

**MD PLUS SERIES**

# **DART**

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# **CONTROLS**

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## **Instruction Manual**

**Field Programmable Closed Loop DC Speed Control**

Re-Order from  
**Omegamation™**  
**1-888-55-66342**  
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# Quick Jump

**What models and options are available?**

**See page 38.**

**Looking for detailed specifications?**

**See page 38 & 39.**

**Want to get started fast?**

**See basic electrical hook-up details on page 6.**

**See mechanical installation details on page 3,4 & 5.**

**See some sample applications starting on page 34.**

**Need Help?**

**See troubleshooting on page 37.**

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NOTE: Carefully check the control for shipping damage. Report any damage to the carrier immediately. Do not attempt to operate the drive if visible damage is evident to either the circuit or to the electronic components.

All information contained in this manual is intended to be correct, however information and data in this manual are subject to change without notice. DCI makes no warranty of any kind with regard to this information or data. Further, DCI is not responsible for any omissions or errors or consequential damage caused by the user of the product. DCI reserves the right to make manufacturing changes which may not be included in this manual.

### WARNING

**Improper installation or operation of this control may cause injury to personnel or control failure. The control must be installed in accordance with local, state, and national safety codes. Make certain that the power supply is disconnected before attempting to service or remove any components!!! If the power disconnect point is out of sight, lock it in disconnected position and tag to prevent unexpected application of power. Only a qualified electrician or service personnel should perform any electrical troubleshooting or maintenance. At no time should circuit continuity be checked by shorting terminals with a screwdriver or other metal device.**

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NOTE: This manual revision is applicable to MD *plus* software Version 7 and up, and OPT420 software version 2 and up. See pages 16 and 32 for information on determining the software version numbers of a particular unit..

# Introduction

The Micro-Drive *plus* ("MD *plus*") series motor controls are compact, microprocessor-based units capable of being either field or factory configured for a number of industry's motion control needs. These controls are designed around a velocity form PID algorithm. They can be easily configured to operate as a digital speed controller, time-based process controller, or a ratiometric follower controller in master-slave systems. Featuring Dart's new ModularBus expansion slot architecture, the MD *plus* series is ideal for volume OEM Adjustable Speed Drive applications requiring specialized inputs and outputs, such as our OPT420 optically-isolated 4-20mA I/O card that comes factory-installed in the MD40P-420, MD50P-420 and MD50E-420. Contact Dart Controls' Sales Department for details. The unique ModularBus expandability makes the MD *plus* series ideal for applications such as:

Water and Waste Treatment Systems

Conveyor Oven Controllers

Synchronized Conveyor Lines

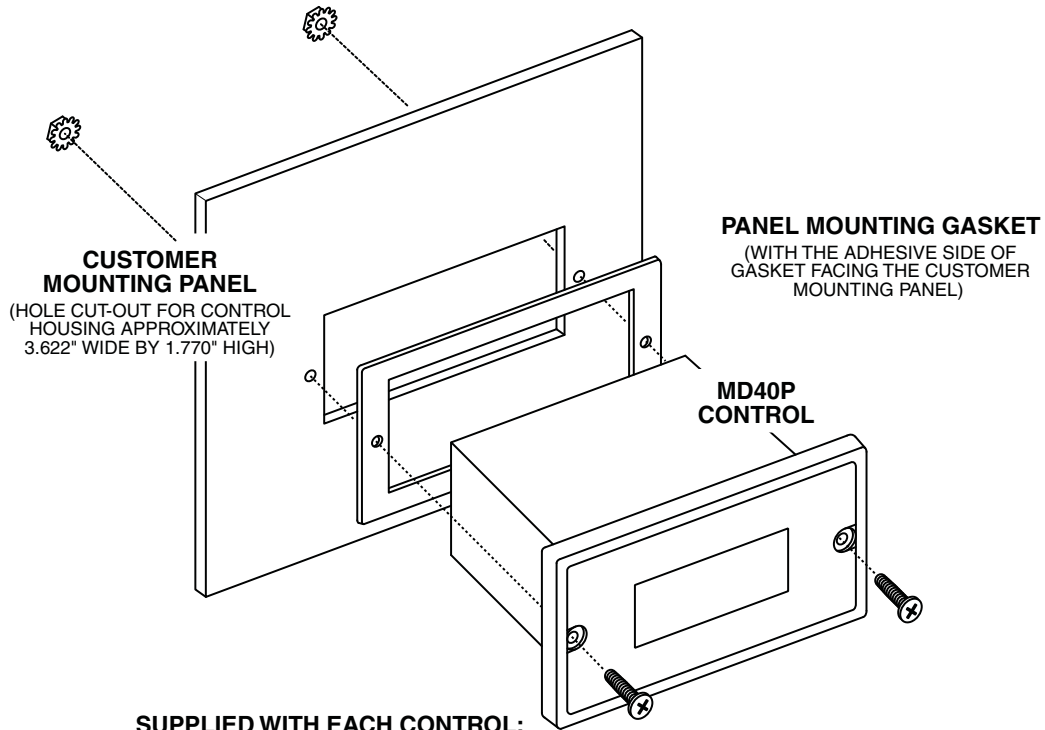
The MD40P and MD50P's Durable 1/8 and 1/4 DIN NEMA 4/4X aluminum housings can be easily mounted in a panel or control cabinet, and the MD50E's fully-enclosed NEMA 4 enclosure can be wall/bulkhead mounted. The new optional pluggable terminal block allows the user to quickly install or replace units without the hassle of physically removing and reattaching wires. The units can be ordered with either the standard European-style 5mm terminal block or the optional "pluggable" connector.

## General Features

- Microprocessor-based design allows for incredible flexibility to suit your process control needs
- ModularBus expansion makes it possible for the MD *plus* to accommodate a wide variety of I/O
- Digital closed-loop algorithm ensures accuracy of  $\pm 1/2$  RPM of set speed or equivalent
- Non-volatile memory stores settings without batteries, even when power has been removed
- Factory or field programmable via front-panel keypad
- Many adjustable settings include min, max, accel, decel, display options, alarm options, and more
- Internal program-enable jumper selectively prevents tampering with unit's configuration
- Universal power supply accepts line voltage inputs from 85-250VAC models @ 50-60Hz without switches or jumpers. The unit automatically adjusts as needed.
- Transient voltage protection prolongs unit's life in harsh industrial environments
- Compatible with a variety of signal input types including: Hall-Effect Pickups, Photoelectric, TTL, etc. Note: Open collector devices must be capable of sinking at least 3mA
- Self-contained power supply for external pickups, limited to 5V @ 50mA
- Two separate programmable alarm outputs with Form C contacts
- Flexible user inputs support Inhibit, Emergency-Stop, and Jog functionality
- Large 4 digit, 1/2" LED display, with user-settable decimal point (colon displayed in Time mode)
- Durable NEMA 4/4X rated aluminum housing with Polycarbonate membrane and gasket (which are included) meet NEMA 4X standards when used with NEMA 4X enclosures
- European-style 5mm terminal block or pluggable terminal block available
- cULus approval pending
- Wide operating ambient temperature range of -10°C to 45°C (14°F to 113°F)
- Multiple operating modes including:
  - Master, Rate Mode – Controls in Engineering Units such as RPM, Gallons per Second, etc.
  - Master, Time Mode – Controls in time units such as HH:MM, MM:SS, SS:TT, or other unit
  - Follower Mode – Controls in percentage of master rate. This mode allows the MD *plus* control to precisely follow the actions of a master process

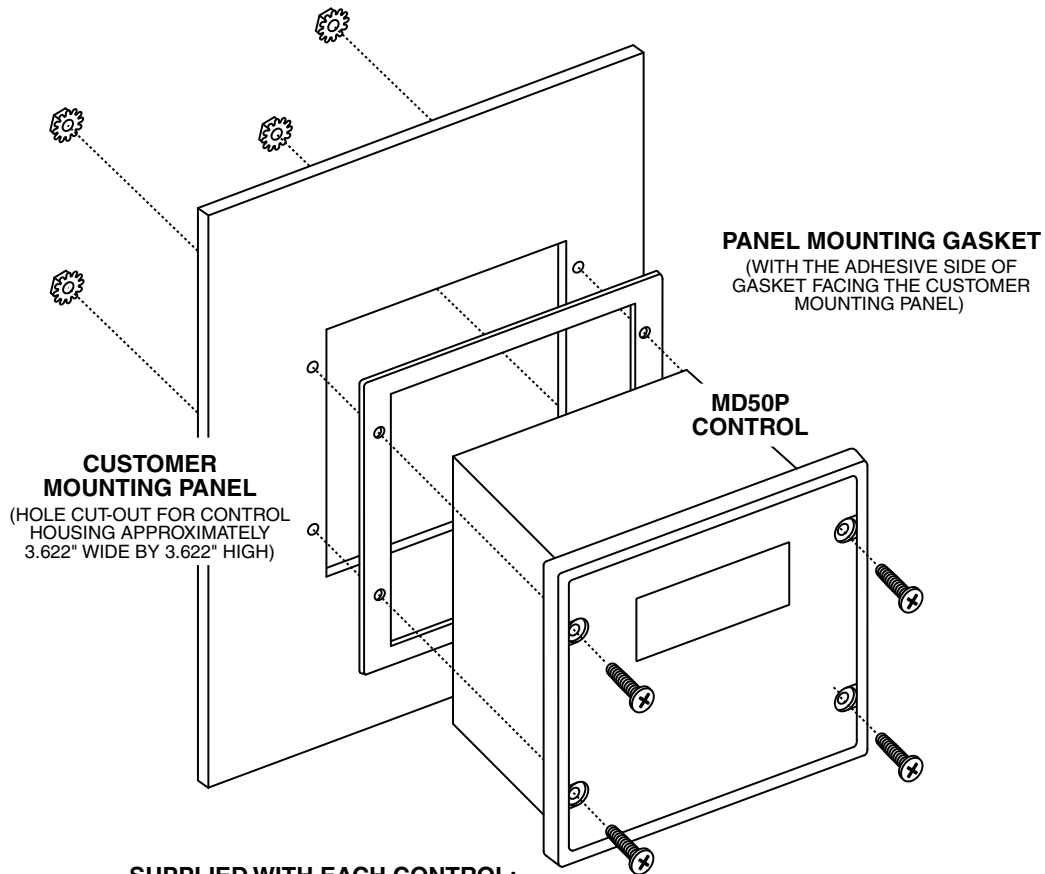
# Installation and Mechanical Dimensions

## Exploded Panel View



### SUPPLIED WITH EACH CONTROL:

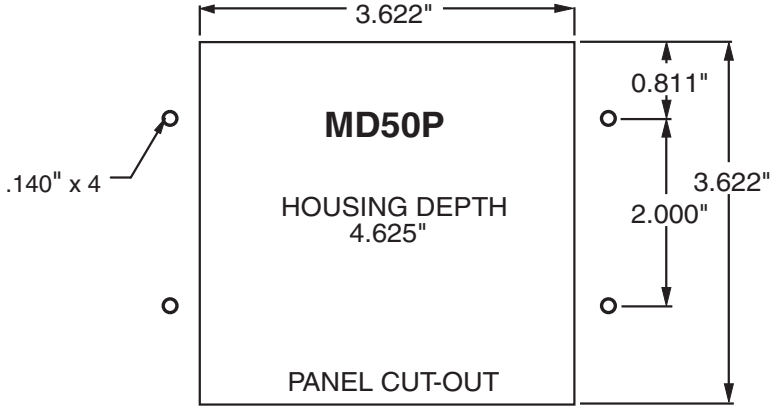
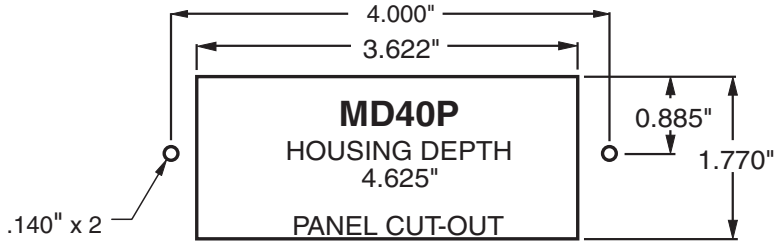
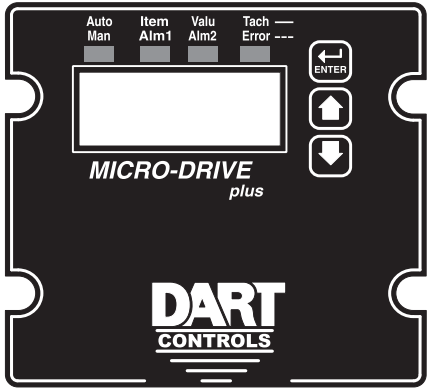
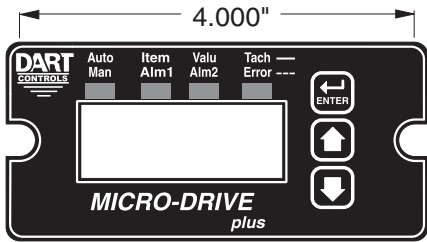
- 1) GASKET
- 2) (2) 6-32 X 3/4 PANHEAD BLACK OXIDE STAINLESS SCREWS
- 3) (2) #6 NUT WITH LOCKWASHER



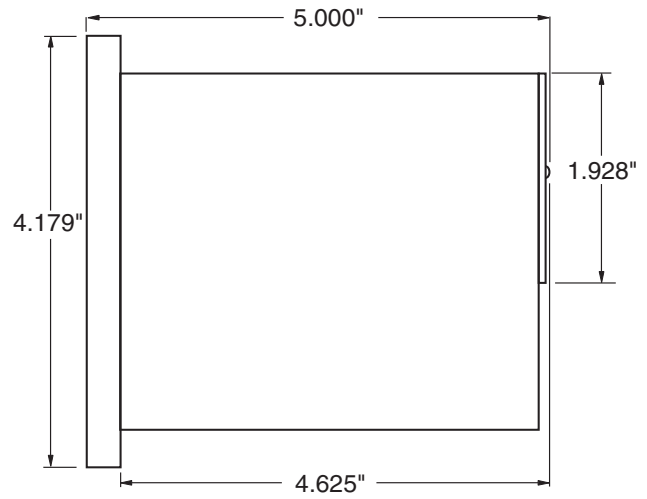
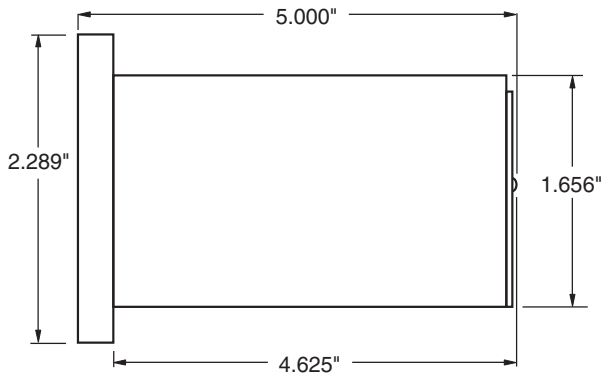
### SUPPLIED WITH EACH CONTROL:

- 1) GASKET
- 2) (4) 6-32 X 3/4 PANHEAD BLACK OXIDE STAINLESS SCREWS
- 3) (4) #6 NUT WITH LOCKWASHER

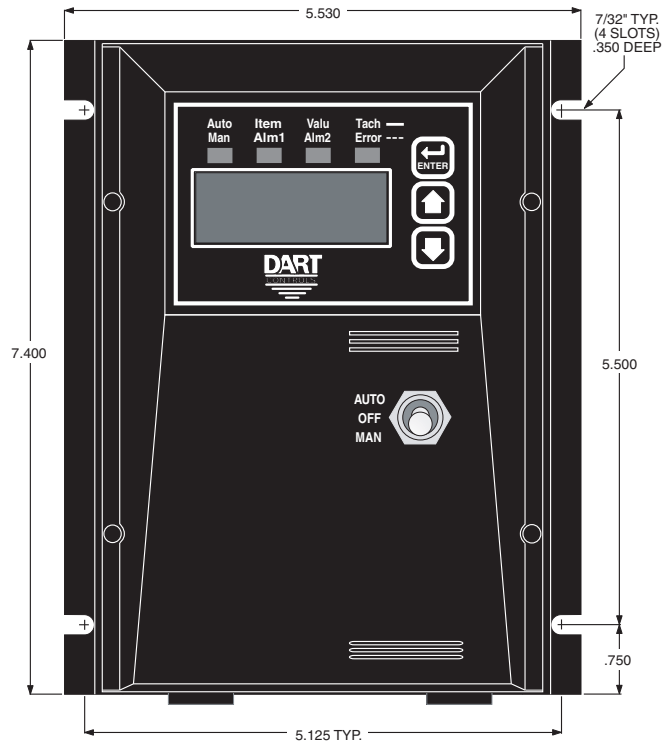
# Cut-out and Mounting Dimensions



## MD40P and MD50P Dimensions



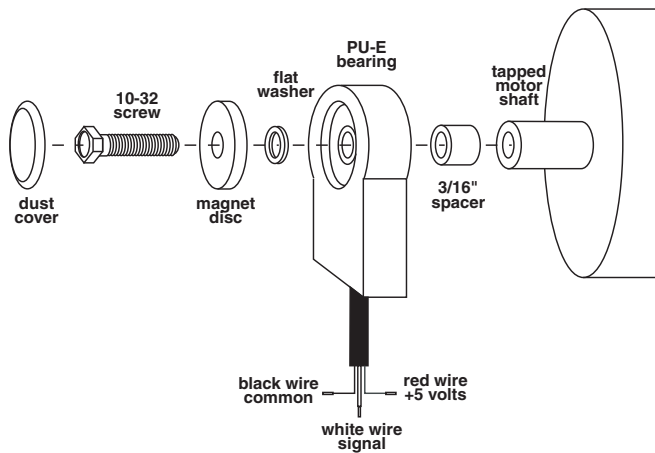
## MD50E Mounting and Dimensions



## PU-E Series Pickup Installation

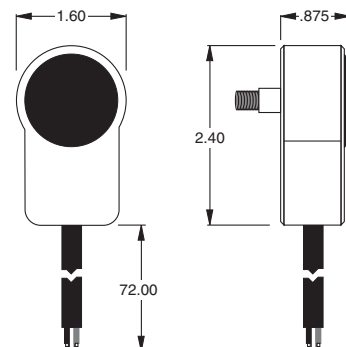
The PU-E series pickup is an economical way to monitor motor speed. Its patented design provides for ease of installation in otherwise difficult to reach areas. The PU-E operates from a +5V power supply, producing a 5 volt square wave whose frequency is proportional to speed. This signal is fed into the MD *plus* control as a speed or position reference for the microprocessor.

