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BATCH INITIATE

The Batch Initiate input is used to reset the batch counter to zero. The feedback sync input is used to increment the counter.

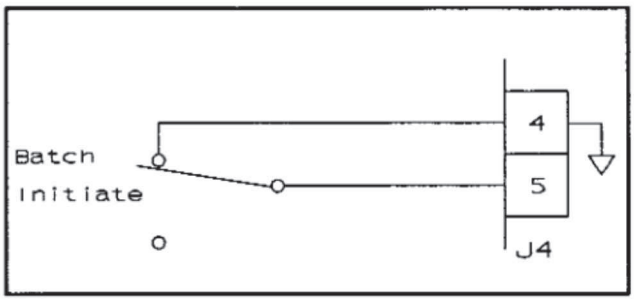


Figure 3-19: Batch Initiate

KEYPAD LOCKOUT

The Keypad Lockout input is used to disable the front operator keypad from making setpoint and other parameter changes.

All functions associated with monitoring or viewing of variables remain enabled during Keypad Lockout.

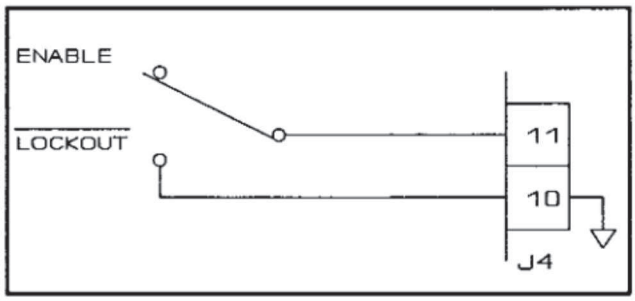


Figure 3-20: Keypad Lockout

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PHASE ADVANCE

It may not always be possible to locate the sync detect sensors at the most optimal location. The PHASE ADVANCE and PHASE RETARD inputs are momentary inputs used to increment an internal phase offset counter allowing proper sync alignment.

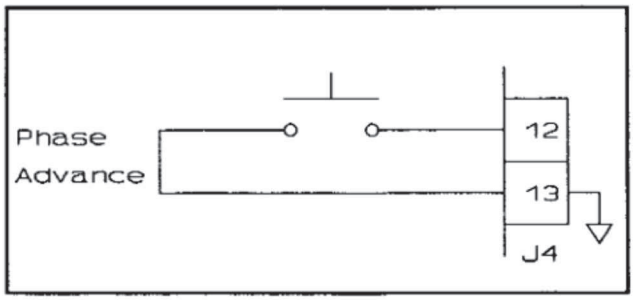


Figure 3-21: Phase Advance

PHASE RETARD

The Phase Retard is a momentary input used in conjunction with the Phase Advance to create a phase offset for sync pulse alignment.

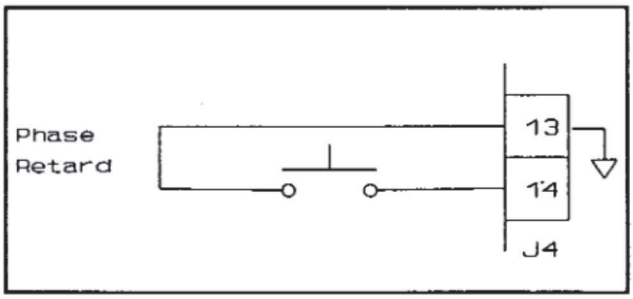


Figure 3-22: Phase Retard

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ALIGN

The ALIGN is used to recover position alignment of the Follower Motor. To do this, Align uses the Gross Error control algorithm. The Gross Error control algorithm, when doing an Align, uses the Out of Position (CP-24) to determine if a move will be made. If CP-24 is less than CP-49, the move will be made until CP-49 is reduced to less than CP-24. This move will be in the direction of the Position Error (CP-49). The direction can not be selected by the Sync Logic (CP-30) because the Lead is not moving. CP-15 (Over Speed Allowance) and CP-61 (Gross Error Reset) will have an effect on how fast the move will be made.

There are several conditions that must be met to activate an ALIGN function. These are:

1. Master must not be moving.
2. Must be in Follower mode.
3. Must have Sync enabled.
4. Must be in R-Stop.
5. Must have positive error if output is unipolar.
6. Must have position known.
7. Must have error greater than CP-24.

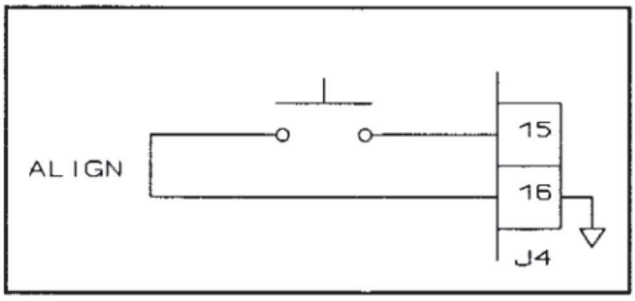


Figure 3-23: Align

$\overline{\text{JOG}}$

$\overline{\text{JOG}}$ is a maintained input which when closed directs a speed command signal to the sync drive at the selected jog speed. As a maintained input, the jog state is only valid for the duration of the time the operator device is held closed. The position memory is reset to zero at the end of the JOG state.

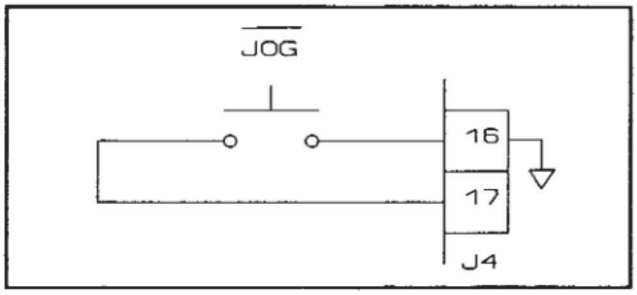


Figure 3-24: Jog Input

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4) ELECTIVE OUTPUTS

The M-Track Elective Outputs are all open-collector relay drivers (specs listed on Page viii). An external DC power supply is required to provide power to the relays. Free-wheeling diodes are incorporated and need not be added externally.

Figure 3-25 illustrates the wiring for the first three elective outputs. The remaining outputs follow the same pattern.

