ACUTRONIC

Acutrol3000 Dual Channel Inner Loop Module

Technical Manual

TM-9418

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Introduction

This document describes the Dual Channel Inner Loop Module that has been developed to work in conjunction with the ACUTROL3000 Motion Control instrumentation. The use of an inner loop is warranted in systems that have servo components that produce a non-linear plant transfer characteristic. Since a non-linearity degrades the performance of a system, additional (analog) transducers are incorporated. These transducers are used by the ACUTROL3000 to close a digital servo around the non-linear plant that produces linear, controllable states for the digital motion control.

A typical application is to implement a digital pressure loop in a hydraulic motion simulator to minimize the effect of the hydraulic resonance produced by fluid compressibility and to reduce the effect of servo valve and actuator non-linearity. The pressure loop bandwidth can be extended beyond the plant dynamics to achieve improved response and tracking.

Other applications include closing a digital torque loop around the hydraulic resonance (in place of pressure), a digital torque loop around the mechanical spring resonance of a harmonic drive, or even a digital torque loop around an electric motor to minimize the effects of cogging, torque ripple and friction.

1. Dual Channel Inner Loop Module Description

The ACUTROL3000 Dual Channel Inner Loop Module (DILM) is a circuit board that is used to interface to sensor and actuators required for the digital inner servo loop. Several differences exist between the ACUTROL3000 Dual Channel Inner Loop Module (1201E17) and the single channel Inner Loop Servo Module (1201E14):

- A dual power Op-Amp (U9, Apex PA60) is used for the valve drive instead of a single Op-Amp. Two outputs allows either independent drive of two servovalve channels, or allows a bridged output to double the voltage drive to a single servovalve.
- Pressure Feedback 2 (Cross Pressure) now has offset and gain adjustments just like Pressure Feedback 1.
- A second valve drive has been added to the field terminal connections.

Figure 1-1 shows an ACUTROL3000 Dual Channel Inner Loop Module. There are seven connectors on the module as defined in Table 1.

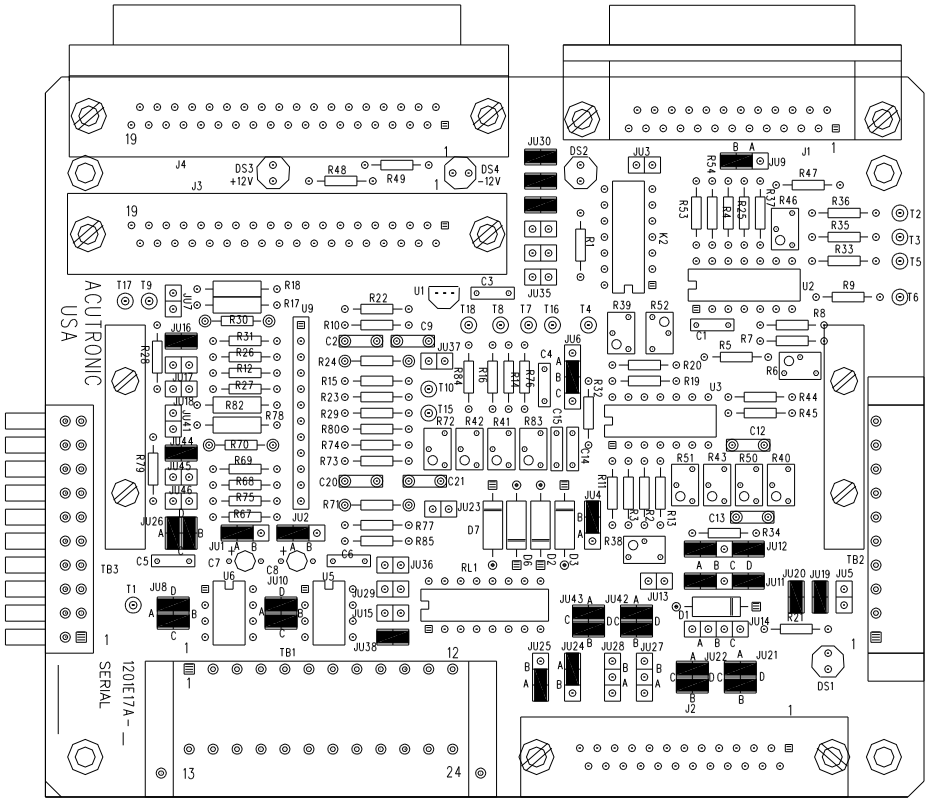

Figure 1-1 - ACUTROL3000 Dual Channel Inner Loop Module

NAME	TYPE	SOURCE	DESTINATION	FUNCTION
J1	DB25M	ACUTROL3000 Servo A Connector	DILM	Valve control and interlocks
J2	DB25F	DILM	Motion Table	Valve Drive, Inner Loop Feedback Sensors
J3	DC37F	DILM	Motion Table	Motion Transducer Drive/Feedback, End-of-Travel Limit Switches
J4	DC37M	ACUTROL3000 DRV/FBK Connector	DILM	Motion Transducer Drive/Feedback
TB1	Terminal Block	DILM	Motion Table	Duplicates function of J2 for Field Wiring
TB2	Terminal Block	DILM	DILM/Field Wiring	Buses signal to next DILM or connects to field wiring
TB3	Terminal Block	DILM	DILM	Buses signal to next DILM.

Table 1 ACUTROL3000 Dual Channel Inner Loop Module Connectors

Figure 1-2 shows three ACUTROL3000 Dual Channel Inner Loop Modules connected together.

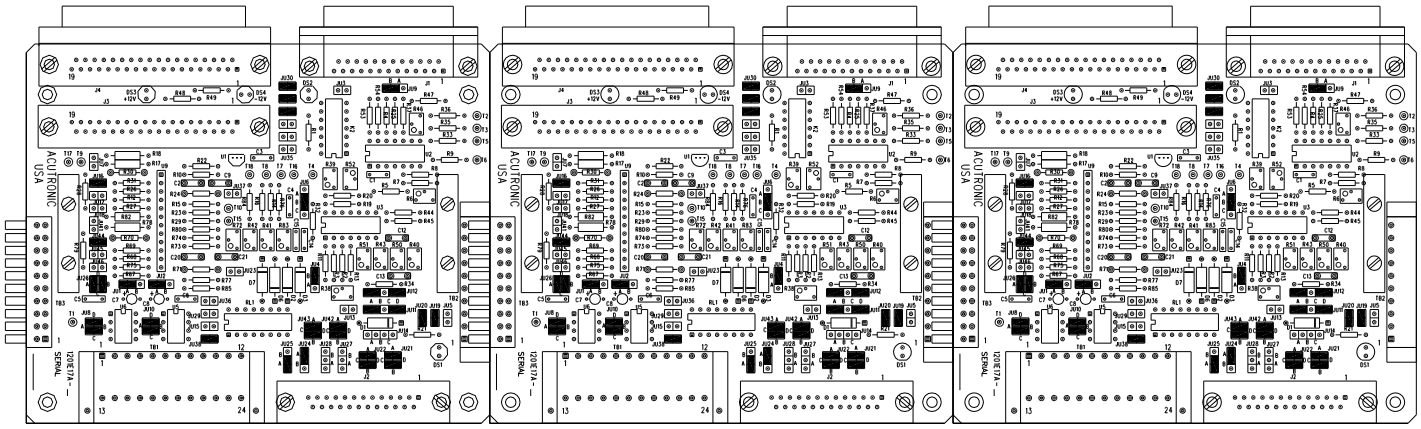

Figure 1-2 Three-Axis ACUTROL3000 Dual Channel Inner Loop Module Configuration

There are three types of control connections that are made to the board:

- **Transducer Drive/Feedback Input/Output (J3/J4).** The ACUTROL3000 Transducer Drive/Feedback cable is routed through the Dual Channel Inner Loop Module for two purposes:
    - The two pressure feedback channels (Average Pressure and Cross Pressure) are routed from the Actuator Interface Cable into **Analog Input 0** and **Analog Input 1** of the Transducer Drive/Feedback cable.
    - End-of-Travel Limit Switches from a transducer package can be routed into the ACUTROL3000 Servo Out Cable.
- **Valve Control, Inner Loop Sensors, and Interlocks (J1, J2, TB1).** The ACUTROL3000 Servo A connector mates to J1. **Servo Out 1** is used to drive the valve in either voltage or current mode. **Servo Out 2** is used to implement a low gain position loop during system initialization. **Enable 1** is used to enable the Output Amplifier. **Enable 0** is used to disable the low gain position loop. **ACK** and **FAULT** Interlocks can be generated by the Dual Channel Inner Loop Module, can be used for End-Of-Travel limit switches, or can be used to interface to an initialization sensor such as a system pressure switch.
- **Bussed Signals.** TB2 and TB3 are used to connect common signals between Dual Channel Inner Loop Modules. Alternatively TB2 can be used to connect the bus signals to field wiring.

Several potentiometers are used to configure the DILM. The potentiometers are:

POT	Function
R6	Dither Frequency
R38	Pressure Feedback 1 Scaling
R39	Pressure Feedback 1 Offset
R40	2nd Order Filter Frequency Spread
R41	Output Amplifier #1 Dither Amplitude
R42	Output Amplifier #1 Offset
R43	2nd Order Filter Depth
R46	Pressure Feedback 2 Scaling
R50	2nd Order Filter Frequency Adjust #1
R51	2nd Order Filter Frequency Adjust #2
R52	Pressure Feedback 2 Offset
R72	Output Amplifier #2 Offset
R83	Output Amplifier #2 Dither Amplitude

Test points are also provided for measurement of critical signals. The test points are spread throughout the board and are best located by the top assembly drawing. Each test point is isolated from its signal with a 1 kΩ resistor. The test points are:

TP	Signal
T1	GND
T2	Raw Pressure Feedback 2
T3	Raw Pressure Feedback 1
T4	Scaled Feedback #1 (deltaP, dP1)
T5	Scaled Feedback #2 (Cross Pressure, dP2)
T6	Dither Generator
T7	Dither Voltage #1
T8	Output Amplifier #1 Command
T9	Output Amplifier #1 Current Sense
T10	Output Amplifier #1 Voltage Output
T15	Output Amplifier #2 Voltage Output
T16	Dither Voltage #2
T17	Output Amplifier #2 Current Sense
T18	Output Amplifier #2 Command

Jumpers are used to configure the functions of the board. The jumpers are spread throughout the board and are best located by the top assembly drawing. Default locations for the jumpers are shown in bold. The jumpers are:

Jumper	Location	Signal
JU1	**A**	+V = +12 VDC (AIM)
	B	+V = +V_{EXT} (from TB3-4)
JU2	**A**	-V = -12 VDC (AIM)
	B	-V = -V_{EXT} (from TB3-6)
JU3	**IN**	**Servo Out 2** Drives Output Amplifier till Enable 0 Asserted
JU15	IN	**DRVB** = **AUX IN** (TB1-16)
JU4	A	Use Feedback Sensor 1 and 2 for Average Pressure
	B	Use only Feedback Sensor 1 for Average Pressure
JU5	IN	**Enable 1** connected to Enable Link
JU6	A	Bus Dither Enable
	B	Internal Dither Enable
	C	Drive Internal Dither onto Bus
JU7	**OUT**	R_s = 20 ohms (Output #1)
	IN	R_s = 5 ohms (Output #1)
JU8	AB	Feedback Sensor 1 Inverted Polarity
	CD	Feedback Sensor 1 Normal Polarity
JU9	A	Use Feedback Sensor 1 and 2 for Cross Pressure
	B	Use only Feedback Sensor 1 for Cross Pressure
JU10	AB	Feedback Sensor 2 Inverted Polarity
	CD	Feedback Sensor 2 Normal Polarity

JU11/JU12	**A**	**Servo Out 1** Drives Output Amplifier Directly
	B	**Servo Out 1** Drives Output Amplifier through Notch Filter
	C	Average Pressure Drives **Analog Input 1** through Notch Filter
	D	Average Pressure Drives **Analog Input 1** Directly
JU13	**OUT**	Output Amplifier Enabled by **Enable 1**
	IN	Output Amplifier Always Enabled
JU14	**AC**	Valve 1 and Valve 2 driven in parallel
	B	Valve 1 and Valve 2 drive in series
JU15	IN	**DRVB** = **AUX IN** (TB1-16)
JU16	**IN**	R_F = 499 ohms (Output #1)
JU17	**OUT**	R_F = 1240 ohms (Output #1)
JU18	**OUT**	R_F = 2550 ohms (Output #1)
JU19	**IN**	**Enable 1** connected to Pressure Switch
JU20	**IN**	**FAULT(C)** connected to Pressure Switch
JU21	**AB**	Valve 1 Drive Normal Polarity
	CD	Valve 1 Drive Inverted Polarity
JU22	**AB**	Valve 2 Drive Normal Polarity
	CD	Valve 2 Drive Inverted Polarity
JU23	OUT	Output #2 Capacitor Short
JU24	**A**	Pressure Transducer EXC+ connected to +12 VDC
	B	Pressure Transducer EXC+ connected to +PP Bus (TB1-8)
JU25	**A**	Pressure Transducer EXC- connected to -12 VDC
	B	Pressure Transducer EXC- connected to -PP Bus (TB1-9)
JU26	**AB**	Valve 1 Drive Normal Polarity (TB1)
	CD	Valve 1 Drive Inverted Polarity (TB1)
JU27/JU28	**A**	Valve Drive #2 from Output Amplifier #1
	B	Valve Drive #2 from Output Amplifier #2
JU29	IN	**DRVB** = **DRVA**
JU30	**IN**	**ACK(C)** connected to **Enable 0+**
JU31	**IN**	**ACK(A)** connected to +12 VDC
JU32	**IN**	**FAULT(A)** connected to +12 VDC
JU33	OUT	**ACK(C)** connected to J3-10
JU34	OUT	**FAULT(C)** connected to J3-29
JU35	OUT	**ACK(C)** connected to J3-29
JU36	IN	**DRVB** = **DRVAOUT**
JU37	OUT	Output #1 Capacitor Short
JU38	IN	**DRVB** = **Servo Out 2**
JU41	**OUT**	R_s = 20 ohms (Output #2)
	IN	R_s = 5 ohms (Output #2)
JU22	**AB**	Output #2 Drive Normal Polarity

	CD	Output #2 Drive Inverted Polarity
JU43	**AB**	Valve 2 Drive Normal Polarity (TB2)
	CD	Valve 2 Drive Inverted Polarity (TB2)
JU45	**OUT**	R_F = 1240 ohms (Output #2)
JU46	**OUT**	R_F = 2550 ohms (Output #2)

1.1 Multi-Channel Operation

As mentioned in Section 1, it is possible to link multiple Dual Channel Inner Loop Modules together via the TB2 and TB3 terminal blocks. Access to the bussed signals is by the TB2 terminal block on the last module in the chain.

