

## SECTION 24

### ACON (Automatic Convergence Option)

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No tables are included in this section.

## 24.1 TECHNICAL DESCRIPTION

### 24.1.1 General Description

ACON is an optional automatic convergence feature for Electrohome ECP 3100 series, 4100 series and future model projectors. The system consists of a Locator Assembly, Control Board and Locator Cable. The Locator Assembly, situated on the front of the projector, is the "eye" of the system. It mechanically scans the projected display in each convergence zone while sensing relative positions of each projected color. Sensory information is directed via wire harness to the Control board in the projector card rack. The Control board analyses this data to determine image positioning, then adjusts the vertical and horizontal positions of the red and blue colors until optimum convergence with the green image is achieved.

The ACON hardware is under the control of software stored in PROM on the Remote Control Board and is run by that board's 80C154 microcontroller. Automatic convergence is performed by the repetition of four fundamental operations: 1) a 'target' is generated at the location in the projected image that is to be converged; 2) the photosensor on the Locator Assembly is pointed at the target using the stepper motors; 3) registration between the color components of the target image is sensed by reading the photosensor; and 4) the color components at the current screen position are moved using the projector's convergence circuitry to register the colors. For off-center points, the Digital Convergence Board provides the correction. For the center, the Remote Control Board generates control voltages that specify the positions of each color raster as a whole. Convergence of the colors must be ensured at the center before converging any other area.

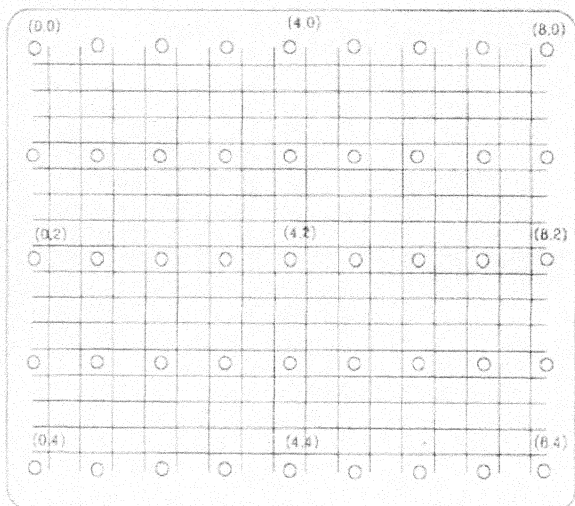


FIGURE 24-1. Screen Convergence Points

There are 45 convergence points arranged in a 9 X 5 rectangular matrix on the projected raster. Figure 24-1 illustrates the position of each convergence point, relationship to the internal crosshatch video pattern. The position of the red, green and blue component images are independently specified at each of these control points. Positioning between control points is calculated by linear interpolation: horizontally by software and vertically by the Digital Convergence board hardware (in real time).

### 24.1.2 Hardware Description

#### 24.1.2.1 Locator Assembly

The Locator Assembly consists of a rigid metal casting supporting two stepper motors in an orthogonal-rotation configuration onto which is mounted a lens/sensor component containing an objective (imaging) lens at one end, and a photosensor device at the other end. The motors allow the optical system to be aimed at any arbitrary point on a projection screen in front of the system.

The photosensor is a custom designed quadrant photodiode array. The function of the sensor is to detect (through the objective lens) the position of a target imaged produced by the projector. The sensor size and lens focal length combine to give the assembly telephoto view of the projected light on the screen. This allows the sensor to accurately determine the position of the image.

### 24.1.3 Circuit Description

The ACON electronics is divided between two circuit boards: the ACON Sensor Board (in the Locator Assembly) and the Control Board (in the projector card rack). The circuits are interconnected by the shielded multi-conductor Locator Cable.

#### 24.1.3.1 ACON Sensor Board

The ACON Sensor Board is mounted at the back end of the lens/sensor component in the Locator Assembly. The photodiode array is mounted at the center of the board on the optical axis of the imaging lens. It is surrounded by surface-mounted amplifier circuitry; one amplifier channel for each quadrant of the sensor.

The board operates on +12V and -12V. It outputs four analog voltages proportional to the amount of light on each of the inner quadrant photodiodes. These signals are sent via the Locator Cable to the Control Board in the projector card rack.

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#### 24.1.3.2 ACON Control Board

The ACON Control board (in the projector card rack) contains motor control, data acquisition and software recognition circuitry.

##### Motor Control Circuitry

The two stepper motors in the Locator Assembly are controlled by identical circuits, each consisting of a micro-step controller IC (U10 and U12) and a motor driver IC (U11 and U13). The micro-step controller IC specifies the levels of current in each of the two motor windings, as set by internal DACs that are loaded by the system microcontroller. The motor driver IC provides the specified current at 14VDC to both motor phases.

The +14V supply is obtained from the projector's +5V supply by means of an on-board boost converter.

##### Data Acquisition Circuitry

Each of the four photodiode quadrant signals are fed to analog peak-hold circuits (U1, U2, U3 and U4) which hold the highest voltage levels received until selectively discharged. The resultant "peak" signals are fed to a 4 channel 12-bit analog-to-digital converter (U9). Input range of the analog inputs is 0 - 5V. Channel selection and initiation of data conversion is made via data bus (D0 to D7), address bus (A0 to A15), and address-decoded 'select' lines (SEL6 and SEL7) under the control of the 80C154 microcontroller resident on the Remote Control Board.

