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INTRODUCTION

The Abbott COMMANDER® FPC consists of five major sections:

- Computer System
- Sensor Module (F-LINK)
- Bar Code Reader
- Pipettor
- Automatic Bar Code Reader

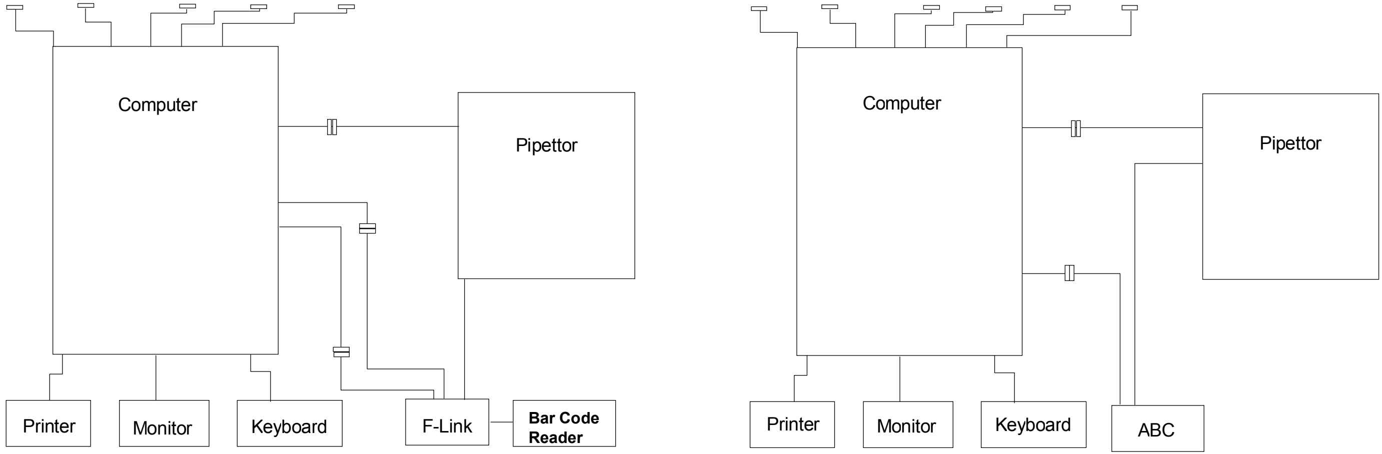

Figure 3-1. Flexible Pipetting Center Block Diagrams

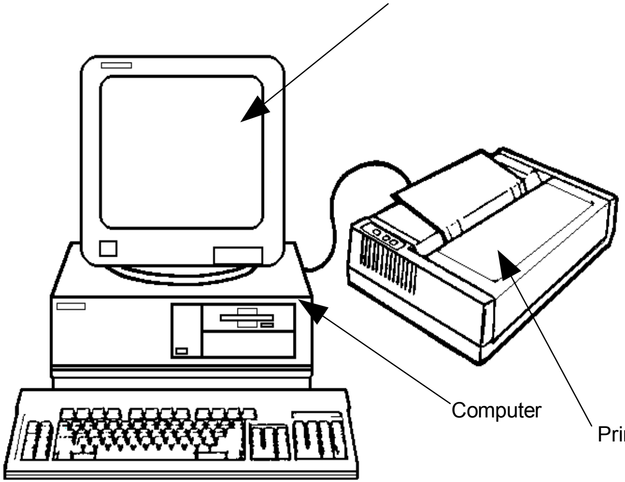

Figure 3-2. Computer System Components

COMPUTER SYSTEM

COMPUTER SYSTEM PURPOSE

The Computer System provides:

- Storage of database information (tray, rack, and assay information)
- Manual Input/Command Entry
- Overall Function Control
- Regulation of Internal and External Interfacing
- Monitors the status of the FPC and interface operations

COMPUTER SYSTEM FEATURES

The Computer System used for the FPC is either a Hewlett-Packard VECTRA®, an Intel® 486™, or Intel Pentium™ system equipped with the following features:

- Intel 486 processor or Intel Pentium processor
- 16/32 Mbytes of memory
- Enhanced 101A Keyboard (US)
- 3.5 inch, 1.44 Mbytes Floppy Disk Drive
- Hard Disk Drive
- Color Monitor
- Parallel port connected to a Printer
- 8 Serial ports (via the Digital Intelligent Serial Communications Board)
- Printer

The computer operates under the 386/ix Operating System. The 386/ix is a multi-user, multi-tasking system based on Release 2-2 of UNIX® System V.

SENSOR MODULE (F-LINK)

SENSOR MODULE (F-LINK) PURPOSE

The Sensor Module (F-Link) detects sample tubes that are placed in the sample rack of the module for sample registration. It links each tube to a specific rack location to generate a matrix of the sample tubes for processing. The Sensor Module is connected to the computer via an RS-232 cable. The Sensor Module uses a pair of optical sensors to detect a tube in each position.

