

## Connecting and Wiring the AGNI Controller:

Newest Controller information is first and older controller information in the following pages.

### Advantages of our USB controller board:

- (1) New 32 bit AGNI Controller Series 20000 has high speed and higher step rate up to 250,000 and FAT or FAT32 formatted SD memory available.
- (2) The major function of this product is to drive your machines with USB connection to your computer without locking up any computer functions. Your computer and the design programs are free and available to you while the previous job is being processed.
- (3) The controller is compatible with USB 2.0 specification. It allows transfer of job at a very high speed. It is not compatible with USB 1.1. **Do not use any USB 1.1 devices on the computer where you install LinkMotion software.**
- (4) **Old Agni Series 10000 and uner** has a slot for SD card memory. It is used as a job buffer and a spooler. The processing of a job on a machine can go on while the PC can be used for other purposes simultaneously. Approximately 1 minute of machine operation for a job uses 1MB of memory and this controller supports up to 4GB of micro memory. **The new version of LinkMotion 3.0 and higher now supports SDHC memory and we have done testing with following ones.**

**Memory chips tested and working with this controller:** Sandisk 1 GB, 512 MB, 256 MB, Topram 1gb, PNY 1gb, PNY 4gb SDHC, Samsung 1gb, Transcend 1gb and 'Made in China Generic' 1gb.

**Memory chips not working with this controller:** Kingston 2gb (not SDHC), Kingston 4gb SDHC

- (5) The USB controller solution is equipped with EMC2 (The Enhanced Machine Control 2) compatible M&G code capability. EMC (the Enhanced Machine Control) is a software system for computer control of machine tools such as milling machines, lathes, engraving machines, torch cutting machines, water jet cutting machines, laser machines, and other multi-axis machines. EMC has been available under Linux and has a very large user base. Now, it is available under Microsoft Windows environment with the same capabilities, precision, and flexibility. Please, visit <http://www.linuxcnc.org/> for additional information.
- (6) The LinkMotion can accept the jobs in the following manner:  
  
2D jobs, 2 1/2D, 3D, 4D, 5D, or 6D jobs created elsewhere using M&G format can be sent to the USB controller using LinkMotion. In other words, the USB controller is totally compatible with M&G codes, one of the most popular command structure for machine control. A list of implemented M&G codes from the complete list of EMC commands is available elsewhere in this document.
- (7) The board will generate step and direction commands for up to 6 drivers for controlling 6 motors. The standard explanation is for 3 axes and refers to **Additional axis control** information if your machine has more than 3 motors.

- (8) The USB controller is capable of sensing Home switches, E-Stop, and other inputs.
- (9) The USB controller has 6 output connectors. The functions are described later in this document.
- (10) It is advisable to mount the controller board in your enclosure such that the USB connector residing on the controller board and the SD memory card slots are accessible without opening the enclosure.
- (11) Optionally, Solustan provides small, standalone enclosure with or without the wiring for the output connector (DB-25 female) for the convenience of initial testing and/or for an on-going configuration. An optional, external 5 VDC power supply is also available along with the enclosure if required.
- (12) **New Agni Series 20000 Controllers** has the capacity for 250,000 steps per second capacity.
- (13) **Old Agni Series 10000 and uner Controller** has the capacity for 125,000 steps per second maximum specified limit. 75,000 steps per second are the maximum specified limit of the older 16 bit USB controller.

### **IMPORTANT WIRING SUGGESTIONS:**

We have tested it in our labs and we are convinced that the wiring is the weakest link in any machinery. Just like User Interface, the wiring is almost always an afterthought in assembling a machine. We cannot stress more that you should look into the following while wiring your laser machine:

- (1) Coming out of the Agni's connectors, use twisted and shielded pairs to wire the controller to the machine.
- (2) Use metal or metalized shells for the cables ending into the connectors when required.
- (3) The shield should be grounded only on one side of the cable, preferably on the machine side. Should not be connected to the controller side.
- (4) The home or limit switches have two wires, use a twisted pair.
- (5) All the I/O's require a ground wire, use a twisted pair.
- (6) Step motors have a pulse (step) and direction wires, use a twisted pair for each of the axes.
- (7) PWM signal wire for the laser power also has a ground wire for return, use a twisted pair.
- (8) American style, 22 or 20 gauge wires with multi-strands are just fine.

What could happen in an electrically noisy environment?

- The controller may sense a noise pulse as reaching home on home switch wires. If you see the lights on the limit switches on the Control Pad fluctuating between red and green colors while the machine is not even trying to go home, it is the electrical noise that may be a culprit.
- After finishing a job, a good machine does not go back to (0,0) position, steps are added or subtracted during operation due to electrical noise.
- If the laser power is fluctuating even while cutting a straight line, it may be the noise again.

**If you are buying Chinese laser machines, you may enlist their help while they assemble the machines. It may add just a few dollars to the cost but may buy you many happy customers.**

## **Warnings for Laser/Agni Controller board:**

1. Plug the LinkMotion controller cable directly into your computer's USB 2.0 connection.
2. It is important to experiment and determine that the USB controller works with the USB hub or extension device if the user plans to use such a device.
3. This Laser/Agni controller does not work with USB1.1 connections. If you connect other USB devices compatible only with 1.1, it may cause problems. All the USB devices including keyboard and mouse in the system shall comply with 2.0 specifications. Always check compatibility for wireless USB devices, if you are using one.
4. Power saver and Screen Saver modes on your computer should be turned off. If these modes are activated, it can cause problems in recognizing the USB connection on a continuous basis.
5. **New AGNI USB Controller / Series 20000** can use 24 VDC - The LinkMotion Agni controller can be configured to power either from the USB connection of the PC or from an external 5 VDC or 24 VDC power supply. There is a jumper on the controller board that allows the selection of the power supply for the controller.
6. **Old AGNI USB Controller / Series 10000** - The LinkMotion Agni controller can be configured to power either from the USB connection of the PC or from an external 5 VDC power supply. There is a jumper on the controller board that allows the selection of the power supply for the controller.
7. In case of Laptop computers, AC power unit shall be connected to an AC outlet while operating external USB devices. Sometimes, aggressive power save mode settings under battery operations could activate the disconnection of USB devices. Re-Launching LinkMotion will re-activate the communication in such a situation.
8. Approximately 1 minute of machine operation uses 1MB of SD memory for vector work. This controller supports up to 4GB Memory. If you are using LinkMotion version 3.5 or higher, you could use either SD or SDHC memory cards.
9. **New AGNI USB Controller / Series 20000** uses FAT or FAT32 formatted SD memory.
10. **Old AGNI USB Controller / Series 10000** - It is impossible to test all the available SD Memory cards in the market but we have listed in the following lists ones that work and ones that do not work with this USB controller.

Memory chips tested and working with this controller: Sandisk (1 GB, 512 MB, 256 MB), Topram 1gb, PNY 1gb, PNY 4gb SDHC, Samsung 1gb, Transcend 1gb and 'Made in China Generic' 1gb.

Memory chips found not working with this controller: Kingston 2gb (not SDHC) and 4gb SDHC.

11. If serial number of the controller is not recognized by LinkMotion then user will see a message "Unrecognized serial number \_\_\_\_". Once you click on OK button it will display the second message as "The maximum working area is 1"x1" or 25.4mm x 25.4mm. LinkMotion software can output only 1"x1" jobs at that point. Unauthorized controller bought from unauthorized vendors can cause this kind of problem. Get in touch with Solustan to verify your serial number. Not making proper USB connection with the controller can also display this kind of message and simply disconnecting USB cable from computer end and reconnect and re-launch LinkMotion should resolve it.