Five signals can be bussed between boards:

- **Feedback Transducer Power (TB2/3-1,2).** The excitation voltages for the feedback transducer are bussed between modules to simplify wiring.

- **Enable 1 Signal (TB2/3-3).** The **Enable 1** signal is used to enable the output amplifier. Installing JU5 will bus the **Enable 1** signal to every card. This will cause the output amplifiers on **ALL** DILMs with JU5 installed to be enabled when **ANY** of the DILMs is enabled.

- **Output Amplifier External Power (TB2/3-4,5,6).** The output amplifier normally operates from a +/- 12 VDC supply (taken from the AIM). When operated in current mode, saturation of the output amplifier under high dynamic conditions can be a problem. If saturation does occur, it is possible to supply the output amplifier from an external supply up to +/-30 VDC supply. Jumpers JU1 and JU2 must be set accordingly. Power dissipation must be considered when using the higher supply voltages. Note that the output amplifier is internally thermally protected against overheating.

- **Pressure Switch (TB2/3-7,8).** These connections allow an external pressure switch to enable the output amplifier.

- **Dither (TB2/3-9).** Each Dual Channel Inner Loop Module has a triangle oscillator for dither generation. The frequency is adjustable from 20 to 550 Hz. The dither is connected to the Output Amplifiers via JU6B. When two or more modules are connected together, only one dither signal should be used for all modules to prevent beat note frequencies from developing. The dither from the first Dual Channel Inner Loop Module should be connected to the **BUS DITHER** and output amplifier by setting jumper JU6 to the AC position. All other modules should use the **BUS DITHER** signal by setting JU6 to the A position. Dither amplitudes are controlled independently with potentiometer R41 (Output Amplifier #1) and R83 (Output Amplifier #2).

1.2 Analog Filter

A second order filter can be used to implement a low pass filter, a notch filter, or a combination notch/low pass filter, depending on the settings of the potentiometers.

Installing jumpers JU11 and JU12 in the A position activates the 2nd order filter on the Output Amplifier Command (**Servo Out 1**). Installing jumpers JU11 and JU12 in the C position activates the 2nd order filter on the Sensor Feedback.

The filter has four adjustments that allow the user to produce the desired response. These are:

- **SPREAD [R40]** - Typically for Notch Filters the complex poles and complex zeros occur at the same frequency with different levels of damping. However, at certain points it may be beneficial to offset the frequency of the zeroes with respect to the poles. The SPREAD adjustment provides this offset control. When the SPREAD adjustment is fully CCW, no separation occurs between the poles and the zeroes. As the SPREAD adjustment moves CW, the zeroes are shifted progressively higher in frequency. When the SPREAD adjustment is full CW, the zeroes have been shifted to infinity, and a second order low pass filter results. The SPREAD is sometimes useful to counteract antiresonance/resonance pairs. The ratio between the poles and the zeros is given as $(1/\gamma)^{1/2}$, where γ is the percentage of the SPREAD (γ = 1 -> R40 full CCW).

- **FREQ1 [R50] and FREQ2 [R51]** – These two adjustments are used to determine both the frequency of the filter and the damping of the complex zeroes. Very high Q notch filters can be created by proper adjustment of FREQ1 and FREQ2. When the time constant created by FREQ1 [R50] and C12 equals the time constant created by FREQ2 [R51] and C13 the damping of the zeroes will be zero and a filter of infinite Q will result (theoretically). Practically, filters with depths over 40 dB can be obtained.

  The two frequency adjustments are useful for other purposes as well. At times it is useful to synthesize a notch filter to be used for dampening a hydraulic plant. The zeroes of the filter are chosen to cancel the poles of the hydraulic plant and the poles of the filter are set to the desired damping of the damped plant. Adjustment of FREQ1 and FREQ2 are made to set the frequency and damping of the filter zeroes. The DEPTH adjustment is then used to set the damping of the filter poles.

- **DEPTH [R43]** – The DEPTH adjustment is used to set the damping of the filter poles. For a notch filter, this adjusts the filter Q, which is manifested as width and phase shift of the filter. For a 2^{nd} order low pass, this also adjusts the Q that is manifested as filter phase shift and peaking.

1.3 Feedback Sensor(s)

The Dual Channel Inner Loop Module can accept either one or two feedback sensors. The polarity of the feedback sensors can be selected with jumper blocks JU8 (Sensor 1) and JU10 (Sensor 2). Normally the jumpers would be installed in the CD position. To reverse the polarity, move the jumpers to the AB position.

Both sensors are buffered with differential amplifiers U5 and U6. Then, either an average and differential feedback can be developed, or the sensors can be scaled and fed directly back to the ACUTROL. Sensor Feedback #2 (Cross Pressure) is scaled through the U2D amplifier and feedback resistor network, and is fed back to the ACUTROL via J4 (**Analog Input 0**), and to terminal block TB1-19 (Cross Pressure). Sensor Feedback #2 U2D has a variable gain adjustment via potentiometer R48 from 1 to 10. Jumper JU9 determines whether one or two sensors are used for the feedback.

Sensor Feedback #2 (dP) is scaled through the U3A amplifier and feedback resistor network. U3A has a variable gain adjustment via potentiometer R38 from 1 to 10. Jumper JU4 determines whether one or two sensors are used for the average feedback. The average feedback is buffered with U2C and fed back to the ACUTROL via J4 (**Analog Input 1**), or to terminal block TB1-20 (Average Pressure).

The Dual Inner Loop Module can be operated on the +/- 12 VDC supplies from the AIM. In this case the feedback sensors should be selected so that 8 volts is produced on T2/T3 when the pressure (torque) is at the peak of the usable range. This scaling is important to insure that the input to the ACUTROL analog to digital converters does not saturate.

1.4 Output Amplifiers

The input to the drive amplifiers (**Servo Out 1/2**) should be scaled for 10 volts maximum to limit the peak output in a controlled manner.

Typically the output amplifier is used in current mode. Factory Select Components (R24, C2, C9, and R71, C20, C21) are provided for current loop compensation if required.

Relay K1 is used to enable the Output Amplifier. When disabled, connection to the output is removed, and R10/R74 forms a low gain voltage loop around U9 to prevent saturation of the output amplifier.

Potentiometers R42 and R72 are to remove any offset voltage from the output amplifier and should be adjusted with the output amplifier enabled.

JU21, JU22, JU26, JU42, and JU43 are used to set the polarity of the output amplifiers. Normally the jumpers would be installed in the AB position. To reverse the polarity, move the jumpers to the CD position. JU14, JU27, and JU28 are used to select whether one or two outputs are to be used, and if they are to be wired in series or parallel.

Jumpers JU7/JU41, JU16/JU44, JU17/JU45, and JU18/JU46 are used to select the full scale range of output currents as shown in Table 2. Alternate full-scale ranges can be developed with the installation of R30/R70.