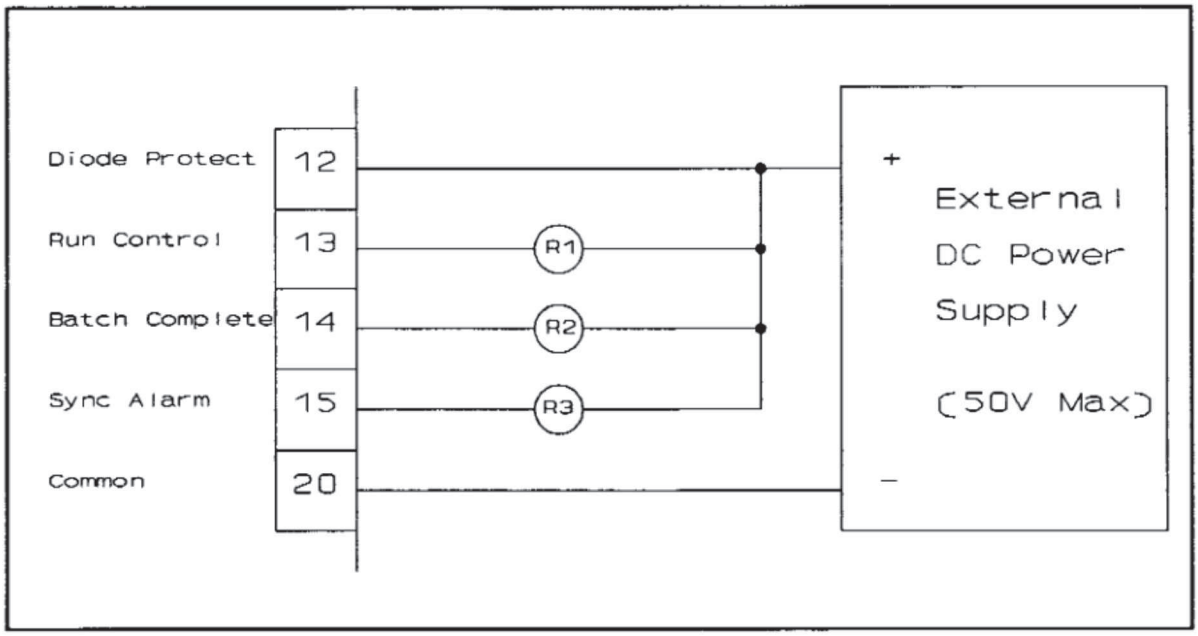


Figure 3-25: Elective Outputs

RUN CONTROL (J1 PIN 13)

The Run Control output is driven low (relay activated) when the M-Track is commanding a speed output to the slave drive in the Run, Jog, Align or Direct States.

BATCH COMPLETE (J1 PIN 14)

The Batch Complete output is driven low (relay activated) when the batch count is reached or exceeded.

SYNC ALARM (J1 PIN 15)

The Sync Alarm output is high (relay deactivated) when the master and slave pulse inputs are in sync. The Sync Alarm output is low (relay activated) when the master and slave pulse inputs are not synchronized.

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POSITIVE/$\overline{\text{INVERTED}}$ (J1 PIN 16)

The Positive/Inverted output indicates the polarity of the Speed Command Output relative to the Voltage Reference Input. If they are the same polarity, the output is high (relay not activated). If they are opposite or inverted, the output is driven low (relay activated).

$\overline{\text{OUT A}}$ (EXT. REF. SYNC ABSENT - J1 PIN 17)

The $\overline{\text{OUT A}}$ output is low (relay activated) when the External Reference Sync Pulse is absent from its sync window. The sync flag window must be enabled (CP-37 = 1) for this output to activate.

$\overline{\text{OUT B}}$ (FEEDBACK SYNC ABSENT - J1 PIN 18)

The $\overline{\text{OUT B}}$ output is low (relay activated) when the Feedback Sync Pulse is absent from its sync window. The sync flag window must be enabled (CP-37 = 1) for this output to activate.

$\overline{\text{OUT C}}$ (LOW/HIGH ALARM - J1 PIN 19)

The $\overline{\text{OUT C}}$ output is low when either a low or high alarm condition is present.

AUXILIARY DC POWER

+5 VOLT (J3 PIN 1) The 5 Volt output is a DC regulated output that can be used to power encoders or other auxiliary equipment used in conjunction with the M-Track.

+12 VOLT (J3 PIN 2) The 12 Volt output is a DC regulated output that can be used to power proximity sensors or other auxiliary equipment used in conjunction with the M-Track.

CAUTION

It is imperative that the current draw not exceed the specifications listed on page ix for the 5 Volt and 12 Volt supplies (250 mA @ 5V and 200 mA @ 12V). Excessive current draw will result in damage to the M-Track device.

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5) SERIAL COMMUNICATIONS

The Serial Communications interface on the M-Track complies with EIA Standard RS-422-A for balanced line transmissions. This interface is provided to permit remote computer variable programming, status or performance monitoring, and remote control. A detailed discussion of the Serial Communications capability is provided in Chapter 7 of this manual.

Figures 3-26 and 3-27 illustrate a multidrop installation of the Serial Communications link.