**Caution:** The PU-E cord should not be grouped with other wires or cords. For applications with PU-E wire over 6 feet long, or noisy environments, a shielded cable is recommended. Connect the shield to the common terminal on the MD *plus*, leaving the shield on the PU-E end floating.



Model Number	Pulses per Revolution
PU-2E	1
PU-4E	2
PU-20E	10
PU-40E	20

## Dimensions

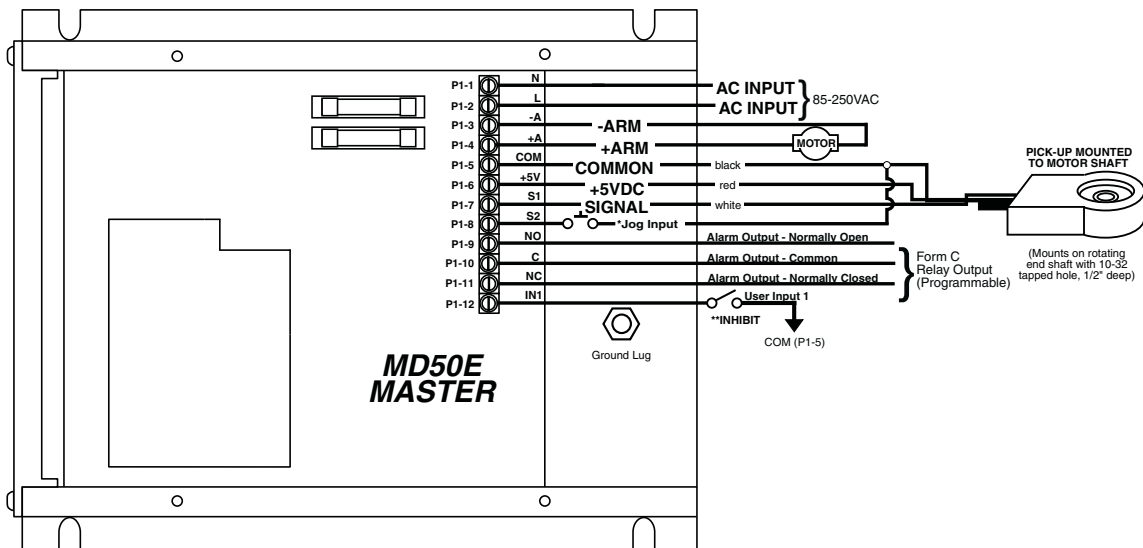
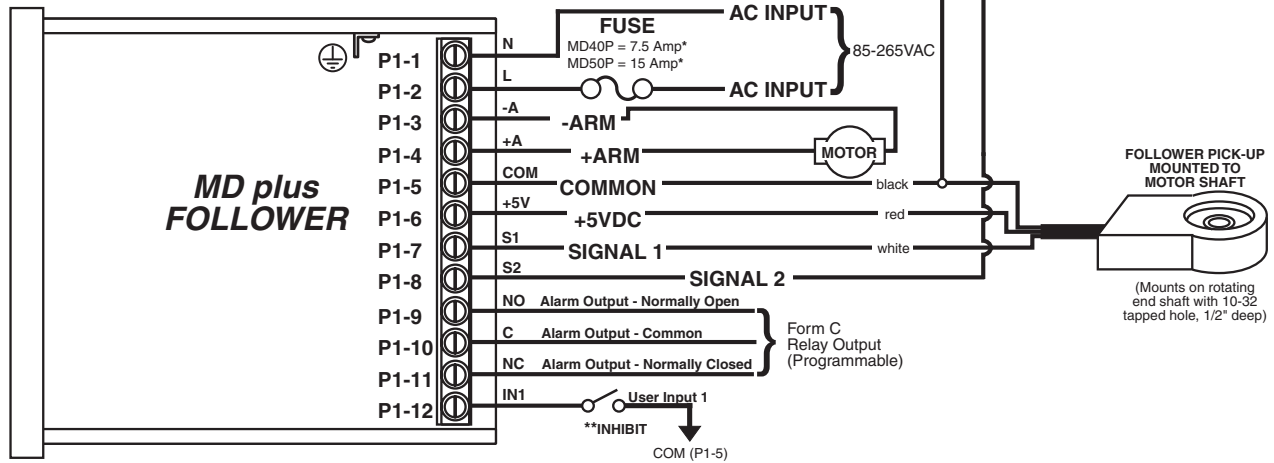
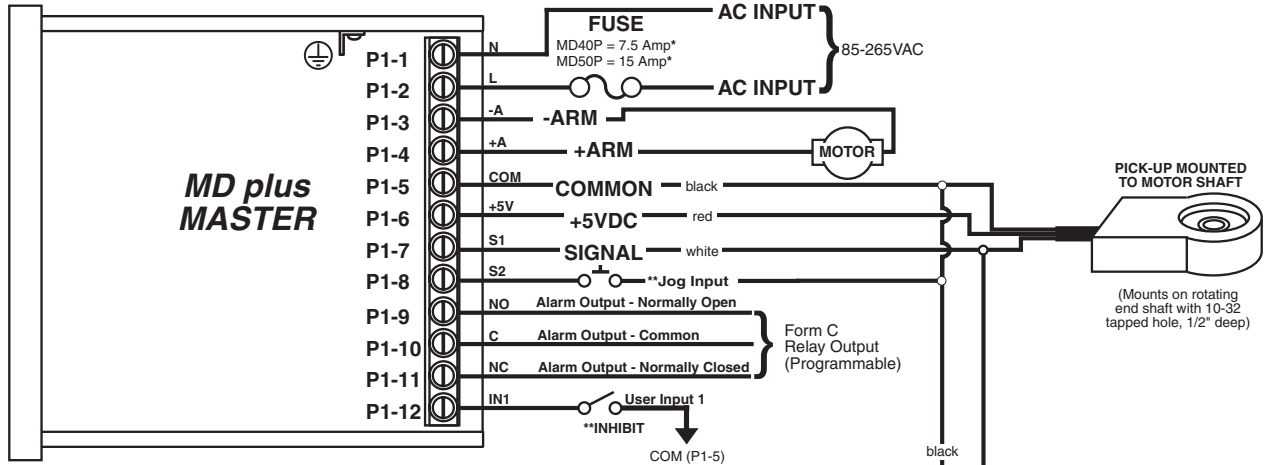


**CAUTION:**  
**DO NOT OVERTIGHTEN MOUNTING SCREW !!**

No other mounting screws are necessary, as the cord will keep the unit from rotating.

# Electrical Installation & Diagrams

## P1 Terminal Block Hook-Up Diagrams



\* For AC inputs utilizing two hot lines, both inputs should be protected with appropriately sized fuses or circuit breakers.

\*\* P1-8(Master) & P1-12 user input may be programmed for a number of functions, including (jog, inhibit, etc.)

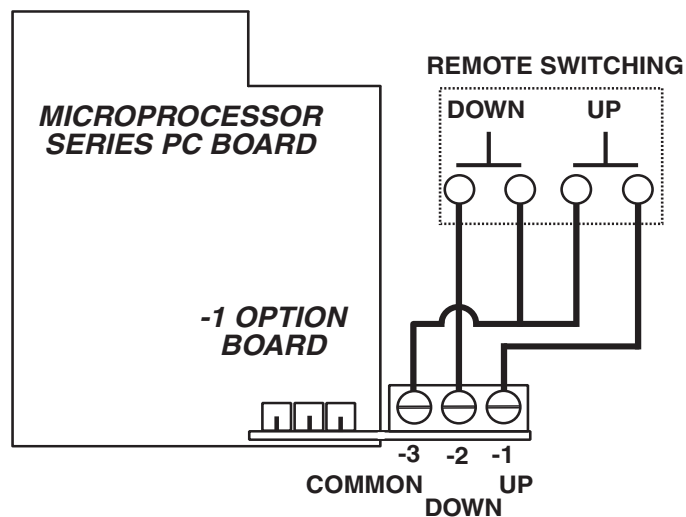


## MD40P / MD50P / MD50E P1 Terminal Block Descriptions

- P1-1 (AC / N) – For single phase AC lines connect the Neutral side of the AC line to this terminal. For systems with two hot AC lines, connect either of the Hot AC lines to this terminal.
- P1-2 (AC / L) – For single phase AC lines connect the Hot side of the AC line to this terminal. For systems with two hot AC lines, connect either of the Hot AC lines to this terminal.
- P1-3 (-A) - This is the -Armature terminal. For normal rotation of the motor, the -Armature lead of the motor should be connected to this terminal. The +Armature lead of the motor will be connected here when a reverse directional rotation of the armature is desired.
- P1-4 (+A) - This is the +Armature terminal. For normal rotation of the motor, the +Armature lead of the motor should be connected to this terminal. The -Armature lead of the motor will be connected here when a reverse directional rotation of the armature is desired.
- P1-5 (COM) – This is the common point for the control logic. The speed sensor common lead as well as any other source needing to reference the control common will be connected to this terminal.
- P1-6 (+5V) – This is a self-contained +5VDC power supply capable of up to 50mA. The speed sensor supply lead can be connected to this terminal for its power source.
- P1-7 (S1) – This is the signal input terminal for the motor's digital pickup or encoder. This signal is internally "pulled-up" to +5VDC via a 2.2K ohm resistor.
- P1-8 (S2) – This input can be programmed to perform a number of advanced functions. In Follower Mode, this input is the signal input terminal for the master's digital pickup or encoder. In Master modes (Rate and Time), this input can be configured to function as an emergency stop, inhibit, or jog command. This signal is internally "pulled-up" to +5VDC via a 2.2K ohm resistor.
- P1-9 (NO) – This is the normally-open contact of the user assignable relay output.
- P1-10 (C) – This is the common contact of the user assignable relay.
- P1-11 (NC) – This is the normally-closed contact of the user assignable relay output.
- P1-12 (IN1) – This input can be programmed to perform a number of advanced functions. It can be configured to function as an emergency stop, inhibit, or jog command. This signal is internally "pulled-up" to +5VDC via a 2.2K ohm resistor.

### -1 Option Wiring

The -1 option board is a module which allows external up and down push buttons to be wired to the unit. These buttons operate exactly like the Up and Down buttons on the user interface. This module is commonly used to allow PLCs or hand-held pendants to operate the front-panel remotely. The wiring for the external buttons is attached via a 3mm European terminal block on the -1 option board. The buttons are activated by shorting the terminal labeled Com to either the Up or Down terminal.



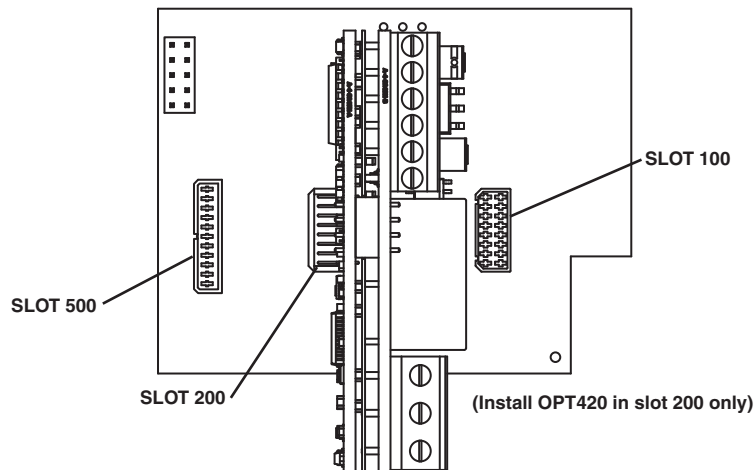
# OPT420 Installation & Diagrams

## Installing the OPT420 in Slot 200 (ONLY!) of the Host Drive

The OPT420 is a Dart ModularBus "option card" featuring an Optically-Isolated 4-20mA Current Loop Input and an Optically-Isolated 4-20mA Current Loop Output. Both the input and output are Optically-Isolated from the Host Drive, circuit common, earth ground, and from each other. In addition, a non-isolated SPST switch input is provided. In the typical application with an MD40/50-420, that switch is used to determine where the Host Drive gets its "Target Speed" setting from. Additionally, the MD40P-420, MD50P-420 and MD50E-420 have an "Auto/Manual" LED Annunciator which displays whether the source of the Target Setting comes from the 4-20mA input ("Auto") or from the "front panel" Target setting ("Manual").

In "Manual Mode", the Host Drive uses its normal Front Panel display and Up/Down buttons to set the Target Speed (or Time). However, in "Auto Mode", the Host Drive follows the OPT420's 4-20mA Current Loop signal. In either mode, the OPT420's Current Loop Output provides a real-time updating 4-20mA signal that represents the Host Drive motor's Actual (Tach) Speed. This is primarily used by a SCADA system to provide "feedback" that the SCADA's speed setting was received and acted upon by the Host Drive.

### OPT 420 INSTALLATION



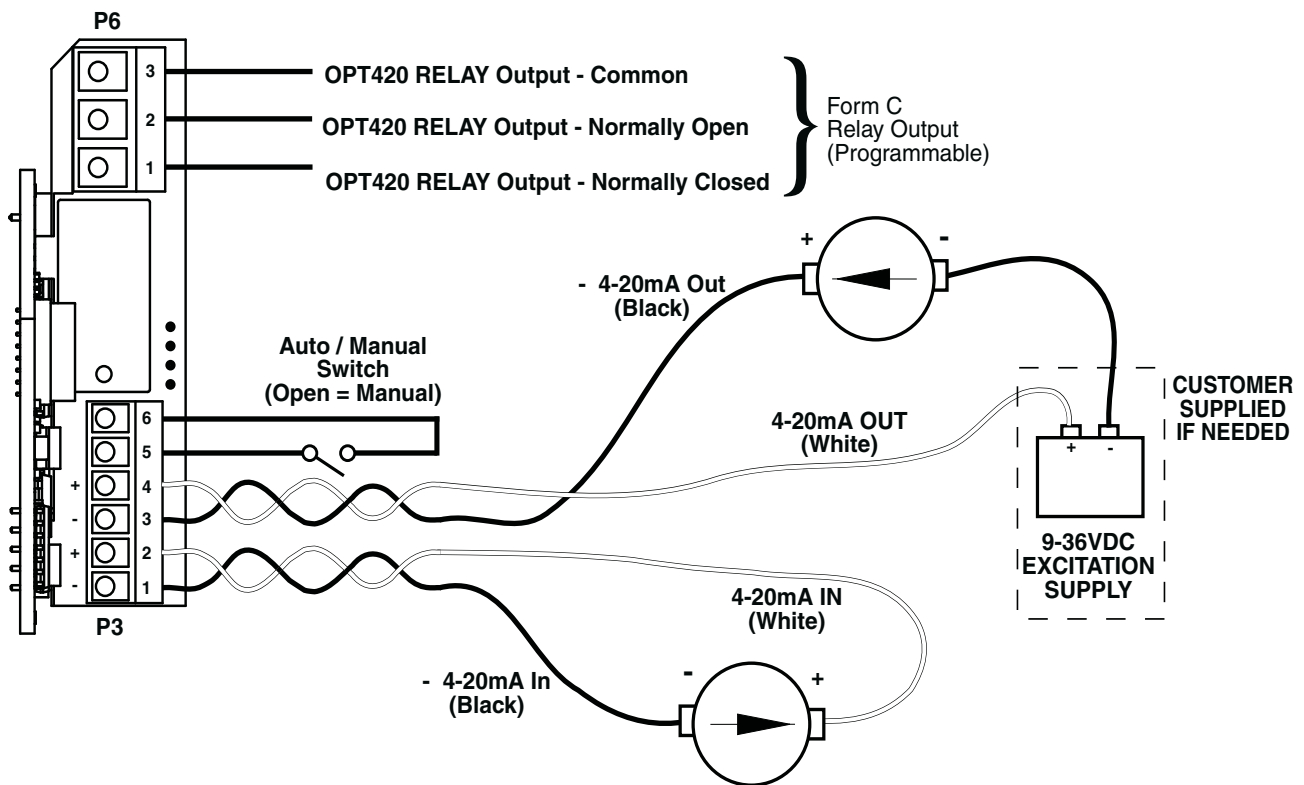
**IMPORTANT: THE OPT420 MAY ONLY BE INSTALLED IN MODULARBUS SLOT "200".** Installing in any other slot will simply result in the OPT420 "not working". Normal operation will resume when the OPT420 is placed in the Host Drive's ModularBus Slot "200".

