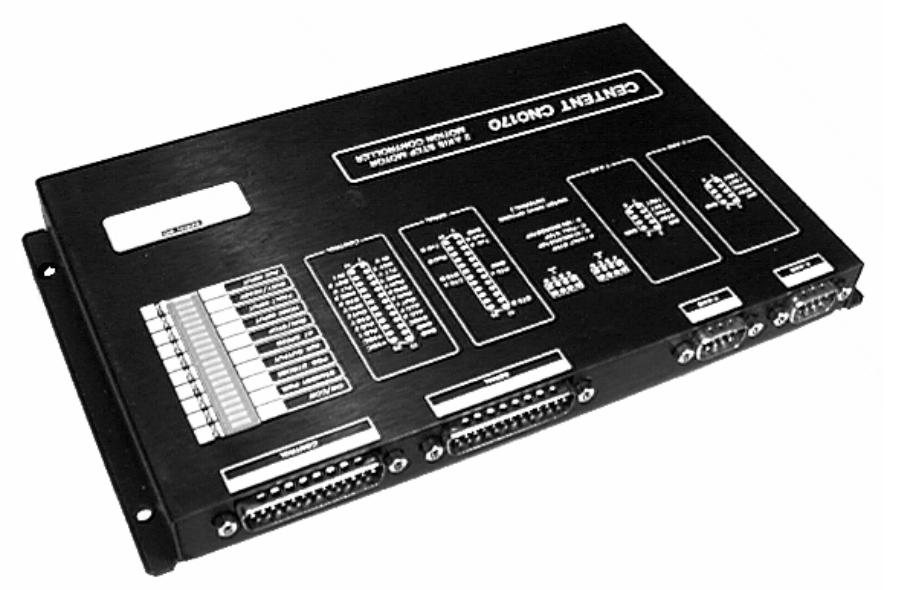
CN0170
2 AXIS MOTION CONTROLLER

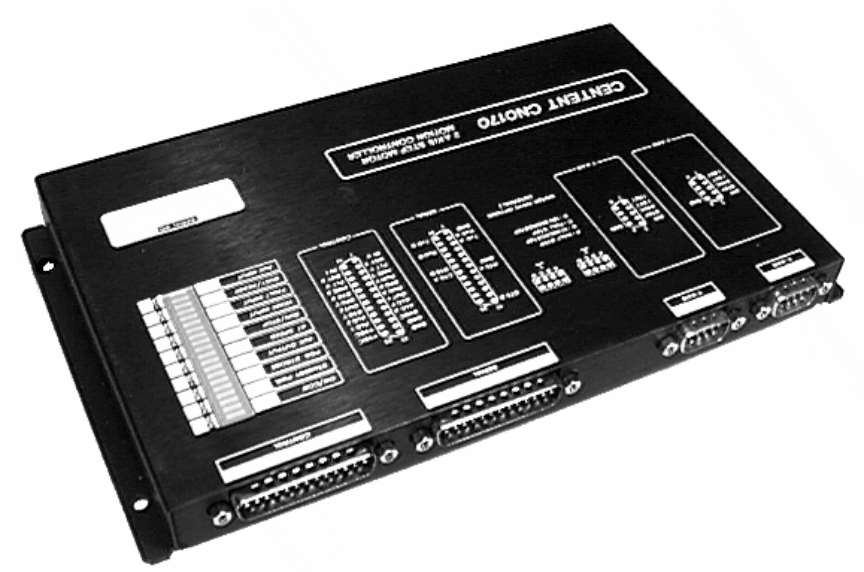


USER GUIDE

CENTENT COMPANY
3879 SOUTH MAIN STREET 714-979-6491
SANTA ANA, CALIFORNIA 92707-5710 U.S.A.

This manual contains information for installing and operating the following Centent Company product:

- CN0170 Motion Controller



GENERAL DESCRIPTION:

The CN0170 is a two axis programmable motion control computer for step motor systems. It is designed to operate with a host computer or as a stand-alone controller. When connected to a host PC or terminal the CN0170 serves as a peripheral device, receiving instructions and returning data via a standard RS-232 serial port. Operating alone, the CN0170 can recall up to 3000 random x,y co-ordinates.

The CN0170 is a CMOS Z80A microprocessor based system. A CMOS RAM stores motor operating parameters and application programs. The RAM is battery backed-up, allowing retention of program and parameters in the event of power interruption. Extensive use of CMOS circuitry insures minimum power consumption and maximum noise immunity.

The CN0170 motion controller can generate 65,535 different speeds and acceleration rates. The internal position registers of the controller have a range of 4,194,304 full steps. This covers most practical applications. Position is calculated to 1/1024 of a full step regardless of the pulse rate selected. Velocity is resolved in ¼ step per second increments. Acceleration resolution is 64 steps per second squared.