### **12. USB Controller Board Lights:**

**New AGNI USB Controller / Series 20000** - There is only one LED lights available to attach to the new Agni Controller board Series 20000 – Blue. This light will behave in the following manner when connections are made and the board is powered:

**Blue LED** – Steady Blue light means USB powered up and ready. If blue light flashes fast it means it is waiting to make the USB connection. At this point, If you launch LinkMotion app it should become steady. If Blue light is flashing slowly it means it is in boot load mode.

**We have an additional programmable LED connections available. We will inform you as we add more LED and its functions.**

**Older AGNI USB Controllers / Series 10000** - There are three LED lights available to attach to the Agni Controller board – Blue, Amber, and Red. These lights behave in the following manner when connections are made and the board is powered:

**Blue LED Flashing Slowly** – No USB Connection

**Blue LED Steady** – USB powered up and ready

**Amber LED Flashing Slowly** – Waiting for firmware update

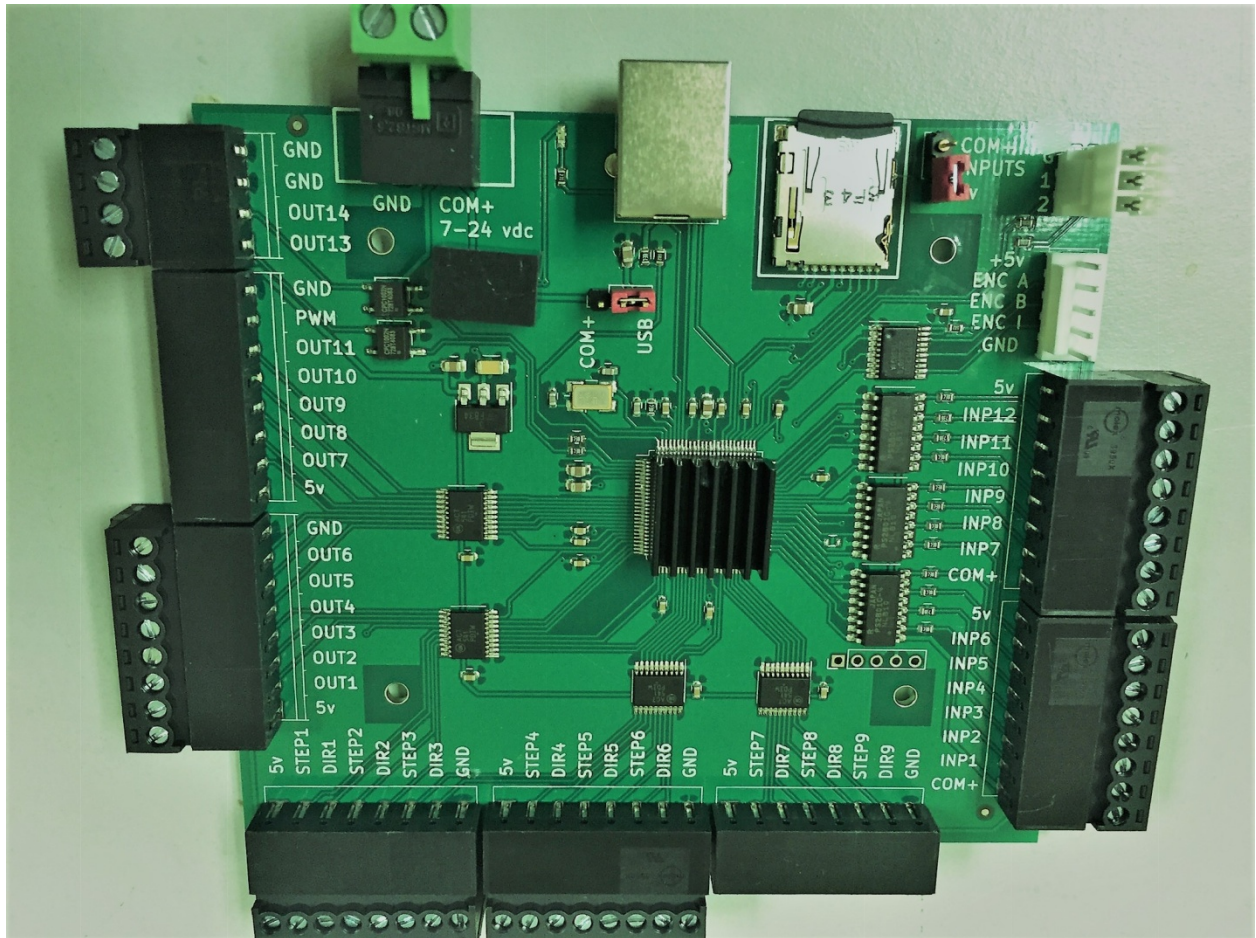
**Amber LED Flashing Fast** – No SD (Memory) card

**Amber LED Steady** – USB ready with SD card

**Red LED** – Turns on when the board is powered. It turns off when it makes a proper connection with LinkMotion. It also turns on every time when any machine motion is detected.

**Red LED Flashing** – If hardware switch for Repeat is installed on the Laser/Agni controller and LinkMotion.INI file is set up properly, then, Red LED starts flashing after a job is processed one time. Pressing the Repeat switch will send the job again to the machine. After a job is processed one time it is ready to repeat the last job using the repeat button on the USB controller as many times as user wishes.

## The New High Speed Controller – Agni III - Series 20000



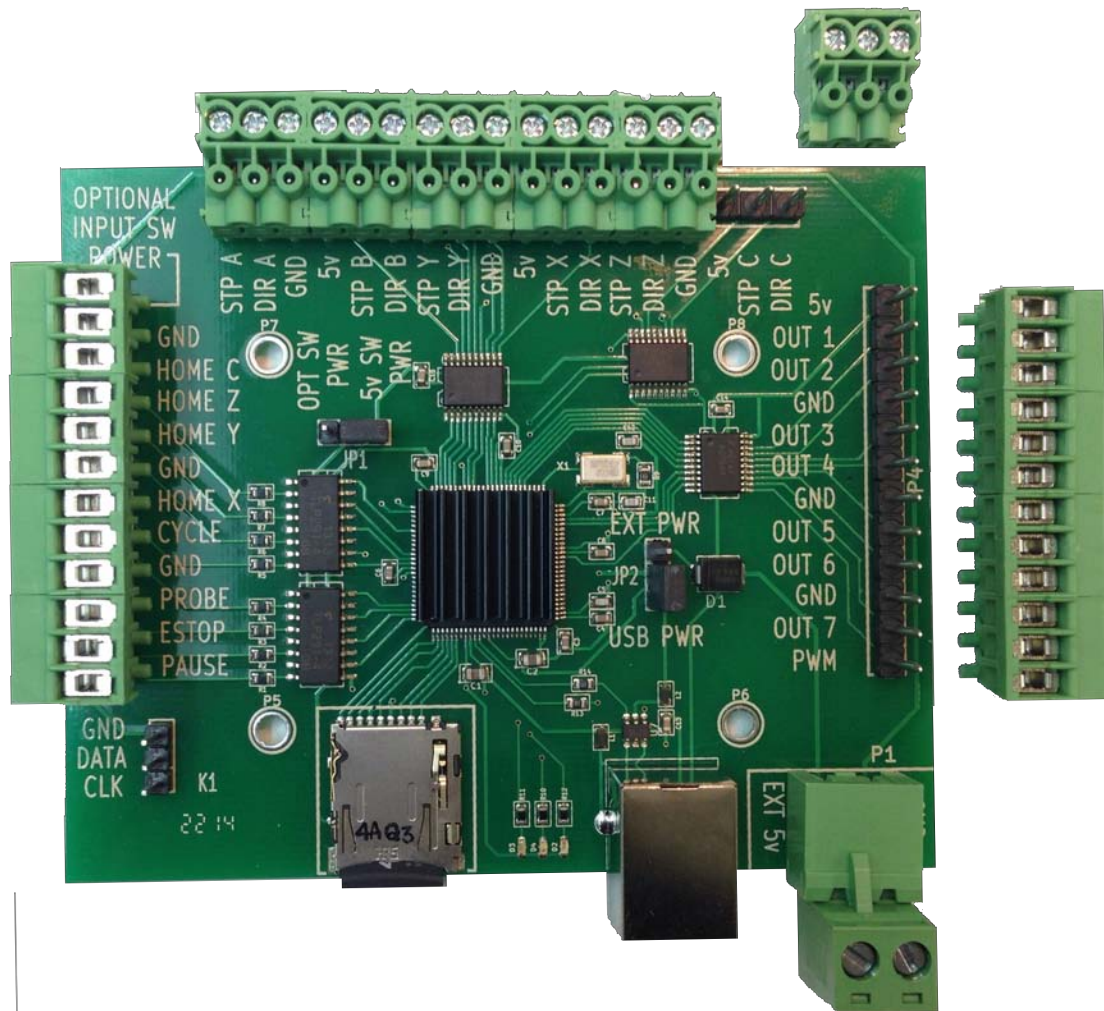
The hardware details of the Agni III controller:

1. Our previous controller Agni II had the maximum step rate of 125,000 steps per second. The Agni III controller doubles the speed to 250,000 steps per second.
2. It offers up to 9 axes control, M&G code processing, and lot more inputs and outputs.
3. The SD memory cards are used as formatted cards for improved reliability of stored information. Use a PC to format the SD memory card using FAT or FAT32 method.
4. The controller can be powered directly from the USB port by taking power from a PC.
5. Alternately, it can also be powered externally with an on-board power supply regulator. The external power supply can be as low as 7 VDC and as high as 24 VDC. There is only one jumper on the controller to select the power source. The jumper is positioned close to the USB connector.
6. Place the jumper toward the COM+ side to accept external power through the 2 pin Green connector. The picture shows the COM+ side (7 to 24 VDC) and the GND side for the connections.
7. Place the jumper toward the USB side in order to accept the power from the USB port of the PC. With this selection, the 24 VDC output will not be available through outputs 13 and 14.
8. All the outputs are driven through line driver IC's. Each output can source or sink up to 20 ma current.
9. All inputs are opto-isolated to reduce noise and interference.

10. Of the 9 axes, the very first axis, X axis can work with step or a servo motor. However, the servo motor driver is required to be able to handle pulse and direction inputs. A special connector is setup for encoder feedback.
11. The 9 axes are X(1), Y(2), Z(3), A(4), B(5), C(6), U(7), V(8), and W(9). The G code file shall have the alphabet values for it to be processed properly.
12. The controller is equipped with one blue LED on-board for USB connections and other functions like firmware updates. The 3 pin white connector is equipped with connections for two more LED's. Many different indications can be programmed. We are looking to bring these LED's to a Control Panel that can be implemented on a machine. We would like to have feedback from users describing the features they want to see implemented using the LED's for appropriate feedback.
13. The second jumper is placed by the SD memory card. The input lines can be TTL (+5 VDC) or they are allowed to be as high as 24 VDC. Some active home switches may send signals anywhere from 5 to 24 VDC. The jumper allows the selection of TTL or higher input levels. Input lines are programmed based on the selection here.
14. Outputs 1 will work with Output 13. Both of them will turn ON and OFF at the same time. However, Output 1 is a TTL output while Output 13 switches an SSR (Solid State Relay) to switch either +5 VDC or 7 to 24 VDC with the capability to drive a load requiring up to 500 ma current.
15. Outputs 2 will work with Output 14. Both of them will turn ON and OFF at the same time. However, Output 2 is a TTL output while Output 14 switches an SSR (Solid State Relay) to switch either +5 VDC or 7 to 24 VDC with the capability to drive a load requiring up to 500 ma current.
16. Outputs 1, 13, 2, and 14 turn ON when the laser is ON or the CNC tool is cutting and they turn OFF when the laser is OFF or the CNC tool is not cutting during a job.
17. Outputs 3 and 4 turn ON and stay ON throughout a job and turn OFF at the end of a job.
18. Outputs 5 through 11 are not controlled by the LinkMotion application at this point. However, they can be turned ON and OFF using M commands in the G codes. M64P(x) to turn ON and M65P(x) to turn off the output.
19. Here are the Input settings:
  - Input 1 is for the X axis Limit Switch
  - Input 2 is for the Y axis Limit Switch
  - Input 3 is for the Z axis Limit Switch
  - Input 4 is for the A axis Limit Switch
  - Input 5 is for the B axis Limit Switch
  - Input 6 is for the C axis Limit Switch
  - Input 7 is for the Cycle Start or Start
  - Input 9 is for the E-Stop
  - Input 10 is for the Pause
20. Solustan plans to design a Control Panel using Cycle Start, E-Stop, Pause, and the two LED's for additional feedback.



## **AGNI-IIP Controller for CO2 Laser or CNC Machines:**

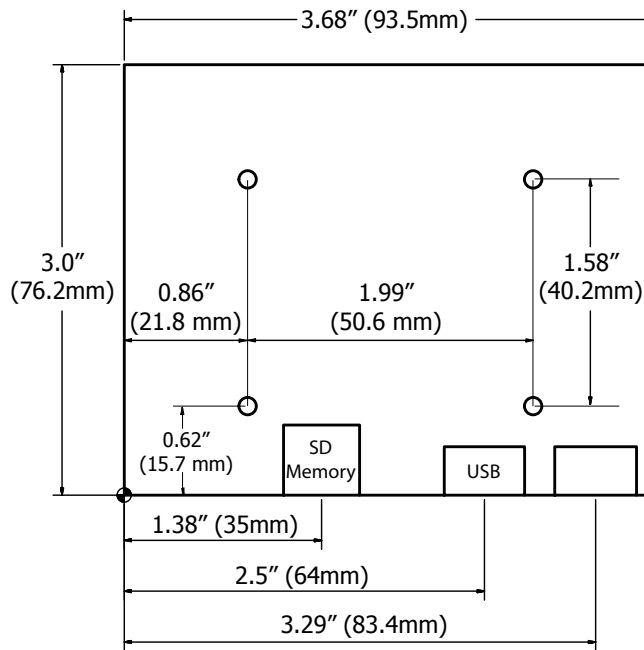


This newest **AGNI-IIP controller** has Phoenix-type connectors that can be plugged in two different ways compared to earlier AGNI II version that had screw terminals. Two different positions are available such that wires can come out either from the sides or from the top. It is slightly smaller in size and all dimensional details are given on the following page. Wiring information is printed on the board and remaining other technical information is provided in the following pages.

Four plastic standoffs may be provided with the controller. They require 0.125" or 3.2mm holes for the mounting surface. The material thickness of the mounting surface should not be greater than 0.062". If you have thicker material then you should use screws with spacers.

