INSTALLATION
and
OPERATION
MANUAL

AC651

SERVO CONTROL
MODULE

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Paw-Taw-John Systems, Inc.

AC651 SERVO CONTROL MODULE

INTRODUCTION

ABOUT Paw-Taw-John Services, Inc.™

Paw-Taw-John Services, Inc.™ is a designer and manufacturer of semi-custom servo controller systems and associated components used in wood products and other manufacturing industries. The company brings together individuals with decades of experience in systems and software design, custom electrical and electronic systems manufacturing, and technical sales with expertise in sawmill operation and automation.

Paw-Taw-John Services, Inc.™ specializes in systems that provide greater user flexibility, lower maintenance, increased productivity, quicker pay-back, and higher yield. Our systems are in use worldwide by companies wanting more intelligence with their controllers.

Paw-Taw-John Services, Inc.™ systems are easier to setup, modify, and use in everyday operation than most programmable controllers. No special programming language must be learned and all programming may be done from a keypad terminal or 486 computer terminal. Our systems also interface with most popular position and limit sensors directly or via economical interfaces boxes we can supply with systems. **Paw-Taw-John Services, Inc.™** can also control most all popular servo and proportional valves directly. This offers a significant reduction in equipment suppliers required to construct your servo system.

ABOUT SERVO CONTROLLERS

A servo control system, when applied to positioning, is an electro-mechanical system that knows where it is at all times and provides for external data input, whether from sensors, computers, or humans, to act upon or produce a response to the input. Most often in industrial applications the servo system is used to control a linear motion such as positioning of a saw or movement of knees on carriage.

Each isolated linear motion is referred to as an axis. **Paw-Taw-John Services, Inc.™** systems are used to control one or more axes. Several of the axes may be interactive in multi-axis systems such as moving multiple saws simultaneously while still permitting individual saw adjustment.

A typical servo control system might consist of a hydraulic cylinder used to move a saw. The hydraulic fluid power is directed by a servo valve under the control of the servo controller. Some type of position sensor attached to the saw would provide positional data to the controller. To make the system usable an operator console might permit the selection of several cut lengths. In a real-time example the operator could choose a 10" cut width by pressing the 10" button on the console. This requests the servo controller via a PLC to move the saw to the 10" position. The controller sends a signal to the servo valve to move the hydraulic cylinder in the correct direction. Information returned to the controller from the saw position sensor is compared with the operator requested position and movement of the cylinder continues until the saw position reaches 10". At that position the controller removes the signal from the servo valve and the saw stops.

Paw-Taw-John Services, Inc.™
SERVO CONTROL SYSTEMS

Paw-Taw-John Services, Inc.™ servo controllers are semi-custom systems designed and assembled from a group of standard components. The heart of the system is an **AC651** servo control module. The **AC651** is designed to accept positional information from many industry standard sensors. It will output the appropriate control for most industry standard servo valves. Sixteen inputs and a data strobe are provided for receiving positioning information from a PLC.
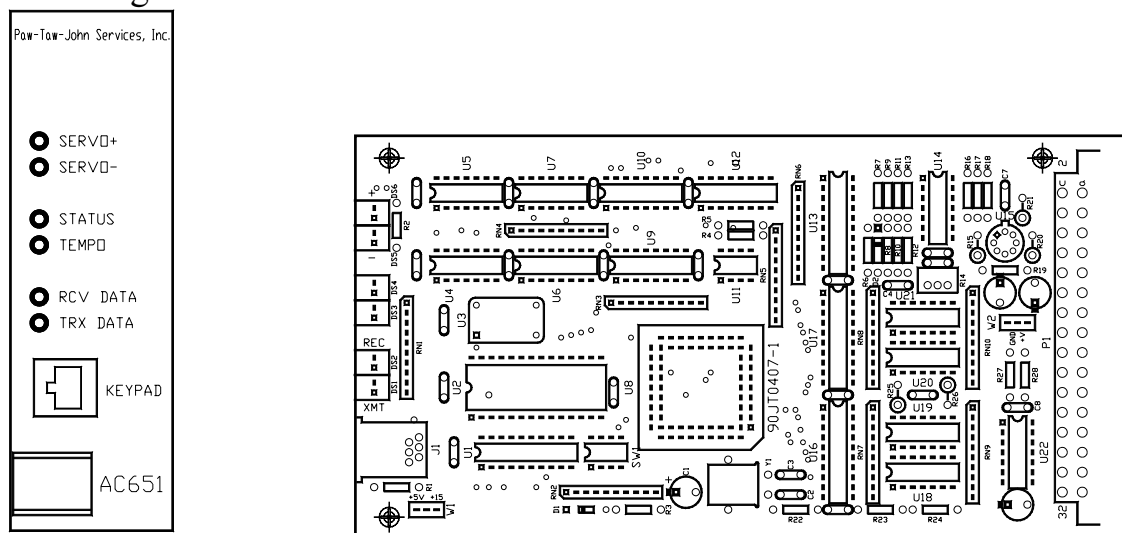
The specific operating characteristics and personality of the **AC651** are a function of the firmware programming that directs the microcontroller contained within. This program is created special to meet each PLC system's specific operating requirements.

The **AC651** servo controller high speed serial communications port may be connected to a terminal or computer via a telephone style modular jack for system setups and calibration, data tracking, and certain operating program modifications. Presently the Computerwise **TransTerm 5** terminal and 486DX computers are used. This feature makes possible on-site setup changes or accommodates for mechanical component wear or replacements.

One final serial communications port allows several **AC651s** to intercommunicate making possible multiple controller systems that can work in harmony. In this manner one command BYTE from a PLC control might permit separate and different actions from two or more controllers simultaneously.

The **AC651** has 16 inputs and 1 output that can operate between 5vdc to 30vdc. A 4-position dip switch, located on the component side of the circuit board, provides the addressing necessary in multiple card configurations and for special functions. The **AC651** operates from a Firmware program stored in a 28-pin memory IC. The card has another memory device for storing set and servo dynamics parameters, stroke limits, and transducer interfacing information. Both of these devices are non-volatile so there data is not lost if power is removed.

The main I/O connector opposite of the face of the card is a Euro-style 32 pin dual readout. This provides the card with flexibility to mount in single or multiple cardrack configurations. A complete custom **Paw-Taw-John Services, Inc.™** servo control system is built from one or more **AC651** controllers. Servo systems also typically include power supplies, wire and cable terminating blocks, suitable enclosures, PLC's and custom operator panels.

TYPICAL SYSTEM COMPONENTS

A typical servo system from **Paw-Taw-John Services, Inc.™** will be constructed from one or more of the components below:

1. **System Control Enclosure:**
   The servo control enclosure contains a cardrack used for support and interconnection to one or more AC651 Servo Controller Cards, power supplies necessary to operate the controller cards and other system components, AC power switch and fuses, and suitable terminal blocks for connecting external component wiring. All of these parts are housed in an NEMA 12 enclosure designed for wall mount. Care is taken in design to provide wire ducting so that primary AC and secondary DC may be kept separated. The enclosure should be drilled for attachment of conduits during installation.

2. **Temposonic Probe:**
   A linear transducer mounted inside the center of each cylinder used to measure position. A magnet that moves with the piston reflects an internal square wave generated at the probe head.
   The reflected wave is processed and provides accuracy to 0.001 inches.

3. **Recirculation Box:**
   The Recirculation box contains a circuit card (**AC700**) that distributes the servo drive and Temposonics' signals for a single axis. A system may have one or more Recirculation boxes. The card controls the number of "recirculations" that the position signal will make in the **Temposonic probe**. The more recirculations the greater the resolution. The **AC700** also sets the probe operating frequency and triggering signal. Please refer to Recirculation box manuals for setup and operation information.

4. **Operator Control Panel:**
   The **Operator Control Panel** is the main user system operating and control interface. This panel is typically custom designed and constructed to suit the requirements of the servo system. An assortment of **Set** control lighted push-button switches and other switches or joysticks for jog and cut control allow the operator to control the system. This panel is connected to the **System Control Enclosure** via a multi-conductor cable.

5. **TransTerm 5 Terminal:**
   The keypad terminal is used to display system status and adjust operating parameters, axis offsets, jog functions, and for troubleshooting. Refer to system to the System Operation section of this manual for specific operating details. The **TransTerm 5** terminal connects directly to the **AC650** cards inside the **System Control Enclosure**.

6. **Servo/Proportional Valves:**
   Servo Valves, and in some systems proportional valves, control the flow of hydraulic pressure to the hydraulic cylinders. One valve will be associated with each axis. The **Servo Valves** are controlled from the servo output of **AC651** cards located in the **System Control Enclosure**. Refer to the system installation section of this manual for adjustments to the **AC651** that may be required by any specific valve type.

7. **486DX computer:**
   These computers are interfaced to the **AC651** cards via a high-speed dual channel interface card (**PC1**) mounted inside the **486DX** computer and communications cable. This system interface is used for more complicated system controls. All setup and operational characteristics are controlled from the computer.

8. **PLC's:**
   These machine controllers are interfaced to the **AC651** cards via a 16 point DC output module connected to a 16 point terminal strip located on the **AC651MB** card rack. A data strobe is also required from the PLC to strobe data into the **AC651** cards.

AC651 SERVO CONTROLLER CARD FEATURES AND

ELECTRICAL SPECIFICATIONS

The AC651 servo control card is used for linear positioning and hydraulic servo valve control. It is used with PLC's as a external servo controller. A PLC can control 1-8 axes per bank.

FIRMWARE FEATURES:

- **Isolated 17 inputs (5-32VDC)**

- **Non-volatile memory storage so no battery backup is required.**

- **High-speed RS485/RS422 SDLC serial port.**
Baud rates of 1.2 m standard

- **Low-speed RS-422 serial port accessible through a 6 pin phone jack.**
Baud rates of 2400 to 19.2k.

- **Digital interface to MTS(R) Temposonics(R) linear transducers.**

- **Provides +/- 0-100 mA current output for Servo valves.**

- **Has +/- 10vdc output capability.**

- **Dip switch auto-null selection.**

- **Addressable Dip switch settings for up to 8 axes per bank.**

- **Red status LED's mounted on the face of the board.**

- **Uses Euro-style connector for easy installation in single or multiple card racks.**

- **Can be interfaced to RS-232 serial communication port through inexpensive converter.**

SOFTWARE FEATURES

- **Custom programs embedded on UV EPROM.**

- **Programs written to interface card control through a phone jack to dummy computer terminals.**

- **Programs written to interface card to PC's through high-speed serial port.**

- **Personal Computer (PC) High-speed communications board (PC1) available.**

- **Data presented in thousandths of inches or centimeters.**

- **Programs written for special applications.**

POWER SPECIFICATIONS

- **+5vdc @ .5 amps**

- **+15vdc @ .1 amps***

- **-15vdc @ .1 amps**

*When using TransTerm 5 Computer terminal, +15vdc .5 amps is required.

OPERATING TEMPERATURE

-40 TO 150 deg. F (-40 to 66 deg. C.)