In addition to linear acceleration, the CN0170 offers the option of "stored profile" acceleration or user defined acceleration. The controller contains 16 stored profiles corresponding to the speed-torque curves of the most common step motors available. By selecting the curve that most closely matches the motor used, it is possible to take maximum advantage of the available motor power, yielding the shortest time-to-speed ratio. The user may choose from these 16 predefined profiles or enter a custom profile of his own specification.

For motion systems requiring more than two step motors, multiple CN0170s may be linked together in a "daisy-chain" configuration and controlled by the host via a single serial port. A maximum of ten step controllers (20 axis) may be linked in this fashion. The host synchronizes the positioning of the various motors in the system by querying each controller's status on the serial interface. Linear and circular interpolation is possible with motors operated by the same CN0170 within the system. Point-to-point moves are possible between any motors in the system.

The CN0170 comes enclosed in a compact black anodized aluminum case. All connections to the controller are by "D" type plugs located along one edge of the unit. Separate connectors are provided for each motor drive, the serial interface, and for control functions (limit switches etc.). LED indicators, showing the status of the controller, are visible through a window on the top surface of the case. Legends on the case identify these LEDs and provide hook-up information. Mounting holes are provided in each corner of the bottom plate, which also serves as a heat sink. Overall package size is small, measuring 9.375 inches wide, 5.5 inches deep, and .875 inches high.

PROGRAMMING THE CN0170

The CN0170 comes with a built in operating system and high level language for motion control. Through the use of the serial interface the host can send the programming instructions and control the program operation. All operating commands and program instructions are comprised of ASCII character strings, utilizing simple mnemonics, that may be written and maintained with a word processor. The CN0170 can also be operated by a dumb terminal or any program that can communicate in ASCII format.

The CN0170 may be operated in any one of three modes. Mode 3 is the Operate Mode, where stored programs are executed. Mode 2 is the Program Mode for loading instructions into the program queue. Mode 1 is the Immediate Mode, where instructions are executed as soon as they are received. Mode 1 instructions are not stored in the program queue.

Commands or instructions always begin with the letter unique to it followed by operators and parameters where required. Illegal instructions or syntax errors result in the controller echoing the entire input string back to the host, indicating that no instruction was accepted. When a legal command or instruction is received, the controller executes it (Immediate Mode), or compresses it and stores it in the program queue (Program Mode).

The Operate Mode is selected to operate programs stored in the program queue. Operation in this mode begins with a “Go” command. It is not necessary to maintain the serial link between the host and the motion controller while running from Operate Mode.

Operating system commands are not normally loaded to the program queue. They direct the CN0170 at the operating system level and are executed immediately. Included are commands to select mode of operation, assign and select unit numbers, start and stop program operation, and set or query the real time clock. Some commands may be placed in the program queue. When program operation reaches these commands they execute as they would if entered by the host on the serial interface.

Program instructions are divided into three groups; motor parameter, motor positioning, and input/output control. Input/output instructions control the analog and digital I/O functions of the CN0170. Motor positioning instructions cause the step motors to move. Motor parameter instructions define the performance envelope for motor operation.

The two motor outputs of the CN0170 may be controlled independently or treated as a two axis co-ordinate system. Instructions are included for point to point, linear and circular interpolation. Home routines feature built-in algorithms to accurately reference the motors to their limit switches. Other positioning instructions include jogging, where the motors are controlled by a joystick or other analog input, and speed control operation, where the motor runs at an exact speed.

Another method of positioning the motors involves the use of the Ratio instructions. This servos one motor to the other at a precise speed ratio. When the master motor is instructed to move, the slave motor also moves at the specified percentage of the master's speed. This allows the host to “gear” one motor to the other. Instructions are included to specify whether the slave motor moves in the same or opposite direction as the master motor. The Ratio instruction is canceled when the host sends a motion instruction to the slave motor, taking it out of Ratio mode.

Motor parameter instructions do not directly cause the motors to move. These include instructions for velocity, acceleration, joystick enable, home direction, driver resolution, and position preset. These parameters may be changed at any time in the program, affecting the motion instructions that follow. The host may query the status of various parameters during motor operation. Instructions are included for querying motor position, velocity, acceleration rate, acceleration profile, and ratio rate.

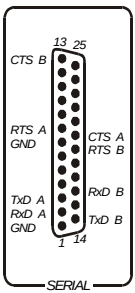
By utilizing the joystick feature of the CN0170 in conjunction with the position query instructions, the host may implement a teach/learn scheme for motion control. Motors may be manually jogged to desired locations and the co-ordinates recorded by the host. By sending the position data back to the controller in the form of motor positioning instructions, the system is able to recall the points on the x,y plane provided by the joystick.

Unit numbers are used in systems consisting of more than one motion controller. In systems requiring only one CN0170, unit numbers may be ignored. Each CN0170 in the system is assigned a number (0-9) to distinguish it from the other units in the system. The host then selects one (and only one) active unit. All commands and instructions are directed to the active unit. Information sent back to the host is preceded by the unit number of the controller transmitting the data.

