MSC-3

Option Board 1

Instruction Manual

ZENER TECHNOLOGY AND QUALITY ASSURANCE

Since 1978 Zener Electric has supplied many thousands of AC drives to industry. These drives have been installed 'to 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 it 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.
7. Goods not of our own manufacture incorporated in our supply or sold by us, carry their maker's warranty only.
8. 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.
9. 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

Contents

Warning

Please note the following:

1. Your MSC-3 Option board 1 must be applied, installed and operated in a safe manner in accordance with all local rules and regulations.
2. 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.
3. The MSC-3 contains high energy circuits that may be hazardous. Do not operate the MSC-3 with the door or enclosure opened.
4. Faults in external wiring or devices may render the control circuit live. Installers should provide appropriate segregation between power and control wiring, including thermistor connections.

Receiving

Inspect the MSC-3 Option Board 1 for any shipping damage. If any damage is found, report it to the carrier immediately.

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

After the initial inspection, the MSC-3 Option Board 1 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.

Compatibility

This manual describes features of Industrial Option Board 1 with software version 1.1 and is **only compatible** with MSC3 control board software version 1.25 or later.

MSC-3 Option Board 1 Description

Option Board 1 extends the feature list of the MSC3. Additional features include:

Thermal protection input

A thermal device is simply wired in and the motor or process is thermally protected. The input is a hardware feature that is always active and so does not require any user setup. Thermal devices include thermistors, thermal switch and thermal overload.

Analog input

The input may be set for voltage or current input by on board switch combinations. The analog input may be used as an additional speed reference or used in conjunction with the in built PID controller as the process variable. When used with the PID controller, the analog input may be rescaled through the menus of the MSC-3 and includes under and over compare functions.

Analog output

The output may be set for voltage or current output by on board switch combinations. This feature permits internal signals of the MSC-3 to be accessed by external monitoring equipment such as panel meter displays, etc. Signals available are: Motor frequency, motor speed, motor load, motor current, DC link voltage, MSC-3 output power, power circuit temperature and the PID control signal.

Digital inputs

Four digital inputs are present and the function of each input is user selectable. The list of functions that may be assigned is that of the digital inputs found on the main control board.

Relay Output

An additional relay output is provided the function of which is user selectable. The list of functions that may be assigned is that of the relays found on the main control board.

User and Preset speed reference selection

Option Board 1 has a speed reference selector where combinations of digital inputs select up to 8 speed references: 2 user selectable reference sources (e.g. analog input, motorised potentiometer) and 6 preset speeds. The reference selector function is composed of three digital input functions.

PID Controller

The in built PID controller function with anti-windup has been designed to integrate into the MSC-3 control system with minimal user intervention. The PID controller is tuned by changing parameters through the MSC-3 menus and is able to use the reference selection capabilities as the set point or feed forward reference.

Specifications

Thermal Protection

- TH+ (terminal 7) / TH- (terminal 8)
- Thermistor 3k3 nominal @ rated temperature.
- Microtherm, thermal switch or thermal overload.

Analog input

- IN+ (terminal 9) / IN- (terminal 10)
- Differential input configurable as either: 0 to 5V; 0 to 10V; 0 to 20mA; 4 to 20mA
- Common mode range: +/- 25Vdc to AN COM of the MSC3 control board

Analog output

- OUT+ (terminal 11) / OUT- (terminal 12)
- Differential output configurable as either: 0 to 5V; 0 to 10V; 0 to 20mA; 4 to 20mA
- Common mode range: +/- 42Vdc to chassis
- Menu selectable signal source.

Digital inputs

- D1 (terminal 1), D2 (terminal 2) , D3 (terminal 3) and, D4 (terminal 4)
- Used in conjunction with MSC3 control board +5V supply
- Logic low 0~2V, logic high 3~5V
- Loading 5 mA / input maximum

Digital output

- O+ (terminal 5) / O- (terminal 6)
- Contact current ratings: Resistive load: 1A at 30Vac, 0.75A at 42Vdc
Inductive load: 0.4A at 30Vac
- Contact voltage rating: 30 Vac, 42.4 Vdc
- Menu selectable logic sources

Preset speeds

- Six internal preset speed specified as a percentage of either:
+/-100 % of the **C02 MAX Hz** value or
+/-100 % of the Process variable range if used for the PID set point

PID controller

- Adjustable Integrator anti-windup
- Adjustable Output saturation with anti-windup
- Open loop to closed loop initialization
- Selectable set point and feed forward input signals
- Input / Output signal spanning
- Process variable UNDER and OVER Alarm

Installation

WARNING! The MSC3 under operation has hazardous internal voltages. Ensure all power sources are remove for the duration of the Option Board installation. Allow at least 2 minutes for hazardous voltage levels to discharge.

IP30 Chassis A Installation

1. Ensure all power sources have been removed for at least 2 minutes and that they remain that way for the rest of the installation.
2. Remove the bottom section of the MSC3 blue plastic moulding to reveal the power terminals.
3. Remove the screw holding the control board/display assembly and pull it off the drive.
4. Turn the control board/display assembly over and plug the Option Board into one of the available option connectors.
5. Lay the mylar insulation sheet on top off the exposed metal work and replace the control board/display/option assembly.
6. Replace the original mounting screw and install the Option Board mounting screw. The Option Board is ready for control wiring. Refer to the wiring diagram for wiring examples.
7. Once control wiring is complete replace the bottom moulding.
8. When the MSC3 is switched on, restore defaults for each new option fitted or existing options that occupy an alternate connector. Refer to the J00 OPN DEFAULTS section of this manual for details.

IP 66 Chassis A Installation and all other chassis

1. Ensure all power sources have been removed for at least 2 minutes and that they remain that way for the rest of the installation.
2. Open the front door and remove the screws securing the control board to the chassis and lift of the control board.
3. Turn the control board over and plug the Option Board into one of the available option connectors.
4. Lay the Mylar insulation sheet on top off the exposed metal work and replace the control board/option assembly.
5. Replace the mounting screws. The Option Board is ready for control wiring. Refer to the wiring diagram for wiring examples.
6. Once control wiring is complete close the front door.
7. When the MSC3 is switched on, restore defaults for each new option fitted or existing options that occupy an alternate connector. Refer to the J00 OPN DEFAULTS section of this manual for details.

