Overview

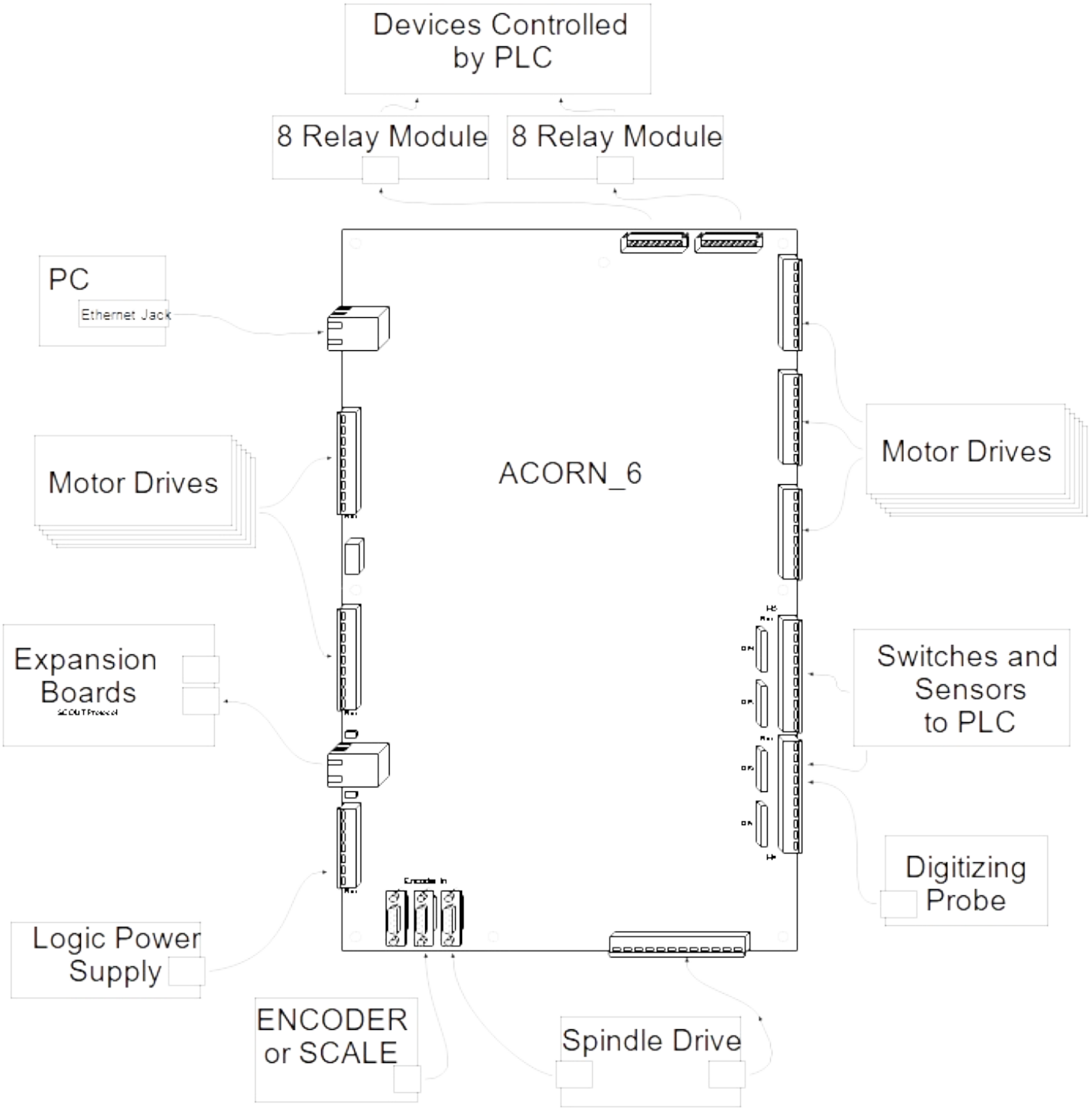
The ACORNSIX is an all in one CNC control board with integrated PLC and on board motion control processor. ACORNSIX interfaces to axis motor drives with open collector, 5V logic, or differential signals (optional). Motor drives may be servo or stepper type. Encoder feedback is not connected to ACORNSIX from the drives. AcornSix can operate in Open Loop, Hybrid Closed Loop and Scales for position feedback and correction Closed Loop.

Communication with a host PC is performed over Ethernet. Three encoder inputs are available through DB9 connectors for functions such as MPG handwheels and spindle encoder. The integrated PLC includes 16 digital inputs and 16 digital outputs for general purpose use. Two analog outputs with PWM option for outputs are provided (see “PLC Section” for details). An additional expansion device can be added through the SCOUT protocol fieldbus port H15. This device may be any of the SCOUT protocol expansion devices.

The built in motion control processor section is code named MPU12. The MPU12 section has increased processing power over MPU11 by up to 4 times. The additional speed can be appreciated by those running complex 5 or more axis programs.

Function:	Motion Control Processor, PLC, and Drive Interface
Maximum number of Axes:	6
Encoder and Scale Inputs:	3 Incremental Encoders (A, B, and Z channels)
Control Interface:	100 Mb/s Ethernet to PC
Digital PLC Inputs:	16
Digital PLC Outputs:	16
Analog or PWM Outputs:	2
Analog Output resolution:	Up to 16 bits
Dimensions (W*D*H):	8 * 12 * 0.75 inches

