FLASHCUT CNC

CONTROL MADE SIMPLE

®

USB
I/O Expansion Board
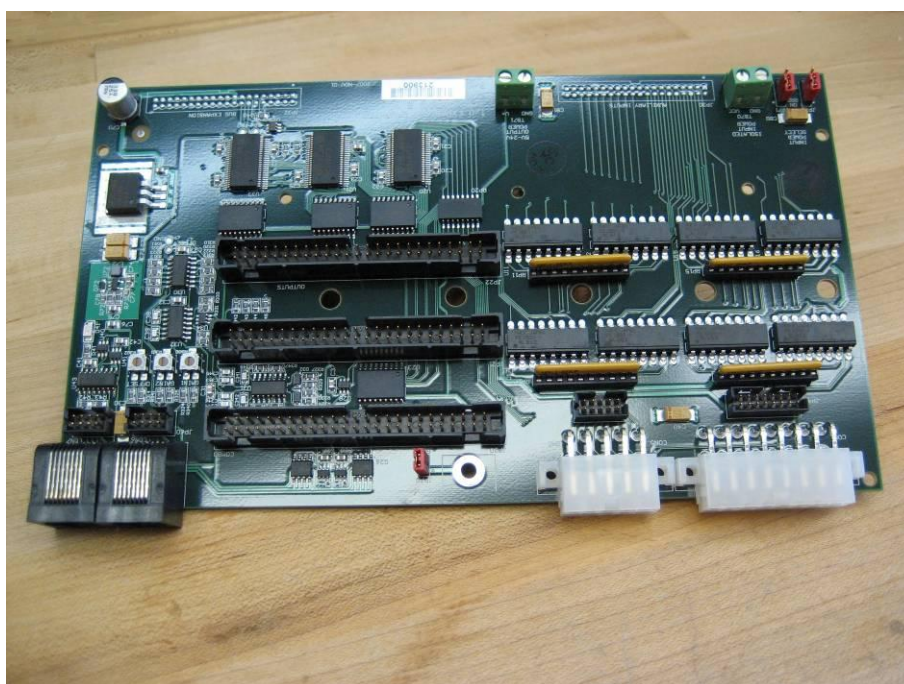
Table of Contents

1. USB I/O Expansion Board Upgrade Kit

Thank you for purchasing the FlashCut CNC USB I/O Expansion Board.

For this device to function with your current control system, you must have the following:

1. Signal Generator with serial number 212xxx or later

2. FlashCut CNC Software Version 3.0.13 or later

Kit Contents

If you are upgrading an existing Signal Generator unit, the USB I/O Expansion board upgrade kit includes the following items, shown in Figure 1:

1.   (1) USB I/O Expansion Board

2. (3) 7/8" Plastic Standoffs

3. (6) 1/4" 4-40 Pan Screws

4. (2) 1/4" 6-32 Pan Screws

5. (1) Right angle mounting bracket with 6-32 holes

6. (1) Aluminum Rear Panel with USB I/O Expansion Board cutouts

Connectors for each of the board's input and output receptacles are not included but may be purchased separately in a USB I/O Adapter Kit.
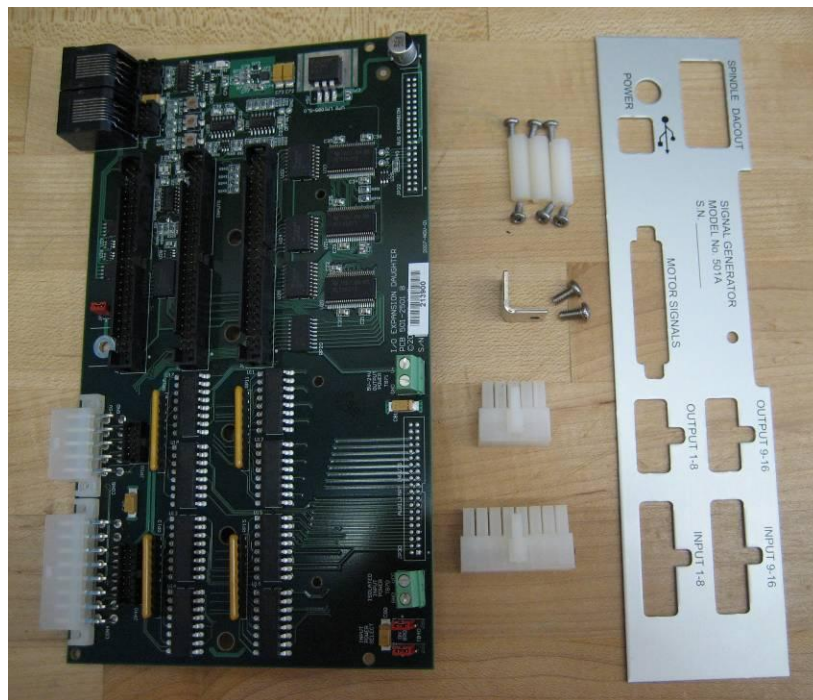

Figure 1: Contents of I/O Expansion Board Upgrade Kit

Installation of the USB I/O Expansion Board

1. Remove the four screws from the bottom of your signal generator enclosure and lift off the top cover of the signal generator.

2. Unplug the white connector from the plug labeled "POWER" on the circuit board.

3. Remove the five 4-40x1/4" screws that fasten the circuit board to the case.
   Note: If there are six screws in place, the switch itself must be carefully removed. Unplug the quick connects and use a channel lock to push down both the top and bottom of the switch so that it may be removed. Now the sixth screw may also be removed.

4. Carefully remove the circuit board as well as the front and rear panels from the remaining enclosure bottom.

5. Remove the power jack assembly from the old rear panel of the signal generator. Take note of the arrangement of the washers and nuts – the phenolic washer is on the inside of the panel, and the shoulder washer, washer, and nut are on the outside of the panel.

