



MCB-4B

4-Motor Programmable Stepping Motor Driver/Controller



ADVANCED CONTROL SYSTEMS CORPORATION

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1. GENERAL INFORMATION

1.1 MCB-4B BOARD FEATURES

This Advanced Control Systems Corp. stepping motor controller board contains control and power drive circuitry to operate up to four stepping motors simultaneously. This enables the host computer to coordinate 4 axis motors. Several boards can be controlled by a single communication port.

Stepping motor drivers are two phase bi-polar type, which are highly efficient, and result in cool operation of motors and drivers.

Motor winding current is jumper selectable in the range of .25 to 3.00Amps. Idle winding current is also adjustable.

Motors can operate in full step mode, half step mode, quarter step mode and one eighth step mode with torque compensation.

The MCB-4B generates constant stepping rates as well as trapezoidal type velocity profiles. Acceleration, deceleration and top speed are all programmable.

For each motor, MCB-4B supports two limit inputs and home position input. The MCB-4B is designed to operate reliably in adverse industrial environments.

All operational variables are retained in the EEPROM nonvolatile memory.

The MCB-4B understands high level instructions in the form of serial ASCII messages. The instruction set covers all aspects of computer controlled motion and is not dependent on the type of host computer or operating systems.

There are two types of communication drivers/receivers on board, standard RS-232C type and RS-485 type for simplex or party line type of operation.

1.2 BLOCK DIAGRAM DESCRIPTION

A functional block diagram of MCB-4B Motor Controller Board is shown in Fig. 1.

