Hz in forward, maximum speed 40Hz using the 0-5V input range.</p> $m = \frac{30 - 40}{4 - 1} = 0.583$ $\text{REFAT0\%} = \left(\frac{30}{40} - 0.583 * 4 \right) * 100 = -158$ $\text{REFAT100\%} = 100 * 0.583 * 5 - 158 = 133$
<p>Reduced Input Range At 2V input we want 30Hz and at 4V input we want 40Hz, maximum speed 60Hz using the 0-10V input range.</p> $m = \frac{40 - 30}{4 - 2} = 0.083$ $\text{REFAT0\%} = \left(\frac{40}{60} - 0.083 * 4 \right) * 100 = 33$ $\text{REFAT100\%} = 100 * 0.083 * 10 + 33 = 117$	<p>Inverse Acting Bipolar Input At 10V input we want 60Hz in reverse and at 0V input we want 60Hz, maximum speed 60Hz using the 0-10V input range.</p> $m = \frac{60 + 60}{0 - 10} = -0.2$ $\text{REFAT0\%} = \left(\frac{60}{60} + 0.2 * 0 \right) * 100 = 100$ $\text{REFAT100\%} = 100 * -0.2 * 10 + 100 = -100$

R01 REF AT 0%

Default value: 0%

Range: - 1000% to 1000%

This value specifies what the reference will be when 0% of the input signal is present at the analog input terminals. For a 4 to 20mA input signal, R01 REF AT 0% must be set to -25%.

R02 REF AT 100%

Default value: 100%

Range: -1000 to 1000% of input span

This value specifies what the reference will be when 100% of the input signal present at the analog input terminals.

R03 PRESET

Default value: 60%

Range: -100% to 100% of CO2 MAX Hz

If PRESET is chosen as the speed source you must enter the preset speed value. Use the up or down buttons to adjust the preset speed. The preset speed is entered in % of CO2 MAX Hz. Press Enter to accept the speed value or press ESC to abort.

R04 MOTORIZD POT

Motorised Pot operation requires two input terminals, Up and Down. If the Up terminal is energised the drive speed will increase. If the Down terminal is energised the speed will decrease. If neither is energised the drive maintains a constant speed. If MOTORIZD POT is selected as the speed source you must select the mode of operation.

Available choices: R05 PersistENT

R06 RESET (default)

Use the up or down buttons to select either R05 PERSISTENT or R06 RESET. Press Enter to accept the selection or ESC to abort.

In **PERSISTENT** mode the Motorized Pot speed will be remembered when power is removed. The Motorized Pot reference will return to this value the next time the MSC-3 is run.

In **RESET** mode the Motorized Pot speed will not be remembered when power is removed. The Motorized Pot reference will always start from zero after power is applied.

R07 CONSOLE REF

When this is selected, the reference is set from the console using the up and down arrows when the MSC-3 is in the run mode.

G00 INPUT/OUTPUT

There are two ways to assign terminal strip functions in the MSC-3.

The user can choose a standard terminal configuration from the standard list.

The user can create a custom terminal configuration.

The simplest way to set a terminal configuration is to choose from one of the standard terminal configurations tabulated below. From the console menu press enter. Use the up arrow and down arrow buttons to move through the list of standard terminal configurations CONFIG 1 - CONFIG 8. When you have chosen a configuration press the enter button. Selecting one of these loads the terminals with the listed functions. **The MSC-3 does not remember which configuration was selected but remembers the individual terminal functions.** It does this so that you can then modify any of the terminals to suit your specific application. This also means that every time you go to the G01 Terminal CFG menu, the first option displayed is G02 CONFIG 1. To see the terminal configuration you must look at each terminal individually.

Note: The MSC-3 must be disabled to select another terminal configuration.

Remember if you make a mistake press the escape button twice. This will take you out of the menu mode and move you into the run mode.

Standard Terminal Configurations

Term Config.	D1 2	D2 3	D3 4	D4 5	EN 6	RL1 13,14,15	RL2 16,17,18	refer to page
G02 CONFIG 1 Industrial	RESET	~STOP	FWD & LATCH	REMOTE	ENABLE	RUN	TRIP	30
G03 CONFIG 2 VSC 2000	RESET	~STOP	FWD & LATCH	REV & LATCH	ENABLE	RUN	TRIP	31
G04 CONFIG 3 HVAC	~STOP	FWD & LATCH	ESO	REMOTE	ENABLE / RESET	PROOF	ESO	31
G05 CONFIG 4	~STOP	FWD & LATCH	REV & LATCH	REMOTE	ENABLE / RESET	RUN	TRIP	31
G06 CONFIG 5	~STOP	FWD & LATCH	JOGFWD	REMOTE	ENABLE / RESET	RUN	TRIP	31
G07 CONFIG 6	FWD	REV	JOGFWD	JOGREV	ENABLE / RESET	RUN	TRIP	32
G08 CONFIG 7	~STOP	FWD & LATCH	UP	DOWN	ENABLE / RESET	RUN	TRIP	32
G09 CONFIG 8	FWD	UP	DOWN	REMOTE	ENABLE / RESET	RUN	TRIP	32

~ STOP means the logical inverse of STOP i.e. this input must have 5V applied for the drive to run.

