

WATERS CORPORATION

PERFORMANCE SPECIFICATION

TYPE OF SPECIFICATION (check one):



SYSTEM



SUB ASSEMBLY

PRODUCT: 2695

DOCUMENT NUMBER: 810000416

ASSEMBLY NAME: FLUIDICS DRIVER PCB

REVISION: A

PART NUMBER AFFECTED: 210000416

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DATE: May 5, 2014

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1.0 INTRODUCTION

1.1 DOCUMENT INTENT

The intent of this document is to provide the reader with a detailed summary of the design criteria which must be maintained in order to insure product performance. The three perspectives considered are performance to the customer, testing of the product and future applications of the product.

Note that this is a copy of WAT270696 Rev B, written by Fred Gomes. Part number references have been updated for the new 210000416 PCB part number which was changed from WAT056453 for RoHS compliance. The motor driver was also changed from the Allegro 3977 to the 3982 for a cost reduction.

1.2 PRODUCT DESCRIPTION

The Fluidic Driver Board may be broken down into the following major functional sections required to operate a Sample Handling Auto Sampler.

- **Seven Half Step Motor Drives with PWM**
- Carousel Z Axis (0.68 Amp) with Hold
- Carousel Rotation (0.68 Amp) with Hold
- Injector Needle (1.4 Amp) with Hold
- Inject Valve V1 (0.93 Amp)
- Syringe Valve V2 (0.93 Amp)
- Carrier Rotation (0.93 Amp) with Hold
- Dissolution Needles (0.93 Amp)
- **Syringe Motor Drive Half Step (24V Voltage Drive)**
- **Sample Handling Sensors**
- Syringe Top & Bottom Switch
- Carrier Home Opto
- Carrier Position Opto
- Carousel Home Opto
- Carousel Position Opto
- Z Home Opto
- Dog Pin Opto
- Carousel ID Reed Switch
- Injector Top & Bottom Opto
- Dissolution Top & Bottom Opto
- * Dissolution Present
- **PLD Logic and Reset Circuit**
- Address Decode
- Motor Select Logic
- Motor Hold Select Logic
- Reset Circuit
- **Vial Present Sensor**
- **Solenoid Drives**
- Waste Valve V3
- Needle Wash Valve V4
- **Needle Wash Pump DC Motor Drive**

The main function of this PCB is to provide the drive electronics for controlling 8 step motors, 2 solenoid valves, 1 DC motor, 14 different sensors and a vial verify sensor.

The control signals originate from the host CPU via register addressing and the TPU. All address decoding and I/O selections are provided by the Fluidic Drivers PLD. The Fluidic Driver PCB requires two power supplies +24 VDC and +5VDC with their grounds tied together at the power supply. The board also ties the grounds together at the power connector. This is to minimize the voltage drop between the grounds at the seven motor driver ICs which PWM their currents.

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1.3 REFERENCE DOCUMENTATION

The following table describes the reference material needed with this document.

WATERS PART NUMBER	DOCUMENTATION DESCRIPTION
210000416	Assembly, Fluidic Driver
710000416	Schematic, Fluidic Driver
610000416	PCB, Fluidic Driver
510000416	Artwork, Fluidic Driver

2.0 FUNCTIONAL DESIGN AND PERFORMANCE SPECIFICATIONS

2.1 FUNCTIONAL DESCRIPTIONS

Figure 1.0 shows the major functional blocks and Input/Output connections of the Fluidic Driver PCB.

