ARTISAN®
TECHNOLOGY GROUP

Your **definitive** source for quality pre-owned equipment.

Artisan Technology Group
(217) 352-9330 | sales@artisantg.com | artisantg.com

Full-service, independent repair center
with experienced engineers and technicians on staff.

We buy your excess, underutilized, and idle equipment
along with credit for buybacks and trade-ins.

Custom engineering
so your equipment works exactly as you specify.

- Critical and expedited services
- In stock / Ready-to-ship
- Leasing / Rentals / Demos
- ITAR-certified secure asset solutions

Expert team | Trust guarantee | 100% satisfaction

All trademarks, brand names, and brands appearing herein are the property of their respective owners.

Find the *Newport / Klinger CC1.2* at our website: ***Click HERE***

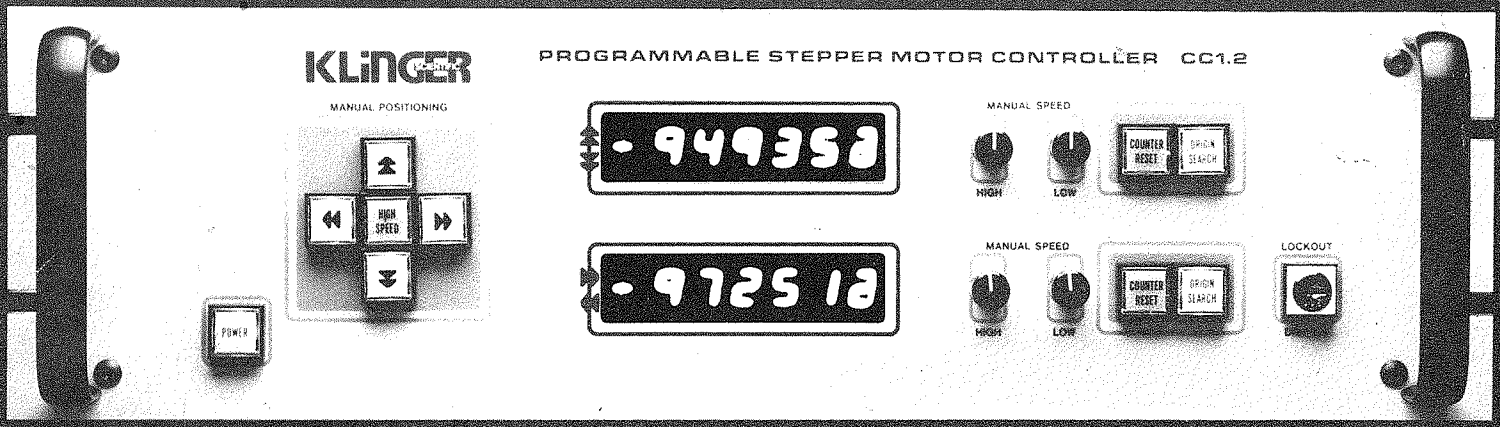
Maintenance Copy

A Universal Programmable Indexer for Computer or Manual Precision Control of Stepping Motors

model

CC-1

OPERATING MANUAL



KLINGER SCIENTIFIC
999 Stewart Avenue, Garden City, New York 11530 • (516) 745-6800

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

CC-1 operating manual

CONTENTS

I. INTRODUCTION 3

II. FRONT PANEL CONTROLS AND FEATURES 5

III. REAR PANEL CONTROLS, CONNECTORS AND FEATURES 6

IV. PREPARATION AND START-UP 10

V. MANUAL OPERATION 12
- 5.1 Single Stepping 12
- 5.2 Low Speed Operation 12
- 5.3 High Speed Operation 12
- 5.4 Counter Reset 13
- 5.5 Origin Search 13
- 5.6 Operational Tests 13
- 5.7 Factory Presets 14

VI. PROGRAMMING 15
- 6.1 Instruction Set 15
- 6.2 Programming Modes 16
- 6.3 Detailed Description of Commands 19
- 6.4 Data Modes and Formats 22
- 6.5 Step Rate Control 23
- 6.6 Application Hints and Techniques 26

VII. IEEE-488 COMMUNICATION 30
- 7.1 IEEE-488 Theory of Operation 30
- 7.2 CC-1 Operation on the IEEE-488 Bus 31
- 7.3 Steps for Correct IEEE-488 Programming 32
- 7.4 Sample Programs 33

VIII. RS-232-C COMMUNICATION 36
- 8.1 RS-232-C Theory of Operation 36
- 8.2 CC-1 Operation Using the RS-232-C Interface 37
- 8.3 Sample Programs 38

IX. 20 MILLIAMPERE CURRENT LOOP COMMUNICATION 40
- 9.1 20 mA Current Loop Theory of Operation 40
- 9.2 CC-1 Operation Using the 20 mA Current Loop Interface 41

KLINGER SCIENTIFIC 999 Stewart Avenue, Garden City, New York 11530 • (516) 745-6800

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

X. 8-BIT PARALLEL COMMUNICATION 42
10.1 8-Bit Parallel Theory of Operation 42
10.2 CC-1 Operation Using 8-Bit Parallel 42

XI. GENERAL PURPOSE I/O CONNECTOR 45

XII. STEP COUNTER AND ASSOCIATED OUTPUT CONNECTOR 48
12.1 Step Counter Operation 49
12.2 Decoding of the Front Panel Display Digits 49

XIII. ORIGIN SEARCH 53
13.1 Origin Search Implementation 53
13.2 Top Zero Pulse 55
13.3 Origin Search Activation 55

XIV. CC-1 THEORY OF OPERATION 57
14.1 Main Board 57
14.2 Front Panel Display Board 58
14.3 Power Supply and Motor Driver Board 59

XV. IN CASE OF DIFFICULTY 63

XVI. TK-2 LISTENER/TALKER INTERFACE 65
16.1 Introduction 65
16.2 IEEE-488 Address Selection 65
16.3 Programming 67
16.4 Interrupt Generation and Processing 71
16.5 Sample Programs 73
16.6 TK-2 Usage Techniques 75

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

CC-1 OPERATING MANUAL

I INTRODUCTION

The model CC1.1 and CC1.2 Programmable Stepper Motor Controllers are designed to control stepping motors in response to commands, either from a computer or from front panel pushbutton controls. When used in conjunction with Klinger's stepping motor driven positioning stages, they allow for precision single or dual axis micropositioning.

The CC-1 programmable controllers efficiently drive SLO-SYN Stepping Motor model #M062-FC03 (Klinger model #UE72) and stepping motor Klinger model #UE30, among others. The two motor types and their characteristics are shown in Figure 1.1. The controllers must be properly configured for the particular stepping motor they will be driving.

CAUTION

Consult Section IV before connecting CC-1 controller to any stepping motor.

The CC-1 programmable controller is a completely integrated control system that includes all the logic and power supply boards necessary to drive stepping motors. It features a variety of useful capabilities:

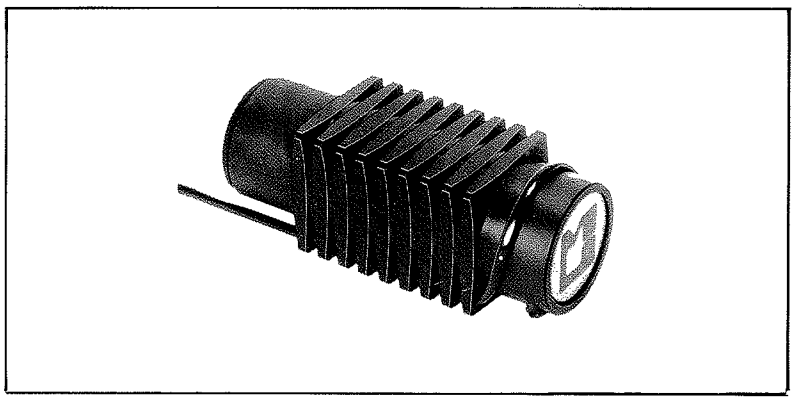
1) It can be:
   — programmed from a computer, single board microcomputer, or an ASCII data terminal
   — used in manual mode, accessed by a bank of front panel switches
   — driven by an external pulse source or by remote switch closures

2) It will:
   — return a positioning stage/stepping motor rapidly and with repeatability to a predetermined (home) position
   — output status signals for synchronization with other instruments
   — indicate stage/motor position via LED display and external outputs
   — make program decisions (i.e., perform conditional branching) based on external events

3) It comes standard equipped with IEEE-488, RS-232-C, 20 milliampere current loop and 8 bit parallel (Centronics-like) communication protocol implementation.

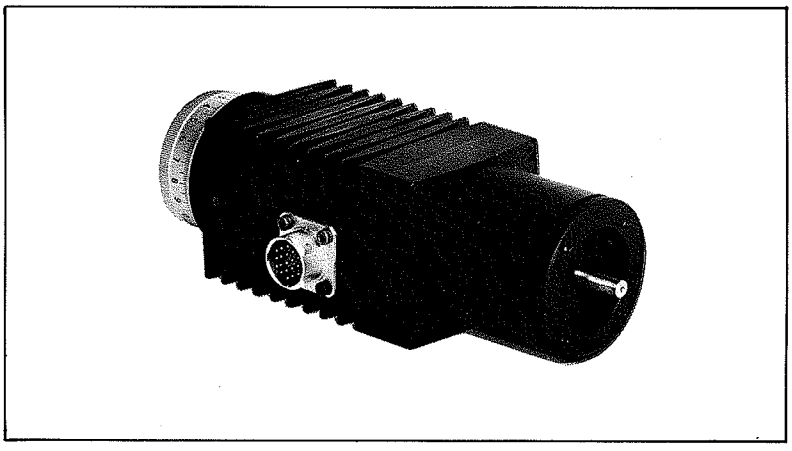
Sections II and III introduce you to all the features of the CC-1 accessible to the user. These will be discussed briefly there and explained fully in the appropriate sections. It is essential that you familiarize yourself with the existence of these features. It will allow you to better understand the functioning of the CC-1 when these features are discussed later.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com



UE30 Stepping Motor

Type: Variable reluctance
Rated voltage: 28 V
Rated current: 200 mA
Resistance/winding: 140-150 Ω
Inductance/winding: 100 mH



UE72 Stepping Motor

Type: Permanent magnet
Rated voltage: 5.3 V
Rated current: 1.6 A
Resistance/winding: 3.3 Ω
Inductance/winding: 9 mH

Figure 1.1 - UE30 and UE72 stepping motors

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

II FRONT PANEL CONTROLS AND FEATURES

The front panel controls described in this section are shown in Figure 2.1 for a double axis unit. The single axis unit simply has half of double axis controls.

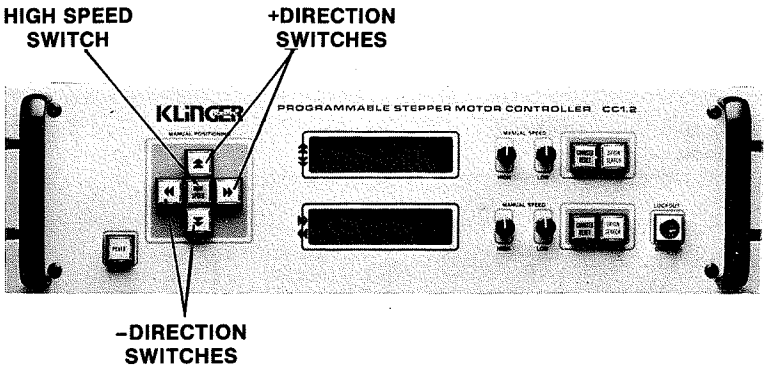


Figure 2.1 - Dual Axis Front Panel

POWER SWITCH
This is a dual position switch. Pressing it once, the unit will turn on. When pressed again, the unit will turn off. The switch will be lit while the unit is turned on.

DIRECTION SWITCHES
These switches are labeled with arrows. The switch with the arrow pointing to the right and the switch with the arrow pointing up (for a dual axis CC-1) are considered + direction switches. The other two switches are considered – direction switches.

These switches control the direction of rotation of a stepping motor and, correspondingly, the direction of stage travel. For all Klinger micropositioners, the + direction switch moves a linear stage away from the motor, and a rotary stage in the clockwise direction. The – direction switch does the opposite.

HIGH SPEED SWITCH
This switch is used simultaneously with either a + direction switch or – direction switch to perform high speed stepping in the corresponding direction.

DISPLAY
The display indicates the number of steps taken relative to the zero position, as defined by the user.

HIGH SPEED ADJUST
This is a potentiometer that varies the high speed stepping rate.

LOW SPEED ADJUST
This is a potentiometer that varies the low speed stepping rate.

COUNTER RESET SWITCH
This switch resets the display to zero and can reset the main logic circuitry to the power-up state, if desired. Refer to dip switch setting explanation in section III, specifically dip switch S2-10.

ORIGIN SEARCH SWITCH
This switch is used to trigger the origin search circuitry to return a stage to a predetermined origin (home) position.

LOCAL LOCKOUT SWITCH
This switch is used to allow or override front panel controls lockout when the unit is operated on the IEEE-488 bus or pin 12 on the General Purpose I/O connector is grounded. Refer to section 7.2 and section 11.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

III REAR PANEL CONTROLS, CONNECTORS AND FEATURES

The rear panel controls described in this section are shown in Figure 3.1. The rear panel for a dual axis unit is shown in Figure 3.2. The dual axis unit has all single axis controls and connectors duplicated except for the IEEE-488 connector, which is shared.

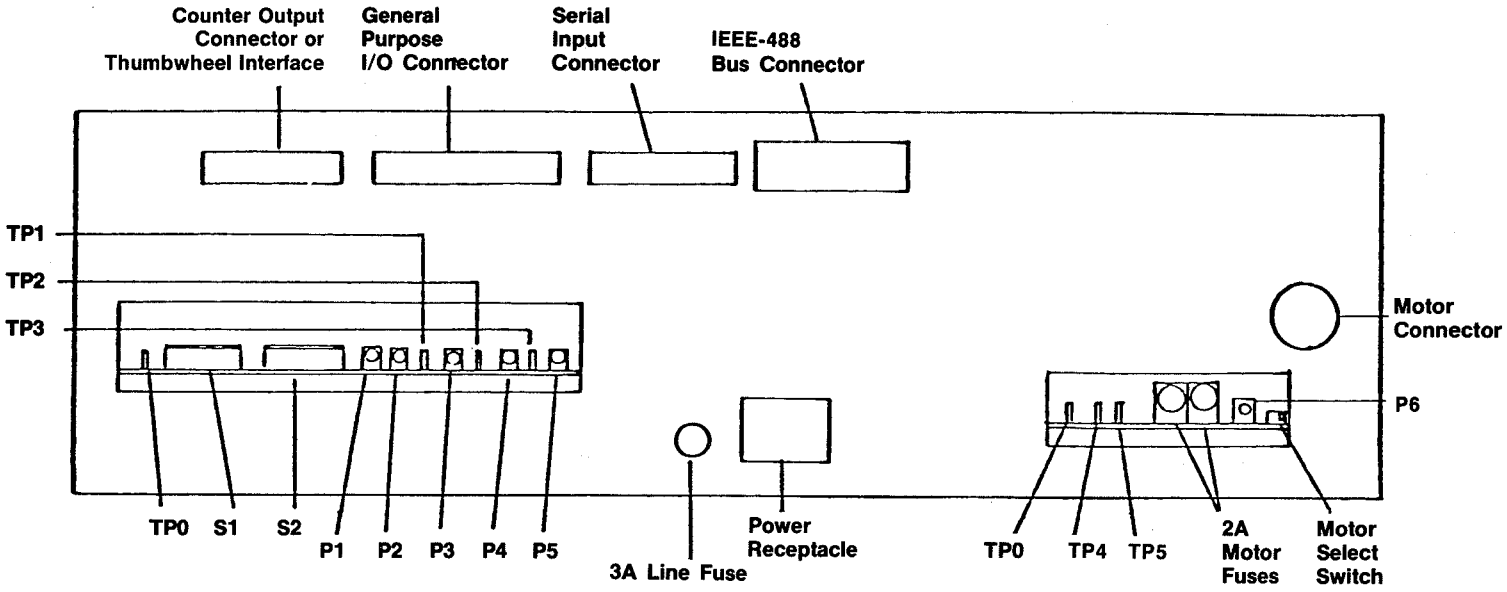


Figure 3.1 - Single Axis Rear Panel

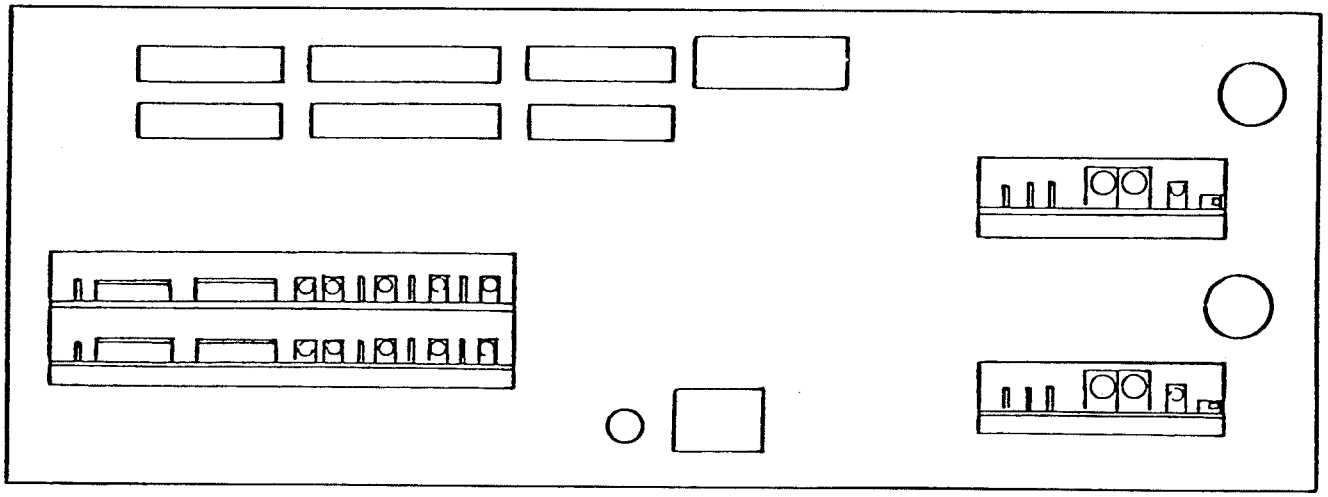


Figure 3.2 - Dual Axis Rear Panel

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

IEEE-488 CONNECTOR
This connector is used to connect the CC-1 to the IEEE-488 bus.

SERIAL INPUT CONNECTOR
This connector is used to access the CC-1's RS-232-C and 20 milliampere current loop interfaces.

GENERAL PURPOSE I/O CONNECTOR
This connector provides the user with the following:
- — CC-1 status outputs
- — inputs to control the CC-1 remotely
- — 8 bit parallel data input with handshake
- — timing pulse inputs and outputs for synchronization with other instruments

COUNTER OUTPUT CONNECTOR
This connector provides the user with a BCD multiplexed representation of the value displayed on the front panel LEDs, along with several other inputs and outputs associated with the display.

MOTOR CONNECTOR
This is a Jaeger 19 pin female connector used to connect stepping motors and Klinger's micropositioning stages to the CC-1 controller.

TEST POINTS

TP0
There are two test points labeled TP0. They are both system ground connections.

TP1
This test point allows you to:
1) observe the low speed stepping rate and
2) observe the high speed stepping rate when the low speed and high speed switches are pressed simultaneously.

TP2
This test point allows you to observe the duration of a high voltage control pulse. This pulse turns on an electronic switch which allows 64 VDC to be applied across the stepping motor's coils. This is necessary to ensure a quick current rise through the motor coils. TP2 is used only for UE30 stepping motors or equivalents.

TP3
This test point allows you to observe the slope of the acceleration and deceleration ramp used in transition from low speed to high speed, and from high speed to low speed, respectively. The two slopes are the same.

TP4, TP5
These test points allow you to determine the duration of 64 VDC applied across the stepping motor coils when driving a UE72 stepping motor or equivalent by observing the coil current rise through a current sensing resistor.

POTENTIOMETERS

P1
This potentiometer is used to set the range over which the low speed adjust (on front panel) will vary the low speed step rate.

P2
This potentiometer is used to set the range over which the high speed adjust (on front panel) will vary the high speed step rate.

P3
This potentiometer is used to vary the duration of the high voltage control pulse when driving a UE30 stepping motor or equivalent.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

P4
This potentiometer is used to vary the slope of the acceleration and deceleration ramps.

P5
This potentiometer allows you to control the amount of phase overlap. Phase overlap means that the next logical phase in the stepping sequence will turn on before the preceding phase turns off. P5 controls the amount of time that the two phases are on simultaneously. A proper amount of phase overlap will result in smoother stepping.

P6
This potentiometer allows you to vary the current trip point, and correspondingly, the duration of 64 VDC applied across the motor coils when driving a UE72 stepping motor or equivalent.

DIP SWITCHES

There are two sets of switches with ten switches per set. The correct setting of these switches is essential to have a properly functioning unit. These switches:

- match the features offered by Klinger's positioning stages to the electronics of the CC-1, and
- match the communication protocol between a computer or data terminal and the CC-1.

The switches are labeled S1-1, S1-2 ... S1-10, S2-1, S2-2 ... S2-10. The numbers 1, 2, 3 through 10 designate individual switches within a group (S1 or S2), starting from the left.

S1-1	Top zero enable (D)
S1-2	Origin by origin switch (D) / Origin by zero counter (U)
S1-3	Origin search by programmable line (U)
S1-4	Combined Busy (U)
S1-5	ASCII (U) / Binary (D)
S1-6	Serial (U) / Parallel (D)
S1-7 S1-8 S1-9 S1-10	Baud Rate for Serial
S2-1	Parity bit checking enable (D)
S2-2	Stop bit select - 2 bits (U) / 1 bit (D)
S2-3	Word length select - 8 bits (U) / 7 bits (D)
S2-4 S2-5 S2-6 S2-7 S2-8	MSB IEEE-488 Address LSB
S2-9	Internal count enable (D) / Encoder count enable (U)
S2-10	System reset by counter reset switch (U)

U = Up D = Down

S1-1 Top Zero Enable (D)
Top zero is an optional feature available on Klinger's positioning stages and certain stepping motors. Used in conjunction with an origin switch, it allows for accurate and repeatable returns to a home position when an origin search command is given. Note that S1-1 must be up if no top zero is present.

S1-2 Origin by Origin Switch (D)
Origin by Zero Counter (U)
This switch configures the CC-1 to seek the home position by providing proper directional pulses to:

- move a stage towards, and position it at an origin switch, or
- return the display count to +000001

S1-3 Origin Search by Programmable Line (U)
This switch is used if you wish to effect origin search through program control. It ties the origin search circuitry to an addressable output pin on the processor.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

S1-4 Combined Busy (U)
This switch enables the CC-1 to present a busy signal to the communication interface (IEEE-488, RS-232-C, 20mA current loop, 8 bit parallel) when origin search is in progress or when the CC-1 is executing a program stored in its program storage buffer.

S1-5 ASCII (U) / Binary (D)
This switch specifies to the CC-1 the format of the incoming command data.

S1-6 Serial (U) / Parallel (D)
This switch configures the CC-1 for serial communication (RS-232-C, 20mA current loop) or parallel communication (IEEE-488, 8 bit parallel).

S1-7 - S1-10 Baud Rate
These switches are used to match the CC-1's data bit acceptance rate to the data terminal's data bit transmission rate.

S2-1 Parity Bit Checking Enable (D)
This switch indicates to the CC-1 whether or not a parity bit is present in a serially communicated word.

S2-2 Stop Bit Select
This switch indicates to the CC-1 how many stop bits are present at the end of each serially communicated data byte.

S2-3 Word Length Select
This switch indicates to the CC-1 how many bits comprise the command data byte.

S2-4 - S2-8 IEEE-488 Address
These switches are used to assign an address to the CC-1 on the IEEE-488 bus.

S2-9 Internal Count Enable (D)
Encoder Count Enable (U)
This switch controls which source of count pulses drives the display. The internal count pulses are the same pulses that drive the stepping motor. An encoder is an optional feature available on Klinger's positioning stages and other stepping motors. It provides two square waves, 90° out of phase, for positive verification that a stepping motor has taken the proper amount of steps. Note that internal count enable **does not** disable encoder counting.

S2-10 System Reset by Counter Reset Switch (U)
This switch allows you to reset the CC-1 to its power-up state by connecting the COUNTER RESET switch on the front panel to the CC-1 reset circuitry. However, some program parameters are not erased. Refer to section 5.4.