Also, the OPT420 comes with Default Values that should allow a simple checkout procedure to verify that everything is hooked-up correctly and functioning. See the OPT420 Item (Parameter) Table for further details.

## OPT420 P3 & P6 Terminal Block Hook-Up Diagrams

**IMPORTANT: THE OPT420 DOES NOT SUPPLY LOOP "EXCITATION VOLTAGE".** If the flowmeter, SCADA system, etc. does not have a Loop Excitation supply, an external voltage must be provided from +9 to +36VDC capable of at least 50mA for each of the two 4-20mA Current Loops (Input and Output), as shown in the diagram below. Additionally, if the Input and Output must be isolated from each other, two excitation supplies may be needed.

# OPT 420 HOOK-UP DIAGRAM (TYPICAL)



## OPT420 P3 Terminal Block Descriptions

- P3-1 (- 4-20mA Input) – Connect this terminal to the next 4-20mA device in the loop, or, if the OPT420 is the last device in the current loop, then connect this terminal to the - (negative) side of the current loop.
- P3-2 (+ 4-20mA Input) –Connect this terminal to the previous 4-20mA device in the loop, or, if the OPT420 is the first device in the current loop, then connect this terminal to the + (positive) side of the current loop.
- P3-3 (- 4-20mA Output) – Connect this terminal to the next 4-20mA device in the loop, or, if the OPT420 is the last device in the current loop, then connect this terminal to the - (negative) side of the current loop.
- P3-4 (+ 4-20mA Output) –Connect this terminal to the previous 4-20mA device in the loop, or, if the OPT420 is the first device in the current loop, then connect this terminal to the + (positive) side of the current loop.
- P3-5 (S1 Input) – Connect this terminal to one side of a SPST switch to control Auto/Manual Operation. If switch is OPEN (or unconnected), MD40/50-420 Target Speed will come from its Target Speed setting (as usual), if the switch is CLOSED, MD40/50-420 Target Speed will follow the OPT420 4-20mA Current Loop Input. This signal is internally "pulled-up" via a 15K ohm resistor.
- P3-6 (COM) – This is the common point for the control logic. Normally, the other side of the SPST Auto/Manual switch would be connected to this terminal. **Note that this means that the Auto/Manual switch is NOT "isolated".**

## OPT420 P6 Terminal Block Descriptions

- P6-1 (NC) – This is the normally-closed contact of the user-assignable OPT420 Alarm 1 relay.
- P6-2 (NO) – This is the normally-open contact of the user-assignable OPT420 Alarm 1 relay.
- P6-3 (C) – This is the common contact of the user-assignable OPT420 Alarm 1 relay.

# Basic Operating Instructions

## Control Algorithm Discussion and P-I-D Tuning

A true P-I-D speed control algorithm is employed in the MD40P-420, MD50P-420 and MD50E-420 which allows precise and quick response to set speed or load changes. The three items, 26, 27 and 28 (Proportional, Integral, Derivative, respectively) are adjustable as shown on page 16. P-I-D can be tuned to get precise speed response and regulation.

When adjusting P-I-D, begin by using the factory defaults the control is preset to: P (Item 26) to 2300, I (Item 27) to 1000, D (Item 28) to 0. If further adjustment of P-I-D is needed, follow the steps below.

### To adjust P: (Item 26)

Run the motor from zero speed to the set speed. If the start up response of the motor is too slow, increase "P" in increments of 20 until the desired start up response time is obtained. If the start up response time is too fast, decrease "P" in increments of 10 until the desired response is reached. "P" is used to adjust the start up response time only. The start up response time is approximately 0 to 60% of the set speed. "I" can be used if adjustment of the upper response time (60 to 100% of the set speed) is needed.

### To adjust I: (Item 27)

Run the motor from zero speed to the set speed. If the upper response time (60 to 100% of the set speed) has any hesitation or has too slow of a response, then increase "I" in increments of 5 until the hesitation is eliminated and/or the desired upper response time is obtained. If the upper response time is too fast or has too much overshoot, decrease "I" in increments of 3 until the overshoot is eliminated and/or the desired upper response time is reached.

### To adjust D: (Item 28)

"D" can be used to dampen the effect of "P". By making "D" too large, the response time of the control can be reduced, so keep "D" as small as possible on non-regenerative controls.

**Note:** The proportion of P-I-D seems to be more critical than the individual values, i.e.. values of 50-50-50 will achieve virtually the same results as 999-999-999.

## Master (Rate and Time) and Follower (Ratio) Modes Explained

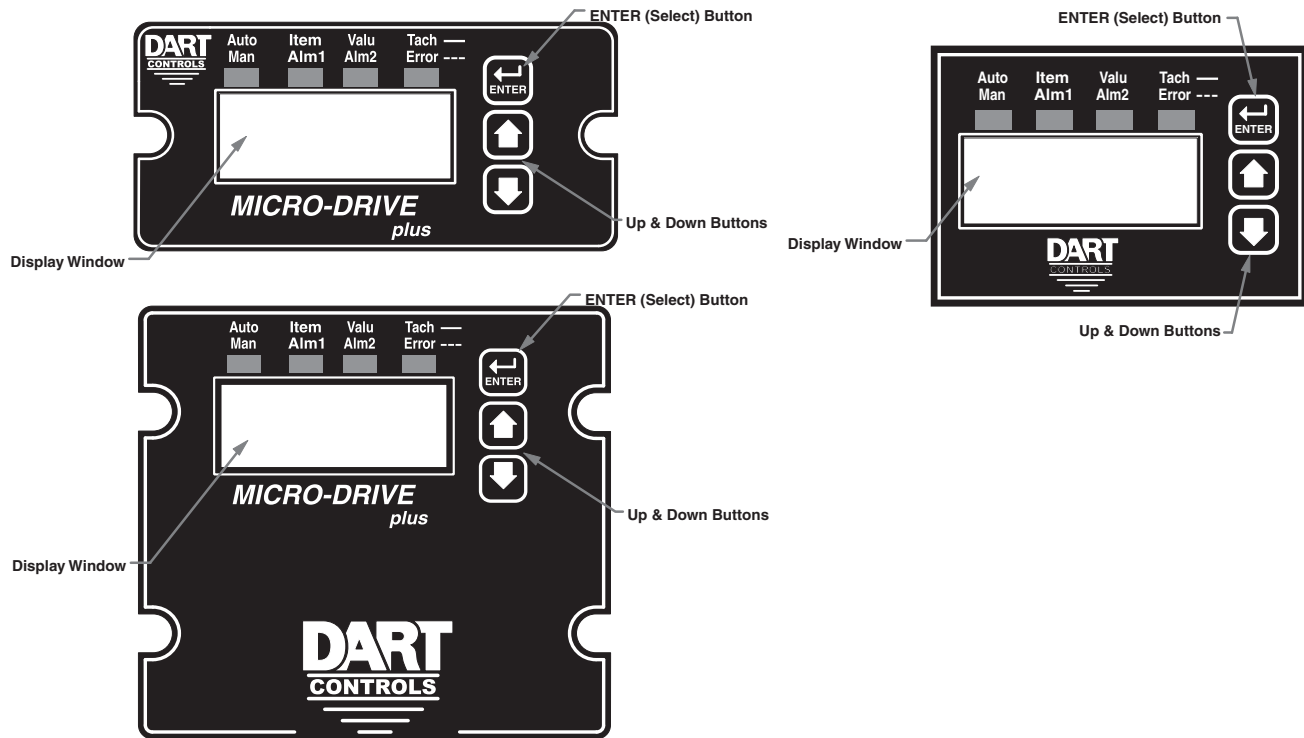
The MD *plus* controls have two basic modes of operation, master and follower. In the Master modes, the controls are capable of operating independently; whereas, in the Follower Mode, the control requires a signal from a master to operate. The Follower Mode is used in applications which require the MD *plus* to closely follow a master process. For example, if a factory has ten conveyors which must be synchronized over long periods of time, an industrial engineer could use one MD *plus* as a master control for the first conveyor and nine MD *pluses* as slaves or followers which would receive their speed commands from the first conveyor's master control or pickup.

In Master Rate Mode, the MD *plus* controls the rate of the motor by tracking the motor's pickup pulses which are applied to signal input 1 (S1). In this mode, the display indicates in rate units such as Gallons-per-minute, feet-per-second, or RPM.

In Master Time Mode, the MD *plus* controls the process time by tracking the motor's pickup pulses which are applied to signal input 1 (S1). In this mode, the display indicates in time units such as HH:MM or MM:SS, where HH is hours, MM is minutes, and SS is seconds. This mode is most-commonly used in time-sensitive processes such as conveyor ovens and plating applications.

In Follower Mode, the MD *plus* tracks the rate of the pulses which are applied to the master signal input (S2). From these pulses, it calculates the speed of the master process in RPMs. This rate is then multiplied by the percentage which is displayed on the user interface. The display is in 0.1% of master units. For example, 67.5 = 67.5 percent of master speed. A master running at 1350 RPM, would cause the follower to run its motor at  $67.5\% \times 1350 \text{ RPM}$  or 911.25 RPM. Typical follower applications include synchronized rotation, synchronized conveyors, and some web-material processes.

## Visual Reference



## How to Change an Item's Value (The Short Story)

1. Hold down the Enter button until Item-Selection Mode is entered. The 'Item' Annunciator will light
2. Using the Up and Down buttons, select the desired Item number to view or edit
3. Press the Enter button to change the value of the Item. The 'Valu' Annunciator will light
4. Using the Up and Down buttons, change the Item's value as desired
5. Press the Enter button to permanently save the changes (Returns to Item-Selection Mode)
6. Select Item Zero ("0") and press the Enter button to return to Running Mode

## Operating the User Interface (The Long Story)

Although the MD *plus* user interface is very versatile, it is also simple to setup and operate. With just a few button presses, it allows the user to configure a number of adjustable Items. The LED display has three basic operating modes: Running Mode, Item-Selection Mode, and Value Mode. "Item" and "Value" modes also have specific visual indicators (LED "Annunciators") that allow the user to immediately determine the current state or mode of the user interface. **Note: Item-Selection Mode (and Value Mode) can only be entered if the Program Enable jumper is in the "On" position.**

**Running Mode** is the default display of the unit when power is applied. The MD *plus* will spend the majority of its time in this mode. In Running Mode, the display shows the Target or Actual ("Tach") speed value in the user-defined Engineering Units format for rate, time, or (in "Follower" mode) percentage of Master. The control will continuously attempt to drive the motor to the requested Target. In this display mode, the Up and Down buttons increase or decrease the displayed target value until either the display minimum or display maximum limit is reached. Depending on the alarm configuration, these buttons may also serve as an alarm-silence or alarm-reset button. For example, displays for rate, time, and follower operating modes could be 13.60, 45:30, and 1000, respectively.

Additionally, the MD40P-420, MD50P-420 and MD50E-420 have an "Auto/Manual" Annunciator which displays a "solid" light if the source of the Target Setting comes from the 4-20mA input ("Auto"), or a "blinking" light if the Target Setting comes from the "front panel" Target setting ("Manual").

**Item-Selection Mode** can be entered by simply pressing and holding the Enter button down for about three seconds. Once in Item-Selection Mode, the "Item" Annunciator will illuminate. The display will indicate the currently selected Item number for editing purposes. Pressing the Up or Down button will increase or decrease the selected Item number on the display. Although the Item numbers are in numerical order, some numbers are skipped. These numbers represent reserved Items that are not yet implemented and are not displayed.

Further, Item numbers above 999 are actually located on the ModularBus card(s) that are installed in the "Host" Drive. The numbering scheme is the ModularBus "slot number (100, 200 or 500) times 10, plus the Item Number. Once the desired Item number is displayed, a press of the Enter button will change the display to the Value Mode. So, for example, to view/edit Item 20 on a ModularBus card in Slot 200, "Browse" to Item number 2020 (200 X 10 + 20).

**When in Item-Selection Mode, pressing the Enter button with Item 0 selected will cause the unit to return to Running Mode.** See the Software Items for a list of available Items.

**Value Mode** is used to modify the value of the selected Item. When in Value Mode, the "Valu" Annunciator will illuminate. Pressing the Up or Down button increases or decreases the selected Item's value. With only one exception, value changes take effect immediately. For example, when adjusting P-I-D settings, the change in response can be observed "live", which greatly facilitates the P-I-D "tuning" process. Once the desired value is showing in the display window, pressing the Enter button again will return to Item-Selection Mode and the new value will be saved in permanent memory. Removing power from the unit while in Value Mode will result in the specified new value being lost, and the previous (old) value being used. This can be used as an "undo", for example, during editing a value that is being edited in the wrong Item. **Note: Changes to Item 10, Operating Mode, do not take effect until power is removed and re-applied to the MD *plus*.**

## Detailed Configuration Instructions

### MD *plus* Default Configuration

When shipped from the factory, the following basic settings are in place:

Rate Mode Operation in RPM

S1 and S2 Signal Input Pulses per Revolution: 20 (to use a PU-40E)

Decimal Point Display: None

Display Range: 0 - 2400

Speed Range: 0 - 2400 RPM

Accel and Decel: 9999 RPM per second

Signal Input 2 (S2) Mode: Jog @ 1000 RPM when Low

User Input 1 (UIN1) Mode: Emergency Stop when Low

Alarm 1 and Alarm 2 Outputs: Disabled

### Resetting the MD *plus* to Factory Defaults

The factory-default settings can be easily restored using either of two methods. Both methods require the Program Enable jumper to be in the "On" position. The first is to apply power to the unit with both the Enter and Down buttons pressed for 3 seconds. The second is to change the value of Item 95 to 5.

### JP1 (Program Enable Jumper)

The JP1 jumper is located under the dust cover on the back end of the upper board. When the jumper is set to the "Off" position, all programming features are "locked out" from the front panel user. When the jumper is in the "On" position, the programming Items are open to change. JP1 is shipped from the factory set in the "On" position.



## Setting and Reading "SoftSwitches"

Like many other devices, the MD *plus* has the ability to select between a number of "yes/no" or "on/off" options, depending upon the application. Traditionally, this sort of option-selecting was done with some sort of physical switch or switches (such as a "DIP switch"), or by other means, such as the "jumper block" used to enable/disable Programming on the MD *plus*. There are two problems with this approach to option-selection: 1) Both DIP switches and "jumper blocks" are physically large, and most require that the device be at least partially disassembled to gain access to them; 2) On a device with more than just a very few options, the number and combinations of switches quickly becomes overwhelming.

Because of these drawbacks, the MD *plus* takes a different approach (where appropriate): SoftSwitches.

It is easiest to think of an Item containing SoftSwitches as a DIP switch containing from one to thirty-two switches. But instead of actually flipping a switch "on" or "off", you can set and read these "switches" as a *Binary-Coded-Decimal*, or "BCD" number. Now, before you say "Binary numbers! Those are for computers!", let's look at this another way. Each "switch", from #1 through #32, has been assigned a decimal number that represents its position in the make-believe DIP switch assembly. When that number is used, it means that the switch is "on". For example, the decimal number that represents switch #4 is 8, the number that represents switch #6 is 32, and so on. See the table below for a full explanation of these values. Note: Due to display limitations, switches 15 through 32 are currently unused.

Switch#	BCD Value	Switch#	BCD Value
1	1	8	128
2	2	9	256
3	4	10	512
4	8	11	1024
5	16	12	2048
6	32	13	4096
7	64	14	8192

So, the **Binary-Coded-Decimal (BCD) number contained in a SoftSwitch Item is nothing more than the *sum* of the numbers representing the "on" switches.** For example, if you wanted to set switches #1, #4, and #7 to the "on" position, you would place the number *73* ( $1 + 8 + 64$ ) into the Item containing those SoftSwitches; if you wanted to set switches #5 and #6 "on", you would place the number *48* ( $16 + 32$ ) into the Item, and so forth. **Simply "add-up" the BCD values of the switches you wish to "turn on", and place the total, or "sum", into the Item containing the SoftSwitches.**

**The settings of the SoftSwitches can also be read the same way:** For example, if an Item containing the SoftSwitches has been set to the number *11*, you can tell that switches #1, #2 and #4 are "on". You can tell this by *subtracting* the BCD values, from highest to lowest, *starting at the highest value that is less than or equal to the "total"*. Keep subtracting, but if you get a negative number as a result, then don't subtract that BCD value (add it back in before proceeding). Work your way "downward" in this manner toward Switch #1, but when your total reaches *zero*, you are finished.