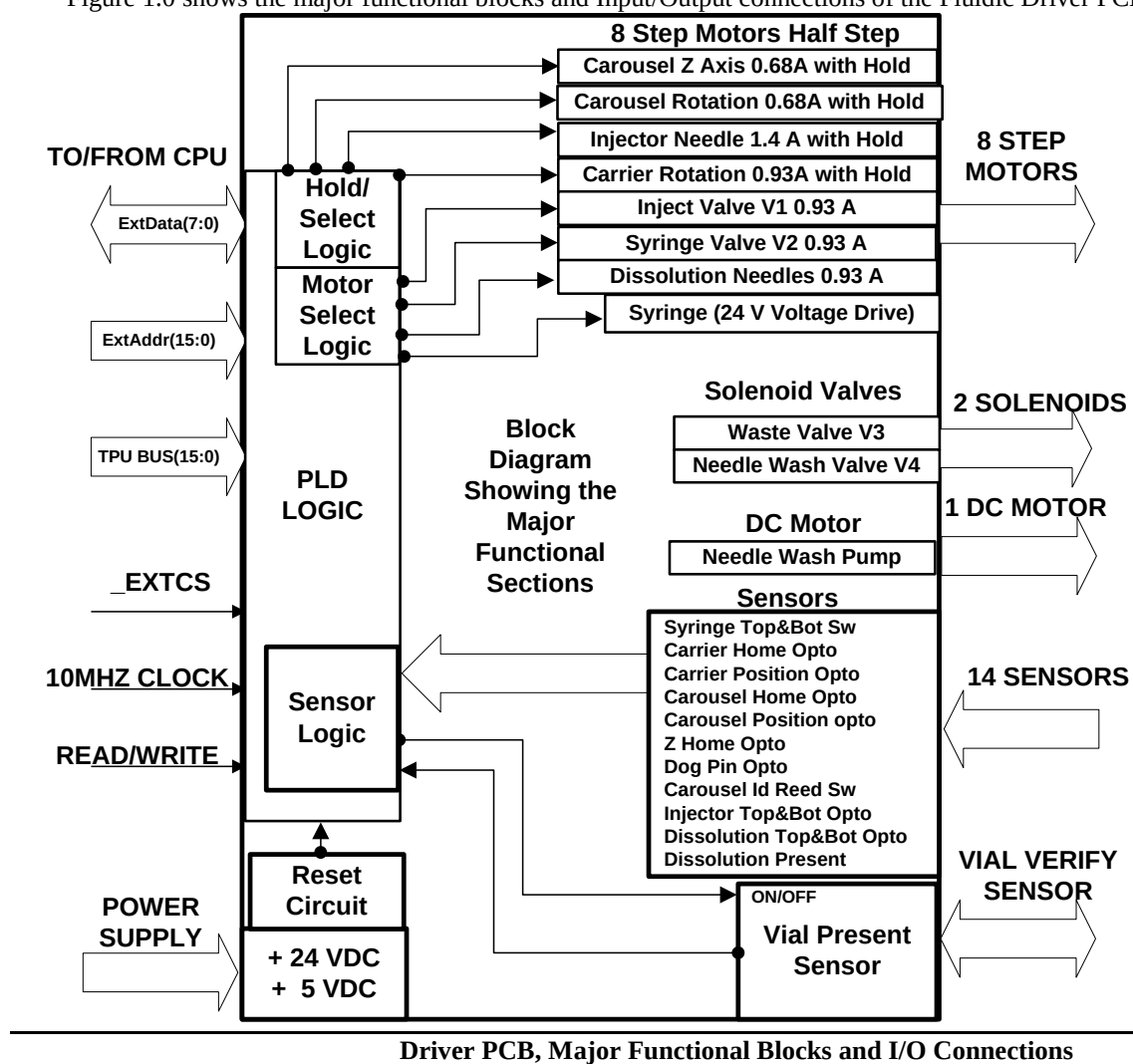


Figure 1.0 Fluidic

Driver PCB, Major Functional Blocks and I/O Connections

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2.2 I/O CONNECTIONS

Figure 1.0 also shows all the input and output connections on the Fluidic Driver PCB. There are a total of 17 connectors located at various places on the PCB (see the Assembly Drawing). In order to ease mating of cables assemblies to their proper connector location on the Pump Driver PCB, all connectors are labeled in silk screen with their functional name instead of a J number like J1, J2, etc. For example the power connector is labeled **Power**.

The following table describes the function of each I/O connector and it's reference designator name. To determine the connector type used refer to the Assembly Drawing. To determine the pin out of each connector refer to the Schematic.

CONNECTOR REF DES NAME	FUNCTIONAL DESCRIPTION
Z_AXIS_MTR	To Z Axis Motor cable assembly
CAROUSEL_ROT_MTR	To Carousel Rotation Motor cable assembly
INJ_MTR	To Injector Motor cable assembly
VALVE1	To Injector Valve (V1) Motor cable assembly
VALVE2	To Syringe Valve (V2) Motor cable assembly
CARRIER_ROT_MTR	To Carrier Rotation Motor cable assembly
DISSOLUTION_MTR	To Dissolution Motor cable assembly and Dissolution present signal _DISS_PRESENT
SYRINGE_MTR	To Syringe Motor cable assembly and both Top&Bottom Switch signals, _SYRING_TOP & _SYRINGE_BOTTOM
Cars&Carr/Home&Pos Sensors	Four signals, which identify home and position for both the carrier and carousel. The signal names are _CARRIER_HOME , CARRIER_POSITION , CAROUSEL_HOME & CAROUSEL_POSITION
ZHome,DogPin&CarsID Sensors	Three signals which identify Z axis home, when the Z axis has engaged the carousel correctly (Dog Pin) and the individual carousel ID's. The signal names are _Z_HOME , _DOG_PIN & _CAROUSEL_ID .
Inj Top/Bot Sensors	Two Opto signals which identify the injector location at Top or Bottom. The signal names are _INJ_TOP & _INJ_BOTTOM
Dissolution Top/Bot Sensors	Two Opto signals which identify the dissolution injectors location at Top or Bottom. The signal names are _DISS_TOP & _DISS_BOTTOM
FROM/CPU	Signals to and from the CPU which are used to control all loads and read all sensors. The signals include EXTDATA , EXTADDR , TPU BUS , _EXTCS which is a CPU board chip select, 10MHZ_CLK which is a 10MHZ clock, and a Read/Write control line.
Power	Provides 24 VDC and VCC (5VDC). Grounds are to be tied together at the power supply and at the power connector itself on the PCB.
Valve3	To the Waste Valve (V3) Solenoid, cable assembly
Needle Wash Val 4	To the Needle Wash Valve Solenoid, (V4) cable assembly
Needle Wash Pump	To the Needle Wash Pump DC Motor cable assembly
U8	The Vial Present Optical fibers connect directly to the Vial Present Sensor

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2.3 FUNCTIONAL THEORY OF OPERATION

Each of the main functional sections of the Fluidic Driver PCB will be described in this section, refer to the schematic for circuit implementation and to Figure 1.0 for a block description. The following table summarizes each page of the schematic and what functional circuits are present.