6. Install the power jack assembly onto the new rear panel in the exact manner that it was installed on the old rear panel. **Note: It is very important that the plastic shoulder washer and phenolic washer prohibit the power jack from making electrical contact with the rear panel.**

7. Use three 4-40x1/4" screws to attach the three standoffs to the three holes in the middle of the host board so that the standoffs are securely perpendicular to the board.
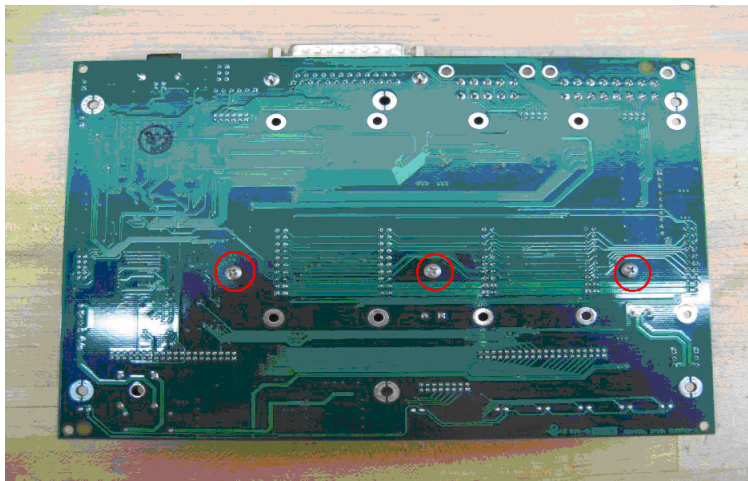

Figure 2: Side view(upper) and bottom view(lower) of Signal Generator host board showing three vertical standoffs (upper) and three mount screws in place (lower) .

8. Slide the main signal generator board, aluminum Front Panel, and new aluminum Rear Panel into the bottom of the case.

9. Secure the signal generator board to the bottom of the enclosure using the five 4-40x1/4" pan screws that were removed earlier.
    Note: If there were originally six screws, screw in only five, leaving out the screw by the switch. Put the switch back into the Front Panel so that the pins are on the bottom.

10. Plug the white connector from the switch and power jack assemblies back into the plug labeled "POWER".

11. Use one 6-32 pan screw to attach the right angle bracket to the USB I/O Expansion through the gold-rimmed hole near the "COMBO" label so that the screw faces upwards and the sides of the right angle bracket are parallel to the board and outward facing.

12. Carefully place the USB I/O Expansion Board onto the standoffs from step 7. Make sure that the male pins on headers JP30 and JP32 line up properly with the female receptacles on the bottom of the expansion board and that the plastic standoffs mate properly with the corresponding holes on the expansion board.

13. Plug female headers JP30 and JP32 of the USB I/O Expansion Board into the male headers JP30 and JP32 (respectively) of the signal generator board.

14. Use the remaining (3) 4-40 screws to attach the USB I/O Expansion board to the standoffs protruding from the main circuit board.
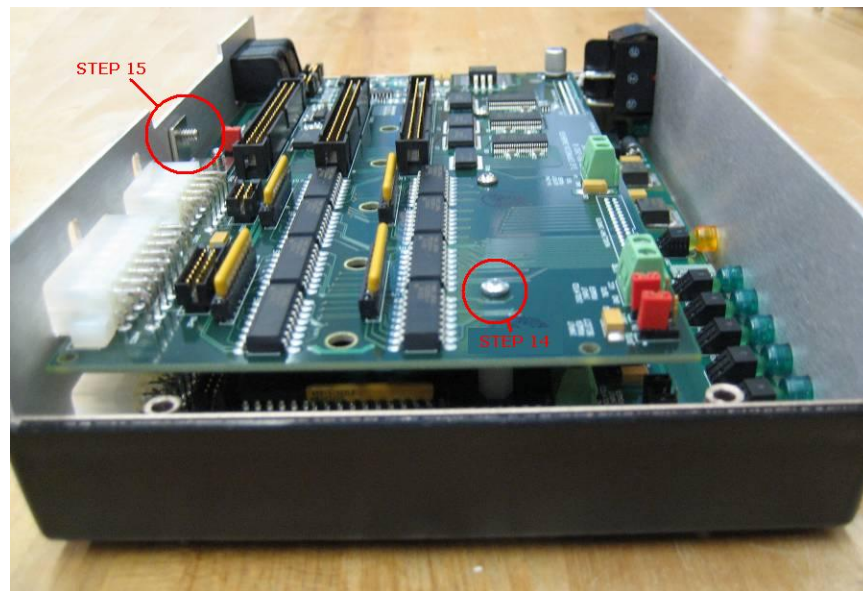

Figure 3: Side view of board in Signal Generator case showing installation steps 14 & 15.

15. Use the remaining 6-32 screw to attach the right angle bracket to the new rear panel.

16. Replace the top half of the plastic case and secure with the 4 enclosure screws.

17. You have now completed the installation process.

2. **Connectors & Capabilities**

The addition of the USB I/O Expansion Boards adds connectors and capabilities to the signal generator unit. These capabilities include 32 input and 32 output lines, 2 analog output voltages for spindle speed control or other level control functions, 2 analog inputs for sampling continuous voltage levels and 1 channel of spindle speed monitoring using single ended or differential quadrature encoders.

Rear Panel

A new rear panel is provided with the kit to replace the standard signal generator rear panel. The new panel allows external access to four of the connectors on the USB I/O Expansion Board as shown in Figure 4 below.
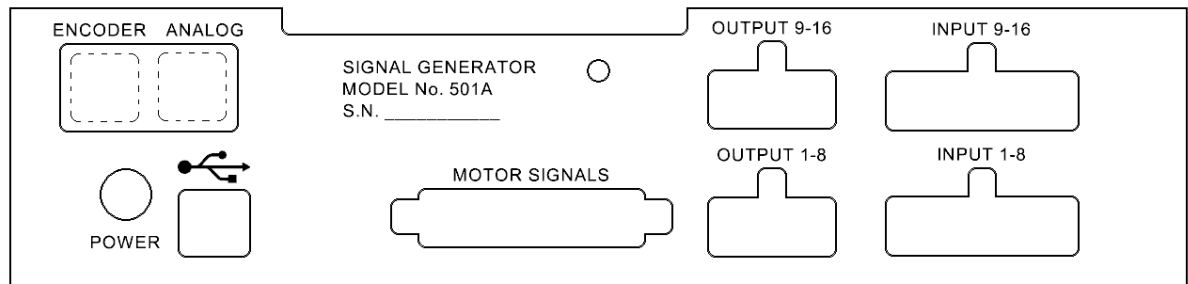
Figure 4: USB I/O Expansion Board Rear Panel

External Connectors

The USB I/O Expansion Board provides four additional connectors to the rear panel of the signal generator as shown in Figure 4. The new connectors are labeled "INPUT 9-16", "OUTPUT 9-16", "ENCODER" and "ANALOG". Each one is described below.