CONFIGURATION OPTIONS

1.   486DX computer to AC651MB card rack.
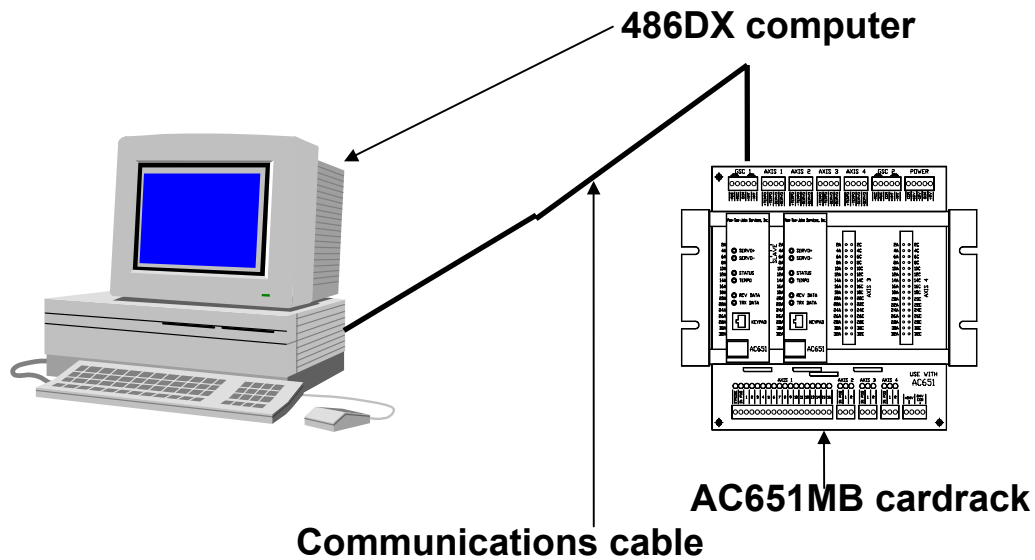
486DX computer

AC651MB cardrack

Communications cable

2. 486DX computer to multiple card rack system
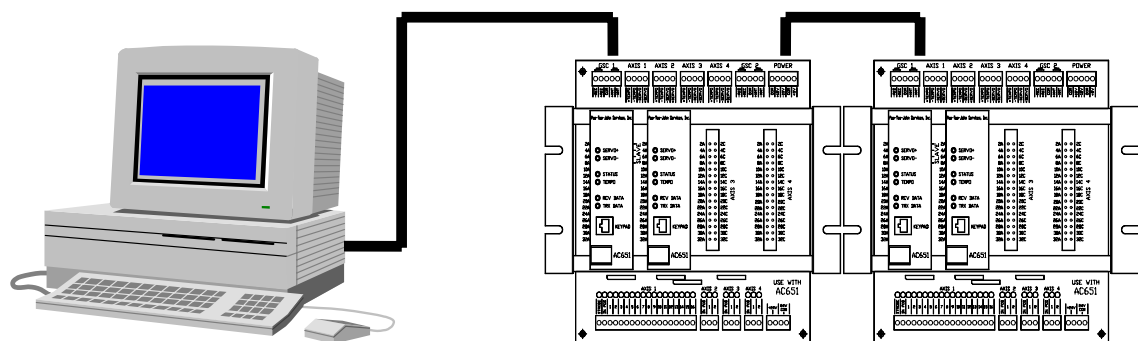
3. Transterm 5 handheld terminal to single card rack
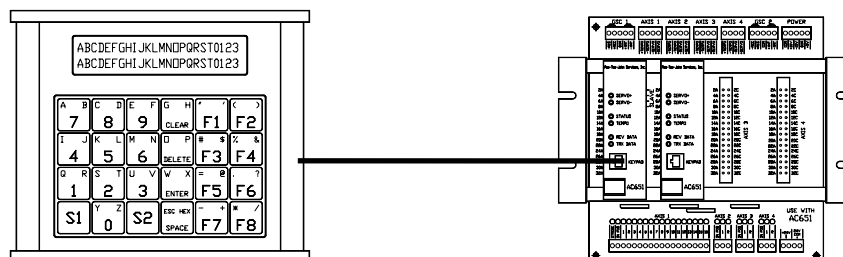
4. PLC with TTL input/out modules interfacing to AC651MB rack.
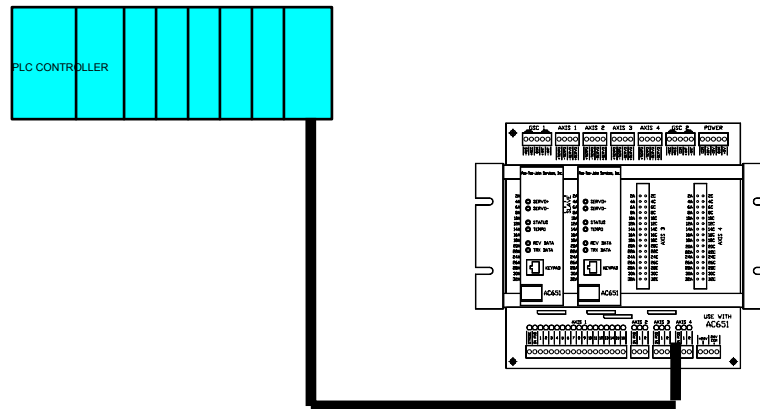
For further information, please contact Paw-Taw-John Services, Inc.™ at 208-687-1478.

CONFIGURATION OPTIONS

1. **486DX computer to AC650MB card rack.**
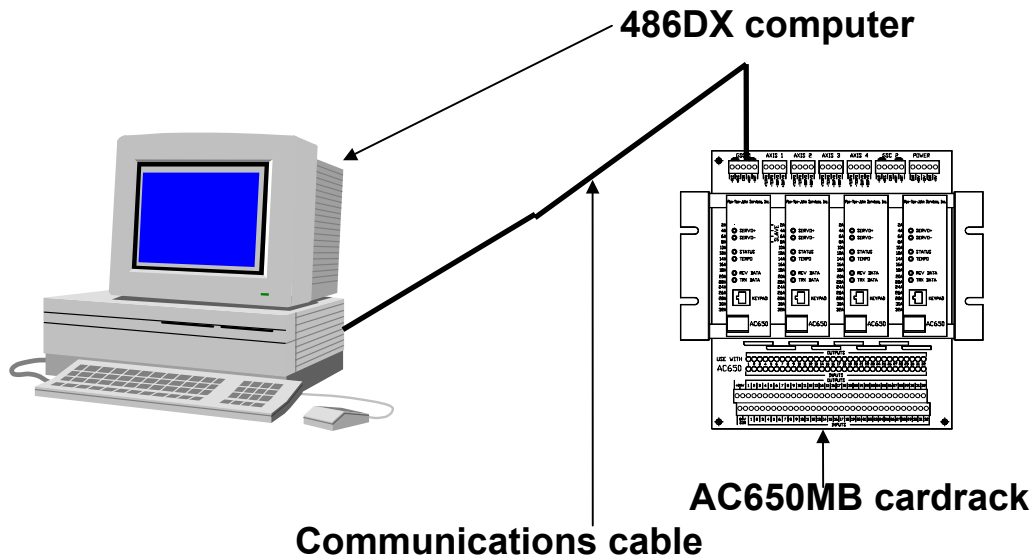
486DX computer

AC650MB cardrack

Communications cable

2. **486DX computer to multiple card rack system**
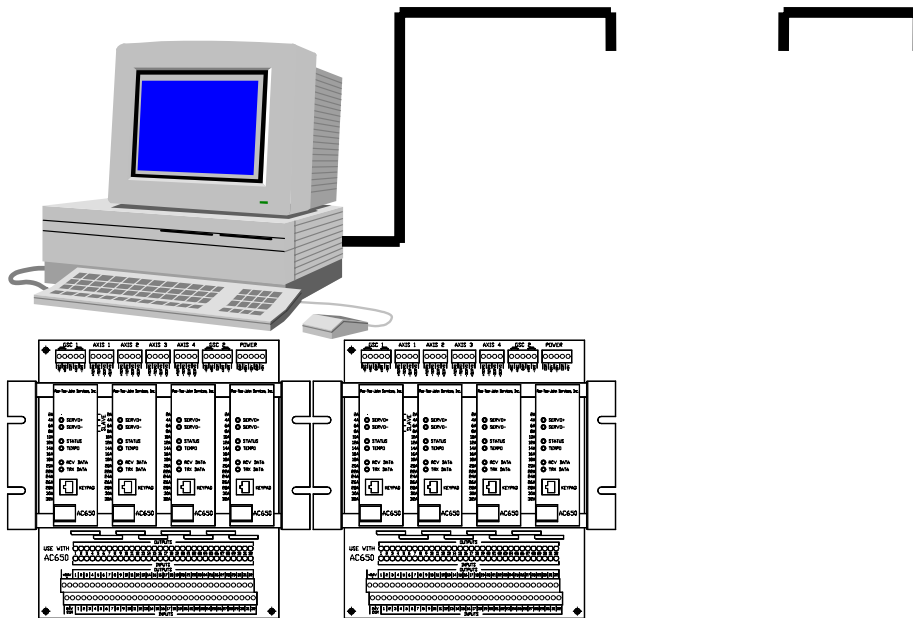
3. **Transterm 5 handheld terminal to single card rack**
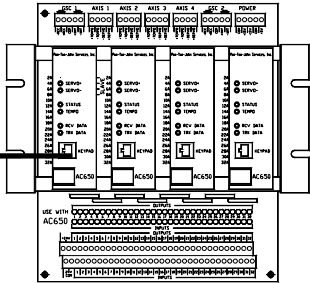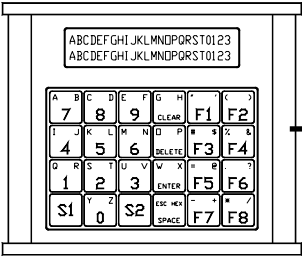
AC651 SERVO CONTROLLER CARD

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FIRMWARE FEATURES:

•Isolated 17 inputs (5-32VDC)
 •Non-volatile memory storage so no battery backup is required.
 •High-speed RS485/RS422 SDLC serial port. Baud rates of 1.2 m standard
•Low-speed RS-422 serial port accessible through a 6 pin phone jack.
Baud rates of 2400 to 19.2k.
 •Digital interface to MTS® Temposonics® linear transducers.
 •Provides +/- 0-100 mA current output for Servo valves.
•Has +/- 10vdc output capability. •Dip switch auto-null selection.
•Addressable Dip switch settings for up to 8 axes per bank.
 •Red status LED's mounted on the face of the board.
 •Uses Euro-style connector for easy installation in single or multiple card racks.
 •Can be interfaced to RS-232 serial communication port through inexpensive converter.

SOFTWARE FEATURES:

•Custom programs embedded on UV EPROM.
 •Programs written to interface card control through a phone jack to dummy computer terminals.
•Programs written to interface card to PC's through high-speed serial port.
•Personal Computer (PC) High-speed communications board (PC1) available.
 •Data presented in thousandths of inches or centimeters.
•Programs written for special applications.