JU7/JU41	JU16/JU44	JU17/JU45	JU18/JU46	RF (Ω)	RS (Ω)	I_{FS} (mA)
OUT	IN	IN	IN	314	20	6.2
OUT	IN	IN	OUT	358	20	7.0
OUT	IN	OUT	IN	419	20	8.2
OUT	IN	OUT	OUT	501	20	9.8
OUT	OUT	IN	IN	839	20	16.4
OUT	OUT	IN	OUT	1250	20	24.5
IN	IN	IN	IN	314	5	24.6
IN	IN	IN	OUT	358	5	28.1
IN	IN	OUT	IN	419	5	32.8
IN	IN	OUT	OUT	501	5	39.3
OUT	OUT	OUT	IN	2550	20	50.0
IN	OUT	IN	IN	839	5	65.8
IN	OUT	IN	OUT	1250	5	98.0
IN	OUT	OUT	IN	2550	5	200.0

Table 2 ACUTROL3000 Dual Inner Loop Module Current Loop Scaling

1.5 Low Gain Proportional Loop

Resistors R31 and R69 can be used to create a low gain proportional loop. **Servo Out 2** is programmed to produce a signal proportional to actuator position. The value of R31 and R69, and the gain of **Servo Out 2** determine the gain of the position loop. This is typically used to implement a low gain position loop to center the actuator before the servo loop is initialized. R31 and R69 are chosen to limit the peak velocity of the actuator during initialization. Practically, a value for R31 should be ~10 * R23, and a value for R69 should be ~ 10 * R85. The gain of **Servo Out 2** is chosen to ensure adequate centering of the actuator.

1.6 Interlock Circuitry

The interface with the Dual Inner Loop Module is designed to be plug compatible with the ACUTROL3000 Servo Out A Connector.

The interlocks can be configured to operate in a variety of ways by jumper plug and software programming. The ACUTROL3000 in conjunction with the Dual Inner Loop Module can automatically sequence the system from shut down to full operation, always observing system and facility safety interlocks.

This sequence nominally occurs as follows for a hydraulic system:

- The operator closes the interlocks on all axes to be servoed.

- If all AIM interlocks are satisfied, **Enable 1** is asserted and the **ANY SERVO** output is enabled. The **ANY SERVO** output can be used to start the hydraulic power supply, and sequence any isolation valves at the motion table.

- Coincident with the assertion of **Enable 1**, a software dwell timer (**Drive Enable Delay**) is started that delays the attempt to servo until the timer expires. If a Pressure Sensor is used as the **ACK** feedback, the **Drive Enable Delay** timer allows the pressure to build to a safe minimum before the servo loops are initialized. If the pressure does not built up to a satisfactory level within the programmed delay time, the startup will be aborted by the AIM.

- On the Dual Inner Loop Module, **Enable 1** activates K1, which enables the Output Amplifiers. During the **Drive Enable Delay** period, the Output Amplifiers are active, but the ACUTROL servo loop is disabled until **Enable 0** is asserted at the end of the **Drive Enable Delay** period. However, it is possible to command the Output Amplifiers with **Servo Out 2** through R31/R69 prior to **Enable 0** being asserted. This path is often used with hydraulic systems to move the axis to a null position during startup. See Section 1.5

- After the **Drive Enable Delay** timer expires, **Enable 0** is asserted and the ACUTROL servo loop is activated. On the Dual Inner Loop Module **Enable 0** disables the low gain proportional loop formed with **Servo Out 2**. **Enable 0** can also be used to generate **ACK** via JU30.

The following are the options available for the **ACK** signal:

- **ACK** generated by **Enable 0**. Insert JU31 to connect **ACK**+ to +12 VDC. Insert JU31 to connect **ACK**- to **Enable 0**.

- **ACK** generated by a CW Limit Switch in the transducer package. In this case the **ACK** is used as a general fault condition to the ACUTROL3000. Insert JU33 to connect **ACK**- to J3-10. Insert JU31 to connect **ACK**+ to +12 VDC. Connect limit switch to J3-10 and J3-8.

- **ACK** generated by a CCW Limit Switch in the transducer package. In this case the **ACK** is used as a general fault condition to the ACUTROL3000. Insert JU35 to connect **ACK**- to J3-29. Insert JU31 to connect **ACK**+ to +12 VDC. Connect limit switch to J3-29 and J3-8.

- **ACK** generated by alternate sensor. Connect the sensor to TB1-21 and TB1-22.

The following are the options available for the **FAULT** signal:

- **FAULT** generated by a CCW Limit Switch in the transducer package. In this case the **FAULT** is used as a general fault condition to the ACUTROL3000. Insert JU34 to connect **FAULT** - to J3-29. Insert JU32 to connect **FAULT** + to +12 VDC. Connect limit switch to J3-29 and J3-8.

- **FAULT** generated by system Pressure Switch sensor. Insert JU32 to connect **FAULT** + to +12 VDC. . Insert JU20 to connect **FAULT** - to Pressure Switch HI (TB2-7). Connect the Pressure Switch to TB2-7 and TB2-8.

- **FAULT** generated by alternate sensor. Connect the sensor to TB1-23 and TB1-24.

2. Dual Inner Loop Module Checkout Procedure

- ❑ Verify the Dual Inner Loop Module is configured per the assembly drawing (page 17) and schematic (pages 19 and 20) (1201E14A,S).
- ❑ Connect the Transducer Drive/Feedback cable from the ACUTROL Axis 1 to J4 of the Inner Loop Servo Module.
- ❑ Verify that LEDs DS3 (+12 VDC) and DS4 (-12 VDC) illuminate.
- ❑ Connect the Transducer Drive/Feedback cable from the J3 of the Inner Loop Servo Module to a transducer package. Verify proper operation of the transducer.
- ❑ With a multimeter, verify the voltage at U1 Pin 1 (or the lead of C3 closest to U1) is 5.00 +-/0.25 VDC. Verify the voltage at U3-14 is –5.00 +-/ 0.01 VDC with respect to TP1 (GND).
- ❑ Attach an oscilloscope to T6 (Dither Output). Adjust R6 for a triangle wave of 3 msec period. Amplitude should be stable at approximately 10 Vp-p.
- ❑ Move the oscilloscope to T7 (Dither Amplitude #1). Adjust R41 to set the dither amplitude to minimum. Move the oscilloscope to T16 (Dither Amplitude #2). Adjust R83 to set the dither amplitude to minimum.
- ❑ Connect a voltage source to TB1-1 (High) and TB1-2 (Low). Parallel to TB1-5 (High) and TB1-6 (Low).
- ❑ Set the voltage source to 0.00 VDC
  - ❑ Adjust R39 till T4 measures 0.00 +/- 0.01 VDC.
  - ❑ Adjust R52 till T5 measures 0.00 +/- 0.01 VDC.
- ❑ Set the voltage source to 5.00 VDC
  - ❑ Verify 5.00 +-/ 0.01 VDC on T2 and T3.
  - ❑ Adjust R38 till T4 measures -5.00 +/- 0.01 VDC.
  - ❑ Adjust R46 till T5 measures -5.00 +/- 0.01 VDC
  - ❑ Display Variable 1087 on the ACUTROL. Verify the voltage displayed is -5.00 +/- 0.01 VDC.
  - ❑ Display Variable 1088 on the ACUTROL. Verify the voltage displayed is -5.00 +/- 0.01 VDC.
  - ❑ Remove the voltage source.

- ❑ Connect the Servo A Cable from the ACUTROL to J1 of the Inner Loop Servo Module.
- ❑ Connect a 100 ohm load resistor across TB1-11 and TB1-12, and TB1-13 and TB1-14.
- ❑ Set Axis 1 Analog Output 5 (Servo Out 1) to reference variable 1000 (Position Demand). Set Axis 1 Analog Output 6 (Servo Out 2) to reference variable 1000 (Position Demand). Set the Axis 1 Position Demand to 0.0.
- ❑ Close the Interlock on Axis 1.
  - ❑ Verify that LEDs DS1 (Enable 1) and DS2 (Enable0) illuminate.
  - ❑ With zero volts on Servo Out #1, Adjust R42 for 0.000 +/- 0.001 on T10.
  - ❑ With zero volts on Servo Out #2, Adjust R72 for 0.000 +/- 0.001 on T15.
  - ❑ Set the Axis 1 Position Demand to 10 degrees (10 VDC on Servo Out #1). Verify ~1.2 Volt on T10 and T15.
- ❑ Open the Interlock on Axis 1.