MOTOR SELECT SWITCH
This is a two position slide switch. It is used to match the motor driver board of the CC-1 to the characteristics of the particular motor it will be driving. The setting of this switch is very important. Please consult section IV for its proper setting before connecting any stepping motor to the CC-1.

MOTOR FUSES
These are 2A fuses that protect the switching transistors on the motor driver board and also signal a defect in the switching transistors if they continually blow.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

IV PREPARATION AND START-UP

In this section we present a step by step procedure that will enable you to set up your system properly. This includes:
- — turning the CC-1 on, and
- — configuring the CC-1 (through dip switches) to match the characteristics of the stepping motor and any of the available options on Klinger's positioning stages.

We mention several CC-1 features. It is essential that you know the function and location of these, described in sections II and III, to get the most out of this discussion.

1. Plug the CC-1 into the AC outlet by using the grounded three-prong AC connector on the back of the unit.

2. Press the POWER switch in until it locks. This will supply power to all the circuits. The following will be apparent:
   - — the power switch will light
   - — the direction switches will light
   - — the display will show all zeros or some random number

3. Press the ORIGIN SEARCH switch. The switch will light but nothing will happen because there is no stepping motor connected.

4. Press the COUNTER RESET switch. The display will show negative zero. The origin search switch light may or may not go out. This will depend on the setting of switch S2-10. If it is up, the origin search circuitry will reset and the light will go out. If it is down, origin search and the rest of the system will not reset. However, the display will reset.

5. Determine which type of motor (UE30 or equivalent or UE72 or equivalent) you are going to use. If it is a UE30 motor type, then slide the MOTOR SELECT SWITCH away from potentiometer P6. If it is a UE72 motor type, then slide the MOTOR SELECT SWITCH toward P6.

6. Connect your positioning stage or stepping motor to the MOTOR CONNECTOR on the back of the CC-1 through an appropriate cable. This connector is a Jaeger 19 pin female connector. The pin-outs are shown in Figure 4.1.

7. Set switch S1-1 for top zero/no top zero option. If a top zero is present in the stepping motor assembly, set S1-1 down. If there is no top zero, set S1-1 up.

8. Set switch S1-2 for origin switch/no origin switch option. If an origin switch is present on the positioning stage, set S1-2 down. If there is no origin switch, set S1-2 up.

9. Set switch S2-9 for encoder/no encoder option. If an encoder is present in the stepping motor assembly, set S2-9 up. If there is no encoder, set S2-9 down.

This completes the basic power-up procedure. You are now ready to use your system.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

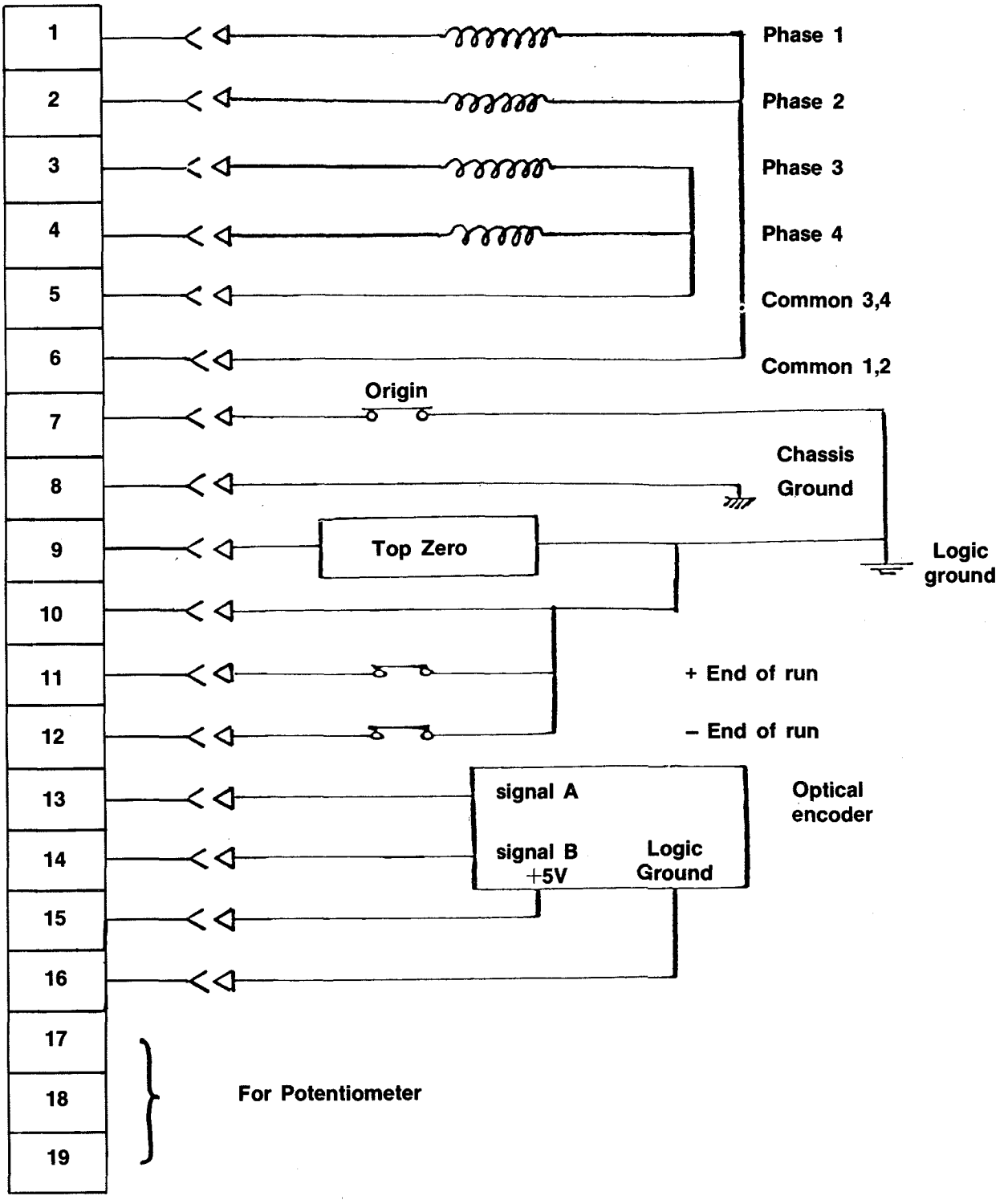


Figure 4.1 - Motor Connector

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

V MANUAL OPERATION

In this section we describe the operation of the CC-1 using the front panel pushbutton switches and the back panel user-accessible potentiometers. In this mode, the CC-1 can be used for certain set-up, test and simple operational procedures.

5.1 SINGLE STEPPING

Pressing any directional switch once and releasing before approximately Ø.3 seconds expire will advance the stepping motor one step in the corresponding direction. This feature allows you to:

1. verify that the stepping motor is sequencing through each and every step, and
2. position the stepping motor and the positioning stage at the exact location desired.

5.2 LOW SPEED OPERATION

Pressing any directional switch and keeping it pressed will perform continuous low speed stepping. Initially the motor will take one step. After a delay of approximately Ø.3 seconds, the motor will step at a predetermined rate set by the low speed potentiometers. You can adjust this speed to match your requirements. The low speed potentiometer (P1) accessible from the back is used to set the range over which the front panel low speed potentiometer will vary the low speed.

The upper limit on the low speed should not exceed 4ØØHz. This limit is due to the inertia of the motor. Operation above 4ØØHz is possible but not guaranteed. Setting the low speed upper limit appreciably above 4ØØHz will cause the motor to stall when starting and overshoot the target position when stopping. To set the upper limit do the following:

1. rotate the front panel low speed potentiometer full clockwise
2. attach a frequency measuring instrument to test point TP1 and adjust potentiometer P1 for the desired speed.

While in single stepping or low speed mode an adjustment of the high voltage duration may be necessary. At the beginning of every step, a high voltage (64VDC) must be applied across the motor coils to ensure a fast current rise. The current through a coil is directly proportional to the torque generated. For varying torque requirements, the duration of the high voltage must be adjusted properly. Adjustment will be necessary if the motor "misses a step" in single stepping mode, and stalls in low speed mode — provided that the low speed rate is not greater than 4ØØHz.

There are two methods for adjusting the high voltage duration. The method used is determined by the type of motor being driven.

UE30 motor type and equivalent

- — rotate potentiometer P3 clockwise to increase the high voltage duration and rotate counter-clockwise to decrease it
- — if you wish to view the length of the high voltage duration control pulse, place an oscilloscope probe on test point TP2 and press any directional switch.

UE72 motor type and equivalent

- — for this motor type we use current sensing through a .12Ω resistor to control the high voltage duration
- — rotate potentiometer P6 clockwise to increase the high voltage duration and rotate counter-clockwise to decrease it
- — if you wish to view the length of the high voltage duration, place an oscilloscope probe on test point TP4 or TP5, set time base to .5 msec/division, set vertical sensitivity to .2V/division and press a directional switch. One test point will show the actual current rise and decay through a current sensing resistor for one coil and the other test point will show likewise for the other coil.

5.3 HIGH SPEED OPERATION

Pressing any directional switch concurrently with the high speed switch will perform continuous high speed stepping. The stepping rate is determined by the setting of the high speed potentiometers. The high speed potentiometer (P2) accessible from the back is used to set the range over which the front panel high speed potentiometer will vary the high speed.

The upper limit on the high speed should not exceed 2ØØØHz. This limit is due to the L/R time constant of the motor coils. Operation above 2ØØØHz is possible but not guaranteed. Setting the high speed upper limit appreciably above 2ØØØHz will cause the motor to stall. To set the upper limit do the following:

1. rotate the front panel high speed potentiometer full clockwise
2. attach a frequency measuring instrument to test point TP1 and while depressing both a directional switch and the high speed switch, adjust potentiometer P2 for the desired speed.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

When a transition from low speed to high speed occurs, the CC-1 generates a ramp type voltage signal to increase the motor speed linearly towards the final high speed stepping rate. The slope of this ramp must be properly set for a good speed transition. If the motor stalls in transition, you must decrease the slope of the ramp. Theoretically, for increasing loads, the slope of the ramp must be decreased. To adjust the ramp, do the following:

1. rotate potentiometer P4 clockwise to increase the slope of the ramp and rotate counter-clockwise to decrease the slope of the ramp
2. if you wish to view the slope of the ramp, place an oscilloscope probe on test point TP3, set the time base to .1 seconds and press a directional switch and the high speed switch simultaneously.

Setting the ramp to increase from zero volts to five volts in .1 seconds will suffice for the majority of applications.

5.4 COUNTER RESET

The counter reset switch has a dual function:

1. it will always reset the display to negative zero when pressed
2. it may reset the main logic circuitry, depending on the state of S2-10. If S2-10 is up, the counter reset switch will a) halt origin search, if in progress, and b) erase the contents of the CC-1 internal program storage buffer. However, it will not erase any distance or rate parameters previously entered. Refer to section 6.2.2 and section 6.6.1.

The counter reset switch is convenient for setting the starting position to zero. This will allow you to easily determine the number of steps taken to any point in the movement by just reading the display.

5.5 ORIGIN SEARCH

The origin search switch is used to place the CC-1 in the origin (home position) seeking mode. The type of origin must be defined to the CC-1 by the proper setting of dip switches S1-1 and S1-2. There are two types of origins:

— one is the position defined by the location of an origin switch mounted on a positioning stage, and
— the other is the position that corresponds to the step count of +000001 on the LED display.

The position defined by an origin switch can be vastly improved in terms of accuracy and repeatability if a top zero pulse is incorporated in the system. The top zero pulse occurs once per revolution and is only valid when the origin switch has been reached.

Switch Settings:

— S1-1 up for no top zero pulse
  S1-1 down if top zero pulse present
— S1-2 up for no origin switch
  S1-2 down if origin switch present

The theory behind origin search and top zero pulse is more fully developed in section XIII.

5.6 OPERATIONAL TESTS

Before proceeding to the intended use of the CC-1 and associated positioning stages, you should verify the integrity of the following:

— step encoder, if present
— end of run switches
— origin switch, if present
— top zero pulse, if present

Step Encoder

Set S2-9 up. Single step the CC-1 and verify that for each step the display changes by one. If the display misses a step don't worry. Single step once and the display will jump two counts to make up for the missed step. At any given time the display value is exactly on or within 1 step of the actual position. See section XV if steps are missed frequently.

End of Run Switches

Run the stage at high speed towards one travel limit. When this point is reached, the end of run switch will open (it is normally closed) and inhibit step pulses from reaching the motor driver board. The corresponding direction switch will light to indicate this condition. Next run the stage in the opposite direction and you will observe the same thing.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

Origin Switch

Press the ORIGIN SEARCH switch to initiate origin search. The switch will light and will remain lit while origin search is in progress. The stage will be moved towards, and stopped at the origin switch. Repeat the procedure several times to verify that the stage returns to the same position. Do this by noting the count on the display. The origin switch is accurate to ±1 step for step sizes of 1 micron or greater. For step sizes less than 1 micron, the origin switch is not as accurate. This is where the need for a top zero pulse becomes evident.

Top Zero Pulse

To see the accuracy and repeatability provided by a top zero pulse do the following:

1. set S1-1 up to disable the top zero pulse and initiate origin search several times. Note the display value each time. You may find that the display value varies by as much as three or four counts.
2. set S1-1 down to enable the top zero pulse and again initiate origin search several times. Note the display value each time. You will notice that the display value is offset from the display value of step 1 ***but*** the count is always within ±1 step.

5.7 FACTORY PRESETS

- low speed upper limit: 400Hz
- high speed upper limit: 2000Hz
- acceleration and deceleration ramp: .1 seconds
- high voltage duration (UE30 motor type): 1-1.5 milliseconds (load dependent)
- current trip point (UE72 motor type): 1.6 amps

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

VI PROGRAMMING

To realize the full potential of the CC-1, it should be operated from a computer or other data source capable of supplying ASCII coded or binary coded commands. These commands enable the CC-1 to perform all of the following:

1. establish a home reference position and make all movements relative to this home position
2. perform movements relative to the present position in the positive or negative direction
3. execute movements over a wide speed range with varying acceleration rates
4. perform similar movements through JUMP and LOOP commands
5. execute conditional branching contingent on external events
6. place a delay of any length between successive movements
7. provide addressable output pins that can be used for synchronizing purposes or to effect origin search.

6.1 INSTRUCTION SET

The CC-1 instruction set is shown in Table 6.1. These instructions should show you the operational versatility of the CC-1. Following a discussion of the programming modes of the CC-1 in section 6.2 we present a detailed description of each instruction in section 6.3.

Table 6.1 **CC-1 INSTRUCTION SET**

ASCII Code	Example (↓=carriage ret.)	Interpretation and Range
A	"A↓"	Establishes zero home position for absolute indexing
B	"B↓"	Sets programmable output line high (G.P. I/O connector, pin 16)
C	"C↓"	Sets programmable output line low (G.P. I/O connector, pin 16)
D	"D↓"	Executes stored program* (when given in command mode) or causes program to loop back to the beginning (when included within stored program)
E	"E↓"	Informs the CC-1 to store the next sequence of commands in its buffer for later execution
F	"F 15↓"	Establishes step rate factor parameter (1-255)
G	"G↓"	Causes a stored relative motion to be executed
I	"I↓"	When entered in program execution mode, halts and erases stored program
J	"J 10↓"	Causes a jump to a specified location (0-47)** within the stored program
L	"L 100 5↓"	Causes the program to loop for a specified count (1-255) to a specified location (0-47)
N	"N 5000↓"	Establishes number of steps to be taken in a relative motion (1-65,535)
P	"P 10000↓"	Establishes target position for absolute motion (0-65,535)
Q	"Q↓"	Instructs CC-1 to quit program entry mode and enter command mode. May also be entered during program execution to abort program execution and re-enter command mode
R	"R 250↓"	Establishes step rate parameter (1-255)
S	"S 3↓"	Establishes step rate acceleration parameter (1-255)
T	"T↓"	Causes the program to loop back to the beginning while the loop input is low (G.P. I/O connector, pin 14)
U	"U↓"	Causes the program to wait while wait input is low (G.P. I/O connector, pin 15)
W	"W↓"	Causes the program to wait while wait input is high (G.P. I/O connector, pin 15)
X	"X 10000↓"	Causes the program to wait for a specified time (1-65,535) in multiples of 1.83 msec.
+	"+↓"	Establishes positive direction for relative motion
–	"–↓"	Establishes negative direction for relative motion
0	"0↓"	Halts program execution and causes unit to re-enter command mode; used to end all programs

The correct format of the ASCII instructions (including spaces) is given between quotation marks in the examples.
*Stored program or program refers to a sequence of commands entered and stored in CC-1 internal buffer.
**The first command entered after an "E↓" command is stored at location 0.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

6.2 PROGRAMMING MODES

The CC-1 has three programming modes:

1. command mode
2. program entry mode
3. program execution mode

6.2.1 COMMAND MODE

In command mode, commands are executed as they are received. The CC-1 powers-up in command mode — no instruction is necessary to enter this mode, initially. However, to re-enter command mode from either of the other two modes, a specific instruction is necessary for each mode. More on this later. An example of a sequence of instructions given in command mode is shown below.

"R 253↓"
"S 2↓"
"F 20↓"
"N 1000↓"
"+↓"
"G↓"
↓ = carriage return

The above sequence will advance a stepping motor 1000 steps in the positive direction at a rate of 1941 steps per second. Note that the movement will not be performed in one-half second because the step rate is slower during acceleration and deceleration. See section 6.5 for step rate calculation.

6.2.2 PROGRAM ENTRY MODE

In program entry mode, a sequence of commands is entered and stored in a program buffer for later execution. There are 48 bytes of memory available for program storage. Table 6.2 gives the number of bytes required for each instruction. It is *imperative that you know the length and correspondingly the location of each instruction to do looping and branching.*

To enter program entry mode, the "E↓" instruction is used. The first instruction entered after "E↓" is stored at location 0. The "0↓" instruction is used to end all programs. It is the last instruction entered before exiting program entry mode. This instruction returns the CC-1 back into command mode after it executes the stored program. Do not forget to include this *instruction at the end of every program.*

To exit program entry mode and re-enter command mode, use the "Q↓" instruction. It is necessary to re-enter command mode in order to give the instruction to execute the stored program. See section 6.2.3.

To save space, the A, F, N, R, S, and + or – instruction may be entered before the E instruction is given. This causes the internal registers to be set in command mode. The values will remain the same during program execution until they are changed during program execution. If the program is to be rerun, care must be taken not to specify parameters in command mode which are changed to a different value within the program (unless they are changed back by the end of the program).

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

Table 6.2 **Instruction Lengths and Parameter Characteristics**

Instruction	Bytes	Parameter	Range
A	1		
B	1		
C	1		
D	1		
E	Ø		
F	2	rate modifier	1-255
G	1		
I	1		
J	2	byte address	Ø-47
L	3	count and address	1-255, Ø-47
N	3	travel distance	1-65,535
P	3	target location	Ø-65,535
Q	Ø		
R	2	rate parameter	1-255
S	2	acceleration parameter	1-255
T	1		
U	1		
W	1		
X	3	time delay (in multiples of 1.83 msec)	1-65,235
+	1		
–	1		
Ø	1		

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

An example of a program entered in program entry mode is given below. This program loops and performs jumps. It does conditional branching. It waits or continues contingent on external inputs. The byte number location of each instruction in the buffer is also shown. This is necessary knowledge when looping and branching is implemented.

Location		
	"R 253↓"	
	"S 2↓"	:set speed and acceleration rate in command mode
	"F 20↓"	
	"N 1000↓"	:set number of steps in command mode
	"E↓"	:enter program entry mode
0	"+↓"	
1	"G↓"	
2	"X 1000↓"	:delay 1.83 seconds
5	"−↓"	
6	"G↓"	
7	"X 2000↓"	
10	"L 10 0↓"	:loop to location 0 ten times
13	"J 41↓"	:jump to location 41
15	"A↓"	:establish home position
16	"W↓"	:wait while external input is high
17	"P 5000↓"	:move 5000 steps from home position
20	"U↓"	:wait while external input is low
21	"P 0↓"	:return to home position
24	"T↓"	:loop back to location 0 if external input is low
25	"R 250↓"	
27	"S 3↓"	:set new speed and acceleration rate
29	"F 50↓"	
31	"N 254↓"	:set new number of steps
34	"+↓"	
35	"G↓"	
36	"X 500↓"	
39	"D↓"	:go to location 0 and repeat indefinitely
40	"0↓"	:return to command mode
41	"C↓"	:pulse programmable output line; S1-3 must be down
42	"B↓"	
43	"J 15↓"	:jump back to location 15
	"Q↓"	:exit program entry mode
	"D↓"	:execute stored program

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

6.2.3 PROGRAM EXECUTION MODE

There are two commands that enable you to enter program execution mode. One command starts program execution from location zero of the program storage buffer and the other starts program execution from the location specified in the command.

To start program execution from location zero, a "D↓" instruction is given in command mode. The CC-1 will remain in program execution mode until it encounters a "Ø↓" instruction in the stored sequence. At this time it will return to command mode.

If the CC-1 encounters a "D↓" in the stored sequence, it will repeatedly execute the program, starting from location zero. In this instance there are four ways to re-enter command mode:

1. send a "Q↓" instruction followed by a "Ø↓" instruction
2. reset system with COUNTER RESET switch (S2-10 must be up)
3. send an "I↓" instruction, or
4. power down and then power up

Note that alternatives 2, 3 and 4 will erase the program.

To start program execution from a location other than zero, a "J n↓" instruction is given, where n specifies the starting location. This is a very useful feature because it allows you to store several programs and execute them at will. Note that "J Ø↓" is equivalent to "D↓".

6.2.4 EMERGENCY STOPPING

If it becomes necessary to halt a step sequence immediately, a "Q↓" command is used. If the step sequence is stopped during program execution mode, the "Q↓" command should be followed by a "Ø↓" command to re-enter command mode and reset the program execution output line.

6.2.5 OUTPUTS DURING PROGRAMMING MODES

In command mode and during program execution, the CC-1 outputs a low level motion complete signal at the end of each motion. This signal appears at pin number 17 on the 37 pin G.P. I/O connector.

In program entry mode, the CC-1 will indicate this mode by a low level signal at pin number 19 on the 37 pin G.P. I/O connector. The "E↓" instruction will bring this pin low while a "Q↓" instruction will bring it high.

In program execution mode, the CC-1 will indicate this mode by a low level signal at pin number 18 on the 37 pin G.P. I/O connector. The "D↓" instruction given in command mode will bring this pin low while a "Ø↓" instruction encountered in the stored sequence or given in command mode will bring it high.

6.3 DETAILED DESCRIPTIONS OF COMMANDS

A **ATHOME** **0100 0001** **1 byte**

The ATHOME instruction defines the "Home" position. This position is set to absolute zero, and is the reference for all POSITION commands. The ATHOME command may be used at any time to define or redefine position zero.

B **BITSET** **0100 0010** **1 byte**

This instruction causes the programmable output pin (#16, G.P. I/O connector) to go high.

C **CLEARBIT** **0100 0011** **1 byte**

This instruction causes the programmable output pin to go low. The user can signal locations in a program sequence to the external world (S1-3 down) or initiate origin search (S1-3 up) via C and B commands.

D **DOITNOW** **0100 0100** **1 byte**

This instruction causes the CC-1 to begin executing the stored program. If no program has been entered, the CC-1 will stay in the program execution mode until a Ø command is executed. If the program exists, the CC-1 will begin execution of the first instruction in the program buffer. If the D command is encountered during program execution, it restarts the program (however, the initial parameters and modes may have been redefined later in the program) and thus may be used for looping or cyclic repetition of the program.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

E **ENTER** **0100 0101** **1 byte**

This instruction causes the CC-1 to begin the program entry mode of operation. All commands following the ENTER command are saved in the program buffer in sequence until "Q↓" is entered. Pin number 19 on G.P. I/O connector goes low to indicate this mode.

F f **FACTOR** **0100 0110** **2 bytes**

a_7 b_0

The factor, f, is a number from 1 to 255 and is used to further define the step rate. See the Rate Equation in section 6.5 for details.

G **GO** **0100 0111** **1 byte**

The GO command causes the stepping motor to step as specified by rate, direction, etc., commands entered prior to the GO command. Stepping will be in the relative mode, with the number of steps defined by the N command.

I **INITIALIZE** **0100 1001** **1 byte**

The INITIALIZE command causes the CC-1 to enter the command mode. None of the distance or rate parameters are altered. Any commands following "I" will be executed with the parameters specified prior to "I". The INITIALIZE command, when encountered during program execution, halts the program execution and returns the system to the command mode. This command erases the program, if any, and sets the direction to CW.