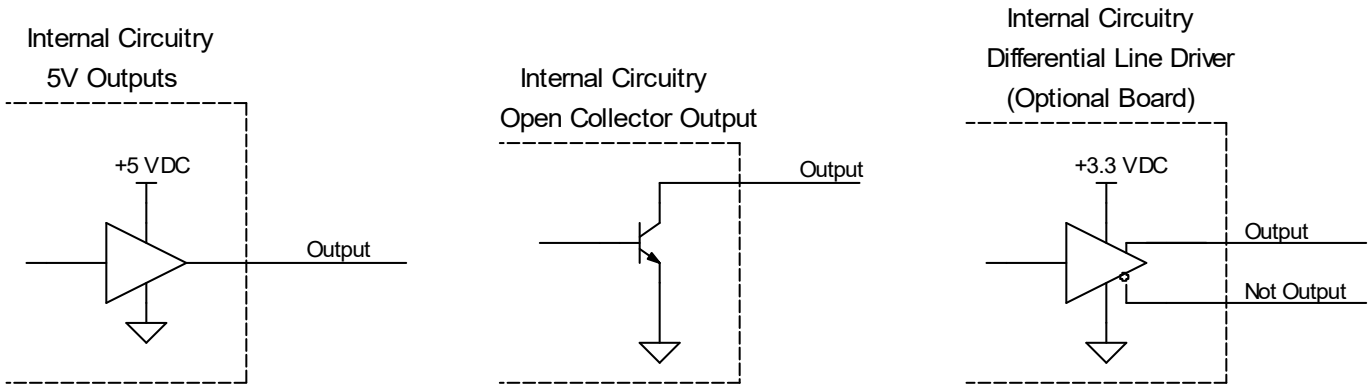
ACORNSIX Typical Connection Overview



Drive Interface Section

ACORNSIX has 6 interfaces to motor drives. The interfaces are duplicated in both open collector and 5V logic output signals. An expansion board is available to also output RS422 compatible differential signals. Output signals to the drives can be switched between step and direction and A/B quadrature pulse forms.

Each axis interface has 3 control signals. A or step, B or direction, and enable. Use “SV_DRIVE_CONTROL_x Bits” “Quad or step out” bit to change between quadrature and step and direction output format. The open collector and differential output headers (optional) have individual enable signals for each axis. 5V output headers have one enable for all axes for a reduced pinout. This “Enable All” signal will activate when any axis on the ACORN_6 is enabled. “SV_DRIVE_CONTROL_x Bits” can be used to invert A/step, B/direction, or enable signals by axis. Enable all signal will be inverted based on the inversion setting of the first axis.

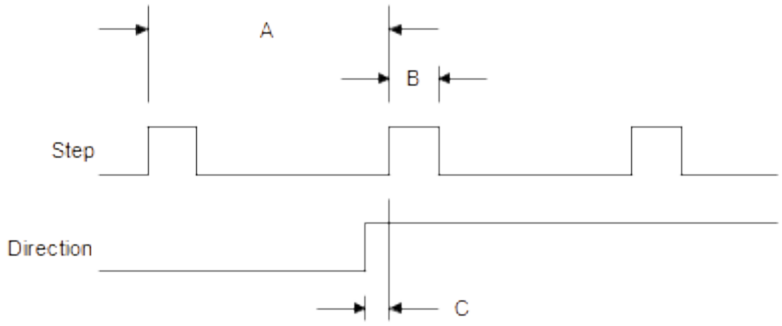


Some parameter setup is required for CNC12 control software to control ACORNSIX axis drives. Drive and encoder mapping does not change for ACORNSIX, so it may be entered directly from the following chart. A step rate must be selected for step and direction output mode. This will specify the maximum possible step rate, and therefore the width of the step pulse. Step rate is 1250khz / (parameter 968). A parameter 968 value of 0 will be changed to 6 internally. Nominal values for parameter 968 are listed in the CNC12 parameter screen.

CNC12 Parameters for ACORNSIX

Parameter	Description	Value
300	CNC11 axis 1 assignment	1
301	CNC11 axis 2 assignment	2
302	CNC11 axis 3 assignment	3
303	CNC11 axis 4 assignment	4
304	CNC11 axis 5 assignment	5
305	CNC11 axis 6 assignment	6
308	CNC11 encoder 1 assignment	7
309	CNC11 encoder 2 assignment	8
310	CNC11 encoder 3 assignment	9
311	CNC11 encoder 4 assignment	10
312	CNC11 encoder 5 assignment	11
313	CNC11 encoder 6 assignment	12
968	Step Rate	0 to 127

Step and Direction Output Waveforms

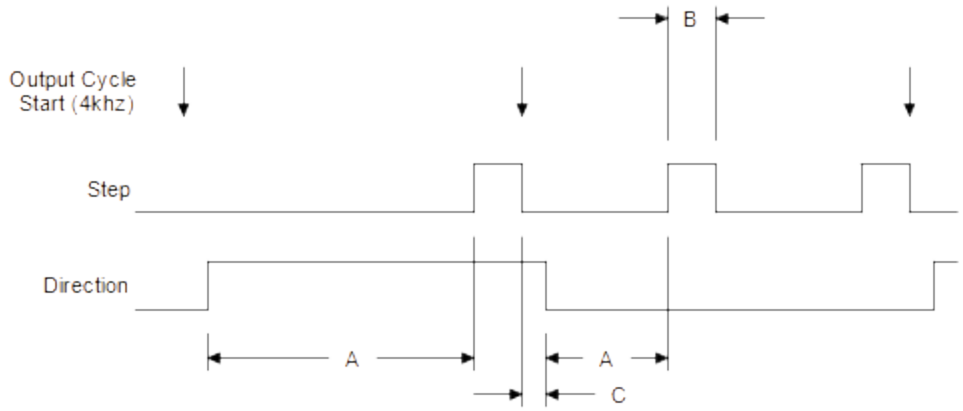


A = 1 / (1250khz / p968) minimum

B = (1 / (1250khz / p968)) / 2

C = B / 2 minimum

Typical Direction Setup Waveforms

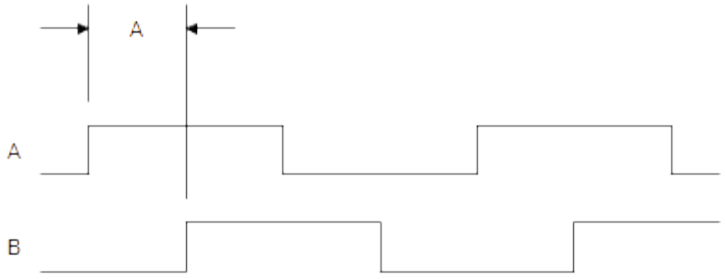


A = Direction is changed at the beginning of a cycle
to give the maximum setup time before step signal

B = (1 / (1250khz / p968)) / 2

C = B / 2 minimum

Typical Quadrature Output Waveforms



A = 0.8us minimum, software limited

Axis setup can be accessed from the PLC program. An error bit is available in SV_DRIVE_STATUS_1 - SV_DRIVE_STATUS_6 and outputs must be written through SV_DRIVE_CONTROL_1 - SV_DRIVE_CONTROL_6.