G02 CONFIG 1 Industrial

Terminal.	D1 2	D2 3	D3 4	D4 5	EN 6	RL1 13,14,15	RL2 16,17,18
Function	RESET	~STOP	FWD & LATCH	REMOTE	ENABLE	RUN	TRIP

1. Sets the REMOTE speed reference to AN1.
2. Sets the LOCAL speed reference to the CONSOLE REF.
3. To change either of the above references go to A35 DIG IN 4 in the menu and select an alternate after you have selected this terminal configuration.
4. See page 9 for typical examples of wiring for this terminal configuration.

G03 CONFIG 2 VSC2000

Terminal.	D1 2	D2 3	D3 4	D4 5	EN 6	RL1 13,14,15	RL2 16,17,18
Function	RESET	~STOP	FWD & LATCH	REV & LATCH	ENABLE	RUN	TRIP

1. The MSC-3 only runs in remote. The remote reference can be set to any available option.
2. AN1 is the default speed reference.
3. To run the drive in reverse the Reverse Direction must be enabled.

G04 CONFIG 3 HVAC

Terminal.	D1 2	D2 3	D3 4	D4 5	EN 6	RL1 13,14,15	RL2 16,17,18
Function	~STOP	FWD & LATCH	ESO	REMOTE	ENABLE / RESET	PROOF	ESO

1. Sets the REMOTE speed reference to AN1.
2. Sets the LOCAL speed reference to the CONSOLE REF.
3. To change either of the above references go to A35 DIG IN 4 in the menu and select an alternate after you have selected this terminal configuration.
4. Sets the ESO speed reference to the PRESET speed. To change this reference go to A34 DIG IN 3 in the menu to select an alternate speed source.
5. See page 10 for typical examples of wiring for this terminal configuration.

G05 CONFIG 4

Terminal.	D1 2	D2 3	D3 4	D4 5	EN 6	RL1 13,14,15	RL2 16,17,18
Function	~STOP	FWD & LATCH	REV & LATCH	REMOTE	ENABLE / RESET	RUN	TRIP

1. Sets the REMOTE speed reference to AN1.
2. Sets the LOCAL speed reference to the CONSOLE REF.
3. To change either of the above references go to A35 DIG IN 4 in the menu and select an alternate after you have selected this terminal configuration.

G06 CONFIG 5

Terminal.	D1 2	D2 3	D3 4	D4 5	EN 6	RL1 13,14,15	RL2 16,17,18
Function	~STOP	FWD & LATCH	JOGFWD	REMOTE	ENABLE / RESET	RUN	TRIP

1. Sets the REMOTE speed reference to AN1.
2. Sets the LOCAL speed reference to the CONSOLE REF.
3. To change either of the above references go to A35 DIG IN 4 in the menu and select an alternate after you have selected this terminal configuration.
4. JOGFWD uses the internal PRESET as the jog speed source. Go to A34 DIG IN 3 to change JOGFWD speed reference.

G07 CONFIG 6

Terminal.	D1 2	D2 3	D3 4	D4 5	EN 6	RL1 13,14,15	RL2 16,17,18
Function	FWD	REV	JOGFWD	JOGREV	ENABLE / RESET	RUN	TRIP

1. The MSC-3 only runs in remote.
2. Analog Input 1 is the speed reference for FWD and REV.
3. JOGFWD and JOGREV use the internal PRESET as the jog speed source. Go to A34 DIG IN 3 or A35 DIG IN 4 to change the jog speed or source after you have selected this terminal configuration.
4. The FWD and REV inputs are non latching. This means a direction signal must be held continuously to make the motor run.

G08 CONFIG 7

Terminal.	D1 2	D2 3	D3 4	D4 5	EN 1	RL1 13,14,15	RL2 16,17,18
Function	~STOP	FWD & LATCH	UP	DOWN	ENABLE / RESET	RUN	TRIP

1. The MSC-3 only runs in remote.
2. The Motorised potentiometer in persistent mode is the speed reference in remote.
3. How fast you can change the Motorized Pot reference is defined by the ramp settings.