The CN0170 motion controller has an internal time clock that includes day, month and year as well as time of day function. The clock is set by the host and remains operational while power is supplied to the controller. The host uses the clock for real time reference of the machine process. The host must re-program the clock after power interruption.

The instruction set is listed on page 12 through page 15 of this guide. For a more detailed explanation consult the CN0170 Operating Manual.

USER INTERFACE (RS-232)



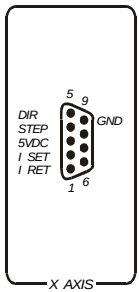
Communication between the step controller and the host is via serial interface. The CN0170 contains two complete serial ports brought out to a single “D25” plug connector. The primary channel is connected to the host processor while the secondary channel connects to another CN0170 if more than 2 axis of motion are required. “Unit ID” numbers allow the host to direct the program instructions to the various controllers in the system, and to differentiate the data returned to the host by the controllers. Each CN0170 reads only the instructions intended for it and relays other data down the chain on its secondary channel.

It is possible to connect the secondary RS-232 channel of the last CN0170 in the daisy-chain to any other RS-232 device. Instructions not trapped by the CN0170s in the system will pass through to the other device (printer etc.). Each controller in the chain will transmit on the secondary channel at the same baud rate as the data received on the primary channel.

The baud rate is automatically set by the CN0170. The host initiates this process by sending a carriage return to the controller. The controller uses this character to measure the baud rate. The host's baud rate is maintained and does not have to set again unless a different rate is desired. Standard baud rates from 300 to 9600 baud are available. The ports operate in full duplex with eight data bits, one stop bit and no parity bit.

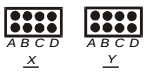
STEP MOTOR DRIVE INTERFACE

The controller provides a “D9” plug connector for each motor drive and has the necessary signals to interface the CN0170 to most step motor drives. The “STEP” and “DIR” outputs can sink 100 milliamps of drive current. The “I SET” output allows standby current reduction for drives with this feature. This reduces motor and drive heating while the motor is at rest. When used in conjunction with Centent step motor drives, straight pin to pin cables simplify the interface. Drives from other manufacturers may be used, assuming they have the same input requirements. Legends are provided on the CN0170 to distinguish the “X-AXIS” from the “Y-AXIS”.



STEP MOTOR DRIVE OPTIONS

The CN0170 is intended for use with full step, half step or microstep drives. It simultaneously generates the pulse rates necessary for 125 microstep, 10 microstep, half step and full step drives. Jumper options on the board allow the user to select the rate that matches the drive in use. All motor speeds are derived from a crystal controlled oscillator; thus the controller has an absolute accuracy equivalent to that of the oscillator.



A-HALF STEP
B-10 MICROSTEP
C-FULL STEP
D-125 MICROSTEP

MOTOR DRIVE OPTIONS
(INTERNAL)

Centent Company manufactures a line of step motor drives that are ideally suited to the CN0170. These include full and half step drives as well as 10 microstep and high resolution microstep drives.

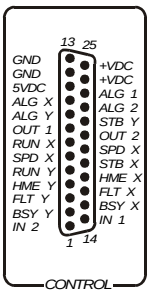
The CN0142 & CN0143 are 10 microstep (per full step), high frequency "chopper" type drives that feature anti-resonance circuitry and opto-isolated step and direction inputs. They compensate for both low speed vibration and mid-band instability. A high efficiency switching "H" Bridge output utilizing power MOSFETs keeps heating to a minimum.

The CN0152 & CN0153 are full/half step versions of these microstep drives and share much of the same circuitry. The CN0142 & CN0152 are intended for hybrid PM step motors with current ratings from .75 to 7 amps per phase. The CN0143 & CN0153 are for motors rated from 1.5 to 14 amps per phase. These drives are small, measuring 4" x 4.5" x .8" and weigh only 1.2 lbs.

In a slightly larger (4.0" x 4.75" x .85") package is the CN0162 high resolution microstep drive. This drive may be configured to deliver step rates from full step to 256 microsteps. It is also a high efficiency, high frequency "chopper" type drive. The CN0162 is designed for motors rated from .1 to 14 amps per phase.

For motors rated from .1 to 2 amps per phase, Centent offers the CN0124 half step motor drive. This is a very economical, compact (3" x 2" x .8") drive. Anti-resonance circuitry and opto-isolation are also featured in this drive. The CN0124 operates from 10 VDC to 46 VDC; the power supply may be unregulated.

CONTROL INTERFACE



In addition to the motor driver output, the CN0170 provides analog input and digital input/output to facilitate the motion system design. These functions are combined with the power supply inputs on the CONTROL connector. Digital inputs and outputs are TTL compatible. The analog inputs have an input voltage range of 0-5 VDC or 2-3 VDC. A jumper option on the printed circuit board selects between the ranges. The conversion resolution of the A/D converter is 8 bits.