SV_DRIVE_STATUS_x Bits		Description
0	Reserved	
1	Reserved	
2	Reserved	
3	Quadrature generator error	Too many counts per interrupt requested (LED1 error 8)
4	Reserved	
5	Reserved	
6	Reserved	
7	Reserved	
8	Reserved	
9	Reserved	
10	Reserved	
11	Reserved	
12	Reserved	
13	Reserved	
14	Reserved	
15	Reserved	

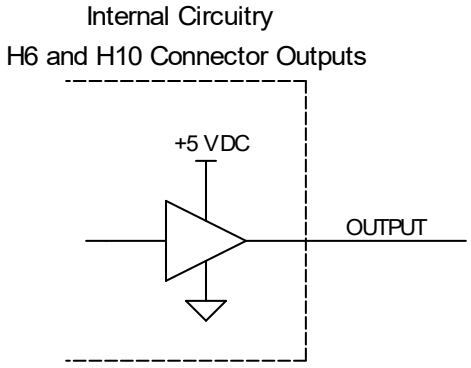
SV_DRIVE_CONTROL_x Bits		Description
0	A / step invert	Signal Invert (1 = invert, 0 = normal)
1	B / direction invert	Signal Invert (1 = invert, 0 = normal)
2	Z / enable invert	Signal Invert (1 = invert, 0 = normal)
3	Quad or step out	Output Form (1 = quadrature, 0 = step and direction)
4	Reserved	
5	Reserved	
6	Reserved	
7	Reserved	
8	Reserved	
9	Reserved	
10	Reserved	
11	Reserved	
12	Reserved	
13	Reserved	
14	Reserved	
15	axis enable	***Axis Enable (1 = enable, 0 = disable)

*** This bit is controlled by the MPU12 firmware. Do not attempt to change it in the PLC program.

PLC Section

Digital Outputs

Sixteen 5 volt logic outputs are available on the ACORNSIX. The outputs are intended to be used with external 8 relay modules. The default (off) logic state is high. A low level will activate a relay on the external board.



Analog Outputs

ACORNSIX is equipped with two analog outputs. One is normally used as a speed request to the spindle drive, while the other is free for special applications. The analog outputs also output a 5V PWM signal. For example, PWM 1 and Analog Out 1 can both be connected on H9, but they are controlled by the same PLC output bits.

Four voltage output ranges are available on the analog output. Mode bits are used to select the output range. The analog output is factory trimmed for high accuracy, and will not require adjustment when changing ranges.

The mode bits also change the PWM frequency to match different applications. For example, laser power controllers often take around 1 kHz and hobby servos can be controlled with 40 to 200 Hz

The analog ground is connected internally to other ACORN_6 GND pins. However, for best wiring results, use the GND pin adjacent to the analog output pin for analog connections. Do not share analog ground wires or connect multiple wires from different devices to an analog GND pin.

Analog Output Ranges

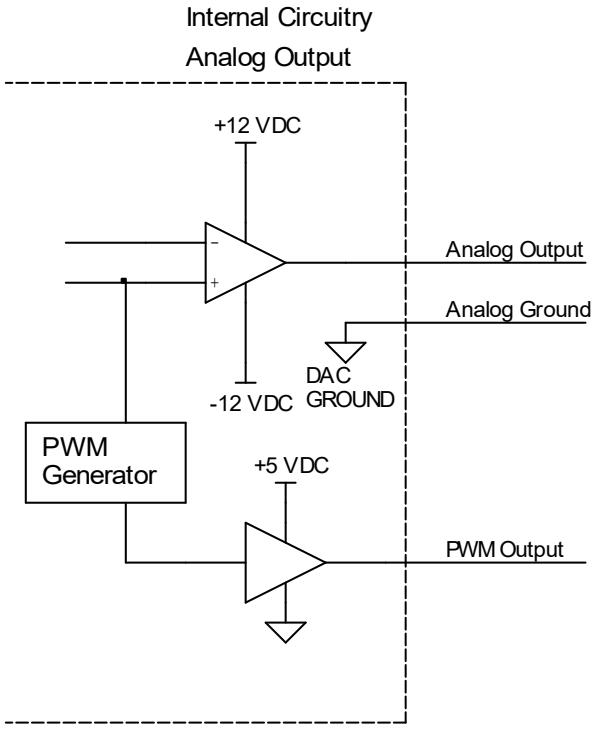
Mode Bit A	Mode Bit B	Range	Resolution
1	1	-10 to 10	16 bits
0	1	-5 to 5	15 bits
1	0	0 to 5	14 bits
0	0	0 to 10	15 bits

PWM Output Frequencies

Mode Bit A	Mode Bit B	Frequency (Hz)	Resolution
1	1	76	16 bits
0	1	610	16 bits
1	0	1221	16 bits
0	0	4883	14 bits

Analog Output Bits

Analog Output	Output Bits	Mode Bit A	Mode Bit B
1	17 - 32	49	50
2	33 - 48	51	52



Analog Output Calculations

0 to 5V Range

$$\text{output voltage} = \frac{\text{Analog Request}}{65536} * 5$$

-5 to 5V Range

$$\text{output voltage} = \left(\frac{\text{Analog Request}}{65536} * 10 \right) - 5$$

0 to 10V Range

$$\text{output voltage} = \frac{\text{Analog Request}}{65536} * 10$$

-10 to 10V Range

$$\text{output voltage} = \left(\frac{\text{Analog Request}}{65536} * 20 \right) - 10$$