POWER SPECIFICATIONS:

•+5vdc @ .5 amps •+15vdc @ .1 amps* •-15vdc @ .1 amps

*When using TransTerm 5 Computer terminal, +15vdc .5 amps is required.

OPERATING TEMPERATURE:

-40 TO 150 deg. F (-40 to 66 deg. C.)

AC651 MOTHERBOARD

The AC651 Motherboard provides housing for up to four AC651 servo controller cards, as well as providing hookup location for power, inputs, outputs, serial communications terminals, servo and MTS® Temposonics®. Multiple card racks can be attained through the serial communications terminal.

AC651 INITIAL SERVO SYSTEM SETUP

HARDWARE CHECKOUT

WARNING
INSURE ALL LOCAL LOCKOUT PROCEDURES ARE FOL-
LOWED!!!

AC651 CARD RACK CONFIGURATION
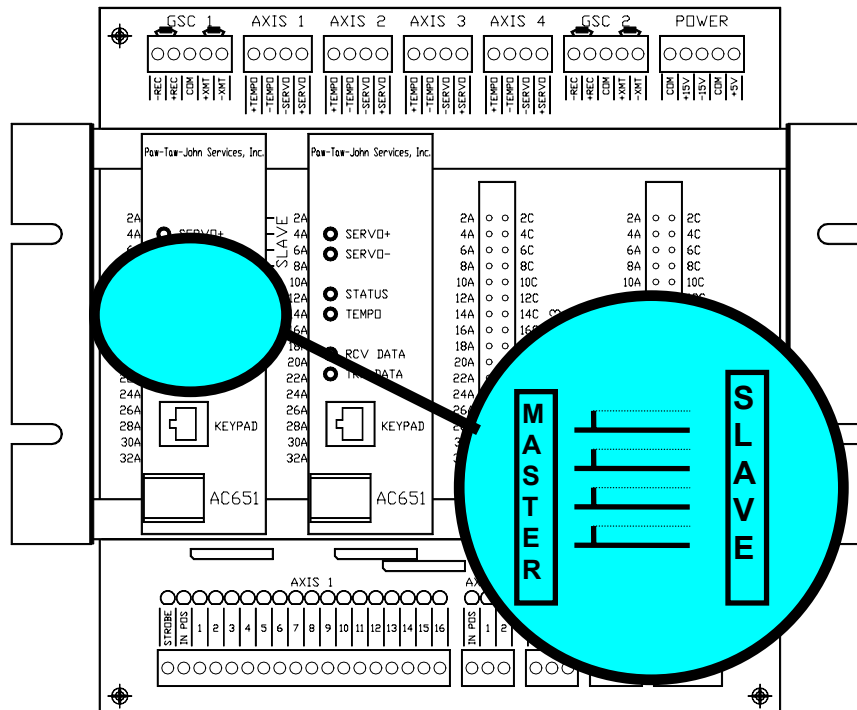
Refer to figure above for the following check.

1. Ensure 4 Master jumpers wires are installed near card 1 connector.
2. Install if not present.

NOTE: In multiple card rack configurations, the second rack has 4 jumpers installed in the Slave locations.

MULTIPLE AC651 CARD RACK CONFIGURATION

Refer to drawing below.
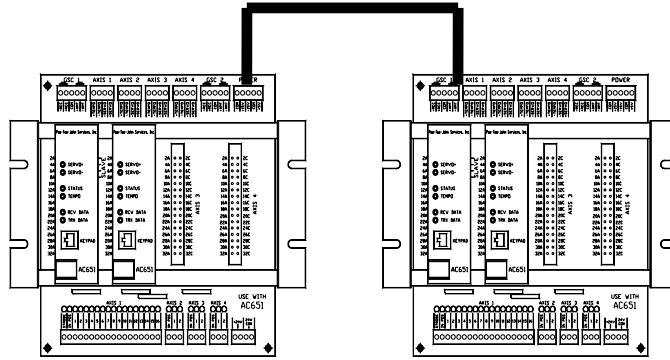
1. Install jumper cable between GSC 2 of rack 1 and GSC 1 of rack 2 using the following cabling diagram.

COMMUNICATIONS CABLE INTERCONNECT					
RACK 1	GSC2			RACK 2	GSC1
"-REC		RED		"-REC	
"+REC		BLK		"+REC	
"COM		WHT/BLK PAIR		"COM	
"+XMT		GRN		"+XMT	
"-XMT		BLK		"-XMT	
SHIELD ARE CONNECTED TO EARTH GROUND					

NOTE: Usually, a three pair shielded cable is used for this jumper.

AC651 CARD ADDRESS SETUP

1. Referring to the **AC651** drawing and the DIP Switch Table below, adjust the card address DIP switch positions on each **AC651** card.
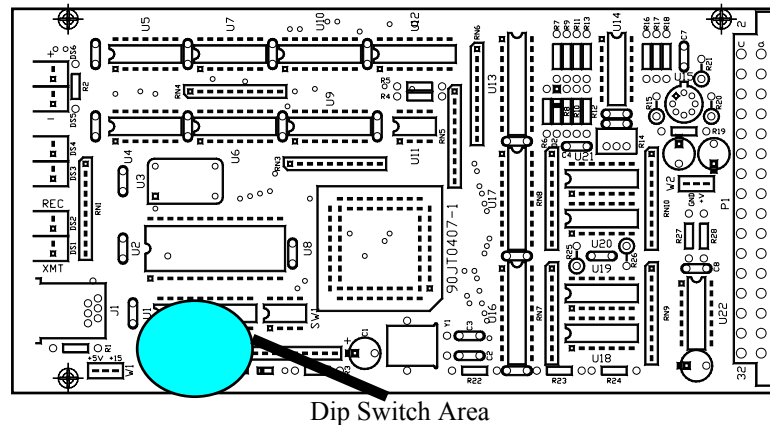
Dip Switch Area

AC651 DIP SWITCH POSITIONS				
AXIS	Switch 1	Switch 2	Switch 3	Program Bit Codes
1	OFF	OFF	OFF	1
2	ON	OFF	OFF	2
3	OFF	ON	OFF	3
4	ON	ON	OFF	4
5	OFF	OFF	ON	5
6	ON	OFF	ON	6
7	OFF	ON	ON	7
8	ON	ON	ON	8

Example, for single axis systems, address switches 1, 2, and 3 are off.

NOTE: Axis 1 is always the **MASTER.**

2. DIP position number 4 is the auto-null enable. When on, the **AC651** card supplies correct servo drive current to counter any out of null conditions the valve might have. In this mode the target position and the actual position on the terminal should be within 0.001".

AC651 CARD SERVO OUTPUT SETUP

1. The **AC651** servo drive output range may require adjustment depending on the type of servo valve being used. Refer to the servo valve manufacture's specifications to determine the amount of servo drive current required.

2. The **AC651** is shipped from **Paw-Taw-John Services, Inc. ™** factory preset to **30mA**. A **50K**-ohm resistor is installed in position **R18**.

3. Care should be taken if the value of **R18** must be changed. A qualified electronic technician should be used to perform the change or the **AC651** card(s) may be returned to **Paw-Taw-John Services, Inc. ™**

4. Refer to the drawing and table below should it be necessary to change servo output current. (**Note:** Each **AC651** card must be matched to it's own servo valve.)

AC651 SERVO OUTPUTS	
Current Adjustment	
Servo Valve Current Required	*R18 Resistor Value*
25 mA	39K-ohm
30 mA	50K-ohm
50 mA	82K-ohm
60 mA	100K-ohm
100 mA	180K-ohm
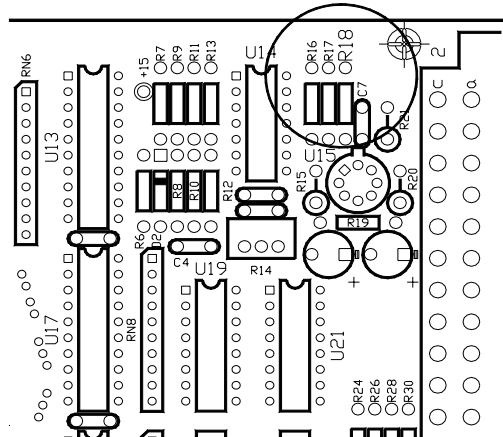
5. Install all **AC651** cards in their correct positions with the **Master** in the left most position. (**Note:** the card connectors are keyed to prevent incorrect orientation.)

VOLTAGE TESTS AND WIRING CHECKS
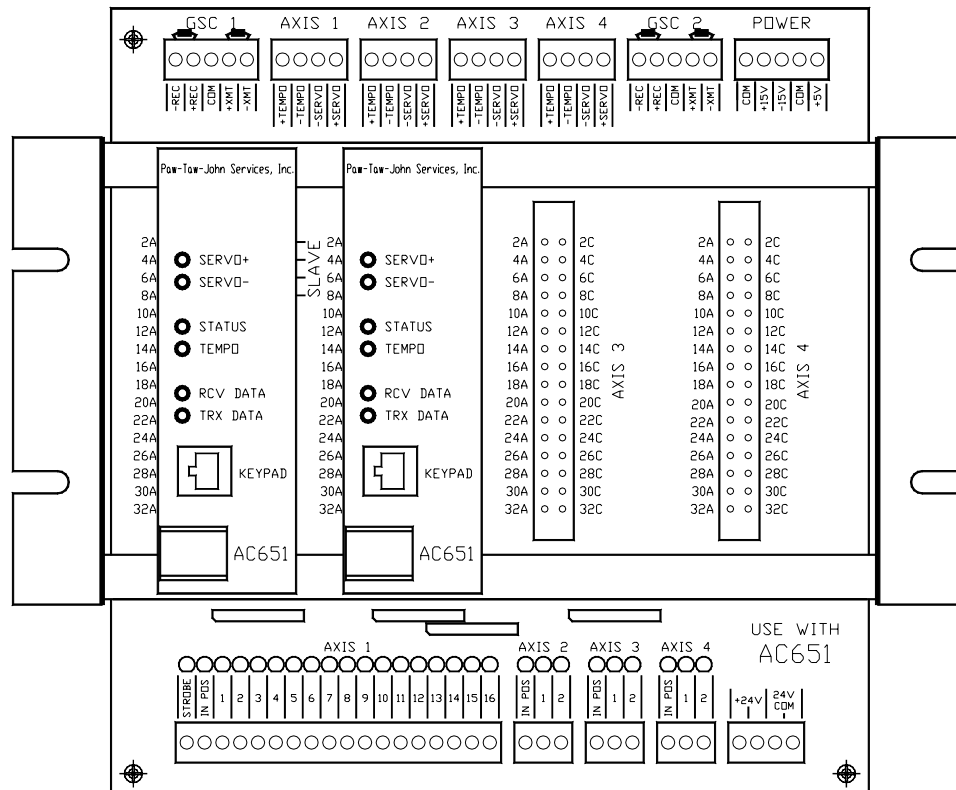
Refer to figure above for the tests and checks that follow.