SENSOR MODULE (F-LINK) COMPONENTS

The Sensor Module (F-Link) consists of the following components:

- CPU Board
- Interface Board
- Sensor Board
- F-Link Communication/Power Cable
- Top and Bottom Covers

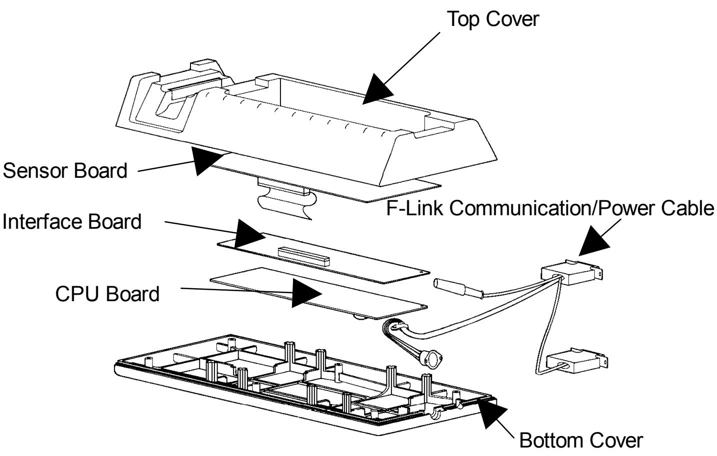

Figure 3-3. F-Link Components

CPU Board

The CPU board uses a Z80® Microprocessor operating at 3.6864 MHz. The board also includes the following circuits:

- 4 Kbytes of EPROM
- 2 Kbytes of RAM
- dual RS-232 controller; Only one of the serial ports of the Z80 DUART is used for communication to the computer system. The communications protocol for the serial port is 9600 Baud, Odd Parity, 7 Bits/Character, and 1 Stop Bit.
- dual parallel port control; transfers the control signal, data, and address information to the Interface Board.

Interface Board

The Interface Board provides analog to digital signal conversion and communicates this information to the CPU Board of the Sensor Module.

Sensor Board

The Sensor Board contains 60 sensors arranged in a 5 row x 12 column matrix used to detect tube presence or absence in each tube position.

Sensor Module (F-Link) Operation

The ROW (ROW 1 - 5) signals are the outputs from the PIO (Bits 0 - 4) on the CPU Board to bus drivers on the Interface Board where they are enabled by the ROW STB signal. The output goes to an “op amp” that converts the digital signal to an analog signal to drive the LED of the optical pair on the Sensor Board. The output of the phototransistor (COL A - M) on the CPU Board is sent to a comparator/amplifier circuit on the Interface Board where it is converted to a digital signal. The output goes to the PIO port A on the CPU Board.

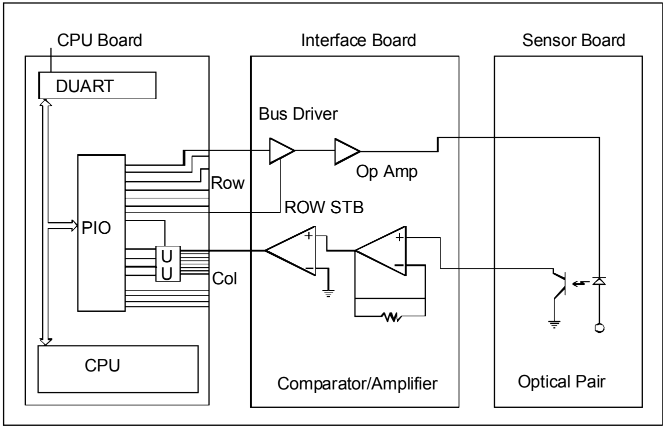

Figure 3-4. F-Link Block Diagram

AUTOMATIC BAR CODE READER

The Automatic Bar Code Reader (ABC) electronics section and associated interfaces are controlled by the ABC Controller Board circuitry. The major control functions are provided by the ABC Control Microprocessor CPU located on the ABC Controller Board. The ABC Controller controls all system functions based on commands received from the host computer. The ABC Controller Processor is an Intel® 80C196 based, 16-bit microcontroller containing the following functional sections:

- *Processor Section (CPU)* with ROM and RAM organized as a world-wide memory, an RS-232 interface, address decoding, and bus interface. Digital and analog input and output signals are also handled by the processor section.
- *Position Detection Section* for the interface of slot and reflective sensors.
- *Switch Detection Section* for the interface of slot and reflective sensors.
- *Bar Code Dual Port UART (DUART) Section* for the hand-held wand interface and fixed-head, tube scanner interface.

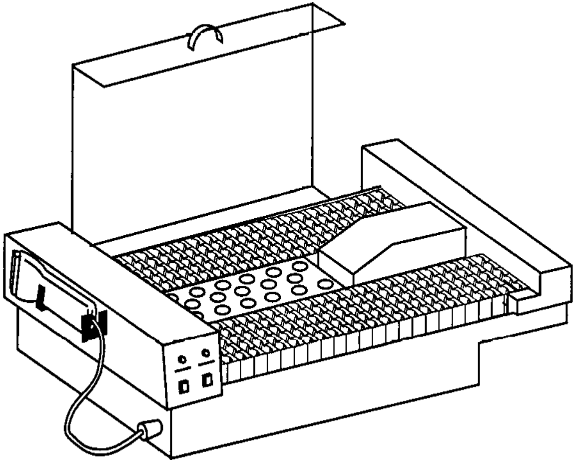

Figure 3-5. Automatic Bar Code Reader

BAR CODE READER

The Bar Code Reader is the primary input device for sample tube, rack, tray, and box identification. The scanner is a hand-held device used to scan bar code labels. A bar code label is read automatically when the reader window is placed over a label. The reader decodes the bar codes into ASCII characters and transmits character information directly to the Main Control Center through the RS-232 ports.