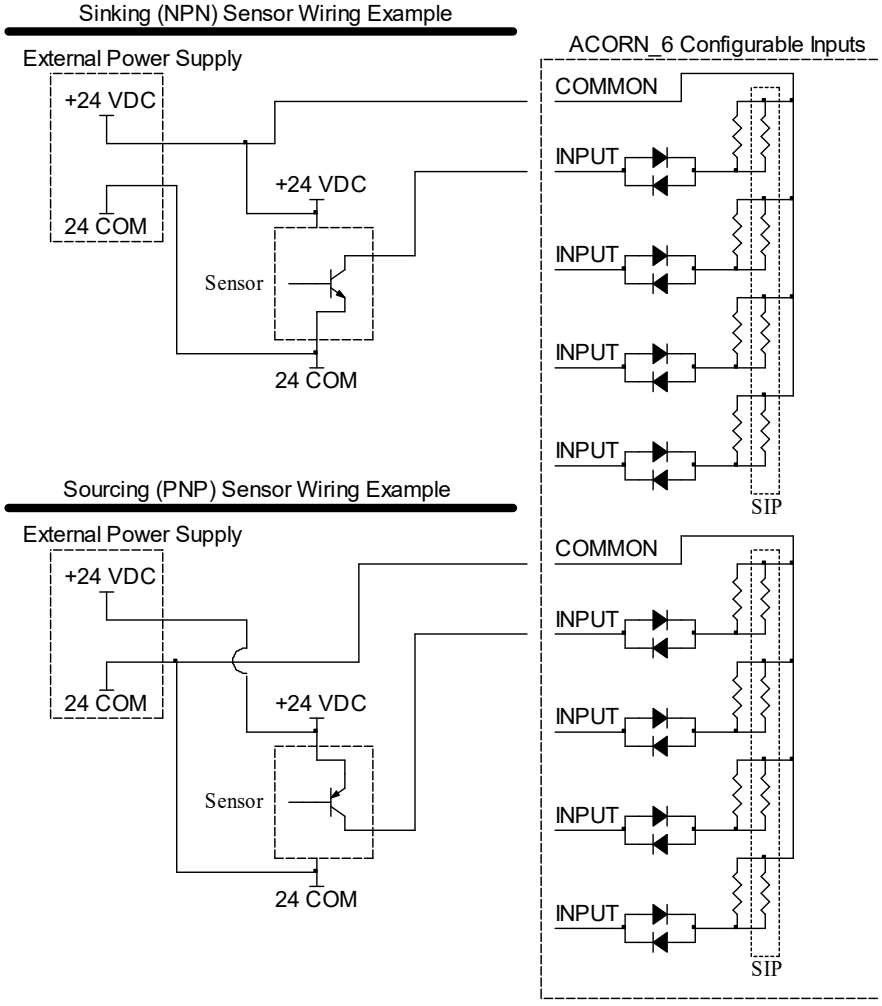
PWM Output Calculations

PWM output can be calculated using the following equation with one exception. Analog request of 65535 will output continuous 5VDC (100% duty cycle, not 99.998%).

$$\text{PWM duty cycle (\%)} = \frac{\text{Analog Request}}{65536} * 100$$

Digital Inputs

ACORNSIX has 16 optically isolated inputs. Inputs are divided into banks of four. Each bank is configurable for various voltages and sinking or sourcing polarity. Voltage may be selected by installing the appropriate value resistor pack or SIP into a socket for each bank. Without a SIP installed, input voltage is set to 24V. Optional SIPs may be installed to use 12V or 5V input voltage. Polarity is determined by wiring the common terminal for the bank to the supply positive or supply common.



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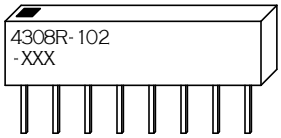
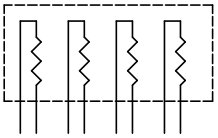
SIP Identification - XXX Indicates Value



SIP Internal Wiring / Pinout



SIP Input Voltage Selection

SIP Value Marking	Resistor Value (Ohms)	Input Voltage
221	220	5
102	1.0k	12
None	None	24

Communication

ACORNSIX uses the SCOUT protocol to communicate with accessories over H15 with RJ45 shielded twisted pair (Ethernet) cables. The communication update cycle is 4000 times per second.

Internally, the I/O section of ACORNSIX is connected over SCOUT. This assigns ACORNSIX to the beginning of I/O space, as discussed below. An additional accessory can be connected with header H15. PLC expansion devices will map their I/O after ACORNSIX on board I/O. JOGBRD12 jog panel controller is assigned a fixed area in memory, so its position in the communication chain is not important for I/O mapping.

Servo drives are assigned in sequence, with the 6 on ACORNSIX first in the communication chain. If a drive device is used with the expansion header, its drive channel(s) will start at 7. See parameters 300 to 307 in the Operator's Manual to map a drive channel to an axis in the CNC12 software.

Accessory Device Memory Assignments

Accessory devices are assigned space based on their connection order. The amount of space required varies depending on the device. Devices may request input and output space in 16 bit increments, which are referred to as slots. The number of input slots must be equal to the number of output slots for all devices.

Jog panel, MPG, and probe devices always map to the same memory areas. These special cases allow for better compatibility with all PLC programs. The location of this I/O is always known. Only one Jog Panel, MPG, and probe expansion device may be used on a system because of the fixed locations for data. The only expansion device expected to be used is the JOGBRD12 jog panel controller. Normally, the probe is wired to ACORNSIX inputs and the wireless MPG uses a USB data path to the PC. Therefore, the mention of probe and MPG expansion devices only applies to special applications.