1. Remove all **AC651** cards from cardrack before applying power.

2.	Apply AC power to system and verify correct DC voltages are present at power terminals on the **AC651** cardrack per table below.

AC651 CARDRACK VOLTAGES			
Terminals		Voltage	
From	To	Minimum	Maximum
+5VDC	GND	+4.9VDC	+5.2VDC
+15VDC	GND	+14.9VDC	+15.2VDC
-15VDC	GND	-14.9VDC	-15.2VDC
+24VDC*	24V RET*	+5VDC	+30VDC
* Input/Output Supply Voltage			

3.	Turn off AC power.
4.	Verify **MTS®** Temposonics® transducer connections are correct per drawing.
5.	Verify SERVO+ and SERVO- lines are present at the correct terminals per drawing.
6.	Verify that 150 ohm resistors are installed Between the **REC+, REC-** and **XMT+, XMT-** terminal pairs of the **GSC 1** and **GSC 2** terminal blocks.

TRANSTERM 5 (TT5 Keyboard) SETUP

1.	Install the keypad cable between **TransTerm 5** and **KEYPAD** jack on face of the left most **AC651** card (master position).

2.	When power is applied the **TransTerm 5** should beep three times. The top line will display the **AC651** firmware program name, date and whether the **AC651** card is a master or slave. The bottom line will initialize for a moment and then display a card status message.

PRGMNAME 1/15/95 MASTER
SYSTEM OK

3.	A **TransTerm 5** register check should be conducted next to make sure the **TT5** is set to properly communicate with **AC651** cards. It is nec-

essary to switch to the setup mode by entering the following key-strokes: **S2** (blue key), **S1** (red key), and **S2** (blue key).

```
  Press Keys:

SR   12345678 12345678
SR1=00000000-

        A    B  C    D  E    F  G    H  "     '  (     )
        7      8      9    CLEAR   F1     F2        S2
        I    J  K    L  M    N  □    P  #    $  %    &          ↓
        4      5      6   DELETE   F3     F4
        Q    R  S    T  U    V  W    X  =    @  .    ?        S1
        1      2      3   ENTER   F5     F6
        Y    Z          ESC HEX   -    +  *    /          ↓
       S1     0     S2   SPACE   F7     F8
                                                            S2

                                                 Cursor Position
```
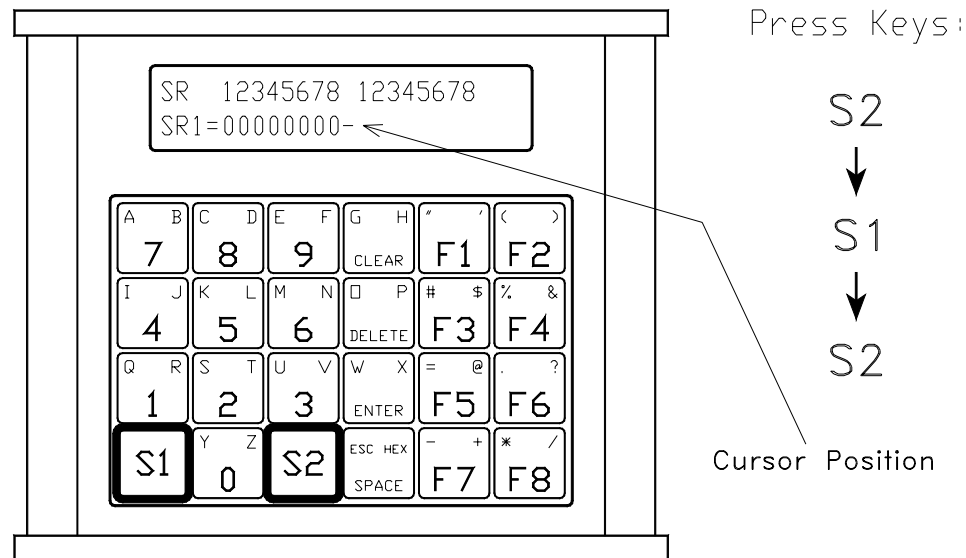
4.   The top line shows **SR** indicating the setup register mode and two sequential counts from 1 to 8 to mark data bit positions.

5.   The bottom line of the display shows which of the four registers (**SR1 - SR4**) is active, the data for that register, and the blinking cursor at the first new data entry position. Each register contains 8 data bits that are either "1" or "0". This data determines how the **TT5** will work. It is necessary to have the registers filled with the exact sequence of "1"s and "0"s so the terminal can talk with the **AC651**.

6.   The bit sequence for register SR1 should be as follows:

SR1=00000000

If the data displayed does not match, key in "00000000". Then press the **ENTER** key. If the data displayed does match the bit sequence, just press the **ENTER** key to accept the data as displayed.

8.   After the **ENTER** key is pressed in step 7, the display will automatically increment to the next register. Repeat the procedure in step seven for all four registers confirming or changing the data bits to match the following:

SR2=00000010
SR3=00001001
SR4=00000000

Hit the **ENTER** key after each register entry.
9. When all four registers are correct press the **CLEAR** key to exit the setup mode.

> Please refer to **TransTerm 5** Troubleshooting if no data is displayed Also refer to the **TransTerm 5 User's Manual** (included with the system) for more detail on terminal setup.

Starting system parameters are loaded by **Paw-Taw-John Services, Inc. ™** at time of manufacture.

TRANSTERM 5 TERMINAL OPERATION

The **TransTerm 5** is a complete dummy terminal capable of all functions used on standard personal computer systems. The **TT5** may be powered using an external 12VDC power unit or powered via it's data cable from the **AC651**. Typically **AC651** cards provide 12 to 15 volts through their 6-pin keypad jacks.

The **TT5** terminal has two shift buttons labeled **S1** and **S2**. **S1** is Red and when first depressed activates all red characters on the keypad. An example would be if a function requires "**I**" to be entered; first press **S1** which activates the Red characters, then press the **I** key to send the command. The **S2** key activates the all Blue characters on the keyboard. To enter a "**P**" requires first pressing the **S2** key to activate Blue characters and then the **P** key to send the command. An example is shown below.
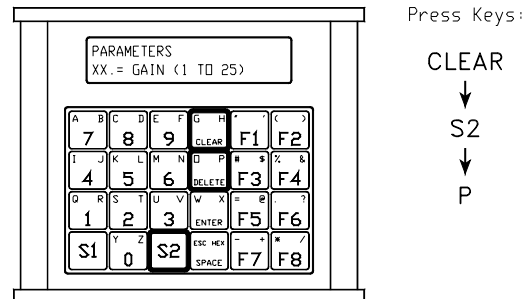
It is a good practice to press the **CLEAR** key before beginning a command sequence to assure the **TransTerm 5** is not already in the middle of a com-

mand sequence. Single character or word commands in Black on the keyboard are direct entry commands in that they may be entered at anytime after the **CLEAR** key has been pressed. Refer to the table below for valid **AC651** commands entered from the **TT5** terminal.

AC651 COMMANDS	
Command Sequence	*Function or Action*
CLEAR	Return system to Run mode
ENTER	Enter values previously typed in
SPACE	Scroll forward to next entry
DELETE	Scroll backward to previous entry
S1 ➜ I	Data transfer information screen
S2 ➜ 4	Enter Servo jog enables
S2 ➜ P	Enter Parameter Table
1	Displays Axis "1" Target and Actual Position
2	Displays Axis "2" Target and Actual Position
S1>2	Servo status data screen

Shortly after power-up of the system, the **TransTerm 5** will display the following:
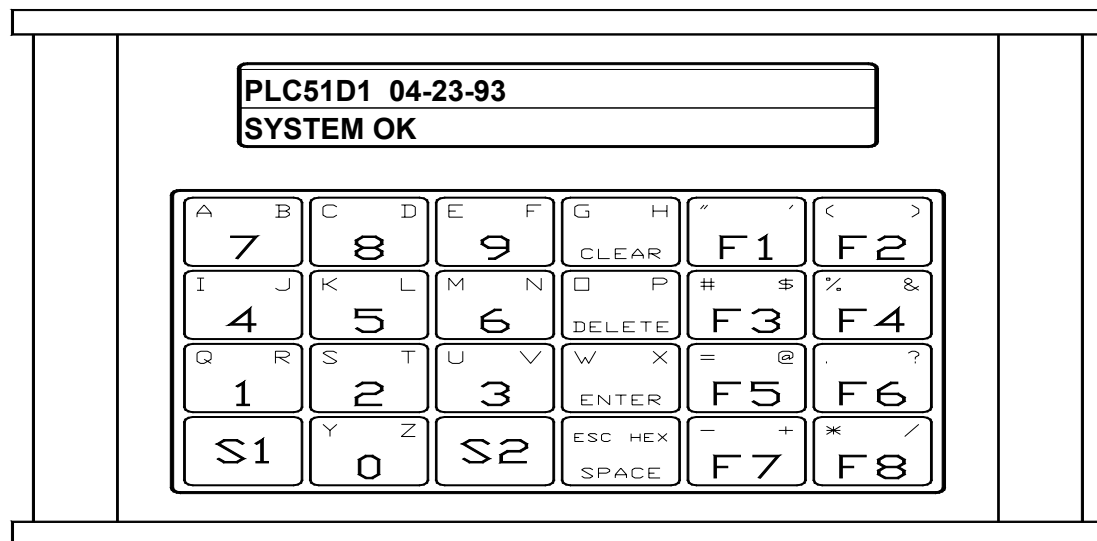
At any time the **TT5** terminal may be placed in or returned to the RUN MODE by depressing the **CLEAR** key. Refer to the above display.

DEFINITION OF SYSTEM PARAMETERS

COORDINATE SYSTEM

1.   The **AC651** servo control system measures movement of the cylinder in inches. The coordinate system can be set up to place the zero reference at any point that is most useful. The direction of "Increasing Position" can also be selected.

2.   The **EXT. TO ZERO IF 1** operating parameter establishes the direction of increasing cylinder position. When set to one (1) the zero position is near the extended end of the cylinder, and position increases toward the retract end of the cylinder.