Option Board Menus

The menus of the MSC3 are extended when Option Boards are fitted. The extensions are the additional features that the option brings to the MSC3. As there may be two of the same Option Boards fitted, duplication of features occurs.

Appended to the code field of each option menu item is either an 'L' for left hand side option or an 'R' for right hand side option. Use the 'L' or 'R' to identify each of the duplicated features.

For example to restore factory defaults for the Option Board installed on the left hand side, the **J00L OPN DEFAULTS** menu item must be found.

The remainder of this manual will not use the 'L' or 'R' when describing menu items or features as it is not possible to know which side the option is installed

Option Defaults

J00 OPN DEFAULTS

Menu location: The first setup menu

Use the up (▲) and down (▼) push buttons to find the **J00 OPN DEFAULTS** menu when the option needs to be initialized to a known state.

IMPORTANT! Restoring factory defaults must be done when the option is commissioned. This is necessary to ensure option settings are updated with connector position information for correct feature identification and operation.

With **J00 OPN DEFAULTS** displayed, press Enter and the message **J01 Check Option** is displayed as a reminder that unexpected behaviour may result due to existing wiring. Press Enter to restore factory defaults.

If the **J00 OPN DEFAULTS** menu cannot be found the Option Board may be initialized by the following procedure:

1. Follow the installation procedure for disassembly details to access the Option Board. Remove the Option Board and locate **J1**.
2. Ensure **J1** is linked and reinstall the option as per the installation procedure.
3. Power the MSC3 up for several seconds and then power it down. The link across **J1** has to be removed. Follow the installation procedure for disassembly details to access the Option Board paying attention to the high voltage caution.
4. Locate J1 and remove the link and reinstall as per the installation procedure.

Thermal Protection Input

Option board 1 provides thermal protection through the TH+ and TH- terminals. To use the thermal input, remove the factory installed wire link and wire in its place the thermal device leads. The MSC-3 will stop the motor / process when the thermal device activates or in the case of a thermistor when its resistance is nominally greater than 3300 Ohms.

The thermal protection input is a hardware feature that is always active and so does not require any user setup. Thermal devices include thermistors, thermal switch, thermal overload.

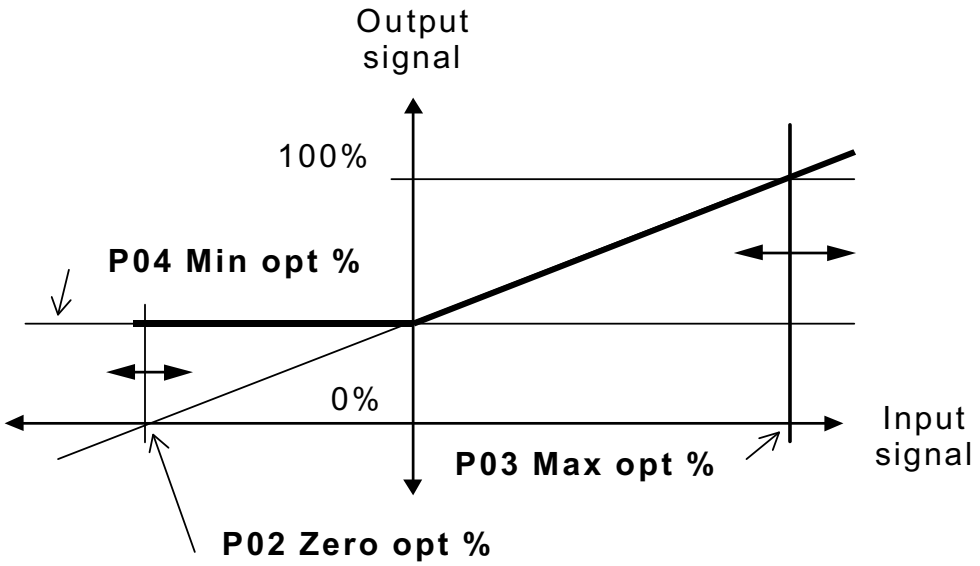
Analog Output

A hardware component of Option Board 1 is a single isolated analog output that is configurable for 0-5V, 0-10V, 0-20mA or 4-20mA by setting the DIP switch as shown.

Range	Option Board 1 SW1		
	3	4	5
0-5V	off	**ON**	**ON**
0-10V	**ON**	off	**ON**
0-20mA	off	off	off
4-20mA**	off	off	off

** See **P02 Zero opt %** and **P04 Min opt %** to specify 4 mA offset.

Several settings contribute to the analog output configuration. They are **P01 Analog Opt**, **P02 Zero opt %**, **P03 Max opt %**. and **P04 Min opt %**. The MSC-3 will display the present settings each time the analog output menu is entered. The following graph shows how these values affect output scaling.



P01 Analog Opt

Default value: **V01 Hz**

Menu location: The **G00 INPUT/OUTPUT** menu

Choose from:

Signal	Comment	0 output	Full scale output
V01 Hz	Output frequency	0	MAX Hz
V02 rpm	Motor shaft speed	0	Synchronous motor rpm
V03 %Load	Motor load	0	Overload current
V04 Amps	Output current magnitude	0	Overload current
V05 Volts DC	DC link voltage	0	1.69 x Vout AC max
V06 kW	Drive output power	0	1.69 x Vout AC max x Overload current
V07 Volts AC	Drive output voltage magnitude	0	1.1 x Vout AC max
V08 °C	Power circuit temperature (Celsius)	-273 (Celsius)	227 (Celsius)
V09 °F	Power circuit temperature (Fahrenheit)	-459 (Fahrenheit)	440 (Fahrenheit)
V10 I2t used	Motor thermal overload level	0	Overload current
P38 PID output	PID control signal output	0	MAX Hz

This menu requires a signal source selection from the list of available signals. Use the up and down push buttons to move through the list. Press Enter to make your choice or ESC to abandon.

P02 Zero opt %

Default value: **0%**

Menu location: The **P01 Analog Opt** menu

Range: -100 to 100% of chosen signal

This value specifies the percentage of the chosen signal that will produce zero output at the analog output terminals. Also, if the chosen signal goes below this value, zero output is found at the output terminals.