Input Lines 9-16

This connector carries eight input lines, representing logical inputs 9-16 in the FlashCut CNC software. The most common use of the input lines is for limit or safety switches. These lines are all TTL and CMOS compatible and are optically-isolated. When a switch is open, its input signal is high (+5V). When the switch is closed, its input signal is grounded low (0V).

Figure 5: External Input connector pinout
as viewed from rear of Signal Generator.

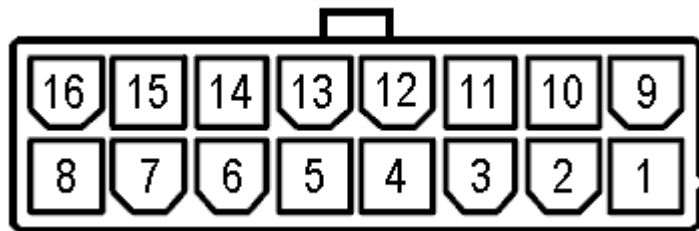The input connector pinout is shown in Figure 5 and the associated pin assignments are presented in Table 1. The "OPT-GND" label refers to optically isolated ground the isolation of which depends on the state of jumpers JP71 and JP72 as described later in this section.

Table 1: External Input Connector Pin Functions

Mini-Fit Jr. Pin No.	Signal	Mini-Fit Jr. Pin No.	Signal
1	OPT-GND	9	INPUT 9
2	OPT-GND	10	INPUT 10
3	OPT-GND	11	INPUT 11
4	OPT-GND	12	INPUT 12
5	OPT-GND	13	INPUT 13
6	OPT-GND	14	INPUT 14
7	OPT-GND	15	INPUT 15
8	OPT-GND	16	INPUT 16

The default setting for each of the input lines is normally closed (NC). Using the FlashCut CNC Software, each input line may be configured for normally closed (NC) or normally open (NO) operation.   Please refer to the "Input Line Settings" section of the FlashCut CNC Software User's Guide for additional information.

In the FlashCut CNC software, the Input Line Status dialog displays "OPEN" for a high-level input voltage, or open switch, and "CLOSED" for a low-level input voltage or closed switch.

The input lines are optically isolated. Jumpers JP71 and JP72 select the power source for the input circuitry to be the internal power of the Signal Generator or isolated power from an external source. Both jumpers must short the same pair of pins; both must be on pins 1 and 2 or both must be on pins 2 and 3.

Internal Power is the most convenient option and it works well for most applications but it bypasses the signal isolation. When JP71 & JP72 are shorted on pins 1-2, the internal VCC and GND circuits, respectively, are connected to the input circuitry. The USB I/O Expansion Board is shipped with this jumper configuration.

For External Isolated Power and the best noise immunity, short pins 2-3 on JP71 and on JP72 and connect an external 5V-24V power supply to TB70 to provide power to the isolated input circuitry. When JP71 & JP72 are shorted on pins 2-3, the input circuitry is powered by the supply connected to the terminals of TB70 and OPT-VCC and OPT-GND remain isolated from the internal power supply, VCC and GND.

BE VERY CAREFUL WHEN DOING ANY WIRING. IMPROPER WIRING WILL DAMAGE THE SIGNAL GENERATOR.

For information regarding input lines 1-8, please consult the Signal Generator Hardware Guide.

Output Lines 9-16

This connector provides eight output lines, representing logical output lines 9-16 in the FlashCut CNC software. These ACT family logic lines will drive TTL/CMOS level inputs

on external circuitry. The output lines will not drive a 24V external system unless it accepts TTL/CMOS levels. Output logic high is normally 5V and can droop as low as 4.3V under full load. Output logic low is normally 0V and can rise as high as 0.4V under full load. Each of the output drivers can provide up to 24mA of current. The output lines are initialized to logic low (0V) when the Signal Generator is powered up.
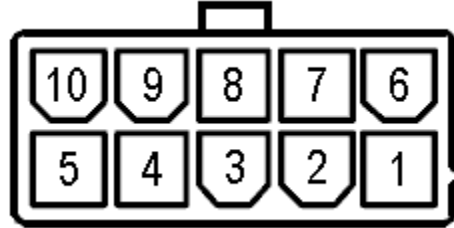

Figure 6: External Output connector pinout
as viewed from rear of Signal Generator.

The output connector pinout as seen from the rear of the Signal Generator is shown in Figure 6 and the associated pin assignments are presented in Table 2.

Table 2: External Output Connector Pin Functions

Mini-Fit Jr. Pin No.	Signal	Mini-Fit Jr. Pin No.	Signal
1	OUTPUT 9	6	OUTPUT 10
2	OUTPUT 11	7	OUTPUT 12
3	OUTPUT 13	8	OUTPUT 14
4	OUTPUT 15	9	OUTPUT 16
5	+5V (VCC)	10	GROUND

Two additional pins on this connector are provided for your output lines: ground and +5V. These are connected to the GND and +5V rails on the USB I/O Expansion Board and are not optically isolated. This 5V circuit can source up to 100 mA. Any larger current demand would require a larger power source.

BE VERY CAREFUL WHEN DOING ANY WIRING. IMPROPER WIRING WILL DAMAGE THE SIGNAL GENERATOR.

For information regarding output lines 1-8, please consult the Signal Generator Hardware guide.

Analog Output ("ANALOG" in Figure 4)

The analog output connector is used primarily for spindle control. Signals provided here include SPON and SPDIR digital outputs that are logically equivalent to outputs 9 and 10, respectively, and two channels of analog 0-10V output.

The analog outputs on this 8-Pin RJ-45 connector are often used to control a variable frequency drive (VFD) or a variable speed spindle.   The connector will accept any standard CAT-5 cable connector (RJ-45 Ethernet plug, 8 position/8 pin).

The analog output connector, as seen from the rear of the signal generator, is arranged as shown in Table 3. The pin orientation is shown in Figure 7 to the right.