G09 CONFIG 8

Terminal.	D1 2	D2 3	D3 4	D4 5	EN 6	RL1 13,14,15	RL2 16,17,18
Function	FWD	UP	DOWN	REMOT E	ENABLE / RESET	RUN	TRIP

1. Sets the REMOTE speed reference to the Motorized Potentiometer. The UP and DOWN buttons on the console operate in parallel to the Up and Down terminals. They will change the value of the motorized pot but will not start the motor.
2. Sets the LOCAL speed reference to the CONSOLE REF. The console then behaves as normal.
3. To change either of the above references, go to A35 DIG IN 4 in the menu and select an alternate after you have selected this terminal configuration.
4. FWD input is non latching.

G10 Enable/Reset

Available Choices: **H00** ENABLE
 H01 DISABLE (Default)

This sets the operation of the Enable terminal between being purely an enable terminal and also being able to reset a trip condition. When set to ENABLED, applying a positive edge to the ENABLE input will attempt to reset a trip condition. When this feature is set to DISABLED the ENABLE input cannot reset the MSC-3 after a trip.

Use the up and down push buttons to select ENABLED or DISABLED. Press Enter to accept the setting or Esc to abort.

G11 DIG IN1

G12 DIG IN2

G13 DIG IN3

G14 DIG IN4

These four menu items permit an individual function assignment to each input terminal. Pressing enter on these menu items presents a list of input functions with the currently assigned function being presented first. These terminals are all active high.

Some input functions require the selection of one or more speed references. When these functions are selected the choice of speed reference will follow with the currently assigned reference displayed first. The list of speed references is as per the F00 REFERENCES menu item.

Use the up and down push buttons to move through the list, press Enter to select the new function or Esc to abort.

Control Terminal Functions

Function	Description	Parameters
I00 FWD&LATCH	A momentary contact closure on this input will start the motor in the forward direction. When the input is removed the motor continues to run in the forward direction (latching). It requires an I02 STOP function to be assigned in order to break the latch and stop the motor.	None
I01 REV&LATCH	A momentary contact closure on this input will start the motor in the reverse direction. When the input is removed the motor continues to run in the reverse direction (latching). It requires I02 STOP function to be assigned in order to break the latch and stop the motor. The reverse direction must be enabled for the motor to run backwards.	None
I02 ~STOP	This input is required to be held for the motor to run. If it is opened any latched input is cleared and the motor will stop running. This is used with FWD&LATCH and REV&LATCH to stop the motor.	None
I03 FWD	While this input is held the motor will run in the forward direction. When the input is removed the motor will stop running (non latching). The I03FWD function disregards the state of the I02 ~ STOP input and the drive will not stop while I03 FWD input is present and the Enable input is wired to +5V. Both I03 FWD & I04 REV inputs must be wired to +5 to activate bipolar operation.	None
I04 REV	While this input is held the motor will run in the reverse direction. When the input is removed the motor will stop running (non latching). The I04 REV function disregards the state of the I02 ~ STOP input and the drive will not stop while I04 REV input is present and the Enable input is wired to +5V. Both I03 FWD & I04 REV inputs must be wired to +5 to activate bipolar operation.	None
I05 UP	Increases the motorised pot reference.	None
I06 DOWN	Decreases the motorised pot reference. For the UP and Down terminals to have an effect the motorised pot must be selected as a speed source. They also require other terminals to stop and start the motor.	None
I07 RESET	Will attempt to reset a trip condition.	None

Function	Description	Parameters
I08 ESO	<p>While this input is held the MSC-3 will operate in essential services override (ESO). After selecting this function you will be asked for a speed source to be selected.</p> <p>When this input is activated:</p> <ul style="list-style-type: none"> • The motor runs at the selected ESO speed, • The following trips are ignored: • Supply Fail I²t Trip • Over Temp • Infinite auto restart of all other trips is enabled • The ramp acceleration and deceleration times are set to 10 seconds • Auto Restart and Ramp parameters cannot be changed whilst ESO is in operation • Bipolar reference mode is activated • Reverse operation may occur and is dependent on speed source. Refer to F03 ESO of the F00 REFERENCES menu for ESO speed source selection. 	ESO speed reference
I09 JOGFWD	<p>Contact closure on this input will run the motor forward at the JOGFWD speed. It will also clear any latched inputs. When the contact is opened the motor will stop. After selecting this function you will be asked for a speed reference to be selected.</p>	JOGFWD speed reference
I10 JOGREV	<p>Contact closure on this input will run the motor reverse at the JOGREV speed. It will also clear any latched inputs. When the contact is opened the motor will stop. After selecting this function you will be asked for a speed reference to be selected.</p>	JOGREV speed reference
I11 REMOTE	<p>Contact closure on this input means that the MSC-3 will follow the control inputs on the terminal strip and the motor will run at the speed set by the Remote speed reference.</p> <p>When the contact is opened the MSC-3 will be controlled from the console and will run at the speed set by the Local speed reference.</p> <p>This input requires other terminals to stop and start the motor. After selecting this function you will be asked for a Remote speed reference and a Local speed reference to be selected.</p> <p>If the I11 REMOTE function is not assigned to an input terminal, remote mode operation is assumed.</p>	2 speed references