For example, with **V02 rpm** as the chosen signal, a 4 to 20mA output is required for the speed range. Set **P02 Zero opt %** to -25% and **P03 Max opt %** to 100%.

P03 Max opt %

Default value: **100%**

Menu location: The **P01 Analog Opt** menu

Range: -1000 to 1000% of chosen signal

This value specifies the percentage of the chosen signal that will produce maximum output at the analog output terminals. Also, if the chosen signal goes above this value, maximum output is maintained at the analog output terminals.

P04 Min opt %

Default value: **0%**

Menu location: The **P01 Analog Opt** menu

Range: 0 to 100% of output signal

This value specifies the minimum output value permitted at the analog output terminals under all conditions. If the signal to be output is below this value, it will be ignored and the minimum value is output instead.

For example, with **V01 Hz** as the chosen signal, a 0 to 5V output is required for the speed range 0 to 50 Hz. It is required that if the speed drops below 10Hz the output is not to drop below 1V. In this case set the P04 Min Opt % to 20%.

Analog Output Setup Checklist

1. Set Option board 1 DIP switches (SW1-3,4,5) for the input signal type to be used (voltage signal or current signal) and connect your monitoring equipment.
2. Find the **P01 Analog Opt** menu item in the **G00 INPUT/OUTPUT** menu.
3. Choose the signal source.
4. Check and/or adjust the **P02 Zero Opt %**.
5. Check and/or adjust the **P03 Max Opt %**.
6. Check and/or adjust the **P04 Min Opt %**.

Option References

P05 OPTION REFS

This menu contains the additional references of the Option Board. Extra references include six presets and two user selectable references that are selected by digital input wiring. The next section explains how the digital inputs select a reference.

P06 User Ref 1

P07 User Ref 2

Default values: **R00 AN1 and P22 Analog input (respectively)**

Menu location: **P05 OPTION REFS** menu

Choose from:

R00 AN1	Control board analog input
R03 PRESET	Control board preset
R04 MOTORIZD POT	Control board Motorized potentiometer
R07 CONSOL REF	Control board console reference
P22 Analog inpt	Option Board analog input
P14 Ref select	Option Board reference selector
P38 PID output	Option Board PID controller output
P37 Zero ref	Option Board zero reference

Note: If **P14 Ref Select** is chosen for either **P06 User Ref 1** or **P07 User Ref 2**, zero speed is sent as the speed reference.

P08 Preset 1
P09 Preset 2
P10 Preset 3
P11 Preset 4
P12 Preset 5
P13 Preset 6

Default values: **10,20,30,40,50,60 % (respectively)**

Menu location: **P05 OPTION REFS** menu

Range: -100 % to +100 % of the **C02 MAX Hz** value or

-100 % to +100 % of the Process variable range if used for the PID set point.

The preset speeds provide extra speed references for the MSC3. When a preset is selected it is adjusted using the console Up and Down push buttons. Setting a negative preset value will specify a reverse speed reference provided reverse operation has been enabled and the FWD and REV inputs are wired to +5v.

Reference Selector

P14 Ref select

Menu location: Reference selection list

This feature of the Option Board is considered to be another speed reference source. It uses three digital inputs (usually the default configuration D1, D2, D3) to select 1 of 8 references.

Speed reference	**P15 Selector 1**	**P16 Selector 2**	**P17 Selector 3**
P06 User Ref 1	Low	Low	Low
P07 User Ref 2	Low	Low	High
P08 Preset 1	Low	High	Low
P09 Preset 2	Low	High	High
P10 Preset 3	High	Low	Low
P11 Preset 4	High	Low	High
P12 Preset 5	High	High	Low
P13 Preset 6	High	High	High

The table lists the references and the respective digital input terminal combinations required to choose each reference. Note the first two combinations are user definable and are described in the previous section.

P15 Selector 1

P16 Selector 2

P17 Selector 3

Menu location: The Digital Input Terminal function list

These additional digital inputs are required to complete the digital input selector. The combination of their input states chooses a reference as described above.

Reference Selector Setup Checklist

1. Find the **P05 OPTION REFS** menu item in the first setup menu after the running display.
2. Find the **P06 User Ref 1** menu item and check the selected reference source.
3. Find the **P07 User Ref 2** menu item and check the selected reference source.
4. The remaining menu items in the **P05 OPTION REFS** menu are for the preset speeds. Check each preset as required.
5. A list of digital inputs appears in the **G00 INPUT/OUTPUT** menu. Check each digital input function to be aware of which terminals are assigned the speed selector functions **P15 Selector 1**, **P16 Selector 2** and **P17 Selector 3**. By default they are assigned to **P18 OP DIG IN 1**, **P19 OP DIG IN 2** and **P20 OP DIG IN 3** respectively.
6. Connect the necessary reference selection wires to these terminals (refer to the connections diagram for example wiring).
7. Find the **F00 REFERENCES** menu item in the first setup menu and know the mode(s) in which reference selection is required e.g. Remote mode. Choose **P14 Ref select** as the speed reference for this mode.

Option Board Digital Inputs

P18 OP DIG IN 1

Default value: P15 Selector 1

P19 OP DIG IN 2

Default value: P16 Selector 2

P20 OP DIG IN 3

Default value: P17 Selector 3

P21 OP DIG IN 4

Default value: **I01 REV&LATCH**

Menu location: The **G00 INPUT/OUTPUT** menu

Choose from:

I00 FWD&LATCH	Control board forward & latch input function
I01 REV&LATCH	Control board reverse & latch input function
I02 ~STOP	Control board /Stop input function
I03 FWD	Control board forward input function
I04 REV	Control board reverse input function
I05 UP	Control board motorized pot up input function
I06 DOWN	Control board motorized pot down input function
I07 RESET	Control board trip reset input function
I08 ESO	Control board essential services override input function
I09 JOGFWD	Control board jog forward input function
I10 JOGREV	Control board jog reverse input function
I11 REMOTE	Control board remote input function
P15 Selector 1	Option Board selector input 1 function
P16 Selector 2	Option Board selector input 2 function
P17 Selector 3	Option Board selector input 3 function

Use the Up and Down push buttons to select a reference and press Enter to accept or Esc to abort.

IMPORTANT! Changing Option Board digital input functions with wiring still connected will require power to be removed until the display blanks out and then power reapplied.