##### Software Recognition Circuitry

The software recognition circuitry allows the projector's system software to recognize the existence of the ACON Control Board in the projector. It is comprised of a read-only register (U5) with a hard-wired identification code (55H), readable at a specific bus address by the projector's microcontroller.

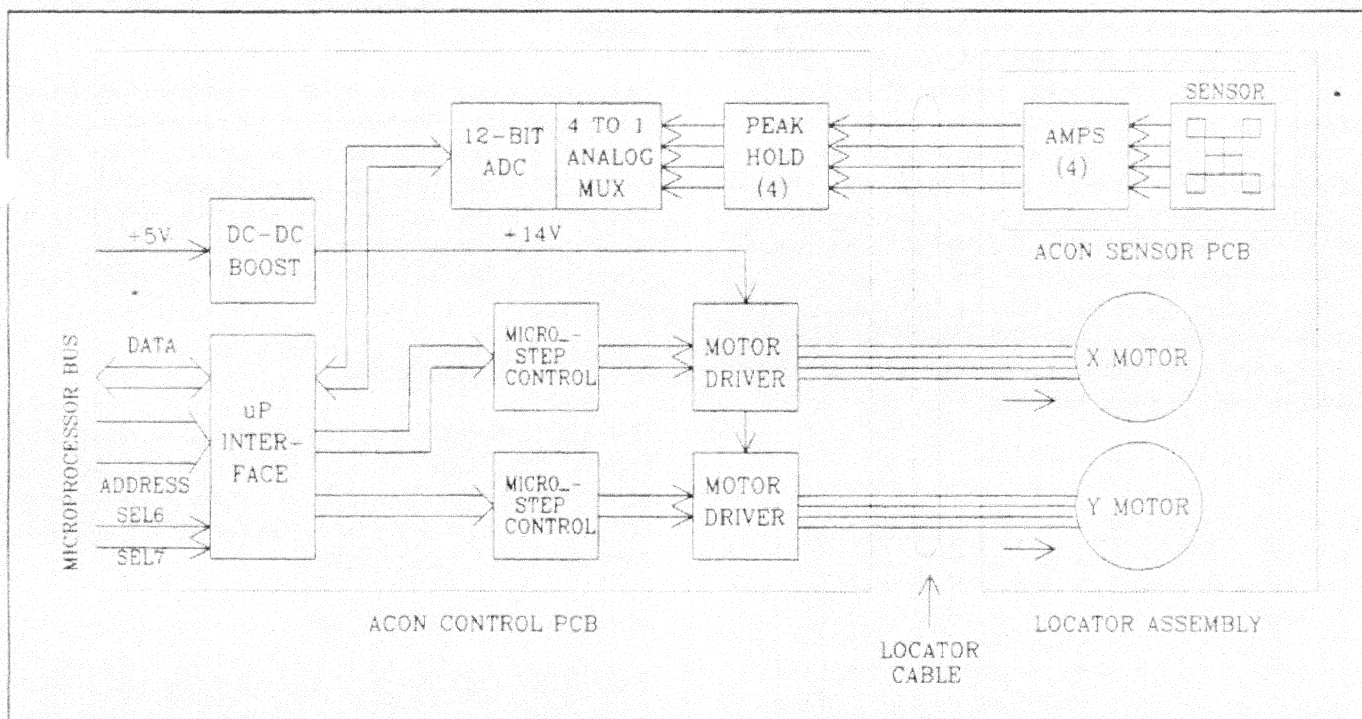


FIGURE 24-2. ACON Function Block Diagram

## 24.2 SERVICING AND ALIGNMENT

### 24.2.1 Disassembly and Access

#### **WARNING**

**STATIC SENSITIVE COMPONENTS**  
**STATIC CONTROLLED WORK STATION REQUIRED**

Module Location:

- card rack (Control Board)
- front panel (Locator Assembly)

#### **Tools & Equipment Required:**

- Phillips screw driver
- circuit board extractor

#### 24.2.1.1 Control Board Removal

- a) Remove the back panel as described in Section 5.
- b) Locate the ACON Control Board in the rear panel card rack. The ACON Control Board is located in the "SPARE" slot of the Card Rack (refer to Figure 5-8). Using the printed circuit board extractor from the tool pouch, pull the module from the card rack as described in Section 5.2.

#### 24.2.1.2 Locator Assembly Removal

- a) Remove the three mounting screws securing the Locator Assembly to the front panel.
- b) Gently Slide the Locator Assembly down (away from lens) about 2 inches. Disconnect the Locator Cable from the assembly by removing the two connector screws.

#### 24.2.1.3 Locator Cable Removal

The Locator Cable connects between the P20 connector on the Mother Board and the Locator Assembly. The Locator Cable path is illustrated in Figure E-1 in Appendix E.

- a) Remove the ACON Control Board per step 24.2.1.1 above. In the same way, remove the Convergence module.
- b) Remove the upper and lower snap-in type card slides and module shields for the two removed boards.
- c) Unplug the Locator Cable at the P20 connector on the Mother Board.
- d) Remove the Locator Assembly per step 24.2.1.2 above.