G15 RELAY1

G16 RELAY2

These two menu items permit an individual function assignment to each relay output. Pressing enter on these menu items presents a list of output functions with the currently assigned function being presented first.

Some relay functions require a value to be set. When these functions are selected the chance to set the value will follow with the current value displayed first.

Use the up and down push buttons to move through the list, press Enter to select the new function or Esc to abort.

Relay Output Functions

Function	Indication when energised	Parameters
O00 RUN	Indicates that the drive is running in either forward or reverse.	none
O01 TRIP	Indicates the presence of a trip that has stopped the output of the drive	none
O02 ESO	Indicates that the MSC-3 is in the essential services mode.	none
O03 PROOF	Indicates that the MSC-3 is enabled and not tripped.	none
O04 ZERO SPEED	Indicates that the MSC-3 is at zero speed.	none
O05 AT SPEED	Indicates that the motor speed is equal to the reference speed.	none
O06 UNDER SPEED %	Indicates that the motor speed is below the entered value.	% of CO2 MAX Hz
O07 OVER SPEED %	Indicates that the motor speed is above the entered value.	% of CO2 MAX Hz
O08 ON	The relay is energized.	none
O09 OFF	The relay is de-energised.	none
O10 A/R FAIL	Indicates that the drive could not auto restart as all restarts have been exhausted.	none
O11 FWD	Indicates that the motor is running in the forward direction.	none
O12 REV	Indicates that the motor is running in the reverse direction.	none
O13 ENABLED	Indicates that the MSC-3 is enabled.	none
O14 I ² t TRIP	Indicates that the I ² t motor overload feature has activated.	none
O15 OVER TEMP	Indicates that the MSC-3 is too hot for safe operation.	none

Display Messages

The MSC-3 displays a variety of messages on the second line of its display to indicate the drive status. These messages may be divided into two types, trip messages and run messages.

The MSC-3 will protect itself under a variety of fault conditions. When one of these conditions is experienced the MSC-3 will trip, shut down the motor output and display one of the following messages. The message will be displayed until the fault is cleared and a reset signal is applied.

Trip Message	Meaning
OPT SC	An output short circuit has been detected. This is caused by either an Over Current or a Ground Fault on the motor terminals.
OV	The DC Bus voltage has exceeded its maximum value.
OC	The output current has exceeded the MSC-3's continuous output current rating.
DC LOW	The DC Bus voltage has fallen below its minimum threshold.
PWR FAIL	All input phases on the input power supply are either low or missing.
SUPPLY F	There is a problem with the input power supply. One phase is either partially or totally missing and motor operation will be impaired.
OT	The MSC-3 is too hot.
I ² T TRIP	An I ² t trip has occurred.

The following messages indicate the current operating condition of the MSC-3.

Run Message	Meaning
CHARGING	The MSC-3 is waiting for the DC Bus capacitors to be fully charged before running the motor.
OPTION TRIP	Option Trip Messages
C LIMIT	The motor is drawing its maximum overload current.
V LIMIT	The motor is regenerating or the input voltage is too high.
ESO	The MSC-3 is operating in Essential Services Override mode
OPTION STATUS	Option Status Messages
FWD	The MSC-3 is running in the FWD direction.
REV	The MSC-3 is running in the REV direction.
ENABLED	The MSC-3 has an enable signal but no direction selected.
NOT EN	The MSC-3 is ON but has no enable signal so it is not able to turn a motor.

