

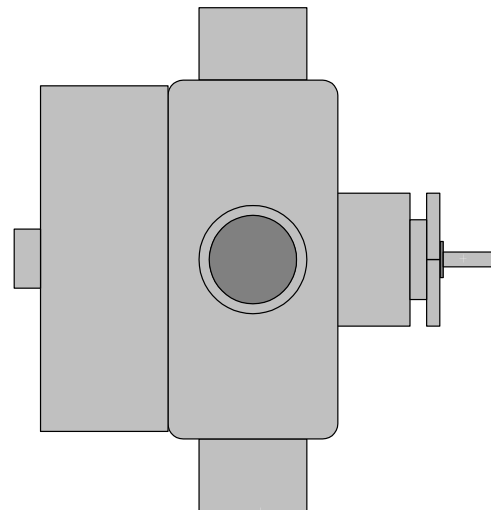
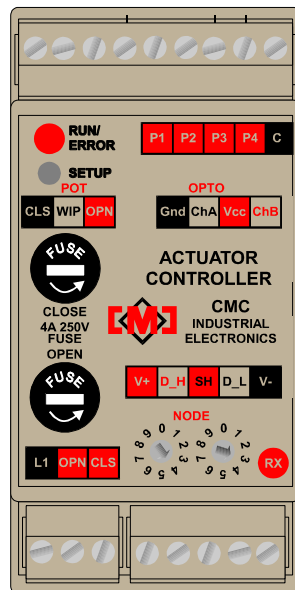


Actuator Controller Modbus
Protocol

1-WIRE[®] INTRINSICALLY SAFE

mAC/GP1X
5-MB

mAC/GP1X5-MB Actuator Controller Modbus Protocol



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Revision Notes:

First Release – November 2004

Revision A – June 2, 2006

- Manual updated to improve detail in drawings and descriptions and correct tables
- Removed mAC165 which is now obsolete

Revision B – August 10, 2006

- Add parameter identifiers for use with mA1085 Actuator Interface
- Add encoder replacement instructions for the mGP145

Revision C – October 26, 2007

- Correct bit map assignments for option registers

Revision D – February 7, 2008

- Correct factory default tables

Revision E – April 18, 2008

- Change maximum number of Modbus writes to 15 registers

Revision F – July 10, 2009

- Manual reviewed and updated to reflect current firmware revision
- Changes to the absolute limits table for parameters

Revision G – October 6, 2011

- Add network termination description



1. Overview

The mAC/GP series of actuator controllers are designed for use with a broad range of actuators. The controllers can position any device with either a rotary or linear movement that can be monitored with a potentiometer or optical encoder and is controlled with a simple open and close mechanism.

Electric, hydraulic and pneumatic actuators are supported. The controllers can directly drive 120VAC devices with current of up to 4 amps using the mAC185-MB, 1A using the mGP145-MB. Inputs are provided for full open and full close limits. Force full open and full close inputs are also provided. The position transducer can be a potentiometer or a quadrature optical encoder. The internal Analog to Digital (A-D) converter has 12 bit resolution allowing for position accuracy's of up to 0.1%. Communications utilizes a Modbus 485 RTU network.

Two models are available. The mAC185-MB is designed for DIN rail mounting in a control enclosure. It requires an external position input from either a potentiometer or optical encoder. It is designed to directly operate hydraulic solenoids, motor starters or electric motors under 4A. The mGP145-MB is for mounting in hazardous area locations and includes an optical encoder. The enclosure is certified for use in a Class II, Group G, Division 1 or 2 environments. It is also suitable for general use either indoors or outdoors. It is designed to directly operate hydraulic solenoids or control electric motors with external motor starters.



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2. Description of Terminals, Operators and Indicators

2.1 mAC185-MB DIN Mount Actuator Controller

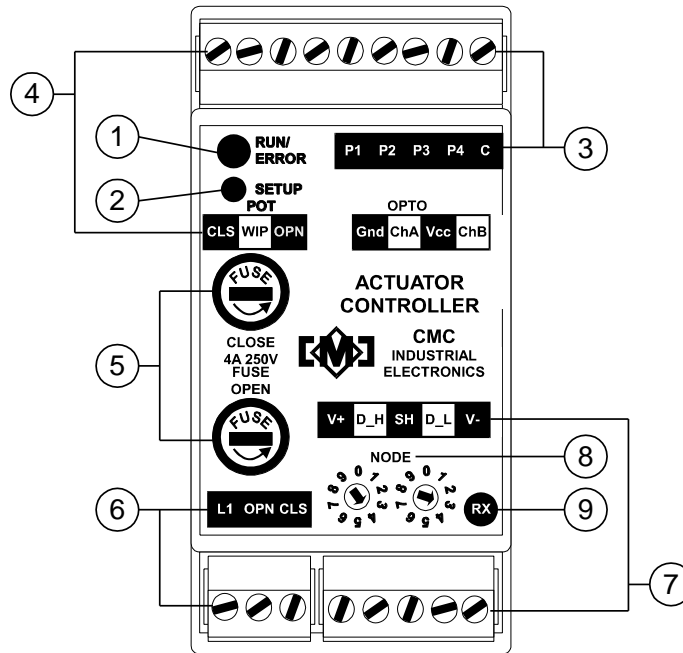


Figure 1 – mAC185 Terminals, Operators and Indicators

ID	Label	Description
1	RUN/ERROR	1 / sec - Controller operating normally 3 / sec - Calibration in progress 10 / sec - Controller in fault
2	SETUP	Pressing while running starts a self calibration cycle Pressed during power-up reloads factory default values
3	P1, P2, P3, P4	Controller inputs, lamps indicate input status, lamp on = contact closed
4	POT/OPTO	Connect potentiometer or quadrature optical encoder to these terminals
5	FUSE HOLDERS	Replace only with fuse of same rating as name plate
6	L1, OPN, CLS	Connect actuator to these terminals, lamps indicate active output
7	V+,D_H,SH,D_L,V-	Communication and power network connections
8	NODE	Controller address selector, left switch tens, right switch units
9	RX	Received data lamp, lights for 0.1 sec with each valid packet



2.2 mGP145-MB Hazardous Area Actuator Controller

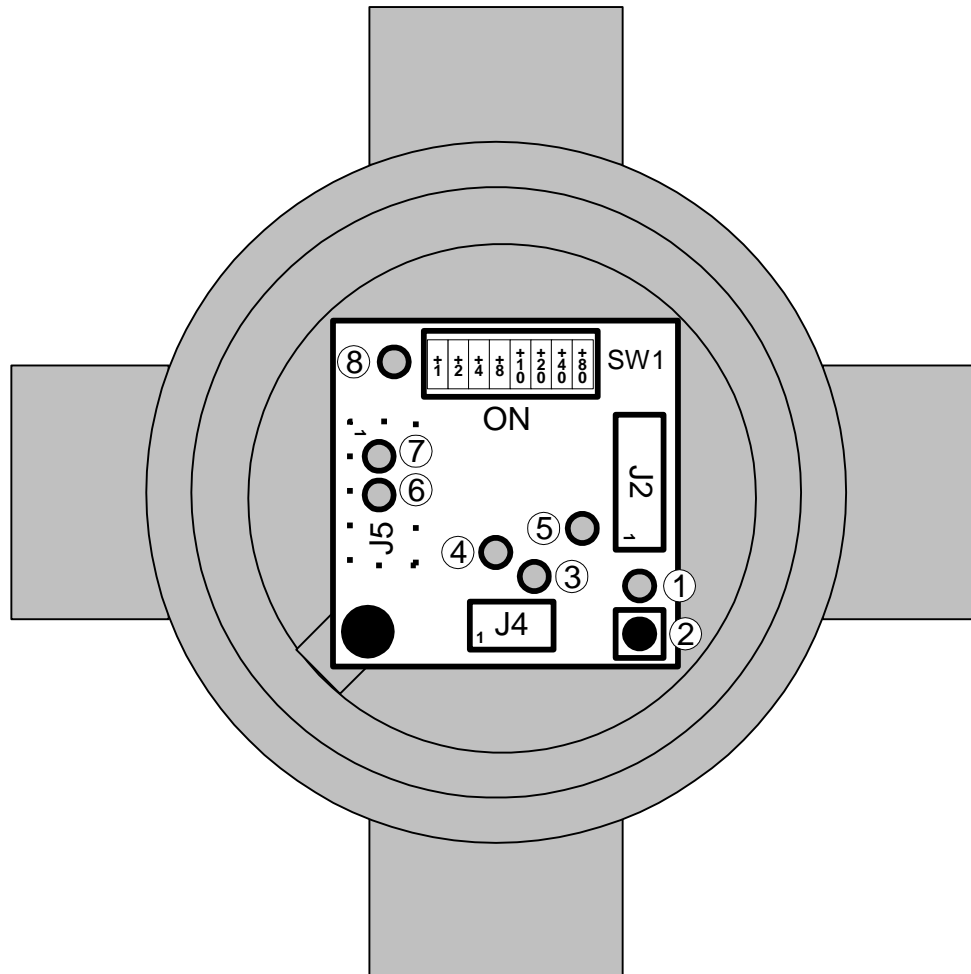


Figure 2 – mGP145 Connectors, Operators and Indicators



ID	Label	Description
J2	GP3 COM, GP3 +, V-, 24V+, D_L, D_H	Communication and power network connections, general purpose input 3
J4	GP1-2 COM, GP1+, GP2+	General purpose inputs connector
J5	CLOSE, OPEN, L1	120VAC Outputs
1	RUN/ERROR	1 / sec - Controller operating normally 3 / sec - Calibration in progress 10 / sec - Controller in fault
2	SETUP	Pressing while running starts a self calibration cycle Pressed during power-up reloads factory default values
3	INPUT 3 ON	General purpose input (fully open), lamp on = contact closed
4	INPUT 2 ON	General purpose input (fully closed), lamp on = contact closed
5	INPUT 1 ON	General purpose input (force close), lamp on = contact closed
6	OPEN ON	Open output is energized
7	CLOSE ON	Close output is energized
8	RX	Received data lamp, lights for 0.1 sec with each valid packet
SW1	NODE	Controller address selector



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3. External Connections

3.1 Power and Communications

A four-wire shielded power and communication cable should be used. Low capacitance twisted pair cable is recommended. The cable should be sized to ensure voltage drop on the power conductor does not exceed input voltage specifications. The mAC185 is a single load RS485 device allowing a maximum of 31 controllers from a single RS485 transceiver. Use repeaters if more than 32 devices, including master and repeaters, are used. Figure 4 details a typical communication system. For example the first network segment would have the master, 30 controllers and a repeater. The remaining segments would have 2 repeaters and 30 gates. Up to 100 controllers can be connected to a mAIO85 Actuator Interface.

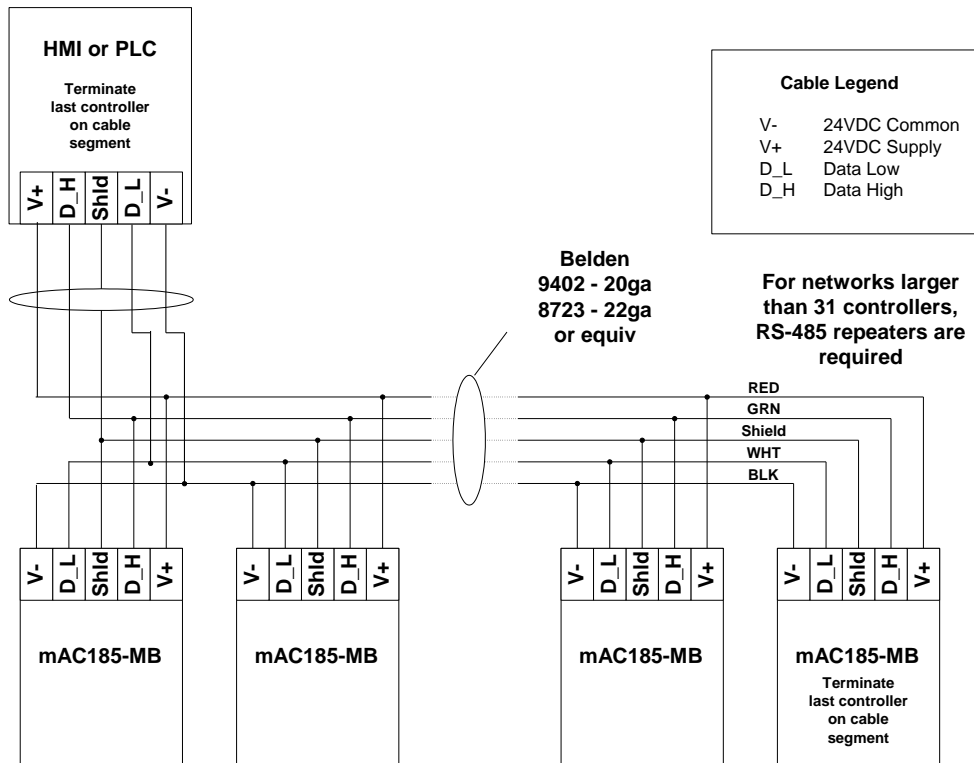


Figure 3 - Typical Data/Power Connections

The RS485 data signals are referenced to the 24VDC common terminal, V-. The D_H line is the non-inverted RS485 data line and the D_L line is the inverted RS485 data line. The data lines can be connected directly to an Modbus485 host or to an RS232 host using a RS232 to RS485 converter. If the Modbus RS232 master host does not have RS485 line driver control, use a RS485 converter with automatic line direction control.



RS-485 networks require termination. Termination is applied at each physical end of the communications cable. If you are using repeaters, then termination must be applied at both the input and output of the repeater if these connections are the physical ends of a cable segment. An example of cable termination is shown below:

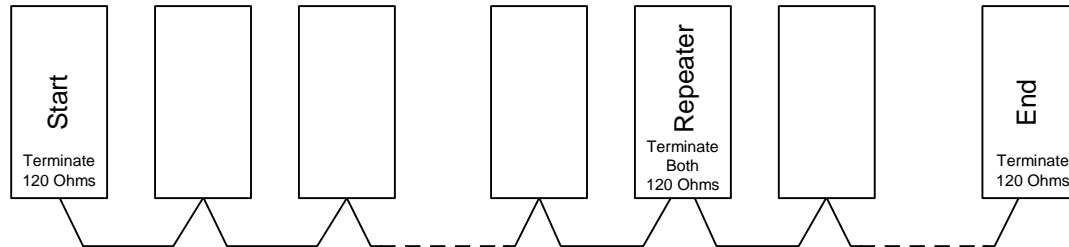


Figure 4 – Communications Cable Termination Diagram

Termination is a 120 Ohm, 1/4W resistor connected between D_H and D_L. Some devices may have a built in termination resistor that can be enabled in software or by using DIP switches. If a device has internal termination, it must be disabled if the device is not at the physical end of a cable segment.

The mAC185MB has internal termination. The termination switch is on the bottom of the controller. To terminate the network, set both switches towards the outside of the controller. The controller is shipped with termination off. The termination switch is shown below:



3.2 Position Translator

Connect either a potentiometer or an optical encoder as described in Figure 5. When used with an optical encoder, a fully closed limit switch is required to provide a zero reference point.