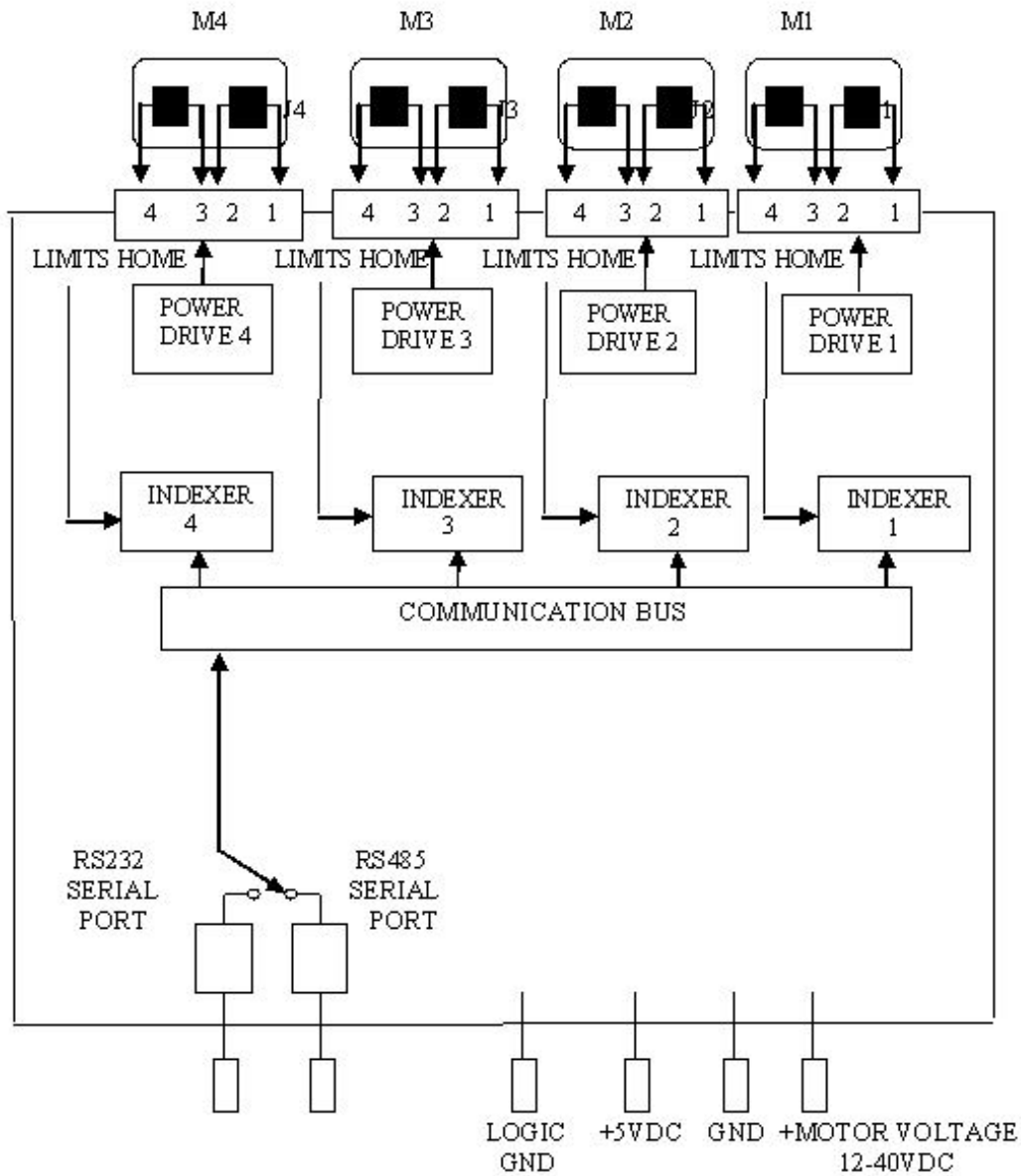


FIG. 1.1 MCB-4B BLOCK DIAGRAM

The microcontrollers (uPs) coordinate operation of the MCB-4B board. They communicate via RS-232 or RS-485 communication interface with the host computer. The programs (firmware) which interprets host instructions are stored in flash memory. Operational variables, which can be changed, are stored in non-volatile memory (EEPROM).

On board are four indexers, which are actually single chip independent microcontrollers. Indexers generate stepping sequences to the power drivers. All these components are accessed via communication bus.

Option jumpers on board are used for various configurations.

1.3 SPECIFICATIONS

POWER REQUIREMENTS:

Logic Power Supply	5VDC \pm 5% @120mA typical
Motor Power Supply	12 to 40 VDC \pm 20% @up to 4A

Motor supply voltages and currents depend on type of motors being connected.

MOTOR REQUIREMENTS:

Number of Motors	Up to four
Type of Motors	Two phase bi-polar stepping motors or four phase motors connected as two phase
Number of Leads	Four, six or eight
Max Winding Current	3 Amp, adjustable down to .25Amp
Duty Cycle	100%

MODE OF MOTOR OPERATION:

BiPolar Chopper Drive
Full Step
Half Step with Torque Compensation
Quarter Step with Torque Compensation
One-Eighth Step with Torque Compensation

MOTOR FUSES:

Four, 4 Amp, Fast blow

PHYSICAL DIMENSIONS:

Length:	13"
Width:	6"
Max. Height:	1"
Edge Connector:	Sullins EZC4ODRXN

Motor Connectors:	Four Phoenix 1757035
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COMMUNICATION PARAMETERS:

Baud Rates:	2400, 9600, 19200, 57600 baud
Byte Structure:	10 bit ASCII characters: Start bit, 8 data bits, stop bit, no parity

ENVIRONMENT:

Operating Temperature:	0°C to 50°C (32°F to 140°F)
Storage Temperature:	-20°C to 70°C (-4°F to 160°F)

Humidity:

<95% non-condensing

2. INSTALLATION SET-UP

2.1 CONNECTORS, JUMPERS, AND ADJUSTMENT IDENTIFICATION

Table 2.1 identifies important points of the MCB-4B board, Appendix A show their location on the printed circuit board.

TABLE 2.1 CONNECTOR JUMPER AND ADJUSTMENT IDENTIFICATION

Designation	Function
J1	CONNECTOR FOR MOTOR1
J2	CONNECTOR FOR MOTOR 2
J3	CONNECTOR FOR MOTOR 3
J4	CONNECTOR FOR MOTOR 4
H1	MOTOR 1 ADDRESS SELECT
H2	MOTOR 2 ADDRESS SELECT
H3	MOTOR 3 ADDRESS SELECT
H4	MOTOR 4 ADDRESS SELECT
H5	MOTOR 1 STEP MODE SELECT
H6	MOTOR 2 STEP MODE SELECT
H7	MOTOR 3 STEP MODE SELECT
H8	MOTOR 4 STEP MODE SELECT
H9	MOTOR 1 LIMITS AND HOME INPUTS
H10	MOTOR 2 LIMITS AND HOME INPUTS
H11	MOTOR 3 LIMITS AND HOME INPUTS
H12	MOTOR 4 LIMITS AND HOME INPUTS
H13	MOTOR 1 CURRENT SELECT
H14	MOTOR 2 CURRENT SELECT
H15	MOTOR 3 CURRENT SELECT
H16	MOTOR 4 CURRECT SELECT
H17	COMMUNICATION AND BAUD RATE SELECT
H18	COMMUNICATION PORT SELECT
P1	MOTOR 1 IDLE CURRENT ADJUSTMENT
P2	MOTOR 2 IDLE CURRENT ADJUSTMENT
P3	MOTOR 3 IDLE CURRENT ADJUSTMENT
P4	MOTOR 4 IDLE CURRENT ADJUSTMENT
F1	MOTOR 1 FUSE
F2	MOTOR 2 FUSE
F3	MOTOR 3 FUSE
F4	MOTOR 4 FUSE
SW0	ALL MOTORS CURRENT ON/OFF SWITCH – TEST SWITCH
SW1	MOTOR 1 JOG +/- TOGGLE SWITCH
SW2	MOTOR 2 JOG +/- TOGGLE SWITCH
SW3	MOTOR 3 JOG +/- TOGGLE SWITCH
SW4	MOTOR 4 JOG +/- TOGGLE SWITCH
H19	JOG INPUTS FOR REMOTE CONTROL