3.   If **EXT. TO ZERO IF 1** is set to any value except one, the zero value will be at the retract end of the cylinder and position will increase toward the extended end of the cylinder.
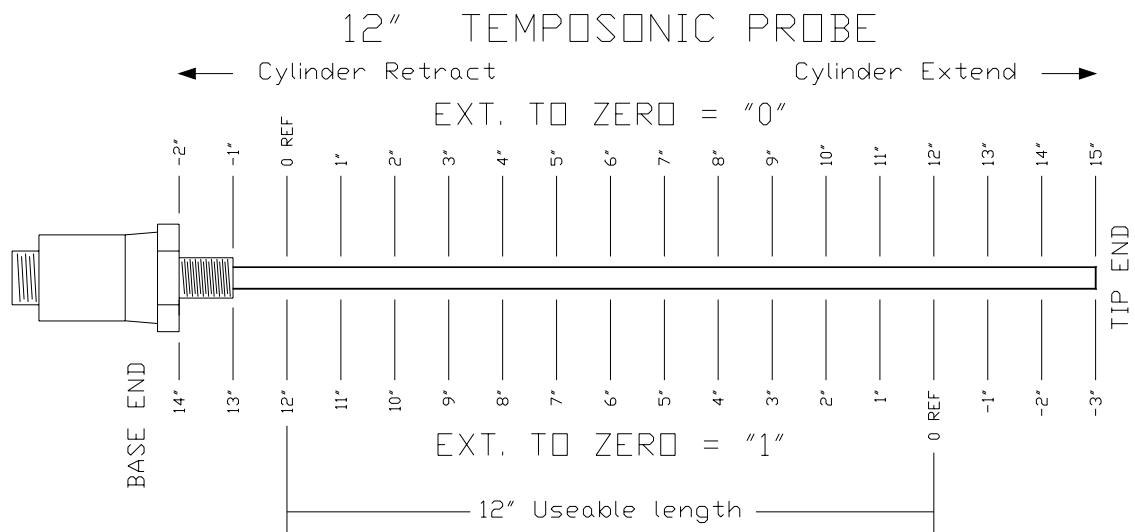
Note: Temposonics probes are physically 4.5" to 5.0" longer than the actual operating length. Please refer to the drawing for discussions below.

4.   The **ZERO ADJUST** is used to place the coordinate system zero reference where it will be most useful for the system. It can be set to any value between 0" and 65".

5.   If the zero reference is best at the extended end of the cylinder **(EXT. TO ZERO IF 1 = "1"),** a value of the probe length plus 3" will place

the zero reference near the extended end of the cylinder (tip of the probe).

Example: The 12" probe would need a value of 15.000" to place the coordinate system zero reference near the extended end. A higher value will move the zero reference beyond the end while a lower value will move the zero reference toward the retract end.

6. If the zero reference is best at the retracted end of the cylinder **(EXT. TO ZERO IF 1 = "0"),** a **ZERO OFFSET ADJUST** value of 12.000" will place the zero reference near the retracted end of the cylinder (base of the probe). Values greater than 12.000" will move the zero reference off the base end of the probe while a **ZERO OFFSET ADJUST** value less than 12.000" will move the zero reference toward the extended end of the cylinder.

7. **EXT. TO ZERO IF "1"** and **ZERO ADJUST** are both set for each axis used in a multiple axis system.

SYSTEM RESPONSE

1 The ability of the system to respond smoothly and quickly to a target position change is set using the **ACCELERATION, MAXIMUM VELOCITY, DECELERATION, MINIMUM DECELERATION** and **GAIN** operating parameters.

2. An example of cylinder action is demonstrated in the graph below where a target position change was made from 1" to 11" by a cylinder with a travel rate of 5" per second. The graph on the next page illustrates the effects of acceleration and deceleration which are necessary to produce smooth start and stop without objectionable jerks or overshooting.

3. Refer to the Servo Output % curve for the following discussion.

a. Cylinder movement begins with the servo output signal from the AC650 card controlling the servo valve by supplying an operating current. The Acceleration (**ACCEL**) parameter sets the rate at which cylinder speed increases. This is demonstrated by the rising part of the curve. The Acceleration parameter can be set to any value be-

tween 1 and 50. The higher the value the faster the acceleration and the quicker the cylinder will jerk to full speed.

b.   When the maximum desired operating cylinder operating speed is less than   the cylinder maximum, Maximum Velocity (**MAX VEL**) may be set to prevent an   over speed condition. The Maximum Velocity may be set at any number from 0 to 99% which is demonstrated by the flat part of the curve.

c.   At some point prior to reaching the new target it will be necessary to slow the cylinder to a stop gradually. This is done in two stages as shown on the following edge of the curve. The first stage, called Deceleration (**DECEL**), is used to reduce speed quickly. The second stage, called Gain (**GAIN**) provides a more   gentle speed reduction making an easy to stop without overshooting the target.

d.   **DECEL** may have a value between 1 and 70. The higher the value the quicker (more abrupt) the approach to the target.

e.   The transition from the Deceleration phase to the Gain phase is controlled by Minimum Deceleration Position (**MIN DECEL POS**). A number between 1 and 999 determines how far from the final target this happens. A larger number makes the transition occur further from the target.

f.   **GAIN** controls the system response while jogging the cylinder in addition to holding the setpoint after leaving the Deceleration mode. The value can be between 1 and 25 (with 5 to 10 being most common). A high value will give quicker system response but could cause cylinder oscillations. A value that is too low will cause sluggish system response and large errors between actual and target position.

SERVO SYSTEM RESPONSE
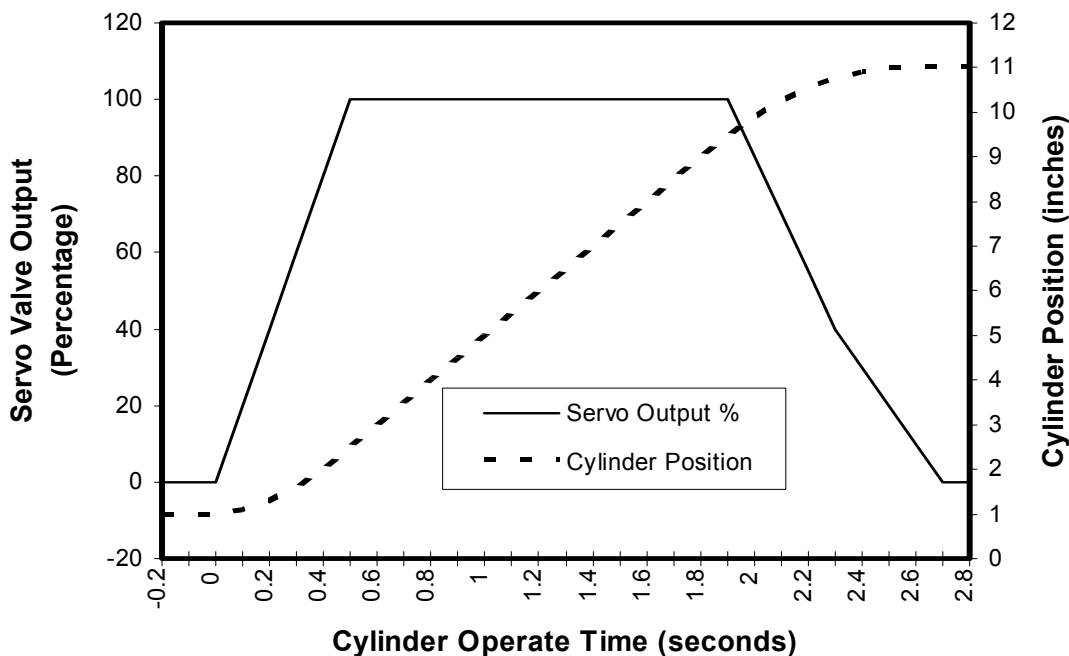
MISCELLANEOUS PARAMETERS

1.   Temposonic Scaling Factor (**TEMPO SCALE**) used to adjust indi-
     vidual Temposonics probes to a standard scale. This value is preset at
     Paw-Taw-John Services, Inc. ™

2.   Minimum Limit (**MIN LIMIT**) sets the minimum allowed cylinder
     position.

3.   Maximum Limit (**MAX LIMIT**) sets the maximum allowed cylinder
     position.

4.   Number of servos (**# OF SERVOS**) is used to set the number of axis
     or servos in the system.

5.   **MAXVEL. INC(1 TO 99%)** determines the amount of drive to the servo valve in the turn on portion of drive.

6.   **MAXVEL DECREASE** determines the amount of drive to the servo valve in the turn off portion of drive.

7.   **(JOG=X)** determines if this module can be jogged.

ENTERING SYSTEM PARAMETERS

The parameter mode is used to set up the dynamics of the servo loop, Temposonics® calibration, starting offset valves or calibration of the hydraulic cylinder to the **0** of the machine, and other selected functions. To enter this mode, do the following:

1.   Depress **CLEAR, S2** and **P** keys in sequence.
2.   Display will show the following:

Display shows:

```
PARAMETERS
XX=GAIN(1 TO 64)
```
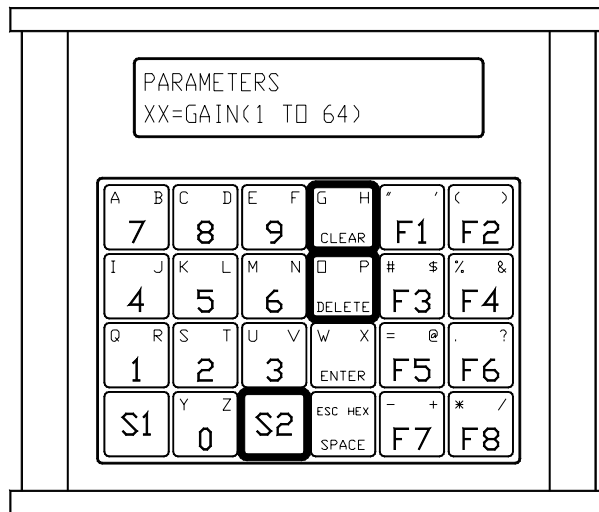
3. To sequence through the parameter mode depress **SPACE**. To sequence the display in reverse depress **DELETE**. The cursor will be present at the beginning of the values that can be changed. To enter a new value, key in the new number on the keypad. Then press the **ENTER** key to send the new number to the system.

4. The following are the parameters that will be scrolled when sequencing through the parameters mode starting at the **GAIN**:

    XX=GAIN (1 TO 48)
    7.997=TEMPO SCALE
    XX.XXX=ZERO OFFSET ADJ.
    XX=ACCEL(1 TO 50)
    XX=DECEL(1 TO 50)
    XX.XXX=DECEL MIN. POS.
    XX=MAXVEL. INC (1 TO 99%)
    XX=MAXVEL DECREASE
    X=EXT. TO ZERO IF 1
    XX.XXX=MIN. LIMIT
    XX.XXX=MAX. LIMIT
    X=# OF SERVOS(1-8)
    (JOG=1)

5. Refer to the previous section, **Definition of System Parameters**, for explanation of terms and values.

6. **NEW ENTRIES SHOULD BE RECORDED ON A PAPER FOR FUTURE REFERENCE.**

7.   Press the **CLEAR** key to exit the **PARAMETER** mode.

TRANSTERM DISPLAY MESSAGES

The **AC651** card status messages have the following meanings:

 # Tempo Bad: - Temposonics transducer system has incorrect or no input to numbered card

Bad Module #: - numbered module not communicating or working

System OK: - all cards are communicating and working null

Bad Null: - card drive to servo valve is unable to maintain (This message can occur during power up or if hydraulic system is not on)

Overtravel: - axis has reached software stroke limit

This completes initial setup. Continue on with the Servo Loop Dynamics Setup.

SERVO LOOP DYNAMICS SETUP

<div style="border:3px solid black;">

WARNING: WHEN USING HYDRAULICS, USERS SHOULD BE CLEAR OF MOVING MACHINES AND ALL LOCAL SAFETY AND LOCK OUT PROCEDURES MUST BE FOLLOWED!!!