Each motor has dedicated inputs for a limit switch and a fault switch. The limit switch, if used, establishes the "Home" position of the step motor. The fault input interrupts the step pulse train to the drive in the event of an error condition. This prevents over-travel of the motor and damage to the system. More than one switch may be connected to the fault input (in parallel) to define the boundary regions of motor travel.

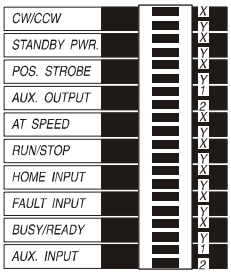
The Busy/Ready input is used in conjunction with the Position Strobe output to provide TTL handshaking for interfacing the CN0170 to external devices. This allows synchronization of motor positioning and machine function. Additionally, the "Run/Stop" and "At Speed" outputs provide logic level status of each motor.

Two general purpose digital inputs and two general purpose digital outputs are also provided. These are the "Aux. Input" and "Aux. Output" connections on the Control Connector as designated on the cover of the CN0170. The status of the inputs is always available to the host on the serial interface. Program commands for turning the outputs on or off are provided in the instruction set. Status LEDs also indicate the condition of these inputs and outputs.

The analog input consists of a dedicated channel for each motor and two general purpose channels. The dedicated channels are normally connected to a joystick for manually jogging the motors. The general purpose channels provide access to other analog devices. The status of all analog inputs may be sampled (via RS-232) at any time.

CONTROL STATUS LED ARRAY

The digital inputs and outputs are mapped to an LED indicator visible through a window in the case of the CN0170. Legends identify the various functions represented. This provides the user with a convenient tool for evaluating the status of the controller during program operation or development.



The following page illustrates an example of a positioning system utilizing the Centent CN0170 Two Axis Step Motor Controller in conjunction with Centent CN0143 and CN0162 step motor drives. This is provided as a guide to the user, specific systems will differ in configuration.

The CN0162 in this example utilizes its built-in Standby Set function as well as the I_{SET} of the controller. The CN0162 Standby Set goes active .1 seconds after the motor has stopped. The user controls the CN0170 I_{SET} time period via the serial interface. With I_{SET} connected directly to the Current Set input of the drive, current reduction is 100% when active. The Current Set Tables list resistor values for the Current Set Resistor and Current Standby resistors of 50%, 25%, and 10% of full current. These values are rounded off to the nearest standard 5% resistor.

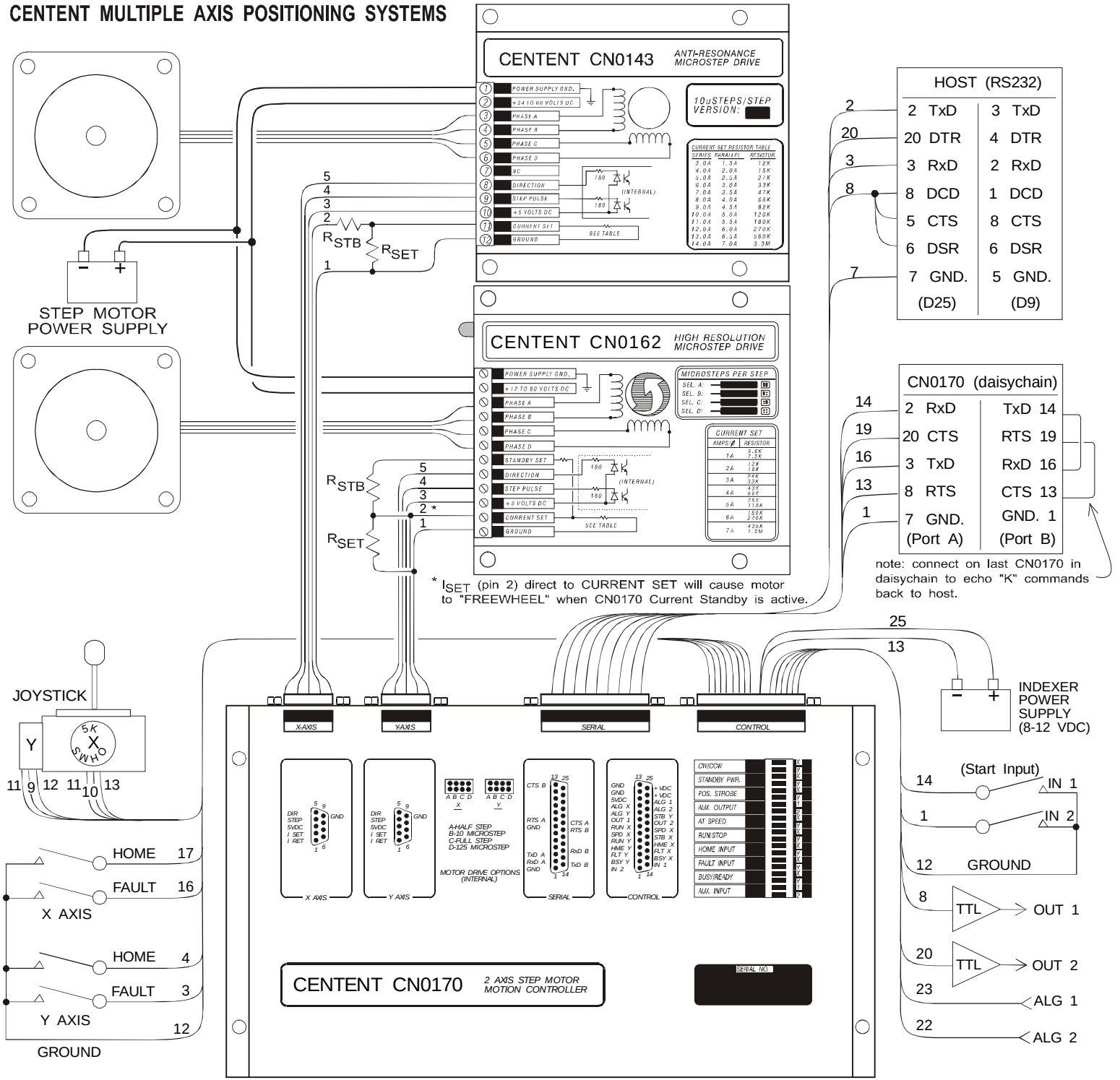
CENTENT MULTIPLE AXIS POSITIONING SYSTEMS