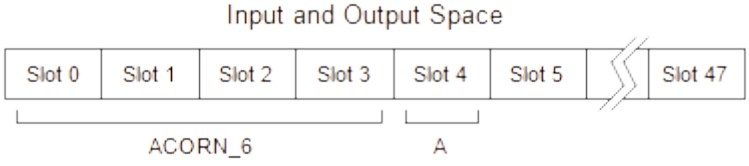
PLC Program INP / OUT, Slot, and I/O Area Relationship

INP / OUT 1 to 16	INP / OUT 17 to 32	INP / OUT 33 to 48	INP / OUT 49 to 64	INP / OUT 65 to 80	INP / OUT 81 to 96	INP / OUT 97 to 112	INP / OUT 113 to 128		INP / OUT 753 to 768
Slot 0	Slot 1	Slot 2	Slot 3	Slot 4	Slot 5	Slot 6	Slot 7		Slot 47

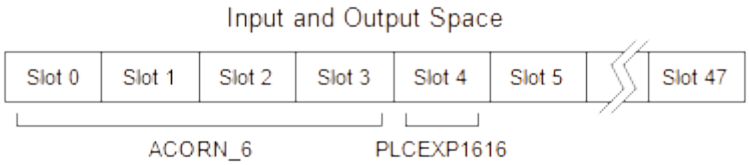
Assignment of I/O slots occurs in a linear fashion starting with the on board I/O. ACORNSIX I/O is the first device in the communication chain. In the following general example, the ACORNSIX I/O takes the first 4 slots. Other devices may change locations if they are plugged into the communication chain in a different order. Additional PLC devices will be assigned starting at the slot marked “A”. ACORNSIX is normally equipped with only one accessible expansion port (5), so the expansion mapping is simplified.

Since I/O space must be reserved in 16 bit increments, some I/O space may be lost if a device has an I/O count that is not a multiple of 16. For example, ACORNSIX output 64 is not used, but must be reserved to match the 16 bit boundary. Input and output space must be reserved in the same quantity. If a device has 16 inputs and no outputs, one slot must be still be reserved in both the input and output space.

PLC Expansion Location Assignment General Example



PLC Expansion Example with PLCEXP1616



PLC I/O Slot Requirements

	Function	Slots Used
Total Available	Any	48
ACORNSIX	Digital and Analog I/O	4
PLCEXP1616	Digital I/O	1

Expansion Board

An expansion board code named ACORN6EXP can be plugged into the top of ACORNSIX. This board provides RS422 differential outputs for drive interfacing. See “Drive Interface Section” for more details.

Four SCOUT protocol expansion ports are also included on the ACORN6EXP. See “PLC Section” “Communication” for details of expansion with this protocol.

PLC I/O Map

Input Specification			Input Location	
Number	Function	Type	Connector	Pin
1	General Purpose	Sink / Source	H4	1
2	General Purpose	Sink / Source	H4	2
3	General Purpose	Sink / Source	H4	3
4	General Purpose	Sink / Source	H4	4
5	General Purpose	Sink / Source	H4	6
6	General Purpose	Sink / Source	H4	7
7	General Purpose	Sink / Source	H4	8
8	General Purpose	Sink / Source	H4	9
9	General Purpose	Sink / Source	H5	1
10	General Purpose	Sink / Source	H5	2
11	General Purpose	Sink / Source	H5	3
12	General Purpose	Sink / Source	H5	4
13	General Purpose	Sink / Source	H5	6
14	General Purpose	Sink / Source	H5	7
15	General Purpose	Sink / Source	H5	8
16	General Purpose	Sink / Source	H5	9
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
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55				
56				

Output Specification			Output Location	
Number	Function	Type	Connector	Pin
1	General Purpose	5V Logic	H10	2
2	General Purpose	5V Logic	H10	3
3	General Purpose	5V Logic	H10	4
4	General Purpose	5V Logic	H10	5
5	General Purpose	5V Logic	H10	6
6	General Purpose	5V Logic	H10	7
7	General Purpose	5V Logic	H10	8
8	General Purpose	5V Logic	H10	9
9	General Purpose	5V Logic	H6	2
10	General Purpose	5V Logic	H6	3
11	General Purpose	5V Logic	H6	4
12	General Purpose	5V Logic	H6	5
13	General Purpose	5V Logic	H6	6
14	General Purpose	5V Logic	H6	7
15	General Purpose	5V Logic	H6	8
16	General Purpose	5V Logic	H6	9
17	Spindle Analog b0	Analog	H9	5,9
18	Spindle Analog b1	Analog		
19	Spindle Analog b2	Analog		
20	Spindle Analog b3	Analog		
21	Spindle Analog b4	Analog		
22	Spindle Analog b5	Analog		
23	Spindle Analog b6	Analog		
24	Spindle Analog b7	Analog		
25	Spindle Analog b8	Analog		
26	Spindle Analog b9	Analog		
27	Spindle Analog b10	Analog		
28	Spindle Analog b11	Analog		
29	Spindle Analog b12	Analog		
30	Spindle Analog b13	Analog		
31	Spindle Analog b14	Analog		
32	Spindle Analog b15	Analog		
33	Analog2 b0	Analog	H9	7,11
34	Analog2 b1	Analog		
35	Analog2 b2	Analog		
36	Analog2 b3	Analog		
37	Analog2 b4	Analog		
38	Analog2 b5	Analog		
39	Analog2 b6	Analog		
40	Analog2 b7	Analog		
41	Analog2 b8	Analog		
42	Analog2 b9	Analog		
43	Analog2 b10	Analog		
44	Analog2 b11	Analog		
45	Analog2 b12	Analog		
46	Analog2 b13	Analog		
47	Analog2 b14	Analog		
48	Analog2 b15	Analog		
49	Analog Out 1 setup A	Internal		
50	Analog Out 1 setup B	Internal		
51	Analog Out 2 setup A	Internal		
52	Analog Out 2 setup B	Internal		
53				
54				
55				
56				

PLC I/O Map (continued)

Input Specification			Input Location	
Number	Function	Type	Connector	Pin
57				
58				
59				
60				
61				
62				
63				
64				

Output Specification			Output Location	
Number	Function	Type	Connector	Pin
57	Step rate b0	Internal		
58	Step rate b1	Internal		
59	Step rate b2	Internal		
60	Step rate b3	Internal		
61	Step rate b4	Internal		
62	Step rate b5	Internal		
63	Step rate b6	Internal		
64				