MSC-3 Trouble Shooting Guide

Symptom	Cause	Remedy
Front Display does not illuminate.	Input power wiring not connected properly. Input voltage not within specification.	Check input power wiring, refer to the MSC-3 Electrical Installation Diagram. Measure the input voltage at the MSC-3 input terminals. Check with specifications.
Motor does not rotate when UP button on the Console is pressed.	Enable signal is not active. MSC-3 is in REMOTE Speed is set to minimum	Check that the EN terminal is connected to +5V Check that the ENABLED message is displayed. Check that if you have a remote terminal it is not at +5V with respect to DIG COM Increase speed by holding down the UP button
Motor does not rotate when remote START signal is activated.	Incorrect control signal wiring. Enable signal is not active. MSC-3 is in LOCAL A direction has not been selected. Speed signal is not correctly connected.	Check control wiring to terminals and the terminal functions assigned. Refer to Control Wiring Diagrams and Terminal Configurations. Check that the EN terminal is connected to +5V Check that the ENABLED message is displayed. Check that your remote terminal is at +5V with respect to DIG COM. Check that either a FWD or a REV terminal has been assigned and that it is at +5V with respect to DIG COM. If the reverse direction is selected ensure that reverse is enabled from the Protection menu. Check the REMOTE speed source in the References menu. Ensure that this source is not at zero.
Motor does not accelerate in the time set by the ACCEL ramp and C LIMIT message appears .	Current limit circuit is operating. <i>CURRENT LIM</i> set too low.	This is a normal operating mode for the MSC-3. When the load is being accelerated too fast, the MSC-3 limits current drawn by the motor by extending the acceleration ramp time. A faster Accel time is not possible with this Current Limit setting. Increase the ACCEL time until the C LIMIT message disappears Increase <i>CURRENT LIM</i> value so that the MSC-3 is not prematurely limiting current. Check that the motor will not be overheated with the new setting.
C LIMIT message appears continuously	Motor mechanically overloaded. Motor shaft jammed. Fault in motor or motor wiring. Incorrect motor voltage selected. Incorrect motor frequency selected. <i>FLUX PLUS</i> is set too high.	Check the actual load is within the motor's capacity at the required speed. Check the mechanical drive system. Check that motor is wired correctly. Enter correct motor voltage from the <i>MOTOR</i> menu. Enter correct motor frequency from the <i>MOTOR</i> menu. Reduce the FLUX PLUS setting.

Symptom	Cause	Remedy
Motor does not decelerate in the time set by the <i>DECEL</i> ramp and <i>V LIMIT</i> message appears.	Voltage limit circuit is operating.	This is a normal operating mode for the MSC-3. When the load is being decelerated too fast, the MSC-3 limits the voltage regenerated by the motor by extending the deceleration ramp time. Increase the <i>DECEL</i> time to make this message disappear. If faster or controlled deceleration is required fit a dynamic braking module.
<i>V LIMIT</i> message appears continuously.	Input voltage has exceeded maximum rating.	See MSC-3 General Specifications for input voltage ratings.
<i>OPT SC</i> message appears	Short circuit on motor terminals. Earth Fault on motor terminals	Check wiring to motor terminals. Check wiring to motor terminals.
<i>OC</i>	Motor current was greater than the MSC-3's maximum current.	Check drive and motor current ratings.
<i>OV</i> message appears.	Input voltage has exceeded maximum ratings. Motor is overhauling.	See general specification and check the input is within ratings. Check input supply for voltage transients. Fix the external source. Ensure load cannot overdrive the motor. If necessary fit dynamic braking.
<i>OT</i> message.	Ventilation problem. Drive is constantly overloaded.	Ensure operating ambient temperature is within specification. Check fans are rotating freely and there is no build up of dust or debris in blades. Visually examine the heatsink fins for build up of dust and debris. Check the MSC-3 continuous current and ambient temperature rating.
Motor is unstable.	<i>SLIP COMP</i> is set too high. <i>FLUX PLUS</i> set too high. Incorrect motor voltage selected. Incorrect motor frequency selected. <i>CURRENT LIMIT</i> is set too low.	Check that <i>MOTOR NAMEPLATE RPM setting</i> is equal to the motor rated speed. Check that <i>NAMEPLATE CURRENT</i> setting is equal to the motor nameplate current. Reduce <i>SLIP COMP</i> setting. Reduce <i>FLUX PLUS</i> setting. Enter correct <i>MOTOR VOLTAGE</i> from the <i>MOTOR</i> menu. Enter correct <i>MOTOR FREQUENCY</i> from the <i>MOTOR</i> menu. Increase <i>CURRENT LIMIT</i> setting.

Symptom	Cause	Remedy
Excessive Motor Heating.	<p>Motor is running at low speeds for long times.</p> <p>Motor damaged or incorrectly wired.</p> <p>Incorrect motor voltage selected.</p> <p>Incorrect motor frequency selected.</p>	<p>Do not run the motor heavily loaded at low speeds for long periods unless the motor has been suitably de-rated or is force cooled.</p> <p>Check the motor and motor wiring for faults.</p> <p>Enter correct <i>MOTOR VOLTAGE</i> from the <i>MOTOR</i> menu.</p> <p>Enter correct <i>MOTOR FREQUENCY</i> from the <i>MOTOR</i> menu.</p>

Your MSC-3 Setup Notes

Photocopy this page or complete in pencil


User Parameters

Date.....