CN0143 CURRENT SET TABLE

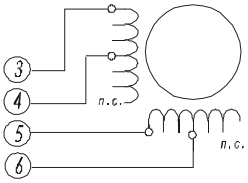
Mode of Operation		Current Set Resistors			
			R_{STB}		
Parallel	Series	R_{SET}	50%	25%	10%
1.50	3.0	12K	—	—	—
1.75	3.5	16K	—	—	—
2.00	4.0	20K	—	—	—
2.25	4.5	22K	—	—	—
2.50	5.0	27K	—	—	—
2.75	5.5	30K	—	—	—
3.00	6.0	33K	18K	—	—
3.25	6.5	39K	20K		
3.50	7.0	47K	22K	—	—
3.75	7.5	56K	24K	—	—
4.00	8.0	68K	27K	—	—
				—	—
4.25	8.5	68K	30K		
4.50	9.0	82K	30K	—	—
4.75	9.5	91K	33K	—	—
5.00	10.0	120K	36K	—	—
				—	—
5.25	10.5	130K	36K	—	
5.50	11.0	180K	36K	—	—
5.75	11.5	220K	36K	—	—
6.00	12.0	270K	39K	12K	—
					—
6.25	12.5	330K	33K	13K	
6.50	13.0	560K	36K	13K	—
6.75	13.5	1.1M	39K	15K	—
7.00	14.0	3.3M	39K	16K	—
					—

CN0162 CURRENT SET TABLE

Mode of Operation		Current Set Resistors			
			R_{STB}		
Parallel	Series	R_{SET}	50%	25%	10%
0.1	0.2	680	—	—	—
0.2	0.4	1.3K	1.3K	—	—
0.3	0.6	2.0K	2.0K	—	—
0.4	0.8	2.7K	2.7K	910	—
0.5	1.0	3.6K	3.3K	1.1K	—
0.6	1.2	4.3K	3.9K	1.3K	—
0.7	1.4	5.1K	4.7K	1.5K	—
0.8	1.6	5.6K	5.1K	1.8K	—
0.9	1.8	6.8K	5.6K	2.0K	—
1.0	2.0	7.5K	6.8K	2.2K	750
1.25	2.5	10K	8.2K	2.7K	910
1.50	3.0	12K	10K	3.3K	1.1K
1.75	3.5	15K	11K	3.9K	1.3K
2.00	4.0	18K	13K	4.3K	1.5K
2.25	4.5	22K	15K	4.7K	1.6K
2.50	5.0	24K	16K	5.6K	1.8K
2.75	5.5	30K	18K	6.2K	2.0K
3.00	6.0	33K	20K	6.8K	2.2K
3.25	6.5	39K	22K	6.8K	2.4K
3.50	7.0	43K	22K	7.5K	2.4K
3.75	7.5	51K	24K	8.2K	2.7K
4.00	8.0	56K	27K	9.1K	3.0K
4.25	8.5	68K	27K	9.1K	3.0K
4.50	9.0	75K	30K	10K	3.3K
4.75	9.5	91K	30K	10K	3.3K
5.00	10.0	110K	33K	11K	3.6K
5.25	10.5	130K	33K	11K	3.9K
5.50	11.0	150K	36K	12K	3.9K
5.75	11.5	180K	39K	13K	4.3K
6.00	12.0	240K	39K	13K	4.3K
6.25	12.5	300K	39K	13K	4.7K
6.50	13.0	430K	43K	15K	4.7K
6.75	13.5	680K	43K	15K	4.7K
7.00	14.0	1.6M	47K	15K	5.1K



Centent step motor drivers are designed to operate 4, 6, and 8 wire motors in a low performance or a high performance configuration (a 4 wire motor is considered as high performance configuration). Please consult the driver's operating manual to determine the best configuration for your application.