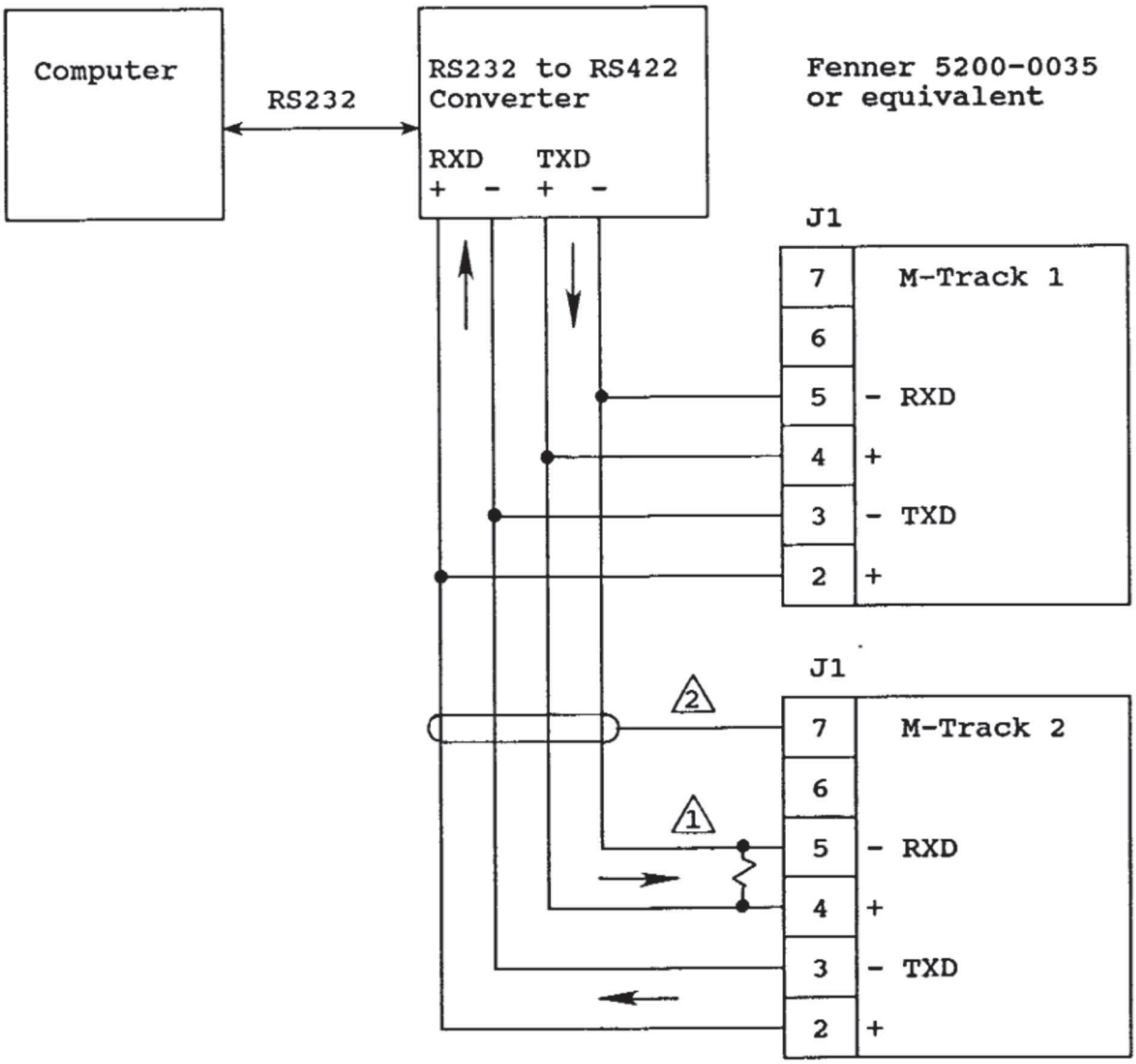


Figure 3-26: Serial Communications Connections

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1. It may be necessary to terminate the communication line at the furthest receiving ends only. A 100 ohm, 1/2 Watt resistor is usually adequate for this purpose. For more information, refer to EIA Standard RS-422-A.

2. Shield at one end of cable only.

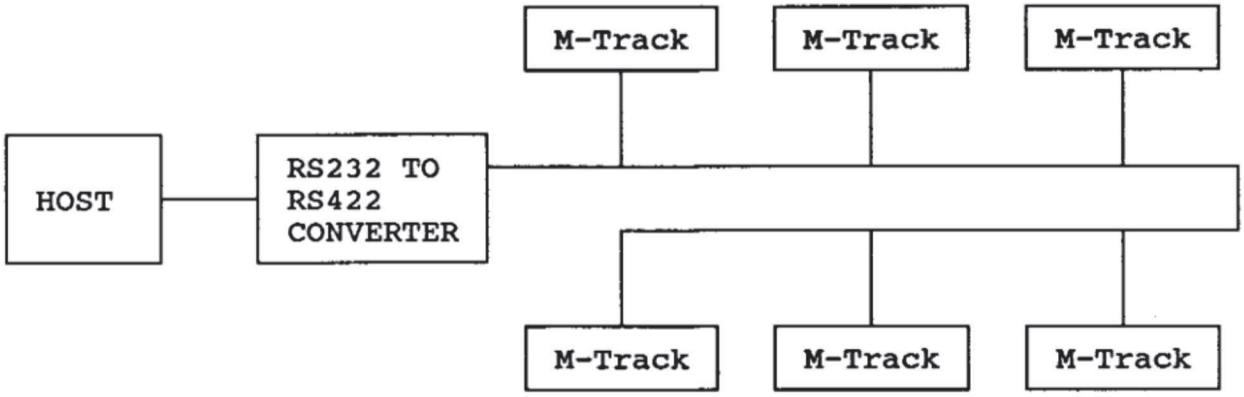


Figure 3-27: Correct M-Track Multidrop Installation

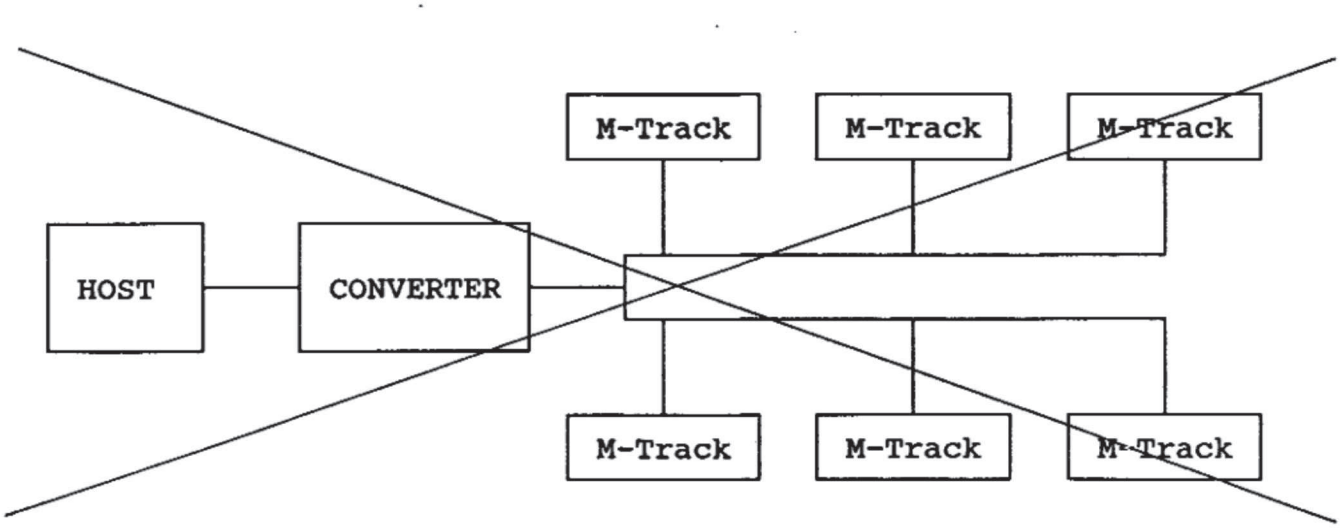


Figure 3-28: Incorrect Installation

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INTRODUCTION

This chapter contains the information required to calibrate the M-Track to the connected motor drive. Prior to using these procedures, the M-Track must be properly configured and installed in accordance with Chapters 2 and 3 of this Manual.

NOTE: The calibration procedures may require the user to first read Chapter 5 (Programming) before proceeding.