<i>Schematic Page Number</i>	<i>Functional Circuits Present</i>
1	Carousel Z Axis Half Step Motor Drive with PWM
2	Carousel Rotation Half Step Motor Drive with PWM
3	Injector Needle Half Step Motor Drive with PWM
4	Valve 1 Inject Valve Half Step Motor Drive with PWM
5	Valve 2 Syringe Valve Half Step Motor Drive with PWM
6	Carrier Rotation Half Step Motor Drive with PWM
7	Dissolution Injectors Half Step Motor Drive with PWM and a Dissolution Present signal named _DISS_PRESENT
8	Syringe Half Step Motor Drive without PWM and top & bottom position switches. Signal names, _SYRINGE_TOP & _SYRINGE_BOTTOM
9	Sensor circuits for the following seven signals, _CARRIER_HOME , _CARRIER_POSITION , _CAROUSEL_HOME , _CAROUSEL_POSITION , _Z_HOME , _DOG_PIN and _CAROUSEL_ID
10	Sensor circuits for the following four signals, _INJ_TOP , _INJ_BOTTM , _DISS_TOP and _DISS_BOTTOM
11	All signals to and from the CPU, the power up reset circuit and the PLD
12	D latches used to present read/write data to the host CPU's 8 bit data bus.
13	Power supply filtering and fuses, de-coupling capacitors, unused gates, Vial Present Sensor, drive for solenoid Waste Valve 3, drive for solenoid Needle Wash Valve 4 and the drive for the DC motor Needle Wash Pump

2.3.1 SEVEN HALF STEP MOTOR DRIVES WITH PWM

The first seven pages of the schematic appear almost identical. They show the motor drive circuits for the following motors, **Carousel Z Axis (0.68 Amp) with Hold**, **Carousel Rotation (0.68 Amp) with Hold**, **Injector Needle (1.4 Amp) with Hold**, **Inject Valve V1 (0.93 Amp)**, **Syringe Valve V2 (0.93 Amp)**, **Carrier Rotation (0.93 Amp) with Hold** and **Dissolution Needles (0.93 Amp)**. Where all circuits are designed using the same Allegro 3977 IC the following discussion will describe the function of the 3977 circuit which applies to all seven of the above mentioned drives.

The Allegro 3982 IC contains a complete microstepping motor driver with built in translator. It is designed to operate bipolar stepper motors in full, half, quarter, or eighth step modes, with output drive capability of 35V and 2.0A. The 3982 includes a fixed off time current regulator that has the ability to operate in slow, fast, or mixed decay modes. This current control scheme results in reduced audible motor noise, increased step accuracy and reduced power dissipation.

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Motor current is set on each drive by the voltage reference attached to the IC and the value of its sense resistors. The following equation is used to determine current. $I = V_{ref} / (8 * R_{sense})$. Each sense resistor is low pass filtered (RC) to minimize noise in the PWM control circuit. All sense resistors are non-inductive to minimize inductive spikes. Some of the drivers have circuits that lower the reference voltage for hold mode to provide about 1/3 current.

Other circuitry is the same for all of the drivers.

Step size

- MS1 pulled high for ½ step operation

Fixed off time

- $T_{off} = R_{osc} / 825 = 14K / 825 = 17 \text{ us}$
- $T_{blank} \approx 1 \text{ us}$

Charge pump

- 0.1uF connected from CP1 to CP2 as recommended

VREG decoupling

- 0.22uF connected from VREG to GND as recommended

Mixed decay mode: fast decay for 31% of Toff then switches to slow decay

Motors are controlled with three signals, Enable, Step, and Dir. A rising edge of the step signal will cause the motor to take one step either clock wise or counter clock wise depending on the Dir signal when the driver is enabled.

The host CPU commands the appropriate motor via address lines, data lines and the TPU. A 10 MHz clock is also provided from the host CPU. The TPU uses four lines from MSB to LSB, **TPUBUS0**, **TPUBUS13**, **TPUBUS14** and **TPUBUS15**. There are eight distinct states from the TPU used to sequence through four full steps (360 electrical degrees, half stepping). They are in hex, **9,8,C,4,6,2,3** and **1**. The direction the sequence is transversed determines the motor rotational direction. The PLD on the Fluidic Driver PCB translates this TPU sequence into the required Step and Dir signals. The address lines used to select the appropriate motor are a chip select line from the host CPU called **_EXTCS**, which represents a base address (in 2690 product = 440000 hex), and five additional address lines called **EXTADDR15**, **EXTADDR3**, **EXTADDR2**, **EXTADDR1** and **EXTADDR0**. The 8 data lines used called **EXTDATA(7:0)**. Of these lines only four lines go to the PLD for motor selection, **EXTDATA(3:0)**. The memory map and proper sequence for the software to drive and hold a motor may be found in the software section of this document. Also a high active read and low active write line is required.