Table 3: Analog Output Connector
Pin Functions

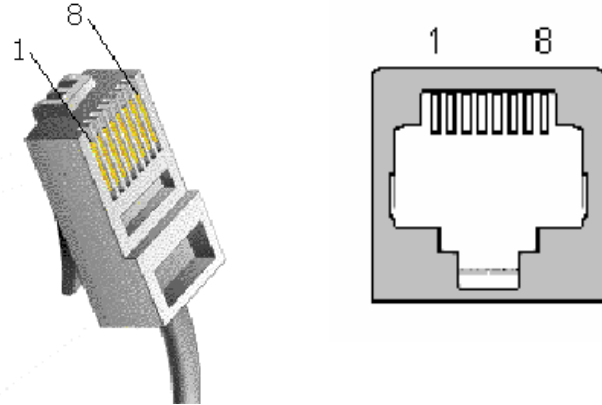| RJ-45 Pin No.	Signal
1	+12V
2	SPON (Output 9)
3	GND
4	SPDIR (Output 10)
5	5-24V Input
6	DACOUT0
7	GND
8	DACOUT1

Figure 7: terminated CAT-5 cable and
RJ-45 jack showing pin orientation.

Pin 1 is a +12V output that can be used as a reference voltage for the analog output circuit as discussed below. This pin can source up to 20 mA. Any larger current demand would require a separate external power source.

Pins 2, 3, 4, and 5 represent two push-pull output circuits. The external voltage applied at the 5-24 V input on Pin 5 will be delivered to the SPON and SPDIR pins when each is activated. This external voltage can also be applied at TB71. For example, Pin 5 can be supplied +24V in order to deliver +24V from SPON when Output 9 is activated in the FlashCut CNC software. The SPON (Output 9) and SPDIR (Output 10) of the RJ-45 connector are logically identical to Output 9 and Output 10 on the 10-pin Molex connector. The SPON and SPDIR outputs can each handle up to 250 mA.

Pins 6, 7, and 8 express the two 12-bit analog output channels. These circuits are able to deliver 0 – 10V DC divided over 4,096 (2^{12}) levels approximately 2.5mV apart. They are typically used to control spindle speed or other devices that require a variable voltage input. The analog output circuitry can be calibrated using the OFFSET and GAIN potentiometers on the USB I/O Expansion Board. See "Calibrating the Analog Output" for a detailed procedure on calibration.

To facilitate external wiring, an 8-pin breakout box may be obtained from Radio Shack (p/n 279-411). See figure 8. The box has a screw terminal for each of the eight pins. The part may be purchased online at www.radioshack.com. A standard CAT-5 drop cable can be used to connect the 279-411 to the USB I/O Expansion Board.

Figure 8: Radio Shack 279-411

Spindle Feedback Control ("ENCODER" in Figure 4)

This 8-Pin RJ-45 Connector is used for spindle encoder input, most commonly as spindle speed feedback to read the spindle speed in real time and to control threading operations on CNC lathes. A CAT-5 cable connector (standard Ethernet drop cable) will plug into this receptacle. For your convenience during the wiring process, you may choose to purchase an 8-pin wiring block from Radio Shack (p/n 279-411) as described in the Analog Output section. This device provides break-out screw terminals for all 8 pins and it can be obtained from www.radioshack.com.

The spindle encoder inputs A, B and INDEX may be single-ended or differential and they may be connected to single channel or quadrature encoders. The index pulse is not absolutely necessary, but it comes in handy if you have to re-start a thread already in progress or if you have a high-resolution encoder and a high spindle speed.

The encoder signal requirements are as follows:

1. TTL Level Signals (0, 5V) for each channel

2. Single ended (A) or differential signals (A+ and A-) acceptable.

3. Single channel (A) or 2 channel (A+B Quadrature) acceptable.

4. Index pulse accepted, but not required

5. 16 to 2048 CPR (contact FlashCut for support using encoders under 100 CPR)

Table 4 shows the pin assignments for this connector and Figure 9 at right shows the pin orientation.

*Table 4: Spindle Feedback/Control
Connector Pin Functions*

RJ-45 Pin No.	Signal
1	CH A-
2	CH A+
3	CH B-
4	CH B+
5	+5V
6	INDEX+
7	GND
8	INDEX-
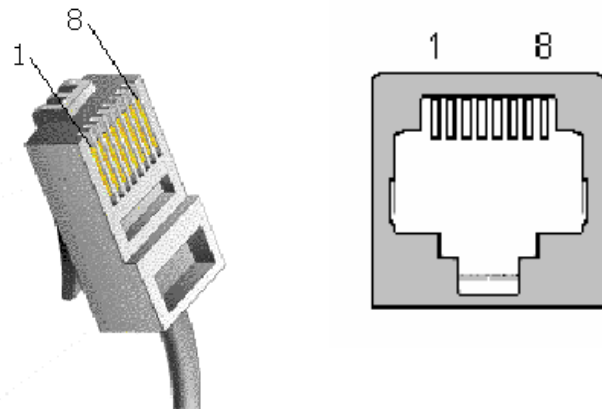
*Figure 9: terminated CAT-5 cable and
RJ-45 jack showing pin orientation.*

Figure 10 shows a plan view of the USB I/O Expansion Board with the external connectors highlighted. Note that there are two RJ-45 connectors on the USB I/O Expansion Board that are used for two different purposes.
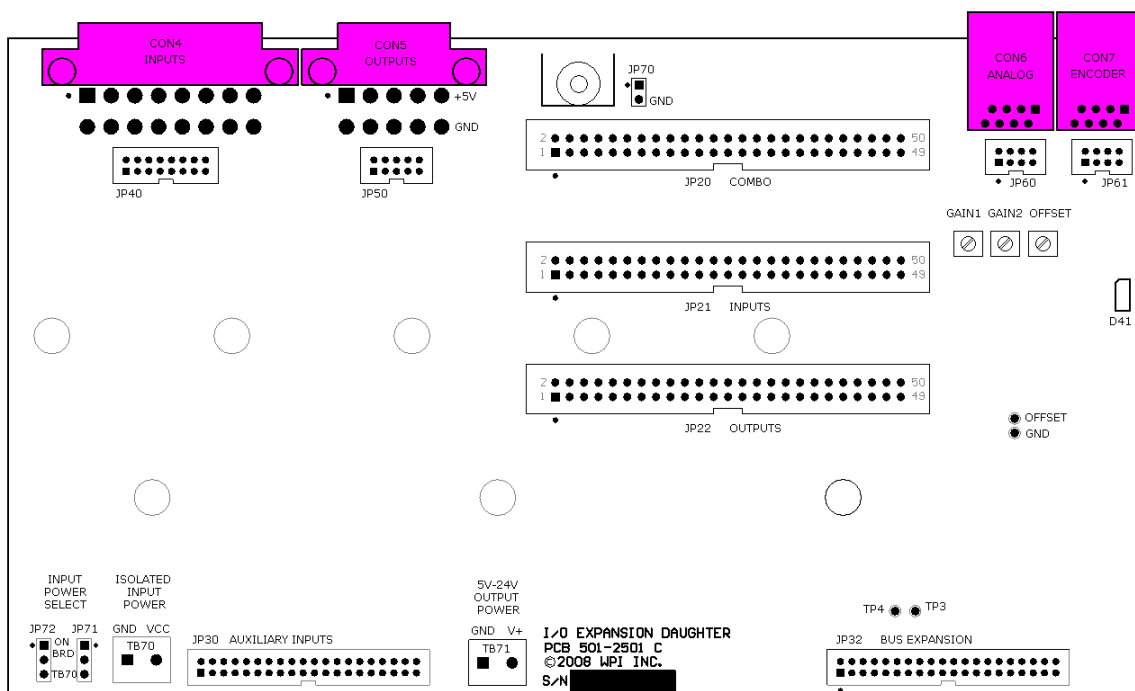
Figure 10: I/O Expansion Board plan view with external connectors highlighted.