MOTOR DRIVE SET UP

In order to provide for proper closed-loop operation, it is necessary to calibrate the motor drive maximum speed and response adjustments according to the following procedure:

1. Set the ACCEL and DECEL POTs on the motor drive to the minimum times (fastest response).
2. Set the I.R.Compensation POT (if present) on the motor drive to its minimum setting.
3. Enter a "1" into CP-19 on the M-Track (places M-Track into Direct Scaling Mode).
4. Enter a "3686" into CP-7 (places the output command to 90% of the full 4095 level).
5. Adjust the Max Speed POT on the subject motor drive for the desired maximum operating RPMs. This value should be the same as the CP-13 variable entry. The speed can be observed in MV-40.
6. Reenter a "0" into CP-19 (places the M-Track out of Direct Scaling Mode).

ON BOARD SCALE POT

For most applications, the On Board Scale POT should be turned fully clockwise (factory default position). The On Board Scale POT is located on the rear of the Power Supply/Isolator board behind the cover plate. (The cover plate must be removed to allow access to this POT.) The Scale POT is the lower POT labeled "R2", just above the AC power connector.

In cases where the subject drive cannot exceed a specific voltage or the M-Track Internal Reference Voltage is utilized (Page 2-3), the On Board Scale POT can be used to range adjust the isolated analog output level of the M-Track. To make this adjustment, follow the procedure below:

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1. Enter a "1" into CP-19 (places M-Track into Direct Scaling Mode).

2. Enter "4095" into CP-7 (puts the output to 100% command output level).

3. Enter the M-Track into the "RUN" state.

4. Adjust the On Board Scale POT until the voltage between J1 Pin 9 and J1 Pin 10 is at the desired maximum voltage.

5. Reenter a "0" into CP-19 to place the M-Track out of the Direct Scaling Mode.

ON BOARD ZERO POT

The On Board Zero POT is factory adjusted to provide a zero volt isolated output level to the subject drive with a zero speed command. The Zero POT is located on the rear of the Power Supply/Isolator board behind the cover plate. The Zero POT is the upper POT labeled "R1", just above the Scale POT and the AC power connector.

Should the On Board Zero POT require further adjustment to compensate for drive errors, follow the procedure below:

1. Enter a "1" into CP-19 (places M-Track into Direct Scaling Mode).

2. Enter "0" into CP-7 (0 speed command)

3. Enter the M-Track into the "RUN" state.

4. Adjust the On Board Zero Pot until the voltage between J1 Pin 9 and J1 Pin 10 is at zero volts.

5. Reenter a "0" into CP-19 to place the M-Track out of the Direct Scaling Mode.

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INTRODUCTION

This section of the manual explains the use of the code select procedure for changing and viewing the M-Track's Programming Codes. All Programming Codes can be divided into two broad categories: Control Parameters (indicated by a "CP-") and Monitor Variables (indicated by a "MV-"). Programming or Scaling the M-Track is accomplished by entering relevant values into the M-Track's Control Parameters to influence the control behavior of the M-Track. Monitor variables are display variables used to view or monitor system performance during M-Track operation.

This chapter is divided into four sections: Code Select Procedure explains the use of the programmer keypad for gaining entry to the Control Parameters and Monitor Variables. Setpoint Selection and Control explains how the setpoints are used in an M-Track. Learn Mode Scaling explains the M-Track Learn Mode Scaling procedure required to sync follower operation. Tuning provides procedures to tune the M-Track for system stability and optimal performance.

CODE SELECT PROCEDURE

The Code Select Procedure indicates how the operator gains access to the various Control Parameters and Monitor Variables through their unique identification codes. Opening the lower door on the front of the M-Track keypad exposes the programming keypad.

Accessing the desired parameter is a simple procedure:

1) Press the "Code Select" Key.
2) Enter the desired parameter code number.
3) Press the "Enter" Key.

At this point, the two digit Programming Code is displayed in the lower display window and the existing parameter value is displayed in the upper six-digit display window. In addition, the keypad is enabled for changing the desired parameter (if applicable). To make a change, simply enter the new value and press the Enter Key *. Values greater than six digits in length are identified by a preceding "H" (high) for the highest significant digits, and "L" (low) for the lowest significant digits. The "ALT" key is used to switch between the high and low values.

NOTE: If the Enter Key is not pressed within approximately ten seconds of a new value being entered, the display reverts to the previous value.

* Variables CP-11, CP-13, CP-18, CP-19, CP-34, CP-35, CP-36 and CP-37 can only be changed in the R-Stop and F-Stop states. All other variables can be changed while in the Run State.

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FOLLOWER SETPOINT SELECTION AND CONTROL (Learn Mode Scaling)

As shipped from the factory, the M-Track is set up for "Learn Mode" Scaling. Learn Mode Scaling is a procedure used by the M-Track to calculate the appropriate follower to lead speed ratio necessary to maintain synchronization between the lead and follower sync pulses. For additional information, refer to the next manual section, "Learn Mode Scaling".

The M-Track is capable of learning and saving the scale ratios for up to eight separate process configurations when set up for Learn Mode Scaling. Each of these configurations is identified by a unique Process Code (1 through 8). These process configuration codes represent the setpoint for the M-Track. The following procedures indicate how the desired process code is selected and activated by the M-Track.

SETPOINT SELECTION

Setpoint Selection for the M-Track is a two step process: preset selection and setpoint activation. To preset select a process code, the unique process code identifier 1 through 8 is entered into either Control Parameter CP-1, CP-2 or CP-3. Any combination of the eight process codes can be preset into parameters CP-1 through CP-3 (See Figure 5-1).

Activation of the preset process code for operation is done through discrete inputs Ratio A (J3 pin 13) and Ratio B (J3 pin 15). If both Ratio A and Ratio B inputs are open (not shorted to common), then the process code preset into CP-1 is activated for control. If only Ratio A is closed (shorted to common), then the process code preset into CP-2 is activated for control. If Ratio B alone or both discrete inputs are closed (shorted to common), then the process code preset into CP-3 is activated for control.

If a process code is preset into CP-1, CP-2 or CP-3 which has not been through the Learn Mode Scaling procedure, the process code will be preceded in the upper display by an "L P" indication. This indicates to the user that the M-Track has not established the proper scale ratio for the selected process setup. As soon as the M-Track has learned the scale ratio during the Learn Mode procedure, the "L P" indicator will disappear from the display.

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The scale ratio can be cleared or reset for a given process code by pressing the "ALT" key after the process code has been activated. The "L P" indication will reappear on the upper display to indicate that "Learn Mode Scaling" has not occurred for the selected process code.