- e) Remove the front top cover per Section 5.2.1.
- f) From the lens area, pull out both ends of the Locator Cable and remove.

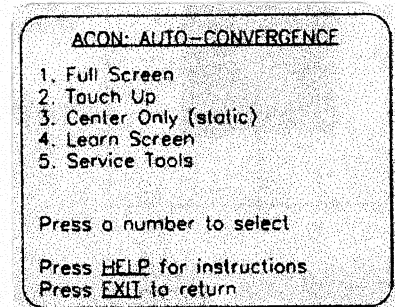
#### 24.2.2 Diagnostics

ACON's software includes a servicing mode to assist when trying to identify or pinpoint the source of an automatic convergence problem. While in service mode, the service technician can:

- 1) Auto-converge at any specified convergence point,
- 2) Record and analyse sensory data for any specified convergence point.

To enter service mode:

- a) Call up the CONVERGENCE menu by pressing the **CONV** button on the projector keypad. Select item 4, *ACON: Auto-Convergence*.
- b) With the ACON Automatic Convergence menu displayed, press the **\*\*** key. Item 5, *Service Tools* will appear as shown.



- c) Select item 5. The screen will display all 45 convergence points. ACON is now in service mode. Leave service mode at any time by pressing the **EXIT** key on the keypad. Pressing the **HELP** key will display a summary of available functions.

To automatically converge or view sensory data of a convergence point, press the **MOV** key on the keypad. The screen will prompt you for the x and y coordinates of the convergence point. Input each coordinate from the keypad (refer to Figure 24-1). Upon completion, a green "target" will be displayed for the convergence point. The sensor motors will position the sensor to the center of the target, based on data stored in the automatic convergence database. Sensory data currently recorded by the sensors is displayed on the screen.



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To converge the selected point:

Press the **CONV** key on the keypad.

Selection of the individual red, green or blue colors for viewing and analysis may be made by pressing the **COLOR** button on the keypad. Repeated presses of the **COLOR** button cycle the colors in the following order:

1. white (all colors)
2. green
3. red
4. blue
5. background (no target)

### How to analyse the positional data

ACON measures the reflected light from a target in each of the four sensor quadrants as illustrated below.

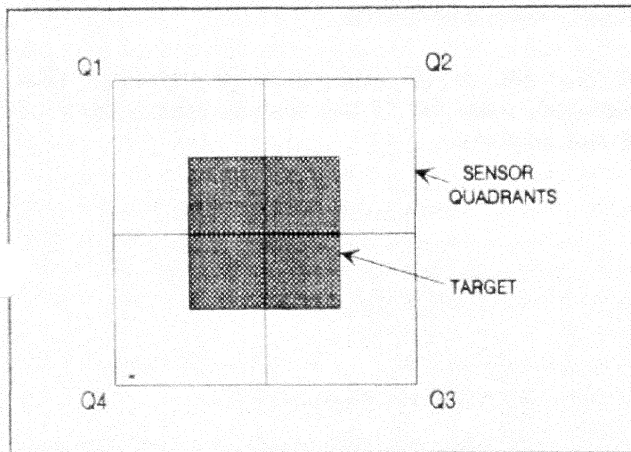


FIGURE 24-3. *Sensor Quadrants*

Analog values are converted by the analog-to-digital converter on the ACON Control Board and displayed in hexadecimal format on the display screen. Calculated positional data based on the above measurements is also displayed. Each data value displayed is described below.

- Q1** A hexadecimal value between 000 and FFF representing the amount of reflected light measured in quadrant Q1.
- Q2** A hexadecimal value between 000 and FFF representing the amount of reflected light measured in quadrant Q2.
- Q3** A hexadecimal value between 000 and FFF representing the amount of reflected light measured in quadrant Q3.

**Q4** A hexadecimal value between 000 and FFF representing the amount of reflected light measured in quadrant Q4.

**CX** A hexadecimal value between -400 and +400 representing the horizontal displacement of the target's centroid relative to the center of the sensor.

**CY** A hexadecimal value between -400 and +400 representing the vertical placement of the target's centroid relative to the center of the sensor.

**MX** A hexadecimal value between 000 and C80 representing the displacement of the horizontal motor relative to the home position.

**MY** A hexadecimal value between 000 and FFF representing the displacement of the vertical motor relative to the home position.

Based on the screen information, it may be possible to pinpoint automatic convergence problems.

Ideally, but impractically, the amount of light measured in each quadrant when the sensor points at a converged target should be identical and constant. As it is not reasonable to expect exact matching, the fact that the displayed values are reasonably close is a good sign. In addition, the values constantly change due to factors such as electrical field noise, magnetic fluctuations, thermal noise and vibration. Changes up to 10 (HEX) are considered normal.

The values CX and CY represent the horizontal and vertical distances, respectively, of an imaged target in a given color from the center of the sensor. For the green color, both CX and CY will normally be less than 80 (Hex). On a converged point, the CX and CY values of the red and blue colors should closely match the corresponding values for the green color.