Internal Connectors

The USB I/O Expansion Board adds eleven internal connectors to the signal generator system as highlighted in Figure 11. The internal connectors are listed below and the associated capabilities are explained in the following text.

> JP20, JP21 & JP22: 50-pin headers for ribbon cable expansion;
>
> JP30 & JP32: bottom side headers connect the USB I/O Expansion Board to the host board;
>
> JP40, JP50, JP60 & JP61: copies of external connectors for internal wiring;
>
> TB70 & TB71: auxiliary power input ports.

JP20, JP21 & JP22: 50-pin headers

The 50-pin headers are provided for ribbon cable expansion of almost all the signals that are available on the USB I/O Expansion Board and that are not expressed in the external connectors. The pinout of each of the three 50-pin headers is shown in Table 5.

All four banks of Byte-wise inputs and outputs are provided on the 50-pin headers. The outputs are presented as active-low current-sinking relay drivers. The input lines are the same style as on the external connector. The Pinouts of JP 21 and JP22 are consistent with pinouts for 50-pin ribbon cables connected to commercially available OPTO-22 and Grayhill I/O racks.

Two channels each of analog in and analog out are also presented on the 50-pin headers.

Table 5: 50-pin Header Pinouts

PINS		JP20 COMBO		JP21 INPUTS		JP22 OUTPUTS	
1	2	5V-24V	GND	IN 32	OPT-GND	OUT 32	GND
3	4	GND	GND	IN 31	OPT-GND	OUT 31	GND
5	6	DACOUT2	GND	IN 30	OPT-GND	OUT 30	GND
7	8	DACOUT1	GND	IN 29	OPT-GND	OUT 29	GND
9	10	GND	GND	IN 28	OPT-GND	OUT 28	GND
11	12	AIN2	GND	IN 27	OPT-GND	OUT 27	GND
13	14	AIN1	GND	IN 26	OPT-GND	OUT 26	GND
15	16	GND	GND	IN 25	OPT-GND	OUT 25	GND
17	18	OUT 9	GND	IN 24	OPT-GND	OUT 24	GND
19	20	OUT 10	GND	IN 23	OPT-GND	OUT 23	GND
21	22	OUT 11	GND	IN 22	OPT-GND	OUT 22	GND
23	24	OUT 12	GND	IN 21	OPT-GND	OUT 21	GND
25	26	OUT 13	GND	IN 20	OPT-GND	OUT 20	GND
27	28	OUT 14	GND	IN 19	OPT-GND	OUT 19	GND
29	30	OUT 15	GND	IN 18	OPT-GND	OUT 18	GND
31	32	OUT 16	GND	IN 17	OPT-GND	OUT 17	GND
33	34	IN 16	OPT-GND	IN 8	OPT-GND	OUT 8	GND
35	36	IN 15	OPT-GND	IN 7	OPT-GND	OUT 7	GND
37	38	IN 14	OPT-GND	IN 6	OPT-GND	OUT 6	GND
39	40	IN 13	OPT-GND	IN 5	OPT-GND	OUT 5	GND
41	42	IN 12	OPT-GND	IN 4	OPT-GND	OUT 4	GND
43	44	IN 11	OPT-GND	IN 3	OPT-GND	OUT 3	GND
45	46	IN 10	OPT-GND	IN 2	OPT-GND	OUT 2	GND
47	48	IN 9	OPT-GND	IN 1	OPT-GND	OUT 1	GND
49	50	OPT-VCC	OPT-GND	OPT-VCC	OPT-GND	5V-24V	GND

JP30 & JP32: USB I/O Expansion Board Interface

These two extended-length connectors are mounted on the bottom side of the USB I/O Expansion Board and they are used to make the necessary electrical connections between the USB I/O Expansion Board and the signal generator host board.

No signals of any relevance to the end user are present on these headers so pinouts are not provided here. It is recommended that these connectors not be touched or probed since damage to either board could result.

JP40, JP50, JP60 & JP61: Embedded Copies of External Connectors

These four headers are exact replicates of the four external connectors described in the previous section: JP40 for the CON4 inputs, JP50 for the CON5 outputs, JP60 for the CON6 analog outputs and JP61 for the CON7 encoder interface. Their respective pinouts are shown in Tables 6 and 7.

Table 6: Embedded Header Pinouts – JP40 & JP50

PINS		JP40 INPUTS		JP50 OUTPUTS	
1	2	IN 9	OPT-GND	OUT 10	OUT 9
3	4	IN 10	OPT-GND	OUT 12	OUT 11
5	6	IN 11	OPT-GND	OUT 14	OUT 13
7	8	IN 12	OPT-GND	OUT 16	OUT 15
9	10	IN 13	OPT-GND	GND	+5V
11	12	IN 14	OPT-GND	-	-
13	14	IN 15	OPT-GND	-	-
15	16	IN 16	OPT-GND	-	-

Table 7: Embedded Header Pinouts – JP60 & JP61

PINS		JP60 ANALOG		JP61 ENCODER	
1	2	GND	5V-24V	GND	+5V
3	4	DACOUT1	DACOUT0	INDEX-N	INDEX-P
5	6	GND	SPDIR	CH-B-N	CH-B-P
7	8	+12V	SPON	CH-A-N	CH-A-P

These four headers are provided to facilitate incorporation of the USB I/O Expansion Board into an embedded application in which the board may not be near enough to an external wall to make use of the external connectors.