Option Board Analog Input

A hardware component of Option board 1 is a single analog input that is configurable for 0-5V, 0-10V, 0-20mA or 4-20mA by setting the DIP switch as shown.

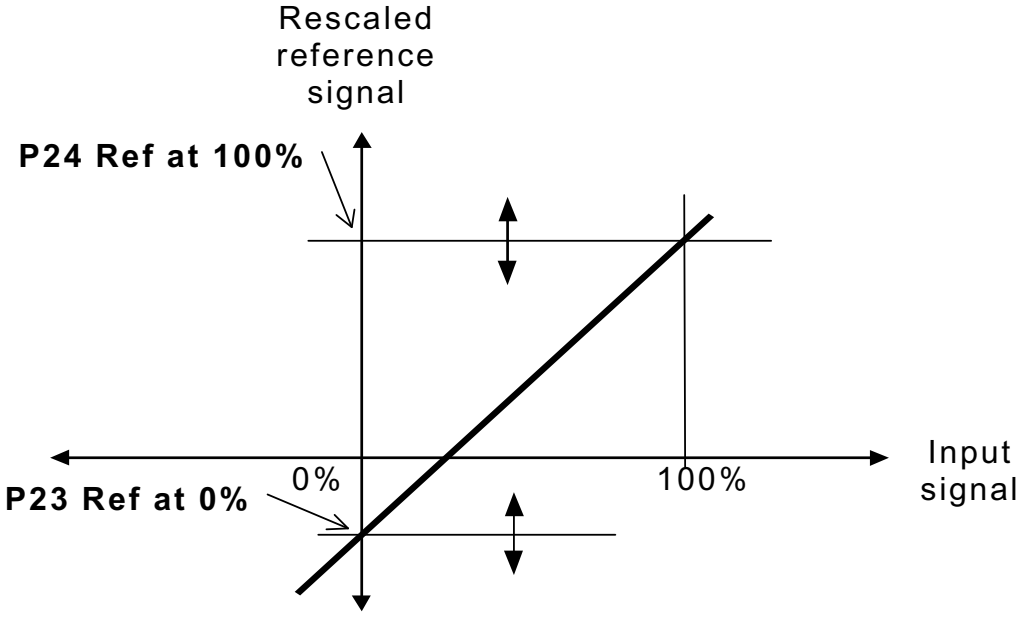
Range	Option Board 1 SW1	
	1	2
0-5V	off	**ON**
0-10V	off	off
0-20mA	**ON**	**ON**
4-20mA**	**ON**	**ON**

For a 4 to 20 mA input signal, **P23 Ref at 0%** must be set to -25%.

P22 Analog input

Menu location: Reference selection list

The analog input of the Option Board requires two parameters to rescale the reference. They are **P23 Ref at 0%** and **P24 Ref at 100%**. Each time the **P22 Analog input** is selected in the menu, each value may be checked or adjusted as needed. The following graph shows how these two values affect input rescaling.



P23 Ref at 0%

Menu location: The **P22 Analog input** menu

Range: -1000% to 1000%

Default value: 0 %

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 20 mA input signal, **P23 Ref at 0%** must be set to -25%.

P24 Ref at 100%

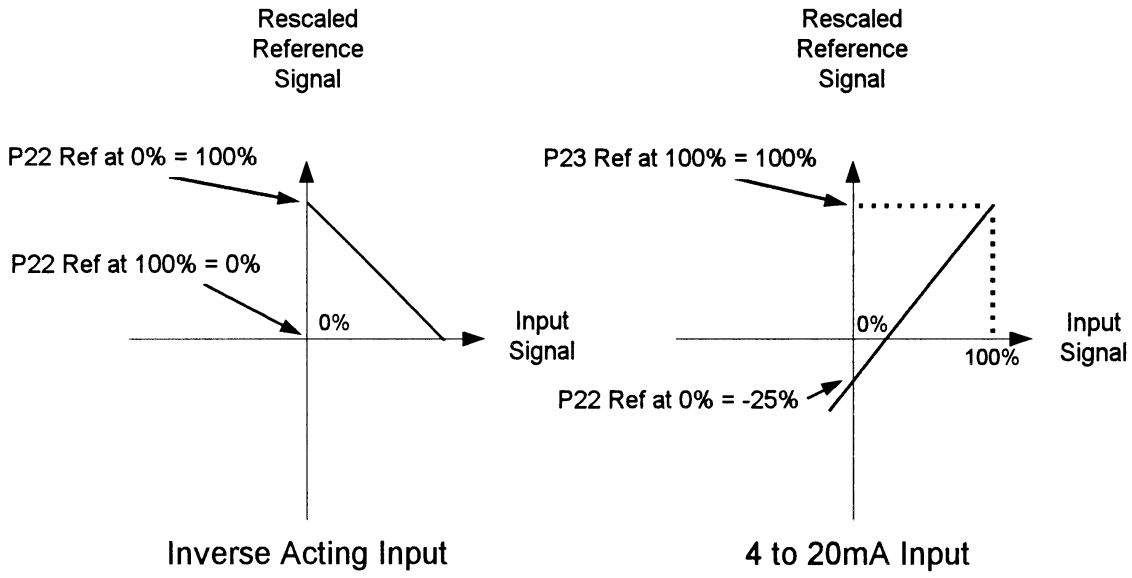
Menu location: The **P22 Analog input** menu