A. Drawings

The Dual Inner Loop Module PCB Assembly is documented as the drawing series 1201E17 and consists of a parts list, assembly, and schematic.

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1201E17L | **REVISION: A**

Inner Loop Module, Dual Channel

ITEM	QTY	PART OR DWG NO	REFERENCE SYMBOLS	MANUFACTURER	PART DESCRIPTION AND NOTES
001	REF	1201E17A		ACUTRONIC USA	Inner Loop Module ASSEMBLY
002	REF	1201E17S		ACUTRONIC USA	Inner Loop Module SCHEMATIC
003	1	1201E17P	PC BOARD	ACUTRONIC USA	GERBER FILE
100	2	INA105KP	U5-U6	TI/BURR-BROWN	DIFFERENTIAL AMPLIFIER
101	2	OPA4277PA	U2-U3	TI/BURR-BROWN	QUAD OP-AMP, PRECISION
102	1	PA60EU	U9	TI/BURR-BROWN	POWER OP-AMP,DUAL
103	1	MC78L05ACP	U1	ANALOG DEVICES**	VOLTAGE REFERENCE, +5V PRECISION
104	4	CMD333UGD	DS1-DS4	CHICAGO MINIATURE**	LED,GRN,T-1 3/4
105	5	1N4001	D1-D3,D6,D7	**	DIODE
200	10	3266W-1-103	R38-R43,R46,R52,R72,R83	BOURNS**	POTENTIOMETER, 10 K, 1/4" SQR., CERMET
201	1	3266W-1-503	R6	BOURNS**	POTENTIOMETER, 50 K, 1/4" SQR., CERMET
202	2	3266W-1-104	R50-R51	BOURNS**	POTENTIOMETER, 100 K, 1/4" SQR., CERMET
203	2	5053YD4R990F	R18,R82	PHILIPS**	RESISTOR, 4.99
204	2	RN55C15R0F	R17,78	**	RESISTOR, 15.0
205	1	RN55C4990F	R26,R68	**	RESISTOR, 499
206	15	RN55C1001F	R9, R14, R16, R28-29, R32-36, R47, R76, R79, R80, R84	**	RESISTOR, 1.00 K
207	1	RN55C1241F	R12,R75	**	RESISTOR, 1.24 K
208	1	RN55C1501F	R5	**	RESISTOR, 1.50 K
209	4	RN55C2001F	R1, R21, R48-49	**	RESISTOR, 2.00 K
210	2	RN55C2551F	R27,R67	**	RESISTOR, 2.55 K
211	1	RN55C5111F	R8	**	RESISTOR, 5.11 K
212	9	RN55C1002F	R3,R4,R7,R11, R19, R20, R25, R37,R45	**	RESISTOR, 10.0 K
213	1	RN55C2002F	R44	**	RESISTOR, 20.0 K
214	6	RN55C2552F	R10, R23,R24,R71,R74,R85	**	RESISTOR, 25.5 K
216	2	RN55C7502F	R15,R77	**	RESISTOR, 75.0 K
217	4	RN55C1003F	R2, R22,R53,R73	**	RESISTOR, 100 K
218	2	RN55C2503F	R31,R69	**	RESISTOR, 250 K
220	2	RN55C5001F	R13,R54	**	RESISTOR, 5.00 K
300	2	199D476X0025FE2	C7, C8	SPRAGUE**	CAPACITOR, 47 mF, 25V, TANTALUM
301	5	IC20X7R104K050B	C3, C5-6, C14,C15	**	CAPACITOR, 0.1 mF,10%
302	2	CK05BX682K	C12-13	MALLORY**	CAPACITOR, 0.0068 mF
303	1	CK06BX474K	C1	**	CAPACITOR, 0.47 mF
304	1	CK06BX105K	C4	MURATA-ERIE	CAPACITOR, 1.0 mF, 50V
400	1	190-22B2UO		TYCO**	RELAY, DIP, DPDT, 12V,2 AMP
401	2	08-3518-10	(U5-U6)	ARIES**	SOCKET, 8-PIN DIP
402	3	14-3518-10	(U2-U3,K2)	ARIES**	SOCKET, 14-PIN, DIP
403	1	16-3518-10	(RL1)	ARIES	SOCKET, 16-PIN, DIP
404	1	JWD-172-161	K2	P+B**	RELAY, DIP, SPDT, 12V, W/DIODE
405	AS REQ	4-103-186-0		ARIES**	HEADER, DUAL ROW, 40 CON

406	1	40-901-11		ARIES**	HEADER, SINGLE ROW, 40 CON
409	AS REQ	ML-100	See Assembly	ARIES	JUMPER
501	1	1-745967-4	J2	AMP**	CONNECTOR,DB25, FEMALE, STRAIGHT, PCB MOUNT,W/FIXED SCREW
502	1	1-747301-4	J3	AMP**	CONNECTOR,DB37, FEMALE, STRAIGHT, PCB MOUNT,W/FIXED SCREW
503	1	747843-4	J4	AMP**	CONNECTOR,DB37, MALE, R ANGLE,BOARD LOCK,FIXED SCREW
504	1	747842-4	J1	AMP**	CONNECTOR,DB25, MALE, R ANGLE,BOARD LOCK,FIXED SCREW
506	1	1843017	TB1	PHOENIX**	TERMINAL BLOCK, PCB MOUNT, DOUBLE ROW, 24 POS
507	1	1862658	TB3	PHOENIX**	TERMINAL BLOCK, PCB MOUNT, SINGLE ROW, 10 POS,FEMALE
508	1	1827949	TB2	PHOENIX**	TERMINAL BLOCK, PCB MOUNT, SINGLE ROW, 10 POS
509	12	10-477-2-01		CONCORD**	TERMINAL, FORK, 0.093 DIA.
510	14	SPCJ-123-01	T1-T10,T15-T18	JOLO**	TEST TERMINAL, WHITE
700	2	209-120		WAGO**	MOUNTING FOOT,35MM DIN RAIL
701	4	209-119		WAGO**	FIXING SCREW

APPROVALS	**INITIALS / DATE**
ENGINEERING	
PROJECT MAN.	
PRODUCTION	
ECO:	