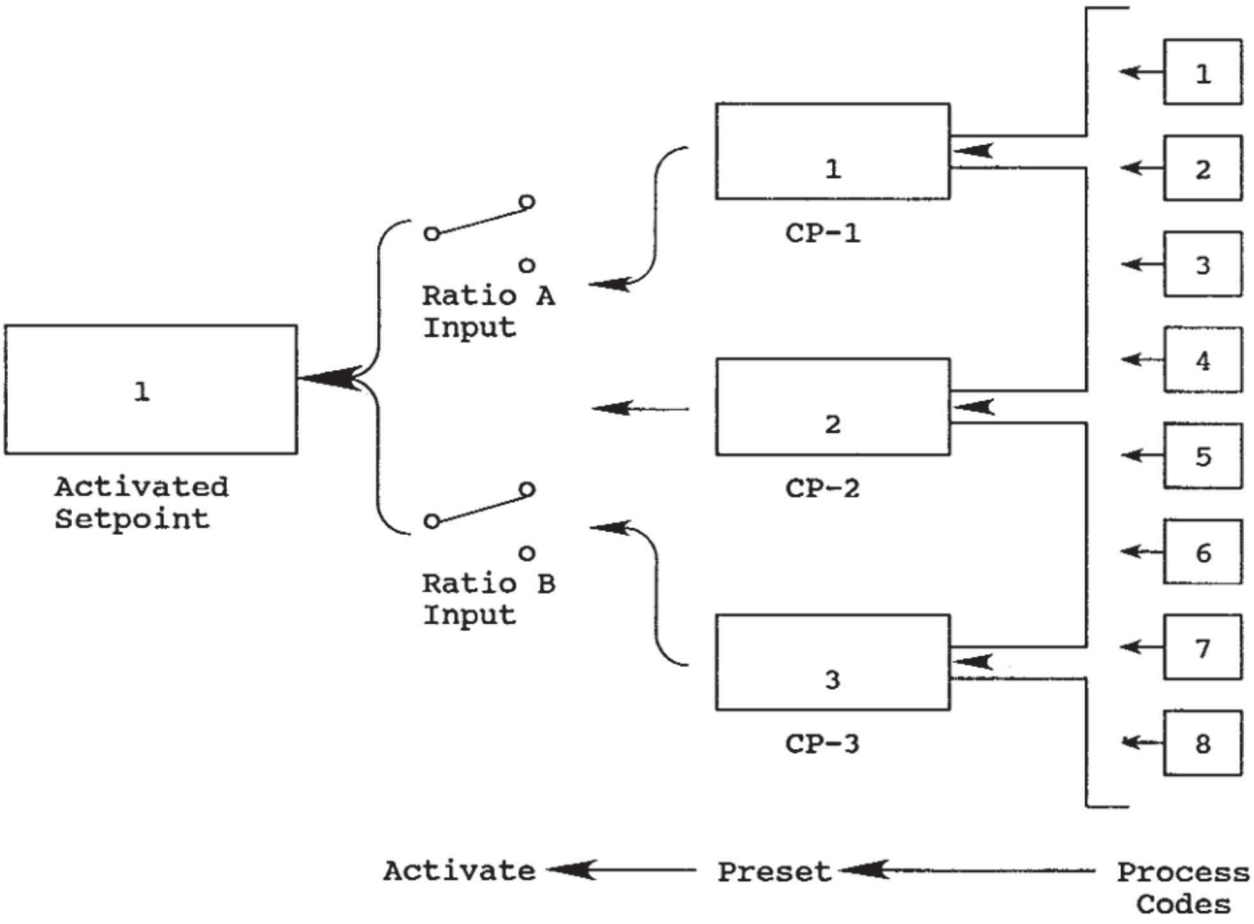


Figure 5-1: Setpoint Selection and Control

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LEARN MODE SCALING

Learn Mode Scaling is the procedure by which the M-Track learns or calculates the proper scaling ratio between the lead and follower frequency inputs required to synchronize the sync pulse inputs. Follow the procedure below to establish the process Scaling:

LEARN MODE PROCEDURE

1. Enter the M-Track into Follower mode by shorting the J4 inputs 1 and 2. See Page 3-12.

2. Lead Polarity - Rotate the lead encoder in the direction of normal operation while monitoring MV-41. If MV-41 is negative, then exchange the lead encoder lines on J3 pins 3 and 5.

3. Motor Direction - Put the M-Track into Direct Mode by entering a value of "1" into CP-19. Enter a positive Direct Mode setpoint of 400 into CP-7. Enter the RUN state. If the follower motor direction does not match the motor direction of the lead during normal operation, then rewire the drive/motor to reverse the motor direction. Take the M-Track out of Direct Mode by entering a "0" value into CP-19.

4. Follower Polarity - Rotate the follower encoder in the direction of normal operation as established in step 2 above while observing MV-42. If the frequency in MV-42 is negative, then exchange the follower encoder lines on J3 pins 7 and 9.

5. Follower Encoder Resolution - Enter the resolution (PPRs) of the follower encoder into CP-11.

6. Follower Maximum RPMs - Enter the maximum RPMs that the follower encoder shaft will reach during normal operation into CP-13.

7. Setpoint Select - Follow the Setpoint Selection procedure (Page 5-2) to activate the desired setpoint. To enter Learn Mode Scaling, the setpoint code must be preceded by an "L P" indication in the upper display. If the "L P" indication is not present, then press the "ALT" key to reset the process scaling and enable the Learn Mode Scaling format.

8. Run/Observe - Run the lead motor in the normal direction. Enter the M-Track and connected drive/motor into the RUN state. The M-Track should operate the follower motor at approximately 10% of the Follower Maximum speed entered into CP-13 during Learn Mode (follower speed is independent of lead speed during learn mode). After two lead sync pulses and two follower sync pulses have occurred, the M-Track will have all the information necessary to establish the proper scaling ratio for the process. The "L P" indication on the upper display will disappear to indicate that the M-Track has completed the Learn Mode scaling procedure. At this point, the M-Track will attempt to synchronize the two sync pulse inputs and maintain the in-sync condition.

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9. Tuning - If the M-Track is too sluggish and unable to achieve and maintain synchronization or is unstable (erratic operation), proceed to the "Tuning" manual section (Page 5-6).

There are numerous Monitor Variables available to monitor the operation of the M-Track in Follower Mode. These include:

MV-40: TACH

MV-40 displays the feedback speed in RPMs. It is valid for Master and Follower scaling modes.

MV-41: EXTERNAL REFERENCE (LEAD)

MV-41 displays the External Reference Frequency input rate in lines/second. It is a signed number to indicate direction (+ indicates forward direction, - indicates reverse direction).

MV-42: FEEDBACK (FOLLOWER)

MV-42 displays the Feedback Frequency input rate in lines/second. It is a signed number to indicate direction (+ indicates forward direction, - indicates reverse direction).

MV-49: POSITION ERROR

MV-49 indicates the difference between the calculated ideal follower position and the actual follower position in encoder lines.

MV-80: LEAD JOB SPACE

MV-80 indicates the size of the average Lead Job Space as determined by the External Reference Frequency and Sync inputs. Units are in encoder lines.