If the displayed values are not as described above, auto-converge the selected point. If a problem still exists, check other convergence points. If the problem is consistent among other convergence points, reduce the amount of room lighting and try again. If the problem persists, the Locator Assembly or the Control Board may require replacement. Inconsistency amongst different convergence points (or the same point tested at different times) may indicate that the eccentric motor stops are not properly positioned. If this is the case, refer to section 24.2.3, *Alignment and Adjustments*.

- CX** A hexadecimal value between -400 and +400 representing the horizontal displacement of the target's centroid relative to the center of the sensor.
- CY** A hexadecimal value between -400 and +400 representing the vertical placement of the target's centroid relative to the center of the sensor.
- MX** A hexadecimal value between 000 and C80 representing the displacement of the horizontal motor relative to the home position.
- MY** A hexadecimal value between 000 and FFF representing the displacement of the vertical motor relative to the home position.

Based on the screen information, it may be possible to pinpoint automatic convergence problems.

Ideally, but impractically, the amount of light measured in each quadrant when the sensor points at a converged target should be identical and constant. As it is not reasonable to expect exact matching, the fact that the displayed values are reasonably close is a good sign. The values constantly change due to factors such as electrical field noise, magnetic fluctuations, thermal noise and vibration. Changes up to 10 (HEX) are considered normal.

If the light measurements (Q1 to Q4) are not reasonably balanced, auto-converge the selected point. If a problem still exists, check other convergence points. If the problem is consistent among other convergence points, amplifier gain of each quadrant channel may not be equal. The Locator Assembly or the Control Board may require replacement. Inconsistency amongst different convergence points (or the same point tested at different times) may indicate that the eccentric motor stops are not properly positioned. If this is the case, refer to section 24.2.3, *Alignment and Adjustments*.

If all light measurements are close to 000 or FFF, the motors may not be placing the sensor at the projected target. This can occur if the setup configuration (Learn Screen) does not match the actual system configuration or the motor drive circuitry is not operating properly. Use the Learn Screen feature as described in the ACON User's manual and re-converge. If the problem still exists, check the physical position of the lens/sensor component. If it does not appear to be positioned toward the specified convergence point on the display, the motor drive circuitry on the Control Board may be at fault.

### 24.2.3 Alignment and Adjustments

Adjustment of the eccentric motor end stops is the only service adjustment which may be performed to the ACON system. This adjustment may be required if ACON does not accurately or consistently auto-converge at each convergence point. There are two end stops, one at each end of the "stop bar" on the Locator Assembly. Each end stop consists of a rubber grommet with an eccentrically placed center hole. When the motors move to their "home" position, the lens/sensor component butts up against each stop. Rotating the stop changes the physical location of the home position.

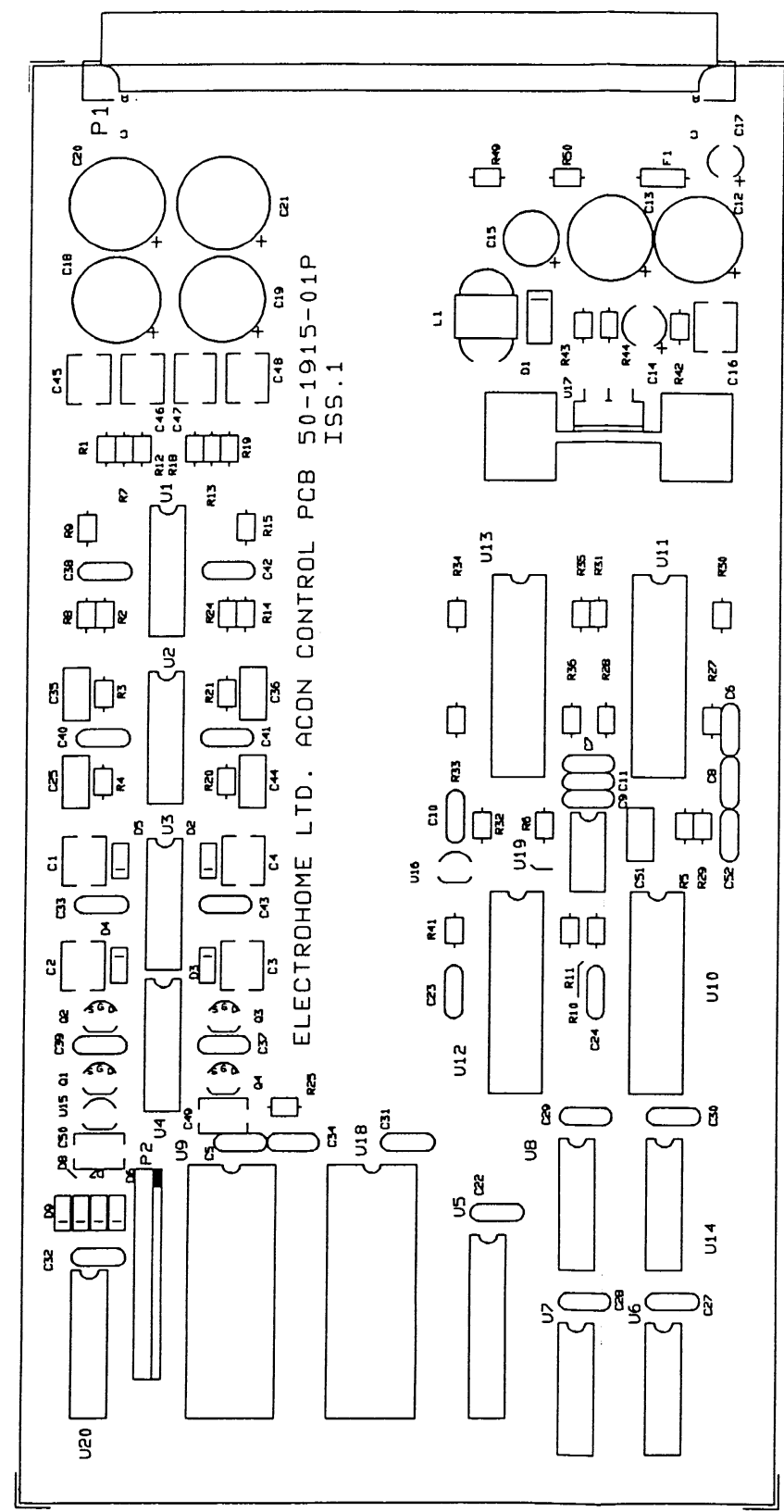
The final end adjustment of each end stop can be critical to assure repeatable and reliable positioning of the Locator Assembly stepper motors. Each motor moves in discrete "steps". To move the lens/sensor component to a specified position, each motor is "stepped" by a known number from the home position. Errors result if the settled home position of the motors is not the same after each motor homing. This may occur if either of the stop positions, set by the eccentric motor end stops, falls between two step positions. A "bounce-back" effect from the end stop occurs which may set the motor home position as many as a few steps away from the true physical home position. This problem does not occur if the physical home position is in-line with one of the natural step positions of each motor. To adjust the eccentric end stops, follow the procedure below.