Try a few examples of your own, and very soon you will be easily setting and reading SoftSwitches.

## Setting and Reading "Alarm" Conditions

Taking advantage of the "SoftSwitches" feature described above, the MD *plus* is equipped with *two* "Alarm" outputs, which can be independently set to Activate on any of 16,384 possible combinations of "conditions" or "events" that could be occurring at any one time. See table below for a list of these Condition "Flags".

The conditions are logically "OR-ed" together to form the particular Alarm output. If the SoftSwitches for the "Tach Outside Limits" and the "Pickup Stalled" Conditions for Alarm1 are set to "On", then Alarm1 will be "true" when either one or both of those Conditions are "true". However, for even more flexibility, each condition can be combined in a logical "AND" fashion to "override" the Alarm output.

Additionally, each Condition can be "inverted" before being sent to the "AND" function, for even greater flexibility. Please note that if a particular Condition is inverted, the corresponding "switch" in the appropriate "AND" Item (52/72) is inverted as well.

Further, setting any of the "Softswitch" Items in the OR/Invert/AND Alarm Conditions (Items 50-52 and 70-72) to a value of zero effectively removes the effect of their "logic" from the "Circuit". Therefore, even though the Alarm logic conditions are "cascaded" OR -> Invert -> AND, if, for example, the application does not need any "AND" conditions, simply set the value of the AND Item (52 and/or 72) to zero, and the "AND" function will be "jumped around". In that case, however, it would also be best to set the "Inverter" Item (51 and/or 71) to zero as well.

**Table: BCD Values for Drive Condition "Flags"**

BCD Value	Description
0	(No Flags are currently Active)
1	Accel/Decel Ramp In Progress
2	S1 (Main) Actual Speed (Tach) is Outside Alarm Limits
4	Target Speed is Outside Alarm Limits
8	Target Speed = 0
16	S1 (Main) Pickup is Stalled
32	S2 (Leader) Pickup is Stopped (Valid only in 'Follower' Mode)
64	Jog Function is Activated
128	Inhibit Function is Activated
256	E-Stop Function is Activated
512	Drive is at Maximum Output
1024	"Run" Condition
2048	Slot 100 Alarm1 Activated (Valid only if ModularBus card installed in this slot)
4096	Slot 200 Alarm1 Activated (Valid only if ModularBus card installed in this slot)
8192	Slot 500 Alarm1 Activated (Valid only if ModularBus card installed in this slot)

## "Alarm" Output Routing

The "output" of Alarm1 is permanently "routed" to drive the Form-C Relay output on the MD *plus* itself (see Hook-up Diagram, P1-9 through P1-11). The "output" of Alarm2, however, can be *Routed* (through the use of Item 81) to any one of the three ModularBus "slots", 100, 200 or 500.

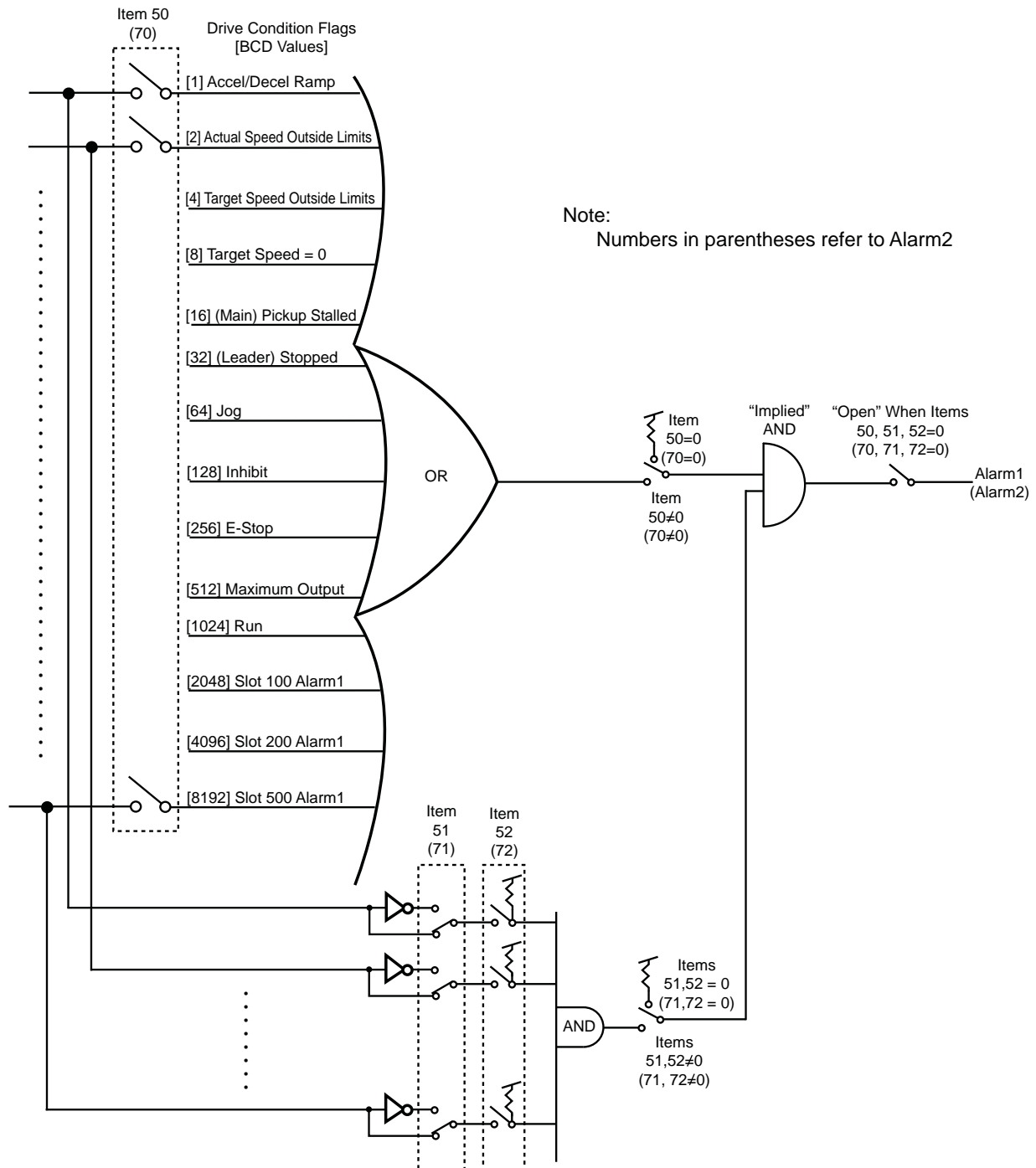


# MD plus Alarm "Logic"

Note: The "circuitry" shown below is actually implemented in software, not hardware, and although it makes little difference to the final output produced, that fact should be kept in mind.

Also note that the "switches" on the outputs of the "OR gate", the "AND gate", and the "Implied" AND gate are only under *indirect* user control. That is, they are set "automatically" by the action of other settings that *are* under user control. For example, the "switch" on the output of the "OR gate" is *automatically* set to the "uppermost" position (as shown on the drawing, below) when Item 50 (or 70 for Alarm2) is set to zero.

Often there is more than one way to "connect" the signals and "logic" to achieve the desired result. But determining the proper signal "polarity" to use is *often* a tricky problem in "logic circuits". Sometimes it takes a bit of careful planning to arrange "inverted" and "non-inverted" signals properly. Also, keep in mind that standard logic "tricks", such as the use of "Negative Logic" techniques, can be used to further expand your options. See the Application Example on page 32 for further details.



## Software Parameters (Items)

Item	Description	Value Range	Units	Factory Default	User Setting
0	Selecting this item exits to "Run" Mode	n/a	—	n/a	n/a
<b>Read-Only Items</b>					
1	Model Number	45 = MD40P-420, MD50P-420, MD50E-420	—	45	
2	Software Version	1 – 9999	—	n/a	
3	Hardware Version	1 – 9999	—	n/a	
4	DartNet Version	1-9999	—	n/a	
5	Serial Number (Major)	0-9999	—	n/a	
6	Serial Number (Minor)	0-9999	—	n/a	
8	Drive Condition Flags	(See "Flags" Table, pg. 14)	BCD	n/a	
<b>General Setup Items</b>					
10	Operating Mode	1 = Rate Mode 2 = Time Mode 3 = Follower Mode	—	1	
11	Display Brightness	0 – 31 (Dim – Bright)	—	20	
12	Display Mode	1 = Target Speed Display 2 = S1 Actual Speed Display 3 = S2 (Leader) Speed Display	—	1	
13	Decimal Point Position	0 = D.P. Disabled [XXXX] 1 = [X.XXX] 2 = [XX.XX] 3 = [XXX.X] 4 = [XXXX.]	—	0	
14	Keypad Mode	1 = Linear, Constant Rate 2 = Non-Linear, Accelerating Rate	—	2	
15	Keypad Scroll Delay	0 – 30 (Fast – Slow)	—	10	
16	Power-up Target Speed	1 = Force Zero Speed 2 = Force Power-up Value 3 = Use Previous Target Speed	—	3	
17	Power-Up Value	0 – 9999	(Eng. Units)	0	
18	Front-Panel DoubleClick Destination	0 = DoubleClick <i>Ignored</i> 1 = Inhibit 2 = EStop 3 = Jog1 4 = Jog 2	—	0	
19	Output Invert (UNUSED ON MD40/50)	0 = Normal 1 = Inverted	—	0	
<b>Control Loop Items</b>					
20	Display Minimum	0 – 9998	(Eng. Units)	0	
21	Display Maximum	1 – 9999	(Eng. Units)	2400	
22	Motor Control Method	0 = Gain Tracking Off, Low Speed Mode Off 1 = Gain Tracking On, Low Speed Mode Off 2 = Gain Tracking Off, Low Speed Mode On 3 = Gain Tracking On, Low Speed Mode On	—	1	
23	Accel Setting	1 – 9999	(Eng. Units)	2500	
24	Decel Setting	1 – 9999	(Eng. Units)	2500	
26	Proportional Gain	0 – 9999	—	2300	
27	Integral Gain	1 – 9999	—	1000	
28	Derivative Gain	0 – 9999	—	0	
29	Startup Lag Compensation	0 – 5000	—	0	

## Software Parameters (Items), cont'd

Item	Description	Value Range	Units	Factory Default	User Setting
<b>Signal Input #1 Setup Items</b>					
30	S1 Display Reference	0 – 9999	(Eng. Units)	2400	
31	S1 Reference RPM	0 -9999	RPM	2400	
32	S1 Pulses Per Revolution	1 – 9999	PPR	20	
33	S1 Initial Stall Timeout	0 – 9999 (0 = Defeat)	Sec.	0	
34	S1 Running Stall Timeout	0 – 999.9 (0 = Defeat)	1/10 Sec.	0	
<b>Signal Input #2 Setup Items</b>					
35	S2 Input Configuration	1 = Disabled (Use for Follower Mode) 2 = E-Stop When S2 High 3 = E-Stop When S2 Low 4 = Inhibit When S2 High 5 = Inhibit When S2 Low 6 = Jog When S2 High 7 = Jog When S2 Low	—	7	n/a
36	S2 Setpoint for Jog Function	1 – 9999	(Eng. Units)	1000	
37	S2 Pulses Per Revolution (Follower Only)	1 – 9999	PPR	20	
38	S2 Stopped Timeout (Follower Mode Only)	0 – 999.9 (0 = Defeat)	1/10 Sec.	0	
<b>User Input #1 (UIN1) Setup Items</b>					
40	UIN1 Input Configuration	1 = Disabled 2 = E-Stop When UIN1 High 3 = E-Stop When UIN1 Low 4 = Inhibit When UIN1 High 5 = Inhibit When UIN1 Low 6 = Jog When UIN1 High 7 = Jog When UIN1 Low	—	3	
41	UIN1 Setpoint for Jog Function	1 – 9999	(Eng. Units)	1000	
42	Inhibit Configuration	0 = No Accel/Decel 1 = Decel Only, No Accel 2 = Accel Only, No Decel 3 = Both Accel and Decel	—	0	
<b>Alarm Output #1 Setup Items</b>					
50	Alarm1 Logical "OR" Activation Conditions	(See "Flags" Table, pg. 14)	BCD	0	
51	Alarm1 Logical Inverters	(See "Flags" Table, pg. 14)	BCD	0	
52	Alarm1 Logical "AND" Activation Conditions	(See "Flags" Table, pg. 14)	BCD	0	
53	Alarm1 Output Style & Reset Mode	1 = Constant & Auto-Reset 2 = Constant & Manual Reset 3 = Pulsed & Auto Reset 4 = Pulsed & Manual Reset	—	1	
54	Alarm1 Reset Configuration	1 = No Silence, Reset on Enter But. 2 = No Silence, Reset on S2 High 3 = No Silence, Reset on S2 Low 4 = Silence & Reset on Enter But. 5 = Silence & Reset on S2 High 6 = Silence & Reset on S2 Low	—	1	
55	Annunciator Alm1 Flash On Active Alarm1	0 = No Annunciator Flash 1 = Annunciator Flash	—	0	
56	Alarm1 Output Pulse "ON" Time	1 – 3600	Secs.	1	
57	Alarm1 Output Pulse "OFF" Time	1 – 3600	Secs.	1	
58	Alarm1 Output Pulse Count	0 – 9999	—	0	
59	Alarm1 Lower Limit	0 – 9999	(Eng. Units)	0	
60	Alarm1 Upper Limit	0 – 9999	(Eng. Units)	9999	

## Software Parameters (Items), cont'd

Item	Description	Value Range	Units	Factory Default	User Setting
<b>Alarm Output #2 Setup Items</b>					
70	Alarm2 Logical "OR" Activation Conditions	(See "Flags" Table, pg. 14)	BCD	0	
71	Alarm2 Logical Inverters	(See "Flags" Table, pg. 14)	BCD	0	
72	Alarm2 Logical "AND" Activation Conditions	(See "Flags" Table, pg. 14)	BCD	0	
73	Alarm2 Output Style & Reset Mode	1 = Constant & Auto-Reset 2 = Constant & Manual Reset 3 = Pulsed & Auto Reset 4 = Pulsed & Manual Reset	—	1	
74	Alarm2 Reset Configuration	1 = No Silence, Reset on Enter But. 2 = No Silence, Reset on S2 High 3 = No Silence, Reset on S2 Low 4 = Silence & Reset on Enter But. 5 = Silence & Reset on S2 High 6 = Silence & Reset on S2 Low	—	1	
75	Annunciator Alm2 Flash On Active Alarm2	0 = No Annunciator Flash 1 = Annunciator Flash	—	0	
76	Alarm2 Output Pulse "ON" Time	1 – 3600	Secs.	1	
77	Alarm2 Output Pulse "OFF" Time	1 – 3600	Secs.	1	
78	Alarm2 Output Pulse Count	0 – 9999	—	0	
79	Alarm2 Lower Limit	0 – 9999 (Eng. Units)	(Eng. Units)	0	
80	Alarm2 Upper Limit	0 – 9999 (Eng. Units)	(Eng. Units)	9999	
81	Alarm2 Output Routing	1 = Reserved 2 = Use Slot 100 Alarm1 Output 3 = Use Slot 200 Alarm1 Output 4 = Use Slot 500 Alarm1 Output	—	3	
<b>Item Memory Commands (Actions)</b>					
95	Restore MD40/50 Settings to Factory Defaults (affects Drive Settings Only)	0 = Do Nothing & Exit 5 = Restore Factory Defaults	—	0	n/a
96	Restore ModularBus Card(s) Settings to Factory Defaults (Card(s) Settings Only)	0 = Do Nothing & Exit 100 = Restore Slot 100 Defaults 200 = Restore Slot 200 Defaults 500 = Restore Slot 500 Defaults	—	0	n/a
98	Save "Environment" (Drive and ALL ModularBus Card(s) Settings) to "User Save" storage area	0 = Do Nothing & Exit 5 = Copy <u>current</u> Settings TO Settings2 (or Settings1 if currently using Settings2)	—	0	n/a
99	Restore/Swap "Environment" (Drive and ALL ModularBus Card(s) Settings) from "User Save" storage area	0 = Do Nothing & Exit 5 = <u>Copy</u> (Restore) <u>current</u> Settings FROM Settings2 (or Settings1 if currently using Settings2) 10 = <u>Swap</u> Between Settings1 & 2	—	0	n/a

# Item (Parameter) Descriptions

## Item 0 – Exit to Running Mode

When Item 0 is selected in Item-Selection Mode, the unit will return to Running Mode and, depending on the value of Item 12, will display the running (Target) or actual (Tach) value. This should be selected once changes to Items are completed.