MV-81: FOLLOWER JOB SPACE

MV-81 indicates the size of the average Follower Job Space as determined by the Feedback Frequency and Sync inputs. Units are in encoder lines.

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MV-82: LEAD JOB SPACE VARIANCE

MV-82 indicates the maximum variance in the Lead Job Space in encoder lines. The calculation time period is coincident with the 16 sync pulse period used to establish the trending scale value.

MV-83: FOLLOWER JOB SPACE VARIANCE

MV-83 indicates the maximum variance in the Follower Job Space in encoder lines. The calculation time period is coincident with the 16 sync pulse period used to establish the trending scale value.

MV-84: SYNC FLAG DIFFERENCE

MV-84 indicates the difference, in feedback encoder lines, between the position of the Lead and Feedback Sync pulses.

MV-85: TRUE SCALE FACTOR

MV-85 displays the calculated ratio between the Feedback Frequency Input and the Lead Frequency Input used to maintain alignment between the two sync inputs.

TUNING

Tuning refers to the procedure of setting the tuning parameters of the control algorithm to achieve stable and optimal performance. The default tuning parameters should provide for stable operation in the majority of applications. The tuning instructions below are provided for those applications which require additional M-Track tuning.

TUNING PROCEDURE - SPEED LOOP

The first step in tuning the M-Track is to achieve stable operation without the position (sync) information present. Disable sync operation by setting CP-34 to zero.

CP-65: GAIN (PROPORTIONAL CONSTANT)

To set the Proportional Constant, first set the Integral Constant (CP-66) and Derivative Constant (CP-67) variables to zero. Increase the Proportional number until the system goes unstable (erratic). This is easily tested by moving between two wide spread lead frequency values. When instability is reached, decrease the Proportional Constant number slightly until the system stabilizes.

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CP-66: RESET (INTEGRAL CONSTANT)

Using only Proportional, the system may exhibit a phenomenon called proportional droop, whereby the setpoint is never reached due to system losses. Integral should be increased until overshoot is exhibited (overshoot occurs when the feedback goes over the desired setpoint before settling to the desired setpoint value). It is necessary to switch between wide spread lead frequencies to observe overshoot.

CP-67: RATE (DERIVATIVE CONSTANT)

Derivative is only required if the control is still too sluggish after setting the Proportional and Integral parameters. Derivative, like Proportional, should be entered up to the point of instability. After the control has reached the instability point, decrease the derivative number until the control action stabilizes.

TUNING PROCEDURE - POSITION LOOP

The second step in Tuning the M-Track is to introduce back the position (sync) loop and adjust the position tuning variables. Enable the position (sync) loop by entering a "1" into CP-34.

CP-25: LAG PULSE UNIT

The Lag Pulse Limit puts a maximum limit on the position error value when the follower lags the lead in position. Restricting the Lag Pulse Limit value (smaller values) can provide for more stable operation as it limits the error value submitted to the PID algorithm. This may be particularly effective in achieving stability with processes with small job spaces (sync rates less than one second). Units are in encoder lines.

CP-26: LEAD PULSE LIMIT

The Lead Pulse Limit is similar to the Lag Pulse Limit except it restricts the position error value when the follower is ahead of the lead in position. Again, reducing the Lead Pulse Limit value may assist in achieving stability especially for processes with small job spaces.

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CP-32: GROSS ERROR BOUNDARY

For processes with large job spaces, it is possible to invoke a separate Gross Error Algorithm when errors exceed a specified value. The Gross Error Algorithm provides a less aggressive but well behaved method of resolving large position errors thereby allowing the PID algorithm to be tuned more aggressively to maintain the in-sync condition. The Gross Error Algorithm will have very limited utility with small job space processes but may be mandatory in achieving stability with large job space processes.

When using the Gross Error Algorithm, always set the Lead and Lag Pulse Limits (CP-25 and CP-26) greater than four times the Gross Error Boundary (CP-32).

CP-32, Gross Error Boundary, determines the error value beyond which the Gross Error control algorithm is substituted in place of the PID control algorithm. If large position errors create system instability, reduce the CP-32 value until stability is reached.

CP-15: OVERSPEED LIMIT

When the M-Track Gross Error algorithm is activated, there are two variables that influence the corrective behavior. The first of these is the Overspeed Limit. The Overspeed Limit puts a limit on the speed by which the follower will exceed the lead to recover the position error. This parameter value is normalized and entered as a percent of maximum follower speed (CP-13).

CP-61: GROSS ERROR RESET

The rate at which the follower reaches the Overspeed limit and later adjusts to the in-sync velocity is determined by the Gross Error Reset (accel/decel only active in Master Mode not Follower Mode).

Increasing the Gross Error Reset value will cause faster rates of velocity correction in the Gross Error control algorithm.

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THEORY OF OPERATION 6

INTRODUCTION

This chapter provides a discussion on the M-Track theory of operation. This discussion is restricted to the M-Track basic level of operation, and is not intended to cover the numerous options that are available for more refined control. With a general understanding of the internal operations of the M-Track, it should be easier to utilize and optimize this control for specific applications.

POSITION CONTROL

The primary control function of the M-Track is to establish and maintain the position alignment of the External Reference (Lead) and Feedback (Follower) Sync signal inputs. This synchronization occurs with a one-to-one correlation of one Lead sync pulse to one Follower sync pulse. Although this occurs in a continuous velocity environment, the primary function, and subsequent control algorithm, is one of position and not velocity. On a one millisecond periodic update rate, the M-Track determines the error between the setpointed position and the actual position of the follower device. This error is then submitted to the position control algorithm for corrective action.

POSITION DETERMINATION

The first task of the control algorithm is to determine the External Reference (Lead) and the Feedback (Follower) positions. At power-up, or after a Position Reset input command, the Lead and Follower positions are both set to zero. Every one millisecond, the number of External Reference and Feedback encoder lines that are received (at the M-Track frequency inputs) are added to the Lead and Follower positions, respectively. This is an accumulative process that repeats until a Resync occurs.

RESYNC

The M-Track performs a Resync operation when a pair of flags occur, one Lead and one Follower. When this occurs, the accumulated Lead position is updated with the Lead position at the time the Lead sync pulse occurred, and the Follower accumulated position is updated with the position of the Follower at the time the Follower sync pulse occurred. Note that this can result in an instantaneous change in position error, particularly if synchronization is being established for the first time.

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SCALE FACTOR

To derive the commanded or setpointed position, the M-Track multiplies the accumulated Lead position by the Scale Factor (MV-86). The Scale Factor is the ratio of the number of Follower encoder lines per Follower job space (MV-81) divided by the number of Lead encoder lines per Lead job space (MV-80). (A job space is the number of encoder lines that occur from one sync pulse to the next). The Scale Factor can be either directly entered in Fixed and Flex Mode or determined by the M-Track in Learn Mode.