2.3.2 SYRINGE HALF STEP MOTOR DRIVE

The Syringe Motor Drive is implemented as a half step 24 VDC stepping motor voltage drive. The same address, chip select, data, read/write and TPU lines are used to drive the Syringe Motor. The PLD again provides the translation to the control lines required by the Syringe Motor so the same TPU sequence may be used as is used by the other 7 step motors. The drive is accomplished with an Octal Darlington Array using two channels per motor winding. The motor winding of 140 ohms provides the current limit at 170 ma per phase with no more than two of the four phases on at a time. The memory map may be found in the software section of this document. The drive is capable of a 1 ampere maximum current per phase winding.

2.3.3 SAMPLE HANDLING SENSORS (14)

There are a total of fourteen sensors, some switches others optoelectronics. All sensor signals are directly readable from the host CPU using the address and data lines. The sensors must be polled by the host CPU to determine sensor state. The following discussion describes each of the 14 sensors and signals along with their function. The address map for reading the 14 sensor is provided in the software section of this document.

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Syringe Top & Bottom Switches -	These are switches located in the syringe assembly which identify the top and bottom travel limit of the syringe. When the switch is reached it simply closes activating a low active signal, either _SYRINGE_TOP or _SYRINGE_BOTTOM . Contact debounce must be performed by the host CPU.
Carrier Home Opto -	The light path is interrupted until the home position is reached, then light is allowed to reach the sensor, causing the signal _CARRIER_HOME to go active low. This identifies a known home position on the carrier. This signal is conditioned with a Schmitt Trigger prior to applying it to the data bus. There is only one home position on the Carrier Encoder Disk
Carrier Position Opto -	The light path is interrupted until the carrier position is reached, then the light is allowed to reach the sensor, causing the signal _CARRIER_POSITION to go active low. This signal is conditioned with a Schmitt Trigger prior to applying it to the data bus. There are a total of five carrier positions corresponding to a maximum carousel capacity of five carousels.
Carousel Home Opto -	The light path is interrupted until the home position is reached, then light is allowed to reach the sensor, causing the signal _CAROUSEL_HOME to go active low. This identifies a known home position on the carrier. This signal is conditioned with a Schmitt Trigger prior to applying it to the data bus. There is only one home position on the Carousel Encoder Disk.
Carousel Position Opto -	The light path is interrupted until the carousel position is reached, then the light is allowed to reach the sensor, causing the signal _CAROUSEL_POSITION to go active low. This signal is conditioned with a Schmitt Trigger prior to applying it to the data bus. There are a total of 48 carousel positions corresponding to a maximum vial capacity of 48 vials. Currently the 2690 product has a maximum of 24 therefore this must be handled in the software using only odd or even positions.
Z Home Opto -	The Z axis motor is used to raise and lower the drive shaft which is used to rotate the carousel located under the injector. The drive shaft moves vertically with an upper limit position identified by the Z Home Opto and a lower position limit identified by the Dog Pin Opto. The light path normally reaches the sensor of the Z Home Opto until the Z Home position is reached, then the light is interrupted, causing the signal _Z_HOME to go active low. This signal is conditioned with a Schmitt Trigger prior to applying it to the data bus.
Dog Pin Opto -	See the Z axis motor description in the Z Home Opto section above. The light path normally reaches the sensor of the Dog Pin Opto until the Dog Pin position is reached locking the drive shaft into the carousel hub, then the light is interrupted, causing the signal _DOG_PIN to go active low. This signal is conditioned with a Schmitt Trigger prior to applying it to the data bus.

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Carousel ID Reed Switch -	Each of the five carousels has a magnet located in a different location relative to carousel home. When this magnet is aligned with the reed switch it causes the reed switch to close. Knowing carousel position when the switch closes identifies each of the five carousels uniquely. The switch is normally open and then closes when the magnet is aligned with it causing the signal _CAROUSEL_ID to go active low. This signal is conditioned with a Schmitt Trigger prior to applying it to the data bus. The host CPU will have to contact debounce this signal.
Injector Top & Bottom Opto -	These are optos located in the injector assembly which identify the top and bottom travel limit of the injector. The light path normally reaches the sensor until the opto is reached where the light path is interrupted activating a low active signal, either _INJ_TOP or _INJ_BOTTOM . This signal is conditioned with a Schmitt Trigger prior to applying it to the data bus.
Dissolution Top & Bottom Opto -	These are optos located in the dissolution injector assembly which identify the top and bottom travel limit of the injectors. The light path normally reaches the sensor until the opto is reached where the light path is interrupted activating a low active signal, either _DISS_TOP or _DISS_BOTTOM . This signal is conditioned with a Schmitt Trigger prior to applying it to the data bus.
Dissolution Present -	This is a signal named _DISS_PRESENT which is a jumper in the dissolution motor assembly which grounds this low active signal. The host CPU can then detect that the dissolution option is present.