### **The physical dimensions of the controller board are as follows:**

1. The size of the controller board is 93.5 mm X 76.2 mm (3.68 in X 3.0 in)
2. There are 4 holes for mounting the controller. The holes are 3 mm in diameter (1/8 inch)
3. Horizontally, the distance between holes is 50.6 mm (2 inches)
4. Vertically, the distance between holes is 40.2 mm (1.57 inch)



## **Specifications:**

The USB connector protrudes by 5 mm outside the board.

The connector for external power supply when connected will extend outward by about 12 mm. (The external +5 VDC connector is NOT required if the jumper is set to accept the power for the controller board from the USB port of a PC.)

The Agni controller has a processor running at 96 MHz with 6 axis controls. It comes with an SD memory card holding a capacity of 4 GB of storage.

## **Caution:**

Controller board is equipped with integrated circuits and high-frequency processors. The components are susceptible to static electricity. We tend to build a static charge on your body while simply walking around in a less than ideal humidity in the environment. It is easy to damage the circuits on the board with a slight touch. It is recommended that a grounding strap on the wrist or other methods to neutralize the build-up of static electricity before handling the controller board. Keep yourself grounded while you continue to work with the controller board.



## **Connections and configuration of the Agni-IIP controller:**

1. Take a look at the above picture of the controller and note that there are only two jumper settings required for physical connections.

Jumper on the left of processor relates to voltage requirement for the Home (Limit) switches. If the Home switches in your machine only require +5 VDC, you do not need to do anything. The default setting of the jumper is set to use the internal power (5v SW PWR). On the other hand, some machines use active home sensing switches that may require higher than +5 VDC for proper operation. In such a case, move the jumper to the optional power input (OPT SW PWR) for home switches. The optional power and Ground input points are at the top left of the board. Connect the switch appropriate power supply here. The voltage of the external power for the Home switches shall not exceed 24 VDC. All the input lines are protected with optoisolators.

**Also, refer to more detail description for connecting home (limit) switches along with output connections in following pages after the general description.**

Note the second jumper situated to the right of the main processor chip in the center of the Agni controller. The Agni controller needs little power. It is possible to power the controller directly from the USB port of the PC. The default setting of the jumper is for the Agni to receive the power from the USB port of your computer (USB PWR). If it is necessary to power the controller from external sources, move the jumper toward the EXT power side (EXT PWR). The optional power and Ground inputs are at the bottom right of the controller. Note a removable, 2 pin, green connector. Required voltage is 5 VDC. The voltage of the external power of the Agni controller shall not exceed 6 VDC.

2. Connecting Agni to the Laser or CNC machine:
  - 2.1 X, Y, Z, and cylindrical axis motors
  - 2.2 The Agni controller generates Step (sometimes called Pulse) and Direction pulses for each of the axis. Maximum step rate is 125,000 per second.
  - 2.3 Ground and +5 VDC connections are available along with step and direction commands for the connections to step motors managing different axis.
  - 2.4 There may not be a need for all four connections. In fact, some step motor drivers require a step, direction, and either ground or +5 VDC connections. Use whatever is necessary to make connections to the step motor drivers.
  - 2.5 If the machine is equipped with servo motors, please, make sure that the servo motor drivers are capable of accepting step and direction commands.
  - 2.6 The Agni controller is equipped to connect up to 7 outputs and one PWM (pulse width modulation) output for laser power control. Out of the 7 outputs, 4 are connected to the LinkMotion driver settings. If and when required, additional outputs can be made available.
    - Output 1 is for laser ON/OFF
    - Output 2 is for red indicator diode control
    - Output 3 is for water control
    - Output 4 is for positive air pressure for laser head

Output 1 and 2 turn on at the beginning of every shape to be lased and turn off at the end of the shape. While output 3 and 4 turn on at the beginning of a job and stay on throughout the job. Sometimes, users do not use output 4 to control water. It may not be desirable to turn off

the water at the end of a job when the laser tube mat still is hot and may require additional cooling. Some users just turn on the water pump at the beginning of a day and leave it on until the end of the shift.

Invert PWM capability is available from Linkmotion V4.27 onwards with a following line in the Linkmotion.INI file under each machine related settings.

**InvertPWM=0 or 1**

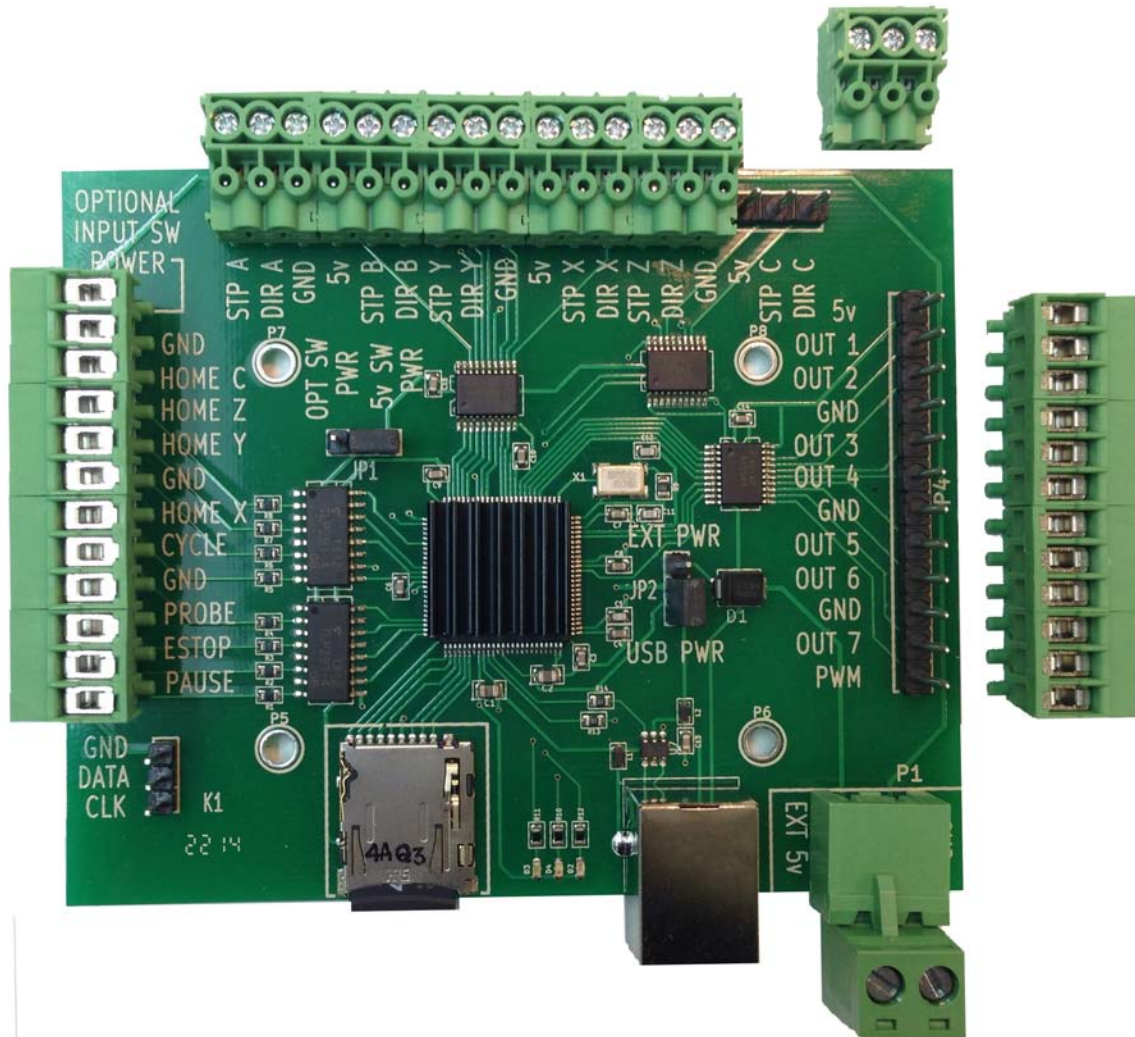
The default value is 0(zero) and the user can change it 1 if required. Change is effective after saving the INI file and Re-launch Linkmotion.