J a **JUMP** **0100 1010** **2 bytes**

a_7 a_0

The JUMP command will branch program execution to the program buffer location specified by the argument, which represents the byte number in the program buffer, starting with zero. Program execution continues from the specified byte number after the jump is executed. When the JUMP command is issued from the command mode, it enables the Run (Program execution) mode, and begins executing from the specified byte number. It is the user's responsibility to insure that the number specified with the JUMP command is the correct value for the desired starting point. The first byte after the "E↓" command is location zero. The byte count specified in table 6.2 determines the number of bytes used by each instruction. Note that "J Ø↓" is equivalent to "D↓".

L c,a **LOOP** **0100 1100** **3 bytes**

a_7 a_0 COUNT

b_7 b_0 LOCATION

The LOOP command uses the first argument as a repetition count, and the second argument as a jump location. Each time the LOOP command is executed, the count is decremented by one. If the count is nonzero after the decrement, program execution will jump to the specified address, which is the second argument of the command. The jump address specifies the location to which execution will loop, and the count represents the number of times the loop is to be repeated. When the count reaches zero, program execution continues with the instruction immediately following the LOOP command. The two arguments may be separated by either a comma, or a single space. LOOP commands may not be nested one inside the other.

N n **NUMBER** **0100 1110** **3 bytes**

a_7 a_0 LSbyte

b_7 b_0 MSbyte

The NUMBER command is used to specify the number of steps to be taken in the "Relative" mode of operation. The argument may be any number from 1 to 64K-1 (65,535). Note that this parameter is stored as 3 bytes in the program buffer.

P p **POSITION** **0101 0000** **3 bytes**

a_7 a_0 LSbyte

b_7 b_0 MSbyte

The POSITION command declares the "Absolute" mode of operation. The argument is treated as the target position relative to position zero. The ATHOME command is used to define position zero. Stepping to the target position begins when the POSITION command is executed. No "G" command is required. Direction to the target position is also determined and set automatically.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

Q **QUIT (Programming)** **0101 0001** **1 byte**

The QUIT command causes the CC-1 to exit the program entry mode of operation, wherein instructions are stored in the program buffer in the order received, and causes the CC-1 to return to the command mode of operation, in which instructions are executed as they are received. It may also be used as any emergency stop operation during a step command.

R r **RATE** **0101 0010** **2 bytes**

a_7 a_0

The RATE instruction sets the rate parameter that determines the step rate. The rate parameter, r, varies from 1 to 255. The rate is non-linear and can be computed from the rate equation. See section 6.5.

S s **SLOPE** **0101 0011** **2 bytes**

a_7 a_0

The SLOPE or slew mode of operation is used when high step rates are required and the initial load on the motor prevents instantaneous stepping at such rates. In such cases, the load is accelerated from rest to the maximum rate and then decelerated to a stop. The user specifies the distance of total travel (via "N" instruction), the maximum rate (via "R") and the ramp rate or change in factor parameter from step to step.

T **loop TIL** **0101 0100** **1 byte**

The "T" command provides a "Do...While..." capability to the CC-1. This command tests pin 14 on G.P. I/O connector and, if low, it executes the DOITNOW (D) command, i.e., it runs the program from the beginning (although using the latest rate, position, etc., parameter). If pin 14 is high, the instruction following the T command is fetched and executed.

U **wait-UNTIL** **0101 0101** **1 byte**

The wait-UNTIL instruction is used to synchronize the program execution to an external event. When the "U" instruction is executed, the WAIT pin (pin #15, G.P. I/O connector) is tested. When the WAITpin goes high, the next instruction is fetched from the program buffer and execution proceeds.

W **WAIT** **0101 0111** **1 byte**

The WAIT instruction is the opposite of the U command. WAIT tests the WAIT pin (pin #15, G.P. I/O connector) for a low level. The stored program will halt until the pin goes low, then it will continue with the next command. Note that the U command may be used to detect the rising edge of the WAIT line signal, and the W command may be used to detect the falling edge.Thus, it is possible to synchronize program execution to either one or both of the transitions.

X x **EXPEND** **0101 1000** **3 bytes**

a_7 a_0 LSB

b_7 b_0 MSB

The EXPEND command will time delay for the number of milliseconds specified by its argument times 1.83 milliseconds. Since the argument is 16 bits, the range of the argument is 1 to 65,535.

+ **CLOCKWISE** **0010 1011** **1 byte**

Direction is set to clockwise by this command. Relative mode steps are taken in the direction last specified, so they will be clockwise until the direction is changed by the "–" or "P" commands.

– **CCW** **0010 1101** **1 byte**

Direction is set to counter-clockwise by this command. Comments under CLOCKWISE also apply to the "–" command.

Ø **COMMAND** **0011 0000** **1 byte**

The CC-1 is placed in the command mode and the next command is executed as it is received. Internally stored programs should be terminated by a "Ø↓" command, returning the CC-1 to command mode at the end of program execution.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

6.4 DATA MODES AND FORMATS

The CC-1 program commands can be encoded in two data types. One data type is ASCII, the other is binary. The CC-1 is configured through dip switch S1-5 for the particular data type. Switch S1-5 is up for ASCII and down for binary.

6.4.1 ASCII COMMAND FORMATTING

The ASCII data mode is the most convenient mode of operation for the CC-1. The format of an ASCII coded single character command is as follows:

The character is transmitted in compact format, i.e., no leading or trailing spaces, followed only by a carriage return terminator. Do not use a carriage return/line feed terminator.

The format of an ASCII coded multiple character command (command plus parameter) is as follows:

The characters are transmitted in compact format followed only by a carriage return terminator. There is one space between the letter of the command and its parameter. For example, the command "N 254↓" must be transmitted as follows:

N :ASCII N = 4E H
:ASCII Space = 2Ø H
2 :ASCII 2 = 32 H
5 ASCII 5 = 35 H
4 :ASCII 4 = 34 H
↓ :ASCII carriage return = ØDH
H = Hexadecimal

6.4.2 BINARY COMMAND FORMATTING

To facilitate control via microprocessors using binary arithmetic, the CC-1 can be placed in the binary data mode of command execution by setting dip switch S1-5 in the down position. The possibility of the occurrence of the Q command in the binary data necessitates the use of a data count sent after each command byte. In the binary mode, "Q"=51H may be inadvertently transmitted, since some of the binary position or rate data may assume this value. For this reason, it is necessary to specify the number of bytes of binary data to be sent to the CC-1. In this mode, the data count and data values are specified in binary form, while the command letters retain their equivalent ASCII values.

Commands are issued by first sending the command letter, which has the same value as in ASCII mode. This is followed by a binary value data count. The data count represents the number of data bytes to follow the command byte. If the command is a single letter with no parameter, such as "A", "B", or "T", the data count will be zero, indicating the end of the command. This is similar to sending the command letter and a carriage return in ASCII mode. Note that the data are not ASCII characters, they are binary values. Commands with parameters in the range of 1 to 255 will have a data count of binary 1, since these values can all be specified in a single byte. Rate, Slope, etc., are in this category. The data count is then followed by the single byte which is the binary value desired for that parameter. Commands such as Loop, Number, etc., will have a data count of binary 2, since their parameters cannot be specified in a single byte. The data count is then followed by the two bytes which represent the 16-bit value for the parameter, or the two parameters used by the Loop command. Note that 16-bit values are sent least significant byte first, while the Loop command parameters are sent as count then address, the same order as specified in the ASCII mode. All commands except QUIT are of the form shown in Table 6.3.

Table 6.3

Allowed Binary Commands and Data Count for Each

Command Byte	Data Count	Data 1	Data 2
A, B, C, D, E, G, I	Ø	****	****
T, U, W, +, –, Ø			
F, J, R, S	1	Factor, Rate, etc.	****
L, N, P, X	2	Number of Step, Target Position, etc. Least significant byte first	

Note that the Q command is not followed by a data count in the binary mode.

****Not applicable.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

Also, it is possible to load an entire program with a single byte count value. To do this, issue the E command with a data count value of zero, followed by the first command character of the program. Instead of following this character by the normal data count, use a count equal to the remaining total characters of the program, up to, and including the Ø command. Do not include the Q command in the count. The Q command should then be issued separately, ending the program entry mode and reverting to command mode. When this method of program loading is used, the Ø command must have a binary value of zero, not the ASCII character "Ø". The program may also be loaded as separate commands, with a normal data count for each command. This is the procedure used for command mode operation as well.

6.5 STEP RATE CONTROL

The CC-1 allows you to define the step rate and acceleration rates in very fine increments (1Ø microsecond changes). This is easily done through the rate, slope and factor (R, S, and F) commands. By proper choice of the R, S, and F parameters, it is possible to control the starting rate, the number of steps from the starting rate to the slew rate, and the final slew rate.

CC-1 Rate Equation

$$\text{Steps per second} = \frac{10^6}{(256-r)\cdot(80) + z\cdot(10) + 75 \pm 7.5}$$

The equation and this discussion use several variables which are defined as follows:

r = Rate parameter as set by the R command
s = Slope parameter as set by the S command
f = Factor parameter as set by the F command
y = Integer (255–f) / s
z = Internal factor value

The variable y represents the number of steps required to ramp up from the starting rate to the slew rate, and the number of steps to ramp down again before stopping.

The internal factor, z, changes in value for each step while ramping. When accelerating, $z = 255 - n \cdot s$, where n is the step number from the start of motion, beginning with n = 1. When z = f (slew speed) the maximum step rate for any particular value of r and f has been reached. While decelerating, $z = f + n \cdot s$, where n is the step number from the start of deceleration.

From the above discussion, we can deduce the starting step rate equation and the final (slew) step rate equation:

Starting Step Rate

$$\text{Steps per second} = \frac{10^6}{(256-r)\cdot 80 + (255-s)\cdot 10 + 75 \pm 7.5} = \frac{10^6}{2845} = 351$$

$(256-253)\cdot 80 + (255-2)\cdot 10 + 75$
$240 + 2530 + 75$

Slew Step Rate

$$\text{Steps per second} = \frac{10^6}{(256-r)\cdot 80 + f\cdot 10 + 75 \pm 7.5} = \frac{10^6}{515} = 1941$$

$240 + 200 + 75$

The rate equation applies as specified when $1 \leq r \leq 254$. In the case where r = 255, the rate will not follow the equation, but will differ, depending on the direction of motion.

The rate for the + direction is $10^6 / (218 + z \cdot 10)$.
The rate for the – direction is $10^6 / (232 + z \cdot 10)$.

The ±7.5 term in the rate equations represents an uncertainty between the exact instant the step time expires and the point at which it is detected. For any given setting of the parameters, the step rate will be a constant within the ± range specified. The CC-1 will not exhibit a jitter from step to step and the exact step rate is repeatable with the same input parameters.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

Table 6.4 is a listing of the range of possible slew rates for a given setting of r. The slowest step rate in each range uses the value f = 255, and the fastest rate is obtained when f = 1.

Table 6.4 **Rate Table**

	Steps/second	
Rate r	**f = 255**	**f = 1**
1	43	48
25	47	53
50	52	60
75	58	68
100	66	79
125	76	94
150	90	116
175	109	152
200	140	219
205	149	240
210	158	265
215	169	297
220	181	337
225	195	389
230	212	461
235	232	566
240	256	732
245	285	1036
250	322	1769
251	330	2061
252	339	2469
253	349	3076
254	359	4081

Note that the CC-1 is capable of outputting step rates much greater than 2000Hz. However, for UE30 and UE72 motor types, operation is not guaranteed above 2000Hz.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

6.5.1 RAMPING MODE OF OPERATION

The maximum step rate is defined by a combination of the rate and factor parameters, as indicated in the step rate equation. For step rates greater than 400Hz, the initial step rate will not be at the maximum rate, but will ramp up to this rate from a slower value. The slope, or number of steps required to attain the maximum rate, is defined by the slope parameter. When stepping begins, an internal factor value (z) is set to 255. The value of the slope parameter is then subtracted from this internal factor once per step, increasing the step rate as the factor decreases (see the equation). Note that the rate parameter is not changed by this process, only the internal factor. When the internal factor becomes less than or equal to the value specified by the factor command (f), the maximum rate has been reached, and the internal factor is set so the specified rate is maintained. The CC-1 will continue slewing until it is time to ramp down to hit the target position. The point at which this occurs is determined automatically and the value of the slope parameter is added to the internal factor once per step, producing a slower step rate until the target position is reached, or the slowest rate is attained (internal factor z = 255).

IMPORTANT

If the number of steps to travel is less than the number required to reach the maximum step rate and then ramp down again, the CC-1 will not ramp. Instead it will just step to the target position at a step rate determined by the value of the R parameter and f equals 255.

The number of steps needed to accelerate is given by (255 – f) / s. This same number of steps is necessary to decelerate. If the number of steps to reach the target position is less than twice the value given by (255 – f) / s, the CC-1 will not ramp at all. It will use the R parameter given, ignore the F parameter given and instead set it to 255. It will then use the slew rate equation to determine the stepping rate. For example, if the following program was entered:

"R 253↓"; "S 1↓"; "F 20↓"; "N 460↓"; "G↓"

The number of steps necessary to accelerate and then decelerate is equal to:

$2 \cdot [(255 - f) / s] = 2 \cdot [(255 - 20) / 1] = 470$

Since our target position is less than 470 steps away, the CC-1 will not ramp. It will step to the target position at a rate determined by:

$\text{steps/sec} = 10^6 / (256 - r) \cdot 80 + 10 \cdot f + 75 \pm 7.5$

The CC-1 will set f = 255 and use the r parameter given.

$\text{steps/sec} = 10^6 / (256 - 253) \cdot 80 + 10 \cdot (255) + 75 \pm 7.5 = 348$

It is recommended that a rate parameter of 253 or higher be chosen for slewing. This minimizes the time it takes to reach the maximum speed.

Depending on the motor used, the load, and the final speed, a fast acceleration ramp (s = 7, 8, etc.) or a slow ramp (s = 1, 2, etc.) may be used. Note that since the slope parameter changes the instantaneous step rate once per step (not at a constant rate) the acceleration is not linear. The effective acceleration rate is higher for higher step rates. For speeds below 400Hz (or higher if your application permits) where ramping is not required, use a value of 255 for the slope (s) parameter.

IMPORTANT

Note that the factor command must always be entered after the slope command. If the slope is changed, the factor command must be repeated after the new slope, to insure proper ramping operation. This is because the variable y is calculated only when a factor value is entered, not when a slope value is entered or before a motion is executed. A new set of parameters is not entered for each motion, but may be entered to change the step rate.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

6.6 APPLICATION HINTS AND TECHNIQUES

Programming the CC-1 is straightforward. However, you may encounter some problems setting the optimal step and acceleration rates. In this section we first present a functional grouping of the CC-1 commands and second, we present a discussion for setting the rate, slope and factor parameters for optimal performance.

6.6.1 FUNCTIONAL GROUPING OF CC-1 COMMANDS

Relative Indexing

Relative indexing makes use of the N, +, –, and G instructions.
N specifies the number of steps in the motion (not a final position).
+ or – is used to set the direction.
G is the command to make the motion.
Motions of equal length may be performed without re-entering the N parameter.

Absolute Indexing

For absolute indexing, the A instruction is used to establish the zero position.
The P instruction is then used to move to a specified positive position.

Although all positions must be positive (with respect to the zero position), the direction of motion depends upon the starting and end positions of a move. For example, if the position before the execution of a "P 5000↓" command is 10000, the direction of the move is negative. If the position before the execution of the command is 1000, the direction is positive. Note that this zero position does not necessarily correspond to the zero position of the display.

Positive and negative relative indexing may be intermixed with absolute indexing provided that any negative relative motion does not move the stage past the established zero position. If this occurs, the position defined by the A command is lost and all subsequent P commands will execute incorrectly.

When mixing absolute and relative indexing you must keep track of the last direction of travel. This is because there is a single direction register for both indexing modes. For example, if a relative move is desired immediately after a negative direction P command is executed, the motion will be in the negative direction, even though you may have outputted a "+↓" command previously. The example below will make this clear.

```
"A↓"
"N 1000↓"
"+↓"              :direction register = +
"G↓"
"P 2000↓"         :direction register = +
"P 0↓"            :direction register = –
"G↓"              :relative motion will be in negative direction
```

Wait Instructions

The X instruction may be executed during command mode or program execution mode to perform a timing function. It takes a numerical argument which is the time in multiples of 1.83 msec.

The U and W instructions are used only in program execution mode to poll the wait input line (pin #15, G.P. I/O connector). If the line is in the wait state, program execution is halted until it changes state.

Loop Instructions

These instructions are used only in program execution mode.

The L instruction takes two arguments. The first argument is the loop counter. The second is the location of the instruction which begins the loop (zero marks the first instruction entered after an E command).

The J instruction simply performs the jump function of the L instruction without having a loop counter. Its single argument is equivalent to the second argument of the L instruction. It can also be used to start stored program execution at any desired location.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

The T instruction will cause the program to loop back to location zero as long as the loop input is low.

The D instruction is normally given in command mode to start execution of a stored program. If it is also included in a stored program, the program will loop back to location zero indefinitely. Program execution can be stopped by resetting the system or by inputting an I instruction or a Q instruction. The Q instruction will halt the execution and return the system to command mode. The I instruction will do the same and, in addition, erase the stored program.

Programmable Output

The B and C instructions are used to set and clear a programmable output line (pin 16 on the General Purpose I/O connector). This line is initialized in the high state.

Rate Control

The R, S, and F instructions are used to define the step rate and acceleration rates in very fine increments (10 μsec changes). By proper choice of the rate, slope, and factor parameters, it is possible to control the starting rate, the number of steps from the starting rate to the slew rate, and the final slew rate.

6.6.2 DETERMINING OPTIMAL R, S, F PARAMETERS

The optimal values of the R, S, F parameters will vary depending on the load, the desired stepping rate and the mechanical properties of the positioning stage. By optimal, we mean achieving the desired stepping rate with the quickest acceleration without stalling the stepping motor.

The determination of the parameters is best done by trial and error when your system is set up. The trial and error method involves varying one parameter while keeping the other two constant.

The equation for steps per second is:

$$\text{steps/sec} = 10^6 / (256 - r) \cdot 80 + 10 \cdot z + 75 \pm 7.5$$

The variable z is equal to $255 - n \cdot s$ and changes in value for each step while ramping. The variable n is the step number from start of low speed motion beginning with n = 1. This implies that the starting low speed is given by:

$$\text{steps/sec (low speed)} = 10^6 / (256 - r) \cdot 80 + (255 - s) \cdot 10 + 75 \pm 7.5$$

The CC-1 will start the stepping at the low speed rate and accelerate towards the high speed rate. For each step taken while ramping, the variable z will decrease. The CC-1 will stop accelerating when z is less than or equal to f. This then is the slew rate. Using the fact that $z = 255 - n \cdot s$ (n = 1) in low speed and z = f in high speed, we can determine the number of steps needed to accelerate. This is handy because it tells you how much travel distance is needed to ramp up to high speed.

$$z = 255 - n \cdot s = f$$

Solving for n, we get $n = \frac{255 - f}{s}$:n = number of steps in ramp

Using the fact that z = f in high speed we deduce the slew rate equation:

$$\text{steps/sec (slew rate)} = 10^6 / (256 - r) \cdot 80 + 10 \cdot f + 75 \pm 7.5$$

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

Studying the equations and considering the properties of a positioning stage with its load the following are apparent:

1. The highest low speed is attained with the largest r and s parameters, regardless of the f parameter.
2. The highest slew rate is attained with the largest r parameter and the smallest f parameter.
3. The quickest acceleration is attained with a large f and a large s. However, a large f will reduce the slew rate. This would imply that we should keep f small and make s larger to compensate. However, we do not get good resolution when we change the value of the s parameter. A numerical example should make this point clear.

For example, let's assign f = 15, and s = 2 in one instance and s = 3 in another instance. From the equation:

$$n = \frac{255-f}{s}$$ we get:

$$\text{for } s=2;\ n = \frac{255-15}{2} = \frac{240}{2} = 120$$

$$\text{for } s=3;\ n = \frac{255-15}{2} = \frac{240}{3} = 80$$

We see that for a small change in s (the smallest possible) we get a drastic difference in the number of steps needed to accelerate. Here you may find that 120 steps is too long an acceleration and 80 steps is too short (it stalls the stepping motor).

To get better resolution so that the number of steps to accelerate is somewhere between 80 and 120 steps we can do one of two things:

1. with s=2, increase f, or
2. with s=3 decrease f

If we choose alternative 1 and increase f, the number of steps to accelerate will go down from 120 but the slew rate will also decrease.

If we choose instead to decrease f, the number of steps to accelerate will go up from 80 but the slew rate will increase. However, even though the number of steps to accelerate has increased, it may still be too quick because the slew rate has also increased.

Point 3 outlines the compromise that you must deal with. The best way to arrive at a solution is through trial and error. As a convenience, the following BASIC program is presented, which allows you to quickly change the value of parameters, prints the starting speed, final speed and the number of steps to accelerate, then outputs the parameters to the CC-1 and initiates a movement. Depending on the result of the movement, you can change the value of the parameters to meet your needs.

The program is written using the IEEE-488 and BASIC commands of the PET Commodore microcomputer. The device address is assumed to be 6. Refer to section VII for explanation of IEEE-488 programming.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

BASIC PROGRAM FOR OBTAINING OPTIMAL R, S, F PARAMETERS

```
10 OPEN 6,6
20 PRINT "ENTER THE RATE, SLOPE, AND FACTOR PARAMETERS"
30 INPUT "R PARAMETER"; R
40 INPUT "S PARAMETER"; S
50 INPUT "F PARAMETER"; F
60 PRINT "R= ";R, "S= ";S, "F= ";F
70 B=(256-R)*80
80 C=(255-S)*10+75
90 D=(10*F)+75
100 SS=1E6/(B+C)
110 FS=1E6/(B+D)
120 PRINT "STARTING SPEED= ";SS
130 PRINT "FINAL SPEED= ";FS
140 Y=(255-F)/S
150 PRINT "STEPS TO ACCELERATE= ";Y
160 REM CONVERT PARAMETERS INTO STRING VARIABLES AND INITIATE MOVEMENT
170 R$=STR$(R)
180 S$=STR$(S)                    :REM make sure that when your computer concatenates strings
190 F$=STR$(F)                    there is a single space between them
200 PRINT#6,"R"+R$
210 PRINT#6,"S"+S$
220 PRINT#6,"F"+F$
230 PRINT#6,"N 1000"
240 PRINT#6, "G"
250 INPUT "ENTER PARAMETER TO BE CHANGED: R,S, OR F";X$
260 IF X$="R" THEN 30
270 IF X$="S" THEN 40
280 IF X$="F" THEN 50
290 GOTO 60
```

In this section we have fully detailed the use and function of CC-1 commands to perform precision stepping. The next question is — how do we input commands to the CC-1. This is the subject matter of the next 4 sections.

In these sections we describe the use of the four communication protocols implemented by the CC-1. These four protocols are IEEE-488, RS-232-C, 20mA current loop and 8 bit parallel with handshake.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

VII IEEE-488 COMMUNICATION

In this section we describe the operation of the IEEE-488 protocol and its use to program the CC-1.

For connection to the IEEE-488 bus, the CC-1 has the standard 24 pin female ribbon connector. Pin assignments for this connector are listed in Table 7.1 and are based on the standard IEEE-488 protocol. This connector is not duplicated for a two axis system because the IEEE-488 is a bus structured protocol.

Table 7.1 **IEEE-488 Bus Connector**
24-Pin Female Ribbon Connector

E 1	DI01	E 9	IFC	E17	REN
E 2	DI02	E10	SRQ	E18	Gnd. for DAV
E 3	DI03	E11	ATN	E19	Gnd. for NRFD
E 4	DI04	E12	SHIELD	E20	Gnd. for NDAC
E 5	EOI	E13	DI05	E21	Gnd. for IFC
E 6	DAV	E14	DI06	E22	Gnd. for SRQ
E 7	NRFD	E15	DI07	E23	Gnd. for ATN
E 8	NDAC	E16	DI08	E24	LOGIC Gnd.

7.1 IEEE-488 THEORY OF OPERATION

The IEEE-488 protocol is a communication standard for parallel data transfer. It consists of eight data lines, three handshake lines, five interface management lines and several ground lines to reduce the effective resistance of the return line.

The IEEE-488 interface bus permits three types of functions in the devices that are connected to the bus. These device functions are listener, talker and controller. A listener device can receive data from other instruments. A talker device can send data to other instruments. A controller device controls the information traffic on the bus lines.

The IEEE-488 bus permits multiple devices to be connected to it. Each device has its own address and before data transfer can occur between a pair of devices, they both have to be addressed by the controller.

7.1.1 IEEE-488 Signals

The signals on the interface bus are in negative true logic with positive potential. This means that a logic one signal is less than or equal to Ø.8 volts and a logic zero signal is greater than or equal to 2 volts.