Range: -1000% to 1000%

Default value: 100 %

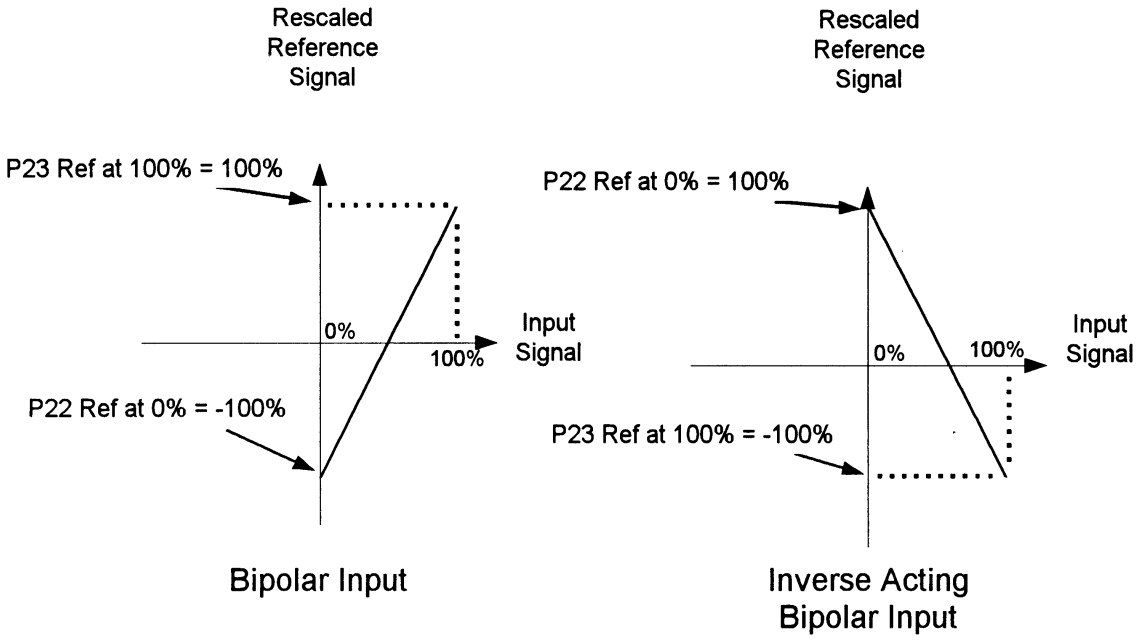
This value specifies what the reference will be when 100% of the input signal is present at the analog input terminals.

Examples of some analog input scaling:



Inverse Acting Input

4 to 20mA Input



Bipolar Input

Inverse Acting
Bipolar Input

REFERENCE SIGNAL SCALING

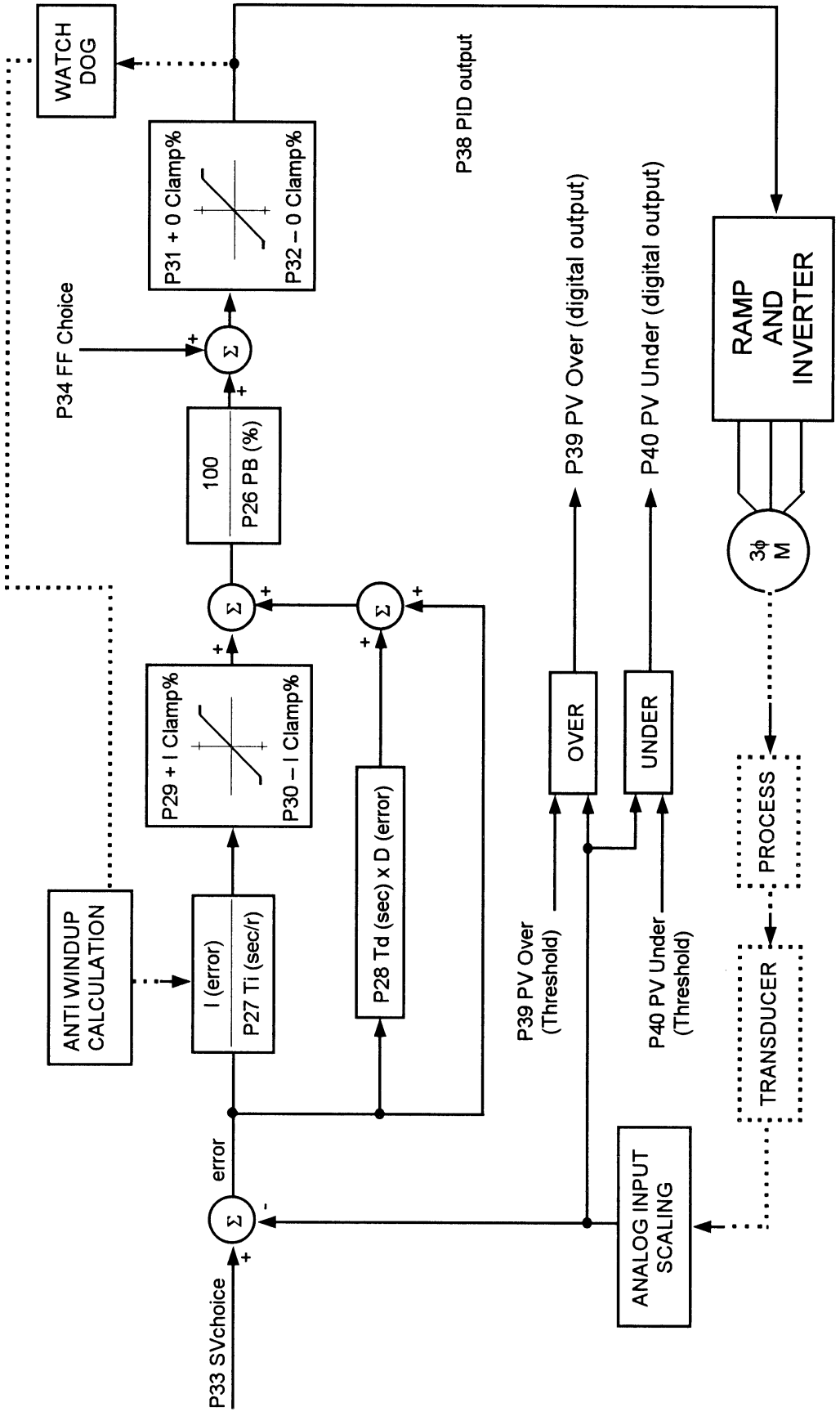
PID CONTROLLER

The PID controller of the MSC3 include the following features:

- Adjustable Integrator anti-windup
- Adjustable Output saturation with anti-windup
- Open loop to closed loop initialization
- Selectable set point and feed forward input signals
- Input / Output signal spanning
- Process variable UNDER and OVER Alarm

PID Structure

PID controllers (also referred to as Three-Term controllers) are used to stabilize and/or regulate a process at a desired operating point. PID controllers function by finding the difference between the required operating point (the Setpoint Variable or SV) and a measured process quantity (the Process Variable or PV). This difference between the two signals is called the ‘error’. In regulator mode, the PID controller operates to reduce the error to zero at which point the measured quantity is equal to the required operating point. The next page has a block diagram of the PID controller.