An audible "beep" prompt is generated at the Bar Code Reader after the reader verifies that bar code data has been successfully transmitted and received. This "beep" indicates that the reader is ready to read another bar code.

The LEDs begin flashing about 5 to 6 seconds after the scanner has judged that there is no bar code at the reading window. The on and off time of the LEDs are approximately 0.1 and 0.17 seconds, respectively. The LEDs stop flashing when the reading window is brought near the bar code label.

The Pipettor supplies power to the Bar Code Reader via the F-Link.

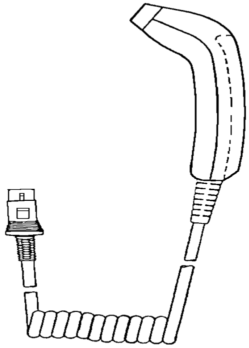

Figure 3-6. Bar Code Reader

Serial Port

The Bar Code Reader communicates acquired bar code label data to the Computer System by way of a serial port. The Bar Code Reader and F-Link Serial Ports share a common cable. The communications protocol for the serial port is 1200 Baud, 8 Bits/Character, No Parity, and 1 Stop Bit.

PIPETTOR

PIPETTOR COMPONENTS

The Pipettor contains the following electrical assemblies and circuits:

- AC Power Supply
- DC Power Supply
- Pressure Sense Circuit
- Pulse Motor Drive Circuits
- Main Control Assembly (PCBs and Batteries)
- Pump Assembly
- Pulse Motor Drive Assembly
- Valve Assembly
- Tip Jamming Sensor Circuit

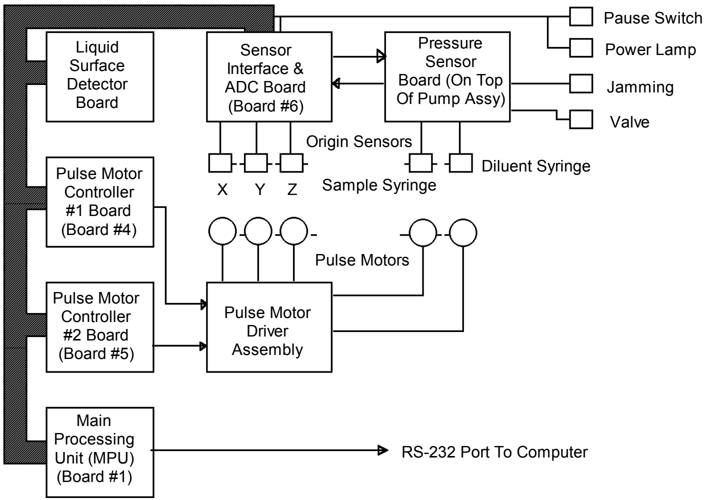

Figure 3-7. Pipettor Functional Block Diagram

AC Power Supply

The AC Power Supply supplies 100VAC and 14VAC to the DC Power Supply from an external power source. The FPC can work with different power sources (100, 120, 220, and 240VAC) by changing the taps on the transformer as described in the Alignments and Calibrations Section of this manual.

The AC comes in at J1 and passes through the Main Power Fuses (F1 and F2) to the Main Power (on/off) Switch (S1). From S1, the signal passes through a line filter (LF1) to the transformer (T1). Each of the outputs of T1 are fused. The 100VAC to the DC Power Supply goes through F3 (4A) to J2. The 14VAC for the DC Power Supply goes through F5 (2A) and F6 (2A) to J2. The 100VAC to the Pulse Motor Drive

Assembly goes through F4 (5A) to J4 and then goes to the fan located above the power supply.

DC Power Supply

The DC Power Supply provides all the DC voltages required by the FPC (+5VDC, ±12VDC, and ±15VDC), and monitors the 14VAC for power failures. The DC Power Supply is composed of the two following components:

1. Switching Power Supply
2. Power Fail Board

Switching Power Supply

The Switching Power Supply uses the 100VAC from the AC Power Supply to generate +5VDC and ±15VDC. These voltages are sent to the rest of the FPC via J2. The +5VDC is also routed to the Power Fail Board.

Power Fail Board

The Power Fail Board detects drops in AC source of 15 to 20% or higher for a minimum of 18 milliseconds. If the above conditions are met, then the NMI signal to the MPU is switched to a logic 0 (low) and exits J2 of the board and out on J3 of the DC Power Supply Assembly.

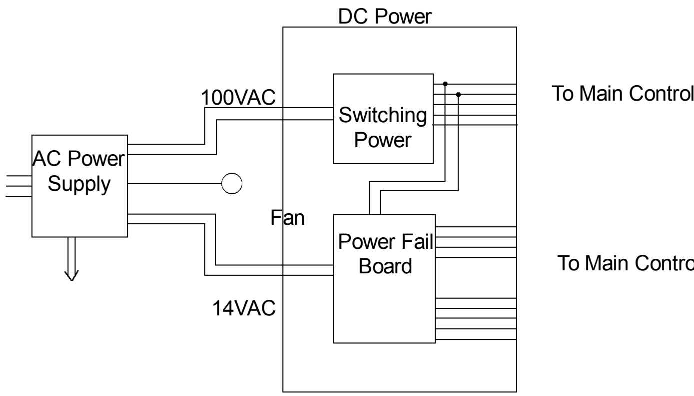

Figure 3-8. AC and DC Power Supply Block Diagram

The Power Fail Board also generates ±12VDC from the 14VAC. The ±12VDC and the +5VDC from the Switching Power Supply exit on J3 of the board and then connects to J4 of the DC Power Supply. J4 supplies power to the Sensor Module and Bar Code Reader. J4 also supplies 12 volts for the ABC Power Relay.