2.3.4 PLD LOGIC AND RESET CIRCUITS

The intent of this section is to provide an understanding of the PLD contents and Reset Circuit. Refer also to Fluidic Driver PCB Schematic and PLD Schematic for additional details.

2.3.4.1 ADDRESS DECODE

The memory map itself may be found in the software section of this document. This section will discuss the signals required to address the available functions. Actual software sequences and information will also be provided in the software section of this document.

There are six address lines and one chip select line used by the host CPU to perform all I/O operations. In addition there is a 10 MHZ clock, an eight bit data bus and a read/write line used by the host CPU. To select the Fluidic Driver PCB both signals **_EXTCS** (chip select) and **_EXTADDR15** must be low. Then **EXTADDR3**, **EXTADDR2**, **EXTADDR1** and **EXTADDR0** may be used to select 16 different read and 16 different write addresses, with data available on the 8 data bus lines **EXTDATA(7:0)**. The I/O operations include selecting motor drives to be stepped via the TPU Bus, Holding a motor in hold current mode and reading status signals from the sensors. All decode logic is located in the PLD.

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2.3.4.2 MOTOR SELECT LOGIC

To select a single motor to be driven, the host CPU writes to the motor enable register address and selects which motor to write to by using the data bus bits **EXTDATA(3:0)**. Currently there are only eight motors to choose from with a maximum of sixteen dictated by the fact that four of the eight data lines go to the PLD. In conjunction with selecting the motor the TPU Bus must also be configured with the proper phase sequence for the chosen motor. Only one motor at a time may be selected to be driven. An exact description and memory map may be found in the software section of this document.

2.3.4.3 MOTOR HOLD SELECT LOGIC

To select a motor to be held, the host CPU writes to the hold enable register address and selects which motor to write to by using the data bus bits **EXTDATA(3:0)**. Currently there are only four motors which may be held. Four is the maximum that may be held because only four data lines go to the PLD. In conjunction with selecting the motor the TPU Bus value last used must be stored away, to be used as the starting value the next time that motor is selected to be driven. A motor must first be driven to be held and may be taken out of hold mode by either selecting that motor to be driven or writing again to the hold enable address and setting that motor's data bit to 0. An exact description and memory map may be found in the software section of this document.

2.3.4.4 STATE MACHINE

A state machine is used to decode the TPU signals into the step and direction outputs. Direction is determined from the eight step sequence. Delay of the Step signal to comply with timing requirements is done inside the PLD.

2.3.4.5 RESET CIRCUIT

There is no reset available from the host CPU. The reset signal available is a power up reset signal called **_RESET** which is used to initialize all the PLD logic at power up. The signal is derived from a simple RC time constant attached to the +5VDC power supply. The reset signal is distributed on the PCB as low active and brought into the PLD as high active. The RC time constant maintains reset active after a power up for a minimum time of 400 milliseconds.

2.3.5 VIAL PRESENT SENSOR

The Vial Present Sensor is an optical component hand soldered to the Fluidic Driver PCB which contains a visible-red light source at 680 nanometers and a light sensor to detect the presence of light. The light is carried from the Vial Present Sensor via two plastic optical fibers which go into the sample handling compartment. The two ends of the optical fibers are located at the cap of the vial under the injector needle. When a vial is present the cap blocks the light from returning to the sensor.

The module is operated in light mode which means the normally open load output NPN transistor conducts when the sensor sees the transmitted visible red light. Therefore without a vial the output NPN transistor is on pulling the input of the inverting Schmitt Trigger to ground causing **_VIAL_DETECTED** to be high. If a vial is present then the light path is broken and the low active signal **_VIAL_DETECTED** is activated.

The Vial Present Sensor has an input signal **VIAL_LED_ENABLE** which uses 1/8 of an octal Darlington array and transistor to turn the Vial Sensor ON/OFF. This is a high active signal which turns ON the Vial Present Sensor when high and OFF when low. The ability to turn the sensor ON/OFF is required to prevent light interference when the bar code reader option is installed. So when using the bar code reader the host CPU may shut OFF the Vial Present Sensor.

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Over time the quality of the plastic fiber optics may degrade and result in a decrease in sensing gain. The alarm output NPN transistor is normally open and it conducts whenever the sensor's excess sensing falls below 1.5x in the light condition. This places the input of the Schmitt Trigger at ground and causes the high active signal **VIAL_SIGNAL_FAIL** to be active. This may be used as a notification that a PM is required to replace the optical fibers.