PID FUNCTION BLOCK DIAGRAM

PID Specifications

Display
- LCD back-lit display
- Display of set point and process variables
- Custom units and display scaling
- Clamp indication messages

PID Inputs
- Choice of any available reference for set point, process variables and feed forward inputs including presets and analogue inputs (0-5V, 0-10V, 4-20mA)
- Adjustable span for analog inputs

PID Outputs
- The analog output may be configured for 0-5V, 0-10V, 0-20mA, 4-20mA
- Galvanically isolated to ±42 Volts
- Adjustable span for analog output
- Output signals available for output: PID output

Digital Outputs
- A total of 3 relay outputs: two available as standard and one present on the option
- Additional outputs: PV over alarm, PV under alarm.

Alarms
- PV Under and Over alarms

Proportional Band
- Adjustable range -1000...1000 % (negative PB% inverts the PID output)

Integral Time
- Adjustable range 0...20.00 seconds / repeat (Ti = 0 disables integral action).

Derivative Time
- Adjustable range 0 ...5.00 seconds

Integrator clamp
- Adjustable range ±100% of the maximum output frequency

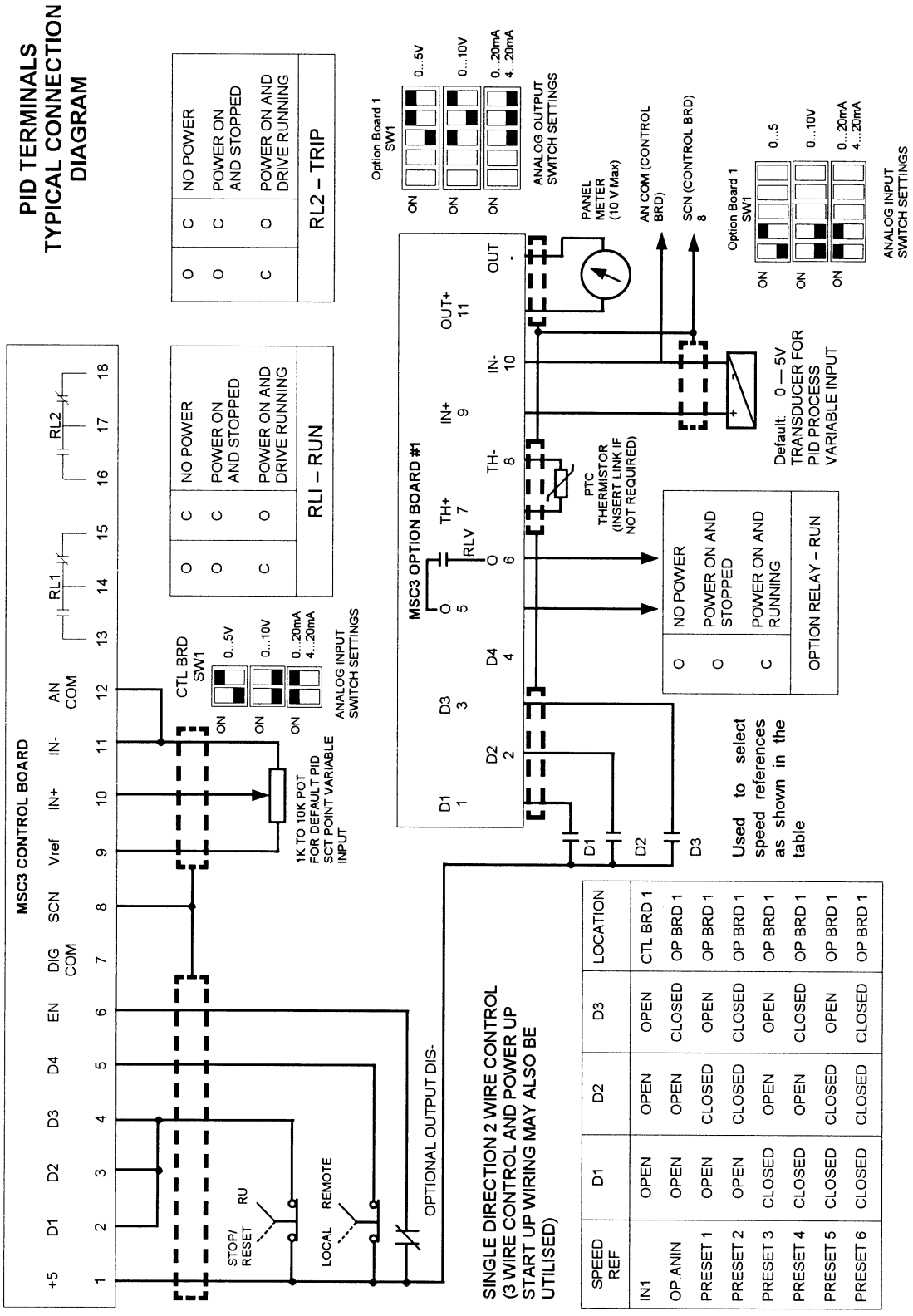
Output clamp
- Adjustable range ±100% of the maximum output frequency

Resolution
- ±32,767 steps

Accuracy
- 0.4% 8 bit sampling, 255 steps ± 1 step

Sample time
- 50 ms

PID Control Wiring



SPEED REF	D1	D2	D3	LOCATION
IN1	OPEN	OPEN	OPEN	CTL BRD 1
OP.ANIN	OPEN	OPEN	CLOSED	OP BRD 1
PRESET 1	OPEN	CLOSED	OPEN	OP BRD 1
PRESET 2	OPEN	CLOSED	CLOSED	OP BRD 1
PRESET 3	CLOSED	OPEN	OPEN	OP BRD 1
PRESET 4	CLOSED	OPEN	CLOSED	OP BRD 1
PRESET 5	CLOSED	CLOSED	OPEN	OP BRD 1
PRESET 6	CLOSED	CLOSED	CLOSED	OP BRD 1

PID Menu Structure

P25 PID Control

Menu location: The first setup menu

This menu is the entry point for the PID controller menus where adjustments can be made. When the menu is selected, using the Up and Down pushbuttons will scroll through the PID parameter menu. The table below lists the parameters that may be adjusted. When each parameter is selected for adjustment use the up and down push buttons to adjust, Enter to select and Esc to abort.