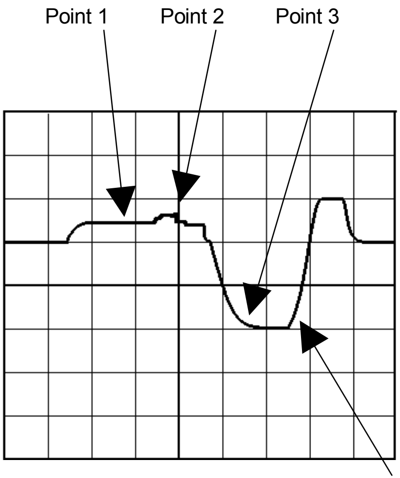

Figure 3-9A. Normal Pressure Sense Detection

Figure 3-9B. Short Sample Detection

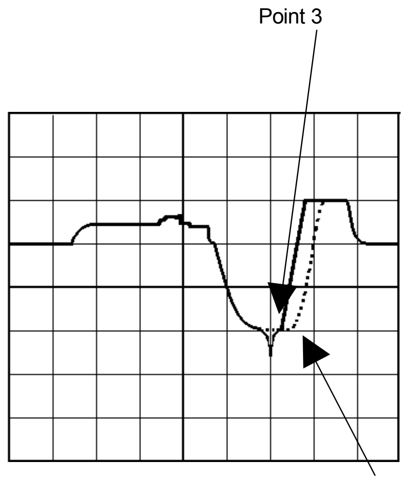

Figure 3-9C. Clot Detection

Figure 3-9. Pressure Waveforms for Pressure Sensing

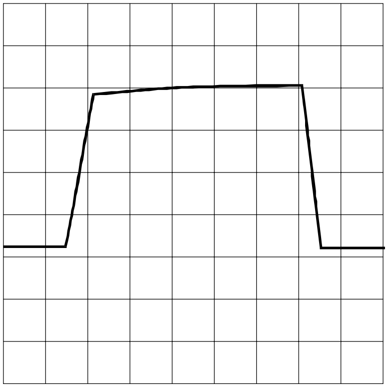

Figure 3-10A. Normal Dispense Waveform

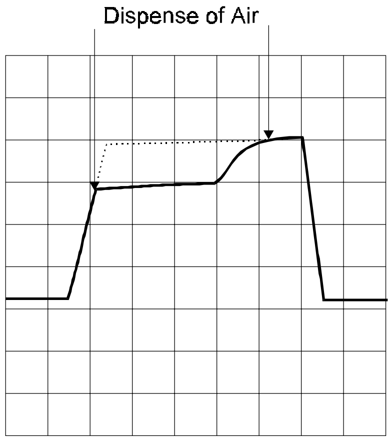

Figure 3-10B. Short Dispense Waveform

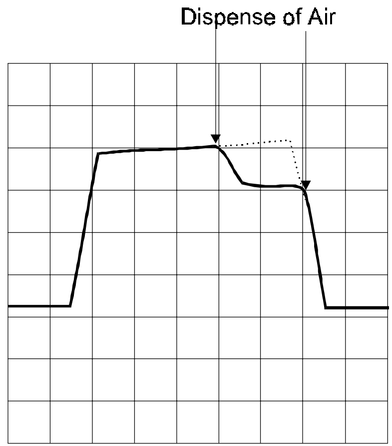

Figure 3-10C. Short Dispense Waveform

Figure 3-10. Dispense Waveforms

Pressure Sense Circuit

The Pipettor monitors pressure in the tip to check for Level Sense, Clot Detection, and Short Sample during aspiration. The output of the pressure sensor for these three conditions is shown in Figure 3-9. The system also monitors the pressure behavior during the dispense phase.

Level Sense (Normal Pressure Sense Detection)

The first waveform shows the output of the pressure sensor when a normal sample is aspirated. While the tip is being lowered, air is forced out to maintain steady, positive pressure (Point 1 in Figure 3-9A). This positive pressure continues until the fluid surface is contacted, which then causes a sudden increase in pressure (Point 2 in Figure 3-9A). At this point, the pipette tip is raised to the fluid surface and the air flow is stopped. Next, the tip is lowered 2 to 3 mm below the surface of the fluid. Fluid is then aspirated into the tip, causing a negative pressure to develop. (Point 3 in Figure 3-9A).

Short Sample Detection

In the case of a short sample, the pressure waveform will be the same up to Point 2. When air is aspirated instead of fluid, the end of the negative pressure will occur much sooner than it should (Point 4 in Figure 3-9B).

Clot Detection

If a clot is in the sample, the pressure waveform will be the same up to Point 2 (Figure 3-9A). The clot will cause an obstruction when it is touched by the pipette tip. This will result in a sudden increase in negative pressure as shown in Figure 3-9C (Point 4).

Dispense Waveform (Normal)

The Pipettor monitors pressure in the tip to check for the delivery of the sample during the dispense phase. (Refer to Figure 3-10A for an example of a normal dispense waveform).

Air Dispense Error Detection

Refer to Figures 3-10B and 3-10C for examples of air dispense error detection waveforms.