## Item 1 – Model Number (Read Only)

This number represents the base model number for the product. The model code for the MD40P-420, MD50P-420, and MD50E-420 is 45. In this manual, where appropriate, the “Drive” portion of these products are referred to as the “Microdrive *plus*”, or “MD *plus*”.

## Item 2 – Software Version (Read Only)

The software version is a code which identifies the software “build number” of the unit.

## Item 3 – Hardware Version (Read Only)

The hardware version is a code which identifies which hardware was used to build the unit.

## Item 4 – ModularBus Protocol Version (Read Only)

The ModularBus protocol version is a code which identifies the *highest* (most-recent) version of the ModularBus protocol with which this unit is compatible.

## Item 5 & 6 – Serial Number, Major & Minor (Read Only)

These Items are reserved for future use as an electronic serial number and are unique to each manufactured unit.

## Item 8 – Drive Condition Flags (Read Only)

This is a Binary Coded Decimal (“BCD”) representation of the currently active “Flags” representing certain real-time conditions and/or modes in which the drive is operating. This display is updated several times per second to reflect the up-to-the-second status of the drive and its ModularBus cards, if any. See “Flags” table on page 14 for the BCD values.

## Item 10 – Operating Mode

This Item defines the operating mode for the entire unit. There are two basic modes of operation, master and follower. In master modes, the unit controls the load using either rate or time units. In follower mode, the unit controls the load in percentage of master rate.

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**NOTE:** Power must be removed and re-applied to the MD *plus* for a change in Operating Mode to take effect. It is also strongly suggested the Target Speed be reduced to zero and the setting of Items 16, 17, 20, 21, 30 & 31 be reviewed carefully prior to doing so.

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The following Operating Modes are available for the MD *plus*:

### Mode 1 – Master, Rate Mode

In Rate Mode, the MD *plus* displays in user-defined rate “Engineering Units” such as RPM, Gallons per Hour, or Feet per Second.

### Mode 2 – Master, Time Mode

In Time Mode, the MD *plus* displays in time units using the format AA:BB. By default AA:BB represents minutes (AA) and seconds (BB). Optionally, it can be configured to represent hours (AA) and minutes (BB) or other user-defined units with a 1:60 relationship. When setting Items which are configured in engineering units, the programmed value is determined by the formula  $(AA * 60) + BB$ . In HH:MM displays, this is the total number of minutes. In MM:SS displays, this is the total number of seconds.

### Mode 3 – Follower Mode

In Follower Mode, the MD *plus* displays in percentage units, where 1000 equals 100.0 percent of the master rate. For example, if the display indicates 985, 98.5, or 9.85, the MD *plus* will attempt to run at exactly 98.5 percent of the master rate. Display settings are always entered ignoring the decimal point’s position.

### **Item 11 – Display Intensity**

This Item adjusts the intensity of the LED display digits in the front panel of the unit. The values of 0 – 31 correspond to a gradual change from very dim to very bright. This is often useful when the MD *plus* is used in the same panel as other pieces of equipment with LED displays and a uniform display brightness is desired. Simply adjust the MD *plus* to match its surroundings.

### **Item 12 – Display Mode**

This Item selects what the MD *plus* will show on its display during Run Mode. Note that it can “toggle” between whatever the Display Mode is set to and its “opposite” by briefly pressing and releasing the ENTER button. For example, if this Item is set to 1 (Target Speed/Time), pressing the ENTER button will briefly show the Actual (Tach) Display (and illuminate the “Tach” LED Annunciator). Conversely, if this Item is set to 2 or 3 (Main Tach or Leader Tach, respectively), pressing the ENTER button will briefly show the Target Speed/Time.

The following Display Modes are available for the MD *plus*:

#### **Mode 1 – Target Speed/Time Display**

In Rate Mode, the MD *plus* displays the Target Speed in user-defined rate Engineering Units such as RPM, Gallons per Hour, or Feet per Second. In Time Mode, the MD *plus* displays the Target Time in time units using the format AA:BB. In Follower Mode, the MD *plus* displays the Target Speed in percentage units, where 1000 equals 100.0 percent of the Master rate.

#### **Mode 2 – S1 (Main Pickup) Actual Speed (Tach) Display**

In Rate Mode, the MD *plus* displays the Actual Speed in user-defined rate Engineering Units such as RPM, Gallons per Hour, or Feet per Second. In Time Mode, the MD *plus* displays the Actual Time in time units using the format AA:BB. In Follower Mode, the MD *plus* displays the Actual Speed in percentage units, where 1000 equals 100.0 percent of the Master rate.

#### **Mode 3 – S2 (Leader) Actual Speed (Tach) Display**

Mainly useful for diagnosing and setup of Master-Follower applications, selecting this Mode shows the Leader Speed (on the S2 Input) in RPM Units (only).

### **Item 13 – Decimal Point (DP) Position (used in Rate and Follower Modes Only)**

This selects the format of the display with respect to the decimal point’s position. This Item does not effect the value entry for other Items. For example, if the user desires to display 10.00 at 300RPM, then Item 30 would be set to 1000, Item 31 would be set to 300, and Item 13 would be set to 2.

**Mode 0: Fixed XXXX**

**Mode 1: Fixed X.XXX**

**Mode 2: Fixed XX.XX**

**Mode 3: Fixed XXX.X**

**Mode 4: Fixed XXXX.**

### **Item 14 – Keypad Mode**

This Item selects the operating mode of the front-panel push buttons. In some applications, increasing or decreasing the scroll rate provides the user more controllability when entering settings. Items 14 and 15 affect only the Up and Down buttons when the user interface is in Running Mode. These settings also apply to remote Up / Down buttons which are attached via the -1 option board.

#### **Mode 1: Linear, Constant Rate**

In linear mode, pressing and holding the Up or Down buttons will cause the display to continuously change value in the requested direction until either the Display Minimum or Display Maximum is reached. The displayed value will scroll at a constant rate which is specified using Item 15.

#### **Mode 2: Non-linear, Accelerating Rate**

In non-linear mode, pressing and holding the Up or Down buttons will cause the display to continuously change value in the requested direction until either the Display Minimum or Display Maximum is reached. The displayed value will initially scroll at a slow rate and increase in speed until the maximum scroll rate is achieved. The initial scroll rate is specified using Item 15.

### Item 15 – Keypad Scroll Delay

This Item sets the scroll speed for the front-panel push buttons. The function of this Item varies slightly depending on the Keypad Mode. See Item 14 for more details.

### Item 16 – Power-up Target Speed

This Item determines the default Running Value when power is initially applied to the MD *plus*.

#### Mode 1: Default to Zero

When in this mode, the unit will default to zero (engineering units).

#### Mode 2: Default to Power-Up Value

When in this mode, the unit will default to the Power-up Value, Item 17.

#### Mode 3: Default to Previously Running Value

When in this mode, the unit will default to the previous running value before power was removed. *A previous running value must have been active for at least 3 seconds to be recalled after power has been disconnected and reapplied.*

### Item 17 – Power-up Value

When Power-up Mode is set to 2, this Item will designate the default display value at power-up in the user's desired units of measure ("engineering units"), e.g. RPM, GPM, FPM, etc.

### Item 18 – Front Panel DoubleClick Routing

This Item determines what happens if the user "Double-Clicks" the Enter Button (two button presses quickly) on the front panel of the MD *plus*.

#### Mode 0: DoubleClick Ignored

When in this mode, DoubleClicking on the Enter Button will have no effect.

#### Mode 1: Route DoubleClick to Inhibit

When in this mode, Double-Clicking on the Enter Button with the drive is "running" will place the Drive in Inhibit, obeying the "accel/decel rules" found in Item 42. Additionally, if the S2 and/or UIN1 inputs are set up to provide Inhibit control, they are active as well, with the following rules. Either the DoubleClick and/or S2/UIN1 can cause the control to go into Inhibit, but both the DoubleClick AND S2/UIN1 have to be "negated" (set to allow the control to "run") before the control will exit "Inhibit" mode and begin to "run" normally again. **Note that the DoubleClick action works as a "toggle"**, so the operation could be somewhat confusing if S2/UIN1 are "routed" to the Inhibit, along with the DoubleClick, but this behavior is necessary for "safety" reasons.

#### Mode 2: Route DoubleClick to EStop

Same as Mode 1, but DoubleClick is Routed to the E-Stop function.

#### Mode 3: Route DoubleClick to Jog1

Same as Mode 1, but DoubleClick is Routed to the Jog1 function, causing the control to temporarily run at the Target Speed in Item 36. See, also, Item 36.

#### Mode 4: Route DoubleClick to Jog2

Same as Mode 1, but DoubleClick is Routed to the Jog2 function, causing the control to temporarily run at the Target Speed in Item 41. See, also, Item 41.

### Item 19 – Reserved

### Item 20 – Display Minimum

This Item defines the lower end of the display range. This is the value which limits how low the user is able to scroll the displayed value in Running Mode. In Rate and Time modes, this value is set in engineering units. In Follower Mode, this is set in percentage (actually, 10ths of percentage) of the master rate. For example, in Follower Mode, a Target of 150 represents 15.0 percent of the master rate.

### Item 21 – Display Maximum

This Item defines the upper end of the display range. This is the value which limits how high the user is able to scroll the displayed value in Running Mode. In Rate and Time modes, this value is set in engineering units. In Follower Mode, this is set in percentage (actually, 10ths of percentage) of the master rate. For example, in Follower Mode, a Target of 1250 represents 125.0 percent of the master rate.



### **Item 22 – Motor Control Method**

This Item controls two behaviors in the MD *plus*, Low-Speed "Gain-Tracking", and Ultra-Low-Speed Control Mode ("gearbox" mode). When set to a value of 1 (or 3), this item automatically (and proportionally) reduces the "gain" of the PID values when the Target Speed (in RPMs) is less than 200. This greatly increases the overall stability at low speeds in applications that require a very wide range of Target Speeds, without having to unduly compromise control responsiveness at higher speeds. When set to a value of 2 (or 3), this Item adjusts the speed-control characteristics of the MD *plus* to enhance the smoothness of speed control when in a situation where the "tach pickup" must be installed on the "low speed side" of a very slowly turning gear-motor output shaft. A rule of thumb would probably be that you may consider enabling this Mode if that shaft is turning less than 10 RPM, and the pickup produces less than 10 Pulses Per Revolution (PPR). Use this Mode only if speed stability can not be achieved by adjusting the PID settings (Items 26 – 28).

#### **Mode 0: Disabled**

Both Low-Speed-Gain-Tracking and Ultra-Low-Speed Control Mode are Defeated.

#### **Mode 1: Low-Speed-Gain-Tracking (Only) Enabled**

Low-Speed-Gain-Tracking is Enabled, Ultra-Low-Speed Control Mode is Defeated.

#### **Mode 2: Ultra-Low-Speed Control Mode (Only) Enabled**

Low-Speed-Gain-Tracking is Defeated, Ultra-Low-Speed Control Mode is Enabled.

#### **Mode 3: Low-Speed-Gain-Tracking and Ultra-Low-Speed Control Mode (Both) Enabled**

Both Low-Speed-Gain-Tracking and Ultra-Low-Speed Control Mode are Enabled.

### **Item 23 – Acceleration Setting**

This Item determines how fast the MD *plus* will accelerate toward the displayed target setting. This Item is set in engineering units of change per second, such as RPM, GPM, or feet per second. In Follower Mode, this Item is set in RPM units.

### **Item 24 – Deceleration Setting**

This Item determines how fast the MD *plus* will decelerate toward the displayed target setting. This Item is set in engineering units of change per second, such as RPM, GPM, or feet per second. In Follower Mode, this Item is set in RPM units.

### **Item 26 – Proportional (P) Gain**

The Proportional Gain is the first of three Items which define the responsiveness of the control with respect to how fast it responds to changing loads. Because the MD *plus* controls are true velocity-form PID control, the higher the P Gain, the more aggressively the unit will respond to a change in load or target speed. See the "Basic Operating Instructions" section of the manual for more details.

### **Item 27 – Integral (I) Gain**

The Integral Gain is the second of two Items which define the responsiveness of the control with respect to how fast it responds to changing loads. The higher the I Gain, the more aggressively the unit will drive the load. However, it will sometimes be necessary to decrease the I Gain and/or increase the P Gain to prevent unwanted oscillation and instabilities. See the "Basic Operating Instructions" section of the manual for more details.

### **Item 28 – Derivative (D) Gain**

The Derivative Gain is the third of the three Items which define the responsiveness of the control with respect to how fast it responds to changing loads. Although most applications will run fine with the D Gain set to zero, sometimes adding a little "D" will help minimize overshoot and undershoot. See the "Basic Operating Instructions" section of the manual for more details.

### **Item 29 – Startup Lag Compensation**

Somewhat analogous to a "Min. Speed" control on analog motor speed controls, this sets a "minimum output" that is applied as soon as the Target Speed is above Zero RPM. Careful use of this setting can help with "stiction" (the tendency for motors to require a bit more "oomph" to "break free" when starting from a dead stop). However, values that are too high will make the motor "creep" or even be unable to attain a desired target speed. In Follower Mode, this setting can also help the Follower start up in better "sync" with the Leader.



### **Item 30 – Signal Input 1 (S1) (Main Pickup) Display Reference**

This is **the number to be displayed when at the user-specified motor Reference RPM**. In Rate Mode, this value represents rate units such as feet, ounces, or revolutions. In Time Mode, this value represents the reference time measured in seconds or minutes. If the desired display is HH:MM, then all values should be entered in minutes. If MM:SS is desired, then all values should be entered in seconds. In Follower Mode, this value is the percentage of the master rate in 0.1% units. For example, 1000 equates to 100%.

### **Item 31 – Signal Input 1 (S1) Reference RPM**

This is the **reference RPM at which the Display Reference value should be displayed**. In Rate and Time Modes, this value represents the RPM of the encoder to which the Display Reference corresponds. In Follower Mode, this value is not used.

### **Item 32 – Signal Input 1 (S1) Pulses per Revolution**

This is the number of pulses per revolution for the signal input 1 (S1). The MD *plus* supports pickups and encoders from 1 to 9999 pulses per revolution.

### **Item 33 – Signal Input 1 (S1) Initial Stall Timeout**

When the Target Speed is above zero RPM, this Item determines the maximum time in units of seconds that can elapse before the *first* S1 pickup pulse before the MD *plus* considers itself in a “Stall” Condition. It is not advisable to set this lower than approximately 10 seconds (a value of 10), or it may be difficult to achieve startup in a low-speed application. A value of zero defeats this timeout.

### **Item 34 – Signal Input 1 (S1) Running Stall Timeout**

When the Target Speed is above zero RPM, this Item determines the maximum time in units of 0.1 Seconds that can elapse between S1 pickup pulses before the MD *plus* considers itself in a “Stall” Condition. It is not advisable to set this lower than approximately 10 seconds (a value of 100), or it may be difficult to achieve startup in a low-speed application. Also note that the S1 Pulses Per Revolution (PPR) must be taken into account when determining the proper setting for this timeout. A value of zero defeats this timeout.

### **Item 35 – Signal Input 2 (S2) Input Configuration**

This Item determines the operating mode of signal input 2 (S2).

#### **Mode 1: Disabled (Follower Mode)**

The S2 input is inactive. This is the required setting for Follower Mode.

#### **Mode 2: Emergency Stop When S2 High (Not Wired To Common)**

When the S2 input is at an electrically high (+5V) state or allowed to float disconnected, the MD *plus* will enter emergency-stop mode. While in this mode, the armature output will immediately be turned off. Once the S2 input returns to an electrically low state or wired to the unit's common, the output will become active.

#### **Mode 3: Emergency Stop When S2 Low (Wired To Common)**

When the S2 input is at an electrically low state or wired to the unit's common, the MD *plus* will enter emergency-stop mode. While in this mode, the armature output will immediately be turned off. Once the S2 input returns to an electrically high (+5V) state or allowed to float disconnected, the output will become active.

#### **Mode 4: Inhibit When S2 High (Not Wired To Common)**

When the S2 input is at an electrically high (+5V) state or allowed to float disconnected, the MD *plus* will enter inhibit mode. While inhibited, the armature output will decrease according to the decel setting until zero output is reached. Once the S2 input returns to an electrically low state or is wired to the unit's common, the output will start to accelerate toward the previous running value.

#### **Mode 5: Inhibit When S2 Low (Wired To Common)**

When the S2 input is at an electrically low state or wired to the unit's common, the MD *plus* will enter inhibit mode. While inhibited, the armature output will decrease according to the decel setting until zero output is reached. Once the S2 input returns to an electrically high (+5V) state or allowed to float disconnected, the output will start to accelerate toward the previous running value.

**Mode 6: (JOG1) Jog When S2 High (Not Wired To Common)**

When the S2 input is at an electrically high (+5V) state or allowed to float disconnected, the MD *plus* will enter JOG1 mode. While in JOG1 mode, the display will immediately change to the programmed JOG1 setpoint, Item 36. The unit will start accelerating or decelerating toward the JOG1 setting at the configured accel and decel rates. Once the S2 input returns to an electrically low state or is wired to the unit's common, the output will start to accelerate or decelerate toward the previous running value. In Follower Mode, the unit will operate as its own master. This allows an application to jog by overriding a stopped master.