Table 2.1

2.2 MOTOR CONNECTION

Stepping motors are connected to MCB-4B controller via J1, J2, J3 and J4 connectors at the edge of the board (see Appendix A). Each connector accepts one four pin screw type plugs. Two or four phase stepping motors can be operated by the MCB-4B controller 1 board. Stepping motors equipped with four, six, or eight leads can be connected in several ways

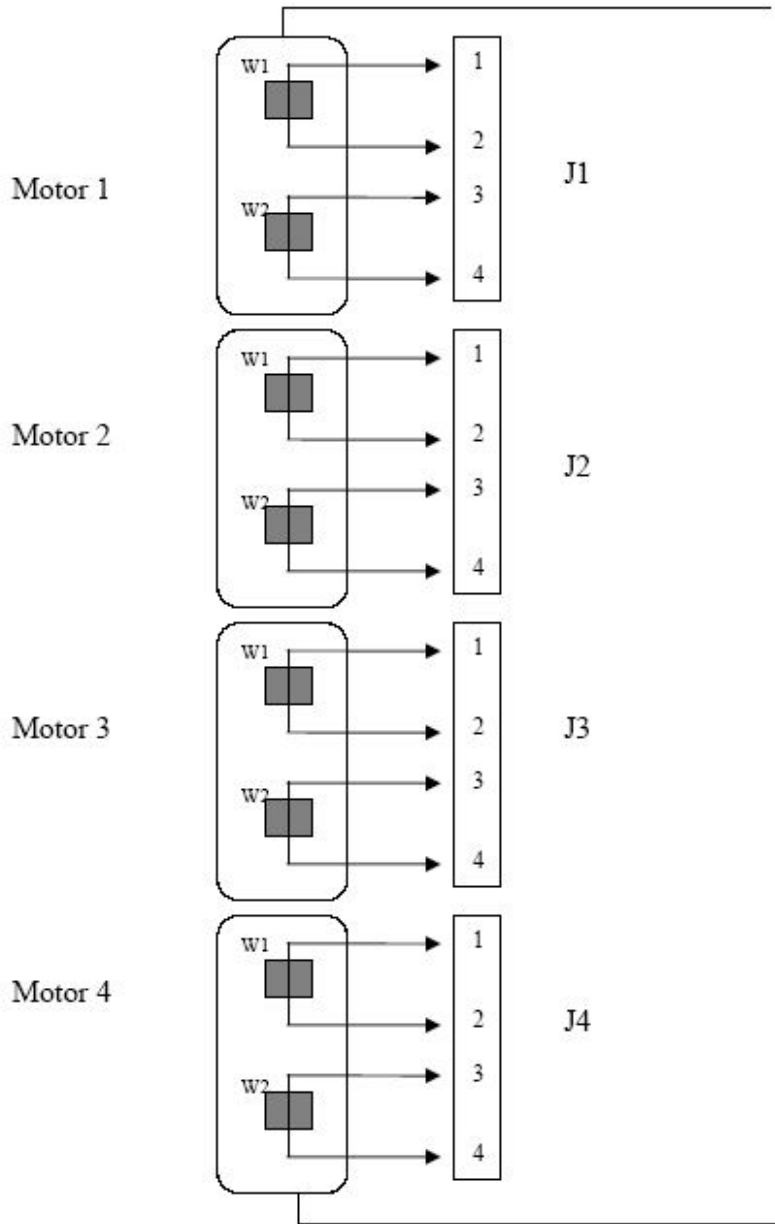


Figure 2.2 Four lead motor connections to MCB-4B unit

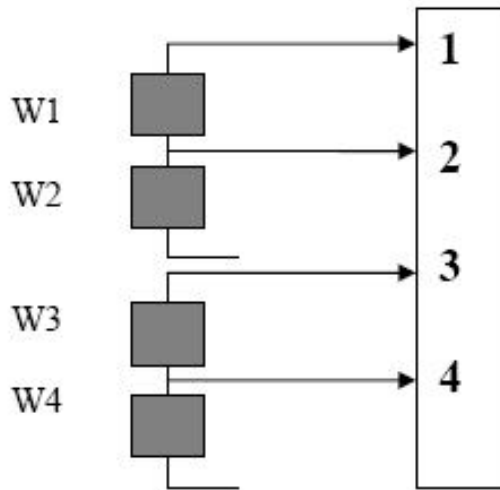


Figure 2.3 Six Lead Motor – Half Winding Connections

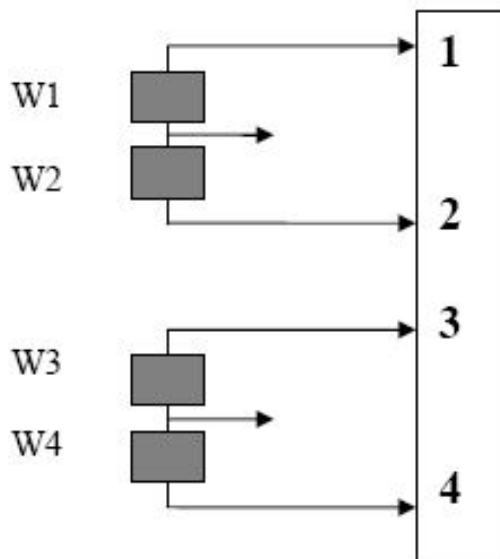


Figure 2.4 Six Lead Motor – Full Windings Connections

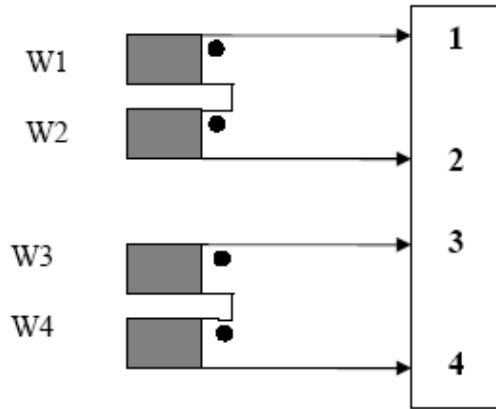


Figure 2.5 Eight Lead Motor – Serial Connections

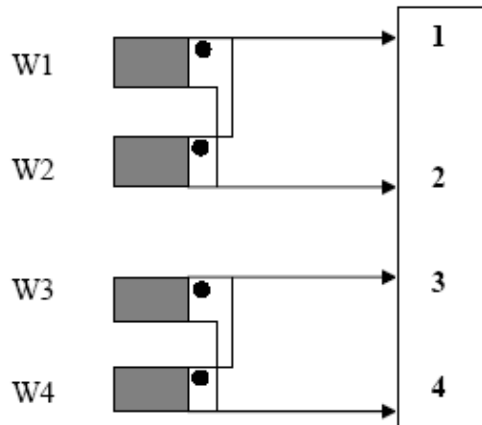


Figure 2.6 Eight Lead Motor – Parallel Connectors

2.3 LIMITS, HOME INPUTS

Limits and home inputs are connected to MCB-4B via four six pin headers. All inputs are normally closed. Refer to Appendix A for H9, H10, H11, H12 header location on the board.

PIN	INPUT	PIN	GND
2	LIMIT +	1	GND
4	LIMIT -	3	GND
6	HOME	5	GND

2.4 COMMUNICATION INTERFACE SELECTION

MCB-4B has two options with respect to communication interfaces.

- A. RS-232C
- B. RS-485 two wire party line.

When several boards are controlled by a single communication line, option B, RS485 is to be selected.

Refer to Appendix A for H18 header location on the board and to Table 2.4 for selection.