The high performance configuration is called half-winding operation in a 6 wire motor and parallel operation in an 8 wire motor. Both 6 and 8 wire motors in this configuration are commonly referred to as being operated in parallel. The following tables show the wire color codes for various manufacturer's motors operated in the high performance configuration.

HALF WINDING OPERATION - 6 WIRE MOTORS

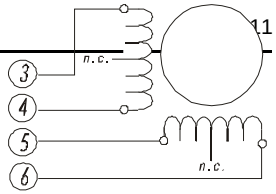
MANUFACTURER	MOTOR TERMINAL 3	4	5	6
SUPERIOR ELECTRIC	WHITE	GREEN	BLACK	RED
RAPIDSYN	WHITE	GREEN	BLACK	RED
IMC	WHITE	GREEN	BLACK	RED
EASTERN AIR DEV.	WHITE	GREEN	BLACK	RED
PACIFIC SCIENTIFIC	BLACK	ORANGE/BLK	RED	RED/YELLOW
WARNER ELECTRIC	BLACK	ORANGE	RED	WHITE
VEXTA	BLUE	WHITE	YELLOW	GREEN
JAPAN SERVO	BLUE	WHITE*	WHITE*	GREEN

* white wires are not interchangeable, use ohm meter to find white-blue & white-green pairs

PARALLEL WINDING OPERATION - 8 WIRE MOTORS

MANUFACTURER	MOTOR TERMINAL 3	4	5	6
SUPERIOR ELECTRIC	RED WHITE	BLACK RED/WHITE	GREEN BLACK/WHT	ORANGE GREEN/WHT
PACIFIC SCIENTIFIC	BLACK ORANGE/WHT	BLACK/WHT ORANGE	RED YELLOW/WHT	RED/WHITE YELLOW
BODINE	BROWN ORANGE/WHT	BROWN/WHT ORANGE	RED/WHITE YELLOW	RED YEL/WHT
PORTESCAP	BROWN ORANGE	BROWN/WHT ORANGE/WHT	RED YELLOW	RED/WHITE YEL/WHT
DIGITAL MOTOR	BLACK ORANGE/WHT	BLACK/WHT ORANGE	RED YELLOW/WHT	RED/WHITE YELLOW

The low performance configuration is called full-winding operation in a 6 wire



motor and series operation in an 8 wire motor. Both 6 and 8 wire motors in this configuration are commonly referred to as being operated in series. The following tables show the wire color codes for various manufacturer's motors operated in the low performance configuration.

The CN0170 Instruction Set is listed on page 12-15 for quick reference. For more explanation, consult the CN0170 OPERATING MANUAL. The CN0170 includes a diskette with RUN170.EXE; a program to operate the controller from an IBM PC or compatible. The disk includes updates, programming examples, and a text file of the manual.

FULL WINDING OPERATION - 6 WIRE MOTORS

MANUFACTURER	MOTOR TERMINAL 3	4	5	6
SUPERIOR ELECTRIC	GREEN/WHITE	GREEN	RED/WHITE	RED
RAPIDSYN	GREEN/WHITE	GREEN	RED/WHITE	RED
IMC	GREEN/WHITE	GREEN	RED/WHITE	RED
EASTERN AIR DEV.	GREEN/WHITE	GREEN	RED/WHITE	RED
PACIFIC SCIENTIFIC	BLACK	ORANGE	RED	YELLOW
WARNER ELECTRIC	BROWN	ORANGE	RED	YELLOW
VEXTA	BLUE	RED	BLACK	GREEN
JAPAN SERVO	BLUE	RED	YELLOW	GREEN

SERIES WINDING OPERATION - 8 WIRE MOTORS

MANUFACTURER	MOTOR TERMINAL 3	4	5	6
SUPERIOR ELECTRIC	RED (BLACK—WHITE)	RED/WHITE	GREEN (ORANGE—BLK/WHT)	GREEN/WHT
PACIFIC SCIENTIFIC	BLACK (BLK/WHT—ORG/WHT)	ORANGE	RED (RED/WHT—YEL/WHT)	YELLOW
BODINE	BROWN (BRN/WHT—ORG/WHT)	ORANGE	RED (RED/WHT—YEL/WHT)	YELLOW
PORTESCAP	BROWN (BROWN/WHITE—ORANGE)	ORANGE/WHT	RED (RED/WHITE—YELLOW)	YELLOW/WHT
DIGITAL MOTOR	BLACK (BLK/WHT—ORG/WHT)	ORANGE	RED (RED/WHT—YEL/WHT)	YELLOW