Signal Path

The pressure signal starts at the Pressure Sensor Board and is routed to the Sensor Interface and ADC Board, and then to the Liquid Surface Detector Board.

Pressure Sensor Detector Board

The pressure in the tip is detected by a differential-pressure transducer connected to the tubing from the Sample Syringe to the Sampling Nozzle Assembly. The output of the transducer goes to a differential amplifier (IC2), then through a buffer amplifier and out of the Pressure Sensor Board as SIG1 on J2 - 14.

Sensor Interface and ADC Board

SIG1 comes into the backplane of the Main Control Assembly on J2 - 14 and is routed to the Sensor Interface and ADC Board. The SIG1 is converted to a digital signal by an Analog to Digital Converter (IC6, ADC0809). The control lines (Start, OE, A, B, and C) for the A/D IC come from the Liquid Surface Detector Board. The output of the A/D IC (D0 - D7) goes to the Liquid Surface Detector Board.

Liquid Surface Detector Board

The Liquid Surface Detector Board takes the information from the A/D IC and compares that data with reference data stored in the memory of the board. From this comparison the Liquid Surface Detector Board can determine whether it detects level sense, short sample, or a clot. For a description of how the Pipettor detects the different conditions, read the above description of the Pressure Sense Circuit.

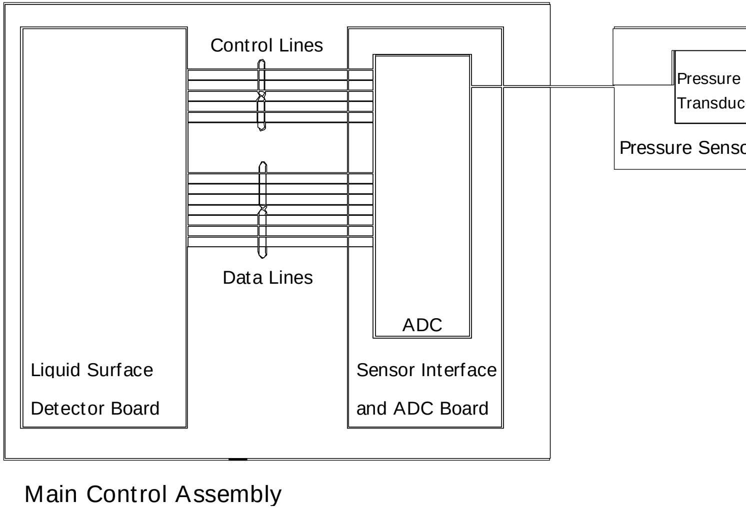

Figure 3-11. Pressure Sense Circuit Block Diagram

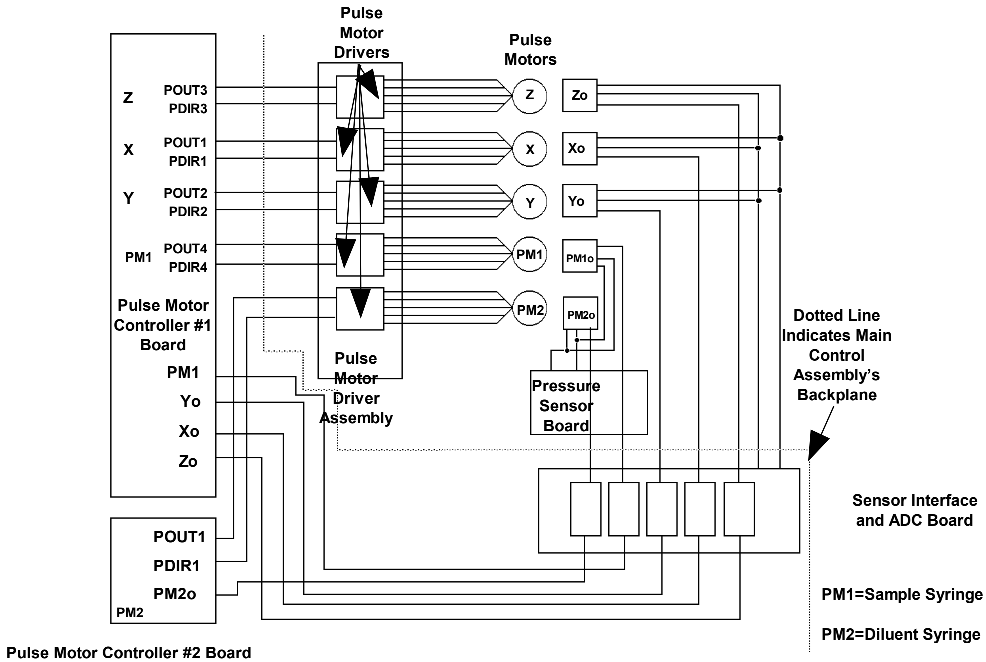

Figure 3-12. Pulse Motor Drivers Block Diagram

Pulse Motor Driver Circuits

There are five pulse motor driver circuits. They are for the following motors:

- Sample Syringe Motor
- Diluent Syringe Motor
- X-Axis Motor
- Y-Axis Motor
- Z-Axis Motor

The positioning for each is determined by the number of motor steps from the origin sensor of each motor.

Sample Syringe Pulse Motor Driver Circuit

The drive for the Sample Syringe originates at the controller chip (PG4, pins 27 and 28) as PDIR4 and POUT4 on the Pulse Motor Controller #1 Board. The two signals go to the Pulse Motor Driver Assembly and then to the appropriate driver board. The output of the driver board goes to the Pump Assembly and on to the Sample Syringe Pulse Motor.