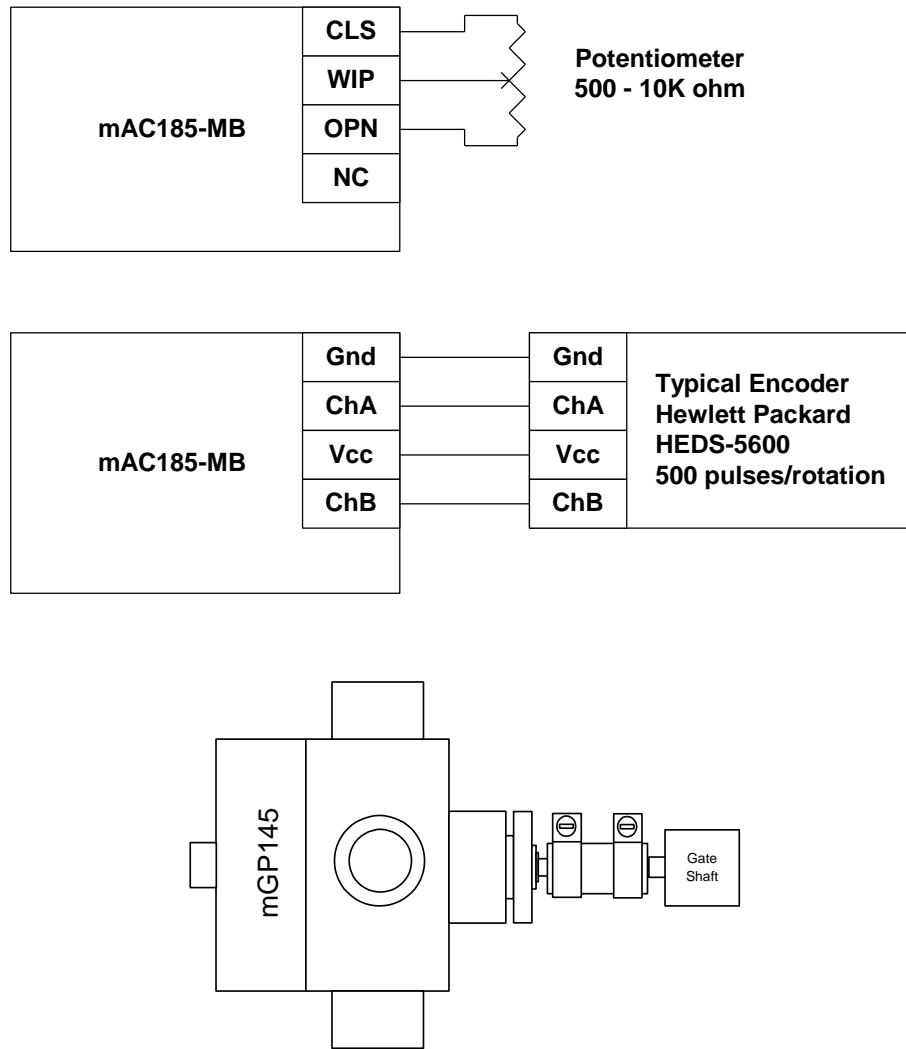


Figure 5 - Position Translator Connections

NOTES:

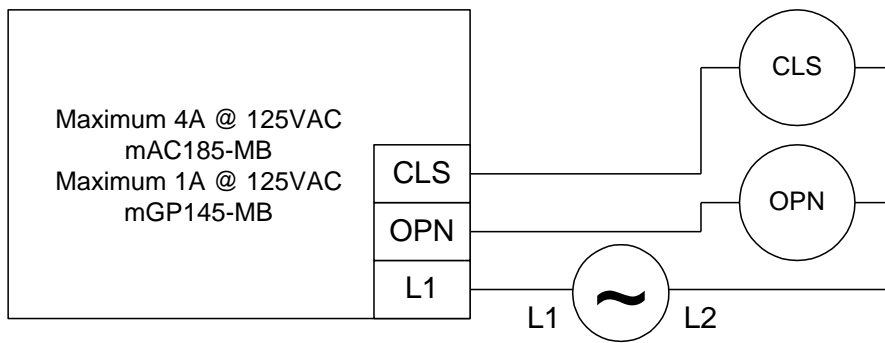
1. A-D converter accuracy is 1 in 4096, use 2 A-D divisions for each division of required accuracy
2. Use shielded cable if distance exceeds 3 feet or if excessive electrical noise is present
3. A closed limit switch is required with optical encoders
4. Encoder output frequency must not exceed 1000 Hz
5. Encoder outputs must be active or have pull-up resistors
6. Allow twice as many encoder counts as the required position accuracy



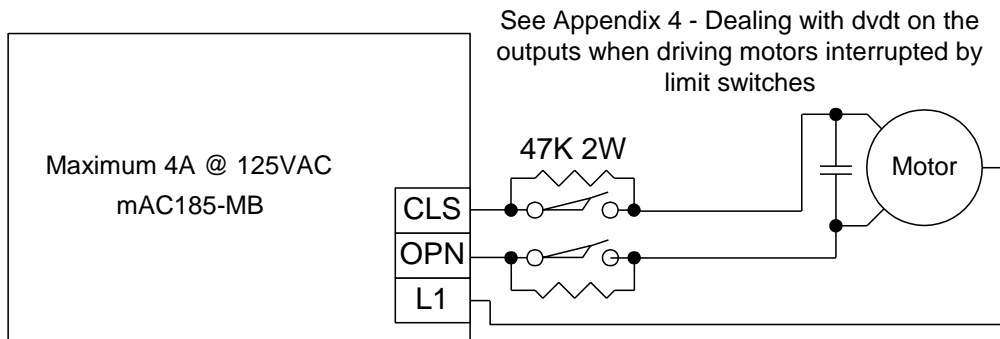
3.3 Actuator Control Outputs

The Controller will directly drive any actuator with 120VAC coils or motors with up to 4 amps current requirement. The duty cycle of the Controller is 25% with a maximum on time of 120 seconds at full load. Figure 6 shows a typical connection for the Controller outputs.

When driving inductive loads, such as motors or solenoids, care should be taken to avoid rapid voltage changes on the outputs. Fast rise time voltages on the outputs may cause the Controller's outputs to momentarily turn on with unexpected results. Note the resistors shown when using an electric motor with limit switches. See **Appendix 4, Dealing with dVdt** for more details.



Relay or Solenoid Connection



Capacitor Start Motor With End of Travel Limits

Figure 6 - Output Connections



3.4 Controller Inputs

The Controller has four powered inputs. Connections to the inputs should be with dry contacts or open collector DC devices capable of sinking current. The input load is 5VDC at 10ma. Each of the four inputs can be configured during setup to be either a full open or full closed limit switch or a force full open or force full close input. The inputs can also be used as general purpose status inputs as their current state is contained in the Controller status message. Figure 5 details a typical input connection.

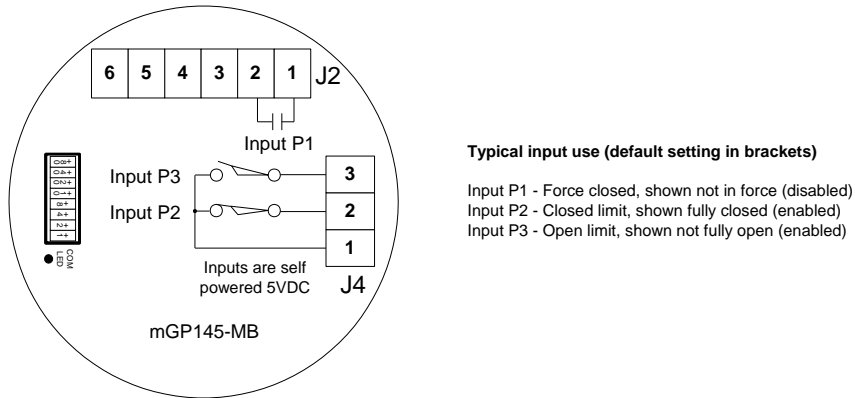
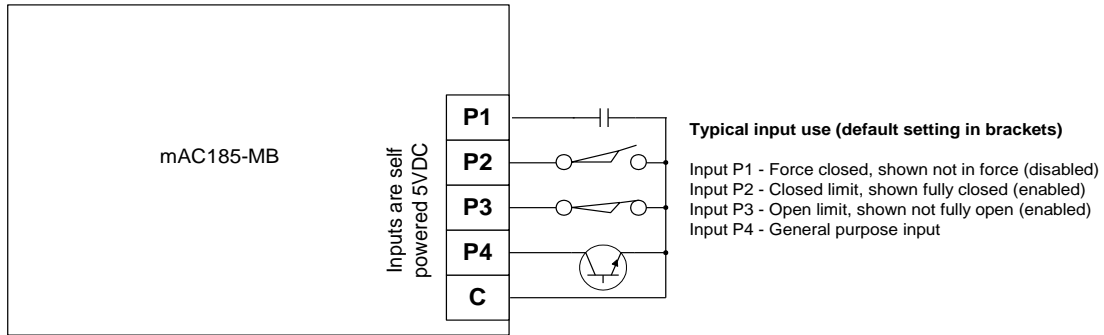


Figure 7 - Typical Input Connections



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4. Controller Parameters

The operation and accuracy of the controller is determined by user configurable parameters. This section describes each of these parameters and the effect they have on the operation of the controller. Some parameters are automatically set during calibration. Some parameters are arrays of bit flags. These parameters are described using the parameter number and the adder to turn on the required bit (e.g. Register 40043, Adder = 2). The value for these parameters is obtained by summing the adders for the required bits and using the sum for the parameter value. Bits are read from left to right with first bit being bit 0.

4.1 Reloading Factory Default Values

There are two methods to restore the controller's parameters to the factory default values.

4.1.1 Using the SETUP Push Button

Pressing and holding the SETUP push button during a power-up sequence will restore factory default values. The RUN/ERROR indicator will flash at a 10/sec rate when the parameters have been reloaded. All of the reloaded values will be in effect after this operation.

4.1.1.1 Soft Reset [Register 40001 - Bit 4]

The controller can be forced to perform a power-up sequence using the communication system. By setting bit 4 of the command register, the controller will perform a full power-up sequence. For this command, the upper byte of the command register must be set to 0x55. Communication will be lost temporarily during the power-up sequence.

4.1.2 The Default Values

The following values will be loaded into the controller's parameter table:

Identifier	PARAMETER	Register	VALUE
oFT	Zero offset	40012	0
SPn	Span factor	40013	101
Osb	Open setback	40014	0
CSb	Close setback	40015	0
Stl	Seek tolerance	40016	1
oLT	Open limit tolerance	40017	2
CLt	Close limit tolerance	40018	2
FSC	Full scale value	40019	100
MLC	Maximum load current	40020	400
iLC	Idle load current	40021	50
JMt	Jog movement tolerance	40022	1
LoF	Load zero offset	40023	425
LSP	Load span factor	40024	415



Identifier	PARAMETER	Register	VALUE
CFP	Communications fault position	40025	0
UPt	Update time	40026	4
Trt	Turn around time	40027	10
Cft	Command fault time	40028	90
Jit	Jog wait time	40029	20
Jrt	Jog run time	40030	20
PCt	Peak current cycle time	40031	16
AFt	Average load fault time	40032	0
Ift	Idle load fault time	40033	0
LJt	Minimum jog run time	40034	1
HJt	Maximum jog run time	40035	255
CPC	Continue past close time	40036	0
Art	Re-close every x seconds	40037	0
CFd	Communications fault time	40038	30
in1	Input 1 function	40039	0
in2	Input 2 function	40040	6 [2]
in3	Input 3 function	40041	5 [1]
in4	Input 4 function	40042	0
Sop	Seek options	40043	0
EnC	Input Source Selection	40044	0 [2]
PLt	Pseudo limit switch options	40045	0
FrC	Force system options	40046	3
Cdl	Calibrate wait delay	40047	5
CSP	Baud rate	40048	1

[x] Indicates mGP145

4.2 Communication Port

4.2.1 Serial Port Speed (CSP) [Register 48]

The communication port can operate at 5 standard baud rates. The default value is 1 for 19200 baud. The controller only determines its baud rate during a power-up sequence and must be reset for a new baud rate to take effect. Cycling power or issuing a **Soft Reset** over the communication system will reset the controller. The following is a list of available baud rates:

1	19200
2	9600
3	4800
4	2400
5	1200



4.2.2 COM Fault Position (CFP) [Register 25]

In the event of a communication interruption, the controller can be programmed to go to a preset position. The value is set by this parameter determines the position set.

4.2.3 COM Fault Time (CFd) [Register 38]

If a communications interruption should occur the controller will wait the time specified in this parameter before setting the position to the COM Fault Position.

4.3 Position Translator

4.3.1 Input Source Selection (EnC) [Register 44, Options 0 - 8]

The position input source can be either a potentiometer or optical encoder. When using an optical encoder, one of the programmable inputs must be designated for a fully closed limit switch (See **Input Options**). The controller uses this limit switch to determine the actuator fully closed position. Each time an operation completes, the closed limit switch is monitored. Upon expiry of the turnaround timer, the position is set to 0 if the closed limit switch is detected. The default setting is 0 for potentiometer for the mAC185 and 2 for encoder with force close for the mGP145.

4.3.1.1 Force Close on Power-up (EnC) [Register 44, Options 2, 4, 6 and 8]

On power-up, the controller is not aware of the current actuator position when using an optical encoder. To ensure the controller locates the fully closed position, this option forces the actuator fully closed, until the closed limit switch is detected, when the controller is powered up. If this option is not selected, the host computer will have to force the controller to the closed limit after each power-up.

4.3.1.2 Encoder Direction (EnC) [Register 44, Options 3, 4, 7 and 8]

Selecting the CCW option can change direction of rotation interpreted by the optical encoder. Note the open and close outputs and limit switches must be wired to reflect the direction of rotation. The default is CW.

4.3.1.3 Encoder x 2 (EnC) [Register 44, Options 5, 6, 7 and 8]

The normal count value from the encoder is 500 counts per revolution. Where sufficient input rotation can not be achieved, the encoder input can be doubled using this option. No loss of accuracy occurs using this option, the controller doubles the input by counting both the rising and falling edges of the quadrature signal from the encoder. The default is x2.



OPTION	VALUE
Potentiometer Input	0
CW Encoder	1
CW Encoder with Force Close	2
CCW Encoder	3
CCW Encoder with Force Close	4
2 x CW Encoder	5
2 x CW Encoder with Force Close	6
2 x CCW Encoder	7
2 x CCW Encoder with Force Close	8

Figure 8 – Input Options

4.4 Input Options

The mAC185 have 4 input terminals. The mGP145 has 3 input terminals. These terminals can be configured for dedicated functions or used as general purpose inputs. The value of each of the inputs can be read from the **Status Register [Register 40003, bits 0 - 3, using the communication system. A status bit set to 1 indicates the input is open (lamp off), a status bit set to 0 indicates the input is closed (lamp on).**

4.4.1 Inputs 1 to 4 (in1 – in4) [Registers 40039, 40, 41 and 42]

Each input can be set to be either a open or closed limit switch or a force open or force close command input of either polarity. The following table describes the function for each allowable value:

VALUE	FUNCTION
0	Off
1	at full open when switch closed
2	at full closed when switch closed
3	force full open when switch closed
4	force full closed when switch closed
5	at full open when switch open
6	at full closed when switch open
7	force full open when switch open
8	force full closed when switch open
9	Bin empty indicator on when switch closed (mAI085 use only)
10	Bin empty indicator on when switch open (mAI085 use only)



The default value for input 2 is 6 (actuator at full closed when switch open). The default value for input 3 is 5 (actuator at full open when switch open). The default value for inputs 1 and 4 is 0, no function assigned.

4.4.2 The Pseudo Limit Switch System

The pseudo limit switch system allows for the creation of open and closed limit switches using the transducer position value. This system can not be used to substitute for a closed limit switch when an optical encoder is used. In all other cases the pseudo limit switch will emulate the limit switch functions available to an input limit switch.

4.4.2.1 Open Pseudo Limit Switch Enabled (PIt) [Register 40045, Adder = 1]

When this bit is set, the open pseudo limit switch is enabled. The default value is off.

4.4.2.2 Closed Pseudo Limit Switch Enabled (PIt) [Register 40045, Adder = 2]

When this bit is set, the closed pseudo limit switch is enabled. The default value is off.

4.4.2.3 Open Pseudo Limit Switch Offset Value (oLt) [Register 40017]

This value determines when the open pseudo limit switch will be activated. The switch will be active when the transducer position is less than or equal to full scale minus this value. The default value is 2 for 2%.