The sensor has two LEDs, one yellow, one green and a sensitivity adjustment on it's top side to ease calibration of the sensitivity adjustment. The following table shows the status conditions indicated by the two LEDs.

LED Color	LED State	Status Condition
GREEN	Glowing Constant On	DC Power On
GREEN	Flashing	Output Overload
YELLOW	Glowing Constant On	Excess Gain in Light Condition is > 1.5x
YELLOW	Flashing	Excess Gain in Light Condition is marginal < 1.5x. Same as VIAL_SIGNAL_FAIL being active.

The single turn sensitivity control should be adjusted with the signal **VIAL_LED_ENABLE** high which turns on the Vial Present Sensor and no vial in the position under the injector needle. The control should be adjusted until both LEDs are glowing constant on.

2.3.6 SOLENOID DRIVES

The Waste Valve V3 and the Needle Wash Valve V4 are the subjects of this section. Both are solenoid valves.

2.3.6.1 WASTE VALVE V3

The Waste Valve V3 has a drive signal named **VALVE_3** which is high active and applies 24VDC across the valve causing the valve activate. The drive is accomplished using 1/8 of an Octal Darlington Array. Another signal is also provided to hold the valve activated after it has been on for 0.5 seconds or more. This signal is named **VALVE_3_HOLD** which is also high active and drops the voltage across the valve to 12 VDC thereby minimizing the power dissipation in the valve. It accomplishes this with 1/8 of an Octal Darlington Array and a 75 ohm 4 watt resistor in series with the valve across 24 VDC.

2.3.6.2 NEEDLE WASH VALVE V4

The needle wash valve simply has one high active drive signal named **NEEDLE_WASH_VALVE** which applies 24 VDC across the valve to activate it. It accomplishes this by using 1/8 of an Octal Darlington Array.

2.3.7 NEEDLE WASH PUMP DC MOTOR DRIVE

The Needle Wash Pump uses a 24 volt DC motor. The drive is applied with a high active signal named **NEEDLE_WASH_PUMP** which uses 3/8s of an Octal Darlington Array driver to apply 24VDC across the motor.

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2.4 ELECTRICAL PERFORMANCE SPECIFICATION

2.4.1 HOST CPU TO FLUIDIC DRIVER PCB INTERFACE

The current communications interface for the Fluidic Driver PCB is designed to operate with the address and data bus of a 68332 Motorola Microprocessor. The signals utilized in this interface are **_EXTCS** which is a combination of the base address lines (440000 hex in 2690 product) and the host CPU's 68332 Address Strobe. Also five other address lines are required from the host CPU **EXTADDR15**, **EXTADDR3**, **EXTADDR2**, **EXTADDR1** and **EXTADDR0**. An 8 bit data bus **EXTDATA(7:0)** and a **READ (high active)/WRITE (low active)** line are also required. Finally a 10 MHZ clock is also required from the host CPU. The exact timing of these lines may be found in a Motorola Specification Book on the 68332 Microprocessor. Also a memory map for the Fluidic Driver PCB may be found in the software section of the document.

2.4.2 SIGNALS DRIVEN DIRECTLY FROM THE HOST CPU NOT THROUGH THE PLD

The following signal are addressed directly from the host CPU to the Fluidic Driver Electronics. All other signals which are written to from the host CPU are motor controls and interface through the PLD, see sections **2.3.1** and **2.3.2**. The exceptions are the sensor signals read and the Vial Present Sensor which is read directly from the host CPU. However these signals are discussed in sections **2.3.3** and **2.3.5**.

- | | |
|----------------------------|--|
| NEEDLE_WASH_PUMP | - This is a high active signal which drives a DC motor through 3/8s of an Octal Darlington Array Driver. The driver simply applies ground to one side of the DC motor with 24VDC applied to the other. The driver is capable of supplying a maximum continuous current of 1.5 amperes. |
| NEEDLE_WASH_VALVE _ | - This is a high active signal which drives a solenoid valve through 1/8 of an Octal Darlington Array Driver. The driver simply applies ground to one side of the solenoid coil with 24VDC applied to the other. The driver is capable of supplying a 0.5 ampere current continuously to the solenoid. |
| VIAL_LED_ENABLE | - This is a high active signal which applies 24VDC to the Vial Present Sensor. This is accomplished by turning on a bipolar transistor. The intent is to give the host CPU the capability on turning the Vial Present Sensor LED ON and OFF to prevent the light source from interfering with the bar code reader option if present. |
| VALVE_3 | - This is a high active signal for the Waste Valve which will drive (Slam) a solenoid through 1/8 of an Octal Darlington Array Driver. The driver simply applies ground directly to one side of the solenoid with 24VDC applied to the other. The intent here is to reach the pickup current required to move the solenoid. The driver is capable of applying 0.5 amperes to the solenoid. This signal should only be applied long enough to ensure the solenoid has moved then this signal should go low and VALVE_3_HOLD should go high simultaneously. |
| VALVE_3_HOLD | - This is a high active signal for the Waste Valve designed to be used to provide enough current to the solenoid simply to keep the moved solenoid in the moved state. The drive is accomplished through 1/8 of an Octal Darlington Array Drive and a resistor equivalent to 75 ohms 4 watts in series with the solenoid coil. The purpose of the resistor is to drop half of the applied 24VDC, so only 12VDC is applied across the solenoid coil. Therefore only half of the pickup current is actually flowing through the solenoid when in hold mode to minimize power dissipation. |