- a) Press the **RESET** key on the projector keypad. This sets the motors to their home position.
- b) Select one of the converge points using the **MOV** command.
- c) Record the cx and cy coordinate values.
- d) Repeat a) to c) above. If either the cx or cy coordinate values are significantly different than the first readings, slightly rotate the appropriate end stop grommet. Repeat a) to d) until the readings are reasonably close between measurements.

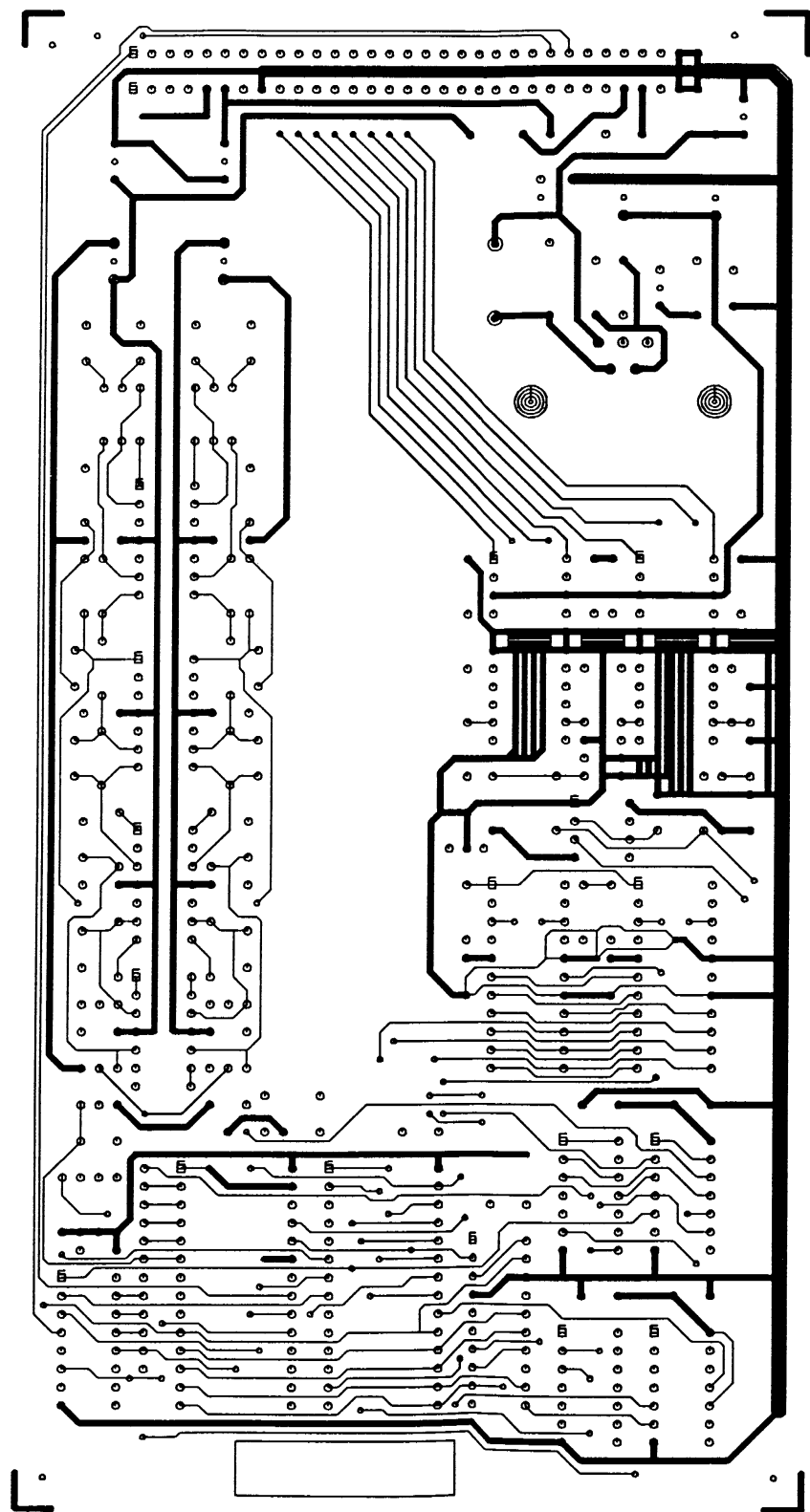
Note: The upper grommet affects the vertical positioning and the lower grommet affects the horizontal positioning.