The 8 Data Input/Output lines are used for sending data bytes, addresses, programming instruction, status bytes and special bus commands. The logic state of one of the interface management lines, the ATN line, informs the devices on the bus of the nature of the data on the data lines.

The three handshake lines are Data Valid (DAV), Not Ready for Data (NRFD) and Not Data Accepted (NDAC). The controller or talker will poll NRFD and NDAC and assert DAV accordingly. A listener will assert NRFD and NDAC and poll DAV. The handshake sequence to implement the listener function is shown in Fig. 7.1. The dotted lines represent the varying response times of different devices on the bus.

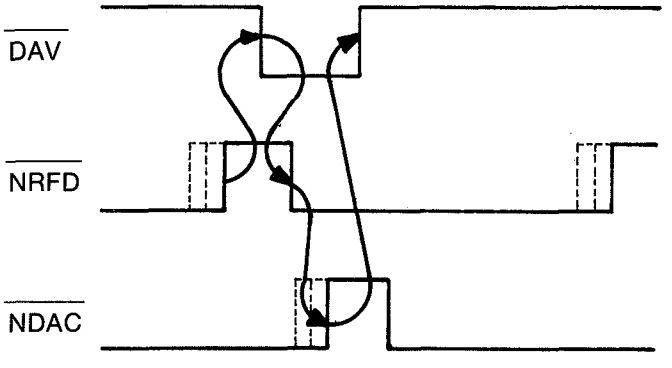


Figure 7.1

IEEE-488 Handshake Sequence

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

We see from the handshake sequence that NRFD goes false, i.e. ready for data only after the slowest device is ready and NDAC goes false, i.e. data accepted only after the slowest device accepts the data.

The five interface management lines are: interface clear (IFC), attention (ATN), service request (SRQ), remote enable (REN), and end or identify (EOI). The IFC can only be asserted by a system controller and is used to set the interface of all instruments to a predefined state. The ATN line is asserted by a controller and indicates whether the data on the bus is a message such as addresses and special control commands or whether it is device-specific data and instructions. The SRQ is asserted by a device needing service from the controller. The REN can only be asserted by a system controller and is used to switch instruments on the bus from local (front panel) control to remote control. The EOI can be asserted by a talker to indicate the end of a multiple byte transfer or can be asserted by a controller when it is executing a parallel poll.

7.2 CC-1 OPERATION ON THE IEEE-488 BUS

The CC-1 is used as a listener on the IEEE-488 bus. To establish communication, the CC-1 must be properly configured through its dip switches:

— set S1-5 up for ASCII coded commands and parameters
— set S1-6 down for parallel data transfer

IMPORTANT

If you have a dual axis CC-1 indexer and plan to use only one axis on the IEEE-488 bus, you must set S1-6 down on both axes. This is because both axes are connected to the bus and thus must respond to system commands. You must also set the address of the unused axis to an unused address so that it will not respond to any device-specific instructions.

— use S2-4 through S2-8 to set the desired device address. The address setting is in binary form. S2-4 is the most significant bit; S2-8 is the least significant bit. The up position of the switch corresponds to a binary one. Table 7.2 shows the switch positions for each possible address.

Table 7.2

IEEE-488 Interface Address

	S2-4	S2-5	S2-6	S2-7	S2-8		S2-4	S2-5	S2-6	S2-7	S2-8
0	D	D	D	D	D	16	U	D	D	D	D
1	D	D	D	D	U	17	U	D	D	D	U
2	D	D	D	U	D	18	U	D	D	U	D
3	D	D	D	U	U	19	U	D	D	U	U
4	D	D	U	D	D	20	U	D	U	D	D
5	D	D	U	D	U	21	U	D	U	D	U
6	D	D	U	U	D	22	U	D	U	U	D
7	D	D	U	U	U	23	U	D	U	U	U
8	D	U	D	D	D	24	U	U	D	D	D
9	D	U	D	D	U	25	U	U	D	D	U
10	D	U	D	U	D	26	U	U	D	U	D
11	D	U	D	U	U	27	U	U	D	U	U
12	D	U	U	D	D	28	U	U	U	D	D
13	D	U	U	D	U	29	U	U	U	D	U
14	D	U	U	U	D	30	U	U	U	U	D
15	D	U	U	U	U						

U = Up D = Down

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

The "Remote Enable" and "Device Clear" commands of the IEEE-488 standard are implemented. The Remote Enable command will disable all front panel controls of the addressed axis. The front panel key switch labeled "Local Lockout"* or "Lockout Disable"* (depending on manufacture date) may be used to enable the front panel controls while Remote Enable is active.

The Device Clear command will:

1. stop a programmed motion in progress
2. stop an origin search if in progress
3. erase an internally stored program
4. cause the CC-1 to exit program execution mode and return to command mode

The Device Clear command will not reset the counter display to zero and will not erase the R, S, F, N, A and ± parameters previously entered. This means that you do not have to re-enter these after a Device Clear command if they will remain the same.

*The CC-1 does not implement the Local Lockout bus command of the IEEE-488 standard. It only responds to the Remote Enable signal when addressed. The key switch allows you to override the CC-1's response to this signal. The key switch is labeled Local Lockout or Lockout Disable (depending on manufacture date) solely to facilitate understanding of its function. Its function is to either allow or disallow a controller to disable (lockout) the front panel (local) controls.

7.2.1 CC-1 / IEEE-488 HANDSHAKE PROCEDURE

When the CC-1 is idle or performing a motion, its NRFD and NDAC lines are in the proper state to receive a command data byte from the controller. This data byte will most frequently be an address. The CC-1 will read the address and compare it with its own. Its response will depend on the outcome of the comparison.

If the two addresses are different, the CC-1 will complete the handshake and will not "hang-up" the bus, regardless of its status state. This is a very important feature because the interface is free to address other units while the CC-1 is executing a command or a sequence of stored commands.

However, if the two addresses are the same, the response will depend on the status state of the CC-1:

- — if the CC-1 is in power-up idle, i.e., not executing an "X x↓" command, it will complete the handshake, accept the data byte and execute the command.
- — if the CC-1 is executing an "X x↓" command or executing a motion command, it will place its NDAC and NRFD lines in the true state, thus preventing the new data transfer from occurring. Once the delay or motion is complete, both lines will go to the false state and the data transferred is completed. Essentially, the CC-1 will "hang-up" the bus until the execution of the command is complete.

This same data transfer inhibition can be made to occur when origin search is in progress and when the CC-1 is in the program execution mode.

- — setting S1-4 up will allow the CC-1 to hang-up the bus when it is addressed and an origin search is in progress.
- — inserting the optional diode D29 (1N4148, 1N914 or equivalent) into the main logic board and setting S1-4 up will allow the CC-1 to hang-up the bus when it is addressed and an internally stored command sequence is being executed.

7.3 STEPS FOR CORRECT IEEE-488 PROGRAMMING

In this section we reiterate in an orderly fashion the steps necessary to communicate commands to the CC-1 using the IEEE-488 bus:

1. set S1-5 up for ASCII coded commands.
2. set S1-6 down. (Set S1-6 down on both axes if you have a dual axis CC-1).
3. set S2-4 through S2-8 for device address. See Table 7.2.
4. format the commands properly.
   - — single character commands are sent with no leading or trailing spaces, terminated only by a carriage return — line feeds must be suppressed
   - — multiple character commands are sent with (a) no leading or trailing spaces, (b) a single space between a command and its parameter and (c) terminated only by a carriage return — line feeds must be suppressed

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

7.4 SAMPLE PROGRAMS

In this section we present an XY raster scan program transferred to the CC-1 in command mode over the IEEE-488 bus using three different sample computers. The three computers are the PET Commodore, the HP85 and Digital's Minc-11.

The X direction scan consists of four equal movements of 1000 steps, initially in the positive X direction and then in the negative X direction. There is a delay between successive X direction movements of approximately 1 second. The Y direction scan consists of one 10 step movement when the X direction scan reverses sign. The whole scan consists of 10 scans; 5 in the positive direction and 5 in the negative direction. The X axis is at IEEE-488 address 6 and the Y axis is at address 7. Figure 7.2 shows how the scan is programmed to occur.

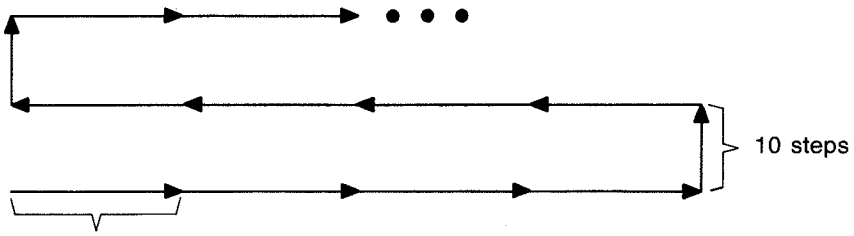


Figure 7.2 X-Y Raster Scan

For an illustration of the program entry and program execution modes of operation, see the programs written for RS-232-C communication in section 8.3.

7.4.1 PET Commodore

```
10 OPEN 6,6: OPEN 7,7
20 DATA "R 253", "S 2", "F 20"
30 FOR I=1 TO 3
40 READ A$
50 PRINT#6, A$                    :output speed parameters
60 PRINT#7, A$
70 NEXT I
80 PRINT#6, "N 1000"              :set number of steps for corresponding movements
90 PRINT#7, "N 10"
100 S$="+"
110 PRINT#7, S$
120 FOR K=1 TO 10                 :perform 10 scans
130 PRINT#6, S$
140 FOR I=1 TO 4                  :one scan=4 equal movements
150 PRINT#6, "G"
160 PRINT#6, "X 555"
170 NEXT I
180 PRINT#6, "B"                  :freeze bus until last movement complete (see page 34)
190 PRINT#7, "G"
200 PRINT#7, "B"                  :freeze bus until 10 step movement complete
210 IF S$="+" THEN GOTO 240
220 S$="+"
230 GOTO 250
240 S$="-"
250 NEXT K
260 END
```


Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

7.4.2 HP 85

```
 10 RESET 7
 20 CLEAR 7
 30 CONTROL 7, 16; 1                  :suppress line feed output in carriage return/line feed terminator
 40 DATA "R 253", "S 2", "F 20"
 50 FOR I=1 TO 3
 60 READ A$
 70 OUTPUT 706 USING "K" ; A$         :output A$ (speed parameters) in compact format
 80 NEXT I
 90 OUTPUT 706 USING "K" ; "N 1000"   :set number of steps for corresponding movements
100 OUTPUT 707 USING "K" ; "N 10"
110 S$="+"
120 OUTPUT 707 USING "K" ; S$
130 FOR K=1 TO 10                     :perform 10 scans
140 OUTPUT 706 USING "K" ; S$
150 FOR I=1 TO 4                      :one scan = 4 equal movements
160 OUTPUT 706 USING "K" ; "G"
170 OUTPUT 706 USING "K" ; "X 555"
180 NEXT I
190 OUTPUT 706 USING "K" ; "B"        :freeze bus until last movement complete*
200 OUTPUT 707 USING "K" ; "G"
210 OUTPUT 707 USING "K" ; "B"        :freeze bus until 10 step movement complete*
220 IF S$="+" THEN GOTO 250
230 S$="+"
240 GOTO 260
250 S$="-"
260 NEXT K
270 END
```

*Note that the B command itself does not freeze the bus. It is merely used as a dummy statement to attempt access to the device that is presently busy.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

7.4.3 DEC MINC-11

```
 10 ALL_INST_CLEAR
 20 IEEE_BUS_CLEAR
 30 C$=CHR$(13)                    :create <CR> for CC-1 commands
 40 DATA "R 253", "S 2", "F 20"
 50 FOR I=1 TO 3
 60 READ A$
 70 SEND(A$&C$,6)                  :output speed parameters
 80 SEND(A$&C$,7)
 90 NEXT I
100 SEND("N 1000"&C$,6)            :set number of steps for corresponding movements
110 SEND("N 10"&C$,7)
120 S$="+"
130 SEND(S$&C$,7)
140 FOR K=1 TO 10                  :perform 10 scans
150 SEND(S$&C$,6)
160 FOR I=1 TO 4                   :one scan = 4 equal movements
170 SEND("G"&C$,6)
180 SEND("X 555"&C$,6)
190 NEXT I
200 SEND("B"&C$,6)                 :freeze bus until last movement complete (see page 34)
210 SEND("G"&C$,7)
220 SEND("B"&C$,7)                 :freeze bus until 10 step movement complete
230 IF S$="+" THEN GOTO 260
240 S$="+"
250 GOTO 270
260 S$="-"
270 NEXT K
280 END
```


Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

VIII RS-232-C COMMUNICATION

In this section we describe the operation of the RS-232-C protocol and its use to program the CC-1. The CC-1 uses the standard 25 pin female "D" connector for coupling to a serial data terminal. Pin assignments for this connector are listed in Table 8.1 and are based on the standard RS-232-C protocol. There is one connector for each axis.

Table 8.1

Serial Input Connector
25-Pin Female "D" Connector

1	"Protective Ground" (chassis ground)	14	N.C.
2	"Transmitted Data"	15	N.C.
3	N.C.	16	N.C.
4	N.C.	17	N.C.
5	"Clear to Send"	18	+12V
6	N.C.	19	N.C.
7	"Signal Gound"	20	N.C.
8	N.C.	21	N.C.
9	Transmitted Data for 20mA current loop anode	22	N.C.
10	Transmitted Data for 20mA current loop cathode	23	N.C.
11	Buffered Clear to Send	24	N.C.
12	N.C.	25	−12V
13	N.C.		

RS-232-C Standard Lines are in quotation marks

8.1 RS-232-C THEORY OF OPERATION

The RS-232-C protocol is a communication standard for asynchronous serial data transfer. Serial data transfer is the transmission of data, one bit after another, requiring one wire for the data and one wire for the ground. The data bits are grouped into a serial word and transferred one word at a time using a handshake for synchronization. The format of a serial word is shown in Figure 8.1.

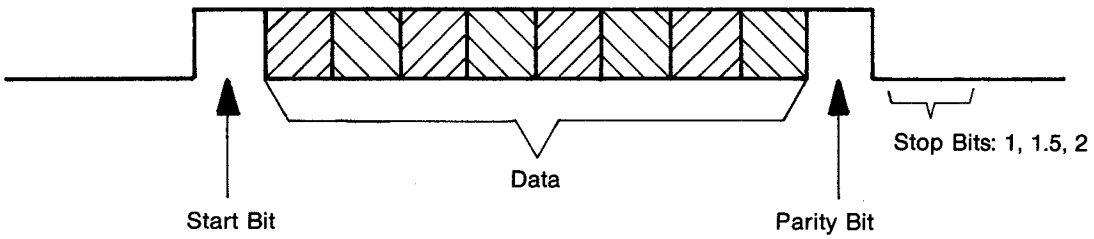


Figure 8.1 Serial Word Format

When data is not being transmitted, the line is held in the low state. When the transmitting device has data to send, it raises the line to the high state for one bit time. This is called the start bit. Following the start bit -- the data, parity bit and stop bits are transmitted.

Start Bit

The start bit is used to signal the receiving device that the transmission of a character is starting. When the start bit is detected, the receiver starts its internal clock to synchronize itself to the input data.

Data Character

The data character consists of the binary bit pattern representing the information. The length of the character must be specified to the receiving device.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

Parity Bit
The parity bit is an optional feature of a serial word used for error detection. The logic level of the parity bit depends on the number of "1" bits in the data character and on whether odd or even parity is used.

Stop Bits
Stop bits are used to keep the line low for a specific amount of time before another start bit can occur. The possible stop bit parameters are 1, 1½ or 2 units of time.

Transfer Rate (Baud Rate)
When two devices are communicating, they must transfer and receive data at the same rate. This requirement is satisfied either through software or through switches.

To synchronize data transmission, the RS-232-C standard provides several signals for handshaking. These signals indicate the state of the transmitter and receiver, i.e., if it is ready to transmit or receive, respectively.

8.2 CC-1 OPERATION ON RS-232-C INTERFACE

For serial data entry, the 25 pin female "D" connector is used. This serial input connector is configured like an RS-232-C ~~Data Terminal Equipment~~ DCE (a location in a network where information can enter).

To establish communication, the CC-1 must be properly configured through its dip switches:

- set S1-5 up for ASCII coded commands and parameters.
- set S1-6 up for serial communication.
- set S1-7 through S1-10 for the desired baud rate. Table 8.2 shows the switch positions for each available baud rate.
- set S2-1 for parity bit checking enable/disable. Set S2-1 up to inhibit checking for the presence of a parity bit; set S2-1 down to enable checking for the presence of a parity bit. However, no checking of parity is performed.
- set S2-2 for the number of stop bits at the end of the serial word. Set S2-2 up for 2 stop bits; set S2-2 down for 1 stop bit. For the CC-1, one stop bit will suffice.
- set S2-3 for the length of the serial word. Set S2-3 up for a length of 8 bits; set S2-3 down for 7 bits.

The CC-1 implements four of the standard RS-232-C control signals. These are 1) chassis ground, 2) signal ground, 3) transmitted data and 4) clear to send.

The CC-1 outputs the Clear to Send signal to the data terminal to synchronize the data transfer. A true Clear to Send signal indicates that the CC-1 is able to accept a new command. A false Clear to Send signal indicates that the CC-1 is busy and thus cannot accept new data. +12 Volts indicates a true Clear to Send and –12 Volts indicates a false Clear to Send.

The CC-1 will output a true Clear to Send when:

1. it is first turned on
2. it finishes accepting a command
3. it finishes executing a command

The Clear to Send will of course be false during command acceptance and execution.

If S1-4 is up, it will output a true Clear to Send after origin search is complete or is idle. The Clear to Send will, of course, be false while origin search is in progress.

If S1-4 is up and the optional diode D29 (1N4148, 1N914 or equivalent) is installed in the main logic board, the CC-1 will output a true Clear to Send after it finishes executing a stored program. The Clear to Send will, of course, be false during program execution.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

Having configured the CC-1 for serial communication, only one task remains. You must properly format the CC-1 commands:

— single character commands are sent with no leading or trailing spaces, terminated only by a carriage return — line feeds must be suppressed.

— multiple character commands are sent with (a) no leading or trailing spaces, (b) a single space between a command and its parameter, and (c) terminated only by a carriage return — line feeds must be suppressed.

Table 8.2

Serial Baud Rate Selection

Rate	S1-7	S1-8	S1-9	S1-10
50	U	U	U	U
75	U	U	U	D
110	U	U	D	U
134.5	U	U	D	D
150	U	D	U	U
300	U	D	U	D
600	U	D	D	U
1200	U	D	D	D
1800	D	U	U	U
2000	D	U	U	D
2400	D	U	D	U
3600	D	U	D	D
4800	D	D	U	U
7200	D	D	U	D
9600	D	D	D	U
19200	D	D	D	D

U = Up D = Down

8.3 SAMPLE PROGRAMS

In this section we present two simple illustrative programs using the RS-232-C interface of the HP85 to program the CC-1 Controller. The first program is written in CC-1 command mode, wherein commands are executed as they are received. The second program is written in CC-1 program entry and program execution mode, wherein commands are stored in an internal buffer for later execution.

The two programs perform the same movements and delays. They initially perform an origin search, if S1-3 is up. Next they make three movements of 1000 steps in the positive direction and then two movements in the negative direction. There is approximately a 1 second delay between each movement.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

Program 1:

```
 10 RESET 10                                  :10 is the serial interface number
 20 CONTROL 10,16 ; 1                         :suppress line feed output in carriage return/
                                                line feed terminator
 30 CONTROL 10,3 ; 15,7,16                    :baud rate=9600, 8 bits/character, no parity,
                                                enable transmit handshake
 40 DATA "C","B","R 253","S 2","F 25","N 1000","+"
 50 DATA "X 550","G","X 550","G",
    "X 550","G", "X 550","-","G"
 60 DATA "X 550","G","END"
 70 READ A$
 80 IF A$="END" THEN 110
 90 OUTPUT 10 USING "K" ; A$                  :output A$ in compact format
100 GOTO 70
110 DISP "COMMAND MODE PROGRAM EXECUTION COMPLETE"
```

Program 2:

```
 10 RESET 10
 20 CONTROL 10,16 ; 1
 30 CONTROL 10,3 ; 15,7,16
 40 DATA "C","B","R 253","S 2","F 25","N 1000","+"
 50 DATA "E","X 550","G","X 550",
    "G","X 550","G","X 550","-","G"           :E command enables program entry mode
 60 DATA "X 550","G","0","Q","D","END"        :0 command causes exit from program execution mode
                                                when encountered
                                              :Q command exits program entry mode
                                              :D command starts execution of stored program
 70 READ A$
 80 IF A$="END" THEN 110
 90 OUTPUT 10 USING "K" ; A$
100 GOTO 70
110 DISP "PROGRAM ENTERED --- EXECUTION NOW IN PROGRESS"
```


Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

IX 20 MILLIAMPERE CURRENT LOOP COMMUNICATION

In this section we describe the operation of the 20 milliampere current loop interface and its use to program the CC-1. The 20mA current loop interface of the CC-1 is accessed through the 25 pin female "D" connector at pins 9, 10 and 11. Pin assignments for this connector are listed in Table 8.1 in section VIII.

9.1 20 MILLIAMPERE CURRENT LOOP THEORY OF OPERATION

The 20mA current loop interface is a current controlled asynchronous serial data transfer methodology. This is in contrast to the RS-232-C protocol which is voltage controlled. The current control relies on currents of 20mA to encode a logic 1, and zero current to encode a logic 0. The basic idea of the electrical connection is shown in Figure 9.1.

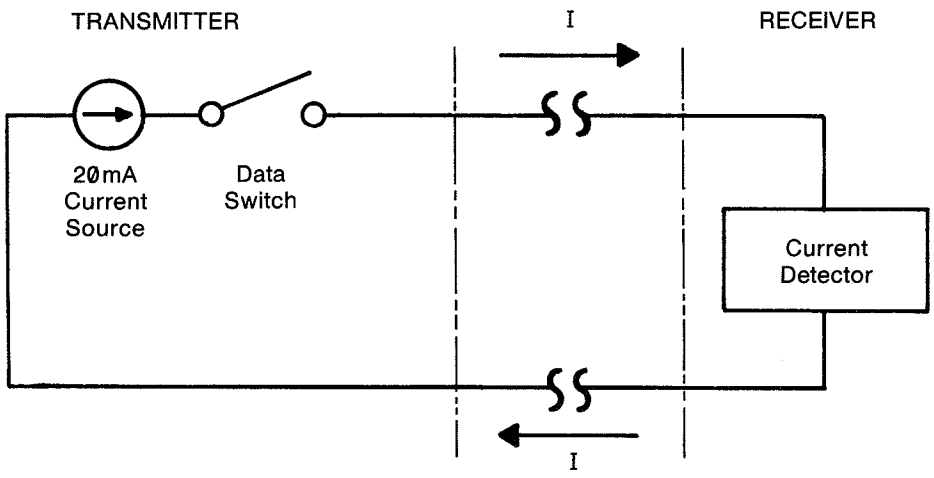


Figure 9.1 20mA Current Loop Electrical Connection

The transmitter simply opens and closes the data switch, which pulses current through the loop and which is sensed by the receiver.

The advantages of using the 20mA current loop interface are:

1. it is double ended which provides good common mode noise rejection. Double ended connections keep the voltage drops the same even though the voltage may change at the two terminals of the device.
2. it can be used for long distances, much longer than RS-232-C, because isolation can eliminate problems caused by ground loops. The isolation is accomplished through optical coupling.

The 20mA current loop interface uses the same serial word format as the RS-232-C protocol. The serial word consists of a start bit, data bits, parity bit (optional) and stop bit(s). Refer to section 8.2 for an explanation of these terms.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

9.2 CC-1 OPERATION USING THE 20mA CURRENT LOOP INTERFACE

The receiver section of the CC-1 is an opto-isolator consisting of a light emitting diode and a phototransistor. The schematic is shown in Figure 9.2.