SELECTION	H18 JUMPERS
RS-232C	5-6, 7-8
RS-485 (2 WIRE)	1-2, 3-4

Table 2.4 Communication Selection

2.5 EDGE CONNECTION ASSIGNMENTS

PIN #	ASSIGNMENT
1, 2	LOGIC GND
3, 4	LOGIC +5V DC
5, 6	NO CONNECTION
7	RS-232 SERIAL OUTPUT
8	RS-232 SERIAL INPUT
9	RS-232 AUXILIARY OUTPUT
10	NO CONNECTION
11	RS-232 SIGNAL GND
12	RS-485 NON-INVERTING I/O
13	RS-485 INVERTING I/O
17	RS-485 REPEATER CONTROL OUTPUT
18	RS-485 REPEATER CONTROL INVERTING OUTPUT
14-22	NO CONNECTION
23-28	MOTOR POWER SUPPLY GND
29-34	NO CONNECTION
35-40	MOTOR POWER VOLTAGE INPUT

Table 2.5 Edge Connection Assignments

2.6 COMMUNICATION SPEED, PARITY SELECTION

Header H17 (See Appendix A for location) is to be jumped for required type of communication. Selections are no parity and four baud rates.

JUMPER H17		
2	1	BAUD RATE
OUT	OUT	57600 BAUD
OUT	IN	19200 BAUD
IN	OUT	9600 BAUD
IN	IN	2400 BAUD

Table 2.6 Baud Rate Selection

2.7 MOTOR ADDRESS SELECTION

MCB-4B motors can be addressed for up to 32 different addresses. Headers H1, H2, H3, and H4 select binary addresses of the motor. See Table 2.7 for some examples. See Appendix A for header locations.

JUMPER H1, H2, H3, H4					MOTOR ADDRESS
16	8	4	2	1	
OUT	OUT	OUT	OUT	OUT	0
OUT	IN	OUT	OUT	OUT	8
OUT	IN	IN	OUT	OUT	12
IN	IN	IN	IN	IN	31

Table 2.7 Address Selection

2.8 ON-BOARD TOGGLE SWITCHES

MCB-4B has five toggle switches:

SW0: Turns all four motor currents ON or OFF.