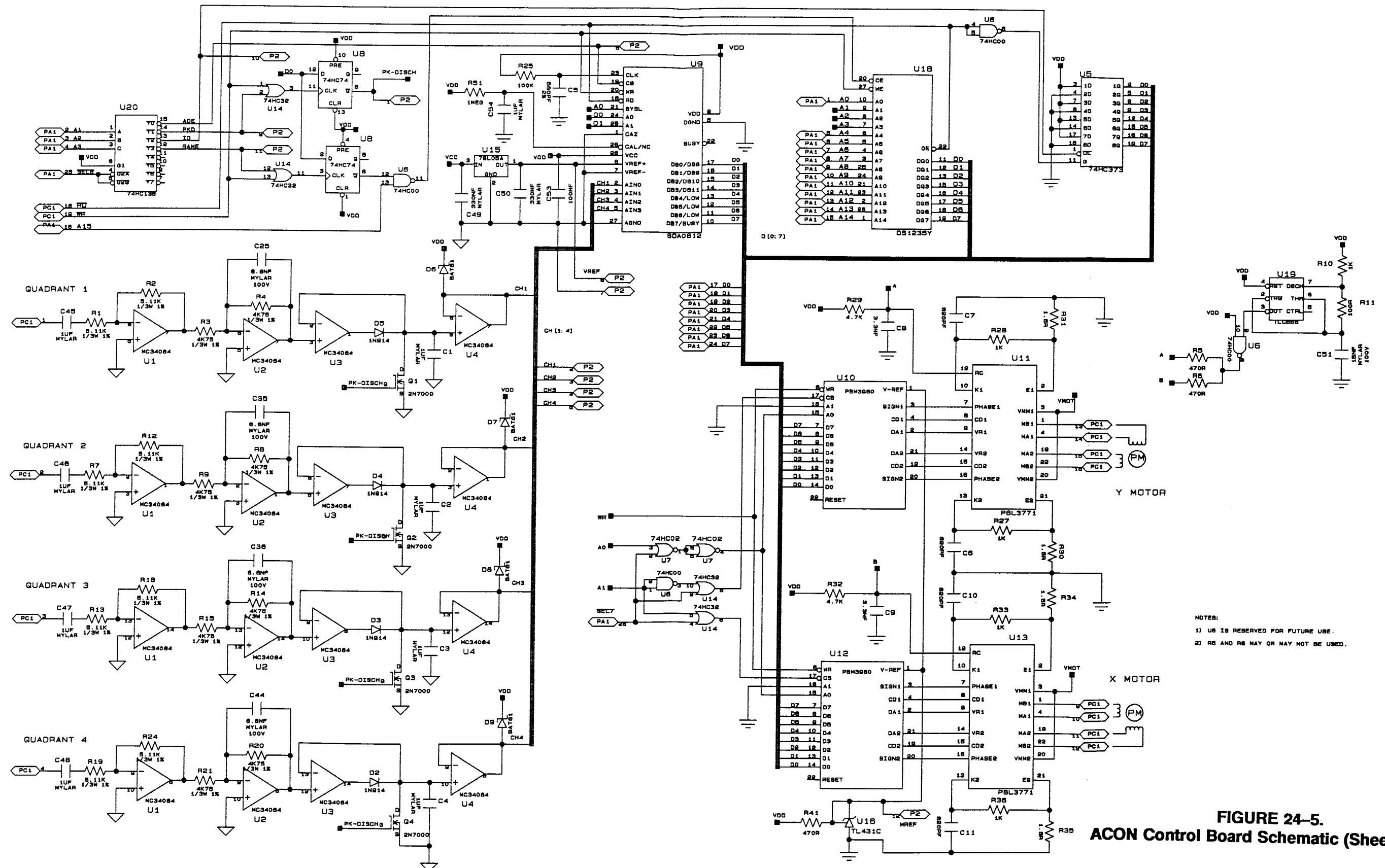
### 24.3 COMPONENT LAYOUT AND SCHEMATICS

Refer to the following pages for component layouts and schematics of the ACON Control Board.