POSITION ERROR

The position error (MV-49) is calculated by subtracting the accumulated Follower position from the commanded or setpointed position (Position Error = Accumulated Lead Position * Scale Factor - Accumulated Follower Position). A positive position error indicates that the Follower is behind or lags the commanded position. A negative position error indicates that the Follower is ahead of or leads the commanded position. The calculated position error may be limited to the Lead (CP-25) and Lag (CP-26) Pulse Limits before being submitted to the compensation algorithm.

COMPENSATION ALGORITHMS

There are two separate compensation algorithms present in the M-Track, the Gross Control Algorithm and the PID Algorithm. If the position error is less than the Gross Error Boundary, the PID algorithm is utilized. However, once the PID algorithm is invoked, the error must reach a value of four times the Gross Error Boundary before control is passed back to the Gross Control Algorithm from the PID Algorithm.

GROSS CONTROL ALGORITHM

The purpose of the Gross Control Algorithm is to gracefully reduce large position errors down to a point where the more aggressive PID algorithm can establish and maintain synchronization. Because the Gross Control Algorithm is a slower dynamic algorithm, it may not be necessary or suitable for high sync rate applications with small job sizes.

Three variables determine the behavior of the Gross Control Algorithm. The first variable, Gross Error Boundary (CP-32), establishes the error band at which the Gross Control Algorithm passes control over to the PID Algorithm. The second variable, Gross Error Reset (CP-61), determines the rate of velocity change used by the Follower device to reduce the position error. The third variable, Overspeed Allowance (CP-15), places a limit on the amount of velocity difference between the Follower and Lead that is permitted to reduce the position error. The calculated result of the Gross Control Algorithm is added to the Feedforward term to provide the velocity command signal to the motor drive.

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PID ALGORITHM

The PID Control Algorithm is designed to resolve the final position error to zero and maintain synchronization. It is a more aggressive compensation algorithm typically working with smaller or more limited position errors. Three variables (terms) determine the behavior of the PID Control Algorithm. The proportional (P) term (CP-65) is derived by multiplying the proportional or gain constant by the position error. The integral (I) term (CP-66) is derived by multiplying the integral constant by the integrated or accumulated position error (error * time). The derivative (D) term (CP-67) is derived by multiplying the derivative constant by the derivative or change in the position error. The results of the P, I, and D terms are all added together (MV-48) along with the Feedforward term and output to the motor drive as a velocity command signal (MV-47).

FEEDFORWARD

Whereas the compensation algorithms operates on instantaneous, accumulated and differential changes in error, the Feedforward term is calculated by multiplying the changes in Lead position or setpoint by an internally derived constant. Two of the parameters used to calculate the Feedforward constant are the Follower PPR (CP-11) and the Follower Max RPM (CP-13). It is important that both these values be correctly entered by the user to properly scale the Feedforward term. The purpose of this term is to quickly bring the M-Track output to an approximate level whereby the error compensation algorithms need only converge on the final error. The Feedforward term will not influence system stability.

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NOTES

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INTRODUCTION

The M-Track serial communications protocol utilizes a polling technique. A message or record is sent to the M-Track from the host computer to establish communications. The M-Track then responds with a confirming or error message.

Messages sent to the M-Track can be categorized into three types:

1. Parameter Send
2. Data Inquiry
3. Control Command Send

The Parameter Send message is used to change any of the control parameters in the M-Track (CP-xx). All of the parameters accessible via the front keypad are also accessible through the serial communications interface.

The Data Inquiry message is used to request the current value of any of the control parameters (CP-xx) or monitor variables (MV-xx) in the M-Track.

The Control Command Send message is used to provide computer control of M-Track Operations - e.g., run, stop, etc.

All M-Track messages use the USA Standard Code for Information Interchange {ASCII} (see Appendix I).

This chapter is divided into seven sections. M-Track Serial Communications Setup describes which CP-xx variables to alter to allow an individual M-Track to utilize serial communications. The next six sections provide a character level description for each of the three message types and their responses:

Parameter Send - Host Transmission
Parameter Send - M-Track Response

Data Inquiry - Host Transmission
Data Inquiry - M-Track Response

Control Command Send - Host Transmission
Control Command Send - M-Track Response

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M-TRACK SERIAL COMMUNICATIONS SETUP

The following parameters are used to physically structure a M-Track to utilize the RS422 serial communications network.

70 - DEVICE ADDRESSES

The M-Track's physical address may be set from 1 to 32. This address is used to uniquely identify individual M-Track units on a multidropped RS422 line.

NOTE: Messages using a device address of zero are accepted by all M-Track Units.

71 - BAUD RATE

There are six different baud or data rates for the M-Track:

1 = 300 Baud
2 = 600 Baud
3 = 1200 Baud
4 = 2400 Baud
5 = 4800 Baud
6 = 9600 Baud

72 - CHARACTER FORMAT

The M-Track accepts 3 different character formats:

1 = 8 Data Bits, No Parity, One Stop Bit
2 = 7 Data Bits, Even Parity, One Stop Bit
3 = 8 Data Bits, No Parity, Two Stop Bits

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73 - CONTROL MASK

It is possible to allow the computer to control some of the functions associated with the discrete switch inputs. These functions are:

1 = Run/R-Stop
2 = Batch Initiate
4 = Master/Follower

To delegate control of the selected function to the computer, simply add the associated function number to the total. For example, a value of 5 for code 73 would mean the computer has control of the Master/Follower Mode and the Run/R-Stop functions.

NOTE: The computer changes these functions using the Control Command Send Message.

SUMMARY: M-TRACK SERIAL COMMUNICATIONS PROTOCOL

Table 7-1 summarizes the character structure for the M-Track serial communications protocol.

Character #	Description	Codes (Hex)	Codes (ASCII)
1	STX	02	STX
2	Device # 10's	30-39	0-9
3	Device # 1's	30-39	0-9
4	Message Type	31=Command	1
		32=Data Inquiry	2
		33=Parameter	3
5	Variable # 10's	30-39	0-9
6	Variable # 1's	30-39	0-9
7	Data 10,000,000's	30	0
	(Data Inquiry response only:	30-39	0-9)
8	Data 1,000,000's	30	0
	(Data Inquiry response only:	30-39	0-9)
9	Data 100,000's	30-39	0-9
10	Data 10,000's	30-39	0-9
11	Data 1000's	30-39	0-9
12	Data 100's	30-39	0-9
13	Data 10's	30-39	0-9
14	Data 1's	30-39	0-9
15	Data Format	30-3A	0-;
16	ETX	03	ETX

Table 7-1: Receive Queue Format

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PARAMETER SEND-HOST TRANSMISSION

CHARACTER 1: STX

The leading STX character must be received by the M-Track to enable the receive buffer. All characters are ignored until the STX character is received.