PWM output will generate a tickle pulse (if turned on) as well as generate the power levels while modulating the width at the frequency set up in the LinkMotion settings. There is a clear point of connection for the PWM output from the controller to the RF metal laser tubes. It is also possible to take advantage of the PWM and frequency settings in the LinkMotion to achieve better results while controlling the Chinese style glass tubes with its appropriate power supply. (Please, refer to our separate document on the subject.)

- 2.7 The Home switch connections are self-explanatory. Appropriate settings are available in the LinkMotion software configuration.
- 2.8 The controller is equipped with soft Control Pad that shows up on the PC screen with many useful features. Please, refer to our main document, the LinkMotion USB for laser machines. In addition, Solustan provides additional connections for hardware Control Pad that may be required for installing it right on the laser or CNC machine. Please, contact us for protocol information as well as command strings.
- 2.9 Often overlooked, but the important part is the wiring between the controller and the rest of the laser machine. This ounce of prevention will go a long way. All the signals going in and out of the controllers are just that, signals.
  - You do not need thicker than 22 gauge of wire.
  - Twisted and shielded pairs of wires are the best way to go.
  - If possible, use three twisted wires in a shield for each of the step motor connections.
  - If possible, use a twisted pair of wires in a shield for each of the I/O's, and home switches.
  - Use multistrand copper wires.
  - Connect the shield to a ground on only one side of the wire cluster, preferably on the machine side.
  - The laser machine shall be connected to the earth ground, if not already.
  - When you reduce the effect of the electrical noise on the controller, you are going to have fewer problems with step accuracy, sensing of home, and better performance of the system.

## **Input and Output connections including Home/Limit switches:**

This description is for AGNI controller hardware. AGNI controller is available with a USB interface (2.0 and higher) and an SD memory card to spool a job coming from USB connection. Here is a picture of the controller:



Note that there are two jumpers on the board Jumper to the right of the processor and second onto the left and above the processor.

1. The jumper to the right of the main processor selects the power required to run the controller from either the USB port of the PC or from external 5 VDC. The total requirement is maximum 200 milliamp when operating and driving all six axes. When the jumper shorts the two pins closest to the USB connector, it takes the power from the USB port.

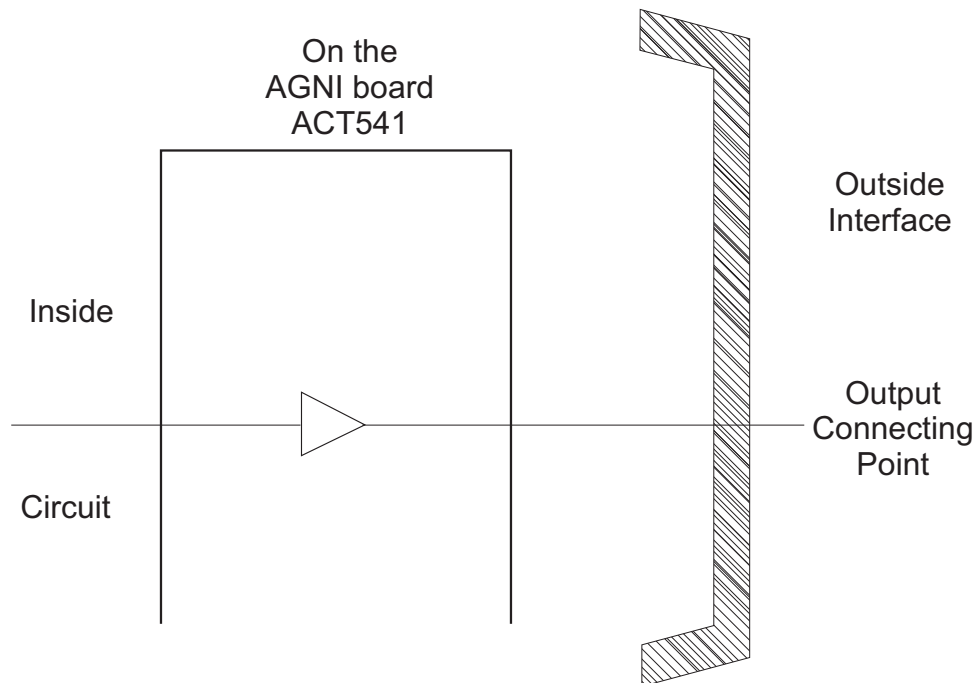
There are ample ground connections on all the connectors in order to connect signal grounds and completing circuits.

2. The second jumper (JP1) is close to the upper left of the processor as shown in the picture. It determines the availability of the power from either internal 5 VDC or externally supplied power for the home/limit switches.

With the above information in mind, let us take a look at the ways to connect the controller to the outside world. The outside world includes step motor drivers for up to 6 axes, either output including PWM, and the following inputs:

- Home/Limit switches for axis X, Y, Z, and C (cylindrical axis).
- Cycle start
- Probe
- E-Stop
- Hardware Pause

3. Here is a circuit of all the outputs:



The controller is equipped with output line drivers IC's ACT541.

Each line is capable of **sourcing or sinking 20 milliamps**. This makes it very nice to directly connect to step motor drivers. An output can connect directly to a solid state relay for controlling the heavy load.

The output connections are;

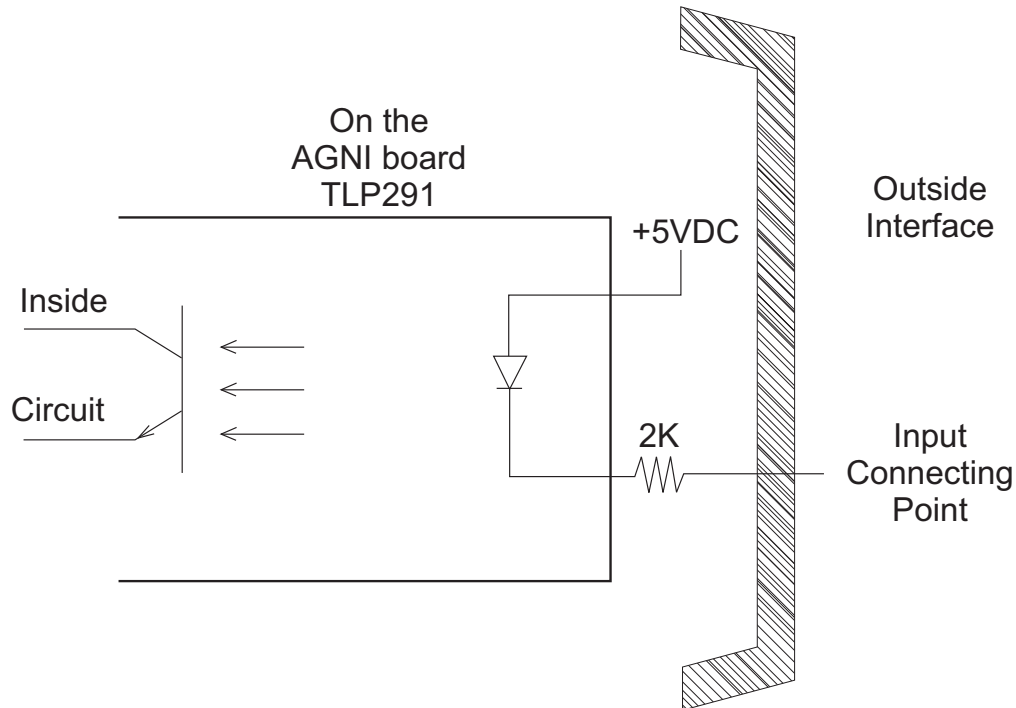
Step X, Y, Z, A, B, and C

Direction X, Y, Z, A, B, and C

Output 1, 2, 3, 4, 5, 6, 7, and PWM

Both, ground as well as 5 VDC output pins are made available along with step and direction commands for the step motor drivers. Step motor drivers may require either ground pin or 5 VDC pin for completing the circuit.