DISPLAY	User	Default	STOP/START	User	Default
Run variable		Hz	Stopping		RAMP
Run Scale		50.0	Dynamic Brk		Disabled
Run Units		Hz	A/R allowed		0
Menu protect		Disabled	A/R clr time		20
MOTOR			Reset by PF		Disabled
Motor Voltage.		*	REFERENCES		
Motor Amps		*	REMOTE		AN1
Motor Hz		*	LOCAL		CONSOLE
Motor RPM		*	ESO		PRESET %
PERFORMANCE			JOGFWD		PRESET %
Min Hz		0	JOGREV		PRESET %
Max Hz		*	INPUT/OUTPUT		
Accel Time		10.0	Terminal Config		1
Decel Time		10.0	OR		
S Time		0.01	ENABLE/RESET		Disabled
Flux Plus		25	DIG IN1		RESET
High Speed Flux Plus		Disabled	DIG IN2		STOP
Slip Comp		0	DIG IN3		FWD + L
Audible Freq		AUTO	DIG IN4		REMOTE
PROTECTION			RELAY 1		RUN
Current Limit		*	RELAY 2		TRIP
I ² t		*	REF AT 0%		0
I ² t zero Hz		*	REF AT 100%		100
I ² t corner Hz		10	PRESET Speed		60
Reverse		Disabled	MOTORIZED POT		RESET
Imbal Trip		Disabled			
DC Input		Disabled			
Serial No.:			Designator		e.g. SF1

* Drive Specific

MSC-3 Specifications

Input Supply Voltage	
MSC-3R	380 to 480Vac, 3Ø
MSC-3J	440 to 600Vac, 3Ø
MSC-3L	208 to 240Vac, 3Ø
All these voltages have a tolerance of -15% to +10%	
Input Frequency	
48 to 62Hz	
Output Voltage	
MSC-3R	0 to 480Vac, 3Ø
MSC-3J	0 to 600Vac, 3Ø
MSC-3L	0 to 240Vac, 3Ø
The output voltage cannot be higher than the input voltage	
Output Frequency	
Range:	0 to 200Hz
Resolution:	0.1%
Linearity:	0.2% of maximum frequency
Enclosure Rating	
IP30 (NEMA 1) IP66 (NEMA 4)	
Environmental Rating	
Storage Temperature: -20 to +70° C -4 to 158° F	
Operating Temperature: 0 to 40° C 32 to 104° F	
0 to 50° C † 32 to 122° C †	
Dependent on load current	
Relative Humidity:	5 to 95%
Non condensing	
Altitude:	0 to 1000m 0 to 3281 feet
Standards Compliance	
Models marked with this symbol comply with the Australian EMC Framework requirements	
	
UL 508C	
Local Controls	
Up, Down, Enter, Escape, Stop/Reset	
Terminal Strip	
Digital Inputs +5V and DIG COM 5Vdc supply, 40mA max current	
D1 to D4 and EN Digital Inputs Logic High 3 to 5Vdc Logic Low 0 to 2Vdc	
Analog Input Vref and AN COM +5Vdc Supply 5mA max current	
IN+ and IN- Differential Input 0 to 5V range 0 to 10V range 0 to 20mA range	

4 to 20mA range	
Common mode range ± 25Vdc to AN COM	
Relay Outputs	2 Form C Outputs (Single pole change over contacts)
Contact Rating (Resistive load)	5A@250Vac 5A@30Vdc
Contact Rating (Inductive load)	2A@ 250Vac 2A@30Vdc
User Parameters	
Motor Voltage	200 to 900V
The output voltage cannot exceed the input voltage	
Motor Current	20 to 150% of max. continuous current
Motor Frequency	30 to 200Hz
Motor Speed	500 to 60 x Motor Frequency in rpm
Minimum Frequency	0 TO 195HZ
Maximum Frequency	5 to 200Hz
Acceleration time	0.5 TO 600S
Deceleration time	0.5 TO 600S
S time	0.01 to 40s
Flux Plus	0 to 150%
Slip Comp	0 to 150% of slip speed
DC Hold	0 to 50% of drive rated current
Audible	2 to 16kHz
Frequency	
Current Limit	20 to 110% of max cont current
I²t	20 to 110% of max cont current
I²t Zero Hz	20 to 100% of max cont current
I²t cnr Hz	2 to 200Hz
Drive Stopping	Ramp to stop Coast to stop Dynamic Braking
Auto Restart	Number of restarts 0 to 20 Reset time: 0.1 to 20 minutes
References	Analog Input Console Reference Preset Motorized Potentiometer
The following functions can be enabled or disabled:	
Menu Protect	
Reverse Direction	
High Speed Flux Plus	
DC Input	
Dynamic Braking	
Reset by Power Failure	
Power Failure Ride Through	