4.4.2.4 Closed Pseudo Limit Switch Offset Value (CLt) [Register 40018]

This value determines when the closed pseudo limit switch will be activated. The switch will be active when the transducer position is less than or equal to this value. The default value is 2 for 2%.

4.5 The Force Close/Open System

The controller can have inputs designated to force the actuator fully open or closed. This function allows the actuator to be forced open or closed independently of the communication system. These inputs are immediate and take precedence over all other commands except a **Calibration** command. A force close input overrides a force open input. This system is typically used to close all actuators when the down stream route has failed.

4.5.1 Force Close Command Time Out Sets Position Fault (FrC) [Register 40046, Adder = 1]

When enabled a command time out during a force close operation will set the **Position Fault** bit in the **Error Register**. The default is on.

4.5.2 Force Close Command Time Out Stops Close Output (FrC) [Register 40046, Adder = 2]

When enabled a command time out during a force close operation will turn off the close output. The default is on.



4.5.3 Force Open Command Time Out Sets Position Fault (FrC) [Register 40046, Adder = 4]

When enabled a command time out during a force open operation will set the **Position Fault** bit in the **Error Register**. The default is off.

4.5.4 Force Open Command Time Out Stops Open Output (FrC) [Register 40046, Adder = 8]

When enabled a command time out during a force open operation will turn off the open output. The default is off.

4.5.5 Seek to Position When Force Removed (SoP) [Register 40043, Adder = 2]

When a force input is removed the controller will leave the gate at the forced position unless this option is selected. If this bit of the Seek Options parameter is set, the controller will position the actuator to the last selected seek position upon the removal of a force input. The default is off

4.6 Positioning Accuracy

The following parameters determine the accuracy of the final position achieved by the controller. These parameters should be configured before an automatic calibration sequence is initiated.

The controller uses a two step process to position the actuator. The first step runs the actuator until the position reaches the requested position, less a setback tolerance. If jogging is disabled, the operation completes at step 1 with the actuator at the current position. If jogging is enabled, step 2 uses a series of timed pulses to achieve the final position of the actuator.

4.6.1 Full Scale (FSC) [Register 40019]

The full scale value determines the number of divisions displayed for a fully open actuator, and determines the positioning accuracy of the actuator. For purposes of this manual the controller is configured using % of full scale, and the default register value is 100 for 1% accuracy. However, the controller can be set up to use any units for full scale (i.e. inches, millimeters, etc.).

Setting this value to an accuracy higher than the actuator can achieve may cause hunting, excessive actuator wear, and positioning faults.

The number of divisions available to an application using a potentiometer is [1000 x (% of potentiometer used / 100)], to a maximum of 1000.

When using an encoder, the number of input counts available is [encoder pulses per turn X number of turns]. Maximum counts remain 4096 for the encoder. At least 2 input counts are required for each full scale division.

4.6.2 Jogging (SoP) [Register 40043, Adder = 8]

The controller can use jogging to achieve higher accuracy. Jogging uses precisely timed pulses to move the actuator. During calibration, the controller determines if jogging is required to achieve the selected accuracy. If required, jogging is automatically enabled and



calibrated. Setting bit 3 of the **Seek Options** register will enable jogging. The default value is off.

4.6.3 Position Seek Tolerance (StL) [Register 40016]

This parameter determines the position accuracy when jogging is enabled. The controller will continue to jog the actuator until the difference between the current position and the requested position is less than or equal to this value. The default value is 1 division.

4.6.3.1 Jog Run Time (Jrt) [Register 40030]

This parameter specifies the jog on time to be used after a power-up sequence. The controller moves the value from this parameter to an internal working variable during the power-up sequence. The controller modifies the internal working variable after each jog sequence.

Setting this value will not change the current controller jog on time. The current jog on time will only be changed during a power-up sequence or by issuing a **Soft Reset** command. The default value is 20 for 0.2 seconds. Jog Idle Time (Jit) [Register 40029]

After each jog, the controller waits for this time interval before calculating how far the actuator has moved. This time should be set to a value longer than the settle time of the actuator. This parameter must be longer than or equal to the **Turn Around Time** parameter. The default value is 20 for 2.0 seconds.

4.6.3.2 Minimum Jog On Time (Ljt) [Register 40034]

After each jog the controller adjusts the jog on time. This value is the shortest jog on time the controller will allow. The actuator should just not move when a pulse of this time is applied. The default value is 1 for 0.01 seconds.

4.6.3.3 Maximum Jog On Time (Hjt) [Register 40035]

After each jog the controller adjusts the jog on time. This value is the longest jog on time the controller will allow. The actuator should move more than the **Jog Move** value when a pulse of this time is applied. The default value is 255 for 2.55 seconds.

4.6.3.4 Continuous Seek (SoP) [Register 40043, Adder = 1]

The controller will terminate a seek operation after the requested position is attained. Some actuators (i.e. hydraulic actuators) can drift from the selected position over time. Enabling this option will cause the controller to continuously monitor the actuator's position. If the actuator drifts from the current seek position, a new seek operation is initiated. The new seek will only utilize the jogging function to position the actuator. For this option to have effect, the jogging system must be enabled.

Setting bit 0 of the **Seek Options** register enables this option. The default value is off.

4.6.3.5 Seek Value of 0 Sets Force Close (SoP) [Register 40043, Adder = 4]

This option will cause the controller to emulate a force close input whenever the seek value is 0. This option is used to ensure the gate closes fully when a 0 value is selected. The option may also be used for actuators that may drift from the fully closed position (i.e.



hydraulic actuators). Details on a Force Close operation can be found in **The Force Close/Open System**. Setting bit 2 of the **Seek Options** register enables this option. The default value is off.

4.6.4 Calibration Parameters

The controller can perform an automatic calibration sequence. This sequence automatically sets the controller's calibration parameters. See **Calibration** for details on initiating a calibration sequence.

4.6.4.1 Position Zero Offset (oFt) [Register 40012]

The actuator is run in the close direction until no further motion is detected. The raw position value is captured as the zero offset. This offset is subtracted from the raw position value in the position calculations. The default value is 0.

4.6.4.2 Position Span (SPn) [Register 40013]

The actuator is run in the open direction until no further motion is detected. The raw position value is captured and used to calculate the span. The calculations used are detailed in **Appendix 1 - Positioning System Calculations**. The default value is 101 for 100% with 4096 A-D divisions.

4.6.4.3 Open Setback (Osb) [Register 40014]

The actuator is run in the open direction to 75% open. The amount of over travel is calculated. This amount is subtracted from the position to be attained on an open operation. The default value is 0.

4.6.4.4 Close Setback (CsB) [Register 40015]

The actuator is run in the close direction to 25% open. The amount of over travel is calculated. This amount is subtracted from the position to be attained on a close operation. The default value is 0.

4.7 Timing

The controller uses a series of timers during a positioning operation.

4.7.1 Output Turn Around Time (trt) [Register 40027]

Most actuators require a delay between open and close operations. The turnaround timer forces a delay between all operations. Anytime an output is turned off, both outputs will remain off until this timer has expired. When jogging is enabled this time must be less than or equal to the **Jog Wait Time** or no jogging will occur. The default value is 10 for 1.0 seconds

4.7.2 Command Fault Time (Cft) [Register 40028]

Each time a motion command is executed this timer is reset. The command will continue until this timer expires, at which point the command will stop and an error will be indicated. Motion commands can be initiated over the communication channel or by designated **Force**



Open or **Force Close** input terminals. Command fault time is calculated by the controller during a calibration cycle based on the actuator's determined time to achieve commanded positions. Setting this parameter to 0 disables command faults. The default value is 90 for 90 seconds.

4.7.3 Controller Update Time (Upt) [Register 40026]

The controller will process new A-D or encoder values at intervals set by this timer. The default value is 4 for 10.0 milliseconds or 100 updates second

4.7.4 Continue Past Close Time (CPC) [Register 40036]

In some applications it is desirable to leave the close output energized for a period of time after the closed limit switch has been activated. This is especially useful for hydraulic actuator systems. This parameter determines the length of time the closed output will remain on after the closed limit switch input is activated. Setting this parameter to 0 disables this function. For this option to have effect, the Seek Value of 0 Sets Force Close (SoP) option must also be enabled. The default value for this parameter is zero and the units are in 0.1 seconds.

4.7.5 Re-close Every Time (Art) [Register 40037]

In applications where actuator drift off zero occurs this timer will automatically re-close the actuator at a preset interval. This parameter determines the delay in minutes between re-closes. The delay is multiplied by the controller's communications address to prevent all of the actuators on a network from re-closing simultaneously. If the multiplied time is longer than the re-close interval, the time will subtracted from the re-close interval to remain within the re-close interval window. If the value in the Continue Past Close Time register is non-zero, the controller's close output will remain energized for that interval when reclose occurs.

4.8 The Load Monitoring System

The controller continuously monitors the current flowing through its output terminals. The load monitoring system can be used to disable the outputs should the output current exceed a preset value during an actuator movement. Additionally, the current measured while the controller is idle can be used to set an alarm should the current exceed a preset value. The average load current for the last movement and the idle load current can be read from the controller.

4.8.1 Maximum Average Load (MLC) [Register 40020]

During an actuator movement, the controller continuously calculates the average current for the movement. If the average current exceeds the maximum average current value, the **Average Load Alarm Timer** will be started. If the load remains over the maximum allowed for the duration of the timer, the actuator is stopped and the **Overload Fault** bit is set in the fault register. The default value is 400 for 4.00A.

4.8.2 Maximum Idle Load (iLC) [Register 40021]

While the controller is idle, with no outputs active, the idle load current is measured. If the idle load current exceeds this value, the **Idle Load Alarm Timer** will be started. If the load



remains over the maximum allowed for the duration of the timer, the **Idle Load Fault** bit is set in the fault register. The default value is 50 for 0.50A.

4.8.3 Over Current Fault Time (AFt) [Register 40032]

During an actuator movement, the controller continuously calculates the average current for the movement. If the maximum average current is exceeded, the **Average Load Alarm Timer** will be started. If the load remains over the maximum allowed for this duration, the actuator is stopped and the **Overload Fault** bit is set in the fault register. A duration of 0 disables the **Load Monitoring System**. The default value is 0.

4.8.4 Idle Current Fault Time (iFT) [Register 40033]

While the controller is idle, with no outputs active, the idle load current is measured. If the idle load current exceeds the **Maximum Idle Load**, the **Idle Load Alarm Timer** will be started. If the load remains over the maximum allowed for this duration, the **Idle Load Fault** bit is set in the fault register. A duration of 0 disables the **Idle Load Fault**. The default value is 0.

4.8.5 Current Calculation Time (PCt) [Register 40031]

The load current monitoring system reads the load at intervals set by this timer. The load monitor utilizes a peak detector that is reset after each measurement. This timer should be set to record the peak current for at least 2 cycles of the AC line. The default value is 16 for 160 milliseconds.

4.8.6 Load Current Zero Offset (LoF) [Register 40023]

During the load calculations this value is used to remove any zero offsets from the detector. This value is automatically determined during a calibration sequence. The default value is 540.

4.8.7 Load Current Span (LSP) [Register 40024]

During the load calculations this value is used to convert the raw peak detector output to load current in amps. See **Appendix 3 - The Load Current Monitoring System Calculations** for details on how the load current is calculated. The default value is 2400.



5. Calibration

5.1 Initiating an Automatic Calibration

The mAC185 Actuator Controller has an automatic calibration system. There are two ways to initiate the calibration sequence:

To calibrate the controller from the communication system, issue the **Start Calibrate Command [Register 40001 - Bit 5]**. Note the high byte of the command register must be set to 0xAA to initiate the calibrate command. To stop a calibration over the communication system, issue a **Stop All Operations Command [Register 40001 - Bit 1]**. To calibrate the controller locally, press and hold the **Setup** push. After 2 seconds, the Run/Error indicator will begin flashing at a 3 per second rate. Release the push button and the calibration sequence will begin. To stop the calibration cycle, press the Setup button again.

The controller saves the calculated calibration parameters at the end of the calibration cycle. Aborting a calibration sequence will return the controller to the previous calibration. The calibration sequence is as follows:

1. Capture current monitor load offset
2. Open the actuator for 2 seconds
3. Close the actuator and capture zero offset
4. Open the actuator fully and capture span
5. Close the actuator to 25% and calculate close offset
6. Open the actuator to 75% and calculate open offset
7. Jog the actuator if required and determine jog on time
8. Save all parameters to EEPROM
9. Exit the calibration routine
10. If the actuator's position is now different than the current seek position, the controller will immediately move the actuator to the seek position.

The parameters modified by a calibration sequence are detailed in **Controller Parameters - Calibration Parameters**.

The controller will automatically determine the best jog timing if jogging is required for the selected seek tolerance. During this portion of the calibration the calibration will fail if the number of jog attempts exceeds 30 during the determination phase.



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6. Controller Commands

Commands are executed by setting bits in the **Command Register [Register 40001]**. The bits are automatically cleared by the controller.

6.1 Motion Commands

Details of the seek operation are included in **Appendix 2 - Seek Operation Sequence**.

6.1.1 Seek to Position [Register 40001 - Bit 0]

This command moves the actuator to the value specified in the command. The position is selected by writing the value to **Seek Position [Register 40002]**.

6.1.2 Stop Current Operation [Register 40001 - Bit 1]

This command stops the current operation. The command also terminates a calibration sequence.

6.2 Calibration Commands

6.2.1 Set Parameter Protect On [Register 40001 - Bit 2]

This command sets Parameter Protection on. After execution the controller will no longer accept modifications to the parameter table. Issuing a Set Parameter Protect Off will disable this function. On power up, parameter protection is automatically set on.

6.2.2 Set Parameter Protect Off [Register 40001 - Bit 3]

This command sets Parameter Protection off. After execution the controller will accept modifications to the parameter table. For this command, the upper byte of the command register must be set to 0xAA. The command will not execute if the upper byte is not correctly set.

6.2.3 Soft Reset [Register 40001 - Bit 4]

The controller can be forced to perform a power-up sequence using the communication system. By issuing a soft reset command, the controller will perform a full power-up sequence. For this command, the upper byte of the command register must be set to 0x55. The command will not execute if the upper byte is not correctly set. Communication will be lost temporarily during the power-up sequence.

6.2.4 Start a Calibration Sequence [Register 40001 - Bit 5]

This command starts a controller automatic calibration sequence. See **Section 5 - Initiating a Calibration Sequence** for further details on this operation. The upper byte of the command register must be set to 0xAA to execute this command. A **Stop Current Operation [Register 40001 - Bit 1]** command terminates calibration.



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7. Reading Values From The Controller

The controller has a series of internal values that provide details of the current operation. These values can be read using the communication system.

7.1 Positioning Values

7.1.1 Read Current Position [Register 40004]

Returns the current position in percent of full scale.

7.1.2 Read Raw Position [Register 40008]

Returns the internal A-D or encoder value.

7.1.3 Read Seek Value [Register 40002]

Returns the last seek value selected.

7.1.4 Read Jog On Time [Register 40010]

Returns the current jog on time calculated by the controller. This value may differ from the **Jog Run Time** parameter as the controller continuously adjusts the jog on time during operation.

7.2 Load Monitoring System Values

7.2.1 Read Average Load [Register 40005]

Returns the average load current for the current or last operation in amps (0.00).

7.2.2 Read Peak Load [Register 40006]

Returns the peak load current for the current or last operation in amps (0.00).

7.2.3 Read Idle Load [Register 40007]

Returns the idle load current for the current or last idle period in amps (0.00).

7.2.4 Read Raw Load [Register 40009]

Returns the raw load in internal A-D converter units. This value can be used to improve the calibration of the load monitoring system at low load levels. See **Appendix 3 - Load Current Monitoring System Calculations** for complete details.