The Sample Syringe Origin Sensor is an optical sensor. The signal (PM1o IN) from the optical sensor goes to the Pressure Sensor Board. It goes next to the Sensor Interface and ADC Board where it is routed through an isolation circuit (type B on the schematic). The new signal (PM1o Out) goes to a LED and also to the Pulse Motor Controller #1 Board.

Diluent Syringe Pulse Motor Driver Circuit

The drive for the Diluent Syringe originates at the controller chip (PG1, pins 27 and 28) as PDIR1 and POUT1 on the Pulse Motor Controller #2 Board. The two signals go to the Pulse Motor Driver Assembly and then to the appropriate driver board. The output of the driver board goes to the Pump Assembly and on to the Diluent Syringe Pulse Motor.

The Diluent Syringe Origin Sensor is an optical sensor. The signal (PM2o IN) from the Optical Sensor goes to the Pressure Sensor Board. The signal goes through the circuitry on the Pressure Sensor Board. It next goes to the Sensor Interface and ADC Board where it is routed through an isolation circuit (type B on the schematic). The final signal (PM2o OUT) goes to an LED and also to the Pulse Motor Controller #2 Board.

X-Axis Pulse Motor Driver Circuit

The drive for the X-Axis Pulse Motor originates at the controller chip (PG1, pins 27 and 28) as PDIR1 and POUT1 on the Pulse Motor Controller #1 Board. The two signals go to the Pulse Motor Driver Assembly and then to the appropriate driver board. The output of the driver board goes to the X-Axis Pulse Motor.

The X-Axis Origin Sensor is a mechanical switch. The signal (Xo IN) from the switch goes to the X-Axis Assembly. It next goes to the Sensor Interface and ADC Board where it is routed through an isolation circuit (type A on the schematic). The new signal (Xo OUT) goes to an LED and also to the Pulse Motor Controller #1 Board.

Y-Axis Pulse Motor Driver Circuit

The drive for the Y-Axis Pulse Motor originates at the controller chip (PG2, pins 27 and 28) as PDIR2 and POUT2 on the Pulse Motor Controller #1 Board. The two signals go to the Pulse Motor Driver Assembly and then to the appropriate Driver Board. The output of the Driver Board goes to the Y-Axis Pulse Motor.

The Y-Axis Origin Sensor is a mechanical switch. The signal (Yo IN) from the switch goes to the Y-Axis Assembly. It next goes to the Sensor Interface and ADC Board where it is routed through an isolation circuit (type A on the schematic). The new signal (Yo OUT) goes to a LED and also to the Pulse Motor Controller #1 Board.

Z-Axis Pulse Motor Driver Circuit

The drive for the Z-Axis Pulse Motor originates at the controller chip (PG3, pins 27 and 28) as PDIR3 and POUT3 on the Pulse Motor Controller #1 Board. The two signals go to the Pulse Motor Driver Assembly and then to the appropriate driver board. The output of the driver board goes to the Z-Axis Pulse Motor.

The Z-Axis Origin Sensor is a mechanical switch. The signal (Zo IN) from the switch goes to the Z-Axis Assembly. It next goes to the Sensor Interface and ADC Board where it is routed through an isolation circuit (type B on the schematic). The new signal (Zo OUT) goes to an LED and also to the Pulse Motor Controller #1 Board.

Main Control Assembly

The Main Control Assembly is comprised of the Card Cage and the five printed circuit boards. These boards control all functions of the Pipettor. The printed circuit boards are (refer to Figure 3-13):

- Main Processing Unit (MPU) Board (Slot #1)
- Slot #2 is unused
- Liquid Surface Detector Board (Slot #3)
- Pulse Motor Controller #1 Board (Slot #4)
- Pulse Motor Controller #2 Board (Slot #5)
- Sensor Interface and ADC Board (Slot #6)
- Battery Pack
- F-Link Power Connection/ABC Relay
- RS-232 Communication Connection

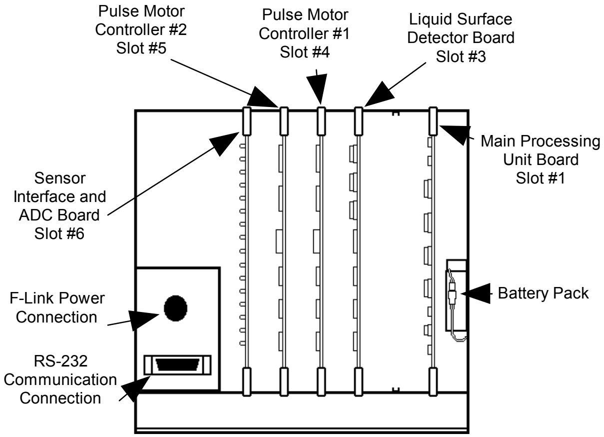

Figure 3-13. Main Control Assembly Board Locations

Main Processing Unit (MPU) Board

The MPU Board controls all functions of the Pipettor.

CPU

The CPU (Central Processing Unit) chip for the MPU Board is a 68B09 device (19B in the schematic).

The CPU chip communicates to the other devices by way of an address bus and data bus. The bus drivers located in 14A (74HC541) and 16A (74HC541) interface with the CPU to the Address Bus (MA0-MA15). The bus driver located in 17A (74HC245) interfaces with the CPU to the Data Bus (MD0-MD7).