Parameter	Default value	Minimum	Maximum	Units
P26 PB (%)	300	-1000	1000	%
P27 Ti (sec/r)	2.00	0 (note 1)	20.00	sec/r
P28 Td (sec)	0.00	0.00	5.00	sec
P29 +I Clamp %	100	0	100	%
P30 -I Clamp %	-100	-100	0	%
P31 +O Clamp %	100	0	100	%
P32 -O Clamp %	-100	-100	0	%
P33 SV choice	**R00 AN1**	(note 2)		
P34 FF choice	**P37 Zero Ref**	(note 2)		
P35 PID Units	%	(note 3)		
P36 Scaling	100	0	9999	(note 4)

Notes:

(1) A value of less than 0.05 will disable the integrator action.

(2) Reference choices are made from the list of available references. Motorised pot or Reference Selector of another Option Board are unavailable for use with PID. If selected, a reference of zero will be used.

(3) Units contain a maximum of eight characters chosen from the set of characters found in appendix A.

(4) Units are those entered at the **P35 PID Units** menu. Upon acceptance of the scale value the decimal point is ready to be specified. The decimal point position is adjusted using the up & down pushbuttons and is accepted by the Enter push button and aborted with the Esc push button.

PID Speed Reference

P38 PID output

Menu location: Reference selection list

Selecting the **P38 PID output** as the speed reference will connect the PID controller to the MSC3 speed controller. The PID controller uses the standard features of the MSC3 as its output stage that provides the necessary power to drive the process.

The PID loop is closed when **P38 PID output** is selected as the reference for the inverter. This may be done either by terminal function (Remote, local…) or through the reference selector. The PID controller output is accessed regularly and each access resets the internal PID watchdog function. The role of the internal PID watchdog is to determine when the PID controller is to be initialised.

PID Run Variable

P38 PID Output

Menu location: Run Variable selection list

When the **P38 PID Output** is the selected run variable, the displayed information is different from regular MSC3 operation. The table below indicates the operational differences.

	Mode	
	Standard MSC3 display	**PID controller display**
Top line	Run variable (speed, load, etc). If **VO1 Hz** selected, the value is displayed according to the scale and units entered in the **A02 RUN SCALE** and **A03 RUN UNITS** menus.	The process variable displayed according to the **P35 PID Units** and **P36 PID Scale**
Bottom line	The speed reference displayed according to the scale entered in the **A02 RUN SCALE** menu.	The value of the setpoint variable according to the **P36 PID Scale**

PID Digital Outputs

P39 PV Over %

Default value: **80%**

Range: -100 to 100%

Menu location: Digital output selection list

The **P39 PV Over** function (when assigned to a relay) will activate when the PV output is above the **P39 PV Over** threshold. The threshold may be adjusted when this function is selected. There is a 2% switching hysteresis around the threshold. This function is available even when the PID controller is not in use.

P40 PV Under %

Default value: **20%**

Range: -100 to 100%

Menu location: Digital output selection list

The **P40 PV Under** function (when assigned to a relay) will activate when the PV output is under the **P40 PV Under** threshold. The threshold may be adjusted when this function is selected. There is a 2% switching hysteresis around the threshold. This function is available even when the PID controller is not in use.

Setup Checklist and Tuning

1. Control Wiring (Assumes factory defaults are loaded)

WARNING! All wiring must be done while the MSC3 is disconnected from the power supply. Refer to the Control Wiring Diagram for details

1.1. Wire in the transducer that measures the process variable (PV) to the analog input of the Option Board.

1.2. Wire in the set point variable (SV) to the analog input found on the control board.

1.3. Wire in any metering device to the analog output of the Option Board

1.4. Ensure the signal levels are compatible with the input/output specifications of each feature. Refer to the PID Control Wiring diagram for details.

2. Source selection

Variation from the default SV and FF references are done in the **P33 SV choice**, and **P34 FF choice** menus. If variations are made rewire as necessary

3. Preparing for PID Control

3.1. After initial power on alter any MSC3 settings and/or selections.

3.2. Specifically check the desired maximum motor frequency at which the process may be safely driven. Refer to **C02 MAX Hz** to check the maximum Hz setting.

3.3. Perform any analog input adjustments of each analog input in use.

3.4. Perform any analog output adjustments of each analog output in use.

3.5. Perform any PID parameter adjustments e.g. **P26 PB (%)**, **P27 Ti (sec/r)**, etc.

4. Tuning

CAUTION! The following steps are applicable in most cases. However, running the controller system without defined limits must be done with caution in case excessive speeds result in hazardous conditions or damage.

4.1. PV signal verification: run the drive/motor/process in open loop mode if possible at a known speed and check the feedback signal is correct for the operating point.

4.2. If possible, operate the system at the maximum (safe) operating point and verify that the PV signal is now at the expected level.

4.3. Switch off the integrator by setting **P27 Ti (sec/r)** to zero.

4.4. To close the loop the MSC-3 inverter speed reference (Remote, Local, ESO, JOGFWD or JOGREV) must be set to P38 PID output.

4.5. Closing the loop: after the loop has been closed observe the PV behavior. If the system is unstable increase the **P26 PB (%)** to stabilize the system. In

general, increasing the **P26 PB (%)** will stabilize the system. Decreasing **P26 PB (%)** will produce a faster response at the expense of system stability.

4.6. If the system response oscillates momentarily, the system is under damped. An increase of the derivative time **P28 Td (sec)** can improve damping but excessive use may increase the systems response to noise.

4.7. Allow the system to settle. If the PV value does not equal the SV value then the system has a steady state error. To remove steady state error, set the **P27 Ti (sec/r)** to the maximum. Decrease the **P27 Ti (sec/r)** remove the steady state error more rapidly.

4.8. Minor adjustments to **P26 PB (%), P27 Ti (sec/r)** and **P28 Td (sec)** may be performed to achieve the desired system response. Use the PID Tuning Summary below for general remedies to common problems.