CN0170 COMMAND SUMMARY

MODE

IMMEDIATE	M1	instruction executes when received
	M1\+	RTS prevents queue overflow
	M1\-	message on queue overflow
PROGRAM	M2	instruction loads to program queue
OPERATE	M3	operates from program queue
QUERY	M?	“what is the mode ?”
(reply)	Mn	where “n” is 1-3

PROGRAM OPERATION

GO	G	run program
	Gn	“n“ = positioning instructions to run
HALT	H	stop program operation
QUIT	Q	stop motors, reset program
KILL	K	interrupt pulse train, relay command
(reply)	K	relayed on 2nd RS-232 channel

UNIT NUMBERS

ASSIGNMENT

DIRECT.U=n	where “n” is 0-9	
ABSOLUTE	.Un=n	where “n” is 0-9
(reply)	[Un]	where “n” is 0-9
RELATIVE	.U+i=n	where “i” is 0-8 and “n” is 0-9
(reply)	.U+j=n	relayed on 2nd channel “j” is “i”-1
SELECTION	.Un	where “n” is 0-9
QUERY	.U?	request unit # (all units respond)
(reply)	[Un]	where “n” is 0-9
	.U?	relayed on 2nd channel

REAL TIME CLOCK

TIME SET	T=hh:mm.ss	hh = hours (24 hour clock) mm = min. ss = sec. (opt.)
TIME QUERY	T?	
(reply)	hh:mm.ss	
DATE SET	D=mm/dd/yy	mm=mo. dd=day yy=yr.
DATE QUERY	D?	
(reply)	mm/dd/yy	

CN0170 INSTRUCTION SUMMARY

MOTOR POSITIONING INSTRUCTIONS (where shown for X; same for Y)

HOME	XH	home single axis
	XYH	home both axis
SPEED CONTROL		
	X++	run one motor CW direction
	X--	run one motor CCW direction
	X++n	(CW) where “n” is temp. velocity
	X--n	(CCW) where “n” is temp. velocity
SINGLE AXIS		
ABSOLUTE	X=n	where “n” is motor position
RELATIVE	X+n	“n” adds to current position
	X-n	“n” subtracts from current position

POINT to POINT (axis velocity and accel. rates & profile)

ABSOLUTE	X=n & Y=n	X must come first
RELATIVE	X+n & Y+n	may be “-” for either axis
MIXED	X=n & Y+n	any mix of abs. & rel.

LINEAR INTERPOLATION (vector vel., x-axis accel. & profile)

ABSOLUTE	X=n,Y=n	X must come first
RELATIVE	X+n,Y+n	may be “-” for either axis
MIXED	X=n,Y+n	any mix of abs. & rel.

CIRCULAR INTERPOLATION (present position is p1))

ABSOLUTE	X=n,Y=n ^ X=m,Y=m	“n” = p2 “m” = p3
RELATIVE	X+n,Y+n ^ X+m,Y+m	may be “+” or “-”
MIXED	X=n,Y+n ^ X=m,Y+m	any mix of abs. & rel.

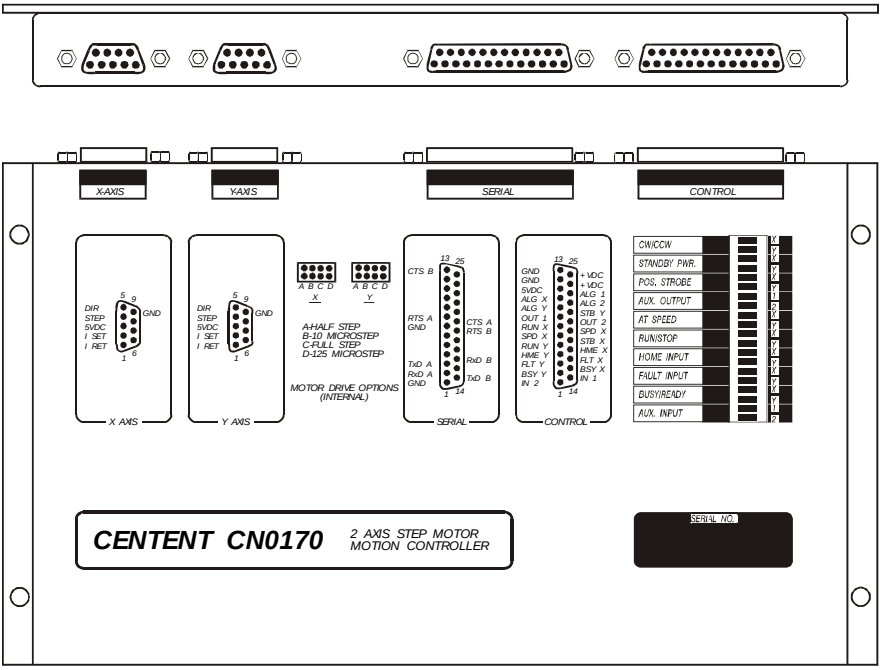
MOTOR PARAMETER INSTRUCTIONS (where shown for X, same for Y)