TB70 & TB71: auxiliary power input ports

These two 2-pin terminal blocks allow external or embedded connection to auxiliary power supplies, one for the isolated inputs (TB70) and one for the 5V-24V supply that will bias the general purpose outputs plus SPON and SPDIR (TB71).
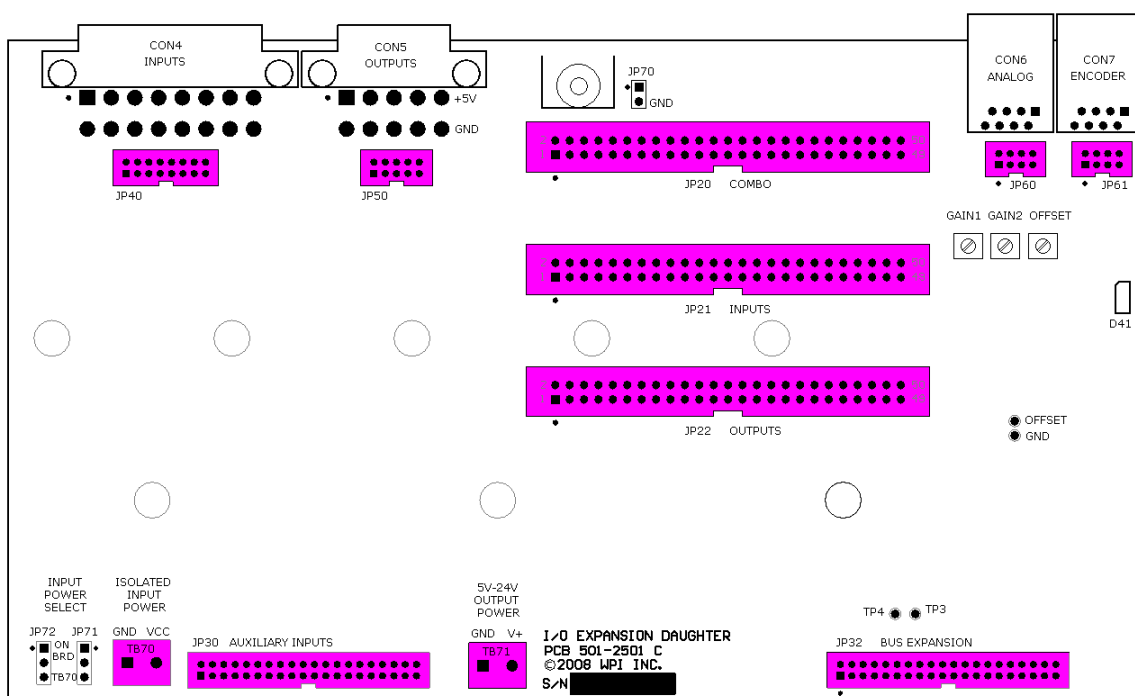

Figure 11: I/O Expansion Board plan view with internal connectors highlighted.

Analog Input

Except for the analog inputs, all signal types that appear on the internal connectors have been described in previous sections. The analog input pins are present only on the 50-pin header labeled JP20 "COMBO".

A single-channel analog-to-digital converter (ADC) receives two multiplexed input channels at 10-bit resolution over a range of 0-10V (9.8 mV increments). Inputs over 10V should be avoided. They are clipped to 10V by the input circuitry anyway. Anything over 12 VDC or

any AC voltage will damage the circuit. There is a 4 kHz lowpass filter on each channel and the input impedance is approximately 50 kOhms.

3. Configuration Jumpers

There are three configuration jumpers on the USB I/O Expansion Board as shown in Figure 12. Pin 1 of each jumper is indicated by a small white dot printed on the PCB.

JP70 – Shield & Ground

JP70 connects the internal signal ground of the USB I/O Expansion Board that is tied to the same ground on the host Signal Generator board to the enclosure or chassis at the L-bracket mount hole in the center rear portion of the USB I/O Expansion Board. This jumper should be left in its factory-configured state unless otherwise directed by FlashCut CNC technical support.

JP71 & JP72 – Input Power Select

These two jumpers choose for the input bias voltage between the +5V power rail on the USB I/O Expansion Board and an isolated, external power source provided via system wiring. Both of these jumpers must be set on the same pair of pins (either both must be on pins 1 and 2 or both must be on pins 2 and 3). These jumpers serve the same function as jumpers JP84 and JP85 on the host Signal Generator Board. Each pair of jumpers is relevant only to the inputs on its board and receives power only from the terminal block on its board so it is not necessary to set the pairs to the same configuration.
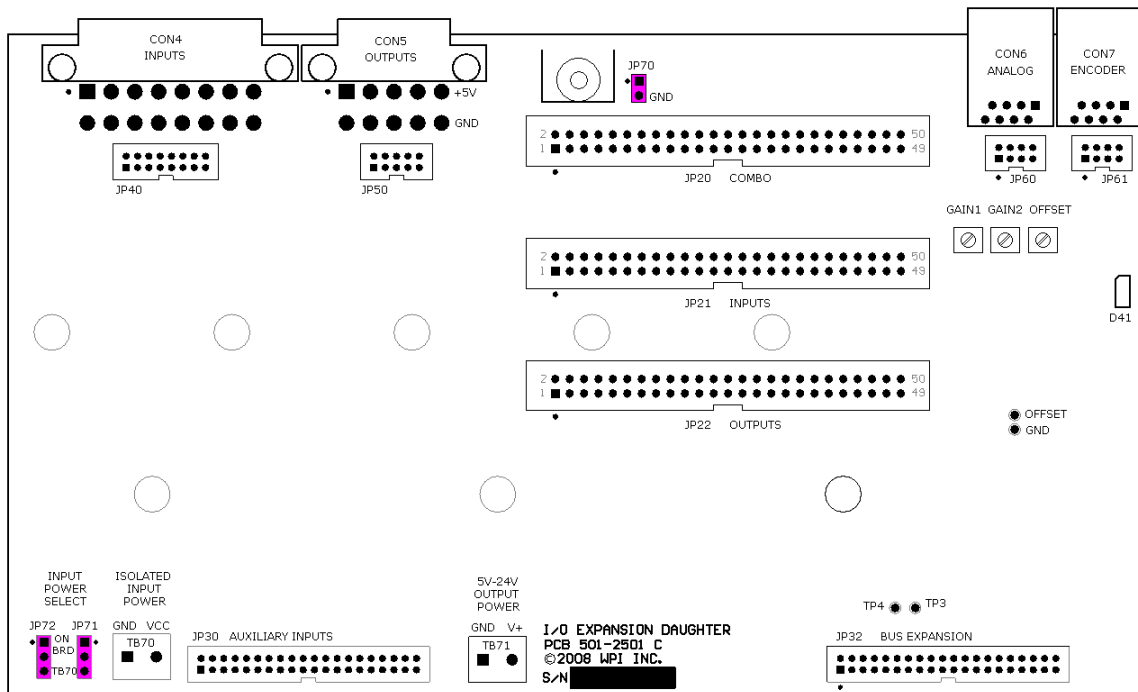