</div>

1. Ensure Transterm 5 is connected to the Master AC651 servo card. **Each AC651 card in the system must have the same parameters loaded.**

2. To prevent any violent movement when the hydraulics is turned on, enter the parameter mode (**Clear>S2>P**) and enter the following:

06=	**GAIN**
XX.XXX=	**ZERO OFFSET ADJ.(MAKE EQUAL TO CYLINDER STROKE LENGTH)**
25=	**ACCEL**
25=	**DECEL**
00.200=	**DECEL MIN. POS.**
30=	**MAXVEL.**
30=	**MAXVEL DECREASE**
X=	**1 OR 0 FOR STROKE DIRECTION**
00.500=	**MIN. LIMIT**
XX.XXX=	**MAX.LIMIT (ENTER MAXIMUM VALUE THAT CYLIN-DERS WITHIN THE LIMITATIONS OF THE MACHINE.**
X=	**ENTER THE NUMBER OF AC651 CONTROLLER CARDS IN THE CARD RACK.**
(JOG=1)	**DEPRESS CLEAR>S2>4 AND ENTER 1 OR 0 FOR EACH AXIS THAT REQUIRES THE JOG FEATURE.**

3. After the Master AC651 servo card is loaded, remove the cable from the phone jack and install in the next AC651. Repeat entering the above parameter values. Perform this procedure for all AC651 servo cards used.

CAUTION: WHEN HYDRAULICS IS TURNED ON, CYLINDERS MIGHT MOVE ERRATICALLY UNTIL AIR IS BLED FROM THE CYLINDERS. PERSONNEL MUST REMAIN CLEAR OF THE MACHINE!!!

4. Turn on the hydraulics, and enter a position value from the set panel.

5. Exercise the cylinders by changing sets on the set panel until they move smoothly. (User is bleeding air from the cylinders.)

6. With the Transterm 5 cable installed in the master AC651 phone jack, depress Clear > 1 and note the "TO1" position and the "P" position.

7. Increase the gain value in the parameter mode by 5 and enter a change in the set value from the set panel. Observe the cylinder reaction and note the TO1 and P readings. The readings should be within .004" of each other.

8. Continue increasing the gain value until the cylinder becomes erratic or enters a condition called "hunting". (The cylinders oscillates.)

9. When the "hunting" condition is reached, decrease the gain value until the oscillations stop.

10. While making set changes from the set panel, adjust the ACCEL and DECEL values until the desired response is obtained.

11. Increase the MAX VEL INC and MAX VEL DECREASE values until the desired speed is obtained.

12. Repeat 1 through 11 for axis 2 and so on.

13. Minor adjustments might be needed for each axis after all cylinders are adjusted. Using the parameter value entries stated above, adjust accordingly.

14. Proceed to the Offset Calibration Procedure for alignment of the cylinders to the machine.

OFFSET CALIBRATION PROCEDURE

To adjust the OFFSET (Calibrate the set system to the sizes to be cut), use
the following steps:

1.　　Enter set values from the set panel for each axis. Example: 4.000
　　　inches.

2.　　Depress **CLEAR, "1".**

Press Keys:
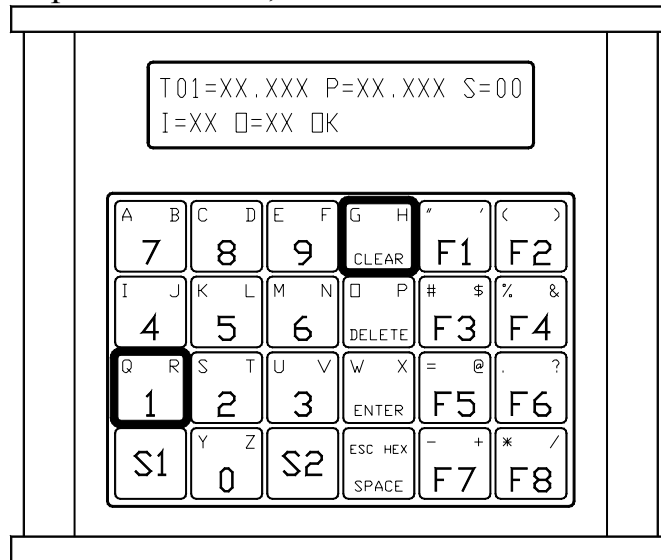
CLEAR
↓
1

T01=XX.XXX P=XX.XXX S=00
I=XX □=XX □K

3.　　The TransTerm 5 displays the following:
　　T01=XX.XXX P=XX.XXX S=XX
　　I2=XX　　I1=XX OK

4.　　Depress **S1, DELETE**. The display shows the following:

Press Keys:

S1
↓
DELETE

The display reads:
```
T01=XX.XXX  P=XX.XXX  S=XX
+XXX=OFFSET (0-255)
```
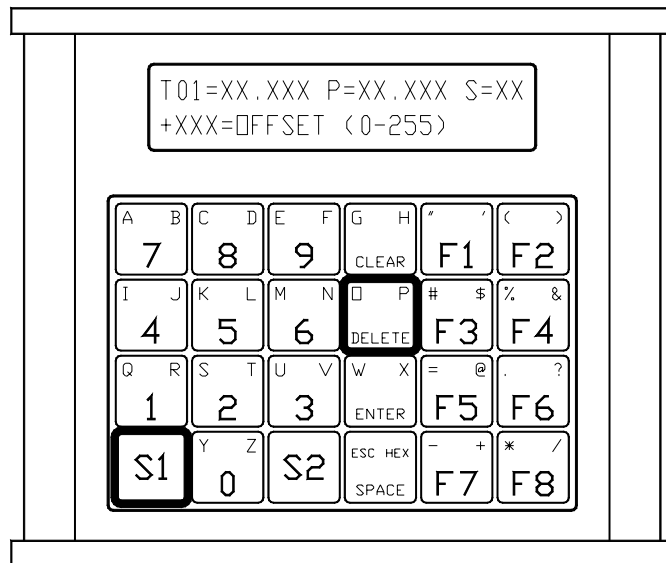
5. To add .060" to the position of the saw enter **+.060**. Depress **ENTER**. Subsequently, each time the **ENTER** key is depressed the saw will move .060".

6. To subtract .060" from the position of the saw depress **S1, F7**. The minus sign appears before the offset entry area. Enter .060 and depress the E**NTER** button. Again, each time the **ENTER** key is depressed the saw will move back .060".

7. To change the sign back to a positive value, depress **S2, F7**. The plus sign will reappear before the offset entry area.

8. Press the **CLEAR** key to exit the **OFFSET CALIBRATION** mode.

9. Press **2** on the Transterm 5 keypad. This shows positioning and status information for axis **2**.

10. Repeat steps 4 through 8 above for axis used in the system.

11. Return the Transterm 5 display to the run mode by depressing **"CLEAR"**.

NOTE: When product is processed, check for users desired accuracy. Due to machine inaccuracies, some fine adjustments will be needed. Follow the procedures stated above. This completes the Servo Loop adjustments.

AC651 FACE PLATE INDICATIONS

```
Paw-Taw-John Services, Inc.




    ● SERVO+
    ● SERVO-

    ● STATUS
    ● TEMPO

    ● RCV DATA
    ● TRX DATA

    ┌──┐  KEYPAD
    │  │
    └──┘

    ┌────┐  AC651
    │    │
    └────┘
```
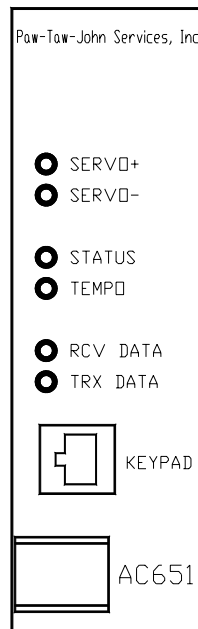
The indicators on the faceplate of the AC651 servo card provide valuable information about the status of the module. The following is a brief explanation of each indicator.

1.   The **Servo +** and **-** LED's illuminate when the card is sending servo current to a valve. The LED's will glow brighter as more current is applied to a valve. **Servo +** is one direction while **Servo -** is the opposite direction.

2.   The **Status** LED will remain on while the cylinder is within .050" of the target position. If not or while the cylinder is moving, the LED will flash.

3.   The **Tempo** LED must remain on at all times. No blinking or intermittent blinking is acceptable. If so, the Temposonics loop has a problem.

4.   The **RCV** and **TRX DATA** lamps will blink most of the time in a random mode.

5. The Transterm 5 cable is connected at the **KEYPAD** area.

PLC INTERFACING TO AC651MB RACK

The following discussions encompass the AC651MB rack inputs, their functions and PLC data transmission requirements.

AC651MB RACK DATA INPUTS/OUTPUTS

AXIS 1 AXIS 2 AXIS 3 AXIS 4 AC651

STROBE IN POS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 IN POS 1 2 IN POS 1 2 IN POS 1 2 +24V 24V COM
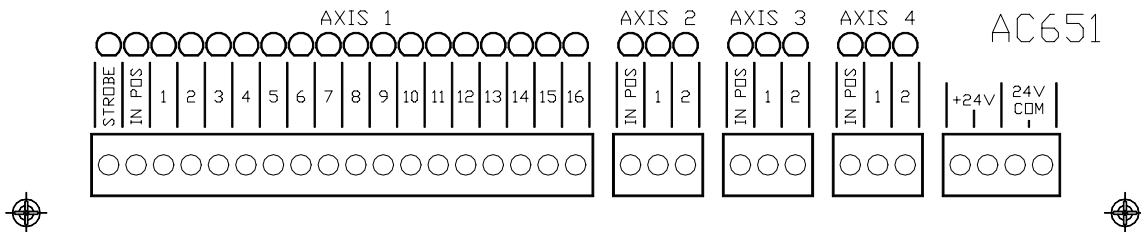
Shown above is the connections used to interface a PLC to the AC651MB card rack. The following is an explanation of the inputs and outputs for Axis 1.

1.   **Strobe** is an input used to transfer address and data from the PLC to the AC651 servo control cards. When the strobe is activated, address information is transferred; data is transferred when the strobe is deactivated.

2.   **In Pos** is an output generated by the AC651 servo control card for each axis. This output is a 24 volt high when the target and actual position data are within .050" of each other.

3.   **Inputs 1, 2, 3 & 4 (or Inputs 1, 3, 5 &7 with some programs)** are used for addressing each AC651 servo control card. When the Strobe input goes active and any of these inputs are active as per the following tables, an AC651 servo card is selected to receive data.