Static RAM

The MPU board has 64 Kbytes of Static RAM. The Static RAM is located in two IC's (62256) at locations 13E and 15E. The RAM has backup power from the batteries located in the Main Control Assembly.

EPROM

The MPU Board has 112 Kbytes of EPROM (**E**rasable **P**rogrammable **R**ead **O**nly **M**emory). The EPROM chip is located in one IC 27C101 device at location 16E.

EEPROM

The MPU Board contains 8 Kbytes of EEPROM (**E**lectrically **E**rasable **P**rogrammable **R**ead **O**nly **M**emory). The EEPROM has the memory locations for the physical table positions downloaded from the computer during alignments.

I/O Ports

The MPU has two serial ports and one parallel port to communicate to external devices (i.e. the computer).

Serial Port

The MPU Board utilizes a MPSCC (**M**ulti **P**rotocol **S**erial **C**ommunications **C**ontroller) located at 1D (uPD7201) to handle serial communications. The MPSCC device can handle two serial ports. The two serial ports are interfaced through buffers at 8A and 6A. The serial port at 6A is not used. The serial port buffered at 8A goes to the computer. The data communications protocol is 9600 Baud, Even Parity, 7 Data Bits, 2 Stop Bits, and No Handshaking.

Parallel Port

The MPU Board also has a Centronics® compatible port on the IC at 6B. This port is not currently used.

Liquid Surface Detector Board

The Liquid Surface Detector Board receives the pressure signal from the Pressure Sensor Board and determines whether there is level sense, a short sample, or a clot. This board has its own CPU and memory for making this determination.

CPU

The CPU (Central Processing Unit) chip for the Liquid Surface Detector Board is a 68B09 device (2B in the schematic).

The CPU communicates to the other devices by way of an address bus and data bus. The Bus Drivers located in 2F (74HC541) and 3F (74HC541) interface with the CPU to the Address Bus (A0' - A15'). The bus driver located in 4C (74HC245) interfaces from the CPU to the Data Bus (D0' - D7').

Static RAM

The board has 16 Kbytes of Static RAM. The Static RAM is located in two IC's (6264) at locations 2G and 3G. The RAM has backup power from the batteries located in the Main Control Assembly.

EPROM

The board has 32 Kbytes of EPROM (**E**rasable **P**rogrammable **R**ead **O**nly **M**emory). The EPROM is located in one IC (27C256) at location 1G.

Pulse Motor Controller #1 Board

This board has the control circuitry for the X-Axis, Y-Axis, Z-Axis, and Sample Syringe Pulse Motors. The controller chips for each pulse motor are as follows:

- X-Axis (PG1 in schematic)
- Y-Axis (PG2 in schematic)
- Z-Axis (PG3 in schematic)
- Sample Syringe (PG4 in schematic)

Pulse Motor Controller #2 Board

This board has the control circuitry for the Diluent Syringe. The controller chip for the Diluent Syringe Pulse Motor is PG1.

Battery Pack

Used to maintain alignment positions during a power failure.

F-Link Power Connection

The F-Link plugs into this jack for DC power.

RS-232 Communication Connection

This connects to the FPC system computer via the Digiboard™.

Sensor Interface and ADC Board

The main function of this board is to provide isolation from the sensor and switch outputs and the rest of the control circuitry in the Main Control Assembly.

This board also provides status LEDs for each of the origin switches and sensors. Refer to Figure 3-14 to find out what each LED indicates. It also contains the Analog to Digital Converter for the pressure sense circuit (refer to Pressure Sense Circuit Description in this section).

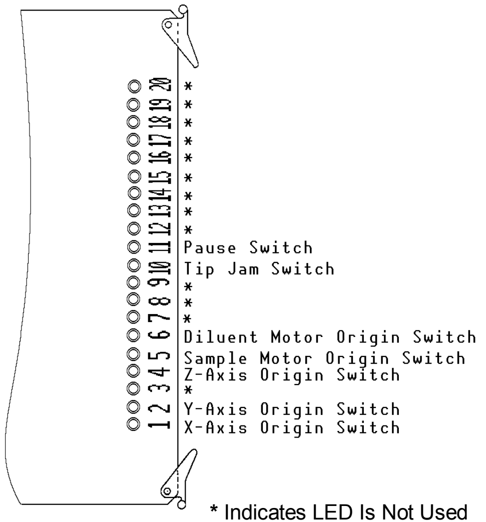

Figure 3-14. Sensor Interface and ADC Board LED Position

Pump Assembly

The Pump Assembly contains the following items:

- Pressure Sensor Board
- Pump Unit

Pressure Sensor Board

This board contains the Pressure Sensor as well as the Differential and Buffer Amplifier for the Pressure Sensor. The control relay for the valve is also on this board. The signal from the Jamming Sensor goes through this board.

Pump Unit

The Pump Unit contains the following components:

- Diluent Syringe Pump Motor
- Diluent Pump Motor Origin Sensor

Pulse Motor Driver Assembly

The Pulse Motor Driver Assembly contains the following driver assemblies:

- X-Axis Motor Driver Assembly
- Y-Axis Motor Driver Assembly
- Z-Axis Motor Driver Assembly
- Sample Syringe Motor Driver Assembly
- Diluent Syringe Motor Driver Assembly

These driver assemblies provide all the circuitry necessary to drive the Pulse Motors. The driver assemblies are the same except for the Y-Axis Motor Driver Assembly which has a different switch setting.