CHARACTERS 2 & 3: DEV

Characters 2 and 3 are the device number (address) of the M-Track that is to be accessed. This number differentiates the individual M-Track devices on the multidrop RS-422 communications line. Data is only accepted if there is a match between these characters and Control Parameter 70 (the Device Address set on the M-Track). The only exception is device address 00, which is universally accepted by all the M-Tracks on the RS-422 line.

CHARACTER 4: MSG TYPE

Should always be a 3 for a Parameter Send message.

CHARACTERS 5 & 6: PARAMETER NUMBER

These characters are the Parameter Code numbers used to identify which Control Parameter is to be changed.

Appendix D lists all valid Control Parameters and their minimum and maximum values.

CHARACTERS 7 TO 14: DATA

These characters are used to transmit the new data for the selected parameter. Data must be within the range specified by Appendix D.

NOTE: Characters 7 and 8 must always be 0. These locations are only used with a data inquiry response.

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CHARACTER 15: DATA FORMAT

The Data Format character determines the sign of the data sent in characters 7 through 14. An ASCII 0 indicates the data is positive, while an ASCII 6 indicates the data is negative.

CHARACTER 16: ETX

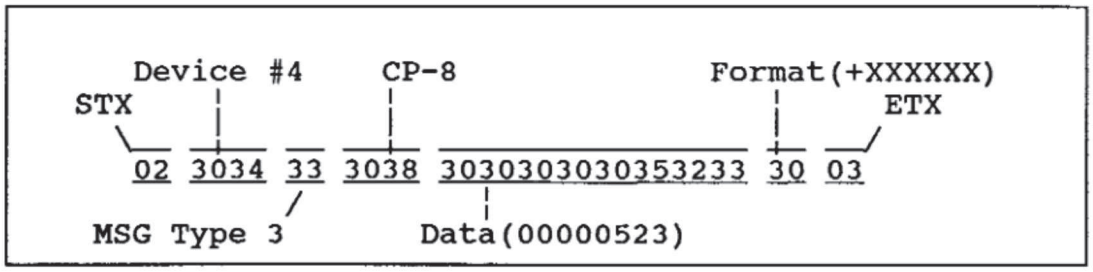
The message or record must always be terminated by the ASCII ETX character.

EXAMPLE:

A new acceleration time of 52.3 seconds is sent to the M-Track with device address 4:

ASCII Representation: STX 0 4 3 0 8 0 0 0 0 0 5 2 3 0 ETX

HEX Representation:



NOTE: Spaces are visual clarity only.

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PARAMETER SEND - M-TRACK RESPONSE

CHARACTER 1: STX

The leading character of the Response message is always the ASCII STX.

CHARACTERS 2 & 3: DEV

The next two characters are the device address.

NOTE: If the universal address is used in the Host Transmission, no response message is transmitted back to avoid line contention.

CHARACTER 4: ERROR CODE

The Error Code indicates if any errors existed in the send message received by the M-Track. This character is bit structured and can be decoded as follows:

Bit 0 - Transmit Error (parity, framing, overrun, no STX or no ETX)
Bit 1 - Parameter Error (invalid parameter or message type)
Bit 2 - Data Error (invalid data)
Bit 3 - Minimum/Maximum Error (out of range)
Bit 4 - Control Mask Error
Bit 5 - Not Used
Bit 6 - Always 1
Bit 7 - Always 0

Refer to Table 7-2 to transfer from the ASCII character sent back from the M-Track and the corresponding binary bit structure.

NOTE: The ASCII error code @ (01000000 binary) (40 HEX) indicates that the Host Transmission contained no errors.

The M-Track only accepts data if no errors were encountered.

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ASCII	BINARY Bit 7 … Bit Ø	ASCII	BINARY Bit 7 … Bit Ø
@	Ø1ØØØØØØ	`	Ø11ØØØØØ
A	Ø1ØØØØØ1	a	Ø11ØØØ1
B	Ø1ØØØØ1Ø	b	Ø11ØØØ1Ø
C	Ø1ØØØ11	c	Ø11ØØ11
D	Ø1ØØØ1ØØ	d	Ø11ØØ1ØØ
E	Ø1ØØØ1Ø1	e	Ø11ØØ1Ø1
F	Ø1ØØØ11Ø	f	Ø11ØØ11Ø
G	Ø1ØØØ111	g	Ø11ØØ111
H	Ø1ØØ1ØØØ	h	Ø11Ø1ØØØ
I	Ø1ØØ1ØØ1	i	Ø11Ø1ØØ1
J	Ø1ØØ1Ø1Ø	j	Ø11Ø1Ø1Ø
K	Ø1ØØ1Ø11	k	Ø11Ø1Ø11
L	Ø1ØØ11ØØ	l	Ø11Ø11ØØ
M	Ø1ØØ11Ø1	m	Ø11Ø11Ø1
N	Ø1ØØ111Ø	n	Ø11Ø111Ø
O	Ø1ØØ1111	o	Ø11Ø1111
P	Ø1Ø1ØØØØ	p	Ø1111ØØØ
Q	Ø1Ø1ØØØ1	q	Ø1111ØØ1
R	Ø1Ø1ØØ1Ø	r	Ø1111ØØ1Ø
S	Ø1Ø1ØØ11	s	Ø1111Ø11
T	Ø1Ø1Ø1ØØ	t	Ø1111Ø1ØØ
U	Ø1Ø1Ø1Ø1	u	Ø1111Ø1Ø1
V	Ø1Ø1Ø11Ø	v	Ø1111Ø11Ø
W	Ø1Ø1Ø111	w	Ø1111Ø111
X	Ø1Ø11ØØØ	x	Ø1111ØØØ
Y	Ø1Ø11ØØ1	y	Ø1111ØØ1
Z	Ø1Ø11Ø1Ø	z	Ø1111Ø1Ø
[	Ø1Ø11Ø11	{	Ø1111Ø11
\	Ø1Ø111ØØ	|	Ø1111ØØØ
]	Ø1Ø1111Ø	}	Ø1111Ø1
^	Ø1Ø1111Ø	~	Ø1111111
-	Ø1Ø11111	DEL	Ø1111111

Table 7-2: Error Code Translation -- ASCII to Binary

CHARACTERS 5 & 6: PARAMETER NUMBER

The Parameter Code number from the send message is echoed back in the return message.

CHARACTERS 7 TO 14: DATA

The Data from the send message is echoed back in the return message.

CHARACTER 15: DATA FORMAT

The Data Format character from the send message is echoed back in the return message.

CHARACTER 16: ETX

The return message is always terminated with the ASCII ETX character.

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