ON=Active   OFF=Inactive

The following table is applicable if the program used is:
PLC51D1.HEX or PLC51LNG.HEX

	INPUT 1	INPUT 2	INPUT 3	INPUT 4
	BIT 0	BIT 1	BIT 2	BIT 3
CARD 1	ON	OFF	OFF	OFF
CARD 2	OFF	ON	OFF	OFF
CARD 3	ON	ON	OFF	OFF
CARD 4	OFF	OFF	ON	OFF
CARD 5	ON	OFF	ON	OFF
CARD 6	OFF	ON	ON	OFF
CARD 7	ON	ON	ON	OFF
CARD 8	OFF	OFF	OFF	ON

The following table is applicable if the program used is:
PLC51B2.HEX or PLC51A6.HEX

	INPUT 1	INPUT 3	INPUT 5	INPUT 7
	BIT 0	BIT 1	BIT 2	BIT 3
CARD 1	ON	OFF	OFF	OFF
CARD 2	OFF	ON	OFF	OFF
CARD 3	ON	ON	OFF	OFF
CARD 4	OFF	OFF	ON	OFF
CARD 5	ON	OFF	ON	OFF
CARD 6	OFF	ON	ON	OFF
CARD 7	ON	ON	ON	OFF
CARD 8	OFF	OFF	OFF	ON

Remember: ON=Active   OFF=Inactive

Note: The "no. of servo's" entry in the Parameter mode of the Master AC651 card determines which group of the first 4 inputs is used for addressing. An example is "no. of servo's entry =2, then inputs 1 and 2 are used.

4. Inputs 1 through 16 are all used during the position entry time. There weighted values are as follows:

AC651 PROGRAM DATA SPECIFICS

The following tables indicate binary bit conversions and specific program data. Please refer to this for specific data on specific programs.

BIT CONVERSION TABLE

BIT #	BIT WEIGHT
0	1
1	2
2	4
3	8
4	16
5	32
6	64
7	128
8	256
9	512
A	1024
B	2048
C	4096
D	8192
E	16384
F	32768

PROGRAM:
PLC51A6.HEX

INPUT	BIT	BIT WEIGHT	PARAMETERS
1	0	1	XX.XXX = GAIN (0 TO 16)

2	8	256	XX.XXX = TMPADJ
3	1	2	XX.XXX = ZROADJ
4	9	512	XX.XXX = ACCEL
5	2	4	XX.XXX = DECEL(1-4059)
6	A	1024	XX.XXX = MIN.DECEL
7	3	8	XX.XXX = MAXVEL(0 TO 2047)
8	B	2048	XX.XXX = EXT.TO ZERO IF 1
9	4	16	XX.XXX = MIN. LIMIT
10	C	4096	XX.XXX = MAX. LIMIT
11	5	32	XX.XXX = # OF SERVOS(1-8)
12	D	8192	XX.XXX = SPARE
13	6	64	
14	E	16384	
15	7	128	
16	F	32768	

PROGRAM:
PLC51B2.HEX

INPUT	BIT	BIT WEIGHT	PARAMETERS
1	0	1	XX = GAIN(1 TO 25)
2	8	256	XX.XXX = TEMPO SCALE
3	1	2	XX.XXX = ZERO OFFSET ADJ
4	9	512	XX= ACCEL (1 TO 50)
5	2	4	XX= DECEL (1 TO 50)
6	A	1024	XX.XXX = DECEL MIN. POS.
7	3	8	XX= MAX. VEL.(1 TO 99%)
8	B	2048	X= EXT.TO ZERO IF 1
9	4	16	XX.XXX = MIN. LIMIT
10	C	4096	XX.XXX = MAX. LIMIT
11	5	32	X= # OF SERVOS(1-8)
12	D	8192	XX.XXX = SPARE
13	6	64	
14	E	16384	
15	7	128	
16	F	32768	

PROGRAM:
PLC51D1.HEX

INPUT	BIT #	BIT WEIGHT	PARAMETERS
1	0	1	XX = GAIN(1 TO 48)
2	1	2	XX.XXX = TEMPO SCALE
3	2	4	XX.XXX = ZERO OFFSET ADJ

4	3	8	XX= ACCEL (1 TO 50)
5	4	16	XX= DECEL (1 TO 50)
6	5	32	XX.XXX = DECEL MIN. POS.
7	6	64	XX= MAXVEL.INCR(1 TO 99%)
8	7	128	XX= MAXVEL DECREASE
9	8	256	X= EXT.TO ZERO IF 1
10	9	512	XX.XXX = MIN. LIMIT
11	A	1024	XX.XXX = MAX. LIMIT
12	B	2048	X= # OF SERVOS(1-8)
13	C	4096	(JOG=1)
14	D	8192	
15	E	16384	
16	F	32768	

Above programs (PLC51A6.HEX, PLC51B2.HEX & PLC51D1.hex) work with probe lengths up to 65".
Above programs have 0.001" resolution.

PROGRAM:
PLC51LNG.HEX

INPUT	BIT #	BIT WEIGHT	PARAMETERS
1	0	1	XX = GAIN(1 TO 25)
2	1	2	XX.XXX = TEMPO SCALE
3	2	4	XX.XXX = ZERO OFFSET ADJ2
4	3	8	XX= ACCEL (1 TO 50)
5	4	16	XX= DECEL (1 TO 50)
6	5	32	XX.XXX = DECEL MIN. POS.
7	6	64	XX= MAX.VEL.INCR(1 TO 99%)
8	7	128	XX= MAXVEL DECR(1-99%)
9	8	256	X= EXT.TO ZERO IF 1
10	9	512	XX.XXX = MIN. LIMIT/2
11	A	1024	XX.XXX = MAX. LIMIT/2
12	B	2048	X= # OF SERVOS(1-8)
13	C	4096	
14	D	8192	
15	E	16384	
16	F	32768	

Above program works with probe lengths up to 130".
Above programs have 0.002" resolution.
Program PLC51LNG.HEX doubles bit weights except on addressing values.

AC651 PLC51LNG.HEX DATA ENTRY

NOTE: This data is only for the PLC51LNG.HEX program on a Rev 3 card or a Rev 4 card configured for active low inputs.

This system accepts inputs in binary format; with input #1 being the least significant bit, and input #16 being the most significant bit. To make a set the first 3 inputs are used to select the axis:

Input	1	2	3	4-16	
1	1	0	0	0	
2	0	1	0	0	1=Grounded
3	1	1	0	0	0=Ungrounded
4	0	0	1	0	
5	1	0	1	0	

While the address is held on the buss, the strobe input is pulled to ground and held there with the strobe line held low. The address is removed and the set position is presented.

NOTE: The set size is a 16 bit binary value with a resolution of .002" per step.
For example a set of 37.125"
1. **$37125 \div 2 = 18562.5$ or 18563**
2. **The value 18563 is converted to binary and presented to the buss as:**

Input															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1	1	0	1	0	0	1	0	0	0	1	0	0	1	0

Remember: 1=Grounded 0=Ungrounded

Once data is present on the buss, the strobe line is ungrounded and finally the data can be removed.
Synopsis:
1. **Present address**
2. **Pull strobe low**
3. **Clear address**
4. **Present data**
5. **Clear strobe**
6. **Clear data**

PLC DATA INPUT TIMING

NOTE: When using AC651 Rev 4 cards, it is possible to reconfigure the cards to respond to an active high signal. This is not a common mode of operation and as

shipped from the factory, all Rev 4 cards are configured in the active low mode. If your cards are configured to respond to active high, reverse all the following data.

The information as shown below applies to AC651 Rev 4 cards in the active low mode and to all earlier revisions.

Inputting data to AC651 cards must be sequenced by the PLC program in a special format. A timing chart is provided below. Remember that a low input is active. Depressing **S1>4** on the Transterm 5 keypad will show the data entering the servo card.
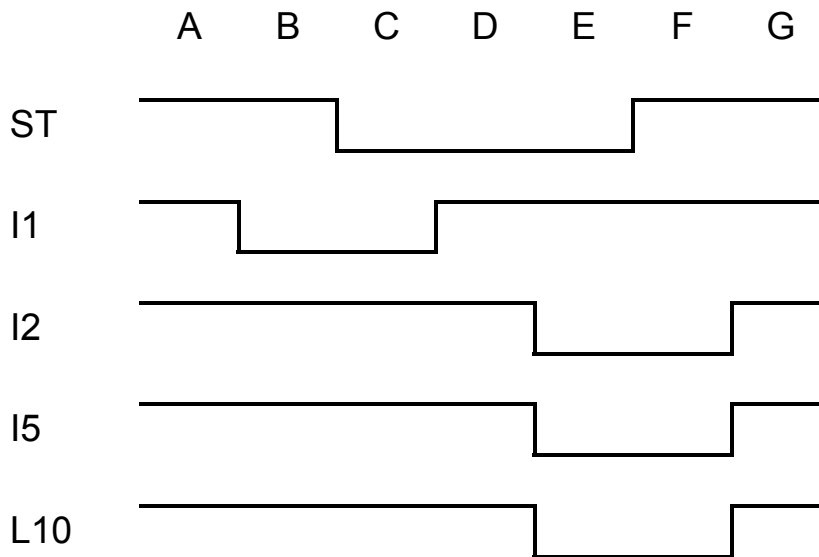
TIME PERIOD

A   **ALL INPUTS ARE NOT ACTIVE (HIGH).**

B   **INPUT 1 IS PULLED LOW TO PRESENT AN ADDRESS (CARD 1) TO THE AC651(S).**

C   **THE STROBE IS PULLED LOW TO TELL THE AC651 (S) THAT THE FOLLOWING DATA WILL BE FOR CARD #1.**

D   **INPUT 1 IS ALLOWED TO RETURN TO IT'S NORMAL (HIGH) CONDITION.**

E   **INPUTS 2, 5, AND 10 ARE PULLED LOW TO PRESENT A POSITION TO THE SELECTED CARD.**

F   **THE STROBE IS ALLOWED TO RETURN TO IT'S NORMAL (HIGH)**

CONDITION. THIS CLOCKS THE POSITION INTO THE CARD.
G **INPUTS 2, 5 AND 10 ARE ALLOWED TO RETURN TO THEIR NORMAL (HIGH) CONDITION FINISHING THE SET.**

If needed, please contact PAW-TAW-JOHN SERVICES, INC. ™ for further programming information 208-687-1478.

TROUBLESHOOTING

INITIAL SYSTEM TROUBLESHOOTING

Discussed below are some common problems sometimes encountered after installation of a new system.

TROUBLE	SOLUTION
When the hydraulics are applied the cylinder extends or retracts to the maximum.	Check the TransTerm parameter **EXT. TO ZERO** value. If okay, switch the **SERVO+** and **SERVO-** cable pair
The ACTUAL POS. Display value is jittery.	Swap the **TEMPO+** and **TEMPO-** cable wire pairs.
The cylinder is hunting when it arrives at target.	**GAIN** value is too high. Lower the value.
The cylinder overshoots or under-shoots the target.	Adjust the **ACCEL** or **DECEL** value to correct. Also check/adjust the **GAIN**.
When power applied to the system the **AC651** doesn't respond consis-ently to commands.	Verify the 150 ohm resistors are installed on the cardrack. Refer to Innitial System Setup, Step 6.
The board sizes get thicker or thinner as the cylinder extends or retracts.	Check **TMP ADJUST** value for linearity of cylinder stroke. Check linkage for security and proper ratios.
The board sizes vary out of tolerance.	Check the cylinder mounting for security and the clevis for integrity.
When a set button is depressed the cylinder doesn't move.	Check that PLC is addressing the correct axis. Refer to data screen on Transterm 5.