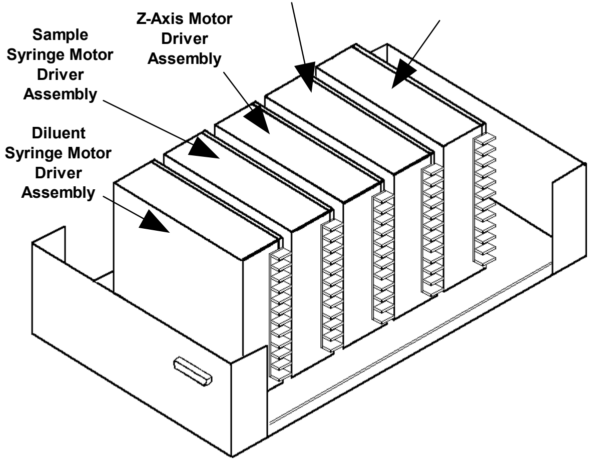

Figure 3-15. Pulse Motor Driver Assembly

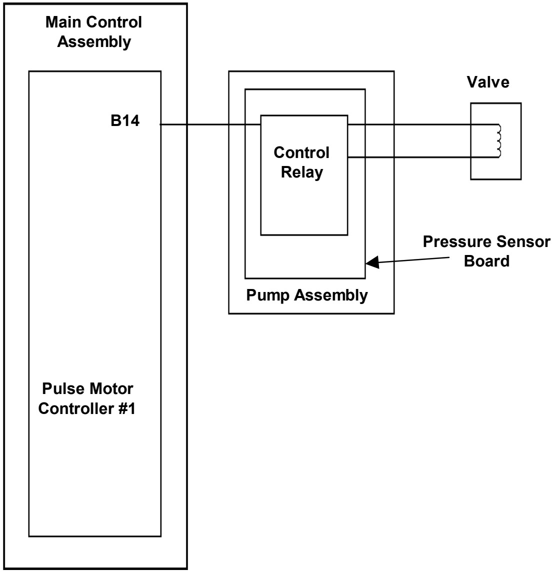

Figure 3-16. Valve Signal Path

Valve Assembly

The Valve Assembly is used to allow Diluent input from the D0 position to the Diluent Syringe or to be pushed through the Diluent Tubing to the Diluent Nozzle.

Valve Signal Path

The valve signal starts at the Pulse Motor Controller #1 on B14 (refer to Figure 3-16). The signal leaves the Main Control Assembly on J2-2 and goes to the Pump Assembly. In the Pump Assembly the signal goes to the Pressure Sensor Board where it drives a control relay which in turn controls the valve.

Tip Jamming Sensor Circuit

The Tip Jamming Sensor Circuit has two functions:

- Disposable Tip Detection
- Tip Jamming Detection

Disposable Tip Detection

The Tip Jamming Switch is located in the Sampling Nozzle Assembly. It is used to detect for disposable tips in the Tip Rack. The Sampling Nozzle Assembly contains a spring that allows the actuator to contact the switch for switch activation. The Pipettor finds a tip by locating it in a rack. The nozzle is moved down to press onto the tip. The tension of the spring in the Sampling Nozzle is altered to deactivate the Jamming Switch indicating that a tip has been found. As the tip is lifted from the Tip Rack, the switch is activated to check for any tip jams. If this does not happen, the Pipettor assumes there is no tip in this location and will go to the next location. It will try 5 times to find a tip before giving an error message.

Tip Jamming Detection

The second function of the Tip Jamming Sensor Circuit is to detect tip jams. When the up or down movement of the tip is obstructed, spring tension is overcome. This results in a Tip Jam Error.

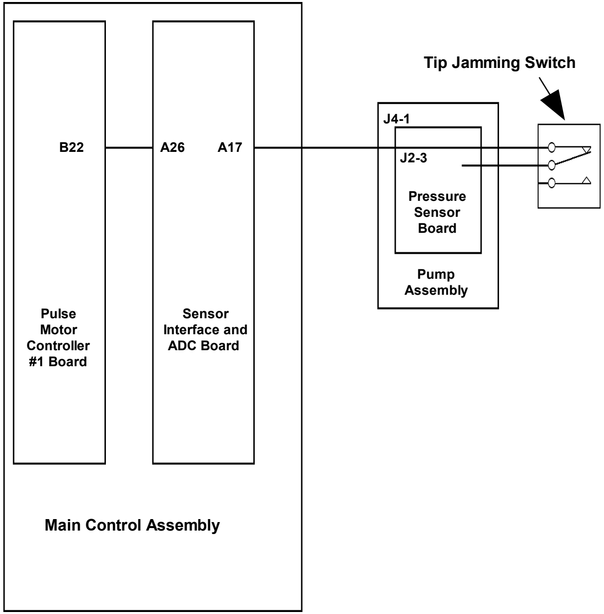

Figure 3-17. Tip Jamming Signal Path

Tip Jamming Signal Path

The Jamming Signal originates at the Tip Jamming Switch and goes to the Pressure Sensor Board that is located on the top of the Pump Assembly (refer to Figure 3-17). The signal passes through the Pressure Sensor Board to the Sensor Interface and ADC Board. The signal (JAMIN) goes through an isolation circuit and to an LED. From the isolation circuit, the signal (JAMOUT) goes to the Pulse Motor Controller #1 Board.