4.9. Change the **P35 PID Units** and **P36 Scaling** to represent the signal PV and SV signals correctly.

5. PID Tuning Summary:

Problem	Remedy
In open loop the PV does not match the desired operating point	Check the transducer signal and check the analog input settings of the **P22 Analog input** menu.
In closed loop operation the system is unstable	Increase the **P26 PB (%)** or decrease the **P28 Td (sec)**.
The system responds too slowly	Decrease the **P26 PB (%)** or decrease the **P27 Ti (sec/r)**.
The system oscillates momentarily	Increase the **P26 PB (%)** or decrease the **P28 Td (sec)**.
PV does not equal the SV	A steady state error exists and is removed by using the **P27 Ti (sec/r)**. Start with a large value and then decrease it until a satisfactory response to a SV change is observed.

Option Digital Output

P41 Op Dig out

Default values: **O00 RUN**

Menu location: **G00 Input/Output** menu

Choose from:

O00 RUN	Drive run status
O01 TRIP	Drive trip status
O02 ESO	Drive ESO status
O03 PROOF	Drive proof status
O04 ZERO SPEED	Drive zero speed status
O05 AT SPEED	Drive at speed status
O06 UNDER SPEED %	Speed compare under threshold status
O07 OVER SPEED %	Speed compare over threshold status
O08 ON	Set the to the on state
O09 OFF	Set the to the off state
O10 A/R FAIL	Auto restart failure status
O11 FWD	Drive running forward state
O12 REV	Drive running reverse state
O13 ENABLED	Drive enabled state
014 I2t TRIP	I2t tripped status
O15 OVER TEMP	Over temperature tripped status
P39 PV over %	Process variable over threshold status
P40 PV under %	Process variable under threshold status

Use the up and down push buttons to move through the list of relay output functions and press Enter to select the displayed function or Escape to abandon the selection.

Your Option Board 1 Setup Notes

Date:

ANALOG OUTPUT
P01 Analog Opt (V01 Hz)
P02 Zero opt % (0 %)
P03 Max opt % (100%)
P04 Min opt % (0 %)
ANALOG INPUT
P23 Ref at 0% (0 %)
P24 Ref at 100% (100 %)
DIGITAL OUTPUT
P41 Op Dig out (O00 RUN)
DIGITAL INPUT
P18 OP DIG IN 1 (P15 Selector 1)
P19 OP DIG IN 2 (P16 Selector 2)
P20 OP DIG IN 3 (P17 Selector 3)
P21 OP DIG IN 4 (Rev & Latch)
OPTION BOARD REFERENCES
P06 User Ref 1 (R00 AN1)
P07 User Ref 2 (P22 Analog input)
P08 Preset 1 (10 %)
P09 Preset 2 (20 %)
P10 Preset 3 (30 %)
P11 Preset 4 (40 %)
P12 Preset 5 (50 %)
P13 Preset 6 (60 %)

PID CONTROLLER
P26 PB (%) (300 %)
P27 Ti (sec/r) (2.00 sec/r)
P28 Td (sec) (0.00 sec)
P29 +I Clamp %(100 %)
P30 -I Clamp % (-100 %)
P31 +O Clamp % (100 %)
P32 -O Clamp % (0 %)
P33 SV choice (R00 AN1)
P34 FF choice (P37 Zero Ref)
P35 PID Units (%)
P36 Scaling (100)
P39 PV Over % (80 %)
P40 PV Under % (20 %)

Appendix A - MSC-3 Character Set

Glossary

PB (%)

The proportional band is defined as the percentage of input signal required to produce 100% output signal. This value adjusts the 'loop gain' of the system. In general a larger PB (%) value will result in a smaller loop gain and subsequently increase system stability.

Ti (sec/r)

The integral time is the number of seconds the integrator output takes to repeat a constant input signal level. For example, if Ti = 5 sec/r and a 10Hz step from 0 Hz is applied to the integrator input, the output will equal (or repeat) the input of 10Hz, 5 seconds later (assuming PB % of 100 %).

The action of the integrator within the PID is to accumulate the error signal fed into it. If the error signal is positive, the integrator output will rise (a negative error will cause the integrator output to fall). The integrator signal will continue to rise (or fall) until either a steady state is reached or the output encounters a limit either **+I Clamp** or **–I Clamp.**

+I Clamp %

This value specifies the upper clamp value of the integrator output. If the integrator output reaches this clamp value, the anti wind up mechanism activates and the integrator output is held at the +I Clamp % value. If the error signal becomes negative, the integrator output will instantly begin to fall.

-I Clamp %

This value specifies the lower clamp value of the integrator output. If the integrator output reaches this clamp value, the anti wind up mechanism activates and the integrator output is held at the -I Clamp % value. If the error signal becomes positive, the integrator output will instantly begin to rise.

+O Clamp %

This value specifies the upper clamp value of the PID output. If the integrator output reaches this clamp value, the anti wind up mechanism activates and the PID output is held at the +O Clamp % value. If the error signal becomes negative, the PID output will instantly begin to fall.

-O Clamp %

This value specifies the lower clamp value of the PID output. If the integrator output reaches this clamp value, the anti wind up mechanism activates and the PID output is held at the -O Clamp % value. If the error signal becomes positive, the PID output will instantly begin to rise.

Set point (SV)

The set point is the value that the system output is required to reach and maintain. For example, a process requires gas pressure in a chamber to be maintained at 100 kPa and so the set point is set to 100 kPa.

Process variable (PV)

Is the output quantity of the process. For example chamber pressure. The sensing equipment measures this quantity and is the feed back quantity.

Feed FWD

The feed forward is primarily used to help linearize the system and is the value that allows the operating point to be shifted, leaving the PID controller to regulate about this operating point. For example in a web tensioning system the feed forward input sets the operating speed and the PID maintains the tension.

Display Scaling

The MSC3 allows the SV and PV values to be rescaled to display with meaningful values. For example a pressure chamber is operated at full motor speed and the feed back transducer produces an electrical signal that corresponds to 200.0 kPa. The **Scaling** value should set to “200.0”.

Display units

The MSC3 allows the SV and PV values to be displayed with meaningful units. For example a pressure chamber is operated at full motor speed and the feed back transducer produces an electrical signal that corresponds to 200.0 kPa. The **Scaling** value should set to “200.0” and Units set to “kPa”.

Notes

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