Figure 12: I/O Expansion Board plan view with configuration jumpers highlighted.

4. FlashCut CNC Software Interface

Software Recognition of Board Installation

In order for the USB I/O Expansion Board to function, you must notify the software that it has been installed. Please go to the Controller Configuration Menu and check the "I/O Expansion Board Installed" checkbox as shown in Figure 13.
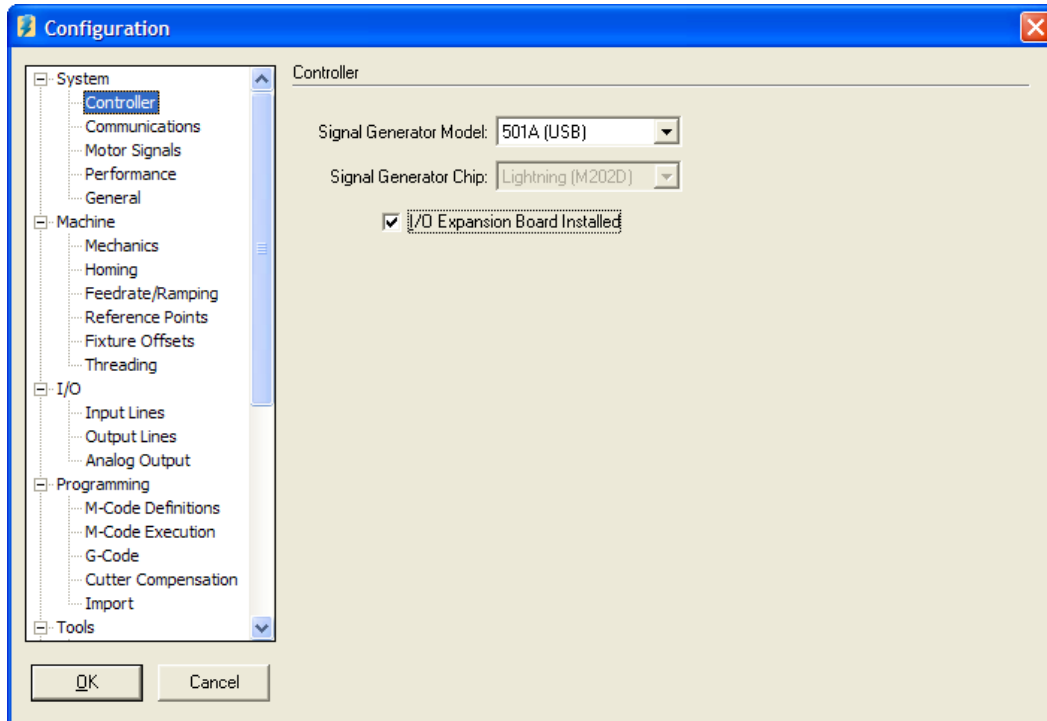

Figure 13: FlashCut CNC Configuration screen capture showing the check box indicating that the USB I/O Expansion Board is installed.

Once the I/O Expansion Board is recognized, the software will enable the control of Input and Output lines (9-32), along with the Analog Output and Spindle Speed Feedback Control features.

Analog Output Configuration

In order to utilize FlashCut CNC's analog output, the Analog Output Configuration screen must be accessed. On this screen, it is possible to specify the range of spindle speeds controlled by the analog output and enable the on-screen slider for the analog output.

The configuration screen is shown in Figure 14. Please refer to the FlashCut CNC Software User's Guide for more detail on this subject.
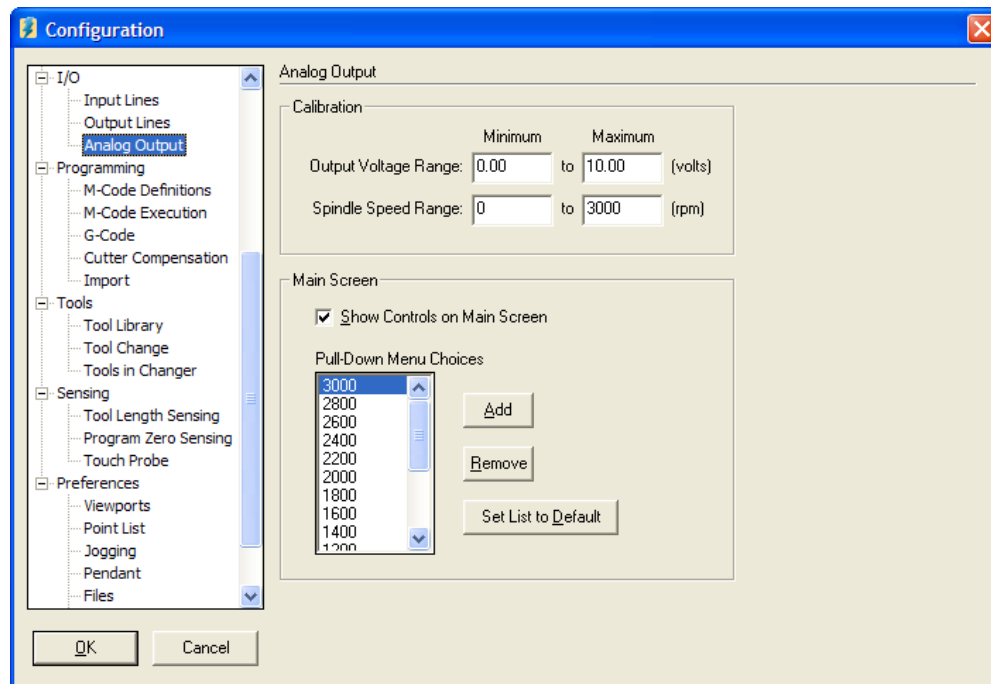
*Figure 14: FlashCut CNC Configuration screen capture showing the
Analog Output Configuration screen.*