4. Here is a circuit of all the inputs:

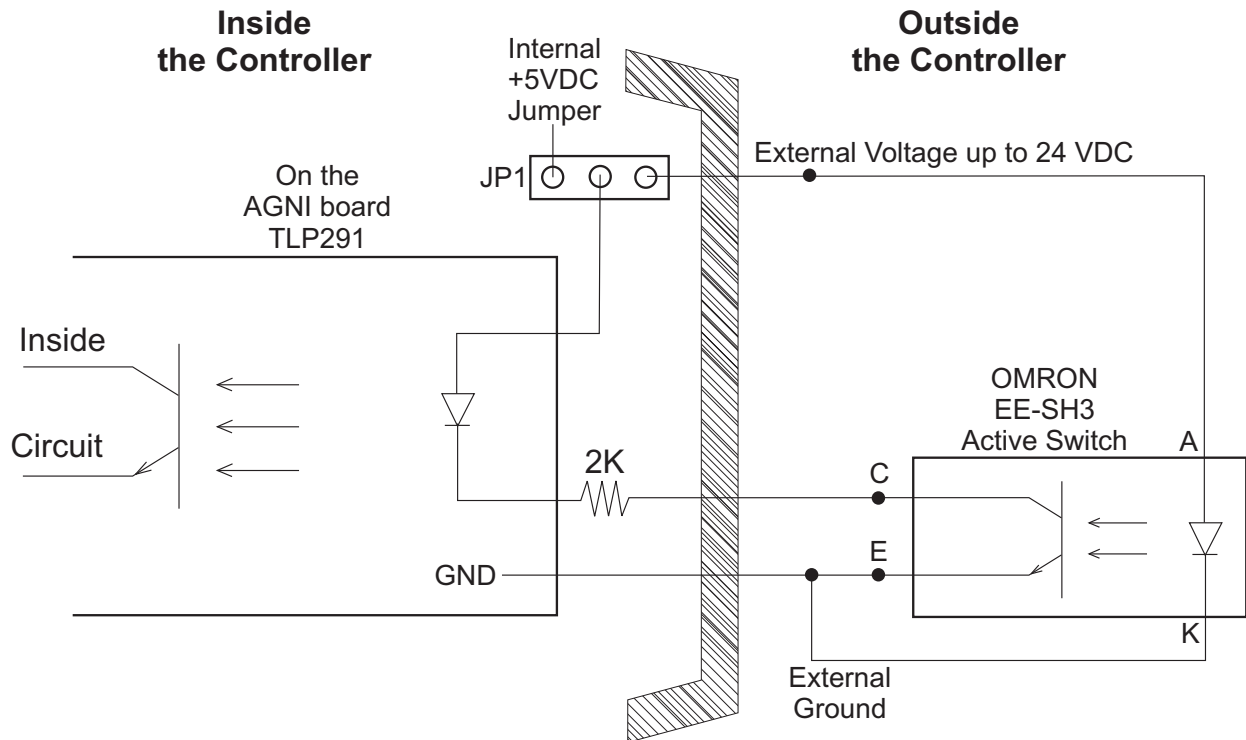


All the inputs are optically isolated with a 2K resistor to limit the current flowing through the diode. Each of the inputs is equipped with the above circuit.

Note that the optoisolator part of the circuit is equipped with its own internal 5 VDC. The outside connections require a signal and a reference ground line. This is totally adequate for either passive Home/Limit switches or active switches that require 5 VDC to operate.

Here is the cool part. If the machine is equipped with active Home/Limit switches that require and use higher than 5 VDC, switch the position of jumper JP1. Apply the appropriate voltage to the optional input power switch at the top left pin on the input side of the connections and its associated ground line to the next pin. The same voltage will be applied to the Home/Limit switch circuit with optoisolation for proper operation. Most of the popular active switches work anywhere from 5 VDC to 24 VDC. **It is important to note that the Optional Input Voltage for Home/Limit switches shall be limited to 24 VDC. Higher voltage may damage the circuits on the controller board.**

To further illustrate a possible circuit connection using an active switch, we studied and created a circuit for an Omron EE-SH3 active switch. Here is a possible circuit:



**It is important to understand that the AGNI controller board contains sensitive electronic circuits. Proper care must be taken to handle the controller board. It is recommended that the person handling and/or wiring the AGNI controller shall use the ground strap and necessary precautions to keep the static voltage away from the controller. Static electricity can easily damage the controller.**

### E-Stop Switch settings:

1. By default, the LinkMotion software is shipped with E-Stop sensing disabled with an entry in the LinkMotion.INI file.  
To change the default, search for the line EStop=-1 in the section of the INI file matching the name of the machine you selected when installing.  
EStop=-1 disables the function.  
EStop=0 enables the emergency stop function for a normally open E-Stop switch.  
EStop=1 enables the emergency stop function for a normally closed E-Stop switch.
2. On sensing a signal on the E-Stop line, the controller will halt any motion in progress, display a message on the PC screen, and terminate any profile that is running on the controller. You will need to reset and restart LinkMotion and then prepare and send the job again.

Laser machines have many safety switches to make sure that all the doors of the cabinets are closed before the laser power turns ON. All of these safety switches must be connected to the E-Stop pin of the controller.

If all switches are normally closed, the switches must be connected in series. Any switch activated will break the circuit and the E-Stop line will become active, stopping laser operations.



If all switches are normally open, the switches need to be connected in parallel. Any switch activated will close the circuit and the E-Stop line will become active, stopping laser operations.

3. There is one jumper on the board. The sensing voltage for the home switches and E-Stop are normally limited to +5 VDC (TTL logic). The controller requires only +5 VDC for its operations. However, home switch sensing may need a voltage higher than +5 VDC.

An external voltage is required for switches that are designed to use higher than 5 VDC. In no case, higher than 24 VDC shall be applied.

The jumper needs repositioning in addition to applying the external voltage for higher voltage.

The jumper position is normally set to the two pins away from the connector 2. For using higher voltages, move the jumper to the pins closest to the DB-25, connector 2. The higher voltage shall be connected to pin 13 on connector 2. The return or the ground for the higher voltage shall be connected to any of the ground lines on connector 2, pin 14-23.

4. There is one jumper on the Agni controller. The jumper is the tallest component of the controller board. When the jumper is in place Agni takes its power from the USB port of the PC. If it is required to provide external power connect it to the +5 VDC power connector on the breakout board, the jumper should be removed before powering the controller. It is very important to make sure that the Agni controller is not powered from both sources: the USB port of a PC and the external +5 VDC power supply.

5. Many Chinese laser tube power supplies accept linear as well as PWM input for power control. Agni generates PWM commands. Please refer to the last part of this document for proper connection details for laser power. The title of this part is – Ways to connect the Chinese CO2 glass tube power supply and Agni controller.