NOTES: ** THESE COMPONENTS MAY BE SUBSTITUTED WITH VERIFIABLE EQUIVALENT PARTS AS NECESSARY

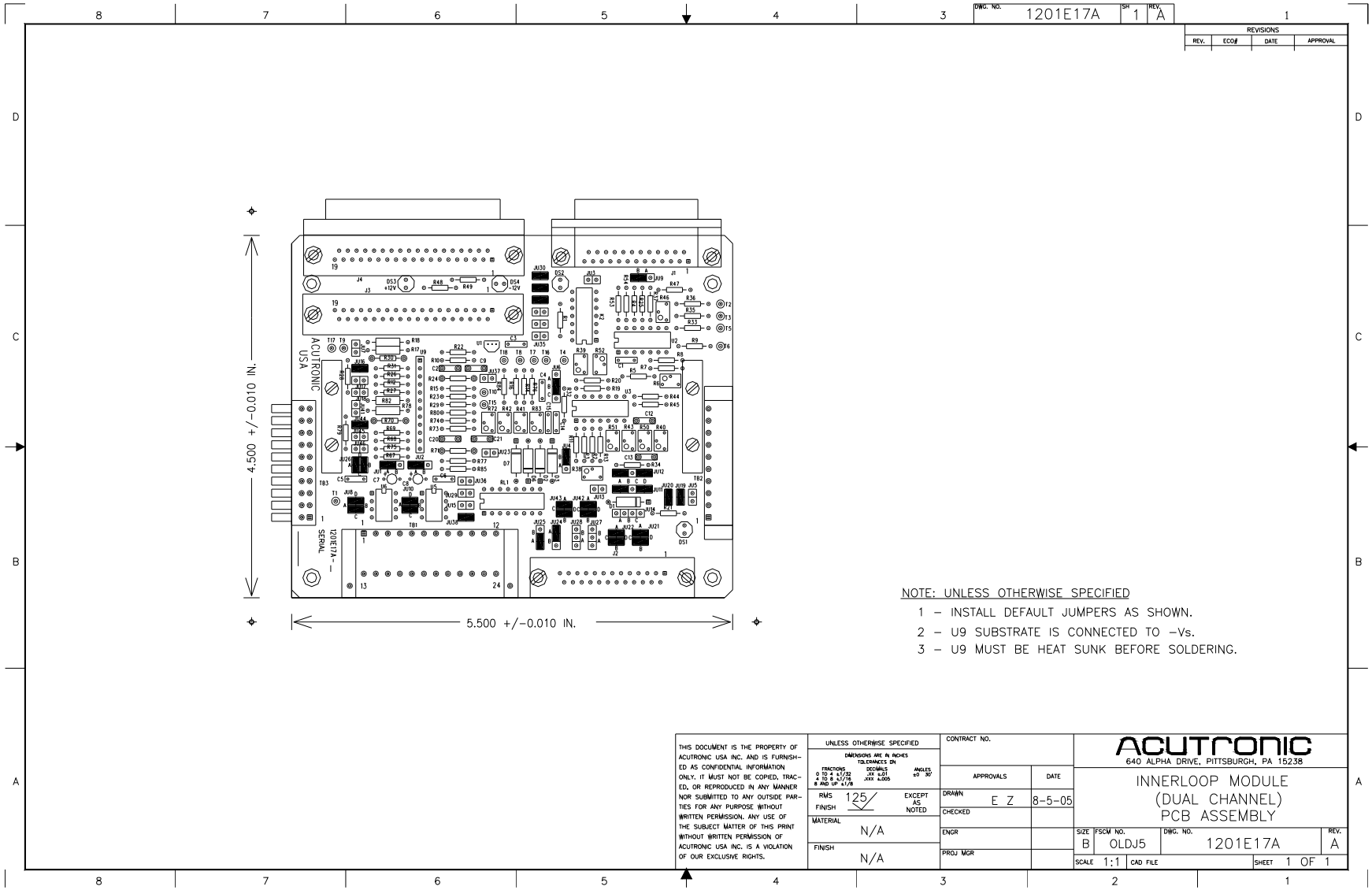

Figure A-1 Dual Inner Loop Module Assembly

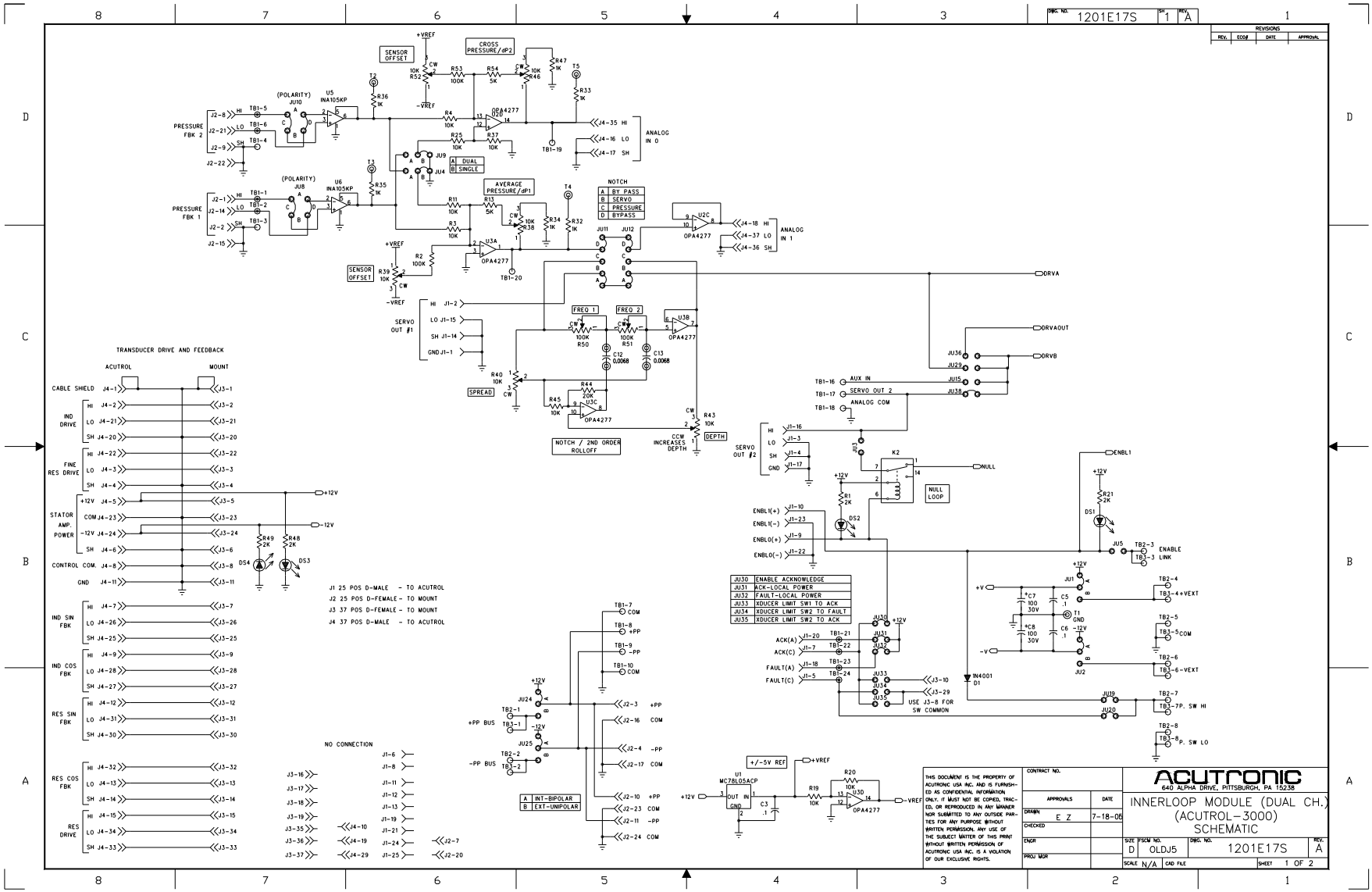

Figure A-2 Dual Inner Loop Module Schematic Sheet 1

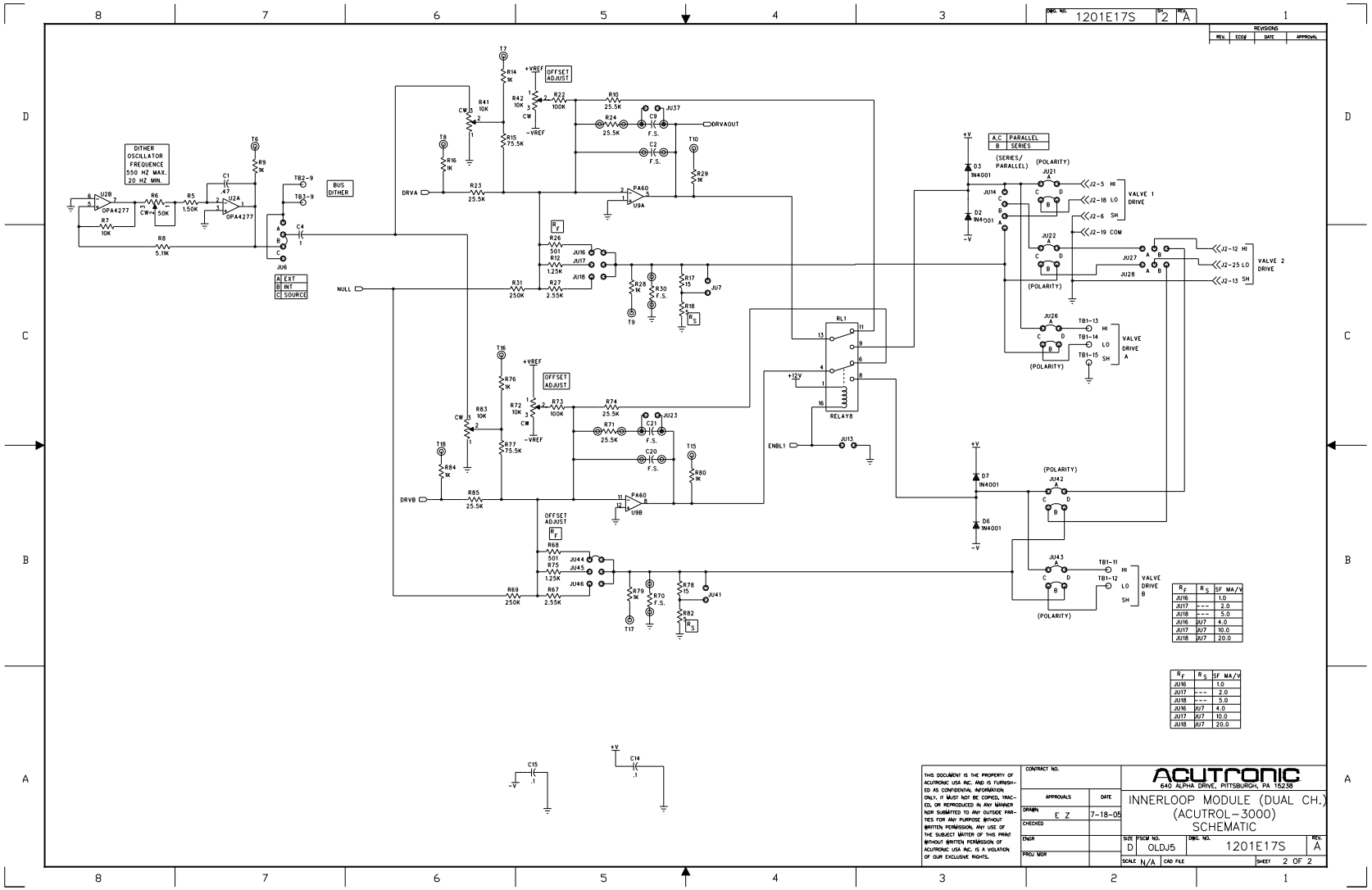

Figure A-3 Dual Inner Loop Module Schematic Sheet 2

B. Connector Pinouts

Following are the pinout definitions for J1, J2, J3, J4, TB1, TB2, and TB3.

Acutronic ACUTROL

Acutrol3000 Servo Out A Interface Connector

Assy ID: Acutrol3000 Inner Loop Module Connector Reference: **J1**

Connector Type: **25 Pin D-sub (Male)** Part Number: AMP 747842-4

Pin I.D.	Signal Name	In/Out	Description
1	GND		Cable drain
14	ServoOut1sh		Servo Output #1 Shield
2	ServoOut1+	I	Servo Output #1 HI
15	ServoOut1-	I	Servo Output #1 LO
3	ServoOut2-	I	Servo Output #2 LO
16	ServoOut2+	I	Servo Output #2 HI
4	ServoOut2sh		Servo Output #2 Shield
17	GND		Spare GND
5	Fault-	O	Power Amp Fault #0
18	Fault+	O	
6	NC		
19	NC		
7	Acknowledge-	O	Power Amp Acknowledge #0
20	Acknowledge+	O	
8	NC		
21	NC		
9	Enable0+	I	Power Amp Enable #0 (Closure)
22	Enable0-	I	
10	Enable1+	I	Power Amp Enable #1 (Closure)
23	Enable1-	I	
11	NC		
24	NC		
12	NC		
25	NC		
13	NC		
			Note: Power Amp Fault and Acknowledge signals are all opto-isolated pairs. + indicates the Anode, and - indicates the Cathode.