**Mode 7: (JOG1) Jog When S2 Low (Wired To Common)**

When the S2 input is at an electrically low state or wired to the unit's common, the MD *plus* will enter JOG1 mode. While in JOG1 mode, the display will immediately change to the programmed JOG1 setpoint, Item 36. The unit will start accelerating or decelerating toward the JOG1 setting at the configured accel and decel rates. Once the S2 input returns to an electrically high (+5V) state or allowed to float disconnected, the output will start to accelerate or decelerate toward the previous running value. In Follower Mode, the unit will operate as its own master. This allows an application to jog by overriding a stopped master.

**Item 36 – Signal Input 2 (S2) Setpoint for JOG1 Function**

When the S2 configuration, Item 35, is set to one of the JOG1 modes, this Item defines the JOG1 setpoint in engineering units. If the MD *plus* operating mode is set to Follower Mode, then this Item is set in RPM units. This allows a follower control to be jogged when the master is stopped.

**Item 37 – Signal Input 2 (S2) (“Leader”) Pulses per Revolution (for Follower Mode Only)**

When in Follower Mode, this is the number of pulses per revolution for the signal input 2 (S2) used as the “Leader” input. The MD *plus* supports pickups and encoders from 1 to 9999 pulses per revolution (PPR).

**Item 40 – User Input 1 (UIN1) Configuration**

This Item determines the operating mode of user input 1 (UIN1).

**Mode 1: Disabled**

The UIN1 input is inactive.

**Mode 2: Emergency Stop When UIN1 High (Not Wired To Common)**

When the UIN1 input is at an electrically high (+5V) state or allowed to float disconnected, the MD *plus* will enter emergency-stop mode. While in this mode, the armature output will immediately be turned off. Once the UIN1 input returns to an electrically low state or wired to the unit's common, the output will become active.

**Mode 3: Emergency Stop When UIN1 Low (Wired To Common)**

When the UIN1 input is at an electrically low state or wired to the unit's common, the MD *plus* will enter emergency-stop mode. While in this mode, the armature output will immediately be turned off. Once the UIN1 input returns to an electrically high (+5V) state or allowed to float disconnected, the output will become active.

**Mode 4: Inhibit When UIN1 High (Not Wired To Common)**

When the UIN1 input is at an electrically high (+5V) state or allowed to float disconnected, the MD *plus* will enter inhibit mode. While inhibited, the armature output will decrease according to the decel setting until zero output is reached. Once the UIN1 input returns to an electrically low state or is wired to the unit's common, the output will start to accelerate toward the previous running value.

**Mode 5: Inhibit When UIN1 Low (Wired To Common)**

When the UIN1 input is at an electrically low state or wired to the unit's common, the MD *plus* will enter inhibit mode. While inhibited, the armature output will decrease according to the decel setting until zero output is reached. Once the UIN1 input returns to an electrically high (+5V) state or allowed to float disconnected, the output will start to accelerate toward the previous running value.

### **Mode 6: (JOG2) Jog When UIN1 High (Not Wired To Common)**

When the UIN1 input is at an electrically high (+5V) state or allowed to float disconnected, the MD *plus* will enter JOG2 mode. While in JOG2 mode, the display will immediately change to the programmed JOG2 setpoint, Item 41. The unit will start accelerating or decelerating toward the JOG2 setting at the configured accel and decel rates. Once the UIN1 input returns to an electrically low state or is wired to the unit's common, the output will start to accelerate or decelerate toward the previous running value. In Follower Mode, the unit will operate as its own master. This allows an application to jog by overriding a stopped master.

### **Mode 7: (JOG2) Jog When UIN1 Low (Wired To Common)**

When the UIN1 input is at an electrically low state or wired to the unit's common, the MD *plus* will enter JOG2 mode. While in JOG2 mode, the display will immediately change to the programmed JOG2 setpoint, Item 41. The unit will start accelerating or decelerating toward the JOG2 setting at the configured accel and decel rates. Once the UIN1 input returns to an electrically high (+5V) state or allowed to float disconnected, the output will start to accelerate or decelerate toward the previous running value. In Follower Mode, the unit will operate as its own master. This allows an application to jog by overriding a stopped master.

### **Item 41 – User Input 1 (UIN1) Setpoint for JOG2 Function**

When the UIN1 configuration, Item 40, is set to one of the JOG2 modes, this Item defines the JOG2 setpoint in engineering units. If the MD *plus* operating mode is set to Follower Mode, then this Item is set in RPM units. This allows a follower control to be jogged when the master is stopped.

### **Item 42 – Inhibit Configuration**

This Item determines the accel/decel profile of the MD *plus* when it is going into and out of “Inhibit” Mode. There are 4 possible settings:

#### **Mode 0: No Accel/Decel**

When going into Inhibit, the MD *plus* will immediately shut off its output, disregarding any Decel setting, and when coming out of Inhibit, the MD *plus* will immediately return to its Target Speed, disregarding any Accel setting. This is exactly like the “E-Stop” behavior.

#### **Mode 1: Decel Only, No Accel**

When going into Inhibit, the MD *plus* will Decel to a stop using the setting in Item 24, but when coming out of Inhibit, the MD *plus* will immediately return to its Target Speed, disregarding any Accel setting.

#### **Mode 2: Accel Only, No Decel**

When going into Inhibit, the MD *plus* will immediately shut off its output, disregarding any Decel setting, but when coming out of Inhibit, the MD *plus* will Accelerate to its Target Speed, using the Accel setting in Item 23.

#### **Mode 3: Use Both Accel and Decel**

When going into Inhibit, the MD *plus* will Decel to a stop using the setting in Item 24, and when coming out of Inhibit, the MD *plus* will Accelerate to its Target Speed, using the Accel setting in Item 23.

### **Item 50 – Alarm 1 Logical “OR” Activation Conditions**

This Item, in conjunction with Items 51 & 52, defines which conditions will result in the Alarm 1 output being activated. The function is that of a Logical “OR”ing of the selected Drive Condition Flags. A setting of zero defeats this “OR” function entirely. Please see the sections “Setting and Reading Softswitches” and “Setting Alarm Conditions” for further details.

### **Item 51 – Alarm 1 Logical Activation Condition Inverters**

This Item, in conjunction with Items 50 & 52, defines which conditions will result in the Alarm 1 output being activated. The function allows selected Drive Condition Flags to be “inverted” before being presented to the “inputs” of the “AND” function (see Item 52). Please see the sections “Setting and Reading Softswitches” and “Setting Alarm Conditions” for further details.

### **Item 52 – Alarm 1 Logical “AND” Activation Conditions**

This Item, in conjunction with Items 50 & 51, defines which conditions will result in the Alarm 1 output being activated. The function is that of a Logical “AND”ing of the selected Drive Condition Flags. A setting of zero defeats this “AND” function entirely. Please see the sections “Setting and Reading Softswitches” and “Setting Alarm Conditions” for further details.

### **Item 53 – Alarm 1 Output Style & Reset Configuration**

This setting configures the output mode and reset method for the Alarm 1 output.

#### **Mode 1: Constant & Auto Reset**

In this mode, the alarm output will remain active until the alarm condition ceases to exist. The alarm will automatically reset when the conditions return to normal.

#### **Mode 2: Constant & Manual Reset**

In this mode, the alarm output will remain active until the alarm is reset manually. See Item 54 for details.

#### **Mode 3: Pulse & Auto Reset**

In this mode, the alarm output will pulse on and off until the alarm condition ceases to exist. The pulsed modes are commonly used for audible alarms where a constant output would be considered distracting or awkward. The alarm will automatically reset when the conditions return to normal.

#### **Mode 4: Pulse & Manual Reset**

In this mode, the alarm output will pulse on and off until the alarm is reset manually. See Item 54 for reset details. The pulsed modes are commonly used for audible alarms where a constant output would be considered distracting or awkward.

### **Item 54 – Alarm 1 Reset Configuration**

This setting determines which actions will cause an active alarm to be silenced or reset.

#### **Mode 1: No Silencing, Reset On ENTER Button Press**

In this mode, an active alarm cannot be silenced. Once the alarm condition ceases to exist, however, the ENTER button may be pressed to cause a manual reset.

#### **Mode 2: No Silencing, Reset On S2 Input High (Not Wired To Common)**

Similar to Mode 1. Once the alarm condition ceases to exist, setting the S2 input to a high (+5V) state or allowing it to float disconnected will cause a manual reset.

#### **Mode 3: No Silencing, Reset On S2 Input Low (Wired To Common)**

Similar to Mode 1. Once the alarm condition ceases to exist, setting the S2 input to a low (COM) state or wiring it to common will cause a manual reset.

#### **Mode 4: Silencing Enabled, Reset On ENTER Button Press**

When the conditions for an active alarm persist, pressing any user-interface button will result in the alarm being silenced or deactivated, but not reset. A second attempt to reset the alarm must be made after the condition ceases to exist to clear the alarm.

#### **Mode 5: Silencing Enabled, Reset On S2 Input High (Not Wired To Common)**

Similar to Mode 4. Setting the S2 input to a high (+5V) state or allowing it to float disconnected will cause the alarm to be silenced or reset depending on the current state of the alarm conditions.

#### **Mode 6: Silencing Enabled, Reset On S2 Input Low (Wired To Common)**

Similar to Mode 4. Setting the S2 input to a low (COM) state or wiring it to common will cause the alarm to be silenced or reset depending on the current state of the alarm conditions.

### **Item 55 – Alarm 1 Annunciator Flash On Alarm**

When set to 1, this will cause the “Alm1” LED Annunciator to flash when an alarm 1 condition is active. A setting of zero defeats this function.

### **Item 56 – Alarm 1 Pulse "ON" Time**

This Item defines the number of seconds the output should be enabled during the ‘on’ phase of an active pulsing alarm’s output.

### **Item 57 – Alarm 1 Pulse "OFF" Time**

This Item defines the number of seconds the output should be disabled during the ‘off’ phase of an active pulsing alarm’s output.

### **Item 58 – Alarm 1 Pulse Count**

This setting determines how many pulses are output when the alarm is activated and is configured in the pulse output style. *When 0 is entered, the unit will be set for continuous pulses while the alarm is active.*

### **Item 59 – Alarm 1 Lower Limit**

This setting defines either the lower limit or the lower end of a range for the alarm region. Alarm limits are set in engineering units without regard to decimal point or colon position. In Rate and Follower Modes, a limit of 123 could represent a display value of 123, 12.3, 1.23, or 0.123. When in Time Mode, a limit of 123 would represent 1:23 on the display.

### **Item 60 – Alarm 1 Upper Limit**

This setting defines either the upper limit or the upper end of a range for the alarm region. Alarm limits are set in engineering units without regard to decimal point or colon position. In Rate and Follower Modes, a limit of 123 could represent a display value of 123, 12.3, 1.23, or 0.123. When in Time Mode, a limit of 123 would represent 1:23 on the display.

### **Item 70 – Alarm 2 Logical “OR” Activation Conditions**

This Item, in conjunction with Items 71 & 72, defines which conditions will result in the Alarm 2 output being activated. The function is that of a Logical “OR”ing of the selected Drive Condition Flags. A setting of zero defeats this “OR” function entirely. Please see the sections “Setting and Reading Softswitches” and “Setting Alarm Conditions” for further details.

### **Item 71 – Alarm 2 Logical Activation Condition Inverters**

This Item, in conjunction with Items 70 & 72, defines which conditions will result in the Alarm 2 output being activated. The function allows selected Drive Condition Flags to be “inverted” before being presented to the “inputs” of the “AND” function (see Item 72). Please see the sections “Setting and Reading Softswitches” and “Setting Alarm Conditions” for further details.

### **Item 72 – Alarm 2 Logical “AND” Activation Conditions**

This Item, in conjunction with Items 70 & 71, defines which conditions will result in the Alarm 2 output being activated. The function is that of a Logical “AND”ing of the selected Drive Condition Flags. A setting of zero defeats this “AND” function entirely. Please see the sections “Setting and Reading Softswitches” and “Setting Alarm Conditions” for further details.

### **Item 73 – Alarm 2 Output Style & Reset Configuration**

This setting configures the output mode and reset method for the Alarm 2 output.

#### **Mode 1: Constant & Auto Reset**

In this mode, the alarm output will remain active until the alarm condition ceases to exist. The alarm will automatically reset when the conditions return to normal.

#### **Mode 2: Constant & Manual Reset**

In this mode, the alarm output will remain active until the alarm is reset manually. See Item 74 for details.

#### **Mode 3: Pulse & Auto Reset**

In this mode, the alarm output will pulse on and off until the alarm condition ceases to exist. The pulsed modes are commonly used for audible alarms where a constant output would be considered distracting or awkward. The alarm will automatically reset when the conditions return to normal.

#### **Mode 4: Pulse & Manual Reset**

In this mode, the alarm output will pulse on and off until the alarm is reset manually. See Item 74 for reset details. The pulsed modes are commonly used for audible alarms where a constant output would be considered distracting or awkward.



#### **Item 74 – Alarm 2 Reset Configuration**

This setting determines which actions will cause an active alarm to be silenced or reset.

##### **Mode 1: No Silencing, Reset On ENTER Button Press**

In this mode, an active alarm cannot be silenced. Once the alarm condition ceases to exist, however, the ENTER button may be pressed to cause a manual reset.

##### **Mode 2: No Silencing, Reset On S2 Input High (Not Wired To Common)**

Similar to Mode 1. Once the alarm condition ceases to exist, setting the S2 input to a high (+5V) state or allowing it to float disconnected will cause a manual reset.

##### **Mode 3: No Silencing, Reset On S2 Input Low (Wired To Common)**

Similar to Mode 1. Once the alarm condition ceases to exist, setting the S2 input to a low (COM) state or wiring it to common will cause a manual reset.

##### **Mode 4: Silencing Enabled, Reset On ENTER Button Press**

When the conditions for an active alarm persist, pressing any user-interface button will result in the alarm being silenced or deactivated, but not reset. A second attempt to reset the alarm must be made after the condition ceases to exist to clear the alarm.

##### **Mode 5: Silencing Enabled, Reset On S2 Input High (Not Wired To Common)**

Similar to Mode 4. Setting the S2 input to a high (+5V) state or allowing it to float disconnected will cause the alarm to be silenced or reset depending on the current state of the alarm conditions.

##### **Mode 6: Silencing Enabled, Reset On S2 Input Low (Wired To Common)**

Similar to Mode 4. Setting the S2 input to a low (COM) state or wiring it to common will cause the alarm to be silenced or reset depending on the current state of the alarm conditions.

#### **Item 75 – Alarm 2 Annunciator Flash On Alarm**

When set to 1, this will cause the “Alm2” LED Annunciator to flash when an alarm 2 condition is active. A setting of zero defeats this function.

#### **Item 76 – Alarm 1 Pulse on Time**

This Item defines the number of seconds the output should be enabled during the ‘on’ phase of an active pulsing alarm’s output.

#### **Item 77 – Alarm 1 Pulse off Time**

This Item defines the number of seconds the output should be disabled during the ‘off’ phase of an active pulsing alarm’s output.

#### **Item 78 – Alarm 1 Pulse Count**

This setting determines how many pulses are output when the alarm is activated and is configured in pulse output style. *When 0 is entered, the unit will be set for continuous pulses while the alarm is active.*

#### **Item 79 – Alarm 1 Lower Limit**

This setting defines either the lower limit or the lower end of a range for the alarm region. Alarm limits are set in engineering units without regard to decimal point or colon position. In Rate and Follower Modes, a limit of 123 could represent a display value of 123, 12.3, 1.23, or 0.123. When in Time Mode, a limit of 123 would represent 1:23 on the display.

#### **Item 80 – Alarm 1 Upper Limit**

This setting defines either the upper limit or the upper end of a range for the alarm region. Alarm limits are set in engineering units without regard to decimal point or colon position. In Rate and Follower Modes, a limit of 123 could represent a display value of 123, 12.3, 1.23, or 0.123. When in Time Mode, a limit of 123 would represent 1:23 on the display.

### Item 81 – Alarm 2 Output Routing

This setting allows the MD *plus* to control the “Alarm 1” Output of a selected ModularBus “Slot”, provided of course that there is a ModularBus card that supports this function installed in the selected slot. The valid values for this Item are:

#### Mode 1: Not Used

#### Mode 2:Route Alarm 2 Output to ModularBus Slot 100 Alarm 1 Output

In this mode, the MD *plus* Alarm 2 Output will directly control the Alarm 1 Output of a ModularBus Card installed in Slot 100, if that card supports this feature.

#### Mode 3:Route Alarm 2 Output to ModularBus Slot 200 Alarm 1 Output

In this mode, the MD *plus* Alarm 2 Output will directly control the Alarm 1 Output of a ModularBus Card installed in Slot 200, if that card supports this feature.