### **Explanation of the important feature of generating power directly from the Control Pad while depressing the I/O 1 key for testing purposes only.**

To generate and check out the operation of the laser tube, LinkMotion allows generation of PWM when the Laser key (I/O 1) is depressed. The key is protected with a latch to prevent generation of power by mistake. LinkMotion is organized with the concern for safety such that along with the PWM, it is necessary to generate proper logic level on pin 1 of connector 3 to enable the power supply.

### **Following procedure explains how to test for laser power using LinkMotion for Co2**

#### **Laser:**

1. Check the Enable Laser box in the Machine Properties tab.
2. Select the power level of your choice (1 to 100 percent) against the black color in the Materials Properties tab. For this testing purpose, the maximum power value selected in the Materials Properties Tab is ignored.
3. Hold down the I/O 1 key in the Control Pad
4. Click on the OK button with an arrow of your mouse to Unlock the latch when asked.
5. The power will be generated as long as you hold down the I/O 1 key.
6. The power will be shut off as soon as you take the finger off the key.

**This section will be updated continuously as we get the reports of Agni connecting to various old and new Laser machines:**

**List of Laser Machines upgraded with AGNI Controller:**

**Emission Technology Laser Machine**

**GCC Laser Machine**

**Leetro 6515/6535 Controllers**

**Model K40 12x8 Shenhui**

**Planes Mart Laser**

**Trotec Laser Machine**

Please contact Solustan for more information for upgrading your laser machine.

**Upgrade Leetro 6515/6535 Controllers:**

1. Agni controller is used for replacing the Leetro 6515/6535 controllers. Leetro controllers are equipped with connectors where the bare wires, after removing the insulation, are inserted into the connectors and are tightened using screws. The breakout board for the Agni controller is equipped with DB-25 style female connectors. Matching male connectors are required to connect the laser machine wiring into the Agni controller. These connectors are commonly available all over the world. They are reliable, easily available, and inexpensive. Simple tools are required to prepare the connectors.
2. For the OEM manufacturer of laser machine, it is easy to prepare the cable harnesses with male DB-25 connectors for a reliable and error-free assembly. It is also easy to connect and disconnect the controllers from the machine.
3. Agni controller does not need 24 VDC power supply. Agni controller's default configuration is to be powered from the USB port of a PC using +5 VDC. It can easily be reconfigured to receive the power from externally supplied +5 VDC.
4. You may have up to 4 step motor drivers for the X, Y, Z, and cylindrical axis. The step motor drivers need a step (pulse), direction, and either +5 VDC or ground connections.

For X axis location, find location Y5 on 6515 and X axis location on 6535 controller. Transfer connection as follows:

<b>Connector 1 on AGNI-I</b>	<b>AGNI-IIP or II</b>	<b>Signal</b>	<b>6515/6535 controller</b>
Pin 1	STP X	Step/Pulse	Pin 1
Pin 2	DIR X	Direction	Pin 2
Pin 13	(5V If required)	+5 VDC (If required)	Pin 3
Pin 14 – 25	(GND If required)	Ground (If required)	Pin 4

For Y axis location, find location Y4 on 6515 and Y axis location on 6535 controller. Transfer connection as follows:

<b>Connector 1 on AGNI-I</b>	<b>AGNI-IIP or II</b>	<b>Signal</b>	<b>6515/6535 controller</b>
Pin 1	STP X	Step/Pulse	Pin 1
Pin 2	DIR X	Direction	Pin 2
Pin 13	(5V If required)	+5 VDC (If required)	Pin 3
Pin 14 – 25	(GND If required)	Ground (If required)	Pin 4

For Z axis location, find location Y3 on 6515 and Z axis location on 6535 controller. Transfer connection as follows:

<b>Connector 1 on AGNI-I</b>	<b>AGNI-IIP or II</b>	<b>Signal</b>	<b>6515/6535 controller</b>
Pin 1	STP X	Step/Pulse	Pin 1
Pin 2	DIR X	Direction	Pin 2
Pin 13	(5V If required)	+5 VDC (If required)	Pin 3
Pin 14 – 25	(GND If required)	Ground (If required)	Pin 4

For cylindrical axis location, find location (?) on 6515 and on 6535 controller. Transfer connection as follows:

<b>Connector 1 on AGNI-I</b>	<b>AGNI-IIP or II</b>	<b>Signal</b>	<b>6515/6535 controller</b>
Pin 11	STP C or STP CYL	Step/Pulse	Pin 1
Pin 12	DIR C or DIR CYL	Direction	Pin 2
Pin 13	(5V If required)	+5 VDC (If required)	Pin 3
Pin 14 – 25	(GND If required)	Ground (If required)	Pin 4

- Many machines have Limit switches at both ends of the axis in all three axes. LinkMotion treats Limit switches as Home switches to find a Home position.

If the user is going to always have a specific location as the home position, only relevant switches can be wired into the Agni controller to bring the machine to the home position. An example would be as follows:

Many Leetro 6515 controller based laser machines use top right as the starting position. In this case, the limit switch that may activate in the X-axis when the X-axis moves to the right-hand side of the working area as well as the limit switch that may activate in the Y axis when the Y axis moves to the top side of the working area only need to be connected to the X and Y axis home pins on the Connector 2 of the Agni controller.

If on the other hand, it is required to change the home position, LinkMotion will allow the change in the configuration. In such a case, both the limit switches on either side of the axis should be connected to the Agni controller for the Home position sensing. Typically, if the switches have normally open configuration, they should be connected in a parallel configuration. However, if the switches have normally closed configuration, they should be connected in series before bringing the connections to the Agni controller.

Agni controller is equipped to handle passive type or active type switches if it requires only +5 VDC. The controller does not need external voltage if the limit switches are workable from +5 VDC.

Manufacturers may use active switches that may require +12 or +15 or +24 VDC for proper operation. In this case, it is necessary to apply an external voltage to the Agni controller only for the purpose of handling the limit switches. Transfer the wires from 6515/6535 to Agni as follows:

For X axis limit switch, find location X5 on 6515 and X-axis location on 6535 controllers. Transfer connection as follows:

<b>Connector 2 on AGNI-I</b>	<b>AGNI-IIP or II</b>	<b>Signal</b>	<b>6515/6535 controller</b>
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Pin 7	HOME X	X Home	Pin 3
Pin 14 – 23	GND	Ground	Pin 4

For Y axis location, find location X4 on 6515 and Y axis location on 6535 controller. Transfer connection as follows:

<b>Connector 2 on AGNI-I</b>	<b>AGNI-IIP or II</b>	<b>Signal</b>	<b>6515/6535 controller</b>
Pin 8	HOME Y	Y Home	Pin 3
Pin 14 – 23	GND	Ground	Pin 4

For Z axis location, find location X3 on 6515 and Z axis location on 6535 controller. Transfer connection as follows:

<b>Connector 2 on AGNI-I</b>	<b>AGNI-IIP or II</b>	<b>Signal</b>	<b>6515/6535 controller</b>
Pin 9	HOME Z	Z Home	Pin 3
Pin 14 – 23	GND	Ground	Pin 4

For external power for home switches, if higher than +5 VDC, bring the appropriate voltage by switching jumper and connect as follows:

<b>Connector 2 on AGNI-I</b>	<b>AGNI-IIP or II</b>	<b>Signal</b>	<b>6515/6535 controller</b>
Pin 13	OPT INPUT SW	PWR	External voltage
Pin 14 – 23	GND	Ground	

There are a jumper JP1 on the Leetro 6515 controller. The position of the jumper will indicate the type of voltage required for the configuration. If Pin 1 and Pin 2 of the jumper are connected, the Home switch configuration requires 24 VDC. If Pin2 and Pin 3 of the jumper are connected, the Home switch configuration requires 5 VDC. If, however, the jumper is removed, the home switches are not connected to the system.