Acutronic ACUTROL

Actuator Drive/Feedback Connector

Assy ID: Acutrol3000 Inner Loop Module Connector Reference: **J2**

Connector Type: **25 Pin D-sub (Female)** Part Number: AMP 1-745967-4

Pin I.D.	Signal Name	In/Out	Description
1 (1)	FDBK1+	I	Transducer#1 Feedback HI
14 (9)	FDBK1-	I	Transducer#1 Feedback LO
2 (2)	FDBK1sh	I	Transducer#1 Feedback Shield
15 (10)	GND	O	GND
3 (3)	+PP	O	Feedback Transducer#1 Excitation HI
16 (11)	PP COM	O	Feedback Transducer#1 Excitation Common
4 (4)	-PP	O	Feedback Transducer#1 Excitation LO
17 (12)	PP COM	O	Feedback Transducer#1 Excitation Common
5 (5)	DRV1+	O	Output Amplifier Drive#1 HI
18 (13)	DRV1-	O	Output Amplifier Drive#1 LO
6 (6)	DRV1sh	O	Output Amplifier Drive#1 Shield
19	GND	O	GND
7	NC		
20	NC		
8 (1)	FDBK2+	I	Transducer#2 Feedback HI
21 (9)	FDBK2-	I	Transducer#2 Feedback LO
9 (2)	FDBK2sh	I	Transducer#2 Feedback Shield
22 (10)	GND	O	GND
10 (3)	+PP	O	Feedback Transducer#2 Excitation HI
23 (11)	PP COM	O	Feedback Transducer#2 Excitation Common
11 (4)	-PP	O	Feedback Transducer#2 Excitation LO
24 (12)	PP COM	O	Feedback Transducer#2 Excitation Common
12 (5)	DRV2+	O	Output Amplifier Drive#2 HI
25 (13)	DRV2-	O	Output Amplifier Drive#2 LO
13 (6)	DRV2sh	O	Output Amplifier Drive#2 Shield
			Note: Numbers in () indicate the pin numbers if the cable is split into two DB15 connections.