POSITION SET	XP=n	preset position to “n”
POS. QUERY	XP?	(reply is 4 byte hexidecimal value)
(reply)	X=n	“=” implies motor is at rest
	X+n	“+” implies motor moving CW
	X-n	“-” implies motor moving CCW
VELOCITY		
SET AXIS	XV=b,m	where “b” = base & “m” = max. vel.
	XV=b	where “b” = base vel.
	XV=,m	where “m” = max. vel.
SET VECTOR	XYV=b,m	where “b” = base & “m” = max.
	XYV=b	where “b” = base vel.
	XYV=,m	where “m” = max. vel.
QUERY	XV?	(reply is 2 byte hexidecimal value)
(reply) XV=n	where “n” = current velocity	
	XYV?	
(reply) XYV=n		
ACCEL. SET	XA=n	set acceleration rate
ACCEL. QUERY	XA?	(reply is 2 byte hexidecimal value)
(reply)	XA=n	
ACCELERATION PROFILE SELECT		
LINEAR	XC\L	select linear profile
PARABOLIC	XC\P	select parabolic profile
STORED	XCn	select profile (“n” = 1-16)
USER CURVE	XC\U	select user curve
ENTER USER CURVE DATA	XC(i)=n	where “i” = 1-16 “n” = 1 byte hexidecimal value
QUERY	XC?	
(REPLY)	XC=L	linear profile is active
	XC=P	parabolic profile is active
	XC=n	stored profile “n” is active
	XC=U	user profile is active
RATIO ENABLE	Y/X+	slave/master - direction is the same
	X/Y+	
	Y/X-	slave/master - direction is opposite
	X/Y-	
RATIO DISABLE	Y+0	(or any motion command)
RATIO %	Y/X=.nn	value of ratio (number less than 1)

RATIO QUERY	Y/X?	
(reply)	Y/x=nn	"nn" is 2 byte hexadecimal value
JOYSTICK SEL.	XJn	where "n" = 1-7
DISABLE	XJ0	(or any motion command)
BUSY/READY	XB+	busy input active
	XB-	busy input inactive
TRIGGERS		
POSITION	XP+	prompt when motor in position
	XP-	disable position trigger
VELOCITY	XV+	prompt when motor at max. velocity
	XV-	disable velocity trigger
I/O LINKAGE	XL+	I/O waits for completion of move
	XL-	I/O independent of motor moves
I SET STANDBY	XI=s	"s" is delay (sec.) to standby
	XI=0	standby disabled
MOTOR HOME	XH-	home routine starts CCW
	XH+	home routine starts CW
RESOLUTION	XRn	"n" = 1, 2, 10, 125 step/full step
MODULO QUIT	XM+	turns on modulo quit for X axis
	XM-	shuts modulo quit off for X axis

INPUT/OUTPUT INSTRUCTIONS

DIGITAL I/O		
OUTPUT	P3=n	where "n" = 1 (on) or "n" = 0 (off)
	P4=n	
QUERY	Pn?	query input (n=1,2); output (n=3,4)
P1 DEFINE	P1\G	P1 configured for "GO" command
	P1\I	P1 configured for general purpose
ANALOG CHANNELS		
QUERY	An?	read analog input ("n" 1,2)
	A\X?	read x-axis joystick
	A\Y?	read y-axis joystick
(reply)	An=n	"n" = 1 byte hexadecimal number
	A\X=n or A\Y=n	
AUX. PORT I/O		
INPUT SET	P\I	set aux. Port to all inputs
OUTPUT SET	P\O	set aux. Port to all outputs
BIT CONTROL	P\nnH	set aux. Port to bit control
OUTPUT	P=nnH	output to aux. port
QUERY	P?	query the aux. Port



SPECIFICATIONS

PARAMETER		MIN.	MAX.	UNITS
POSITION	Range	0	4,194,304	full steps
	Resolution	1/1024	1/1024	full steps
VELOCITY	Range	0	16,383.75	full-step/sec.
		0	32,767.50	half-step/sec.
		0	163,837.5	10 µ step/sec.
		0	2,047,969	125 µ
	Resolution	.25	.25	step/sec.
	Available speeds		65,536	full-step/sec.
ACCELERATION	Range	0	4,194,304	full step/sec^2
	Resolution	64	64	full step/sec^2
	Acceleration time (decel. mirrors accel.)	.004	1024	sec.
OPERATING REQ.	Supply voltage	8	12	VDC
	Supply current	20	400	mA
	Operating temp.	0 (32)	70 (158)	°C (°F)
MECHANICAL	Mounting holes	3.875 W	9.0 L	in.
	Mounting screws	#6	#8	in.
	Size	.875 H x 5.6 W x 9.4 L		in.