SW1, SW2, SW3, SW4: Manual Jog Control/Test Switches. When the motor currents are turned ON with SW0 then SW1 is manual jog control for motor 1. Toggling SW1 in one directions moves motor 1 at jog stepping rate in one direction. Toggling SW1 in opposite direction will move motor 1 in opposite direction. Same is valid for SW2 for motor 2 and SW3 for motor 3, and SW4 for motor 4.

When motor currents are turned OFF with switch SW0 the SW1, SW2, SW3 and SW4 become test switches. Toggling SW1, SW2, SW3, or SW4 outputs a test message in this form: #aaMCB4B-RX, where aa is the motor address and MCB4B is the controller model and RX is the revision number. This helps to set-up addressing and communication speed settings.

2.9 FUSING

The MCB-4B motor control board has four on board fuses. The fuses are to be rated accordingly to protect the motors; 4 Amp fast blow maximum.

F1 protects motor 1
 F2 protects motor 2
 F3 protects motor 3
 F4 protects motor 4

2.10 STEPPING MODE SELECT

There are four selections for stepping mode. Refer to Table 2.8 for jumper options.

JUMPER H5, H6, H7, H8		
2	1	Mode
OUT		FULL STEP
OUT		HALF STEP
OUT	IN	QUARTER STEP
IN		ONE-EIGHTH STEP
OUT		
IN	IN	

Table 2.10 Stepping Mode Selection

2.11 JOG INPUT CONNECTOR FOR REMOTE CONTROL H19

PIN	FUNCTION	PIN	FUNCTION
20	MOTOR 1 JOG + WHEN LO	19	GND
18	MOTOR 1 JOG - WHEN LO	17	GND
16	MOTOR 2 JOG + WHEN LO	15	GND
14	MOTOR 2 JOG - WHEN LO	13	GND
12	MOTOR 3 JOG + WHEN LO	11	GND
10	MOTOR 3 JOG - WHEN LO	9	GND
8	MOTOR 4 JOG + WHEN LO	7	GND
6	MOTOR 4 JOG - WHEN LO	5	GND
4	NO FUNCTION	3	GND
2	ALL MOTOR CURRENT OFF - WHEN LO	1	GND

2.12 MOTOR CURRENT SELECT; HEADERS H13, H14, H15, H16

JUMPER	MOTOR PEAK CURRENT PER WINDING
NONE	3.00 Amp
1-2	2.50 Amp
3-4	2.00 Amp
5-6	1.50 Amp
7-8	1.00 Amp
9-10	.75 Amp
11-12	.50 Amp
13-14	.25 Amp
15-16	IDLE

Note: By plugging more jumpers, current will be lower as determined by the lowest jumper.

2.13 IDLE CURRENT ADJUSTMENT; TRIMPOTS P1, P2, P3, P4

Idle motor winding current (motor stopped) can be automatically reduced to lower value by inserting jumpers at "idle" position on H13, H14, H15 and H16.

The value of idle motor winding current is set by adjusting trimpots P1, P2, P3 and P4 for motor 1, 2, 3, 4 respectively.

3. INSTRUCTION SET

3.1 INSTRUCTION SET SUMMARY

Each instruction message is constructed from ASCII characters. Alphabetic characters can be upper or lower case.

1. # Start Character (Hex 23).
2. aa Board Address Numeric Characters; 00-31 Range.
3. * Character "*" acts as an all numeric character (Hex 2A).
4. I Instruction Alphabetic Character (upper or lower case).
5. +1000 Data Characters.
6. ↵ Termination Character: Carriage Return (Hex 0D).
7. = Equal Sign Indicates Data to be Entered (Hex 3D).
8. En E followed by a number indicates Error in Instruction but Correct Address.

Example: #12I+1000↵ Motor with address 12 is instructed to index 1000 steps in positive direction.

Response: #12R↵ Instruction Processed!

Example: #12G5000↵ Motor with Address 12 is instructed to go to absolute position 5000.

Response: #12E5↵ Error response; bad instruction structure, direction sign is missing.

Each instruction with Start Character correct address and termination character generates a response message from the MCB-4B controller.

3.2 INSTRUCTION CHARACTER – SUMMARY

- J Examine or set jog rate index (2-65535 range).
- C Examine or set constant speed index (2-65535 range).
- V Examine or set high speed index (2-255 range).
- R Examine or set acceleration/deceleration index (1-255 range).
- M Move number of steps at constant speed using C index ($\pm 8,388,607$ steps range).
- G Go to absolute position using V and R indexes ($\pm 8,388,607$ steps range).
- I Index number of steps using V and R indexes ($\pm 8,388,607$ steps range).
- F Decelerate and stop motion (Soft Stop).
- H Seek home position.
- Q Immediate stop of motion (Hard Stop).
- X Examine motor status.
- E Examine limits and home inputs.
- L Examine or enable/disable limit interrupts.
- W Examine or turn on/turn off motor winding current
- P Examine or set absolute position ($\pm 8,388,607$ range).
- S Save motion indexes.
- D Load motion parameters defaults.
- T Test Message

3.3 ERROR RESPONSES

An error response in form #aaEn.↓ is generated for various reasons. Instruction itself is ignored.