ACORNSIX Specifications

Characteristic	Min.	Typ.	Max.	Unit
24 Volt Supply Current	0.75	-	-	A
5 Volt Supply Current	1.75	-	-	A
Input Pullup Voltage (Vinp)	4	-	30	VDC
Input On Voltage*	Vinp-1.25	-	-	VDC
Input Off Voltage*	-	-	1.25	VDC
Input Operating current	9	14	21	mA
Analog Output Current	0	1	10	mA
Analog Output Voltage	-10	-	10	V
Analog Output Resolution	-	16	-	bits
Analog Output Error	-	< 0.1	-	%
Open Collector Output Current	0	10	50	mA
Open Collector Output Voltage	0	24	30	VDC
5V Output High Voltage	4.4	4.9	VCC	VDC
5V Output Low Voltage	0	0.1	0.44	VDC
5V Low Level Output Current	0	3	20	mA
5V High Level Output Current	0	3	20	mA
Encoder channel input low	0	-	0.5	V
Encoder channel input high	3.5	-	5	V
Encoder input frequency low speed**	0	-	1200	khz
Encoder input frequency high speed**	0	-	6000	khz
Size: 12 * 8 * 1 (W*D*H)				Inches

* Inputs may be wired either polarity. Input "on" and "off" ratings in the chart refer to the absolute difference between the input terminal and common terminal. Input devices must meet these specifications for long term reliability.
** Frequency of A or B channel. See parameter 323 for switching encoder filter speed
VCC is supply voltage into H16 pins 1 and 2, 4.5V < VCC < 5.5V

8 Relay Board Specifications

Characteristic	Min.	Typ.	Max.	Unit
5 Volt Supply Current	0.576	-	-	A
Relay Output Current (resistive load)	0.01	-	7	A @ 240VAC
Relay Output Current (resistive load)	0.01	-	7	A @ 28VDC
Relay Output Current (inductive load)	0.01	-	3	A @ 120VAC
Relay Output Current (inductive load)	0.01	-	3	A @ 28VDC

Symptom	Possible Cause	Corrective Action
LED1 out	Power loss	Check 24V wiring to H16
	Power supply overloaded	Check external loads connected to supply and ACORN_6
LED1 segments not scrolling	Offline	Start CNC12 software. Check communication cables.
Encoders or relays not working	Power loss	Check 5V wiring to H16
	Power supply overloaded	Check external loads connected to supply and encoder or relay connectors
Input doesn't work with sensor	Incorrect wiring	Correct wiring for sensor type (sinking or sourcing), check that SIP values are appropriate for the input voltage
	Voltage drop across sensor is too high	Use 3-wire sensors with lower voltage drop spec.

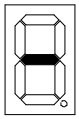
LED1 Error Codes

Error Number	Meaning	Cause	Corrective Action
1			
2			
3			
4			
5			
6	Voltage failure	Power was lost	If error appears briefly at startup, it is normal, otherwise check for loose power connections
7	Communication out of sync	Data in and out are not locked together in a synchronous relationship	Internal error, contact Centroid
8	Too many counts per interrupt requested (>511) or too many steps per interrupt (based on p968 rate)	Communication error or too fast movement requested by CNC12	Cycle Estop to clear. Maximum rate may need to be lowered.
9			

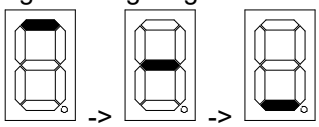
LED1 Operation

A 7 segment display (LED1) is used to display status. At startup, all number segments will light in a rotating pattern until initialization is complete. Initialization takes several seconds.

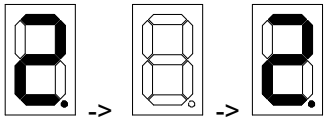
After initialization, one segment will light if ACORN_6 is ready, but not enabled. Usually the ACORN_6 is only briefly in this state immediately after initialization.