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2.4.3 POWER SUPPLY INPUTS

The following table describes the input voltages and currents which must be supplied to the board in order to obtain normal operation. The Power Connector pin assignments can be found in the schematic. The 5 VDC supply is fused with a resetting PTC fuse having a fuse current of 1.5 amperes. Should a short occur causing a current greater than 1.5 A the fuse will become open. Power must be cycled to reset the PTC fuse. The 24VDC supply is fused with a SMD 7 ampere fuse and holder. Should a short occur causing a current greater than 7 A the fuse will blow and will need to be replaced. The intent here is to provide a layer of safety to minimize the amount of energy a board will see should a component short to ground across the supply. In the current 2690 product a full 600 watt supply could be available for a short if the fuses weren't present.

Supply Voltage	Load Current
5 VDC Digital	0.75 Amps Peak
24 VDC	2.0 Amps Peak

3.0 PHYSICAL SPECIFICATIONS

3.1 MECHANICAL SPECIFICATIONS

Most of the Fluidic Driver PCB physical dimensions can be found on the PCB Fabrication Drawing.

Pump Driver PCB Weight 10.5 Oz.

3.2 ENVIRONMENTAL SPECIFICATIONS

Operating temperature range	4 to 40 degrees C
Relative Humidity	20 % to 80 % (non-condensing)
Storage Temperature Range	-20 to 80 degrees C
Air Flow Over PCB	A minimum of 20 CFM

3.3 SAFETY

The only voltages supplied to the Pump Driver PCB are low voltage DC.

4.0 SOFTWARE AND DIAGNOSTICS SPECIFICATIONS

4.1 FAILURE DIAGNOSTICS

The purpose of this section is to provide the host CPU software with information on what failure signals are provided from the Fluidic Driver PCB and what to do when a failure is encountered. All of the motor and solenoid drives are open loop therefore the Fluidic Driver PCB has limited knowledge of what is actually operating as commanded. The software does have a higher level ability to perform system type diagnostics such as rotating the carrier and reading the carrier position thereby closing the loop to verify operation.

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4.1.1 VIAL PRESENT SENSOR DIAGNOSTICS

The Vial Present Sensor is the only component which has a true diagnostic signal, **VIAL_SIGNAL_FAIL**. This signal which is high active activates only if the sensors excess sensing fall below 1.5x in the light condition. So over time as the plastic fiber optics degrade this signal will activate. The software should then notify the operator that a periodic maintenance should be scheduled to replace the fiber optic cables.

Where software has control of applying power to the Vial Present Sensor the following table will show the expected condition of the two Vial Present Sensor Outputs with power on and off.

POWER	VIAL_SIGNAL_FAIL (high active)	_VIAL_DETECTED (low active)
ON	w/o failure = low	w/o a vial present = high
OFF	low	low = vial detected

Note also that a defective LED will always give a vial present signal (**_VIAL_DETECTED** = low). to check for a defective LED the carousel must be rotated and **_VIAL_DETECTED** must be sampled to ensure it transitions from low to high occur between vials. A constant low indicates a defective LED in the Vial Present Sensor. This is true only if the software has applied power to the Vial Present Sensor during this test.

4.1.2 LEDS ON BOARD AND THEIR FUNCTION

Refer to the table below and the assembly drawing for the physical location of the LEDs.

LED REFERENCE DESIGNATOR	FUNCTION
DS1	Syringe Top Sensor
DS2	Syringe Bottom Sensor
DS4	Syringe ValveV2 Motor
DS5	Inject Valve V1Motor
DS6	Carrier Rotation Motor
DS7	Dissolution Needles Motor
DS8	Carousel Z Axis Motor
DS9	Carousel Rotation Motor
DS10	Injector Needle Motor
DS18	Needle Wash Valve V4
DS19	Needle Wash Pump
DS29	Carrier Position Sensor
DS30	Carrier Home Sensor
DS34	Carousel Position Sensor
DS35	Carousel Home Sensor
DS37	Z Home Sensor
DS38	Dog Pin Sensor
DS39	Carousel ID Sensor
DS40	Dissolution Top Sensor
DS41	Dissolution Bottom Sensor
DS42	Injector Bottom Sensor
DS44	Injector Top Sensor

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4.2 SOFTWARE MEMORY MAP

The tables below contains the memory map for all host CPU I/O functions. The base hex address in the current 2690 product is 440000. Where the Fluidic Driver PCB uses only four lower address line **EXTADDR(3:0)** and eight data bus lines **EXTDATA(7:0)**, there is a maximum of 16 eight bit read registers and 16 eight bit write registers. The Fluidic Driver PCB currently only uses 2 eight bit read registers and 3 eight bit write registers.