1. Instruction structure following #aa is not recognizable or data is out of range.
2. A motion instruction is executed while motor is already stepping.
3. A motion instruction is executed but motor current is shut off by manual switch SW0 or W=0 instruction.
4. A motion instruction is executed but limit in that particular direction is activated.
5. Quit or finish instruction is executed but motor is already stopped.

The following table describes error responses.

E1	Wrong instruction character
E2	Motor is stepping
E3	Wrong data
E4	Motor is stopped
E5	Bad instruction structure
E6	Current turned off
E7	Limits activated or current Off

3.4 STEPPING RATE INDEXES

Stepping rate indexes define stepping rate for jog, move, index, and go motion control instructions. Actual stepping rate in steps/sec is calculated by formula:

$$\text{Rate} = 115200/\text{rate index}$$

Jog and move are constant rate instructions (no acceleration) and should be set below start/stop rate. Table 3.1 shows some stepping rate calculations.

Step Rate Index	Step Rate (Steps/Sec)	Step Rate Index	Step Rate (Steps/Sec)
2	57600	60	1920
3	38400	80	1440
4	28800	100	1152
5	23040	150	768
6	19200	200	576
7	16457	250	460
8	14400	300	384
9	12800	400	288
10	11520	600	192
11	10473	800	144
12	9600	1000	115.2
13	8861	1152	100.0
14	8228	2000	57.6
15	7680	4000	28.8
17	6776	8000	14.4
20	5760	10000	11.52
25	4680	11500	10.00
30	3840	20000	5.76
35	3291	40000	2.88
40	2880	57600	2.00
50	2304	60000	1.92
		65000	1.77

Table 3.1 Step Rate Table

3.5 JOG RATE INDEX: J

Instruction: #aaJ=500.↓ Set Jog Rate Index to 500
Response: #aaR.↓ Instruction accepted

Instruction: #aaJ.↓ Examine Jog Rate Index
Response: #aaJ=500.↓ Jog Rate Index is set to 500 which is 230 step per second

Notes: Jog Rate Index range is 2 to 65535. Jog Rate Index controls stepping rate when operating manual jog toggle switches SW1 to SW4; SW0 is to be set to ON. Jog Rate should be set below start/stop stepping rate of motor/load combination. Jog Rate Index can be changed any time. It takes effect on the

next jog motion.

3.6 CONSTANT RATE INDEX: C

Instruction: #aaC=400.↓ Set Constant Rate Index to 400

Response: #aaR.↓ Instruction accepted

Instruction: #aaC.↓ Examine Constant Rate Index

Response: #aaC=400.↓ Constant Rate Index is set to 400 which is 288 steps per second.

Notes: Constant Rate Index is 2 to 65535 Constant Rate Index controls stepping rate when M motion is executed. Constant Rate Index can be changed any time. It takes effect on the next Constant Rate motion.

3.7 VELOCITY RATE INDEX: V

Instruction: #aaV=20.↓ Set Velocity Rate Index to 20

Response: #aaR.↓ Instruction accepted

Instruction: #aaV.↓ Examine Velocity Rate Index

Response: #aaV=20.↓ Velocity Rate Index is set to 20 which is 5760 steps per Second.

Notes: Velocity Rate Index controls top stepping rate while executing G or I motion instruction. Velocity Rate Index range is 2 to 255. Velocity index can be changed any time. It takes effect on the next high speed motion.

3.8 RAMP INDEX: R

Instruction: #aaR=150.↓ Set Ramp Index to 150

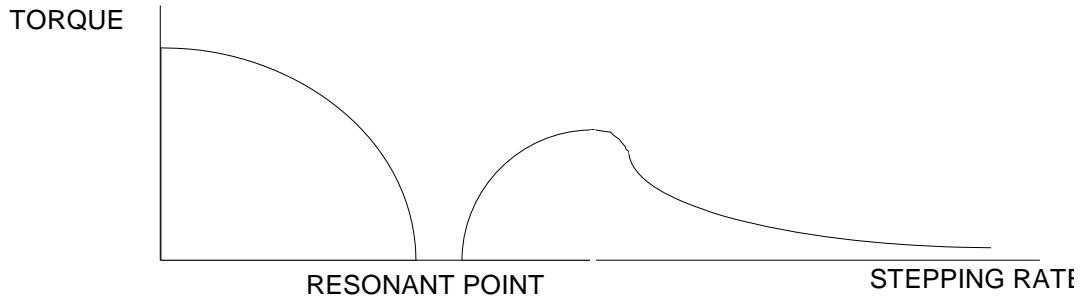
Response: #aaR.↓ Instruction accepted

Instruction: #aaR.↓ Examine Ramp Index

Response: #aaR=150.↓ Ramp Index is set to 150

Note: Ramp Index range is 1 to 255. Ramp index controls acceleration/deceleration. ramp while executing Go or Index instruction. Index 1 sets the slowest ramp, index 255 is the fastest ramp. It can be changed any time and it takes effect on the next high speed motion.