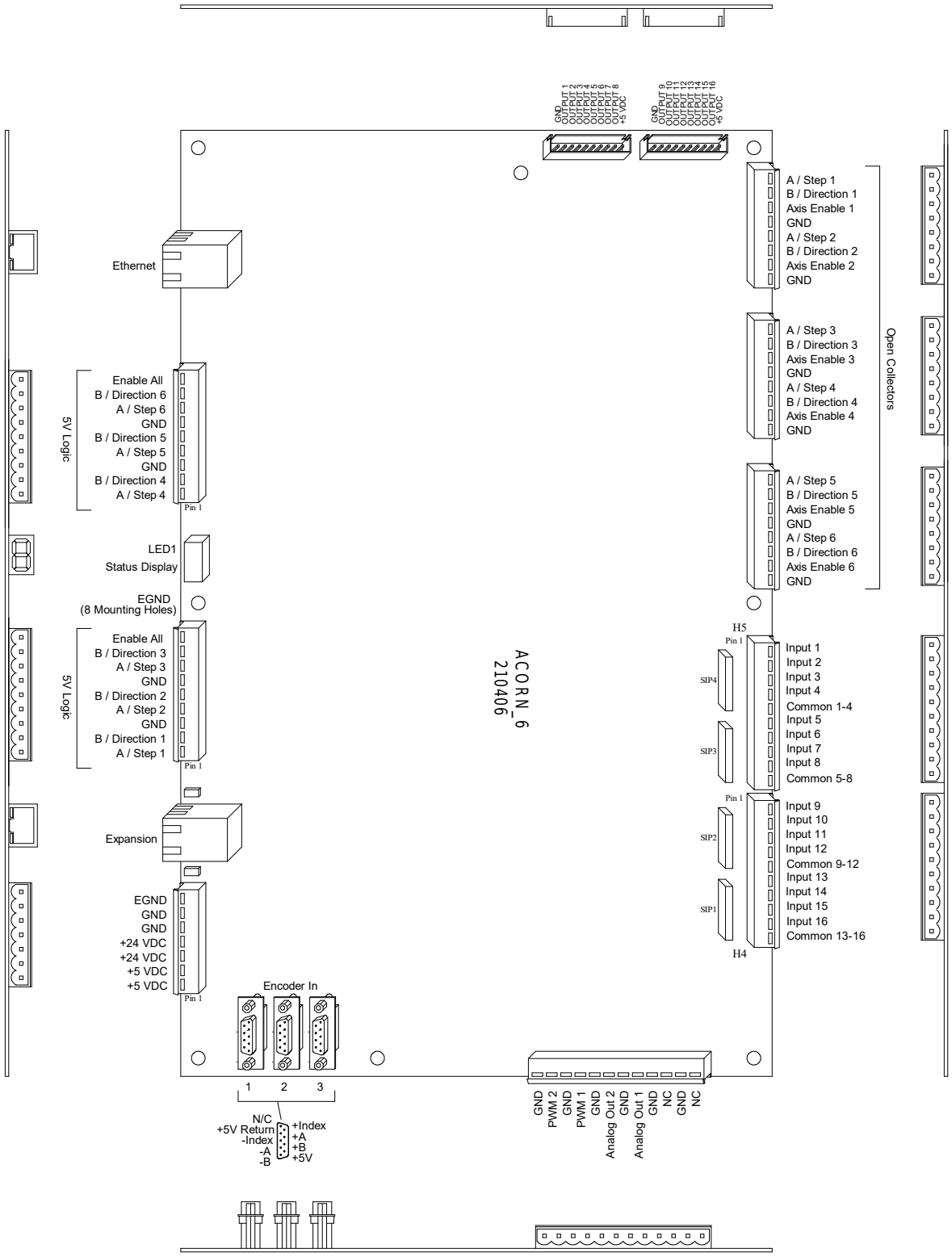
 Ready, but not running

Center segments lighting in a scrolling pattern indicates normal operation.