MSC-3 User's Manual

Model	Max. Supply Short Circuit Rating (Amps rms Symmetrical)	Max. Fuse Size	Fuse Class	Max. Wire Size	Max. Tightening Torque
240V					
MSC-3L3	18,000A , 240V	20	J	10 A.W.G (6mm ²)	15.6 in.lb (1.76 Nm)
MSC-3L5	18,000A , 240V	20	J	10 A.W.G (6mm ²)	15.6 in.lb (1.76 Nm)
MSC-3L7	18,000A , 240V	20	J	10 A.W.G (6mm ²)	15.6 in.lb (1.76 Nm)
MSC-3L11	18,000A , 240V	20	J	10 A.W.G (6mm ²)	15.6 in.lb (1.76 Nm)
MSC-3L15	18,000A , 240V	60	T	6 A.W.G (16mm ²)	16 in.lb (1.8 Nm)
MSC-3L20	18,000A , 240V	60	T	6 A.W.G (16mm ²)	16 in.lb (1.8 Nm)
MSC-3L23	18,000A , 240V	60	T	6 A.W.G (16mm ²)	16 in.lb (1.8 Nm)
MSC-3L30	18,000A , 240V	60	T	6 A.W.G (16mm ²)	16 in.lb (1.8 Nm)
MSC-3L40	18,000A , 240V	60	T	6 A.W.G (16mm ²)	16 in.lb (1.8 Nm)
MSC-3L55 †	18,000A , 240V	200	T	2/0 A.W.G. (70mm ²)	120 in.lb (13.6Nm)
MSC-3L82 †	18,000A , 240V	200	T	2/0 A.W.G. (70mm ²)	120 in.lb (13.6Nm)
MSC-3L109 †	18,000A , 240V	200	T	2/0 A.W.G. (70mm ²)	120 in.lb (13.6Nm)
MSC-3L140 †	18,000A , 240V	200	T	2/0 A.W.G. (70mm ²)	120 in.lb (13.6Nm)
480V					
MSC-3R3	18,000A , 480V	20	J	10 A.W.G (6mm ²)	15.6 in.lb (1.76 Nm)
MSC-3R5	18,000A , 480V	20	J	10 A.W.G (6mm ²)	15.6 in.lb (1.76 Nm)
MSC-3R7	18,000A , 480V	20	J	10 A.W.G (6mm ²)	15.6 in.lb (1.76 Nm)
MSC-3R11	18,000A , 480V	20	J	10 A.W.G (6mm ²)	15.6 in.lb (1.76 Nm)
MSC-3R15	18,000A , 480V	60	T	6 A.W.G (16mm ²)	16 in.lb (1.8 Nm)
MSC-3R20	18,000A , 480V	60	T	6 A.W.G (16mm ²)	16 in.lb (1.8 Nm)
MSC-3R23	18,000A , 480V	60	T	6 A.W.G (16mm ²)	16 in.lb (1.8 Nm)
MSC-3R30	18,000A , 480V	60	T	6 A.W.G (16mm ²)	16 in.lb (1.8 Nm)
MSC-3R40	18,000A , 480V	60	T	6 A.W.G (16mm ²)	16 in.lb (1.8 Nm)
MSC-3R55 †	18,000A , 480V	200	T	2/0 A.W.G. (70mm ²)	120 in.lb (13.6Nm)
MSC-3R82 †	18,000A , 480V	200	T	2/0 A.W.G. (70mm ²)	120 in.lb (13.6Nm)
MSC-3R109 †	18,000A , 480V	200	T	2/0 A.W.G. (70mm ²)	120 in.lb (13.6Nm)
MSC-3R140 †	18,000A , 480V	200	T	2/0 A.W.G. (70mm ²)	120 in.lb (13.6Nm)
600V					
MSC-3J3	18,000A , 600V	20	J	10 A.W.G (6mm ²)	15.6 in.lb (1.76 Nm)
MSC-3J5	18,000A , 600V	20	J	10 A.W.G (6mm ²)	15.6 in.lb (1.76 Nm)
MSC-3J7	18,000A , 600V	20	J	10 A.W.G (6mm ²)	15.6 in.lb (1.76 Nm)
MSC-3J11	18,000A , 600V	20	J	10 A.W.G (6mm ²)	15.6 in.lb (1.76 Nm)
MSC-3J15	18,000A , 600V	60	T	6 A.W.G (16mm ²)	16 in.lb (1.8 Nm)
MSC-3J20	18,000A , 600V	60	T	6 A.W.G (16mm ²)	16 in.lb (1.8 Nm)
MSC-3J23	18,000A , 600V	60	T	6 A.W.G (16mm ²)	16 in.lb (1.8 Nm)
MSC-3J30	18,000A , 600V	60	T	6 A.W.G (16mm ²)	16 in.lb (1.8 Nm)
MSC-3J40	18,000A , 600V	60	T	6 A.W.G (16mm ²)	16 in.lb (1.8 Nm)
MSC-3J55 †	18,000A , 600V	200	T	2/0 A.W.G. (70mm ²)	120 in.lb (13.6Nm)
MSC-3J82 †	18,000A , 600V	200	T	2/0 A.W.G. (70mm ²)	120 in.lb (13.6Nm)
MSC-3J109 †	18,000A , 600V	200	T	2/0 A.W.G. (70mm ²)	120 in.lb (13.6Nm)
MSC-3J140 †	18,000A , 600V	200	T	2/0 A.W.G. (70mm ²)	120 in.lb (13.6Nm)