Some motors have a resonant point where there is no torque at certain frequencies. In such cases, the motor has to be started at a lower speed than the resonant point in order to fly into a higher speed area. To minimize the time to stay on the resonant point, higher ramp index for acc/dec must be applied. It is recommended that a damper should be used to increase the inertia moment if the motor goes in the resonant point with a small load.



Ramping rate in step/sec/sec is calculated by formula:

$$\text{Ramp Rate} = 720,000 / (256 - \text{Ramp Index})$$

Table 3.8 Shows some ramp rate calculations.

RAMP INDEX	RAMP RATE (STEPS/SEC/SEC)	RAMP INDEX	RAMP RATE (STEPS/SEC/SEC)
2	2835	240	45000
10	2927	245	65455
50	3495	250	120000
100	4615	252	180000
150	6792	253	240000
200	12857	254	360000
220	20000	255	720000
230	27692		

3.9 MOVE NUMBER OF STEPS AT CONSTANT RATE: M

Instruction: #aaM+2000␣ Move 2000 steps in positive direction

Response: #aaR␣ Move instruction accepted

Instruction: #aaM-500␣ Move 500 steps in negative direction

Response: #aaR␣ Move instruction accepted

Note: Motion Execute Instruction. Motor steps at constant rate C; no acceleration or deceleration. Constant stepping rate is to be set lower than start/stop rate of the motor load combination. Move commands are used when coordinated motion is required. Stepping rate is precisely controlled.

Notes: I Instruction is similar to G instruction. Motor accelerates to high speed defined by R and V indexes. Runs at high speed, then decelerates and stops, completing the instructed number of steps.

3.12 FINISH, DECELERATING AND STOP: F

Instruction: #aaF↵ Decelerate and stop motor
Response: #aaR↵ Instruction accepted

Instruction: #**F↵ Decelerate and stop all motors
Response: None

Notes: Finish instruction works only when G or I type of motion is being executed. Motor decelerates to base speed and stops. No steps are lost and position counter stays accurate.

3.13 QUIT, IMMEDIATE STOP: Q

Instruction: #aaQ↵ Motor stop immediately
Response: #aaR↵ Instruction accepted

Notes: Quit instruction, works whenever motor is stepping instructed by G, I, M, H instructions.

3.14 SEEK HOME POSITION: H

Instruction: #aaH+↵ Seek Home in positive direction
Response: #aaR↵ Instruction accepted

Notes: Motor moves at constant rate (C) in positive direction until Home position is found (Home Switch activated). Motor will stop if it hits active Limit switch or Quit instruction is received.

Instruction: #aaH-↵ Seek Home in negative direction
Response: #aaR↵ Instruction accepted

Notes: Same as for positive direction.

3.15 EXAMINE MOTOR STATUS: X

Instruction: #aaX↵ Examine if motor is stepping
Response: #aaX=0↵ Motor stopped.

Or

Response: #aaX=1↵

Motor is stepping

Notes: Numeric character zero or one represents motor status.

3.16 EXAMINE LIMITS AND HOME INPUTS: E

Instruction: #aaE↵

Examine Status of Limit and home inputs

Response: #aaE=000↵

All three inputs are Low

Or

Response: #aaE=001↵

Limits are Low, home input is HI

Note: Numeric character zero or one represent Low or High level respectively on time inputs.

First character is L+ (Limit in Positive direction).

Second character is L- (Limit in Negative direction).

Third character is for H (Home input).

3.17 ENABLE, DISABLE, EXAMINE LIMIT INTERRUPTS: L

Instruction: #aaL=1↵

Enable Limits interrupts

Response: #aaR↵

Instruction executed

Instruction: #aaL↵

Examine Limit interrupts

Response: #aaL=1↵

Interrupts are enabled

Note: Numeric character one represents enabled limits, zero represents disabled limits. The same characters are used to enable or disable limits. When limits are enabled, limit inputs must be connected to limit switches which present normally Low status. Limits can also be jumped on the controller board.

3.18 TURN ON/OFF MOTOR WINDING CURRENT OR EXAMINE IT: W

Instruction: #aaW=0↵

Turn Motor Current Off

Response: #aaR↵

Instruction executed

Instruction: #aaW=1↵

Turn Motor Current On

Response: #aaR↵

Instruction executed

Instruction: #aaW↵

Examine Motor Current

Response: #aaW=1↵

Motor Current is On

Note: This is remote (host) control of motor current. Position is not affected by this instruction. Motor current can be turned On/Off manually with on-board toggle switch SW-0. Manual control has higher priority than remote control.

3.19 EXAMINE OR SET ABSOLUTE POSITION: P

Instruction: #aaP=+0↵ Set Position counter to zero
Response: #aaR↵ Instruction executed

Instruction: #aaP↵ Examine Position
Response: #aaP=+0↵ Position is zero

Note: Position can be examined at all times. Direction sign + or – is always required. Position cannot be changed when motor is stepping.