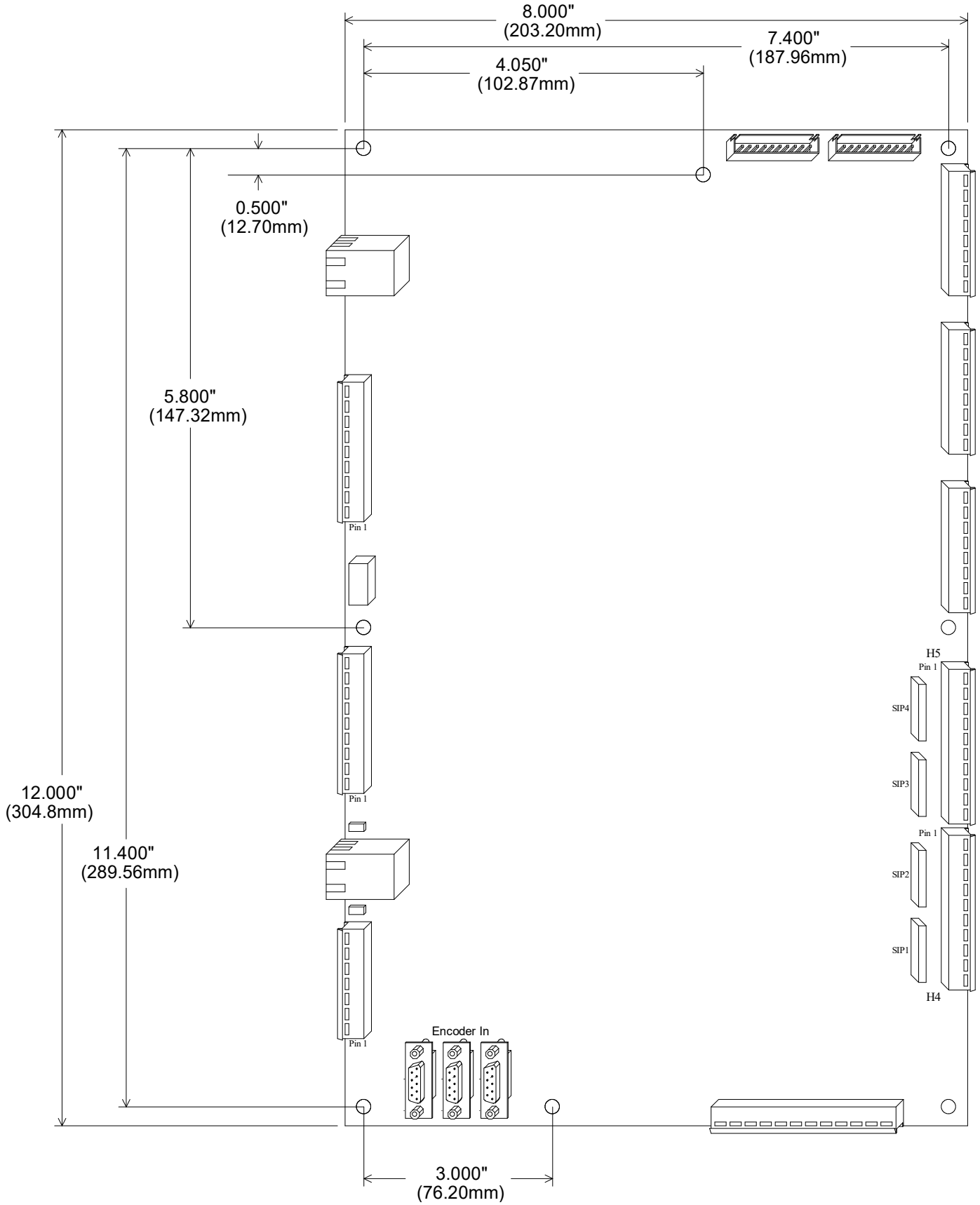
 Running normally

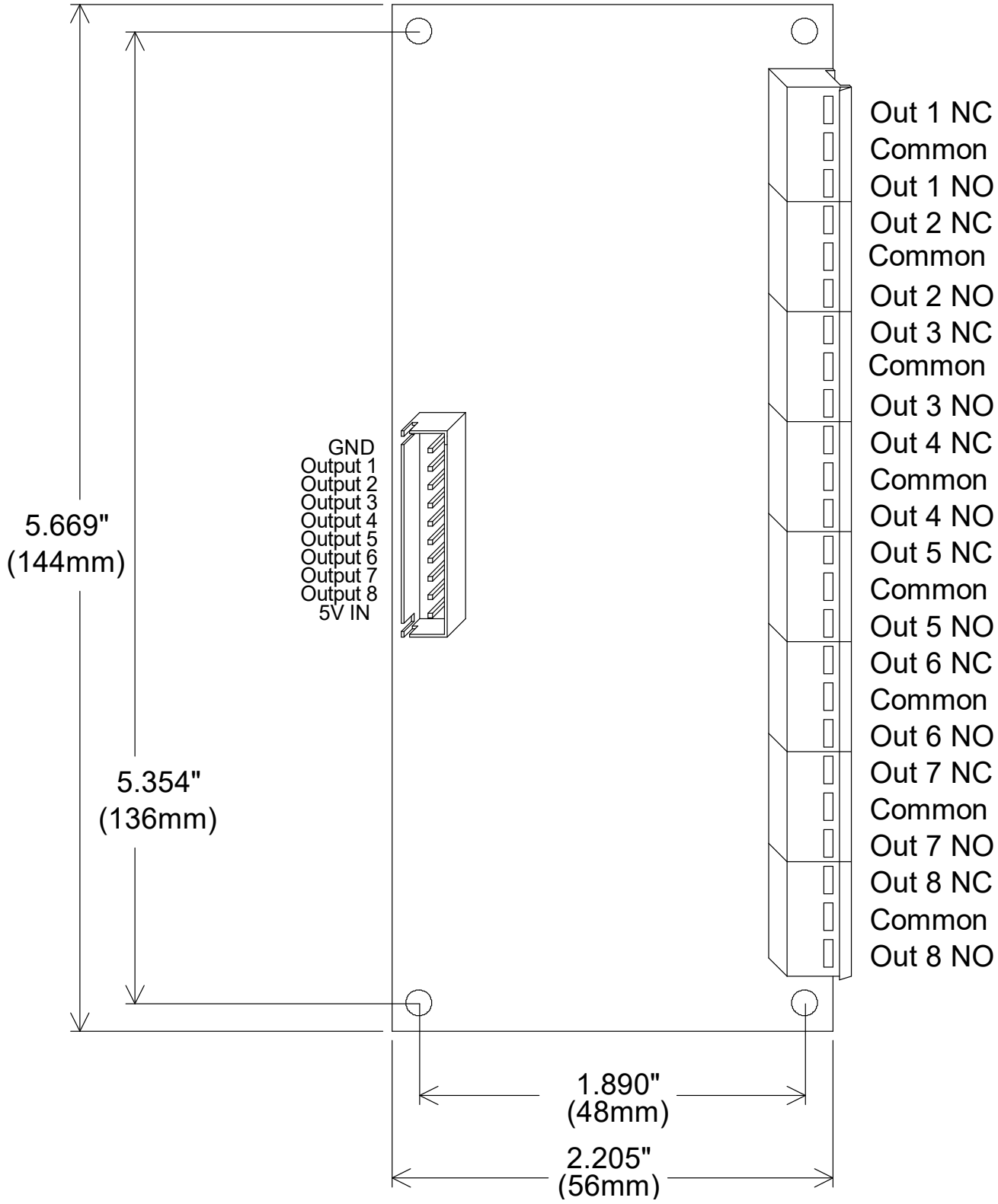
Errors are indicated by a flashing number with the decimal point lit continuously. See “LED1 Error Codes” chart for error descriptions.

 Flashing number indicates an error


GND
OUTPUT 1
OUTPUT 2
OUTPUT 3
OUTPUT 4
OUTPUT 5
OUTPUT 6
OUTPUT 7
OUTPUT 8
+5 VDC
GND
OUTPUT 9
OUTPUT 10
OUTPUT 11
OUTPUT 12
OUTPUT 13
OUTPUT 14
OUTPUT 15
OUTPUT 16
+5 VDC
A / Step 1
B / Direction 1
Axis Enable 1
GND
A / Step 2
B / Direction 2
Axis Enable 2
GND
A / Step 3
B / Direction 3
Axis Enable 3
GND
A / Step 4
B / Direction 4
Axis Enable 4
GND
A / Step 5
B / Direction 5
Axis Enable 5
GND
A / Step 6
B / Direction 6
Axis Enable 6
GND
Open Collectors
Ethernet
Enable All
B / Direction 6
A / Step 6
GND
B / Direction 5
A / Step 5
GND
B / Direction 4
A / Step 4
5V Logic
Pin 1
LED1
Status Display
EGND
(8 Mounting Holes)
Enable All
B / Direction 3
A / Step 3
GND
B / Direction 2
A / Step 2
GND
B / Direction 1
A / Step 1
5V Logic
Pin 1
Expansion
EGND
GND
GND
+24 VDC
+24 VDC
+5 VDC
+5 VDC
Pin 1
ACORN_6
21406
H5
Pin 1
SIP4
SIP3
SIP2
SIP1
Input 1
Input 2
Input 3
Input 4
Common 1-4
Input 5
Input 6
Input 7
Input 8
Common 5-8
Input 9
Input 10
Input 11
Input 12
Common 9-12
Input 13
Input 14
Input 15
Input 16
Common 13-16
H4
Encoder In
1 2 3
N/C
+5V Return
-Index
-A
-B
+Index
+A
+B
+5V
GND
PWM 2
GND
PWM 1
GND
Analog Out 2
GND
Analog Out 1
GND
NC
GND
NC

ACORNSIX Mounting Dimensions




GND
Output 1
Output 2
Output 3
Output 4
Output 5
Output 6
Output 7
Output 8
5V IN
Out 1 NC
Common
Out 1 NO
Out 2 NC
Common
Out 2 NO
Out 3 NC
Common
Out 3 NO
Out 4 NC
Common
Out 4 NO
Out 5 NC
Common
Out 5 NO
Out 6 NC
Common
Out 6 NO
Out 7 NC
Common
Out 7 NO
Out 8 NC
Common
Out 8 NO
5.669"
(144mm)
5.354"
(136mm)
1.890"
(48mm)
2.205"
(56mm)

ACORN6EXP Connections
Optional Expansion Board