#### Mode 4:Route Alarm 2 Output to ModularBus Slot 500 Alarm 1 Output

In this mode, the MD *plus* Alarm 2 Output will directly control the Alarm 1 Output of a ModularBus Card installed in Slot 500, if that card supports this feature.

### “Action” Items (Commands), Items 95 through 99

Rather than being a “setting” or a “switch” type Item, Items 95 through 99 are used to trigger a certain “Action” or “Script” that generally performs some Utility function for the MD *plus*, and/or a ModularBus card installed in the drive. The “value” settings are used as a kind of “key” to make sure these functions are not accidentally “triggered”.

### Item 95 – Factory Default Drive Command

When set to a value of 5, and then pressing the ENTER button, the MD *plus* (Drive only) will be reset to factory default settings. **THIS ACTION CANNOT BE UNDONE!** This Command can also be achieved by applying power to the unit with both the Enter and Down buttons depressed. *The programming jumper must be in the “On” position for this Command to function. Any ModularBus card settings are unaffected.*

### Item 96 – Factory Default ModularBus Card Command

When set to the desired ModularBus Slot number (100, 200, 500) and the ENTER button is pressed, the Default settings for that ModularBus card’s Items will be copied to the selected Slot’s “partition” in the non-volatile storage of the MD *plus*. **THIS ACTION CANNOT BE UNDONE!** Note that the Item settings for a particular ModularBus card are actually stored on its “host” MD *plus*, rather than on the ModularBus card itself. The advantage of this is that if a ModularBus card fails, a replacement can be quickly installed without having to be (re)configured, provided it is installed in the same Slot.

The valid values for this Item are:

#### Mode 100: Restore Factory Defaults for card in ModularBus Slot 100

Assumes there is a card in Slot 100.

#### Mode 200: Restore Factory Defaults for card in ModularBus Slot 200

Assumes there is a card in Slot 200.

#### Mode 500: Restore Factory Defaults for card in ModularBus Slot 500

Assumes there is a card in Slot 500.

### Item 98 – Save (copy) current "Environment" Settings TO User Save Area

When set to a value of 5, and then pressing the ENTER button, the MD *plus* will prompt the user to Save the current "environment" (Settings for the drive and all installed ModularBus cards) TO whichever User Save area ("Settings1" or "Settings2") that is *not* currently being used as the "Working" Settings. **THIS ACTION CANNOT BE UNDONE!** Pressing the "Up" button will Save the settings; pressing any other button will Cancel the operation.

**TIP:** This feature is often used by OEMs to save their customized settings to a "safe" area, that later can be easily Restored if the need arises.

**NOTE:** Unless a "Swap" command has been used (see Item 99), the "Working" area is "Settings1". Therefore, this command will normally Save to "Settings2".

### Item 99 – Restore/Swap current "Environment" Settings FROM User Save Area

When set to a value of 5 (for "Restore") or 10 (for "Swap"), and then pressing the ENTER button, the MD *plus* will prompt the user to Copy the current "environment" (Settings for the drive and all installed ModularBus cards) FROM whichever User Save area ("Settings1" or "Settings2") that is *not* currently being used as the "Working" Settings. or to "Change" (Swap) between using "Settings1" and "Settings2" as the "Working" Settings area. The "Copy" (Restore) is "destructive", but the "Change" (Swap) is not.

The valid values for this Item are:

#### **Mode 5: Restore Environment from whichever User Save area is not "Current"**

Will copy "Settings2" (or "Settings1") settings to the Current ("Working") settings. If the "Working" Settings are coming from "Settings1", then the values in "Settings2" will be used. If the "Working" Settings are coming from "Settings2", then the values in "Settings1" will be used. Either way, the result is that "Settings1" and "Settings2" will end up containing the same values. **THIS ACTION CANNOT BE UNDONE!**

#### **Mode 10: Swap "Working" Settings between "Settings1" and "Settings2"**

Non-Destructively "swaps" the "Working" Settings between using "Settings1" and "Settings2". This allows the user to easily play "what-if" type of speculation with one or more Items, without fear of "losing" their current settings. **THE SWAP CAN BE DONE AS MANY TIMES AS DESIRED.**

**TIP:** The easiest way to find out which area "Settings1 or Settings2" is the "Working" (current) settings, is to enter this mode, and watch the "prompt" to see which area is being offered to "Change to". The current "Working" settings area is the one that is "opposite". For example, if the "prompt" offers to Change to "Settings2", then the MD *plus* (and any ModularBus cards) are currently using "Settings1" as the "Working" area, and vice versa. Then, "Cancel" the "Swap".



# OPT420 Software Parameters (Items)

**Note:** Add the ModularBus “Slot” Number (100, 200, 500) X 10 to the Item number below to determine the actual Item Number in the Host Drive’s Item-Numbering scheme. For example, to set Item 41 of an OPT420 in ModularBus Slot 200, you would select Item 2041 (200 X 10 + 41).

Item	Description	Value Range	Units	Factory Default	User Setting
<b>Read-Only Identification Items</b>					
1	Model Number	420 = OPT420	—	420	
2	Software Version	1 – 9999	—	—	
3	Hardware Version	1 – 9999	—	—	
4	Device Type	100 = Type 1 ModularBus Card	—	100	
5	Minimum Supported Framework Version	1 – 9999	—	—	
6	Maximum Supported Protocol Version	1 – 9999	—	—	
7	Serial Number (Major)	0-9999	—	n/a	
8	Serial Number (Minor)	0-9999	—	n/a	
<b>4-20mA Input Scaling Items</b>					
20	OPT420’s Target Speed to Drive @ 4mA Input Current	0 – 9999 (Limited by Drive’s Display Minimum Setting)	(Drive’s Eng. Units)	0	
21	OPT420’s Target Speed to Drive @ 20mA Input Current	0 – 9999 (Limited by Drive’s Display Maximum Setting)	(Drive’s Eng. Units)	2400	
22	4mA Input Trim	-600 – +600 <sup>1</sup>	—	0	
23	20mA Input Trim	-600 – +600 <sup>1</sup>	—	0	
<b>4-20mA Output Scaling Items</b>					
40	Actual (S1 tach) Speed from Drive needed to Produce 4mA Output Current from OPT420	0 – 9999	(Drive’s Eng. Units)	0	
41	Actual (S1 tach) Speed from Drive needed to Produce 20mA Output Current from OPT420	0 – 9999	(Drive’s Eng. Units)	2400	
42	4mA Output Trim	-600 – +600 <sup>1</sup>	—	0	
43	20mA Output Trim	-600 – +600 <sup>1</sup>	—	0	
<b>Read-Only Real-time Process Variables</b>					
70	Input Current to OPT420	0 – 4095	ADC Steps	n/a	
71	Target Speed to Drive from OPT420	0 – 9999	(Drive’s Eng. Units)	n/a	
72	Output Current to Drive from OPT420	0 – 4095	DAC Steps	n/a	
73	OPT420 Condition Flags (not yet implemented)	0 = No Active “Flags” 1 – 9999 = Flags Activated	BCD	0	
74	OPT420 Auto/Manual Switch State	0 = Auto Mode 1 = Manual Mode	—	0	

<sup>1</sup> Host Drive’s Display will Flash to indicate Negative Values

# OPT420 Item (Parameter) Descriptions

## **Item 1 – Model Number (Read Only)**

This number represents the base model number for the product. The model code for the OPT420 ModularBus card is, logically enough, 420. In this manual, where appropriate, the “Drive” in which this OPT420 card is installed is called, generically, the “Host Drive”.

## **Item 2 – Software Version (Read Only)**

The software version is a code which identifies the software “build number” of the unit.

## **Item 3 – Hardware Version (Read Only)**

The hardware version is a code which identifies which hardware was used to build the unit.

## **Item 4 – ModularBus Card Device Type (Read Only)**

This value is primarily used to determine whether the particular ModularBus card has on-board non-volatile storage for its Item settings. The OPT420 is a “Type 1” ModularBus card (value = 100), which does not have its own non-volatile storage. It depends on the Host Drive to store its Item settings. This means that if an OPT420 must be replaced in a Host Drive, the “new” OPT420 does not need to be configured. It will simply “inherit” the “old” OPT420’s Item settings, provided it is placed in the same ModularBus Slot.

## **Item 5 – Minimum Supported Framework Version (Read Only)**

The lowest software “framework” version that is compatible with this ModularBus card.

## **Item 6 – ModularBus Protocol Version (Read Only)**

The ModularBus protocol version is a code which identifies the *highest* (most-recent) version of the ModularBus protocol with which this ModularBus card is compatible.

## **Item 7 & 8 – Serial Number, Major & Minor (Read Only)**

These Items are reserved for future use as an electronic serial number and are unique to each manufactured unit.

## **Item 20 – OPT420’s Target Speed to Host Drive @ 4mA of Input Current**

This is the Target Speed setting that the OPT420 makes available to its Host Drive when there is 4mA of current flowing through the OPT420’s Input Loop terminals. The setting is in the Host Drive’s “Engineering Units”, just as if the Target Speed was being entered on the Host Drive itself. This setting is limited by the Host Drive’s Minimum Display setting.

## **Item 21 – OPT420’s Target Speed to Host Drive @ 20mA of Input Current**

This is the Target Speed setting that the OPT420 makes available to its Host Drive when there is 20mA of current flowing through the OPT420’s Input Loop terminals. The setting is in the Host Drive’s “Engineering Units”, just as if the Target Speed was being entered on the Host Drive itself. This setting is limited by the Host Drive’s Maximum Display setting. This setting should also be greater than the setting for Item 20, above.

## **Item 22 – 4mA Input Current Trim**

Used to compensate for minor inaccuracies in the overall system that is connected to the OPT420’s Input Loop terminals. This “trim”, which has a range that goes both positive and negative, affects the 4mA endpoint of the OPT420’s input range. To return to the factory-calibrated 4mA endpoint, set this Item to a value of zero.

## **Item 23 – 20mA Input Current Trim**

Used to compensate for minor inaccuracies in the overall system that is connected to the OPT420’s Input Loop terminals. This “trim”, which has a range that goes both positive and negative, affects the 20mA endpoint of the OPT420’s input range. To return to the factory-calibrated 20mA endpoint, set this Item to a value of zero.

**Item 40 – Host Drive’s Actual Speed (Tach) Value to Produce 4mA Output from OPT420**

This is the Actual Speed (tach) value that the OPT420 translates into 4mA of current flow through the OPT420’s Output Loop terminals. The setting is in the Host Drive’s “Engineering Units”, just as if the Tach Display was being viewed on the Host Drive itself.

**Item 41 – Host Drive’s Actual Speed (Tach) Value to Produce 20mA Output from OPT420**

This is the Actual Speed (tach) value that the OPT420 translates into 20mA of current flow through the OPT420’s Output Loop terminals. The setting is in the Host Drive’s “Engineering Units”, just as if the Tach Display was being viewed on the Host Drive itself.

**Item 42 – 4mA Output Current Trim**

Used to compensate for minor inaccuracies in the overall system that is connected to the OPT420’s Output Loop terminals. This “trim”, which has a range that goes both positive and negative, affects the 4mA endpoint of the OPT420’s Output range. To return to the factory-calibrated 4mA endpoint, set this Item to a value of zero.

**Item 43 – 20mA Output Current Trim**

Used to compensate for minor inaccuracies in the overall system that is connected to the OPT420’s Output Loop terminals. This “trim”, which has a range that goes both positive and negative, affects the 20mA endpoint of the OPT420’s Output range. To return to the factory-calibrated 20mA endpoint, set this Item to a value of zero.

## Real-Time Process Variables (Read Only), Items 70 - 74

Rather than being a “setting” or a “switch” type Item, Items 70 through 74 on the OPT420 are used to view (only) certain Real-Time “Process” variables going to/from the OPT420. These Items are mainly useful in troubleshooting a particular application, rather than being of general-purpose use.

**Item 70 – Input Current to OPT420**

This shows the instantaneous input loop current to the OPT420, in raw ADC “steps”. Since the OPT420 uses a 12-bit A/D, the range of this Item can be from 0 to 4095, although it will not get to these extremes in the typical 4-20mA setup. The actual number is of less interest than whether the numbers tend to “follow” a 4-20mA input signal.

**Item 71 – Target Speed to Host Drive from OPT420**

This shows the instantaneous “Target Speed” that the OPT420 has calculated to make available to the Host Drive, in the Host Drive’s Engineering Units, based on the Input Current flowing through P3 1 & 2 on the OPT420, and the setting of OPT420 Items 20 through 23.

**Item 72 – Output Current from OPT420**

This shows the instantaneous output loop current from the OPT420, in raw DAC “steps”. Since the OPT420 uses a 12-bit D/A, the range of this Item can be from 0 to 4095, although it will not get to these extremes in the typical 4-20mA setup. The actual number is of less interest than whether the numbers tend to “follow” the Host Drive’s Actual (S1 Pickup) “Tach” speed.

**Item 73 – OPT420 Condition “Flags”**

Not yet implemented.

**Item 74 – OPT420 Auto/Manual (S1) Switch State**

This shows the instantaneous state of the Auto/Manual switch input. A value of zero means that the OPT420 will report “Auto Mode” to the Host Drive. A value of 1 equals “Manual” mode.

# Application Example

## SCADA-driven Pump Controller with 4-20mA I/O, plus "Fault" and "Run" Relay Outputs

### Description:

An MD *plus* (with OPT420 installed) waste pump control connected to a SCADA system to receive its target speed setting from the SCADA's 4-20mA output. The MD *plus* will display the actual pump rate in liters per minute, and will also continuously report the pump's actual rate to the SCADA system using the OPT420's 4-20mA output. The display should indicate in the format "xxx.x" (LPM).

System features a visual alarm (Annunciator) and dry relay contact output which will warn the operator if any of the following "Fault" conditions have occurred: Actual or Target speed is outside specified limits, the waste flow has stopped, the MD *plus* is at maximum output, or the 4-20mA input signal has dropped below about 3mA (loop broken). Additionally, the "Fault" alarm will not activate if the Target speed is zero, the "Inhibit" input is active, or an accel/decel ramp is in progress. The alarm should not be able to be silenced but should automatically reset when flow rates have returned to normal.

Additionally, the system will provide a "Run" signal (as a dry relay contact) back to the SCADA to signal that the pump is indeed running (or not, as commanded by the SCADA).

### Motor, Pump and Flowmeter Specifications and Alarm Limits:

Pump Output: 9.5 shaft rotations/liter

Flow Transducer: 73 pulses/liter

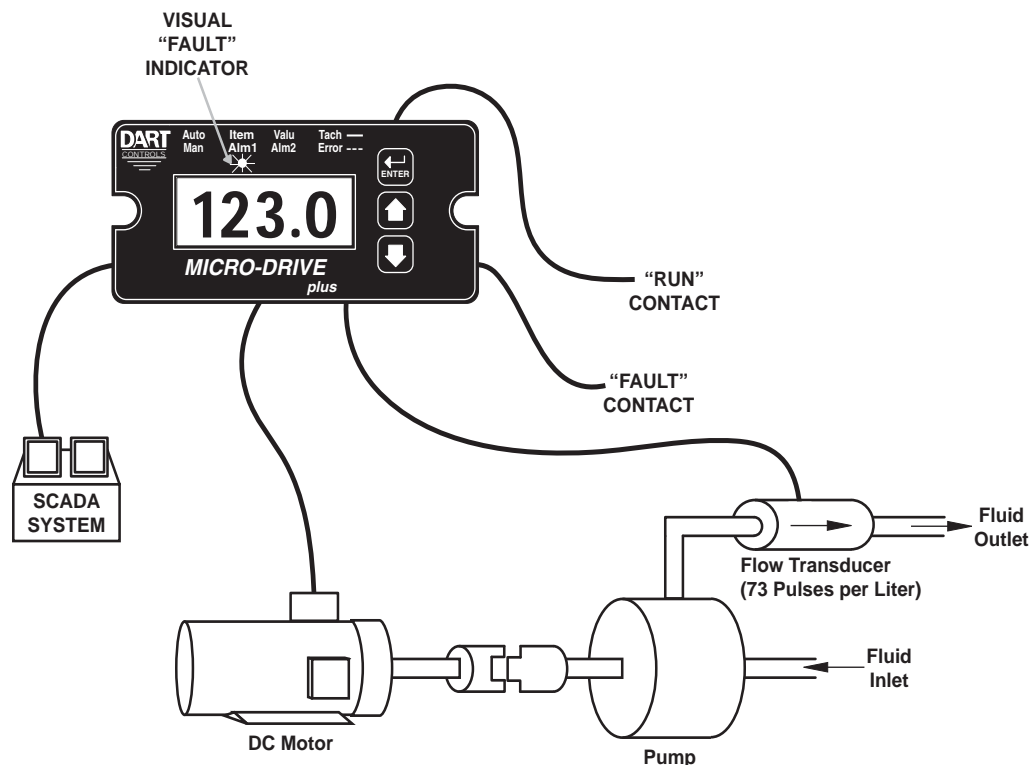
Desired Min. Flow Rate: 20 liters/minute, Max: 150 liters/minute