3.20 SAVE MOTION INDEXES: S

Instruction: #aaS↵ Save motion indexes
Response: #aaR↵ Instruction executed

Note: Motion Indexes J, C, V, R are saved to nonvolatile memory (EEPROM) and are reloaded on the next power-up.

3.21 LOAD MOTION PARAMETER DEFAULTS: D

Instruction: #aaD↵ Load defaults
Response: #aaR↵ Instruction executed

Note: Default indexes are set as follows:

V – Top rate index to 15 (7680 steps/sec)
C - Constant rate index to 300 (384 steps/sec)
J – Jog rate index to 300 (384 steps/sec)
R – Ramp index to 100

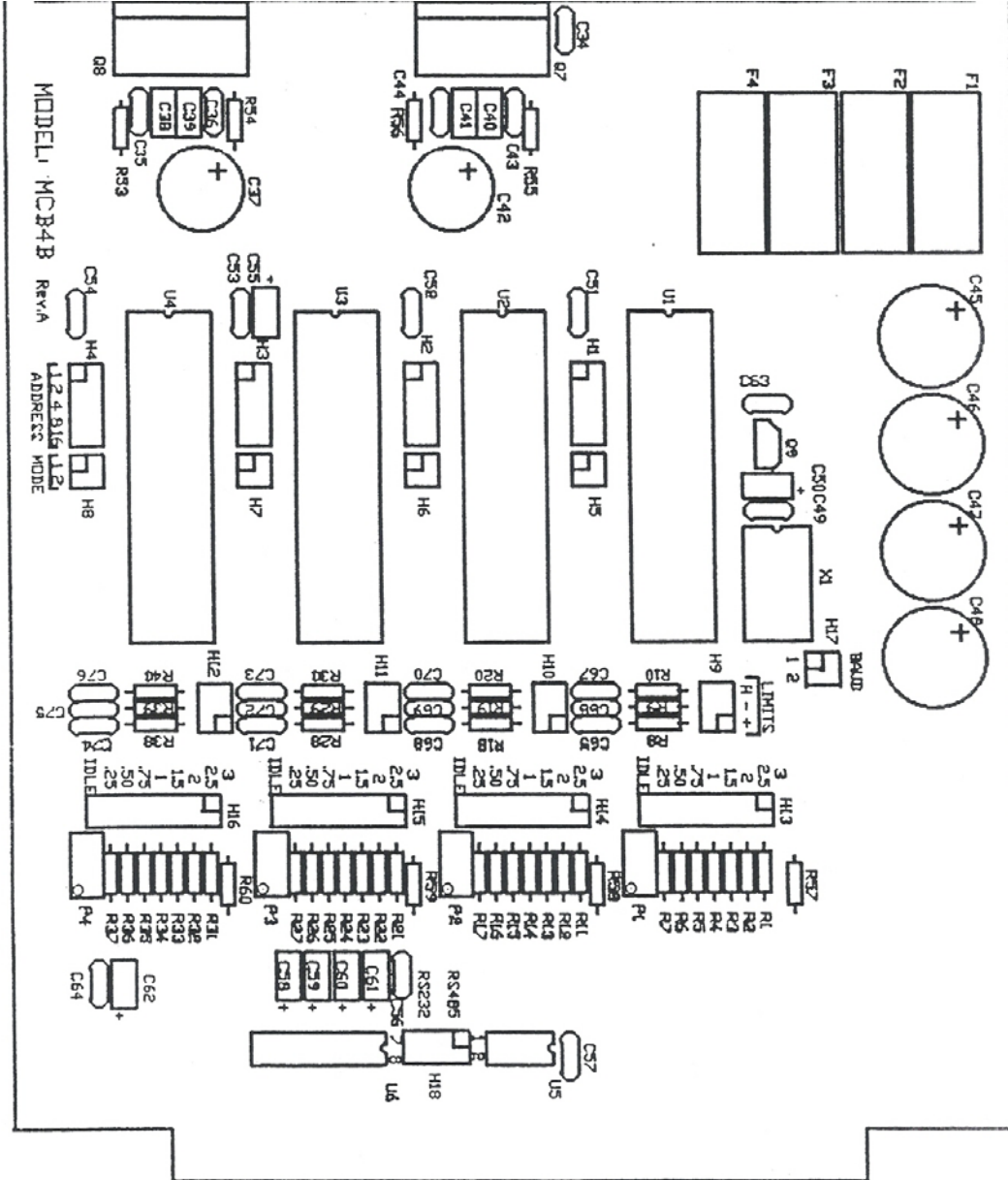
3.22 TEST MESSAGE: T

Instruction: #aaT↵
Response: #aaMCB4B-RX

Note: aa – controller address
x – controller revision number

4. Appendices

A. MCB-4B On-Board Jumper and Setting Locations



5. Manual Revision History

MCB-4B User's Manual Revision History

Revision	Date of Issue	Section	
1.0			Original Release
1.1	8-24-06	2.4	Changes to section