7.3 Version Control

7.3.1 Read Software Revision Level [Register 40011]

Returns the software revision level of the firmware installed in the controller. The revision is returned as XXX indicating revision X.XX in the lower byte of the register. The upper byte should be zeroed before determining the revision level.



8. The Communication System

The Controller utilizes the Modbus485 communications protocol. It is a slave device. The controller will only respond to the following Modbus commands:

Command Value	Command
3 [3]	Read holding registers
6 [6]	Write one holding register
16 [10]	Write many holding registers

The controller can accept register reads up to the complete register set. Register writes are limited to 15 registers. The controller is an RTU device with a CRC16 checksum. The default baud rate is 19200.

The following table describes the complete register layout:

Register	Identifier	Function	R/W	Units	Range	Default
40001		Commands	R/W	bit	0-63	0
40002		Seek Position	R/W	divs	0-FS	0
40003		Status / Faults	R	bit		n/a
40004		Current Position	R	divs	0-FS	n/a
40005		Average Load	R	0.01 A	0-999	n/a
40006		Peak Load	R	0.01 A	0-999	n/a
40007		Idle Load	R	0.01 A	0-999	n/a
40008		Raw Position	R	counts	0-4095	n/a
40009		Raw Load	R	counts	0-4095	n/a
40010		Jog On Time	R	25 ms	0-255	n/a
40011		Software Revision	R	0.00	n/a	n/a
40012	oFT	Zero offset *	R/W	counts	0-4095	0
40013	SPn	Span factor *	R/W	counts	0-4095	101
40014	Osb	Open setback *	R/W	divs	0-FS	0
40015	CSb	Close setback *	R/W	divs	0-FS	0
40016	Stl	Seek tolerance	R/W	divs	0-FS	1
40017	oLT	Open limit tolerance	R/W	divs	0-FS	2
40018	CLt	Close limit tolerance	R/W	divs	0-FS	2
40019	FSC	Full scale value	R/W	counts	100-2000	100
40020	MLC	Maximum load current	R/W	0.01A	0-999	400



Register	Identifier	Function	R/W	Units	Range	Default
40021	iLC	Idle load current	R/W	0.01A	0-999	50
40022	JMt	Jog movement tolerance	R/W	divs	0-FS	1
40023	LoF	Load zero offset *	R/W	counts	0-4095	540
40024	LSP	Load span factor	R/W	counts	0-4095	2400
40025	CFP	Communications fault position	R/W	divs	0-FS	0
40026	UPt	Update time	R/W	10.0 ms	4-80	4
40027	Trt	Turn around time	R/W	1.0 sec	1-255	10
40028	Cft	Command fault time*	R/W	1.0 sec	1-255	90
40029	Jit	Jog idle time	R/W	0.1 sec	1-255	20
40030	Jrt	Jog run time *	R/W	10.0 ms	1-255	20
40031	PCt	Peak current cycle time	R/W	10.0 ms	1-255	16
40032	AFt	Average load fault time	R/W	1.0 sec	1-255	0
40033	Ift	Idle load fault time	R/W	1.0 sec	1-255	0
40034	LJt	Minimum jog run time *	R/W	10.0 ms	1-255	1
40035	HJt	Maximum jog run time *	R/W	10.0 ms	1-255	255
40036	CPC	Continue past close time	R/W	0.1 sec	1-255	0
40037	Art	Re-close every x minutes	R/W	1 min	1-255	0
40038	CFd	Communications fault time*	R/W	1.0 sec	1-255	30
40039	in1	Input 1 function	R/W	#	0-10	0
40040	in2	Input 2 function	R/W	#	0-10	6 [2]
40041	in3	Input 3 function	R/W	#	0-10	5 [1]
40042	in4	Input 4 function	R/W	#	0-10	0
40043	Sop	Seek options *	R/W	#	0-15	0
40044	EnC	Input Source Selection	R/W	#	0-8	0 [2]
40045	PLt	Pseudo limit switch options	R/W	#	0-3	0
40046	FrC	Force system options	R/W	#	0-15	3
40047	Cdl	Calibrate wait delay	R/W	#	1-255	5
40048	CSP	Baud rate	R/W	#	1-5	1

KEY:

*	Set by calibration	FS	Full Scale	R/W	Read/Write
#	Numeric value	ms	milliseconds	[]	mGP145 only
A	Amps	R	Read only	bit	Command/status bits
divs	Divisions of full scale				



The following table is a summary of the registers that have bit values:

Parameter	Register	Bit	Adder	Function
Command	40001	0	1	Start seek
		1	2	Stop all operations
		2	4	Turn memory protect on
		3	8	Turn memory protect off (high byte = 0xAA)
		4	16	Soft reset (high byte = 0x55)
Status / Faults	40003	5	32	Start calibration (high byte = 0xAA)
		0		Input 1 state 0 = lamp on, 1 = lamp off
		1		Input 2 state 0 = lamp on, 1 = lamp off
		2		Input 3 state 0 = lamp on, 1 = lamp off
		3		Input 4 state 0 = lamp on, 1 = lamp off
		4		1 = Seek in progress
		5		1 = Motor output on
		6		1 = Motor direction to close
		8		1 = Actuator did not attain position
		9		1 = Motor current exceeded allowed
Seek Options	40043	10		1 = Idle current exceeded allowed
		11		1 = Parameter memory corrupted
		12		1 = Controller firmware is corrupted
		13		1 = Parameter protect is on
		14		1 = Calibration in progress
Limit Switch Options	40045	0	1	Continuous seek
		1	2	Re-seek when force open/close ends
		2	4	Force close if seek value = 0
Force Options	40046	3	8	Enable jogging system
		0	1	Open pseudo limit enable
Force Options	40046	1	2	Close pseudo limit enable
		0	1	Failed force close sets position fault
		1	2	Failed force close disabled output
		2	4	Failed force open sets position fault
Force Options	40046	3	8	Failed force open disabled output



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9. Specifications

Detailed product specifications can be obtained from the individual product data sheets.

Description	Characteristic
Actuator	
Voltage	120VAC 1Ø
mGP145	
Current	1A (2 minute 25% duty-cycle)
Fuse	GMA 1 replaceable
mAC185	
Current	4A (2 minute 25% duty-cycle)
Fuse	GMA 4 replaceable
Supervisory	
Voltage	10 to 25VDC
Current	30mA @ 24VDC
Communication	
Standard	RS485 differential
Distance	500m (1640ft.)
Input load	12K ohm, standard
Termination	120Ω balanced line
Position	
Resolution	12 bit (1 part in 4096)
Accuracy	0.1% full scale
Potentiometer	1000Ω typical (500 to 10kΩ)
Quadrature Optical Encoder	1000 to 4000 pulses
Environment	
Temperature	-40 to 70C (-40 to 158°F)
Relative Humidity	0 to 95% non-condensing

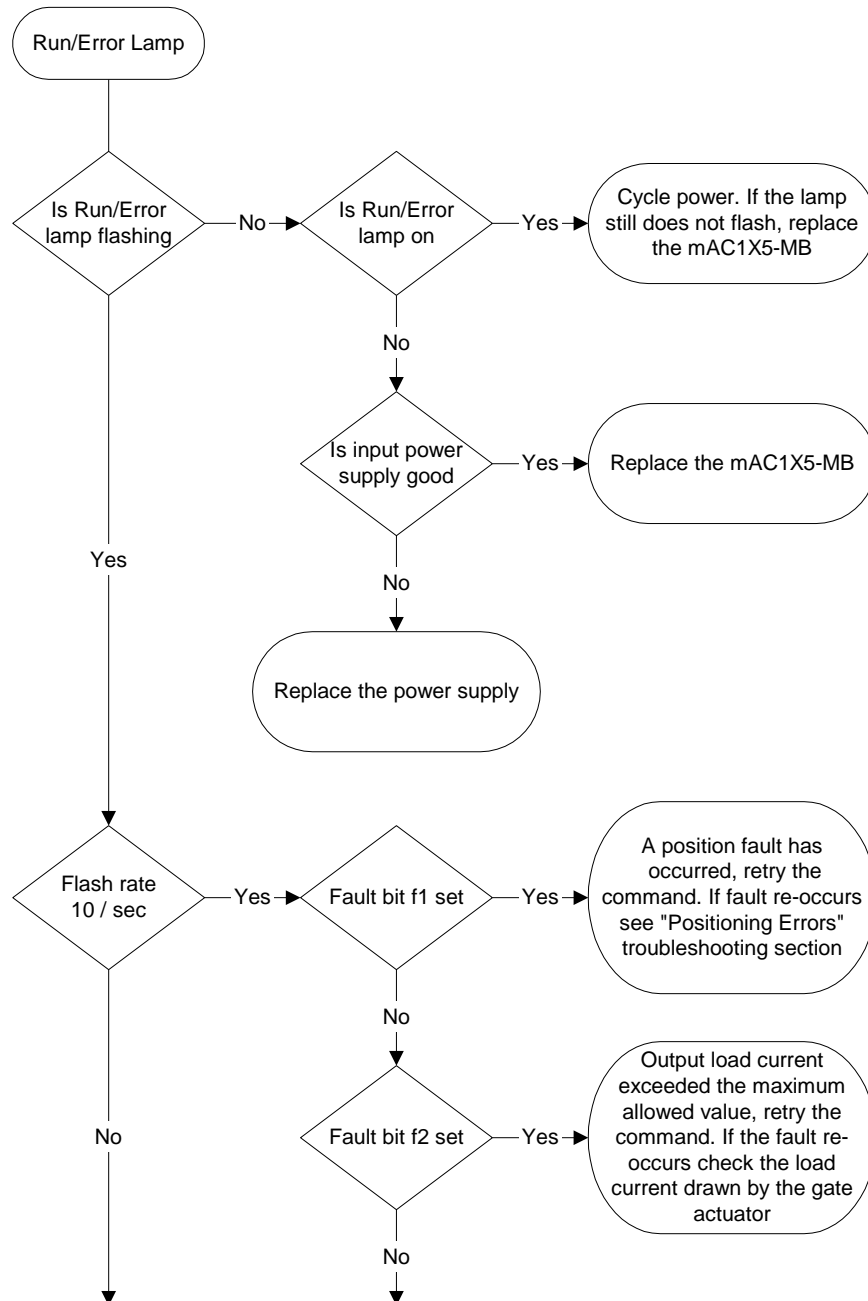


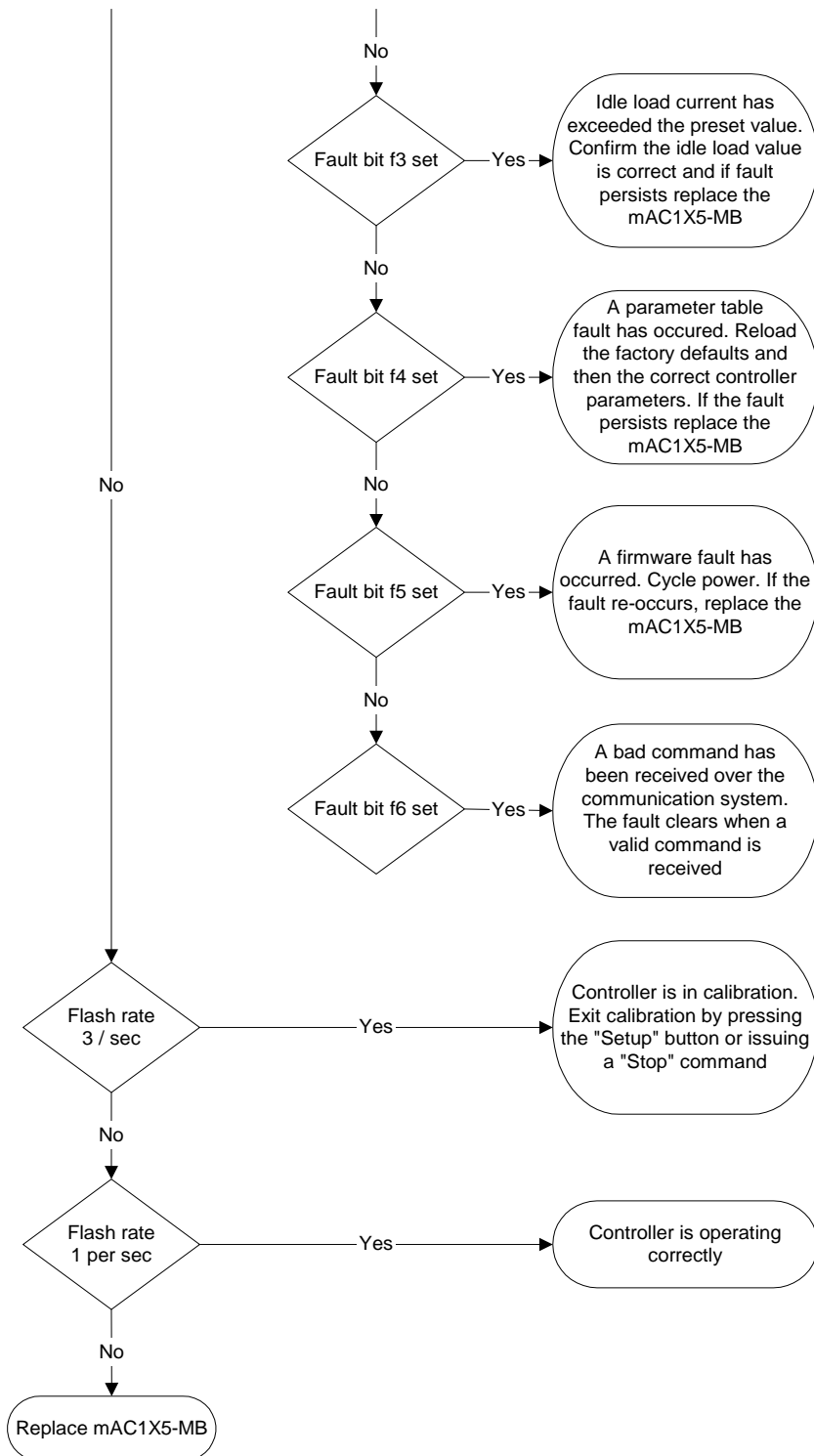
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10. Troubleshooting Guide

10.1 The Run/Error Indicator



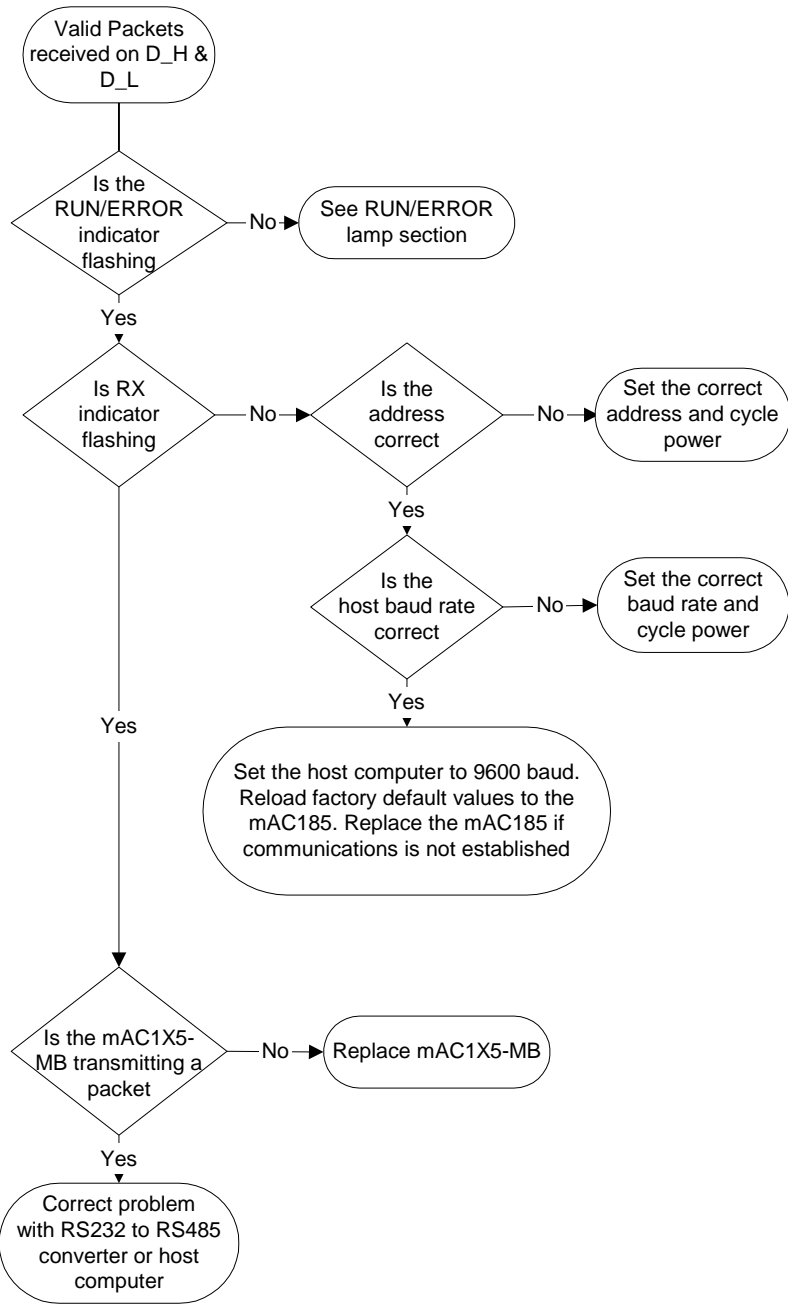


10.2 Communicating with the mAC1X5-MB



Prior to using this guide for troubleshooting communication problems, ensure the following:

1. You are using a proven Modbus 485 Master RTU communications program.
2. Use a breakout box to verify you are sending packets to the RS232 to RS485 converter. The “TX”, “RTS” and “CTS” lamps of the breakout box should be flashing. If the “RX” lamp is flashing, the controller is responding to the packets
3. Be sure power is applied to the RS232 to RS 485 converter and that the converter is working properly. Use a meter to verify the output of the converter.
4. Ensure the polarity of the D_H and D_L lines are correct. The D_H line should be high when idle and the D_L line should be low when idle. The ground reference output of the converter must be connected to the V- terminal of the controller.