Alarm Min. 10 liters/minute, Max: 180 liters/minute

Accel Rate: 100 liters/minute, Decel Rate: 50 liters/minute

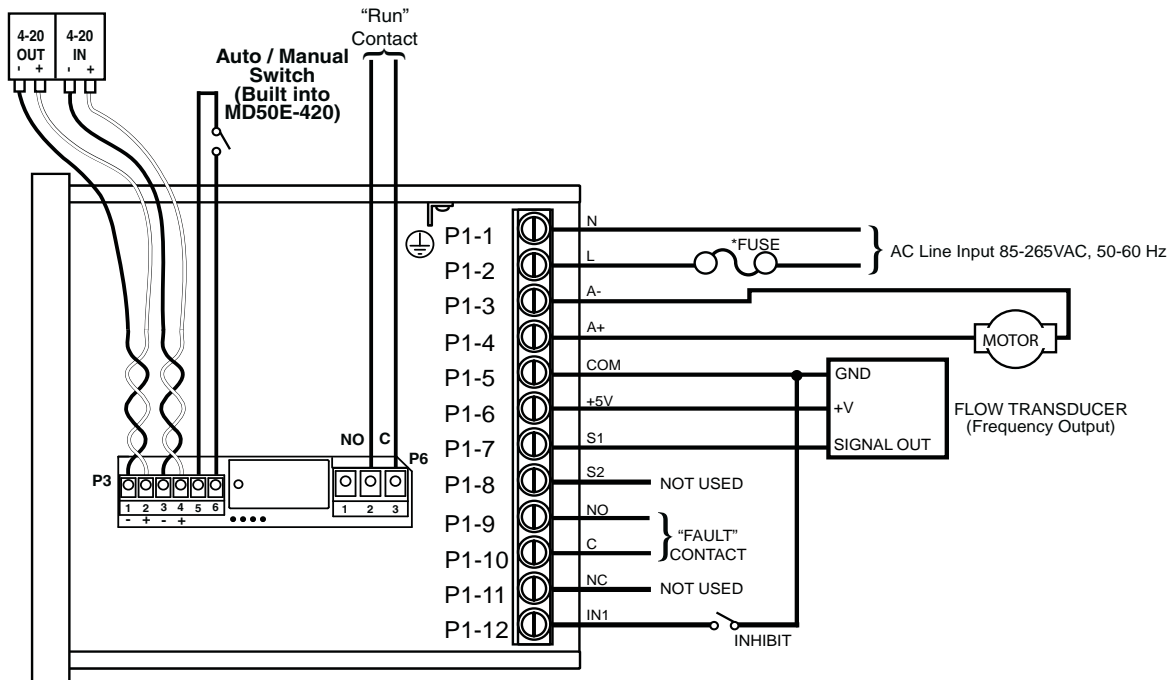
SCADA 4-20mA scaling (both input and output): 4mA = zero LPM, 20mA = 200 LPM

### Application Diagram:



## Wiring Diagram:

**SCADA SYSTEM**  
(Has built in  
Excitation Supply)



MD40P-420  
MD50P-420  
MD50E-420

\* Size fuse according to unit and application. See electrical specifications for maximums.

## Relevant Math and Various Settings for this Application:

Since the pump is 9.5 "shaft rotations" per Liter, and the max. desired flow rate is 150.0 LPM, and the motor is a 1:1 drive, that means the motor speed at 150.0 LPM will be  $9.5 \times 150.0$ , or 1,425 RPM., to which we will set Item 31, S1 Reference RPM.

Next, Item 30, Display Reference will be set to "1500", which is what we want the display to read (disregarding the decimal point) when the motor is running at our Reference speed of 1,425 RPM.

Since we already know that the Flow Transducer has a pulse output rate of 73 pulses per liter, all we need to do is set Item 32, S1 Pulses Per Revolution, (which in this case, is somewhat mis-named) to 73. That way, the controller is "thinking" in LITERS per minute, but "controlling" the motor in REVOLUTIONS per minute.

The Accel and Decel rates are expressed in "Display Units" (Engineering Units) per second, so we have to divide our desired accel and decel rates by 60. Therefore, we will set Item 23, Accel Setting, to 17, which is  $1000 (100.0 \text{ disregarding the decimal point}) / 60$  (and rounded up), and Item 24, Decel Setting, to 8, which is  $500 (50.0) / 60$ .

Even though not really "math", let's talk about the BCD settings for the "Fault" conditions, which are used to control the Alarm1 relay. The application requires that a "Fault" condition is "true" (active) when Actual Speed is Outside Limits, *OR* Target Speed is Outside Limits, *OR* waste flow has stopped (Main Pickup (Flowmeter) Stalled), *OR* the MD *plus* is at Max. Output, *OR* the 4-20mA Input loop appears "broken". Consulting the table on page 14, sees that Item 50, Alarm1 *OR* Conditions, needs to be set to a value of  $2 + 4 + 16 + 512 + 4096$ , which equals 4630.

Conversely, the "Fault" output is wanted to *NOT* activate if any of the following conditions are true: Target speed (either through the 4-20mA input or the "front panel") is set to zero, *OR* an accel/decel ramp is in progress, *OR* an "Inhibit" input is active (UIN1 will be set for use as an Inhibit input). But you say "Wait! We already set the "OR" conditions! How do we do this?"

Here is where the magic of "negative logic" comes in: remember that "NOT" above? That implies that we will be using the "inverters" (Item 51 in the case of Alarm1), and the trick is, in negative-logic-land,

a "Positive Logic" *AND* is actually a "Negative Logic" *OR*. So, to set up that "but *NOT* if this *OR* this *OR* this" condition, we simply set both the Inverters (Item 51 for Alarm1) as well as the *AND* conditions (Item 52 for Alarm1) to the BCD sum of the "Flags" we wish to consider. Therefore, again consulting the table on page 14, we should set Items 51 and 52 to a value of 137, which is the BCD sum of 1 + 8 + 128.

Referring to the "Alarm Logic" diagram on page 15, you will see an additional "implied" *AND* function that "*ANDs*" the result of the *OR* as well as the *INVERT-AND* "cascade". Since an "AND" function is controlled by a "false" condition, (and since a logic "high" is "true"), you can see that any of the conditions selected in the *INVERT-AND* cascaded logic will make the result (output) be false (low), thus preventing any of the *OR'd* conditions from causing Alarm1, which we are using as our "Fault" relay, to activate.

It is important to note that as shown by the Alarm Logic diagram on page 15, when Item 50 (or 70 for Alarm2) is set to zero, the "Implied *AND*" is effectively "removed", thus allowing for "*AND*-only" Alarm condition logic. *OR*-only alarm logic is accomplished by setting both Items 51 and 52 (or 71 and 72 for Alarm2) to zero, which disconnects the output of the *INVERT-AND* logic, and instead substitutes a "pull up" to a "logic true" (high) level, which satisfies the "Implied *AND*", and allows the *OR* conditions to control the Alarm output exclusively.

The BCD programming for Alarm2, which we are using to control the relay on the OPT420 to form a "Run" output, is much simpler. The MD *plus* has an "already cooked" "Run" condition (see Table, page 14), which is true (active) when the Target Speed is greater than zero, *AND* the main pickup has received at least one pulse. Therefore, set Item 70, the Alarm2 "*OR*", to the "Run" condition's BCD value, 1024. Items 71 and 72 are set to zero. To have the OPT420's relay output to be controlled by our "Run" condition (Alarm2), set Item 81, Alarm2 Output Routing, at its default value of 3 (assuming the OPT420 is in slot 200).

In addition to these settings, there are various other Items that control the Alarm Limits, Alarm "Reset" behavior, the Alarm1 "Annunciator", the Displayed Decimal Point position, etc. See the Item Configuration table below for further details

**Table: Item Configuration** (all other Items may be set to factory defaults, or as desired): Note: Item numbers above 999 are located on the OPT420 ModularBus Card

Item #	Value	Notes
12	2	Set the Display to show ACTUAL (not "Target") Liters per Minute flow through the pump
13	3	Desired Decimal Point Display is XXX.X
20	200	Minimum Rate (Target Speed) is 20.0 LPM ("200" on the display)
21	1500	Maximum Rate is 150.0 LPM ("1500" on the display)
23	17	Accel rate is 17 Liters per SECOND, or 100 Liters per MINUTE
24	8	Decel rate is 8 Liters per SECOND, or 50 Liters per MINUTE
30	1500	This is the Display Reference value. 150.0 LPM ("1500" on the display)
31	1425	This is the calculated <i>RPM</i> speed of the pump motor at the Display Reference value, above
33	10	Number of Seconds for "Initial" Stall Timeout
34	100	Number of tenths-of-seconds for the "Running" Stall Timeout
40	5	Using the UIN1 Input for an Active "Low" Inhibit Input (See Wiring Diagram, above)
42	3	Motor will decel to zero speed upon Inhibit, and accel back to speed when Inhibit released
50	4630	"Fault" (Alarm1) will Activate on several conditions. See "Description", above, for details.
51	137	Along with Item 52, forms conditions that will SUPPRESS the "Fault" (Alarm1) from Activating
52	137	This "AND", with Item 51, forms a Neg. Logic "OR" to Suppress "Fault" (Alarm1) Activation
59	100	"Fault" (Alarm1) needs to Activate when Target or Actual "Speed" is less than 10.0 LPM.
60	1800	"Fault" (Alarm1) needs to Acivate when Target of Actual "Speed" is greater than 180.0 LPM
70	1024	"Run" (Alarm2) is being used to reflect the "Run" condition Flag (Routed to OPT420 Relay)
2021	2000	Value to send from OPT420 to Host Drive when OPT420 receives 20mA on its Input terminals
2041	2000	Value from Host Drive to OPT420 that will cause 20mA to flow across its Output terminals



# Troubleshooting

Problem	Possible Case	Solution
Display is blank	Power not applied	Using a volt meter, verify that a voltage between 85 and 250VAC is measured between the L and N terminal block positions.
	Defective unit	Contact technical support for additional help and instructions.
Display is dim	Display intensity parameter is too low	Editing and increasing the display intensity parameter should cause the display digits to become brighter.
When power is applied, "LF-L" is displayed	AC line supplying power to unit has too much noise	Review routing of power wires in machine to minimize electrical noise. Look for other devices which share the same circuit which may be producing unacceptable levels of line noise. In some applications, such as welding equipment, a careful regiment of applying an AC line filter, re-routing wires, dividing circuits, using shielded cable, and properly grounding devices will usually solve the problem.
	AC line supplying power to unit has an abnormally low frequency	The unit is designed to operate with AC lines from 48-62 Hertz (cycles per second). This is typically not a problem because the international standards are 50 and 60 Hertz.
When power is applied, "LF-H" is displayed	AC line supplying power to unit has too much noise	Review routing of power wires in machine to minimize electrical noise. Look for other devices which share the same circuit which may be producing unacceptable levels of line noise. In some applications, such as welding equipment, a careful regiment of applying an AC line filter, re-routine wires, dividing circuits, using shielded cable, and properly grounding devices will usually solve the problem.
	AC line supplying power to unit has an abnormally high frequency	The unit is designed to operate with AC lines from 48-62 Hertz (cycles per second). This is typically not a problem because the international standards are 50 and 60 Hertz.
The alarm output does not seem to function	Alarm output parameters not configured properly	Alarm output parameters not configured properly Review alarm output parameters. The alarm relay output can be tested by selecting the "Always On" value for the Activation Condition parameters for the alarm output. When doing this, the relay click should be audible and the NC (Normally Closed) and C (Common) terminals should become internally shorted at the terminal block.

## Technical Support Options

- Visit the Dart Controls Web Site at: [www.dartcontrols.com](http://www.dartcontrols.com)
- Email technical support at: [techsupport@dartcontrols.com](mailto:techsupport@dartcontrols.com)
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# Models & Options

## Model Table

Model	Input Voltage @ 50 - 60Hz	Output Voltage @ 120VAC (@ 240VAC)	Max. Output H.P. @ 120VAC (@240VAC)	Max Continuous Armature DC Amps	Pickup or Encoder Required?
MD40P-420	85-250VAC	90VDC (180VDC)	1/2 1	5 5	Yes
MD50P-420	85-250VAC	90VDC (180VDC)	1 2	10 10	Yes
MD50E-420	85-250VAC	90VDC (180VDC)	1 2	10 10	Yes

## Available Options

Option Suffix	Description	Example
-1	Expansion board which adds support for remote push button wiring via a European-style terminal block.	MD40P-420-1, MD50P-420-1
-P	Optional pluggable European-style terminal block	MD40P-420-P, MD50P-420-P
-9	Blank Lexan	MD40P-420-9

## Recommended Accessories

Model	Description	Pulses Per Revolution	PPM Output Range
PU-2E	Hall Effect, Single Channel	1	0 – 20,000 <sup>note 1</sup>
PU-4E	Hall Effect, Single Channel	2	0 – 40,000 <sup>note 1</sup>
PU-20E	Hall Effect, Single Channel	10	0 – 200,000 <sup>note 1</sup>
PU-40E	Hall Effect, Single Channel	20	0 – 400,000 <sup>note 1</sup>
CF-60	Hall Effect, Single Channel	60	0 – 600,000 <sup>note 2</sup>

### NOTES:

1 – 20,000 RPM maximum rotational velocity

2 – When used with the MD40P, MD50P or MD50E

## Agency Approvals

MD40P-420, MD50P-420, MD50E-420 .....	cULus Pending
---------------------------------------	---------------

## Specifications

### Electrical

Line Input Voltage.....	Any Voltage from 85-250VAC
Line Input Frequency.....	Any Frequency from 48-62 Hertz
Signal Input Voltage Range .....	5VDC to 24VDC (square wave, referenced to P1-6 COMMON)
Speed Pickup Input Frequency Range (S1 and S2 Inputs).....	0 – 600,000 Pulses per Minute @ 5V square wave
Display Range .....	0.001 – 9,999
Units of Operation (“Engineering Units”) .....	User Programmable, any Units
Sensor / Pickup Power Supply .....	5V @ 50mA
MD40P, MD50P, MD50E Isolated Alarm Relay Output Rating .....	250VAC @ 5A
OPT420 Isolated Alarm Relay Output Rating.....	50VAC @ 1A
Average Armature Output Voltage.....	Line Voltage Dependent (see Model Table)
Design Overload Capacity.....	200% for 1 minute



## Mechanical

Display Type .....	LED, Red, 4 Digit, ½" Height
Housing Type MD40P-420 & MD50P-420 (with supplied gasket) .....	NEMA 4X
MD50E-420 .....	NEMA 4
Connector Style (pluggable connector optional) .....	12-position 5mm European Style
Terminal Block Torque Setting .....	4.4 in. lb. Max (.5Nm)
Faceplate Material .....	Polycarbonate with Polycarbonate Overlay
Housing Material .....	Aluminum
Length MD40P & MD50P(Required Panel Depth) .....	4.625 in. (117.48mm)
Faceplate Width .....	4.539 in. (115.29mm)
Weight MD40P .....	14.94 oz. (423.43g)
MD50P.....	25.78 oz. (730.85g)
MD50E.....	27.85 oz. (789.53g)

## Environmental

Operating Temperature Range.....	10C to 45C (15F to 115F)
Operating Humidity Range (max.).....	95%, non-condensing

## Dimension Chart

<i>Model</i>	<i>Width</i>	<i>Height</i>	<i>Depth</i>
<b>MD40P</b> English (inches)			
Housing	3.62	1.66	4.625
Lens	4.539	2.289	0.375
<b>MD40P</b> Metric (millimeters)			
Housing	91.94	42.16	117.27
Lens	115.28	58.14	9.53
<b>MD50P</b> English (inches)			
Housing	3.60	3.497	4.625
Lens	4.539	4.179	0.375
<b>MD50P</b> Metric (millimeters)			
Housing	91.44	88.82	117.27
Lens	115.28	106.15	9.53
<b>MD50E</b> English (inches)			
Assembly	5.53	7.40	3.90
<b>MD50E</b> Metric (millimeters)			
Assembly	140.46	187.96	99.06

## NOTES:

**NOTES:**

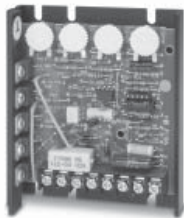
# REPAIR PROCEDURE

In the event that a Product manufactured by Dart Controls Incorporated (DCI) is in need of repair service, it should be shipped, freight paid, to: Dart Controls, Inc., 5000 W. 106th Street, Zionsville, IN. 46077, ATTN: Repair Department.

Those orders received from anyone without an existing account with DCI will need to specify if they will be paying COD or Credit Card (Master Card or Visa). This information is required before work can begin. If you have an account with Dart your order will be processed according to the terms listed on your account.

Completed repairs are returned with a Repair Report that states the problem with the control and the possible cause. Repair orders are returned via UPS Ground unless other arrangements are made. If you have further questions regarding repair procedures, contact Dart Controls, Inc. at 317-733-2133 Ext.460.

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