Component Layout





**FIGURE 24-5.**  
**ACON Control Board Schematic (Sheet 1 of 2)**



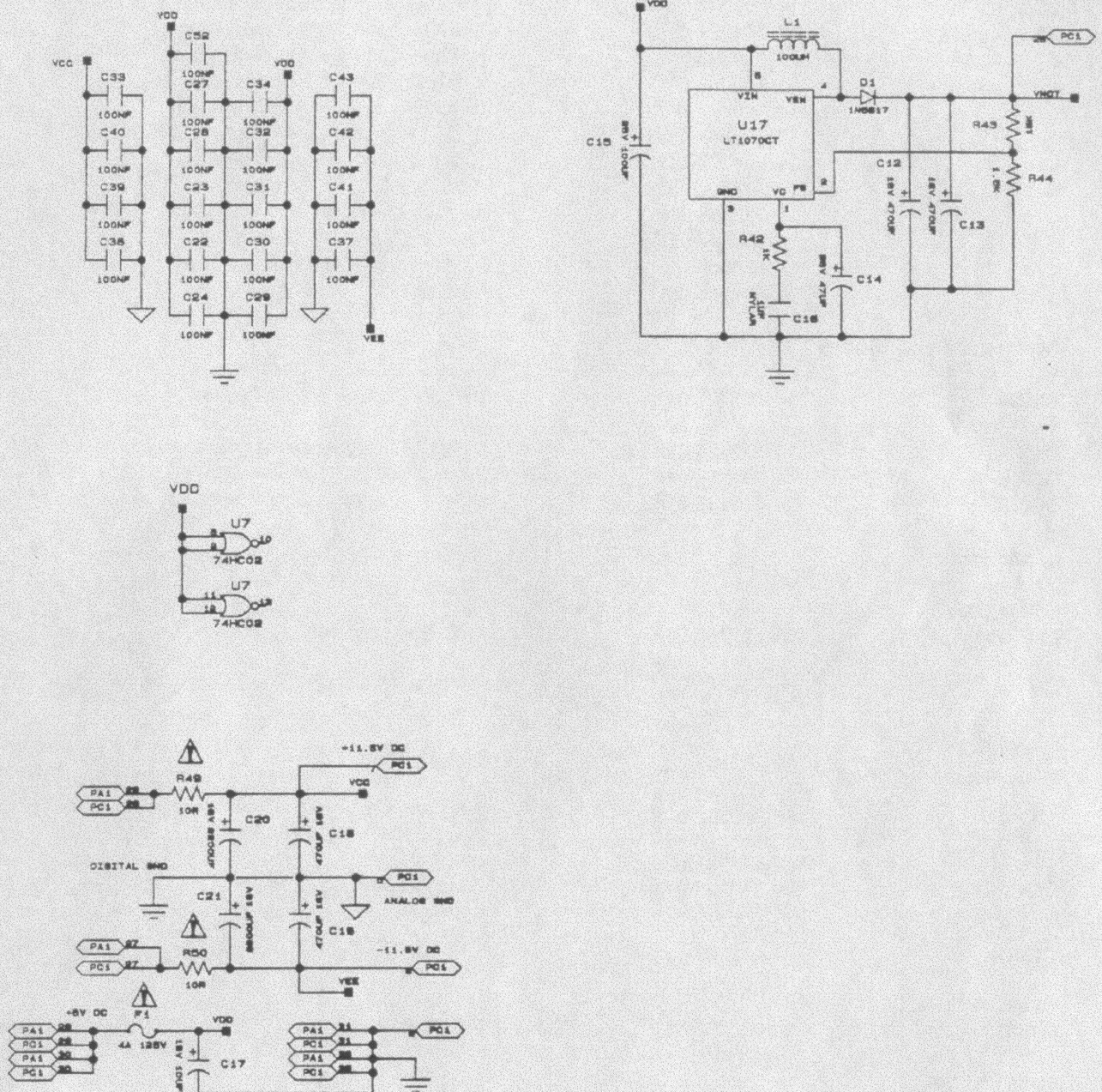


FIGURE 24-6.  
ACON Control Board Schematic (Sheet 2 of 2)