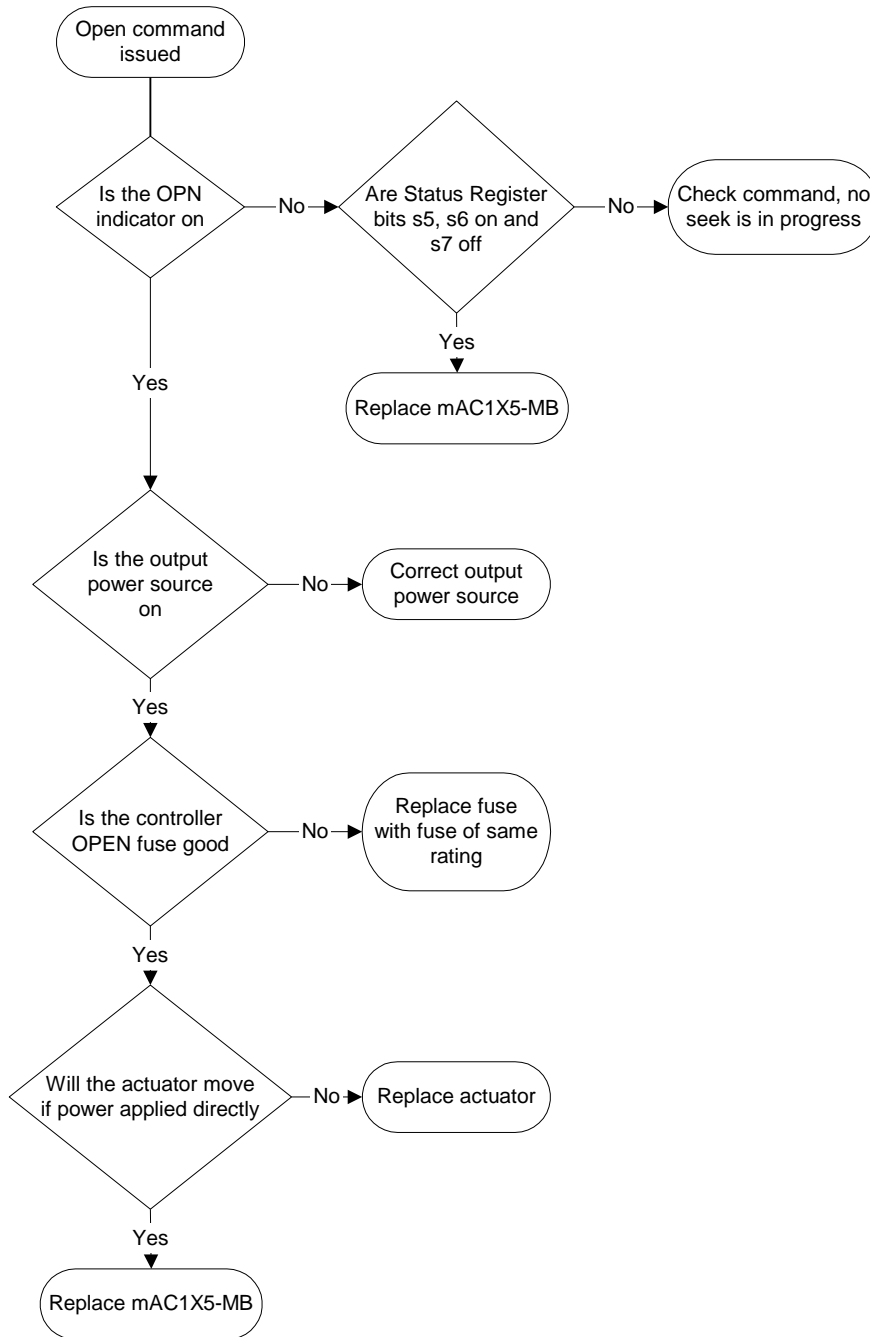




10.3 Positioning Errors

10.3.1 Actuator Will Not Open

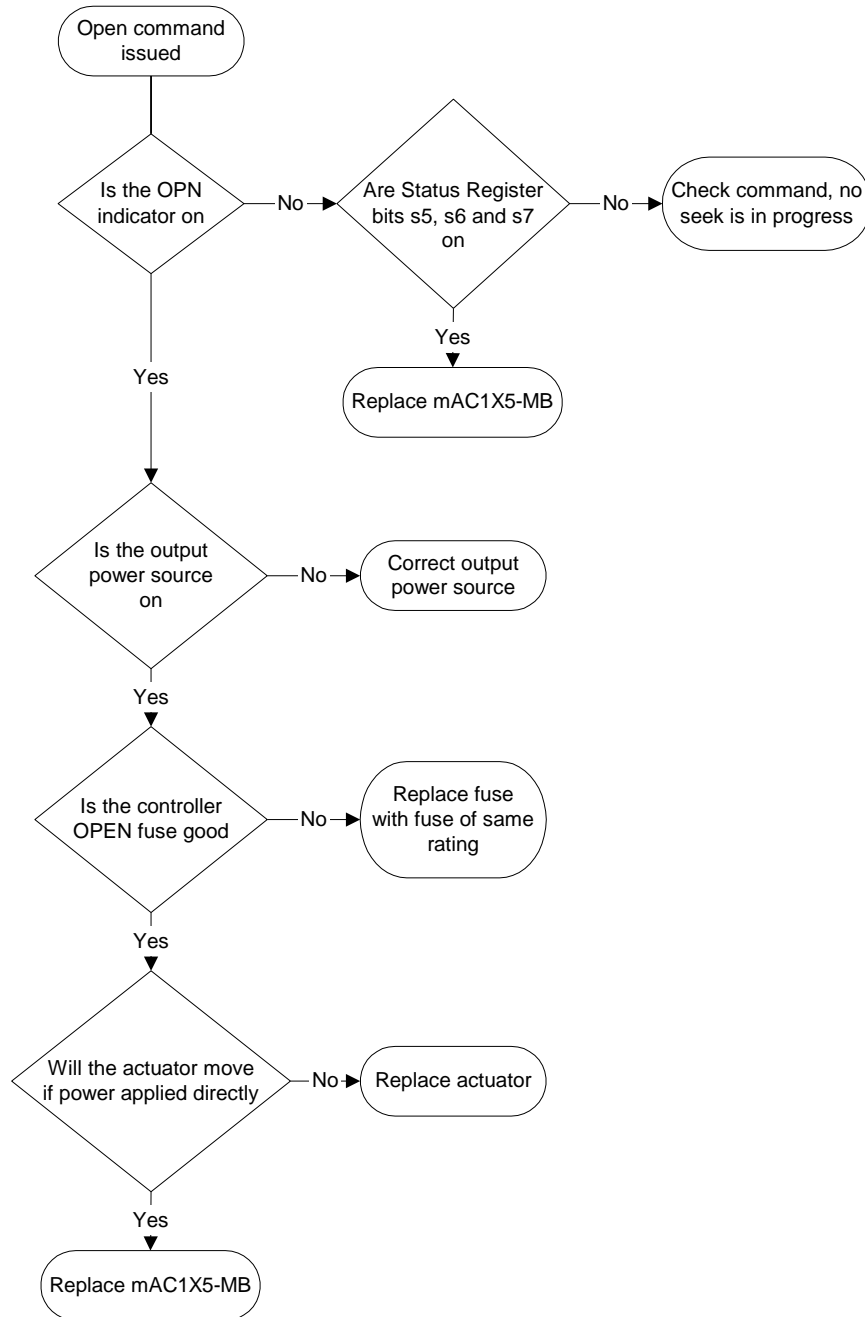
Before using this section if you are using the force open or close options be sure they are not active.





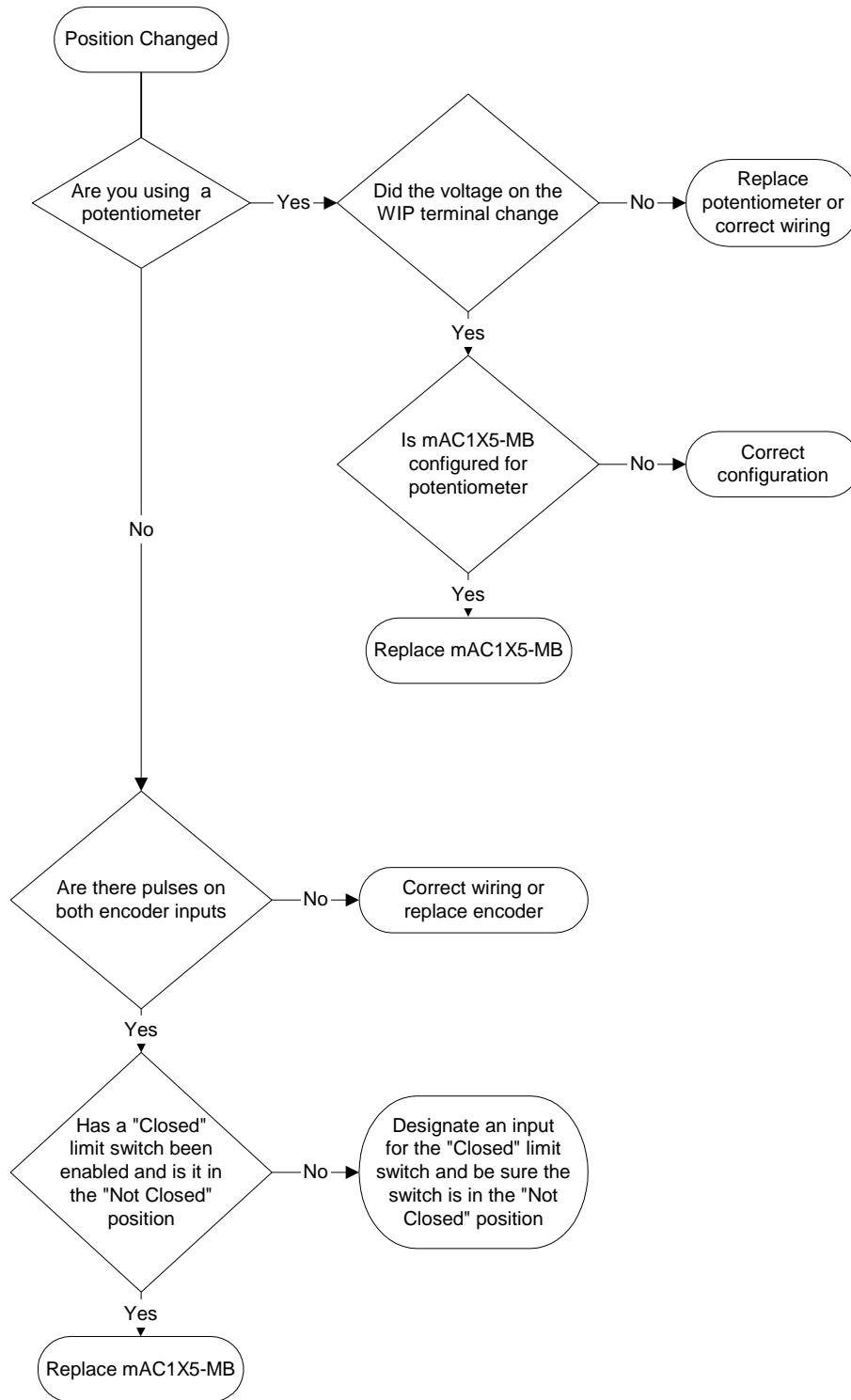
10.3.2 Actuator Will Not Close

Before using this section if you are using the force open or close options be sure they are not active.





10.3.3 Actuator Position Read Back is Incorrect





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10.4 Replacing the Optical Encoder (mGP145-MB)

10.4.1 Removing the Optical Encoder

1. The electronics used in this product are sensitive to static electric discharges. Observe proper handling precautions for static sensitive devices when handling the electronics package. Ensure that both 24VDC and 120VAC power supplies are disconnected. Unplug the data and limit switch connectors from the top circuit board. Remove the electronics package by releasing the single hex head screw and withdrawing the circuit board. Unplug the AC and encoder connectors from the bottom circuit board. Set the electronics package aside.
2. Modify a standard Allen wrench as shown in Figure 8.

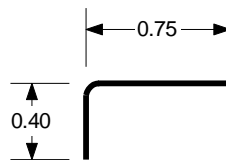


Figure 9 - Standard 0.035" Allen Key Cut to 0.75" Length

3. Using needle nose pliers, insert the Allen wrench into the key access hole in the encoder. See Figures 9 and 10 for access hole location.

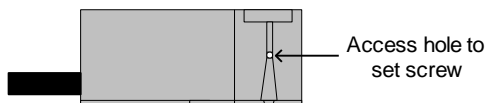


Figure 10 - Encoder Access Hole

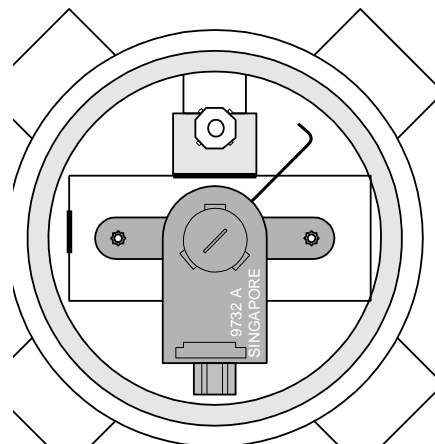


Figure 11 - Allen Key Location

4. Push the key into the encoder with the tip of your finger while rotating the encoder shaft, until the key access hole is located and the Allen key is fully inserted in the set screw.
5. Rotate the Allen wrench counter-clockwise to release the encoder wheel from the shaft.