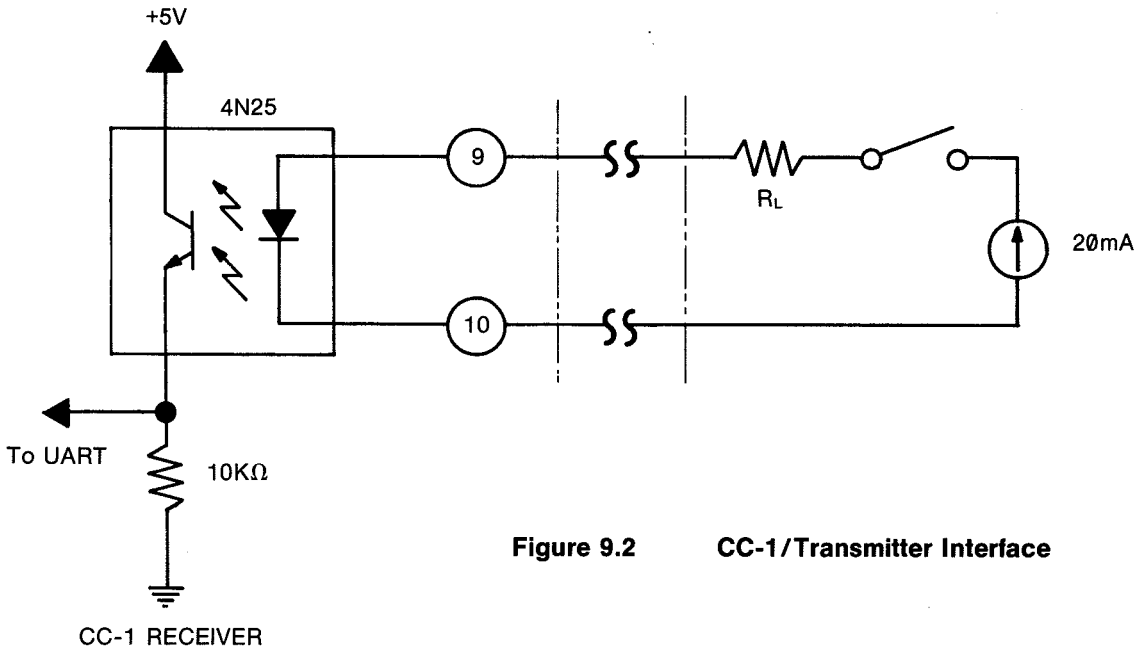


Figure 9.2 CC-1/Transmitter Interface

The transmitter must have a load impedance R_L to drop the source voltage, for otherwise all of the source voltage would appear across the LED in the opto-isolator. Some implementations of a current source are nothing more than a voltage source and a series resistor that limits the current to about 20mA.

To synchronize data transfer with the CC-1, you must poll its Clear to Send line at pin 11 to determine if it is ready or not to receive new data. The schematic of the Clear to Send transmitter is shown in Figure 9.3.

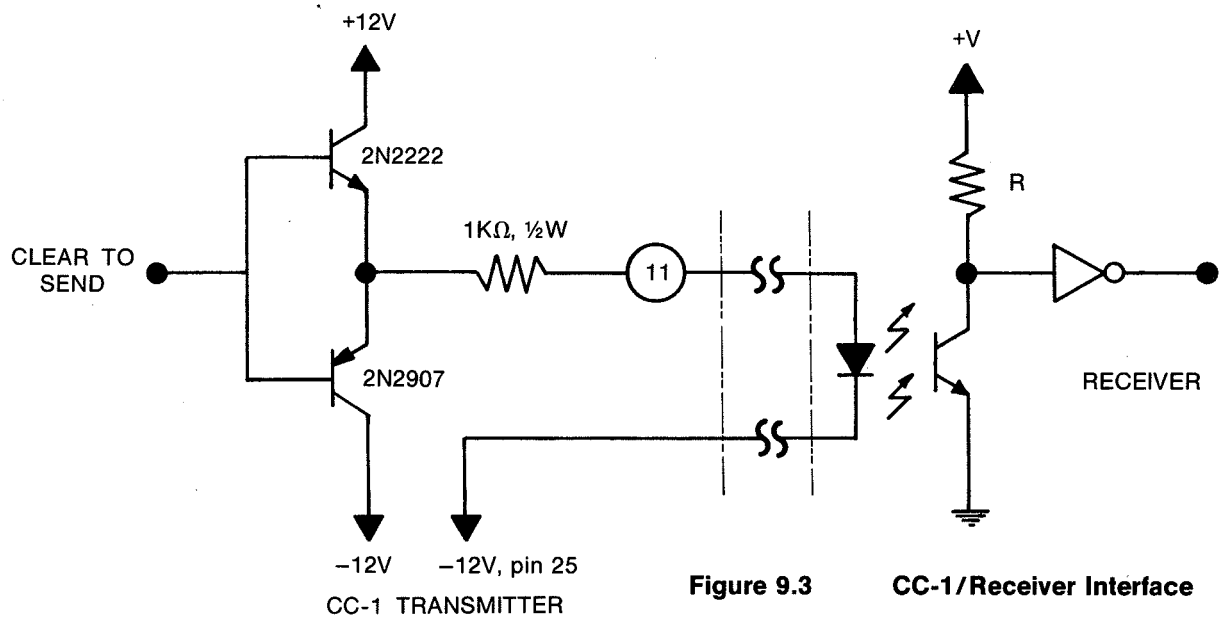


Figure 9.3 CC-1/Receiver Interface

Refer to section 8.2 for details of when the CC-1 outputs a true Clear to Send and when it outputs a false Clear to Send.

Having set up the circuitry, you must now configure the CC-1 for the serial word format and the data transfer rate. The procedure is exactly the same as for RS-232-C so please refer to section 8.2 for this task.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

X 8-BIT PARALLEL COMMUNICATION

In this section we describe the operation and use of the 8-bit parallel data transfer method. This interface is accessed through the 37-pin female "D" connector (the general purpose I/O connector). The pin assignments for this connector are listed in section XI, Table 11.1. The relevant pin numbers are 22 through 29 for the data, pin 20 for the write input handshake and pin 21 for the busy/ready output handshake.

10.1 8-BIT PARALLEL THEORY OF OPERATION

The 8-bit parallel communication method is very convenient for use with single board microprocessor systems. These provide the necessary data and control lines to implement this interface.

The timing diagram for synchronized data transfer is shown in Figure 10.1.

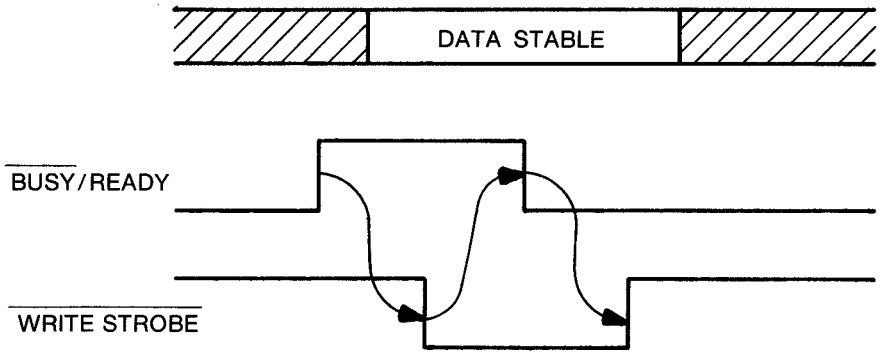


Figure 10.1 Data/Handshake Timing Program

We see from Figure 10.1 that the microprocessor must poll (or be interrupted by) the busy/ready line of the receiver. Once this line goes high to indicate ready, the microprocessor will output the data and lower the write strobe to indicate that data is valid and may be accepted. After accepting the data, the receiver will indicate busy during processing of the received data. Once done, it will assert that it is ready to receive a new data byte by raising the busy/ready line.

10.2 CC-1 OPERATION USING 8-BIT PARALLEL

The 8-bit parallel interface is accessed through the 37-pin general purpose I/O connector. The 8 data lines are in parallel with the 8 data lines of the IEEE-488 interface so disconnect any cable connected to the IEEE-488 connector.

The 8 data input lines are shown in Figure 10.2. These inputs are negative true logic and TTL or open collector compatible. Because of the input inverter, you must invert the actual data before outputting. For example, if you wish to transmit the ASCII command A, whose binary representation is 0100 0001, you would output it as 1011 1110.

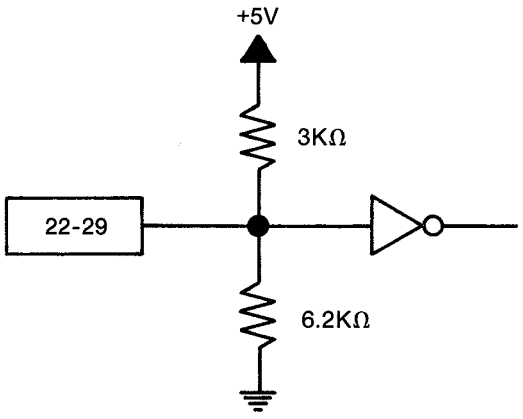


Figure 10.2 CC-1 Data Input Lines

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

The busy/ready output handshake circuit is shown in Figure 10.3. This is an open collector output indicating whether or not the CC-1 can accept new data. Since it is open collector, you must provide a pull up resistor (1KΩ - 10KΩ) to 5 Volts or any other voltage up to 30 Volts.

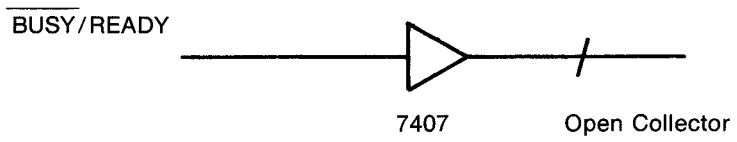


Figure 10.3 Busy/Ready Output Buffer

The CC-1 will indicate ready when:

1. it is first turned on
2. it finishes accepting a command
3. it finishes executing a command

It will indicate busy during command acceptance and execution.

If S1-4 is up, it will indicate ready after origin search is complete or is idle. It will indicate busy while origin search is in progress.

If S1-4 is up and the optional diode D29 (1N4148, 1N914 or equivalent) is inserted in the main logic board, the CC-1 will indicate ready after it finishes executing a stored program. It will indicate busy during program execution.

The write input handshake circuit is shown in Figure 10.4. You pull this line low to indicate to the CC-1 that data is valid, after the CC-1 indicates it is ready to accept.

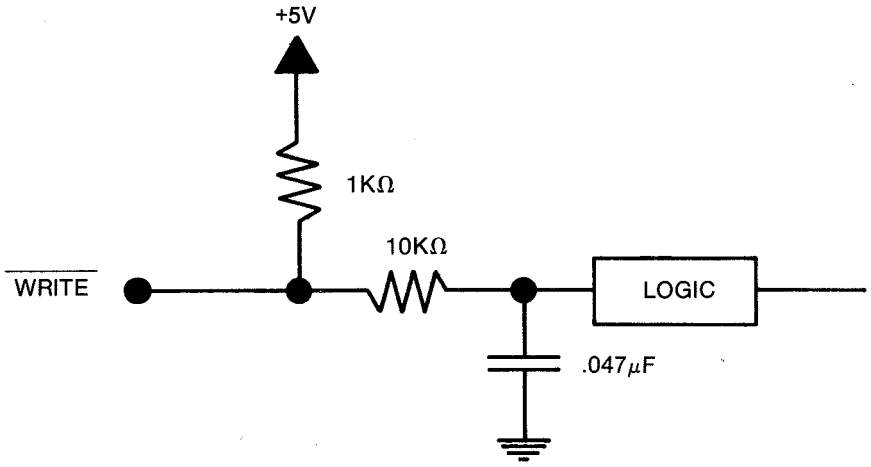


Figure 10.4 Write Input Circuit

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

The flowchart of the proper sequence of events is shown in Figure 10.5. Notice that you must not raise the write input until after the CC-1 goes to the busy state. However, the maximum low time of the write input is 660 microseconds. If you poll the busy/ready line and raise the write input right after busy occurs, you will have no problem.

Now the only task that remains is to configure the CC-1 for parallel communication and the appropriate data format.

— set S1-5 up for ASCII coded commands; set S1-5 down for binary coded commands
— set S1-6 down for parallel data transfer

Refer to section VI for programming ASCII commands and for programming binary coded commands.

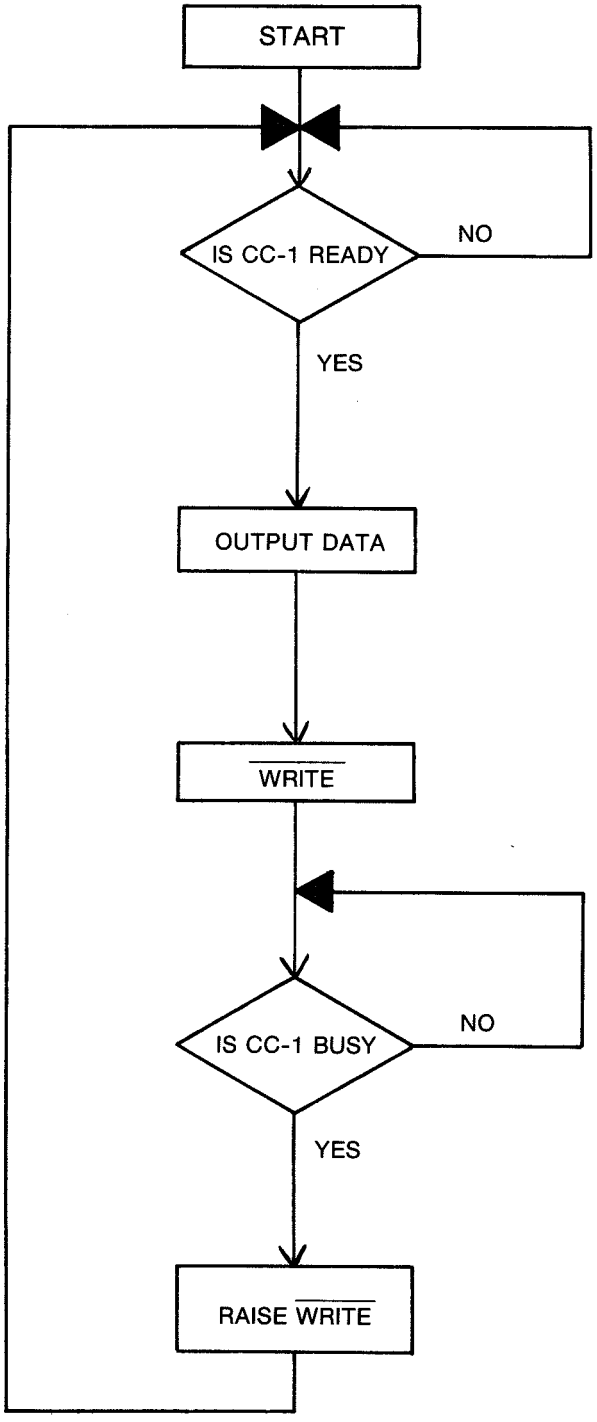


Figure 10.5 8-bit Parallel Flowchart Sequence

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

XI GENERAL PURPOSE I/O CONNECTOR

In this section we will describe the function and use of the inputs and outputs available on the 37-pin female "D" connector. The pin-outs for this connector are listed in Table 11.1.

Table 11.1

General Purpose I/O Connector
37-Pin Female "D" Connector

1	+Direction motion input*†	16	Programmable output line
2	−Direction motion input*†	17	Motion complete output*
3	High speed motion input*†	18	Program execution output*
4	+Direction pulse input	19	Program entry output*
5	−Direction pulse input	20	Write input handshake line*
6	+Direction pulse output	21	Busy/ready output handshake line
7	−Direction pulse output	22-29	8 bit data input (negative true)
8	+Direction end of run output	30	19 pin Jaeger motor connector pin 17
9	−Direction end of run output	31	19 pin Jaeger motor connector pin 18
10	Origin search input*†	32	19 pin Jaeger motor connector pin 19
11	Origin search output*	33	Motor power inhibit input*
12	Remote enable input*	34	+12V
13	Indexer and Origin Search reset*	35	+5V
14	Loop input*	36	Logic ground
15	Wait input	37	Chassis ground

*signifies a low active level
†in parallel with front switches

All inputs are internally pulled up to 5 volts through a 1KΩ resistor, except for the 8 data input lines which conform to the IEEE-488 standard. See Figure 11.1.

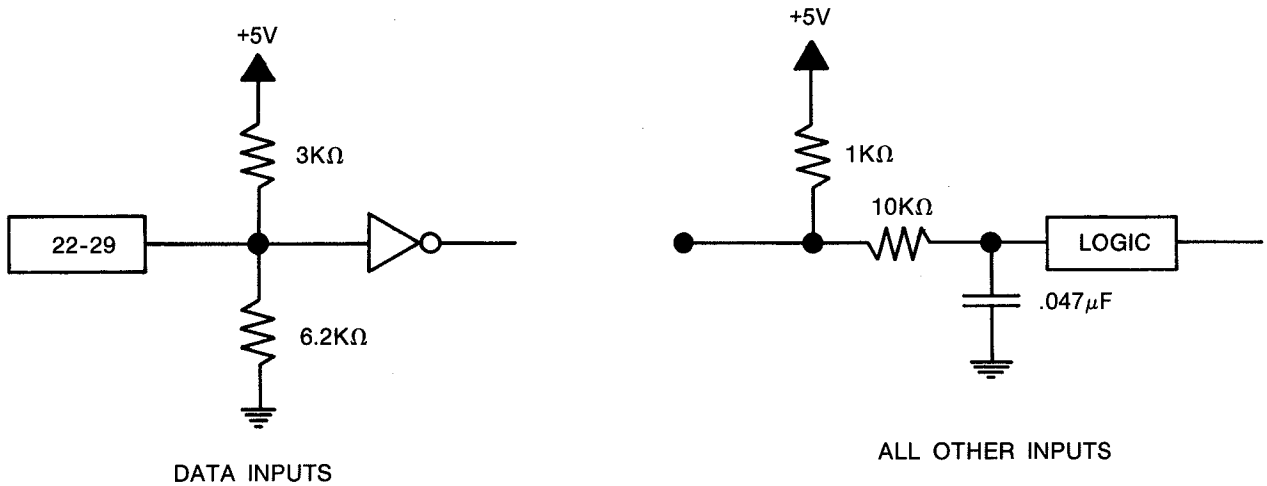


Figure 11.1 37-pin Connector Input Schematics

All outputs are open collector to 30 volts. To use an output, you must provide a pull up resistor from that output pin to a source voltage. The source voltage may be the 5 volts available at pin 35 or any external voltage up to 30 volts.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

1 + Direction motion input
2 – Direction motion input
3 High speed motion input
10 Origin search input
These inputs are directly in parallel with the front panel switches. They allow you to control the operation of the CC-1 from a remote location. To activate the function you simply connect that pin to ground.

4 + Direction pulse input
5 – Direction pulse input
These inputs enable you to bypass the CC-1 oscillator and provide your own pulse train to step the motor. The starting speed should not exceed 400Hz. To step at higher rates, you must provide an accelerating pulse train until the desired rate is reached.

6 + Direction pulse output
7 – Direction pulse output
A low level pulse appears at the appropriate output for each step taken by the stepping motor in the corresponding direction. The actual step occurs on the low to high transition of the pulse.

8 + Direction end of run output
9 – Direction end of run output
These outputs indicate the end of run status. A high output indicates end of run true and a low output indicates end of run false.

11 Origin search output
This output indicates the origin search status. A low output indicates origin search in progress and a high output indicates origin search complete or idle.

12 Remote enable input
This input disables the front panel controls when grounded. However, by turning the front panel keyswitch to OFF (vertical position) you can override the CC-1's response and thus enable the front panel controls.

13 Indexer and Origin Search Reset
This input will reset the origin search circuitry and will erase any program stored in the CC-1 program storage buffer. However, it will not delete the R, S, F, A, N, + or – parameters, if any were entered previously.

14 Loop Input
This input is the basis for the conditional branch performed by the "loop TIL" ("T↓") command. Refer to section 6.3 for a more detailed explanation.

15 Wait Input
This input is used in conjunction with the wait UNTIL ("U↓") and the WAIT ("W↓") commands to determine whether or not program execution should wait or proceed. Refer to section 6.3 for a more detailed explanation.

16 Programmable Output Line
The output level of this pin can be controlled with the "C↓" and "B↓" commands. The output can be used for synchronizing purposes by indicating the beginning or completion of an event. When used in this manner, dip switch S1-3 must be set down to decouple this line from the origin search circuitry.

17 Motion Complete Output
This output indicates the status of a programmed motion. A high level indicates motion in progress or no motion completed (on power up). A low level indicates a move has been completed.

18 Program Execution Output
The level of this output is brought low by a "D↓" command and indicates program execution in progress. The level is brought high by a "0↓" command and indicates program execution complete. The output at this pin can be used in the same manner as the output at pin 16.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

19 Program Entry Output
The level of this output is brought low by a "E↓" command and indicates that a program is being entered. The output level is brought high by a "Q↓" command and indicates the end of program entry. This output can be used in the same manner as the output on pin 16.

20 Write Input Handshake Line
This input is used as a data valid signal for 8-bit parallel communication.

21 Busy/Ready Output Handshake Line
This output is used for 8-bit parallel communication and indicates whether or not the CC-1 can accept new data. A high level indicates ready; a low level indicates busy.

22-29 8-Bit Data Input
These inputs are used for data input for 8-bit parallel communication.

30, 31, 32 19 Pin Jaeger Motor Connector or Auxiliary Bits Input
The function of these pins will depend on whether or not your CC-1 is equipped with Klinger's Talker-2 option board. If no talker is present, the three pins can be used for hook-up of a potentiometer as a position sensing transducer. As the stage moves, it will slide the contact arm across the length of the potentiometer. The output is a voltage proportional to position. A typical set-up is shown in Figure 11.1.

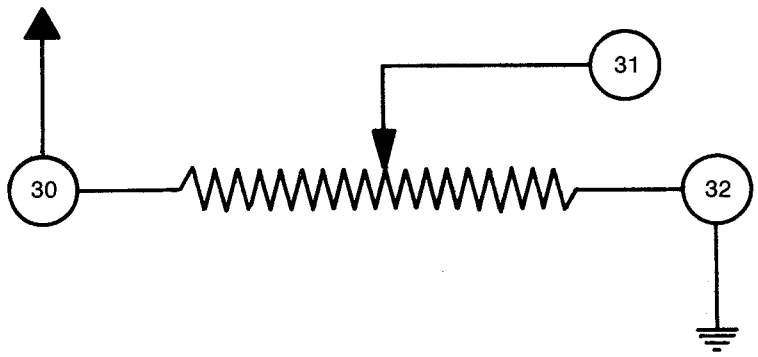


Figure 11.1 Position Sensing Transducer Set-Up

If a talker is present, the three pins serve as auxiliary inputs. These three inputs can be read by issuing a single command to the Talker-2. See section XVI.

33 Motor Power Inhibit Input
This input is used to disable current flow to the motor coils. When the input is active, the motor will lose its holding torque. For a UE72 motor type and equivalent, the only holding torque present will be the one due to its permanent magnet. For a UE3Ø motor type and equivalent, there will be absolutely no holding torque.

Pins 34, 35, 36 and 37 are self explanatory.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

XII STEP COUNTER AND ASSOCIATED OUTPUT CONNECTOR

In this section we discuss:

1. the operation of the step counter, and
2. the functions and use of the outputs and inputs available on the 25-pin male "D" connector.

Pin assignments for this connector are listed in Table 12.1. The information at this connector is associated with the front panel LED step counter display.

Table 12.1

Counter Output Connector
25-Pin Male "D" Connector

1	A (LSB) } Multiplexed BCD Output	14	Output handshake line (flag)
2	B	15	Count inhibit*
3	C	16	Counter reset*
4	D (MSB)	17	Encoded strobe select (+12V active level)
5	Sign output (high for +, low for –)	18	Output level select (tie to +12V for 12V outputs)
6	Units	19	N.C.
7	Tens or encoded (2^0) LSB	20	N.C.
8	Hundreds	21	N.C.
9	Thousands or encoded (2^1)	22	+12V
10	Ten thousands	23	+5V
11	Hundred thousands or encoded (2^2) MSB	24	Logic ground
12	Display and output freezing*	25	Chassis ground
13	Input handshake line (control)*		

*signifies a low active level

All outputs at 5V level (pin 18 open) or 12V level (pin 18 at +12V)
All inputs internally pulled up to 5V through 1KΩ and TTL or open collector compatible.

There are several uses for the display information available at this connector. For one, it can be read by a host computer for verification. It can also be used as an input to a D/A converter to drive a stripchart recorder or for control. The information is presented as multiplexed BCD. The techniques for reading the multiplexed output are given in section 12.2.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

12.1 STEP COUNTER OPERATION

A six digit with sign counter is incorporated on the front panel of the CC-1. The counter display increments or decrements by one for each step of a stepping motor. The counter is driven either from the internal CC-1 logic or by an encoder mounted on the stepping motor shaft. The selection of the step counter source is done through dip switch S2-9.