- Inverse-time circuit breakers can be used provided that the let-through energy (I²t) and peak let through current (I_p) is less than that of the maximum fuse rating specified.
- Use Copper Conductors Only.

MSC-3 Specifications

DC Supply Voltage		Output Voltage	
MSC-3R	400 to 680Vdc †	MSC-3R	0 to 480Vac, 3Ø
MSC-3J	550 to 850Vdc †	MSC-3J	0 to 600Vac, 3Ø
MSC-3L	200 to 340Vdc †	MSC-3L	0 to 240Vac, 3Ø
All these voltages have a tolerance of -15% to +10%		The output voltage cannot be higher than the input voltage divided by 1.414	

† Rating not included in UL listing.

MSC-3 Users Manual

MSC-3 Output Current Specifications

MSC-3	40° C (104° F) Ambient			50° C (122° F) Ambient		
	Continuous Current for		Over Load Current*	Continuous Current for		Over Load Current*
	General Purpose Rating	Extended Duty Rating		General Purpose Rating	Extended Duty Rating	
x3	3.6	2.7	4.7	3.0	2.2	4.7
x5	5.0	3.6	6.3	4.1	3.0	6.3
x7	7.1	5.2	8.9	6.0	4.4	8.9
x11	10.7	7.8	13.4	9.0	6.6	13.4
x15	14.9	10.9	19.0	12.4	9.1	19.0
x20	19.7	14.5	25.0	16.5	12.1	25.0
x23	22.5	16.5	28.6	18.8	13.8	28.6
x30	30.1	22.1	38.4	25.0	18.3	38.4
x40	40.3	29.6	51.1	33.8	24.8	51.1
x55	55.0	40.3	70.0	46.0	33.7	70.0
x82	82.0	60.1	104	69.1	50.7	104
x109	109	79.9	139	91.3	67.0	139
x140	140	102.7	178	119	87.2	178

These currents apply to all ranges MSC-3 independent of the input voltage.

- 60 Second Rating

Appendix A - MSC-3 Character Set

±	0	0	P	'	P	É	Á	'	1	M	3	ç		
≡	!	1	A	Q	a	9	Q	a	í	"	J	t	y	o
7	"	2	B	R	b	r	É	É	ó	°	°	°	°	°
¿	#	3	C	S	c	s	Á	Á	ú	'	V	M	E	φ
¡	\$	4	D	T	d	t	á	á	ç	'	e	7	Z	ω
½	%	5	E	U	e	u	à	à	É	°	°	°	°	°
½	&	6	F	V	f	v	á	á	°	°	°	°	°	°
½	'	7	G	W	w	G	ú	ú	°	°	°	°	°	°
½	(8	H	X	h	x	é	é	°	°	°	°	°	°
½)	9	I	Y	i	y	é	é	°	°	°	°	°	°
½	*	:	J	Z	j	z	é	é	°	°	°	°	°	°
½	+	:	K	C	k	c	i	á	á	°	°	°	°	°
½	=	,	<	L	\	l	i	á	á	°	°	°	°	°
½	~	-	=	M	m	¿	i	á	á	°	°	°	°	°
½	®	.	>	N	n	¿	á	á	°	°	°	°	°	°
½	#	/	?	O	o	¿	á	á	°	°	°	°	°	°

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