6. Remove the threaded spacer holding the ground lug to the housing and then remove the lock washer and lug.
7. Slide the encoder bracket from the housing.
8. Remove the 2 nuts securing the encoder and remove the encoder from the bracket.
9. Remove the electrical connector from the encoder.

10.4.2 Installing the Optical Encoder

1. Ensure the modified Allen key is fully in place within the encoder (See **Removing the Optical Encoder**”).
2. Insert the electrical connector into the encoder.
3. Place the encoder on the bracket and fasten with 2 nuts with lock washers.
4. Install the bracket into the housing over the shaft and grounding stud. Place the ground lug, then the lock washer and finally the threaded spacer on the ground lug. Secure the threaded spacer finger tight at this time.
5. Tighten the set screw using the previously inserted Allen wrench. The encoder shaft should not be able to turn while the wrench is in place with the set screw tightened. Remove the Allen wrench when the set screw is fully tightened.
6. Test that the encoder shaft turns freely, then hold the bracket in place while tightening the threaded spacer. Ensure the encoder shaft turns freely after tightening the spacer. If the shaft binds, release the spacer and re-position the bracket before tightening.
7. Connect the encoder and AC connector to the bottom board of the electronics package.
8. Slip the electronics package into the housing and secure with the hex screw.
9. Connect the data and limit switch connectors. Observe the wiring routing shown in Figure 11.

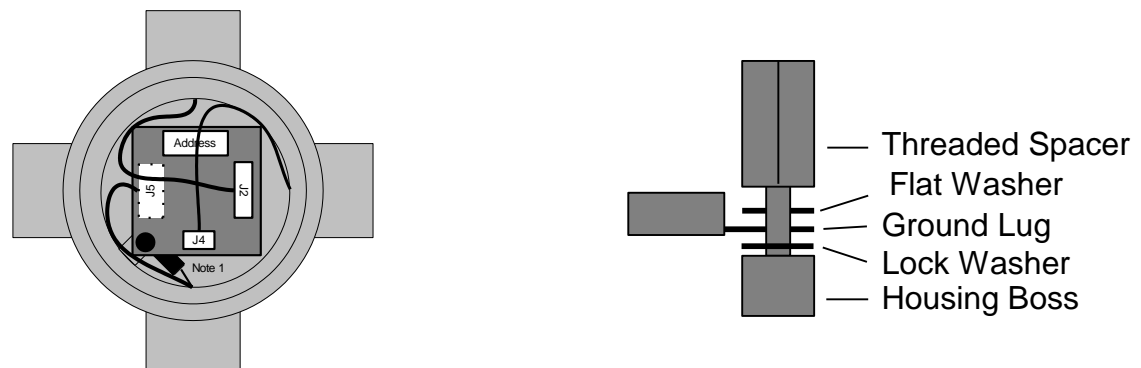


Figure 12 - Wiring Routing Details



Appendix 1 - Positioning System Calculations

The actual position value read from the controller is generated by the following formula:

$$\frac{(\text{Raw counts from the A-D or encoder} - \text{position zero offset value}) * \text{position span value}}{4096}$$



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Appendix 2 - Seek Operation Sequence

When a seek to position, full open or full close command is issued the controller executes a seek operation. The seek operation uses the following logic:

- | | |
|--------|---|
| Step 1 | Determine direction |
| Step 2 | Run output until position, less setback offset is reached |
| Step 3 | If jogging is enabled check current position, otherwise operation is complete |
| Step 4 | If not within seek tolerance jog output for jog on time |
| Step 5 | Wait jog wait time and recheck output, if not within seek tolerance return to step 4 |
| Step 6 | If continuous seek is enabled check position after each jog wait time; restart seek process in jog mode only if position falls outside of seek tolerance. |



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Appendix 3 - Load Current Monitoring System Calculations

The load measuring system uses a current transformer tied to a half wave peak load detector. The value of the peak load detector is read by the 12 bit A-D converter at an interval set by the Current Calculation Timer. The resolution is in 2.08ms increments. It is recommended that this timer be set to 16 for 60hz systems. This ensures at least one full cycle of current flow will have occurred prior to each reading. The following formula is used to calculate the output load current:

$$\frac{(\text{Raw load counts from A-D} - \text{load current zero offset value}) * \text{load current span factor}}{4096}$$

The resulting number scales the output load to x.xx amps. The decimal places are implied and a value read from the controller of 100 would be 1.00 amps.

The load current accuracy improves with applied current. For current under 0.5 amps the accuracy is less than $\pm 25\%$. Between 0.5 and 1 amp the accuracy is $\pm 10\%$ and above 1 amp the accuracy is $\pm 5\%$. For any specific application, the accuracy can be improved by measuring the load current and adjusting the load current span factor.



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Appendix 4 - Dealing with dVdt on the Outputs when Driving Motors Interrupted by Limit Switches

The outputs of the controller utilize TRIACs. TRIACs are susceptible to unwanted turn on if a fast rising voltage is applied across their outputs. The controller incorporates zero crossing switches to prevent these occurrences.

In some applications, especially those that have over travel limit switches protecting motor driven actuators, caution must be taken to prevent the application of voltages capable of causing dVdt.

Figure 14 details the voltages present on a split phase capacitor type motor during operation.

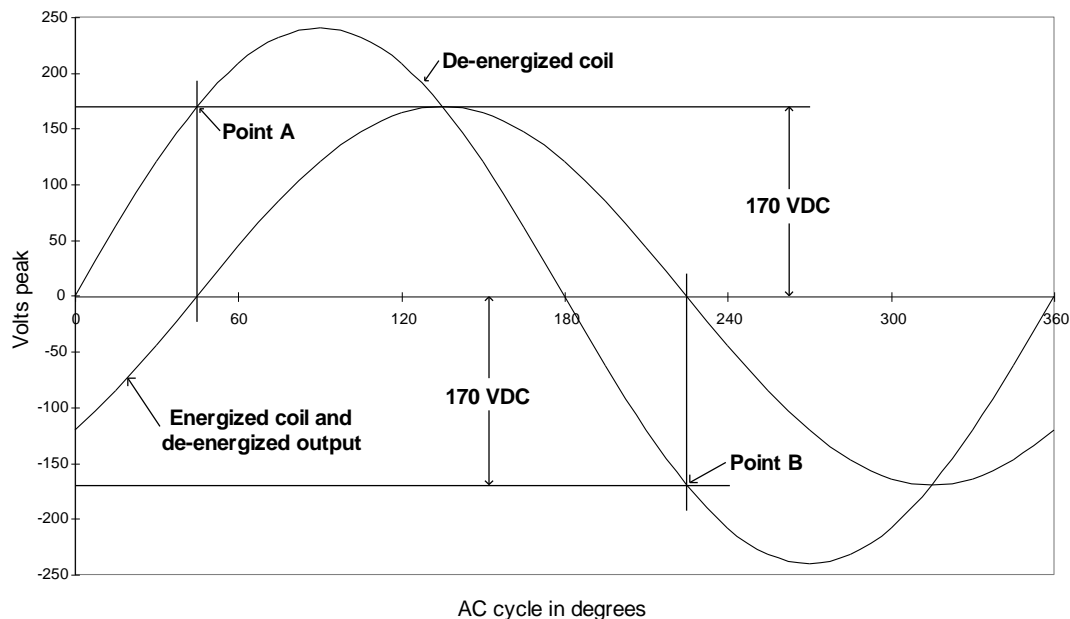


Figure 13 - Phase Comparison Diagram

A problem may occur if the actuator is at one end of its travel and the end of travel limit is open. When the actuator begins to move in the opposite direction, the capacitor used in the motor creates an out of phase voltage on the de-energized winding of the motor. This voltage may exceed the input line voltage. The de-energized output remains in phase with the energized output because of the snubber circuit protecting the TRIAC.

If, by chance, the de-energized output's end of travel limit closes at point A or B on the phase diagram, an immediate high voltage fast rise time pulse occurs on the de-energized output. The rise time of this voltage exceeds the dVdt rating of the output TRIAC turning it on. For one half cycle both TRIACs are on causing excessive current to flow. Repeated operations of this type will damage the output TRIACs.



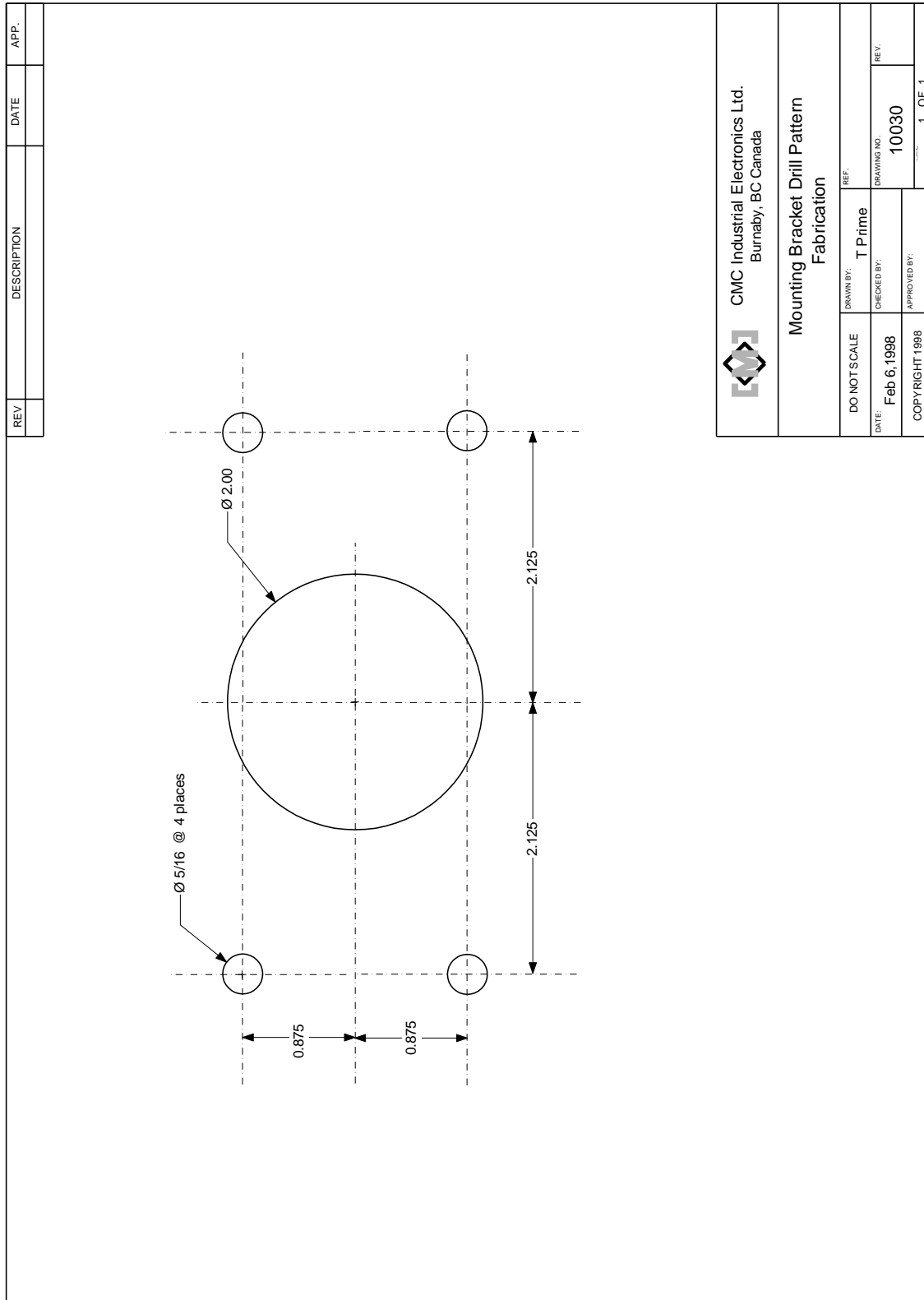
The problem is solved by installing resistors in parallel with the switches as shown in Figure 4 - Output Connections. The resistors override the snubber, forcing the unused output to the same voltage as the motor winding. This prevents sudden voltage changes upon switch closure.

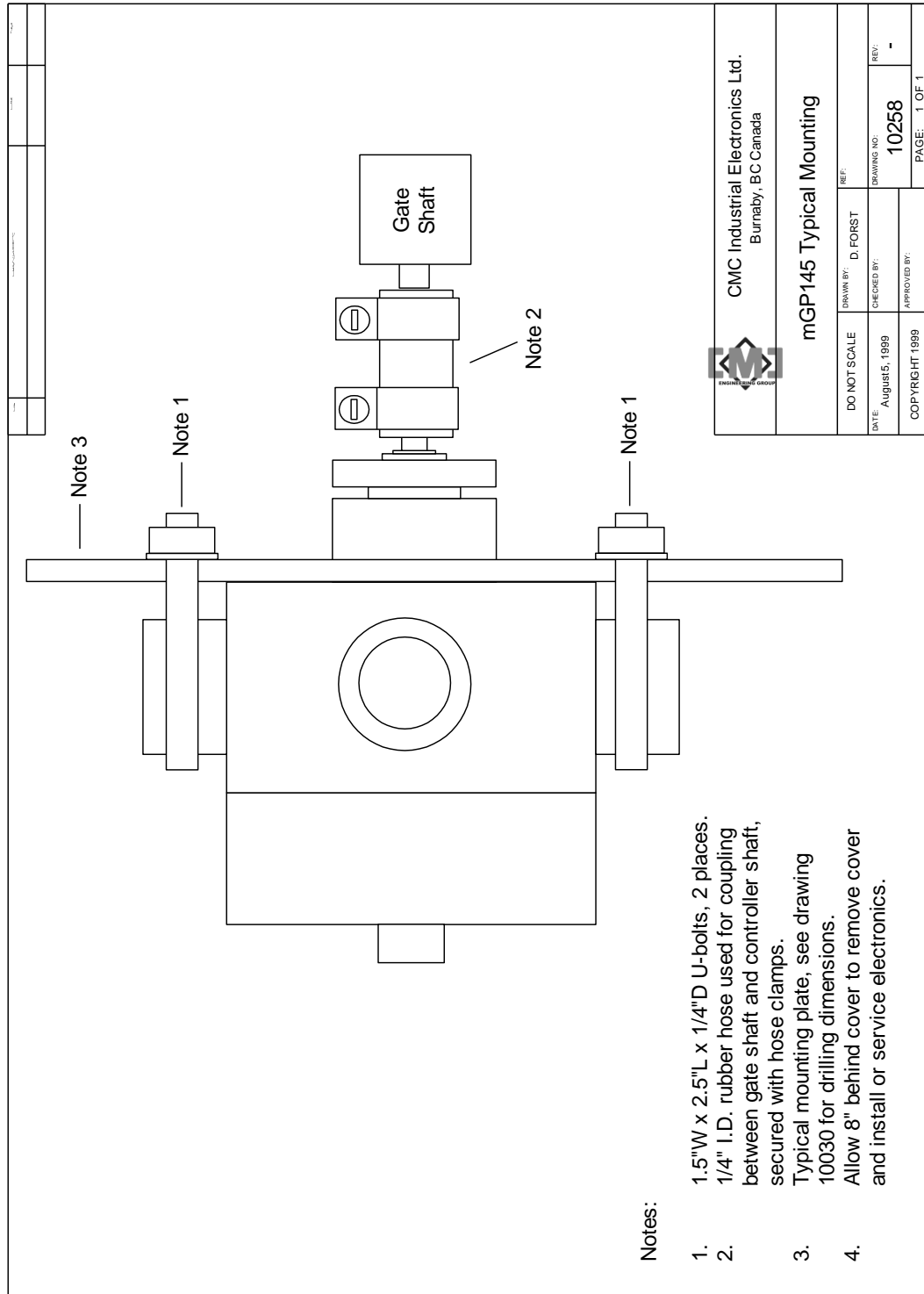


Appendix 5 - Installation Drawings

The following is a list of the installation drawing in this appendix:

10030	Mounting Bracket Drill Pattern
10258	Typical Mounting
10259	Housing Dimension Details
10260	Housing Internal Wiring Details
10267	Schematic Diagram Hydraulic Solenoid Control
10268	Conduit Details Hydraulic Solenoid System
10270	Schematic Diagram Electric Motor Control
10269	Conduit Details Electric Motor System
10284	Gate Positioner Data Cable Wiring Overview
10467	Gate Positioner Terminal Board mTB002 Wiring Overview
10841	mAC185 Actuator Controller Wiring Diagram





Notes:

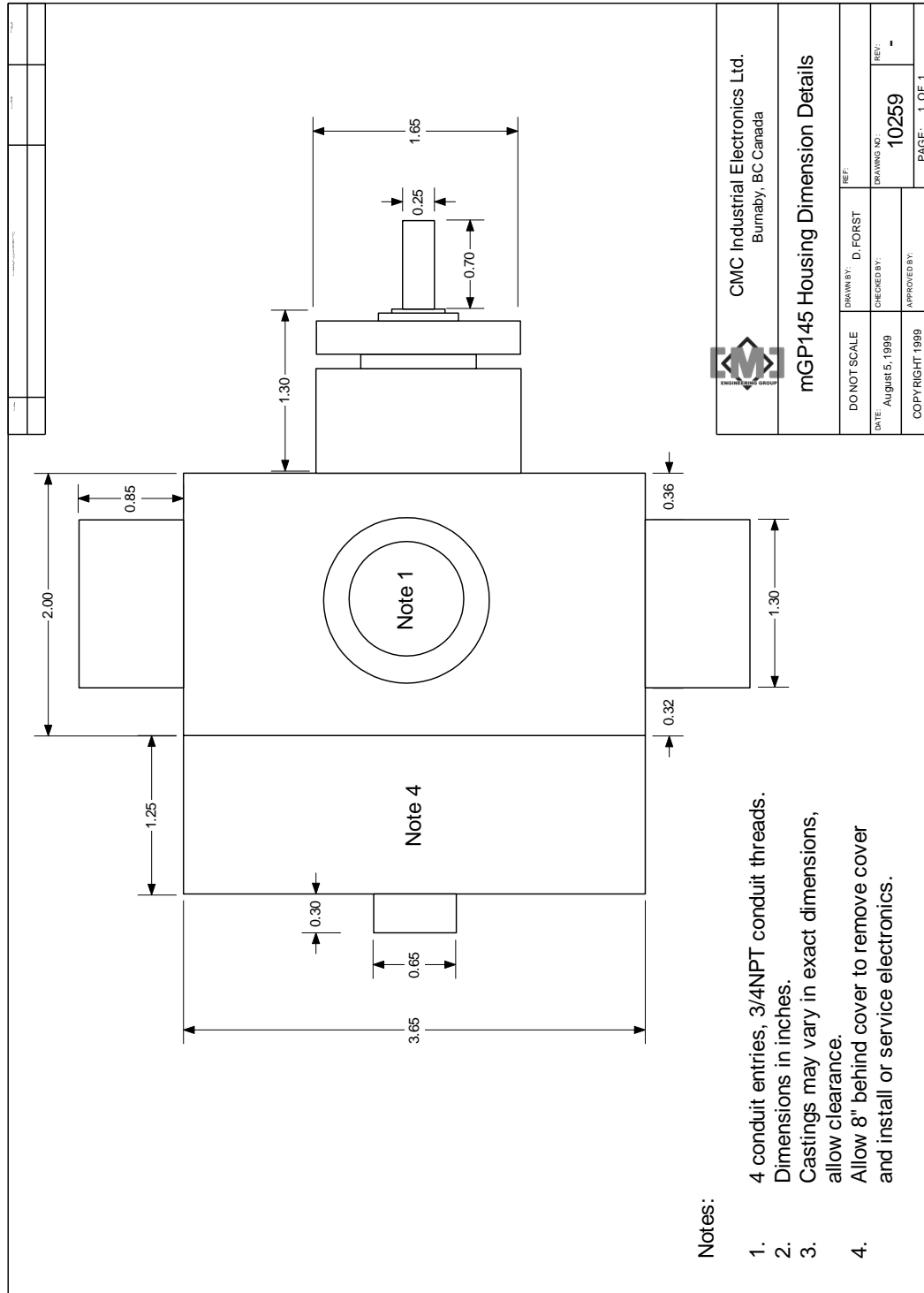
1. 1.5"W x 2.5"L x 1/4"D U-bolts, 2 places.
2. 1/4" I.D. rubber hose used for coupling between gate shaft and controller shaft, secured with hose clamps.
3. Typical mounting plate, see drawing 10030 for drilling dimensions.
4. Allow 8" behind cover to remove cover and install or service electronics.

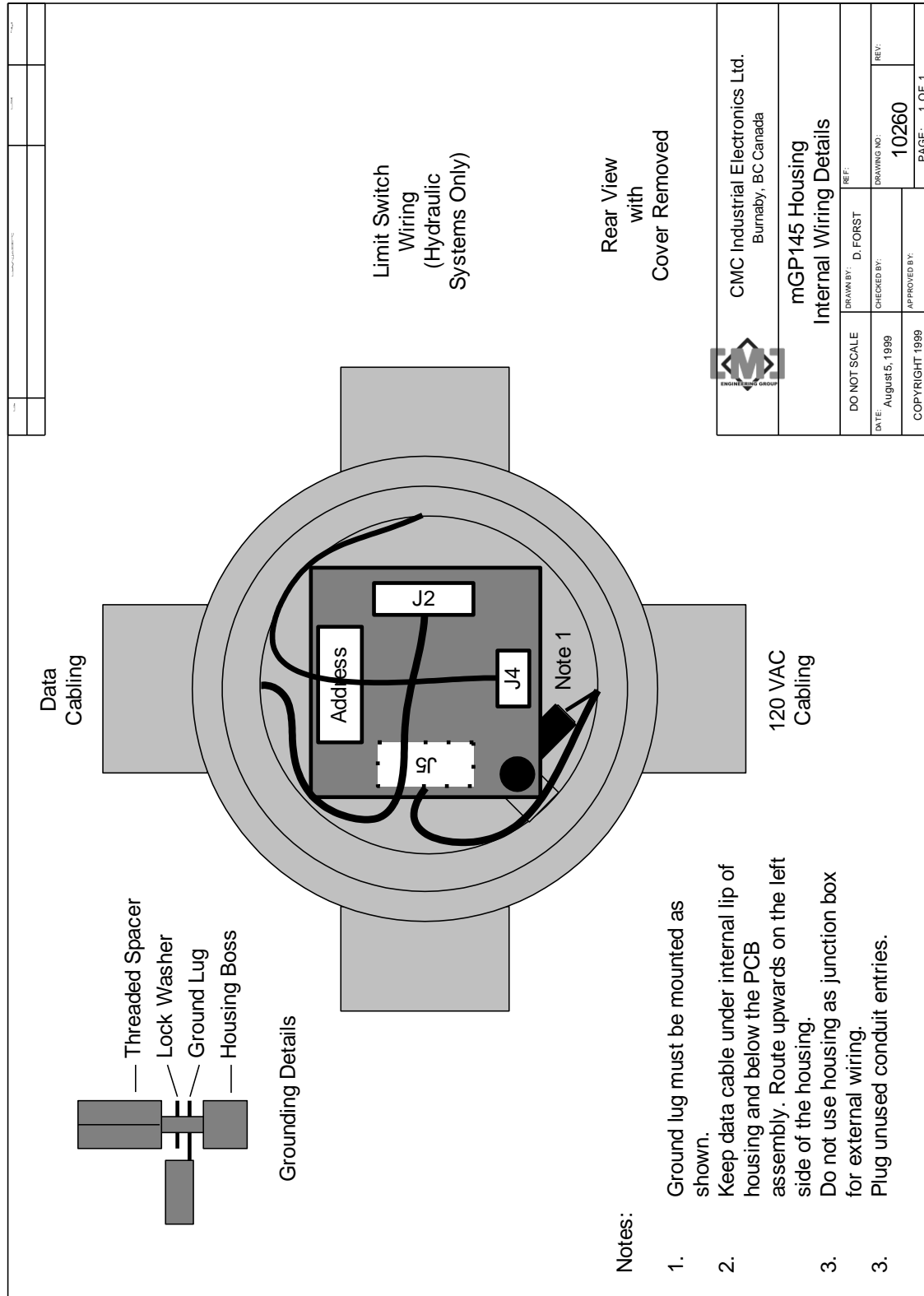


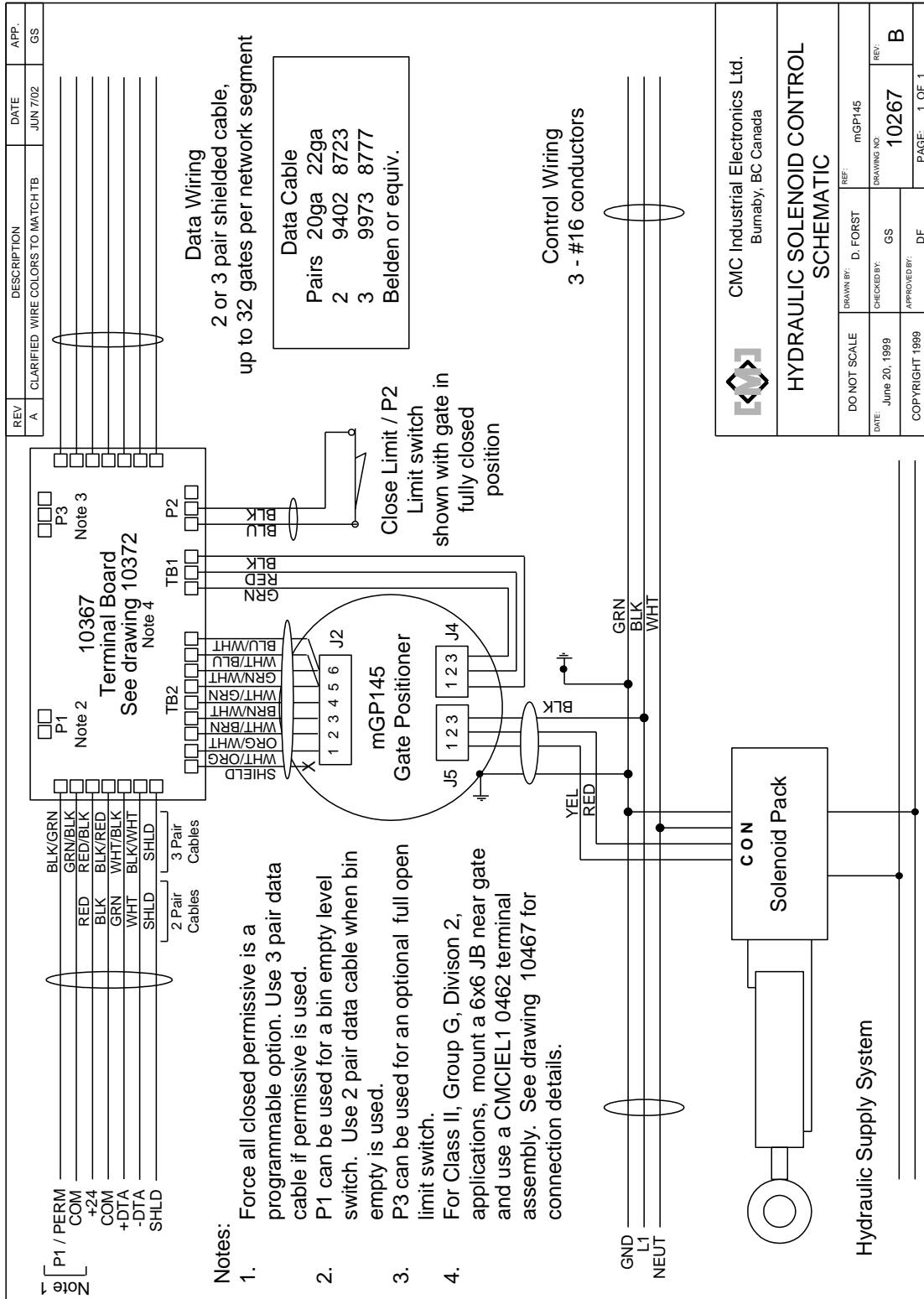
CMC Industrial Electronics Ltd.
Burnaby, BC Canada