— set S2-9 down for internal count source
— set S2-9 up for encoder count source

IMPORTANT

Note than a down position of S2-9 will not disable encoder counting. Rather an erroneous count will be displayed. If an encoder is present but internal counting is desired, the connection to the encoder over the 19 pin Jaeger motor connector must be broken. This is most easily done by disconnecting the 5 volts supplied by the CC-1 to the encoder at pin 15 of the Jaeger motor connector.

Lead Zero Blanking

Lead zero blanking and decimal point location may be adjusted by turning the rotary switch mounted on the circuit board behind the front panel face plate. This feature provides visual conversion of the number of steps taken to the magnitude of the distance traversed. For example, given a linear positioning stage with a 1 micron step size, one thousand steps will appear as +001000 on the LED display. However, using the rotary switch we can blank the two leading zeros and place a decimal point at the thousands digit. Now the display will read + 1.000, which is the distance travelled in millimeters.

12.2 DECODING OF THE FRONT PANEL DISPLAY DIGITS

The outputs and inputs at the 25-pin male "D" connector allow you to latch and decode the display digits. Being able to read the display electronically enables you to make movement magnitude and direction decisions under program control. You can also convert the digits to an analog voltage to operate analog voltage driven instruments.

Counter Data Output

The counter data is available in a multiplexed binary coded decimal (BCD) format. Multiplexed means that all the digits share common data lines but only one digit is valid at a given time. Refer to Table 12.1 for the counter output connector pin definition. Pins 1 (LSB) through 4 (MSB) are positive true logic data outputs. Pin 5 is the sign output. Pins 6 through 11 are the strobe outputs. Pin 6 validates the units digit, pin 11 validates the hundred thousands digit. When the strobe output is high, the BCD code for the value of the corresponding digit is present on pins 1 through 4.

Output Level

Outputs are normally at a 5 volt level. 12 volt outputs are obtained by connecting pin 18 to +12 volts (pin 22).

Input Level

Inputs are internally pulled up to 5 volts through a 1KΩ resistor and are TTL or open collector compatible.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

We now present two methods for decoding the multiplexed BCD digits of the display.

METHOD 1:
The first method uses six quad D-type latches, each with a single enable input. The BCD output data at pins 1 through 4 is wired in parallel to all D inputs of the latches. For example, pin 1 is connected to the D1 input of every latch, pin 2 is connected to the D2 input, etc. The strobe outputs are connected to the enable inputs of the corresponding latches. For example, the units strobe is connected to the units digit latch, the tens strobe to the tens digit latch, etc.

The latched data will update as the display changes. If you plan to take a reading while a motion is in progress (taking data on the fly) you must inhibit the display from changing. This is done by grounding pin 12 of the display output connector. However, note that while the display is frozen, the CC-1 will continue to count internally. Once pin 12 is released from ground, the display will be updated.

METHOD 2:
The second method is tailored for direct interfacing to an 8-bit microcomputer. The essential idea here is that the six strobes are encoded into three bits representing the exponent value (power) of the digit currently on pins 1 through 4. The powers range from zero for the units digit to 5 for the hundred thousands digit.

To encode the strobes into powers, connect pin 17 to +12 volts (pin 22). The binary representations of the powers appear at pins 7, 9 and 11. Pin 7 is the LSB, pin 11 is the MSB. Table 12.2 shows the encoded powers for each digit.

Table 12.2

Counter Strobe Validation Code

Digit Validated	Counter Output Connector Pins		
	11	9	7
Units	Ø	Ø	Ø
Tens	Ø	Ø	1
Hundreds	Ø	1	Ø
Thousands	Ø	1	1
Ten Thousands	1	Ø	Ø
Hundred Thousands	1	Ø	1

This table shows encoded strobe output present when pin 17 is connected to pin 22.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

The data byte is comprised of 4 bits for the BCD digit and 3 bits for the power. The eighth bit can be used for the sign. To guarantee correct data transfer a handshake should be used. Pins 13 and 14 are used for this purpose.

Figure 12.1 shows the timing diagram for a data transfer with handshake. The following step numbers correspond to the number labeled transitions on the timing diagram.

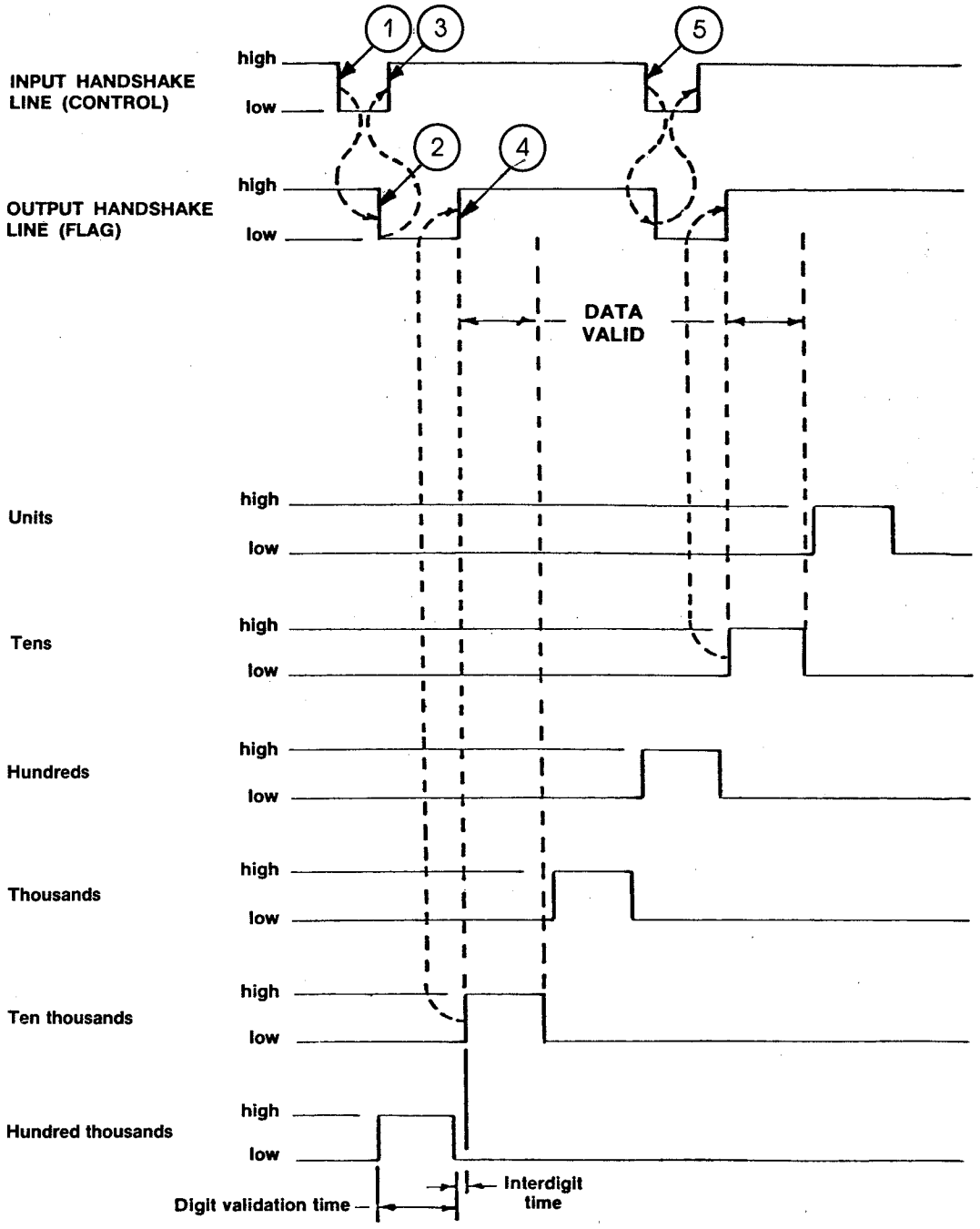


Figure 12.1 Counter Output Timing

1. When the microcomputer is ready to receive a new data byte, it pulls the input handshake line (pin 13) low.
2. In response, the CC-1 will lower the output handshake line (pin 14) immediately.
3. The microcomputer must sense the lowering of the output handshake line, and, in response, raise the input handshake line immediately.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

4. The microcomputer must now poll for, or be interrupted by, a low to high transition on the output handshake line. This indicates that a digit and its power is valid and should be read. The data will be valid only for the duration of the digit validation time, which is approximately Ø.3 milliseconds. The data must be read within this time.
5. Once the microcomputer has read and processed the previous byte, it will again indicate that it is ready by asserting the input handshake line low, and the whole process will repeat.

Note from Figure 12.1 that the strobe which validates the data by raising the output handshake line is determined solely by when the microcomputer asserts ready by lowering the input handshake line. If your microcomputer cannot assert ready within Ø.3 milliseconds after reading a data byte, the data bytes read will be random. In this case, your software will have to determine which digits have been read already and which have not. One way to do this is to compare the present power with the previous powers.

Klinger Scientific offers an optional board that outputs the display information over the IEEE-488 bus interface with a single command. This facilitates step verification for closed loop operation. Refer to section XVI for further details.

Display Freezing and Count Inhibit

As mentioned above, you should always latch (freeze) the display when taking a reading. The display is latched by grounding pin 12. However, internal counting will continue and the display will be updated accordingly when pin 12 is disconnected from ground.

To latch the display and inhibit internal counting, ground pin 15. One use of this feature allows an external event to trigger the counting process. If another event is then used to inhibit the counting, the distance traversed between events can be determined by multiplying the step size by the display value.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

XIII ORIGIN SEARCH

An origin search function is present in the CC-1 which may be used to return the stage to a predetermined origin. There are two types of origin positions that can be defined to the CC-1. One position is the location corresponding to a display count of +000001. The other position is defined by the location of a switch mounted on a positioning stage. The type of origin must be conveyed to the CC-1 through dip switch S1-2.

When no origin switch is included on the stage, the +000001 reading of the counter is used as the origin position. This is a floating origin which can be changed by resetting the counter. The main disadvantage of this approach is that the origin position is lost when power is turned off. To enable "origin by zero counter," set dip switch S1-2 up.

An optional mechanical, electro-optical or electro-magnetic origin switch may be placed on the stage. When origin search is initiated, the CC-1 will move the stage towards, and locate it at the origin switch. In this case, set dip switch S1-2 down. Note that setting S1-2 up will not disable the origin defined by the switch. It only enables "origin by zero counter," causing improper operation and confusion.

13.1 ORIGIN SEARCH IMPLEMENTATION

In describing how the CC-1 implements the origin search function, we mention positive location and negative location, so let's define these first.

For a floating origin the positive location is any location where the display count is positive. Correspondingly, the negative location is any location where the display count is negative.

Using the stepping motor assembly as the reference point, positive location for an origin switch is any location that is on the farther side of the switch. Negative location is any location on the closer side of the switch. See Figure 13.1.

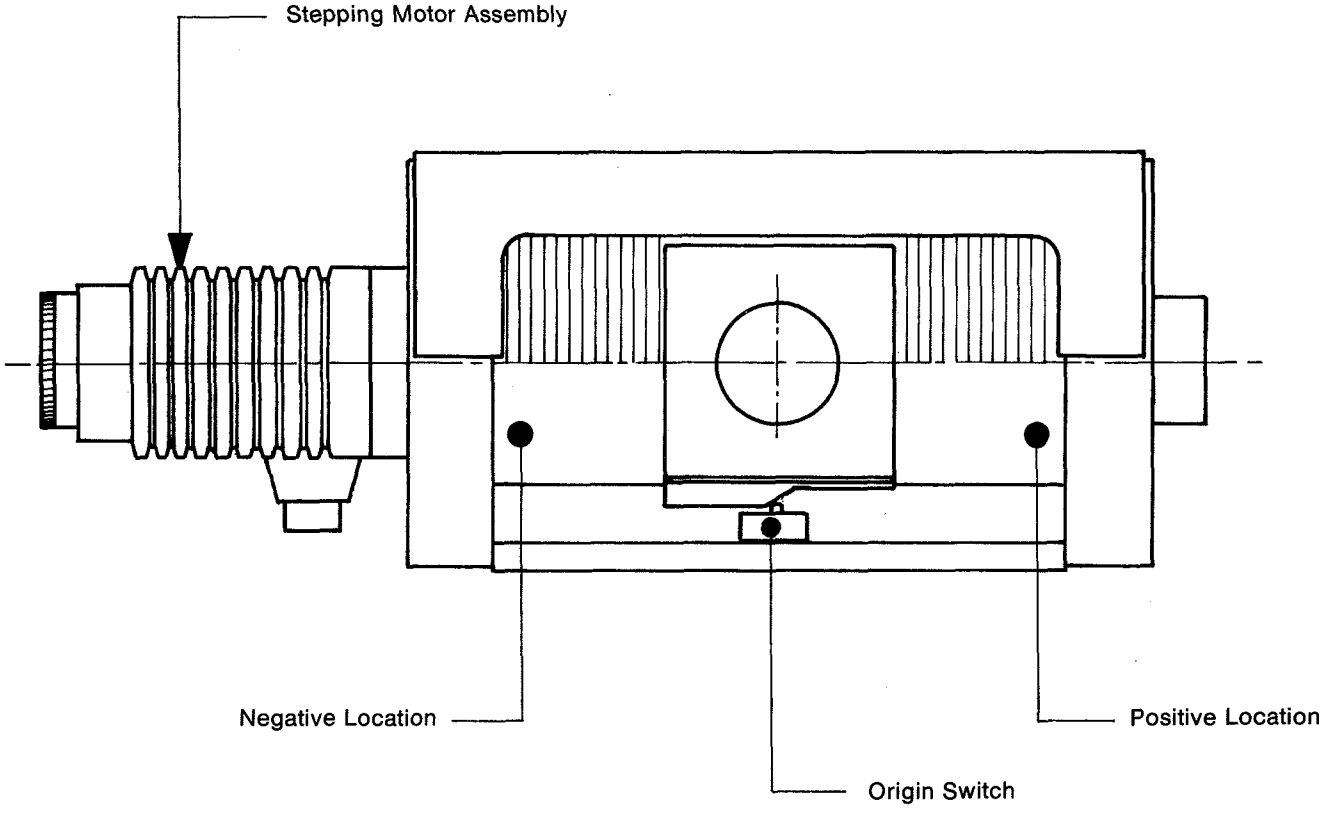


Figure 13.1 Stepping Motor/Stage Reference Points

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

Figures 13.2a and 13.2b show the process of implementing origin search. Figure 13.2a shows the steps for a stage located in a positive location when origin search is initiated. Figure 13.2b shows the steps for a stage located in a negative location when origin search is initiated.

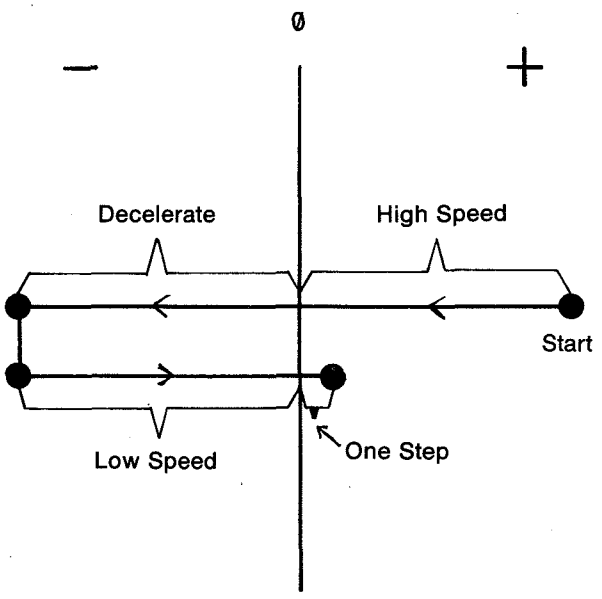


Figure 13.2a

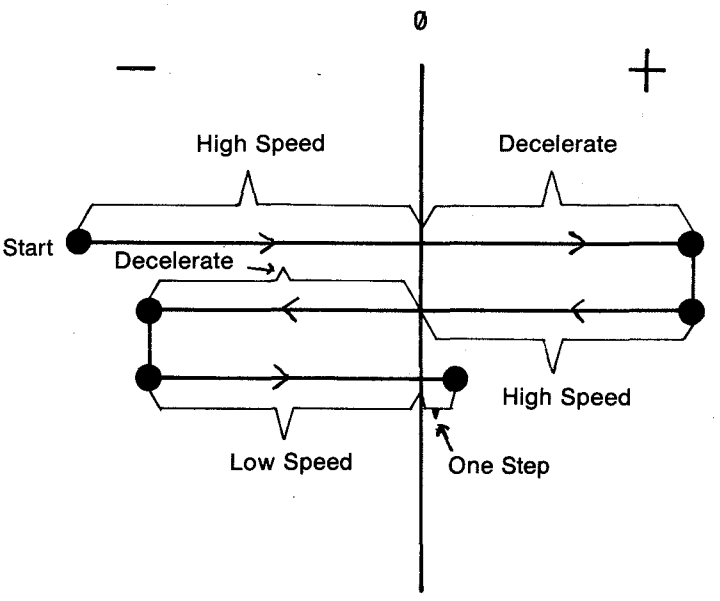


Figure 13.2b

The Ø position is where 1) the display counter changes sign for a floating origin or 2) the origin switch opens and closes. In reality, the switch has hysteresis and thus the opening and closing positions do not coincide. However, for the sake of understanding, this is irrelevant.

Positive Location Starting Point

a) stage approaches Ø in high speed
b) once Ø is reached, stage decelerates to a halt
c) stage approaches Ø in low speed
d) stage halts one step beyond Ø

Negative Location Starting Point

a) stage approaches Ø at high speed
b) once Ø is reached, stage decelerates to a halt
c) same as Positive Location Starting Point

Note that the final approach is always in the same direction at low speed and that the stage stops one step after it crosses Ø. For a floating origin the Ø location is always well defined because we are dealing with electronic switching. However, for a switch, the point at which it closes (+ location, switch is closed, – location, switch is open) is not always the same. As a result, the position defined by an origin switch may vary by a few steps, i.e. the repeatability of the position is bad. To remedy this, a top zero pulse can be used in conjunction with an origin switch to guarantee the accuracy and repeatability of the origin switch position.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

13.2 TOP ZERO PULSE

The top zero pulse is derived from a disk mounted on the stepping motor shaft. This is a negative pulse that occurs once per revolution. Its low level validates the origin position and the stage halts. The occurrence of the low level is made to occur several steps after the switch is sure to have close. See Figure 13.3.

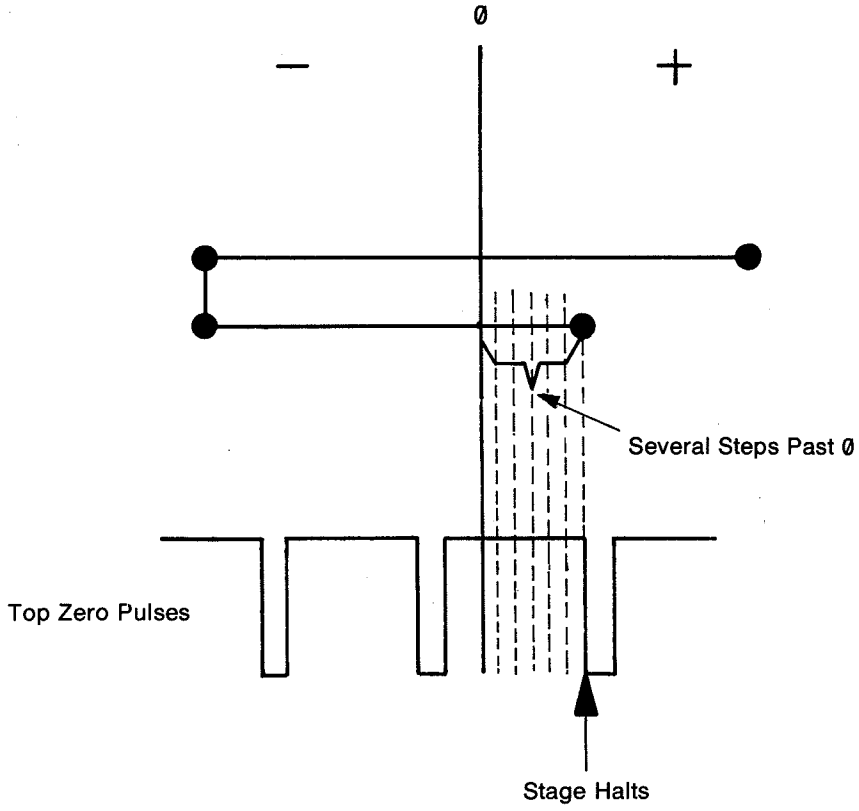


Figure 13.3 Top Zero Pulse Operation Diagram

If a top zero pulse is present, set dip switch S1-1 down. If a top zero pulse is not present, you **must** set S1-1 up. This will ground the top zero input and present a low level to the logic circuitry. The circuitry interprets this as top zero pulse always valid. In this case, the stage will stop the instant the origin switch closes.

13.3 ORIGIN SEARCH ACTIVATION

Origin search can be initiated three different ways:

1. ORIGIN SEARCH switch on the front panel
2. grounding pin 10 on the General Purpose I/O connector
3. pulsing the programmable output line

Steps 1 and 2 need no further explanation but we will expand on step 3. Origin search can be initiated through program control by addressing an output line on the processor. Dip switch S1-3 must be in the up position to tie the output pin to the origin search circuitry. The "C↓" command will bring the output low and will initiate origin search. The line will remain low until the "B↓" command is given or the system is reset. Note that you must set the line high with a "B↓" command before attempting to initiate origin search again with a "C↓" command.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

IMPORTANT

The operation of the origin search circuitry and the command executing processor are independent. As a result, you must be careful when initiating origin search through C, B commands stored in the program buffer, i.e., program execution mode. The problem is that we do not have the benefit of the not ready for data or the not clear to send signals that we do in command mode when origin search is in progress. As a result, if the C, B commands are followed immediately by a motion command (N or P) confusion will result because two pulse sources will be active at the same time.

Below we present a technique that will enable you to delay execution of the commands following the C, B commands until origin search is complete. It involves connecting the origin search status output (pin 11 on the General Purpose I/O connector) to the processor wait input (pin 15 on the G.P. I/O connector) and programming the wait-until command. The sample program below shows the implementation of this technique.

```
"E↓"
"C↓"
"B↓"
"U↓"                    :wait until origin search complete
"N 1000↓"
"G↓"
"0↓"
"Q↓"
"D↓"
↓ = carriage return
```


Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

XIV CC-1 THEORY OF OPERATION

In this section we describe, with the help of block diagrams, how the CC-1 implements its various functions. The CC-1 consists of three boards. These are 1) the main logic board, 2) the power supply and motor driver board, and 3) the front panel display board.

14.1 MAIN BOARD

The main logic board supplies the phase pulses that control the motor driver board. The pulse source will depend on whether the CC-1 is being used in manual mode, in program mode, or an external pulse train is provided by the user. These pulse sources are routed through OR logic and thus decoded by the same circuitry. Refer to PICTORIAL 14.1. The OR logic is designated by OR gate D. The inputs to this gate are:

1. single step pulses from a one shot
2. pulses from an internal oscillator
3. pulses from a programmable stepper motor controller chip, or
4. + or – direction external pulses

The output of this gate:

1. drives an up/down counter which drives a two-to-four decoder which in turn outputs the four phase pulses to the motor driver board
2. triggers a one shot to output a high voltage duration control pulse to the motor driver board (used only for UE30 motor types)
3. provides count pulses to the front panel display board when no encoder is present. In this case, switch S2-9 is open. When an encoder is present, S2-9 is closed thus shorting the internal count pulses.

Note that OR gate D has an inhibit input controlled by the end of run switches. When an end of run is true, the corresponding switch will open and inhibit the gate from outputting any step pulses.

14.1.1 MANUAL MODE

The + direction switch (FORWARD), the – direction switch (REVERSE) and the ORIGIN SEARCH switch are all connected to the output of the open-collector buffer L. The input level to this buffer is determined by the state of the REMOTE ENABLE signal either from the IEEE-488 bus or from the General Purpose I/O connector. During manual operation, the level of the two REMOTE ENABLE signals will be high resulting in a low level output from buffer J. This provides the switches with a path to ground through the saturated output transistor.

Closing a directional switch momentarily will trigger one-shot A to output a single pulse to logic block B. Combined with the direction input, logic block B will output a single pulse to OR gate D. Closing a directional switch continuously will initially trigger one-shot A to output a pulse to logic block B. After approximately 0.3 seconds expire the internal oscillator will provide continuous pulses to logic block B. Combined with the direction input, logic block B will output a continuous stream of pulses to OR gate D.

Closing the HIGH SPEED switch triggers a ramp generator to output a linearly increasing voltage to the oscillator. This ramp voltage linearly increases the frequency of the oscillator from the low speed frequency to the final high speed frequency limit. When the HIGH SPEED switch is opened, the ramp generator outputs a negative going ramp to linearly decrease the oscillator frequency.