6. Other important PWM connections for AGNI-I:  
(AGNI-IIP and II has PWM and GND shown on the board)

<b>Connector 3 on AGNI-I</b>	<b>Signal</b>	<b>Typical Co2 Laser Power Supply</b>
Pin 9	PWM power	Pin 6 (H or HL)
Pin 14 – 25	Ground	Pin 3 (GND.)
		Connect Pin 1(5VDC) to Pin 2 (IN)
		The water flow sensing and safety
		Switches sensing on Pin 4 (P or WP)
		Shall be preserved.

- A. PWM connection for laser power control – PWM is a lot more accurate than the analog power control. However, the laser power source should be capable of accepting the PWM pulses. PWM stands for Pulse Width Modulation. Agni also generates a Tickle pulse on the same connection. Many laser power sources require tickle pulse when the power is applied to the machine but no job processing is taking place. The tickle pulse is specified by the manufacturer of the laser tube. Typically, the specification of the tickle pulse calls for a narrow width of a pulse at a particular frequency (e.g. 1-microsecond pulse at 5000 Hz). The pulses should be wide enough to keep the laser tube in a ready state in order to fire almost instantaneously. However, the pulse should be narrow enough not to generate any power.

There is a jumper JP2 on the Leetro 6515 controller. If the jumper is removed, the laser system is configured for analog laser power control. On the other hand, if the jumper is present, the laser machine is configured for PWM for power control.

For PWM power control of the laser, find location Y2 on 6515 and appropriate location on 6535 controllers. For proper connections, please, refer to the last part of this document - Ways to connect the Chinese CO2 glass tube power supply and Agni controller.

- B. The e-stop connection is available at Pin 2, Connector 2 on AGNI-I and ESTOP for AGNI-IIP or II along with ground if required. All of the safety switches that require pausing of laser operations can be wired through the E-Stop connection. Safety switches for door locks and other protections from laser radiation can be wired for E-Stop. It is best to use all of the switches in normally open or all of them in normally closed configuration. Proper wiring (serial or parallel) will guarantee that tripping of any of the switches will shut down the laser power generation and pause the motor motion operations. E-Stop can be configured for non-presence or normally high or normally low positions.

Whenever the E-Stop switch is activated, LinkMotion will present a message on the PC screen while shutting down the Laser operations. E-Stop is considered to be a serious enough problem where LinkMotion simply kills the job. The user is required to reset the material and restart the job.

- C. The explanation for the remaining connections on Connector 2 on AGNI-I or AGNI-IIP or II. Solustan will make available I2C serial communication protocol on pins 24 and 25 of the Connector 2 of AGNI-I or GND, DATA, and CLK on AGNI-IIP or II. When available, the machine can also be equipped physical Control Pad in addition to the PC based Control Pad. The Laser machine based Control Pad is likely to have following sets of commands:
- Pause
  - E-Stop
  - Cycle start/Repeat
  - Commands for jogging, seeking Home, controlling I/O's, etc.
  - Starting an SD memory card resident job
  - Yellow, Red, and Blue LED's for the feedback on Controller operations
- D. There are four I/O's present on Connector 3 of AGNI-I and 7 outputs on AGNI-IIP and II. These are;
- On/Off Laser power
  - Red Pointer
  - Water Control
  - Positive air pressure control for the lens assembly

All laser machines do not have On/Off controls for the laser. Generally, PWM controls the generation of power. However, there are designs out there that need a command to open the shutter for the lens or other safety measures that may require a logic level present throughout the duration of the laser operation. This is where On/Off output comes in handy. It can also be used if a warning light needed to be turned ON while a laser operation is taking place. It is important to note that the laser power will be turned off in between processing shapes. Whenever laser power is Off, the signal will also change its logic level.

Red Pointer does the same thing as the laser on/off output for the red pointer diode.

The Chinese glass tubes require water cooling. This output, when checked, will change the logic level when the job starts and will reset to the original logic level when the job is complete.

Many lenses used for focusing the laser beam are housed inside an assembly with a small opening at the lowest end. This is designed to repel the dirt and dust from clogging up the lens. A slight film of dust could rob significant power of the focused laser beam. Newer assemblies are also designed with a small positive air pressure to further repel the dust particles. This output can be connected to the generation of the positive air pressure. This output, when checked, will change the logic level when the job starts and will reset to the original logic level when the job is complete.

## **What are the ways to connect and control the laser power output from a Chinese CO2 glass tube using AGNI controller?**

Most Chinese CO2 laser tubes come with appropriate power supplies. Generally, the power supply is designed to generate very high voltages for relatively small currents required to generate the laser power.

Agni controller provides the following control points for connecting to the laser power supplies.

1. On/Off laser power
2. PWM controls and generation
3. Signal ground connections

The typical laser power units have the following connection points:

1. 5 VDC out
2. IN – Analog power levels from 0 to 5 VDC for 0 to 100 percent power. It will also accept PWM (pulse width modulated string of pulses at a selected frequency) and will convert to an analog signal with a simple RC circuit.
3. G – Ground connection
4. P or WP – Water sensing and other protections like open doors can be connected to this pin. If anything is not proper like water is not present or a lid is open, the laser will not fire.
5. L or TL – Logic Lo on this pin will allow the power to be generated.
6. H or TH – Logic Hi on this pin will allow the laser power to be generated.

Here is the preferred way to connect the Agni controller to the glass tube power supply to generate the power most appropriately:

- A. First of all, the P or WP line is not controlled by Agni. It is connected directly to the water pressure sensor, lids, and other safety situations. This is somewhat akin to Emergency Stop controls on CNC machines. One can connect E-Stop switch also into this location and in series with all the



other safety measures. If anyone of them is false, no power will be generated by the laser tube. In other words, the laser tube shall not generate power if the water cooling is not present. Without the water cooling, the glass tube will be destroyed in a hurry.

- B. B. Only, either H (HL) or L (TL) line is required to be used. Either L to be low or H to be high can be used for the power to be generated. If either one is not true, no power will be generated by the laser tube.

This brings us to suggest ways to connect the Agni controller to the laser power supply unit.

### **Steps:**

1. Connect a jumper from +5 VDC out connection on the laser power supply to IN connection. Both connections are next to each other on the laser power supply module. This guarantees full power level at +5 VDC.
2. Connect a ground wire from the Agni controller to the G (ground pin) on the laser power supply.
3. Connect PWM line from the Agni controller to H (HL) connection. The frequency of the pulses and the width of each pulse will determine the power ON time for the selected frequency. The H line will modulate the full power by turning it off and on many times in a second. The average power will be determined by the width of the pulse. Different frequency will generate a different intensity of the laser power beam to allow it to affect the material properly and for a proper job.
4. Although the On/Off laser power line is not connected to the laser power supply unit, it is still functional. If Enable Laser in the Material Properties Tab is not checked in the user interface, it will not generate power and will act as an additional safety measure.

### **Advantages are:**

Modulating the laser power at appropriate frequencies tend to generate sharper power peaks and may do a better job on the material at relatively lower power curves. Many materials react differently to different frequencies. This setting allows actual varying of the frequencies for the material. Also, this is possible while using the standard Chinese glass laser tubes and accompanying power supplies.

As always, please, provide us the feedback. Getting feedback from actual users is the best way for us to continue to improve our products.