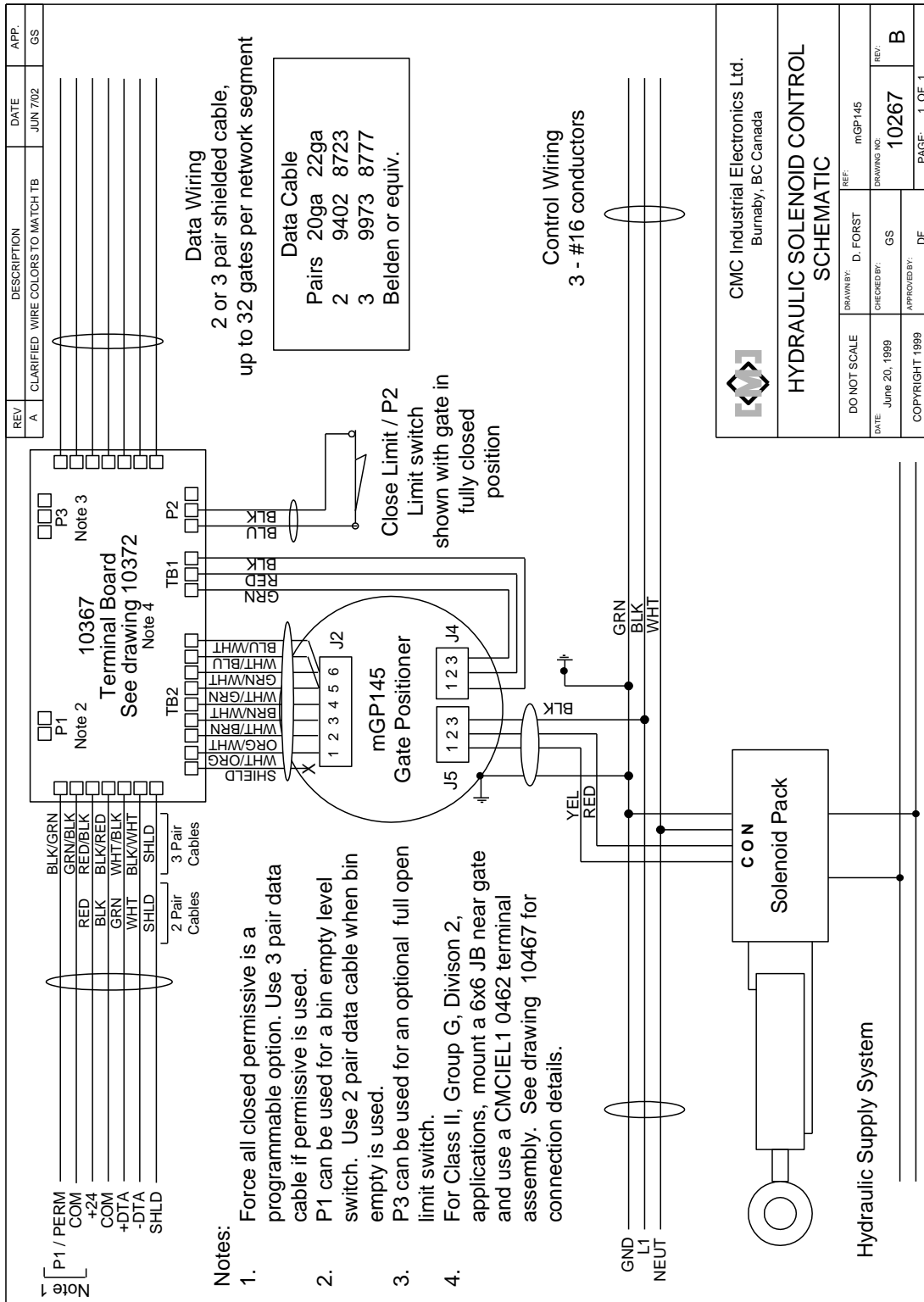
mGP145 Typical Mounting

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		PAGE: 1 OF 1

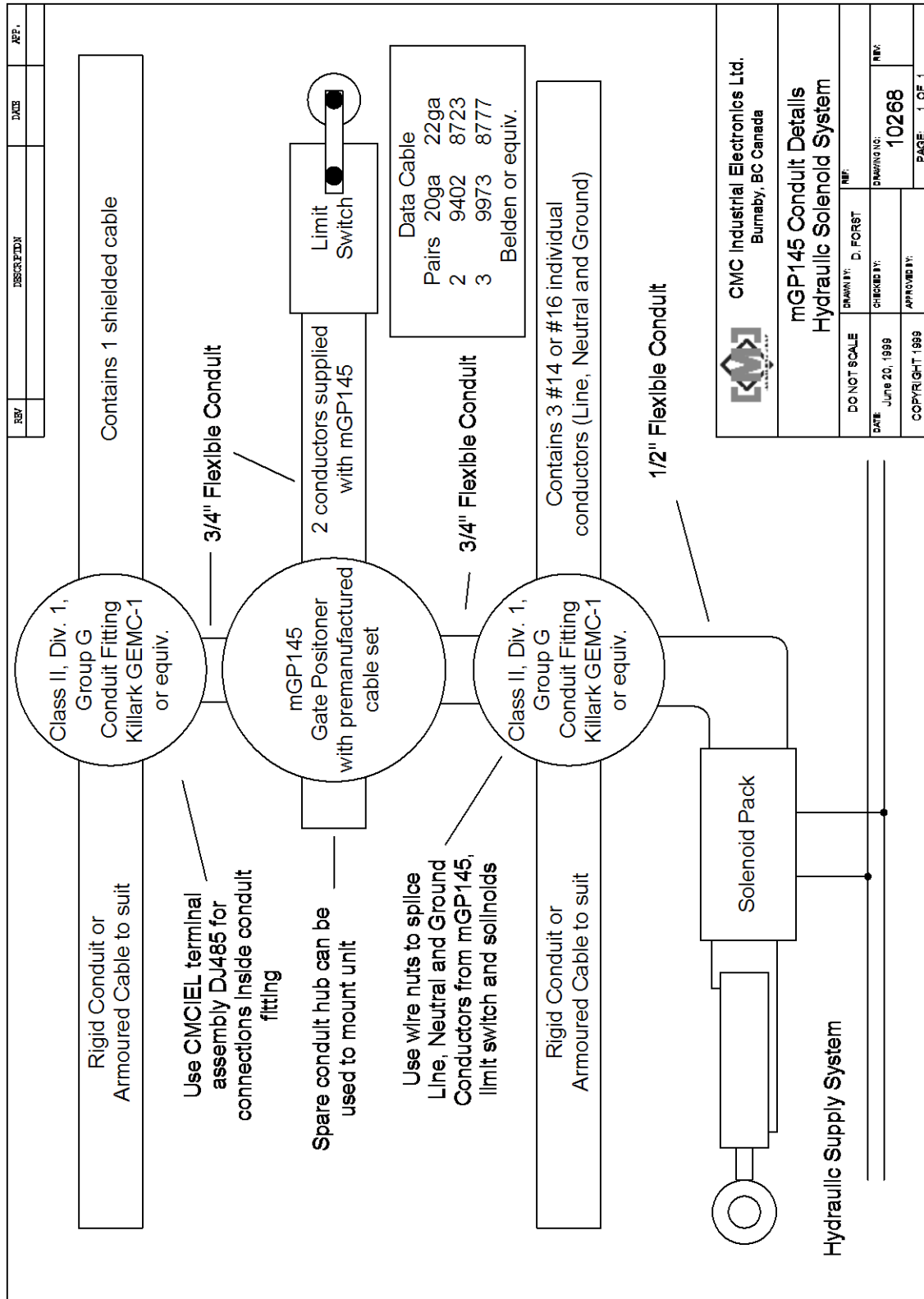




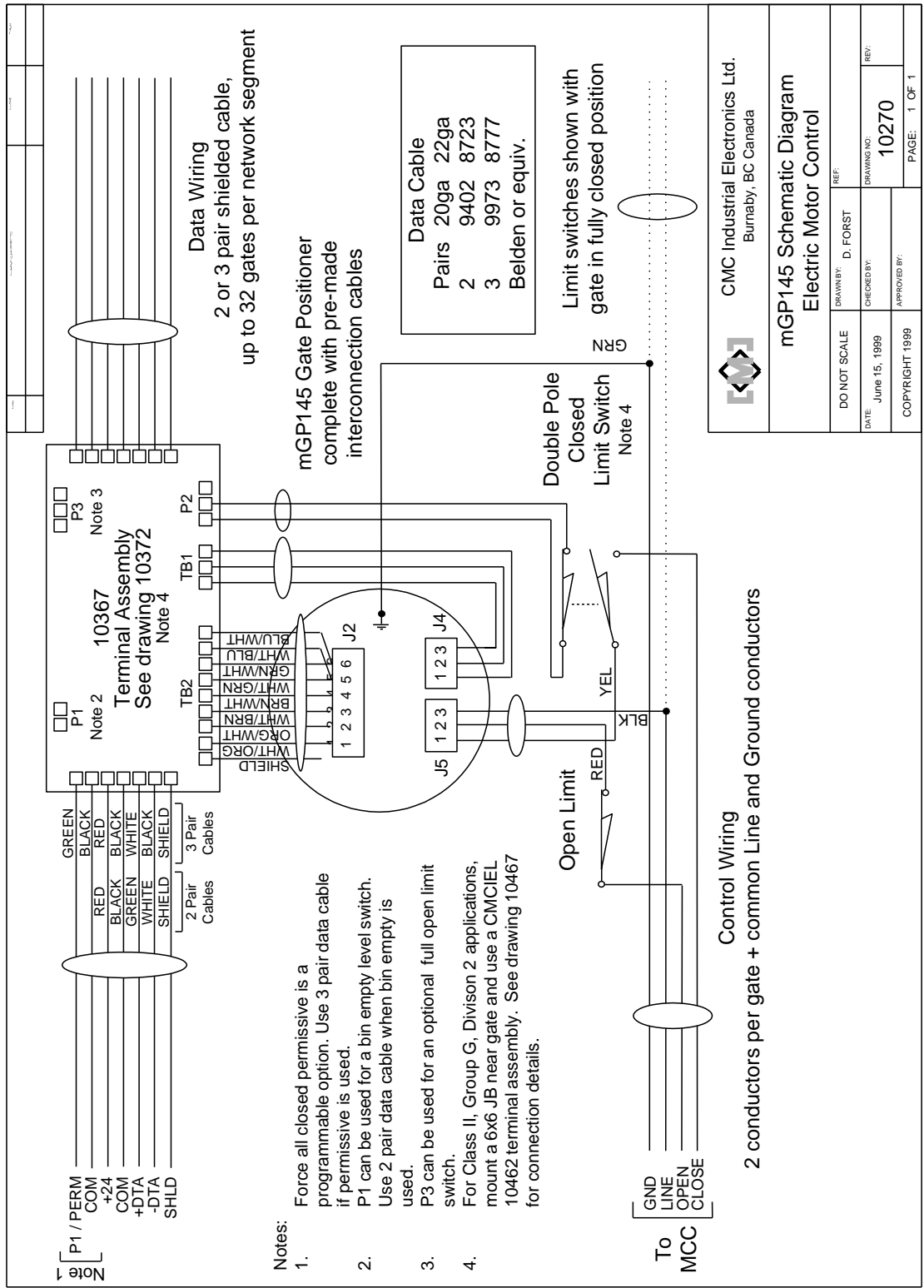




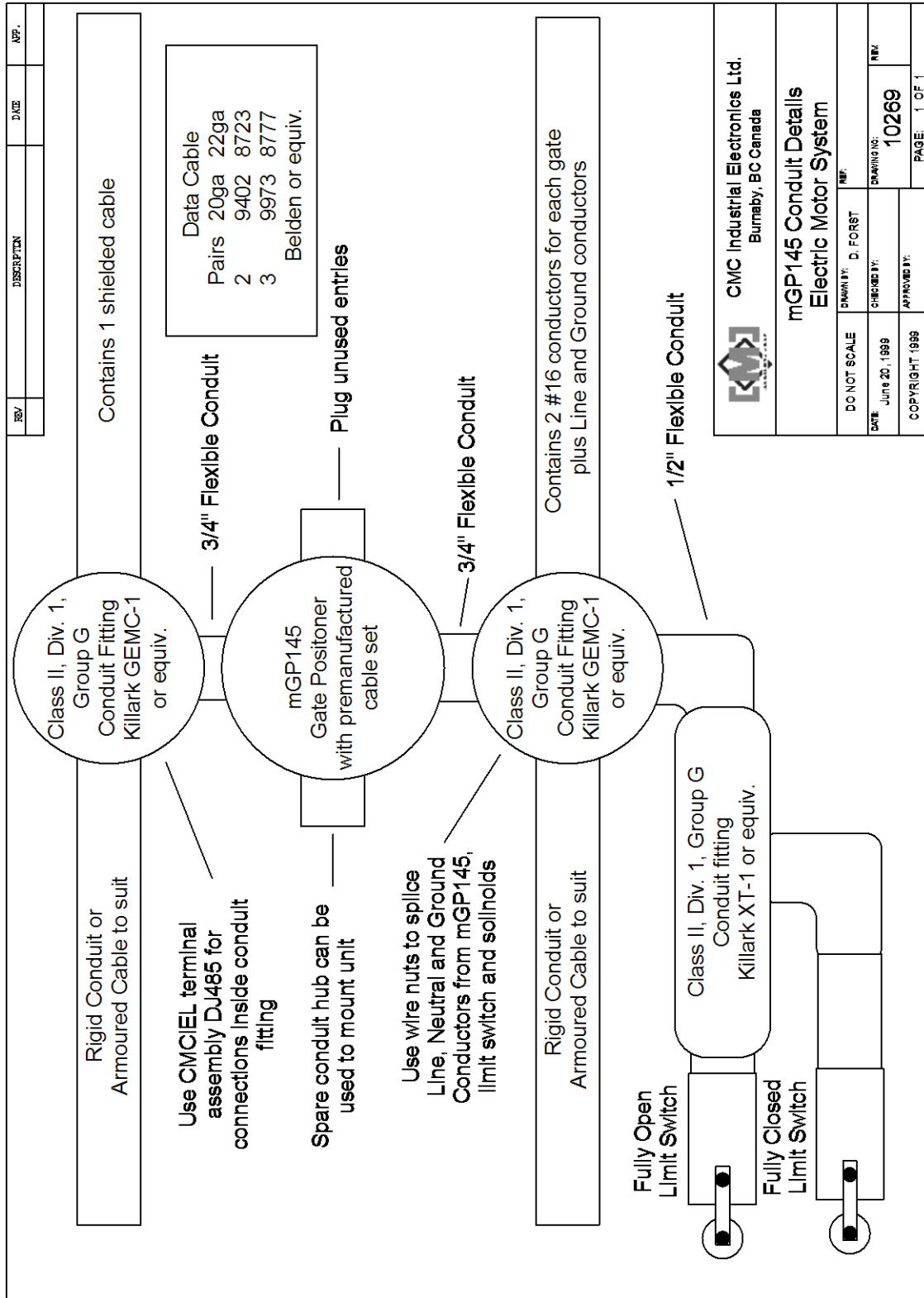
		CMC Industrial Electronics Ltd. Burnaby, BC Canada	
HYDRAULIC SOLENOID CONTROL SCHEMATIC			
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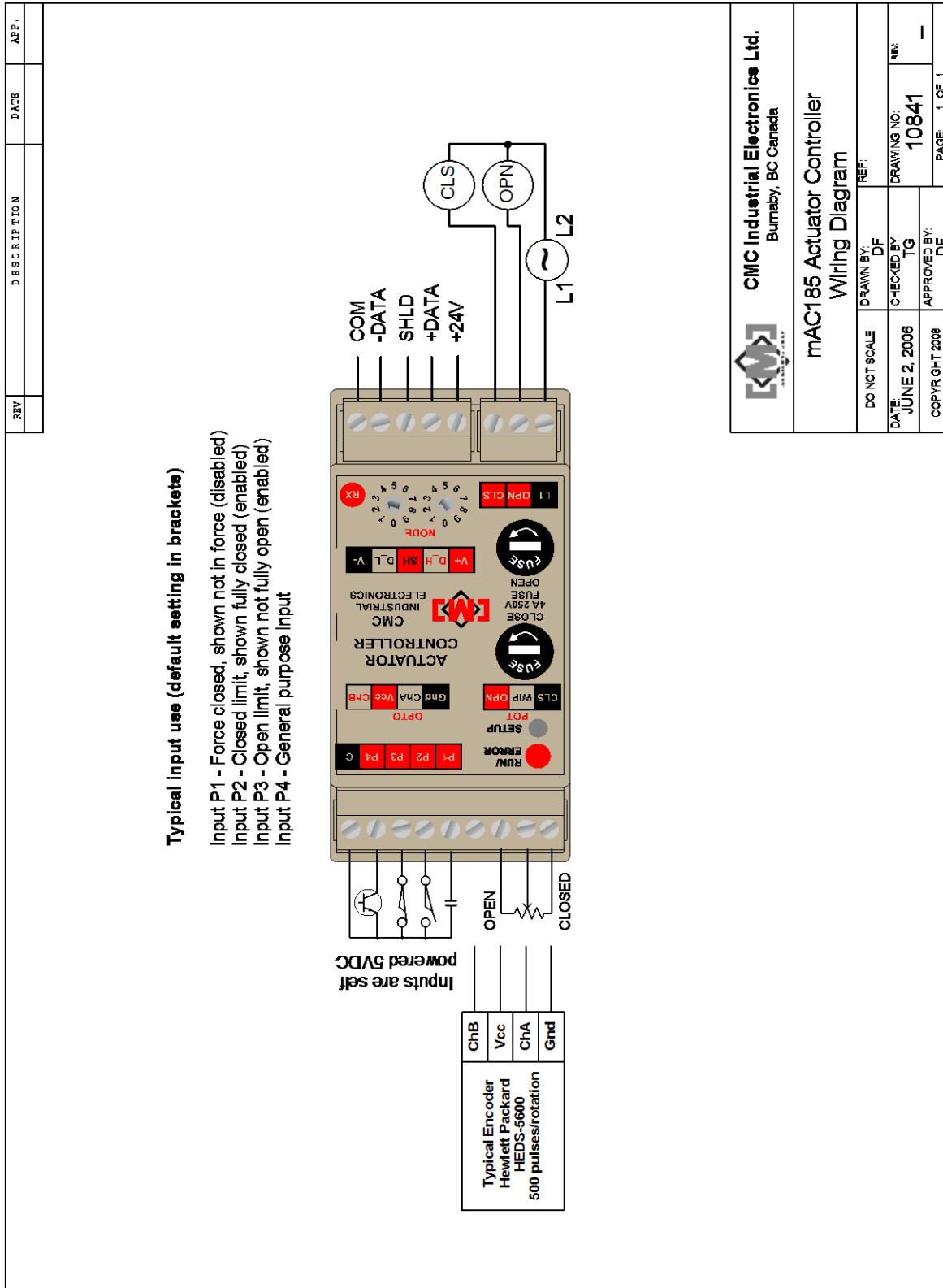


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mGP145 Conduit Details Hydraulic Solenoid System	
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mGP145 Schematic Diagram Electric Motor Control			
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DATE: June 15, 1999	CHECKED BY:	DRAWING NO: 10270	REV:
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