Closing the ORIGIN SEARCH switch will trigger several flip flops into operation. The inputs to the flip flops are:

1. the latched origin search command
2. +/– sign from the front panel board or the logic level determined by an origin switch, and
3. a top zero signal

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

Based on these inputs and previous states, the flip flop will:

1. output direction information to logic block A
2. enable logic block B to output oscillator pulses to OR gate D
3. enable and disable the high speed ramp generator, and
4. reset the origin search command latch when origin search is complete

14.1.2 PROGRAM MODE

The heart of the programming section is the Programmable Stepper Motor Controller Chip. This chip decodes the commands and outputs appropriate step pulses and direction information. Logic block C interprets these outputs and provides OR gate D with proper directional pulses. This chip indicates its status to the outside world through its BUSY/READY and PROGRAM EXECUTION outputs. It also has a programmable output pin that may be used to initiate origin search if S1-3 is closed.

The commands for the chip may come from four different sources. These are routed through OR logic to the chip. For serial communication, either RS-232-C or 20mA current loop is used to drive a UART. The UART converts the serial stream into an 8-bit parallel command byte for the controller chip. The UART receives transmission rate information from the baud rate generator controlled by switches S1-7 through S1-10. It is also configured for the serial word format by switches S2-1, S2-2 and S2-3.

For parallel communication, either IEEE-488 or 8-bit parallel is used to transmit commands. When IEEE-488 is used, the IEEE interface chip will output a low active REMOTE ENABLE signal. This will turn off the output transistor of open collector gate L. Now the front panel switches will no longer have a path to ground and as a result will be disabled. However, note that if the LOCAL LOCKOUT switch is closed, a path to ground exists and thus the front panel switches will be enabled.

The REMOTE ENABLE signal of the IEEE-488 can be simulated when RS-232-C, 20mA current loop or 8-bit parallel communication is used by grounding pin 12 of the General Purpose I/O connector.

The CC-1 will indicate its status (BUSY/READY for parallel communication, Clear to Send [CTS] for serial communication) to synchronize data transfer. The status signal comes from one of three possible sources:

1. the BUSY/READY output of the controller chip
2. if S1-4 is closed, the origin search latch, or
3. if S1-4 is closed and D29 installed, the program execution indication output

14.2 FRONT PANEL DISPLAY BOARD

Refer to PICTORIAL 14.2 for the following discussion.

The heart of the front panel display circuitry is a counter chip which outputs a multiplexed BCD representation of the number of steps completed. The count pulse source is either the output of the encoder signal decoder circuitry or the +/– pulses from the main board.

The BCD output of the chip drives a BCD-to-seven segment decoder chip which in turn supplies power to the appropriate segments of all six LEDs. The strobe outputs of the chip drive a corresponding high current buffer, one at a time, to turn on the corresponding digit.

The COUNTER RESET switch is connected to the open collector output of buffer L on the main board and to the reset input of the counter chip. The outputs from, and inputs to the counter chip are available at the 25 pin male "D" connector on the back of the CC-1 indexer.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

14.3 POWER SUPPLY AND MOTOR DRIVER BOARD

The power supply section generates the 64VDC and 9VDC voltages to energize the motor windings and the ±12VDC and 5VDC voltages to operate the logic circuitry.

The motor driver section consists of four phase switching power MOFSET transistors, two voltage switching transistors and one energy dumping transistor.

The operation of the motor driver circuitry will depend on the type of stepping motor being driven.

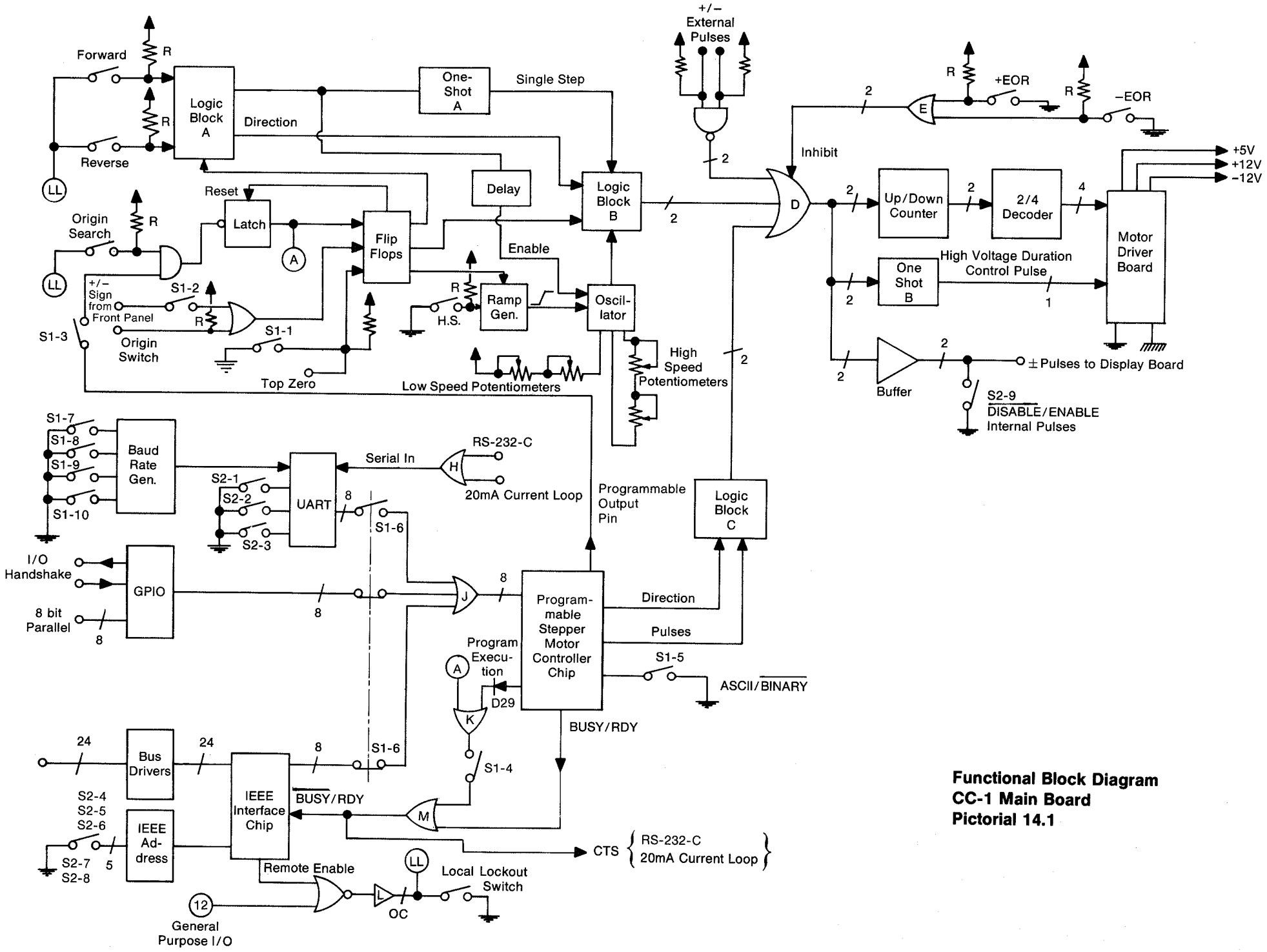
UE30

The phase turn-on control signal will saturate one of the 4 power MOSFET transistors, thus providing a path to ground for one of the motor coils. At the same time a high voltage duration control pulse from the main board will turn on the 64VDC switch. Now 64VDC is applied across the motor coil causing the current to rise quickly. When the control pulse expires, the switch turns off and the 9VDC takes over for the duration of the step.

UE72

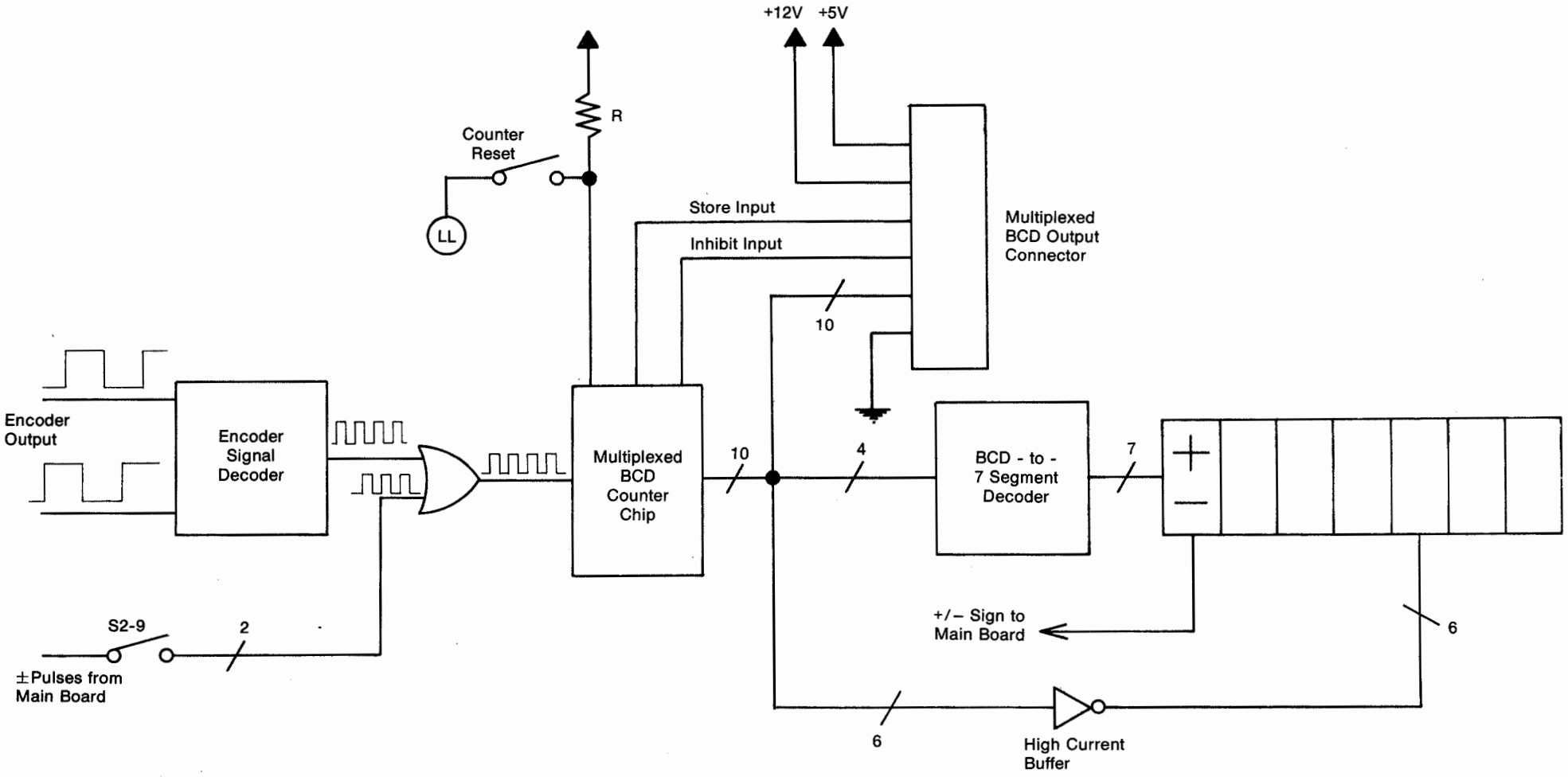
Same as UE30 except that the control of the 64VDC switch is different. The turn-off of the switch is determined by the value of the current through a .12Ω current sensing resistor. At the start of the step the current through the current sensing resistor is zero so the output of the comparator is high, causing the 64VDC switch to turn on. As the current rises through the motor coils and correspondingly through the resistor, the voltage at the negative input of the comparator will rise. When it exceeds the voltage at the positive input, the output of the comparator will go low and turn off the switch. Note that the threshold point of the comparator is adjustable with potentiometer P6.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com



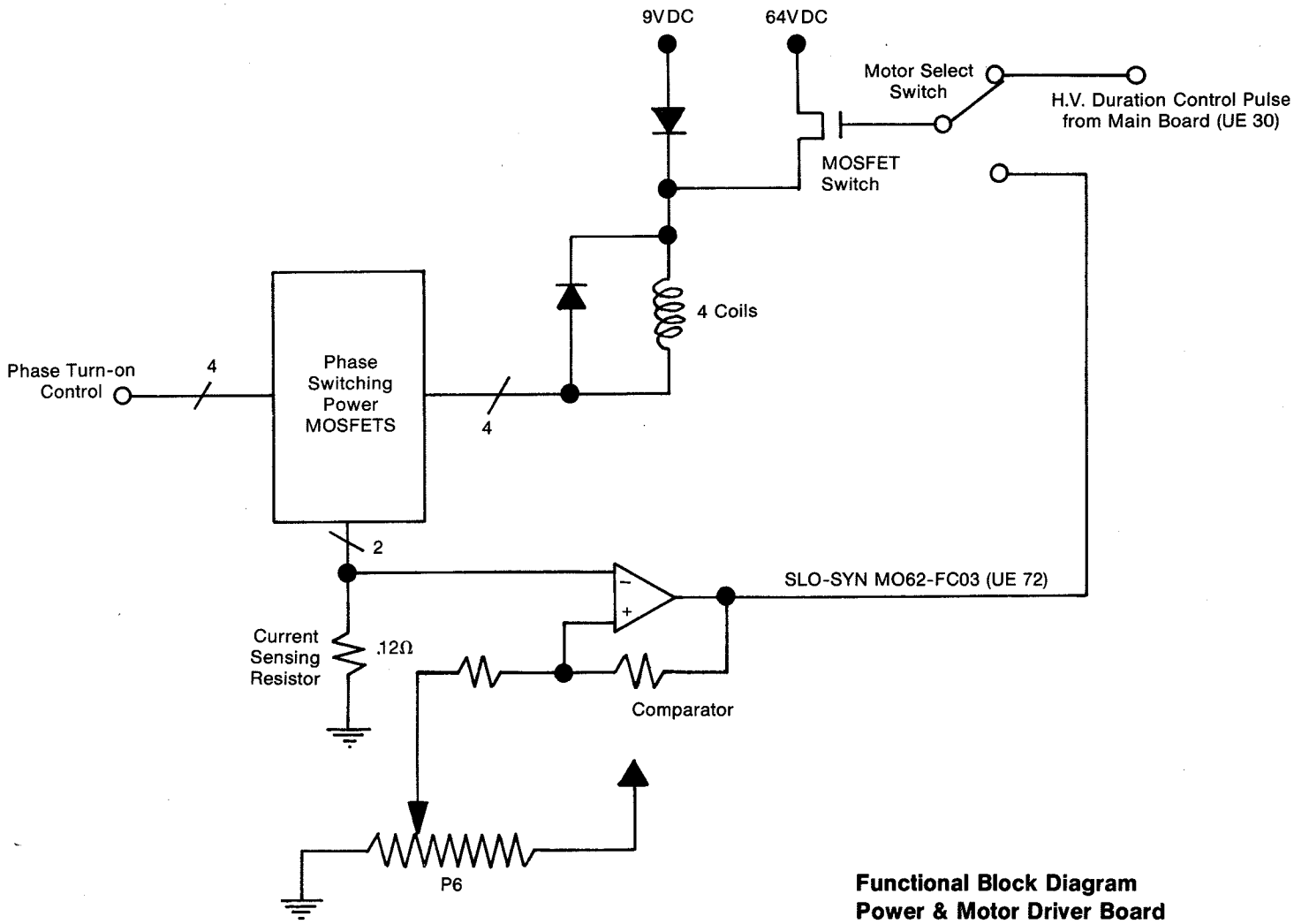
Functional Block Diagram
CC-1 Main Board
Pictorial 14.1

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

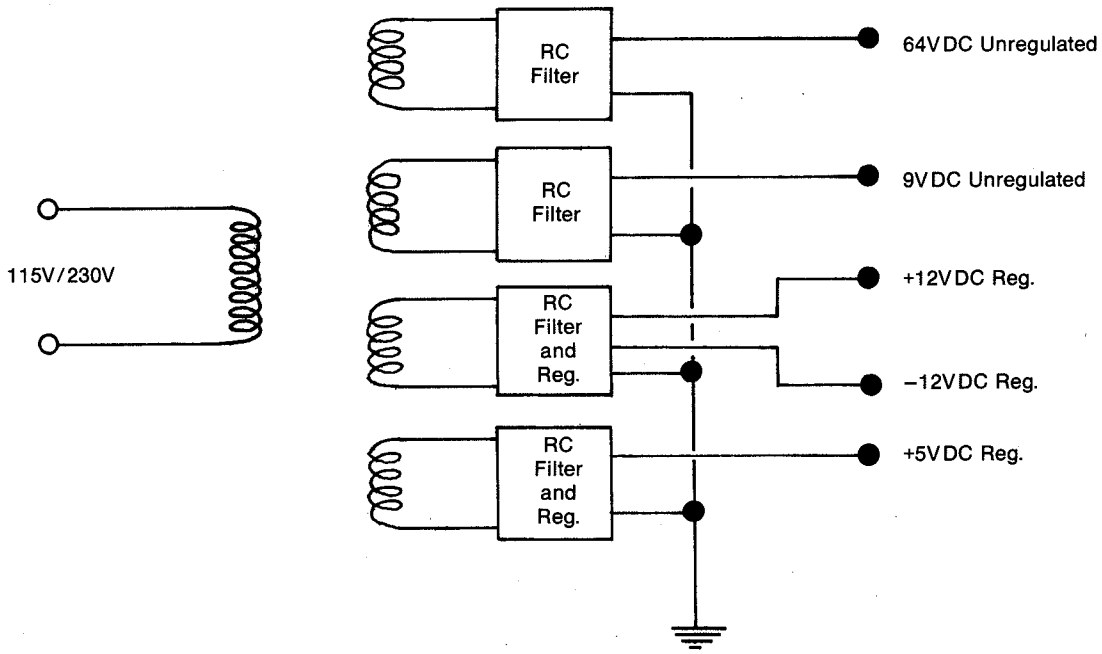


Functional Block Diagram
Front Panel Display Board
Pictorial 14.2

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com



Functional Block Diagram
Power & Motor Driver Board
Pictorial 14.3



Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

XV IN CASE OF DIFFICULTY

In this section we present a troubleshooting guide which will help you solve minor problems that may occur with your CC-1 controller. In manual operation, the problems described occur because of improper setting of dip switches, motor select switch, user-accessible potentiometers and possibly blown fuses. In programming mode, the problems arise because of improper dip switch settings, incorrect instruction formatting, incorrect protocol implementation and possibly bad parameters.

15.1 MANUAL OPERATION TROUBLESHOOTING GUIDE

Problem: CC-1 does not power-up — power switch and display not lit.
Probable Cause: 3A slow-blow power fuse is blown.

Problem: Stage does not move but counter counts when direction switch pressed.
Probable Cause: One or both motor fuses are blown.

Problem: Stage does not move and counter does not count when direction switch pressed.
Probable Cause: One or both motor fuses are blown and count inhibited because S2-9 is high.

Problem: Counter display does not agree with expected value. Single stepping results in increments of two and decrements of one.
Probable Cause: Counter is receiving pulses from an encoder and from motor drive pulses because S2-9 is down. Raise S2-9 up.

Problem: UE30 motor gets very hot after sitting idle or being run a very short time.
Probable Cause:
1. Motor select switch in wrong position. See section IV.
2. Switching transistors have failed. Consult factory.

Problem: UE72 motor continuously blows fuses.
Probable Cause: Switching transistors have failed. Consult factory.

Problem: CC-1 cannot find origin by zero counter. Keeps going in wrong direction.
Probable Cause:
1. S1-1 and/or S1-2 are down. Set them up.
2. Encoder wires (pin numbers 13 and 14 on motor connector) are reversed. Unscrew connector and switch them.

Problem: CC-1 finds origin by zero counter when origin switch is present.
Probable Cause: S1-2 is up. Set S1-2 down.

Problem: Motor/stage stalls during acceleration from low speed to high speed.
Probable Cause:
1. Acceleration ramp too quick. Decrease ramp by rotating potentiometer P4 counter-clockwise several times. Repeat if necessary.
2. High speed too high. Use oscilloscope or frequency counter to set high speed limit to 2K Hz by adjusting potentiometer P2.
3. Friction between stage and housing too high. Consult factory.

Problem: Motor/stage stalls in low speed and/or in high speed.
Probable Cause:
1. Low speed too high.
2. High speed too high.
   Use oscilloscope or frequency counter to set low speed limit to 400Hz by adjusting P1 and set high speed limit to 2K Hz by adjusting P2.
3. Motor torque too low.
   UE30 motor: rotate potentiometer P3 clockwise as many times as necessary.
   UE72 motor: rotate potentiometer P6 clockwise as many times as necessary.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

Problem: Motor does not single step properly. The sequencing is 1, 2, 3, back, etc. Motor seems to "quiver" in low speed.

Probable Cause:
1. Motor torque too low.
   UE30 motor: rotate potentiometer P3 clockwise as many times as necessary.
   UE72 motor: rotate potentiometer P6 clockwise as many times as necessary.
2. One motor phase is not receiving power. Check 19 pin Jaeger connectors on CC-1, stage, and cable for a "pushed-in" pin.

Problem: Display misses steps when driven by encoder.

Probable Cause:
1. Encoder misaligned. Consult factory.
2. Torque too low.
   UE30 motor: rotate potentiometer P3 clockwise as many times as necessary.
   UE72 motor: rotate potentiometer P6 clockwise as many times as necessary.

15.2 PROGRAMMING TROUBLESHOOTING GUIDE

Problem: CC-1 does not respond to any commands.

Check for the following for the different modes of communication.

IEEE-488

1. S1-5 set up for ASCII communication.
2. S1-6 set down for parallel communication.
3. Device address correctly set on S2-4 through S2-8. See Table 7.2.
4. IEEE-488 protocol correct.
5. CC-1 command structure correct.
   a) instruction formats correct, i.e., compact format.
   b) carriage return follows every command, and line feed suppressed.

RS-232-C, 20mA CURRENT LOOP

1. S1-5 set up for ASCII communication.
2. S1-6 set up for serial communication.
3. Baud rate correct — see Table 8.2.
4. Parity bit, stop bits and word length correct.
5. RS-232-C protocol correct.
6. CC-1 command structure correct.
   a) instruction formats correct, i.e. compact format
   b) carriage return follows every command, and line feed suppressed.

PARALLEL

1. S1-5 set up for ASCII communication.
   S1-5 set down for binary communication.
2. S1-6 down.
3. Data levels correct. Data must be negative true. For example, if a carriage return is to be sent, the bits must be the inverted version of the ASCII representation (i.e., CR=0000 1101 must be sent as 1111 0010).
4. Write input handshake line and busy output handshake line correct.
5. CC-1 command structure correct.
   a) instruction formats correct, i.e. compact format.
   b) carriage return follows every command.

Problem: Motor/stage stalls when movement initiated.

Probable Cause: Speed and/or acceleration limit exceeded. Reduce S parameter value to decrease acceleration ramp. Reduce R parameter value and increase F parameter value to decrease the high speed.

Problem: Display shows double the number of steps programmed in the N or P commands.

Probable Cause: Counter is receiving pulses from an encoder and from motor drive pulses because S2-9 is down. Place S2-9 up.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

XVI TK-2 LISTENER/TALKER INTERFACE

16.1 INTRODUCTION

The TK-2 Series Listener/Talker Interface is an add on board that fits in the CC-1 cabinet and is connected to the same IEEE-488 connector as the main listener interface (which is standard equipment). The addition of a TK-2 board permits the host computer to obtain the following information from the CC-1.

- Position Display Information
- End of Run Status
- Origin Search Status
- Internal Program Execution Status
- Indexed Motion in Progress Status
- 3 Bit Auxiliary Input Status

Service requests can also be generated by the TK-2 which is programmed to respond to a Serial Poll. The following sets of conditions may be programmed to generate a service request.

- End of Run Condition or Origin Search Complete
- End of Run Condition or Internal Program Complete
- End of Run Condition or Indexed Motion Complete
- Auxiliary Bit Input rising edge (LSB only)

The TK-2 can also be used to reset the position display to zero.

16.2 IEEE-488 ADDRESS SELECTION

The listen/talk address for each axis of the TK-2 interface is set on a five dip switch, switch bank on the board. These switches are used to set the listen address for the ten TK-2 interface commands and the talk address when data is requested.

IMPORTANT

Note that the listen address for the standard CC-1 listener and the TK-2 interface is set by two different banks of IEEE-488 address switches. The listen address for the CC-1 commands described in section 6.1 is set by dip switch bank S2 accessible from the back of the CC-1 controller and the listen address for the TK-2 commands described in section 16.3.1 is set by the dip switch bank on the TK-2 interface board.