## 24.4 PARTS LIST


### 24.4.1 ACON Control Board

Item Ref.	Part No.	Description
<b>Integrated Circuits</b>		
U1-U4	14-002164-01P	MC34084, op amp
U5	14-A04010-01P	74HC373, H-CMOS transparent octal latch
U6	14-A04001-01P	74HC00, quad 2-input NAND gate
U7	14-A04090-01P	74HC02, quad 2-input NOR gate
U9	14-A03042-01P	SDA0812, 12-bit A/D converter
U10,U12	14-A03043-01P	PBM3960, dual D/A converter
U11,U13	14-A03044-01P	PBL3771, precision stepper motor driver
U14	14-A04005-01P	74HC32, quad 2-input OR gate
U15	14-002814-02P	LM78L05ACZ, +5V regulator
U16	14-002833-01P	TL431C, precision shunt regulator
U17	14-002847-01P	LT1070CT, switch mode regulator
U19	14-A04069-01P	TLC555C, CMOS digital timer
U20	14-A04045-01P	74HC138, 3 to 8 decoder
<b>Transistors and Diodes</b>		
Q1-Q4	14-A00705-01P	2N7000, TMOS, 60V, 0.2A, 4W
D1	14-000533-02P	1N5817, Schottky barrier diode
D2-D5	14-000513-01P	1N914, 0.075A, 75V
D6-D9	14-000533-01P	BAT81, Schottky barrier diode
<b>Capacitors</b>		
C1-C4,C16, C45-C48,C54	88-171053-02P	1 $\mu$ F, 50V, mylar
C5	86-656151-02P	560 pF, 100V, Y5P
C6,C7,C10, C11	86-682151-02P	820 pF, 100V, Y5P
C8,C9	86-633252-02P	3300 pF, 100V, Y5P
C12,C13	49-000020-01P	470 $\mu$ F, 16V, low ESR electrolytic
C14	84-447004-02P	47 $\mu$ F, 25V
C15	84-410104-03P	100 $\mu$ F, 25V
C17	84-410004-01P	10 $\mu$ F, 25V
C18,C19	44-447103-06P	470 $\mu$ F, 16V
C20,C21	44-422203-08P	2200 $\mu$ F, 16V
C22-C24,C27-C34, C37-C43,C52,C53	89-000032-03P	100nF, 50V
C25,C35,C36, C44	88-176821-03P	6800 pF, 100v, $\pm$ 5%
C49,C50	88-173340-02P	330 nF, 63V, 10%, mylar
C51	88-171531-01P	15 nF, 100V, mylar

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24.4 PARTS LIST (cont.)

24.4.1 ACON Control Board (cont.)

Item Ref.	Part No.	Description
<b>Resistors</b>		
R1,R2,R7,R12,R13, R18,R19,R24	82-351111-29P	5.11K, 1/3W, 1%, metal film
R2,R12,R18, R24	82-324311-29P	2.43K, 1/3W, 1%, metal film
R3,R4,R8,R9,R14, R15,R20,R21	82-347511-29P	4.75K, 1/3W, 1%, metal film
R10,R27,R28,R33, R36,R42	80-110015-11P	1k , 1/2W, 5%, metal film
R11	80-110005-11P	100R, 1/2W, 5%, metal film
R25	80-110035-11P	100K , 1/2W, 5%, metal film
R51	80-110045-11P	1M, 1/2W, 5%, metal film
R29,R32	80-147015-11P	4.7K, 1/2W, 5%, metal film
R30,R31,R34, R35	80-115085-11P	1.5R, 1/2W, 5%, metal film
R41	80-147005-11P	470R, 1/2W, 5%, metal film
R43	80-115025-11P	15K , 1/2W, 5%, metal film
R44	80-115015-11P	1.5K, 1/2W, 5%, metal film
 R49,R50	80-110095-11P	10R, 1/2W, 5%, metal film

**Coils and Transformers**

L1	21-001459-01P	100 $\mu$ H, choke
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**Miscellaneous**

 F1	27-000034-06P	4A, 125V, subminiature fuse
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NOTE: The ACON Sensor module is Electrohome part# 02-270016-01P.

## 24.5 SYSTEM SPECIFICATIONS

### 24.5.1 Functional

Projector Models	3100/4100
Screen Sizes	5' to 25'
Screen Types	flat, curved and rear
Convergence Zones	9 horizontal by 5 vertical
Convergence Accuracy	.05% of screen width
Ambient Light Rejection	up to 5 foot-lamberts at screen surface
Convergence Time (typical)	<3 minutes

Operating Power (from projector)	
+5V .....	+5 VDC @ 1.5A
+12V .....	+12 VDC @ 150mA
-12V .....	-12 VDC @ 100mA

Operating Environment	
Temperature	32 to 95° F (0 to 35° C)
Humidity	0 to 90% NC
Altitude	0 to 10,000 ft (0 to 3000m)

Storage Environment	
Temperature	-22 to 149° F (-30 to 65° C)
Humidity	0 to 90% NC

### 24.5.2 Mechanical/Electrical

### Control Board

Data Acquisition Circuits	
Number of channels	4
A/D Conversion Accuracy	12 bits
Input Voltage Range	0 to +5V
Gain Matching between Channels	$\pm 5\%$

### Motor Control Circuitry

Number of Driver Circuits	2
Control Method	micro-stepping
Output Current/Phase	650mA maximum
Drive method	switch-mode constant current

## Locator Assembly

Imaging System	
Lens type	single acrylic plano-convex
Sensor type	photodiode array
Lens Aperture	47mm (1.85")
Focal Length	53mm (2.1")
Focus	fixed
Quadrant Sensor Field of View	3° x 3°

### Lens/Sensor Component

Degrees of Freedom	2, rotational, orthogonal
Motive Force	stepper motors, direct drive
Configuration	
Motor A	azimuth, driving optical system
Motor B	altitude, driving motor A assembly
Sweep Angles	
Motor A	80° minimum
Motor B	120° minimum

### Motor Specifications

Type	hybrid stepper
Step Angle	0.9° (400s/r)
Drive	2 phase, bipolar
Phase Voltage (typical)	14VDC
Current/Phase	300mA maximum
Resistance/Phase	20 ohms
Inductance/Phase	5mH

Size ..... 13x15x10cm (5x6x4")



## NOTES