Acutronic ACUTROL

Position Transducer Interface Connector

Assembly ID: **Transducer Drive/Feedback** Connector Reference: **J3**

Connector Type: **37 Pin D-sub (Female)** Part Number: **AMP 1-747301-4**

Pin I.D.	Signal Name	In/Out	Description
1	GND		Cable Shield (Drain)
20	GND		Inductosyn Drive Shield
2	INDH	O	Inductosyn Drive HI
21	INDL	O	Inductosyn Drive LO
3	FRDL	O	Fine Resolver Drive LO
22	FRDH	O	Fine Resolver Drive HI
4	GND		Fine Resolver Drive Shield
23	GND		12 Volt Power common
5	+12		+12 Volt Power
24	-12		-12 Volt Power
6	GND		12 Volt Power Shield
25	GND (Jumper)		Fine Sine Feedback Shield (Open)
7	FSFBKH	I	Fine Sine Feedback HI
26	FSFBKL	I	Fine Sine Feedback LO
8	GND		Control Line Common
27	GND (Jumper)		Fine Cosine Feedback Shield (Open)
9	FCFBKH	I	Fine Cosine Feedback HI
28	FCFBKL	I	Fine Cosine Feedback LO
10	LS+	O	CW Limit Switch
29	LS-	O	CCW Limit Switch
11	GND		Ground/Shield
30	GND (Jumper)		Coarse Sine Feedback Shield (installed)
12	CSFBKH	I	Coarse Sine Feedback HI
31	CSFBKL	I	Coarse Sine Feedback L0
13	CCFBKL	I	Coarse Cosine Feedback LO
32	CCFBKH	I	Coarse Cosine Feedback HI
14	GND (Jumper)		Coarse Cosine Feedback Shield (installed)
33	GND		Coarse Resolver Drive Shield
15	CRDH	O	Coarse Resolver Drive HI
34	CRDL	O	Coarse Resolver Drive LO
16	NC		
35	NC		
17	NC		
36	NC		
18	NC		
37	NC		
19	NC		

Acutronic ACUTROL

Acutrol3000 Transducer Drive/Feedback Interface Connector

Assembly ID: **Transducer Drive/Feedback** Connector Reference: **J4**

Connector Type: **37 Pin D-sub (Female)** Part Number: **AMP 747843-4**

Pin I.D.	Signal Name	In/Out	Description
1	GND		Cable Shield (Drain)
20	GND		Inductosyn Drive Shield
2	INDH	I	Inductosyn Drive HI
21	INDL	I	Inductosyn Drive LO
3	FRDL	I	Fine Resolver Drive LO
22	FRDH	I	Fine Resolver Drive HI
4	GND		Fine Resolver Drive Shield
23	GND		12 Volt Power common
5	+12		+12 Volt Power
24	-12		-12 Volt Power
6	GND		12 Volt Power Shield
25	GND (Jumper)		Fine Sine Feedback Shield (Open)
7	FSFBKH	O	Fine Sine Feedback HI
26	FSFBKL	O	Fine Sine Feedback LO
8	GND		Control Line Common
27	GND (Jumper)		Fine Cosine Feedback Shield (Open)
9	FCFBKH	O	Fine Cosine Feedback HI
28	FCFBKL	O	Fine Cosine Feedback LO
10	NC		
29	NC		
11	GND		Ground/Shield
30	GND (Jumper)		Coarse Sine Feedback Shield (installed)
12	CSFBKH	O	Coarse Sine Feedback HI
31	CSFBKL	O	Coarse Sine Feedback L0
13	CCFBKL	O	Coarse Cosine Feedback LO
32	CCFBKH	O	Coarse Cosine Feedback HI
14	GND (Jumper)		Coarse Cosine Feedback Shield (installed)
33	GND		Coarse Resolver Drive Shield
15	CRDH	I	Coarse Resolver Drive HI
34	CRDL	I	Coarse Resolver Drive LO
16	ANALOGL0	O	Analog Input 0 LO
35	ANALOGH0	O	Analog Input 0 HI
17	GND		Analog Input 0 Shield
36	GND		Analog Input 1 Shield
18	ANALOGH1	O	Analog Input 1 HI
37	ANALOGL1	O	Analog Input 1 LO
19	NC		

Acutronic ACUTROL

Actuator Drive/Feedback Terminal Block

Assy ID: Acutrol3000 Inner Loop Module Connector Reference: TB1
Connector Type: Terminal Block Part Number: Phoenix 1843017

Pin I.D.	Signal Name	In/Out	Description
TB1-1	FDBK1+	I	Transducer#1 Feedback HI
TB1-2	FDBK1-	I	Transducer#1 Feedback LO
TB1-3	FDBK1sh	I	Transducer#1 Feedback Shield
TB1-4	FDBK2sh	I	Transducer#2 Feedback Shield
TB1-5	FDBK2+	I	Transducer#2 Feedback HI
TB1-6	FDBK2-	I	Transducer#2 Feedback LO
TB1-7	PP COM	O	Feedback Transducer#1 Excitation Common
TB1-8	+PP	O	Feedback Transducer#1 Excitation HI
TB1-9	-PP	O	Feedback Transducer#1 Excitation LO
TB1-10	PP COM	O	Feedback Transducer#1 Excitation Common
TB1-11	DRV2+		Output Amplifier Drive#2 HI
TB1-12	DRV2-		Output Amplifier Drive#2 LO
TB1-13	DRV1+	O	Output Amplifier Drive#1 HI
TB1-14	DRV1-	O	Output Amplifier Drive#1 LO
TB1-15	DRV1sh	O	Output Amplifier Drive#1 Shield
TB1-16	AUX IN	I	Auxilliary Input for Output Amplifier
TB1-17	ServoOut2	O	Servo Output#2 (from J1)
TB1-18	COM	O	Analog Common
TB1-19	PressX	O	Cross Pressure
TB1-20	PressAv	O	Average Pressure
TB1-21	Acknowledge+	O	Power Amp Acknowledge #0
TB1-22	Acknowledge-	O	
TB1-23	Fault+	O	Power Amp Fault #0
TB1-24	Fault-	O	
			NOTE: Mating connector is Phoenix 1827800 (x2)

Acutronic ACUTROL

Bussed Signals Input Connector

Assy ID: Acutrol3000 Inner Loop Module Connector Reference: TB2
Connector Type: Terminal Block Part Number: Phoenix 1858112

Pin I.D.	Signal Name	In/Out	Description
TB2-1	+PP BUS	I	Feedback Transducer#1 Excitation HI
TB2-2	-PP BUS	I	Feedback Transducer#1 Excitation LO
TB2-3	Enable1	I	Enable 1 Link
TB2-4	V_{EXT}+	I	Output Amplifier External Power HI
TB2-5	COM	I	Common
TB2-6	V_{EXT}-	I	Output Amplifier External Power LO
TB2-7	PS+	I	Pressure Switch HI
TB2-8	PS-	I	Pressure Switch LO
TB2-9	DITHER	I	Dither Signal
TB2-10	NC		
			NOTE: Mating connector is Phoenix 1827787

Acutronic ACUTROL

Bussed Signals Output Connector

Assy ID: Acutrol3000 Inner Loop Module Connector Reference: TB3

Connector Type: Terminal Block Part Number: Phoenix 1862658

Pin I.D.	Signal Name	In/Out	Description
TB3-1	+PP BUS	O	Feedback Transducer#1 Excitation HI
TB3-2	-PP BUS	O	Feedback Transducer#1 Excitation LO
TB3-3	Enable1	O	Enable 1 Link
TB3-4	V_{EXT}+	O	Output Amplifier External Power HI
TB3-5	COM	O	Common
TB3-6	V_{EXT}-	O	Output Amplifier External Power LO
TB3-7	PS+	O	Pressure Switch HI
TB3-8	PS-	O	Pressure Switch LO
TB3-9	DITHER	O	Dither Signal
TB3-10	NC		