The TK-2 interface board sits on top of the CC-1 main logic board(s). As a result, the top of the board can be seen through the perforated top of the enclosure. Figure 16.1 shows the parts layout of the TK-2 board.

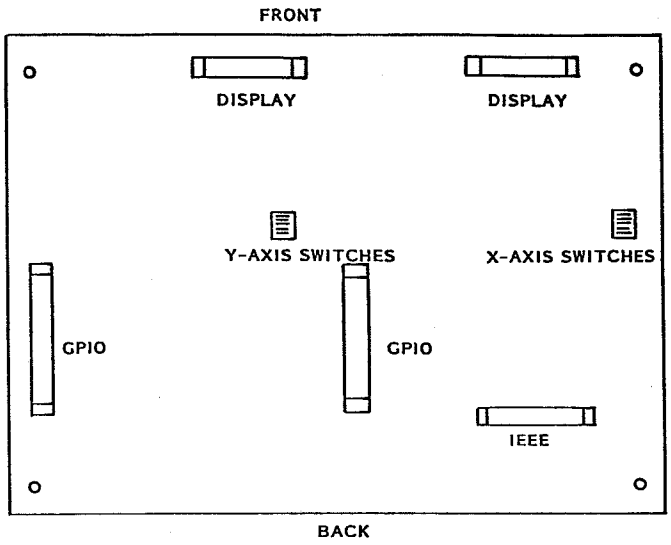
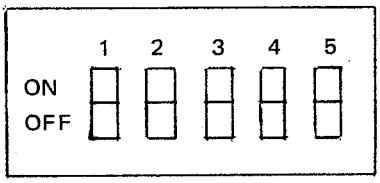


Figure 16.1 TK-2 Interface Board Layout

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

For single axis units only the X axis position is used. After locating the address switches, a needle like object can be used to set the address without removing the cover. Figure 16.2 shows the rocker-type switch bank. The ON and OFF positions are true when the switch is down in the designated area. The ON position is a binary 1 and the OFF position is a binary 0. Table 16.1 shows the switch settings for all available IEEE-488 addresses.



1: Most significant bit
5: Least significant bit

Figure 16.2 TK-2 Address Switch Bank

If removal of the top is preferable, loosen (do not remove) the nine screws along the side and rear panels. The top may then be removed.

To replace the top make sure the retaining strips provide the necessary clearance by pushing the screws toward the panels.

Table 16.1

IEEE-488 TK-2 INTERFACE ADDRESSES

Address	S1	S2	S3	S4	S5	Address	S1	S2	S3	S4	S5
0	Off	Off	Off	Off	Off	16	On	Off	Off	Off	Off
1	Off	Off	Off	Off	On	17	On	Off	Off	Off	On
2	Off	Off	Off	On	Off	18	On	Off	Off	On	Off
3	Off	Off	Off	On	On	19	On	Off	Off	On	On
4	Off	Off	On	Off	Off	20	On	Off	On	Off	Off
5	Off	Off	On	Off	On	21	On	Off	On	Off	On
6	Off	Off	On	On	Off	22	On	Off	On	On	Off
7	Off	Off	On	On	On	23	On	Off	On	On	On
8	Off	On	Off	Off	Off	24	On	On	Off	Off	Off
9	Off	On	Off	Off	On	25	On	On	Off	Off	On
10	Off	On	Off	On	Off	26	On	On	Off	On	Off
11	Off	On	Off	On	On	27	On	On	Off	On	On
12	Off	On	On	Off	Off	28	On	On	On	Off	Off
13	Off	On	On	Off	On	29	On	On	On	Off	On
14	Off	On	On	On	Off	30	On	On	On	On	Off
15	Off	On	On	On	On						

NOTE:

The listen/talk address of the TK-2 interface board is preset at the factory.

X AXIS - IEEE-488 address 6

Y AXIS - IEEE-488 address 7 (if dual axis system)

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

16.3 PROGRAMMING

The operating mode of the TK-2 interface board is set by addressing it as a listener and issuing a command consisting of an ASCII string of the following form:

"V n↓" Where:

"V" is the ASCII "V"

" " is the ASCII space

"n" is an ASCII number from 0 through 9

and "↓" is an ASCII carriage return

Note that the TK-2 command structure includes no leading or trailing spaces. To insure proper communication, you must make sure that your computer outputs the command in this compact format.

The letter V was chosen for the command structure because it does not interfere with the operation of the CC-1 indexing circuitry. This feature permits the use of the same address for the TK-2 interface as for the main CC-1 listener interface.

Once the operating mode of the TK-2 is set, you then use the IEEE-488 input (talk) command of your computer to obtain the desired data. The data is ASCII coded and as a result should be read into a string variable. A typical input statement would be: INPUT#6, A$.

16.3.1 TK-2 INTERFACE COMMAND SET

"V 0↓"

This command programs the TK-2 to output the position display information when it has been addressed as a talker and an output is requested by the host computer. The output is an ASCII string consisting of the sign followed by six digits and a carriage return, line feed combination. All service request conditions are disabled. The state entered after the TK-2 receives this command is identical to the power up state.

"V 1↓"

This command programs the TK-2 to output the end of run status when it has been addressed as a talker and an output is requested by the host computer. The output is an ASCII 0, 1, 2 or 3 followed by a carriage return, line feed combination. The numbers correspond to the following conditions:

0 - No End of Run
1 - + End of Run
2 - – End of Run
3 - Both Ends of Run (stage not connected)



This command leaves the service request conditions unchanged.

"V 2↓"

This command programs the TK-2 to output the origin search status when it has been addressed as a talker and an output is requested by the host computer. The output is an ASCII 0 or 1 followed by a carriage return, line feed combination:

0 - Origin Search complete or idle
1 - Origin Search in progress

When using the "V 2↓" command, one of the following three conditions must be true:

1. "V 2↓" sent before origin search initiated
2. TK-2 listen/talk address and CC-1 listen address are different, or
3. dip switch S1-4 is down

One of the above conditions must be satisfied because when origin search is in progress, the CC-1 will output a busy signal to the IEEE-488 interface when it is addressed as a listener. As a result, you will not be able to input an origin search in progress signal.



This command leaves the service request conditions unchanged.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

"V 3↓"
This command programs the TK-2 to output the indexed motion complete and internal program complete status (pins 17 and 18 of the rear panel 37 pin G.P. I/O connector) when it has been addressed as a talker and an output is requested by the host computer. The output is an ASCII Ø, 1, 2 or 3 followed by a carriage return, line feed combination. The numbers correspond to the following conditions:

Ø - Indexed Motion Complete, Internal Program Complete
1 - Indexed Motion Complete, Internal Program not Complete
2 - Indexed Motion not Complete, Internal Program Complete
3 - Indexed Motion not Complete, Internal Program not Complete

The CC-1 powers up with the Motion Complete signal false. At first this may seem peculiar but it is really logically consistent, i.e., no motion has been completed. Once the first indexed motion has been completed, the Motion Complete signal will go true.

To achieve the full capabilities of the "V 3↓" command, one of the following must be satisfied:

1. "V 3↓" sent before indexed motion initiated or program execution entered. An example will make this clear.

```
10 OUTPUT#6; "V 3↓"
20 OUTPUT#6; "N 1000↓"
30 OUTPUT#6; "G↓"
40 INPUT#6; A$
50 BRANCH on condition motion complete
60 GOTO 40
```

2. The TK-2 listen/talk address and CC-1 listen address are different.

Condition 1 or 2 is necessary because motion in progress will hang-up the bus when addressed and program execution will hang-up the bus when addressed, if diode D29 is installed and dip switch S1-4 is up. If the bus is hung-up, you will not be able to output the "V 3↓" command and read the "not complete" statuses.

This command leaves the service request conditions unchanged.

"V 4↓"
This command programs the TK-2 to output the 3 bit auxiliary input information when it has been addressed as a talker and an output is requested by the host computer. The output is an ASCII number from Ø through 7 (corresponding to the binary configuration of the 3 bits) followed by a carriage return, line feed combination. The auxiliary inputs are over the following connector pins (all bits internally pulled up).

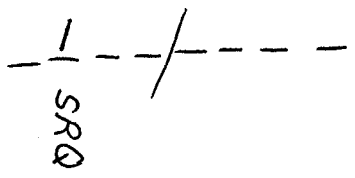
19 pin Jaeger Motor Connector		37 pin G.P. I/O connector	
17	LSB	30	LSB
18		31	
19	MSB	32	MSB

This command leaves the service request conditions unchanged.

Commands "V 5↓", "V 6↓" and "V 7↓" are identical to the "V Ø↓" command except for the fact that various Service Request Conditions are enabled.

"V 5↓"
This command programs the TK-2 to generate a Service Request when an End of Run switch is hit or an origin search is completed. The error condition of origin search initiated with an End of Run condition also generates a Service Request.

"V 6↓"
This command programs the TK-2 to generate a Service Request when an End of Run switch is hit or an internal program is completed. The error condition of internal program initiated with an End of Run condition also generates a Service Request.



Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

"V 7↓"
This command programs the TK-2 to generate a Service Request when an End of Run switch is hit or an indexed motion is completed. The error condition of indexed motion initiated with an End of Run condition also generates a Service Request.

"V 8↓"
This command programs the TK-2 to output the 3 bit auxiliary input information and, more importantly, programs it to generate a Service Request when a rising edge occurs on the LSB of the 3 bit auxiliary input.

"V 9↓"
This command does not affect the type of output provided by the TK-2 or the conditions which will generate a Service Request. The only effect is to reset the Position Display and (if dip switch S2-10 on the main board is up), to reset the origin search and indexing circuitry.

16.3.2 SAMPLE PROGRAMS

In this section we present a sample program to illustrate the use of the TK-2 non-interrupt associated commands, using the IEEE-488 bus commands of three different computers. The program is written in full for the PET Commodore computer. The program is then repeated using the IEEE-488 bus commands of the HP85 and the DEC Minc-11. The last two programs are written partially but with enough detail to show you how to program the particular computer to operate the TK-2 correctly.

PET Commodore

```
10 OPEN 6,6
20 PRINT#6, "V 0"
30 INPUT#6, A$
40 PRINT A$                    :A$ = display value
50 PRINT#6, "V 1"
60 INPUT#6, A$
70 PRINT A$                    :A$ = 0, 1, 2 or 3
80 PRINT#6, "V 2"
90 INPUT#6, A$
100 PRINT A$                   :A$ = 0 or
                                   = 1 if origin search in progress and standard CC-1 listener
                                     and TK-2 listener/talker at different addresses
110 PRINT#6, "V 3"
120 INPUT#6, A$
130 PRINT A$                   :A$ = 0, 1, 2 or 3
140 PRINT#6, "V 4"
150 INPUT#6, A$
160 PRINT A$                   :A$ = 0–7
170 PRINT#6, "V 9"             :reset front panel display
```


Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

HP85

```
10 RESET 7
20 CLEAR 7
30 OUTPUT 706; "V 0"
40 ENTER 706; A$
50 DISP A$
60 OUTPUT 706; "V 1"
70 ENTER 706; A$
80 DISP A$
    .
    .
    .
```

DEC MINC-11

```
10 ALL_INSTR_CLEAR
20 IEEE_BUS_CLEAR
30 SET_TERMINATORS(10)        REM Terminate message from CC-1 on <LF>
40 C$ = CHR$(13)              REM Create <CR> for CC-1 commands
50 SEND("V 0"&C$,6)
60 RECEIVE(A$,,6)
70 DISP A$
80 SEND("V 1"&C$,6)
90 RECEIVE(A$,,6)
100 DISP A$
    .
    .
```

IMPORTANT

When using the HP85 or the MINC-11 to communicate with the TK-2, you must program one of two possible statements in addition to the ENTER or RECEIVE statements to complete the handshake. If you do not, the display will remain frozen after the execution of the input statement. See section 16.6.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

16.4 INTERRUPT GENERATION AND PROCESSING

The TK-2 interface board is designed to interrupt the host computer with a service request whenever an enabled interrupt condition occurs in the CC-1 Controller. To enable an interrupt condition, one of the aforementioned commands, "V 5↓", "V 6↓", "V 7↓" or "V 8↓" is sent to the listener function of the TK-2 board before the interrupt condition is expected to occur.

Once the TK-2 generates a service request interrupt, the host computer will either respond immediately or delay its response until the completion of the command that is in progress when the interrupt occurs. The time of the response will depend on the structure of the program. The following two programs illustrate this point.

Note:
All example programs in this section assume that the standard CC-1 listener is at IEEE-488 address 6 and the TK-2 listener/talker is at address 6 or 7, whichever is appropriate. The generic terms INPUT and OUTPUT are used to imply direction of data transfer. You must supply the equivalent statements unique to your particular computer.

Program A

```
OUTPUT#6; "V 5↓"                    :enable end of run interrupt
OUTPUT#6; "N 1000↓"
OUTPUT#6; "G↓"
FOR I = 1 TO 100
    .                               :any computing task not involving
    .                                IEEE-488 bus
    .
NEXT I
```

Program B

```
OUTPUT#6; "V 5↓"
OUTPUT#6; "N 1000↓"
OUTPUT#6; "G↓"
OUTPUT#6; "G↓"
```

Program A will allow the computer to respond immediately and program B will cause the computer to wait until command execution is complete.

In both programs assume the end of run interrupt will occur during execution of "N 1000↓" command. In program A, once the "G↓" command is transferred, the IEEE-488 bus is free. As a result, when the interrupt occurs it will be processed immediately. In program B, once the first "G↓" command is transferred, the computer will try to transfer the second "G↓" command immediately. However, it will not be able to because the first command execution is in progress. As a result, the computer will continually poll the NRFD line of the IEEE-488 bus and ignore the interrupt for the time being. Once the NRFD line goes false, the computer will transfer the second "G↓" command and respond to the interrupt.

When the interrupt is recognized, the computer will perform a serial poll to learn the identity of the device that caused the interrupt. This is accomplished by using the interrupt handling software of your computer.

To perform the serial poll, you program the computer to address every device on the bus capable of causing an interrupt and output a serial poll enable command. When addressed, the device will output a status byte. A status byte consists of 8 bits labeled 0 through 7. Bit 6 identifies the device that caused the interrupt. Bits 0 through 5 and bit 7 are used for device-specific data. The status byte outputted by the TK-2 is shown and described in Figure 16.3.

The device that caused the interrupt will output a status byte with bit 6 set to a binary 1. All other devices will output a status byte with bit 6 cleared to a binary 0.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

7	6	5	4	3	2	1	Ø
X	SRQ	Auxiliary Bit	Motion Complete	Stored Program Execution	Origin Search	– End of Run	+ End of Run

bit Ø — 1 <=> + end of run true
Ø <=> + end of run false

bit 1 — 1 <=> – end of run true
Ø <=> – end of run false

bit 2 — 1 <=> origin search in progress
Ø <=> origin search complete or idle

bit 3 — 1 <=> stored program execution in progress
Ø <=> stored program execution complete

bit 4 — 1 <=> motion in progress
Ø <=> motion complete

bit 5 — 1 <=> auxiliary LSB high
Ø <=> auxiliary LSB low

bit 6 — 1 <=> CC-1 generated interrupt
Ø <=> CC-1 did not generate interrupt

bit 7 — not used

Figure 16.3 CC-1 Status Byte

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

16.5 SAMPLE PROGRAMS

In this section we present a sample program to illustrate the use of the TK-2 interrupt enable commands, using the IEEE-488 bus commands of two different computers. The program is written in full for the HP85 computer. The program is then repeated using the DEC MINC-11. The DEC MINC-11 program is written partially but with enough detail for you to get the gist of the procedure.

Initially the program asks you to enable an interrupt. It then loads the CC-1 storage buffer with a sequence of commands that perform three 1000 step movements with a delay of 1.83 seconds between each movement. At the end of the third movement an origin search is performed (S1-3 must be up). Depending on the interrupt you enabled and the state of the CC-1 during the execution of the program, the CC-1 will output its status when it is appropriate.

HP85

```
 10 RESET 7
 20 CLEAR 7
 30 CONTROL 7,16 ; 1
 40 ON INTR 7 GOSUB 200                          :service routine at 200
 50 ENABLE INTR 7;8                              :enable interrupt
 60 DISP "ENTER INTERRUPT COMMAND"
 70 DISP "V 5, V 6, V 7, OR V 8"
 80 INPUT B$
 90 OUTPUT 706 ;B$
100 DATA "R 253", "S 2", "F 20", "E", "N 1000", "+", "G",
    "X 1000", "L 3,0", "C", "B", "0", "Q", "D", "END"
110 READ A$
120 IF A$ = "END" THEN 150
130 OUTPUT 706 USING "K"; A$
140 GOTO 110
150 GOTO 150
200 S=SPOLL(706)                                :perform serial poll to get status byte
210 IF BIT(S,6)=1 THEN 300
220 DISP "CC-1 DID NOT REQUEST SERVICE"
230 RESET 7
240 ENABLE INTR 7;8
250 RETURN
300 CLEAR
310 DISP "** CC-1 REQUESTED SERVICE **"@DISP" "
320 DISP "--THE STATUS OF THE CC-1 AT--"
330 DISP "--TIME OF INTERRUPT WAS--"@DISP" "
340 IF BIT(S,0)=1 THEN DISP "POSITIVE END OF RUN TRUE"
350 IF BIT(S,1)=1 THEN DISP "NEGATIVE END OF RUN TRUE"
360 IF BIT(S,2)=1 THEN DISP "ORIGIN SEARCH IN PROGRESS"
370 IF BIT(S,2)=0 THEN DISP "ORIGIN SEARCH COMPLETE OR IDLE"
380 IF BIT(S,3)=1 THEN DISP "PROGRAM NOT COMPLETE"
390 IF BIT(S,3)=0 THEN DISP "PROGRAM COMPLETE"
400 IF BIT(S,4)=1 THEN DISP "MOTION NOT COMPLETE"
410 IF BIT(S,4)=0 THEN DISP "MOTION COMPLETE"
420 IF BIT(S,5)=1 THEN DISP "AUXILIARY BIT IS HIGH"
430 IF BIT(S,5)=0 THEN DISP "AUXILIARY BIT IS LOW"
440 GOTO 230
```


Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

```
 10 ALL_INSTR_CLEAR
 20 IEEE_BUS_CLEAR
 30 SET_TERMINATORS(10)                    REM Terminate message from CC-1 on <LF>
 40 C$=CHR$(13)                            REM Create <CR>for CC-1 commands
 50 SRQ_SUBROUTINE(200)                    REM Service routine at line 200
 60 PRINT"ENTER INTERRUPT COMMAND"
 70 PRINT"V 5, V 6, V 7, OR V 8"
 80 INPUT B$
 90 SEND(B$&C$,6)
100 DATA "R 253", "S 2", "F 20", "E", "N 1000", "+", "G",
    "X 1000", "L 3,0", "C", "B", "0", "Q", "D", "END"
110 READ A$
120 IF A$="END" THEN 150
130 SEND(A$&C$,6)
140 GOTO 110
150 GOTO 150
200 SERIAL_POLL(S,,6)
210 TEST_BIT(6,P,S)
220 IF P=1 THEN 300
230 PRINT"CC-1 DID NOT REQUEST SERVICE"
240 RETURN
300 PRINT "**CC-1 REQUESTED SERVICE**":PRINT" "
310 PRINT "--THE STATUS OF THE CC-1 AT TIME OF INTERRUPT WAS--":PRINT" "
320 TEST_BIT(0,P,S)
330 IF P=1 THEN PRINT "POSITIVE END OF LINE TRUE"
340 TEST_BIT(1,P,S)
350 IF P=1 THEN PRINT "NEGATIVE END OF RUN TRUE"
      .
      .
      .
```


Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

16.6 TK-2 USAGE TECHNIQUES

1. The TK-2 interface board powers up the "V 0↓" mode with all interrupts disabled. As a result, you do not have to output a "V 0↓" command before reading the display.

2. Once the TK-2 is programmed into a mode of operation through a "V n↓" command, it remains in that mode until it is changed by a different "V n↓" command. For example, if a motion complete status signal is desired on several occasions, it is not necessary to continuously output a "V 3↓" command before inputting the status indication.

3. If a status indication is desired at the completion of a movement, then it is necessary to either 1) hang-up the IEEE-488 bus until the movement is complete or 2) poll the motion complete output signal and input the status indication when the motion complete signal is true.

Program C below illustrates the first alternative. It is desired to read the display at the end of the movement. The program uses a dummy command at line 40 to hang-up the bus and thus not allow execution of the input command until after the motion is complete. Note that in the absence of the dummy command, the input command would be executed a few milliseconds after the motion begins resulting in a random and erroneous display reading.

Program C

```
10 OUTPUT#6; "V 0↓"
20 OUTPUT#6; "N 1000↓"
30 OUTPUT#6; "G↓"
40 OUTPUT#6; "B↓"
50 INPUT#6; A$
60 DISPLAY A$
```

Program D below illustrates the second alternative. The program tests the motion complete output signal and branches accordingly.

Program D

```
10 OUTPUT#6; "V 3↓"
20 OUTPUT#6; "N 1000↓"
30 OUTPUT#6; "G↓"
40 INPUT#6, A$
50 IF A$ = "2" THEN GOTO 40
60 OUTPUT#6; "V 0↓"
70 INPUT#6; B$
80 DISPLAY B$
```

4. If the display is being driven by an encoder and you wish to read the display at the completion of the movement, you must include two additional program steps to ensure correct operation: 1) a delay of approximately 10 to 20 milliseconds to allow the stepping motor, and correspondingly the encoder, to settle, and 2) a dummy statement to hang-up the bus until the movement and delay is complete. Program E illustrates this technique.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

Program E

```
10 OUTPUT#6; "V 0↓"
20 OUTPUT#6; "N 1000↓"
30 OUTPUT#6; "G↓"
40 OUTPUT#6; "X 10↓"          :delay of 18.3 milliseconds
50 OUTPUT#6; "B↓"             :hang bus
60 INPUT#6; A$
70 DISPLAY A$
```

5. The following peculiarity about the motion complete output signal should be observed. The motion complete signal will go low to indicate motion complete. Any subsequent command (be it a movement command or not) to the same address will cause the motion complete output signal to go high. This implies that if the standard CC-1 listener and the TK-2 listener/talker are on the same address, you cannot output any TK-2 commands after the movement command. Program F shows the incorrect implementation while Program G is the correct version.

Program F

```
10 OUTPUT#6; "N 1000↓"
20 OUTPUT#6; "G↓"
30 OUTPUT#6; "V 3↓"           :output command to talker
40 INPUT#6; A$
50 IF A$ = "2" THEN GOTO 40
60 DISPLAY "Motion Complete"
```

Program G

```
10 OUTPUT#6; "V 3↓"
20 OUTPUT#6; "N 1000↓"
30 OUTPUT#6; "G↓"
40 INPUT#6; A$
50 IF A$ = "2" THEN GOTO 40
60 DISPLAY "Motion Complete"
```

If it is absolutely necessary to output the "V 3↓" command just before inputting the motion complete status signal, then the standard CC-1 listener and the TK-2 listener/talker must be on different addresses.

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

6. When using the HP85 or the MINC-11 to communicate with the TK-2, you must use an additional statement after the ENTER or RECEIVE statements to complete the handshake. If you omit these statements, the display will remain frozen after the data transfer. Two statements are possible. One statement consists of addressing the TK-2 as a listener and the other is the transmission of the untalk command. The following two programs illustrate this point for the HP85. Program H addresses the TK-2 as a listener after the data transfer and program I sends the untalk command.

Program H

```
10 OUTPUT 706; "V 0"
20 ENTER 706; A$
30 OUTPUT 706; "V 0"                    :complete handshake
40 DISP A$
```

Program I

```
10 OUTPUT 706; "V 0"
20 ENTER 706; A$
30 SEND 7 ; UNT                         :complete handshake
40 DISP A$
```


Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

Artisan Scientific - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisan-scientific.com

Artisan Technology Group is an independent supplier of quality pre-owned equipment

Gold-standard solutions

Extend the life of your critical industrial, commercial, and military systems with our superior service and support.

We buy equipment

Planning to upgrade your current equipment? Have surplus equipment taking up shelf space? We'll give it a new home.

Learn more!

Visit us at **artisantg.com** for more info on price quotes, drivers, technical specifications, manuals, and documentation.

Artisan Scientific Corporation dba Artisan Technology Group is not an affiliate, representative, or authorized distributor for any manufacturer listed herein.

We're here to make your life easier. How can we help you today?

(217) 352-9330 | sales@artisantg.com | artisantg.com

ARTISAN® TECHNOLOGY GROUP