ADDRESS: 440006 READ Register
NAME: Fluidic Sensors Read Register 1

Bit Number	Value Read when Signal is Active	Signal Name
7	0	_VIAL_DETECTED
6	0	_Z_HOME
5	0	_DOG_PIN
4	0	_CAROUSEL_POSITION
3	0	_CAROUSEL_ID
2	0	_CAROUSEL_HOME
1	0	_CARRIER_HOME
0	0	_CARRIER_POSITION

ADDRESS: 440007 READ Register
NAME: Fluidic Sensors Read Register 2

Bit Number	Value Read when Signal is Active	Signal Name
7	0	_SYRINGE_TOP
6	0	_SYRINGE_BOTTOM
5	0	_INJ_TOP
4	0	_INJ_BOTTOM
3	0	_DISS_PRESENT
2	0	_DISS_TOP
1	0	_DISS_BOTTOM
0	1	VIAL_SIGNAL_FAIL

ADDRESS: 440001 WRITE Register
NAME: Fluidic Motor Enable Control Register

Bit Number	Binary Write Value to Select Motor	Binary Value = Motor Selected (Only one Motor may be selected at a time)
7	NOT USED	0 hex = No Motor Selected
6	NOT USED	1 hex = Carousel Z Axis Motor
5	NOT USED	2 hex = Carousel Rotation Motor
4	NOT USED	3 hex = Injector Needle Motor
3	$1=2^3$	4 hex = Inject Valve V1 Motor
2	$1=2^2$	5 hex = Syringe Valve V2 Motor
1	$1=2^1$	6 hex = Not Used
0	$1=2^0$	7 hex = Carrier Rotation Motor
		8 hex = Dissolution Needles Motor
		9 hex = Syringe Motor

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ADDRESS: 440002 WRITE Register
NAME: Fluidic Motor Hold Control Register

Bit Number	Value Written to Hold Selected Motor	Hold Motor Selected
7	NOT USED	
6	NOT USED	
5	NOT USED	
4	NOT USED	
3	1	Injector Needle Motor
2	1	Carrier Rotation Motor
1	1	Carousel Rotation Motor
0	1	Carousel Z Axis Motor

ADDRESS: 440005 WRITE Register
NAME: Fluidic Control Register

Bit Number	Value Written to Activate Signal	Signal Name
7	NOT USED	
6	NOT USED	
5	NOT USED	
4	1	VALVE_3_HOLD (Hold Mode)
3	1	VALVE_3 (Slam Mode)
2	1	VIAL_LED_ENABLE (POWER ON)
1	1	NEEDLE_WASH_VALVE
0	1	NEEDLE_WASH_PUMP

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4.3 SOFTWARE SEQUENCE FOR DRIVING AND HOLDING MOTORS

There are two basic rules which must be followed, first only one motor may be rotated at a time and second only four motors may be selected in the Hold Mode, **Injector Needle Motor**, **Carrier Rotation Motor**, **Carousel Rotation Motor** and **Carousel Z Axis Motor**. Two sequences will be defined below, one to drive a motor and the second to drive then hold a motor then drive again.

Example 1: Move the Carousel Rotation Motor 100 Half Steps.

- (1) Set up the TPU starting phase sequence.
- (2) Write a hex value of 02 to the Fluidic Motor Enable Control Register at address 440001 hex. This selects and enables the Carousel Rotation Motor.
- (3) Sequence the TPU 100 steps (Each is a motor half step).
- (4) Now if you to leave the motor selected in this position it would remain enabled at full current and would heat quickly. This is true for all eight motors. To avoid this you must complete step (5).
- (5) Write a hex value of 00 to Fluidic Motor Enable Control Register at address 440001 hex. This selects no motor.

Example 2: Move the Injector Needle Motor 100 Half Steps, then Hold, then move 100 Half Steps.

- (1) Set up the TPU starting phase sequence.
- (2) Write a hex value of 03 to the Fluidic Motor Enable Control Register at address 440001 hex. This selects and enables the Injector Needle Motor.
- (3) Sequence the TPU 100 steps (Each is a motor half step).
- (4) Write a hex value of 08 to the Fluidic Motor Hold Control Register at address 440002 hex. This selects and holds the Injector Needle Motor. Note there are three other bits which must be masked if any of the other three motors are also being held, see memory map section.
- (5) The ending phase value currently in the TPU must be saved to use as the starting phase sequence when this motor is rotated again from a hold condition.
- (6) Time to rotate the Injector Needle Motor which is currently being held.
- (7) Reload the TPU with the phase value stored in step (5).
- (8) repeat step (2).
- (9) Repeat step (3).
- (10) Now if you to leave the motor selected in this position it would remain enabled at full current and would heat quickly. This is true for all eight motors. To avoid this you must complete step (11)
- (11) Write a hex value of 00 to Fluidic Motor Enable Control Register at address 440001 hex. This selects no motor.

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