OPERATIONAL SYSTEM TROUBLESHOOTING

These are common problems encountered after the system has been operating.

TROUBLE	SOLUTION
Cylinder moves slower and slower.	Check **AC651** drive LEDs for '**ON**'.
Cylinder stops moving.	If ON, use external drive box to check for movement of cyl. If no movement, check filter for blockage or replace. Also check hydraulic unit for 1500 psi or greater.
Cylinder will not move. **AC651** drive LED on.	Check wiring to servo valve. Replace servo valve.
Cylinder will not move. **AC651** drive LED off.	Does the Transterm 5 display show an **Overtravel, Bad module, Temposonics Bad** indication? Repair problem.
Transterm 5 display shows **"Bad Module".**	Replace the **AC651** card associated with the number displayed with the **"Bad Module"** indication.
Transterm 5 display shows **"Tempo Bad".**	Check the corresponding "Tempo Bad" indication with the **AC651** card. The Tempo lamp should be on constantly. Troubleshoot the Temposonics loop.
Transterm 5 display shows **"Overtravel".**	A program software limit has been reached. One of the **AC651** min./max. parameter limits or system max limit parameters is set to high. By depressing **Clear**, 1, through 8 the appropriate servo controller will show the overtravel indication. Enter the **Parameter** mode for that module and correct one of the parameter limits stated above.
"Temposonics Bad" indication.	If using an **AC700** tempo interface card, check the LED indications. If **"POWER"** LED out, check power on board. Fix power problem. If **"RUN"** LED out, replace probe. Follow **AC700** operation manual for repair.

Push button lamp blinks.   Axis has not reached target position. Verify
                                                 target and actual position are within
.050".   Check for mechanical or objects
preventing   the completion of the set.

TRANSTERM 5 TROUBLESHOOTING

The TransTerm 5 is a complete terminal capable of all functions encountered on a normal
personal computer system. The unit can be powered using a 12 volt external power unit
or powered can be applied to the D-25 connector. The **AC651** is usually jumpered to
supply this voltage through the 6-pin telephone jack. Listed below are troubles that are
sometimes encountered and solutions.

TROUBLE   SOLUTIONS

Unit displays erroneous characters.   Check the terminal for proper
                                            configuration.

Unit displays cursor in upper left   Check the connections between the terminal
corner of display only.   and the **AC650**.

With power applied, the terminal   The terminal is I/O bounded. Try another
doesn't display a cursor or characters   **AC651** board or replace the
terminal.
or doesn't beep three times when
powering up.

To check the terminal for proper configuration, depress S2, S1, S2. (Refer to TransTerm
5, operators manual, Chapter 6, page 11, TransTerm 5 set-up). The shift registers are as
follows:
      SR1=00000000; SR2=00000010; SR3=00001001; SR4=00000000; OPERATING
      MODE=001; CONTRAST=007; UNIT ADDRESS=001; TOTAL
COLUMNS=024

The DB25P cable is wired per table. Check connector for broken wires or other damage
and repair as necessary.

TRANSTERM 5 CABLE WIRING		
Signal	*Pin #*	*Color*
DTD+	23	green
DTD-	22	red
DRD+	25	black
DRD-	24	yellow
GRD	7	blue
+12VDC	20	white
DRO	16 to 3	jump to RD
DTR	20 to 5	jump to CTS

Should questions arise, call **Paw-Taw-John Services, Inc.™**
Phone. No. **(208) 687-1478**. Anytime.

PROGRAM IC REMOVAL AND INSTALLATION

Changes to system hardware or requirements for additional software functions may make it necessary to change the Program Integrated Circuit (IC) which operates the AC651 While this may happen seldom or never, we are including procedures for this change.

IC REMOVAL PROCEDURE

1. Using a small screw driver, insert under bottom of Program IC between the IC and socket and lift up (area 2 shown below). Lift approximately 1/8".
2. Position small screw driver at area 1(shown below) between the IC and socket and lift up 1/8".
3. Continue between areas 1 and 2 (shown below) lifting IC further from socket until it comes completely out.

NOTE
This procedure prevents the pins on the program IC from getting bent.

INSTALLATION

1. Check the new Program IC to be installed has all pins straight both vertically and horizontally.
2. Orient the IC matching the indent on one end to the indent on the IC socket. Refer to area (1) of the below drawing.
3. Align the pins of the IC to the socket.
4. With one finger push the IC into the socket. GENTLY!

CAUTION
If the pins don't align up properly they can be bent during installation.

---

1   **3 2**
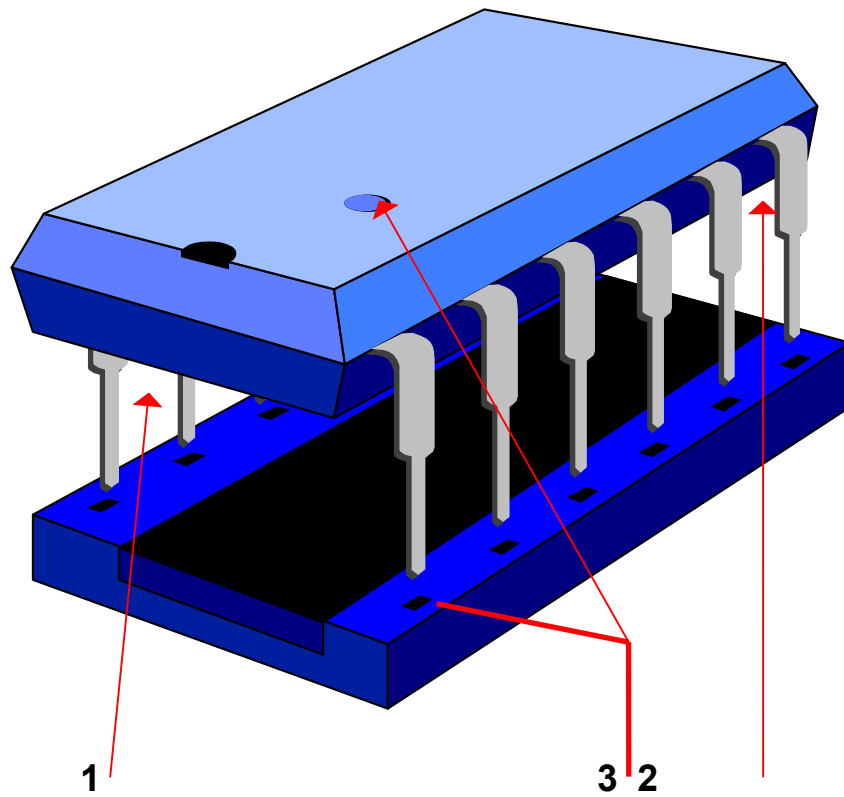
For further assistance, call **Paw-Taw-John Services, Inc.™** at (208)-687-1478.

AC651 PROGRAM DATA SPECIFICS

The following tables indicate binary bit conversions and specific program data. Please refer to this for specific data on specific programs.

BIT CONVERSION TABLE

BIT #	BIT WEIGHT
0	1
1	2
2	4
3	8
4	16
5	32
6	64
7	128
8	256
9	512
A	1024
B	2048
C	4096
D	8192
E	16384
F	32768

PROGRAM: PLC51A6.HEX

INPUT	BIT	BIT WEIGHT	PARAMETERS
1	0	1	XX.XXX = GAIN (0 TO 16)
2	8	256	XX.XXX = TMPADJ
3	1	2	XX.XXX = ZROADJ
4	9	512	XX.XXX = ACCEL
5	2	4	XX.XXX = DECEL(1-4059)
6	A	1024	XX.XXX = MIN.DECEL
7	3	8	XX.XXX = MAXVEL(0 TO 2047)
8	B	2048	XX.XXX = EXT.TO ZERO IF 1
9	4	16	XX.XXX = MIN. LIMIT
10	C	4096	XX.XXX = MAX. LIMIT
11	5	32	XX.XXX = # OF SERVOS(1-8)
12	D	8192	XX.XXX = SPARE
13	6	64	
14	E	16384	
15	7	128	
16	F	32768	

PROGRAM: PLC51B2.HEX

INPUT	BIT	BIT WEIGHT	PARAMETERS
1	0	1	XX = GAIN(1 TO 25)
2	8	256	XX.XXX = TEMPO SCALE
3	1	2	XX.XXX = ZERO OFFSET ADJ
4	9	512	XX= ACCEL (1 TO 50)
5	2	4	XX= DECEL (1 TO 50)
6	A	1024	XX.XXX = DECEL MIN. POS.
7	3	8	XX= MAX. VEL.(1 TO 99%)
8	B	2048	X= EXT.TO ZERO IF 1
9	4	16	XX.XXX = MIN. LIMIT
10	C	4096	XX.XXX = MAX. LIMIT
11	5	32	X= # OF SERVOS(1-8)
12	D	8192	XX.XXX = SPARE
13	6	64	
14	E	16384	
15	7	128	
16	F	32768	

PROGRAM:PLC51D1.HEX

INPUT	BIT #	BIT WEIGHT	PARAMETERS
1	0	1	XX = GAIN(1 TO 48)
2	1	2	XX.XXX = TEMPO SCALE
3	2	4	XX.XXX = ZERO OFFSET ADJ
4	3	8	XX= ACCEL (1 TO 50)
5	4	16	XX= DECEL (1 TO 50)
6	5	32	XX.XXX = DECEL MIN. POS.
7	6	64	XX= MAXVEL.INCR(1 TO 99%)
8	7	128	XX= MAXVEL DECREASE
9	8	256	X= EXT.TO ZERO IF 1
10	9	512	XX.XXX = MIN. LIMIT
11	A	1024	XX.XXX = MAX. LIMIT
12	B	2048	X= # OF SERVOS(1-8)
13	C	4096	(JOG=1)
14	D	8192	
15	E	16384	
16	F	32768	

Above programs (PLC51A6.HEX, PLC51B2.HEX & PLC51D1.hex) work with probe lengths up to 65".
Above programs have 0.001" resolution.

PROGRAM: PLC51LNG.HEX

INPUT	BIT #	BIT WEIGHT	PARAMETERS
1	0	1	XX = GAIN(1 TO 25)
2	1	2	XX.XXX = TEMPO SCALE
3	2	4	XX.XXX = ZERO OFFSET ADJ2
4	3	8	XX= ACCEL (1 TO 50)
5	4	16	XX= DECEL (1 TO 50)
6	5	32	XX.XXX = DECEL MIN. POS.
7	6	64	XX= MAX.VEL.INCR(1 TO 99%)
8	7	128	XX= MAXVEL DECR(1-99%)
9	8	256	X= EXT.TO ZERO IF 1
10	9	512	XX.XXX = MIN. LIMIT/2
11	A	1024	XX.XXX = MAX. LIMIT/2
12	B	2048	X= # OF SERVOS(1-8)
13	C	4096	
14	D	8192	
15	E	16384	
16	F	32768	

Above program works with probe lengths up to 130".

Above programs have 0.002" resolution.

Program PLC51LNG>HEX doubles bit weights except on addressing values.