Calibrating the Analog Output

The locations of the GAIN and OFFSET potentiometers are shown in Figures 15 and 16.
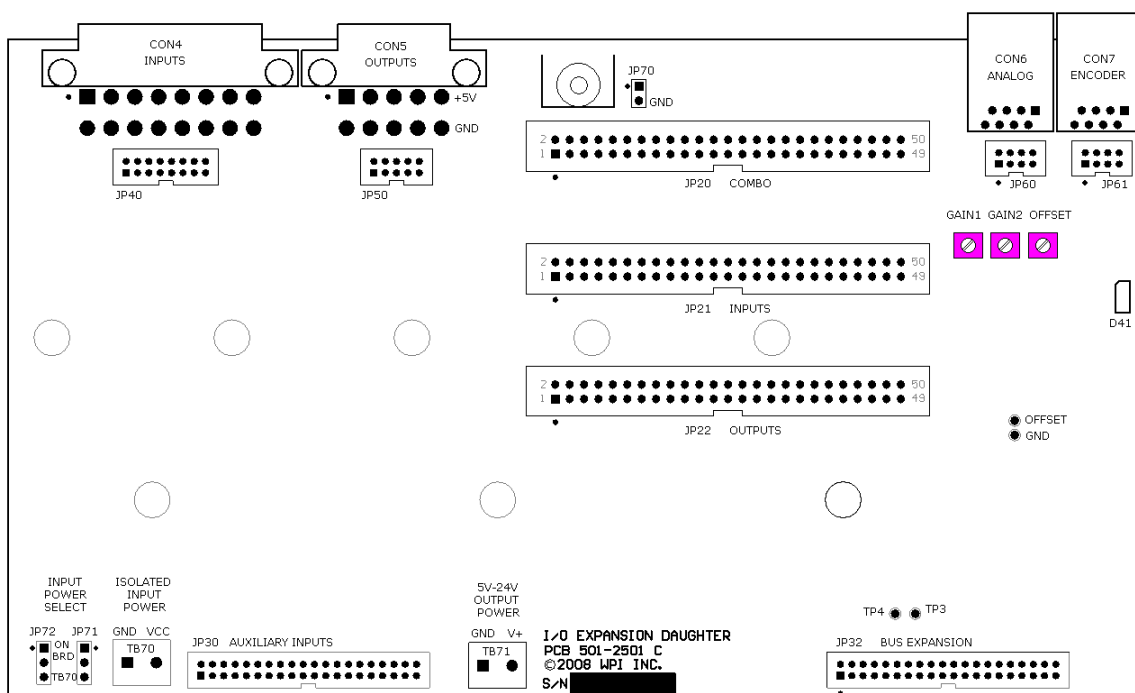The adjustment procedure is described below.

*Figure 15: FlashCut CNC Configuration screen capture showing the
Analog Output Configuration screen.*
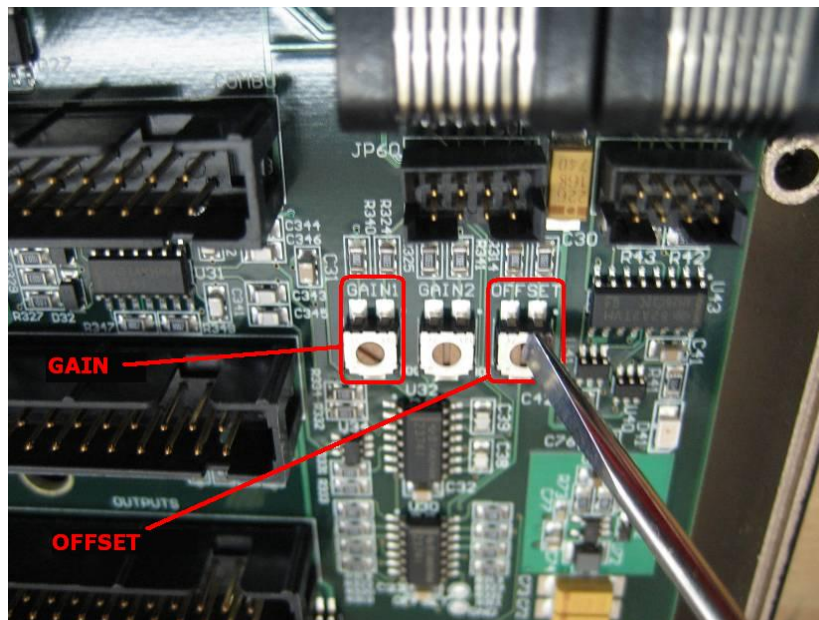
Figure 16: I/O Expansion Board plan view with adjustment potentiometers highlighted.

The analog output on each FlashCut CNC pre-assembled USB Signal Generator with USB I/O Expansion Board has been pre-calibrated. If the USB I/O Expansion Board was purchased as a separate item and was not pre-installed, it is possible to calibrate the analog output using the directions below:

1. Remove the four enclosure screws from the bottom of your signal generator.

2. Remove the top cover of the signal generator.

3. Obtain a cable with a RJ-45 connector on one end and exposed wires on the other.

4. Plug the RJ-45 connector into the "DACOUT" port on the back of the signal generator.

5. In the FlashCut software, select Configuration>>I/O>>Analog Output. Set the Output Voltage Range to have a minimum of 0V and maximum of 10V; set the Spindle Speed Range to have a minimum of 0 RPM and a maximum of 4095 RPM.

6. Use a multimeter to find the DC voltage across the DACOUT0 and GROUND pins on the RJ-45 connector (Pins 6 and 7).

7. In the AUX panel of the FlashCut software, set the analog spindle RPM to 0.

8. Using a small flathead screwdriver, carefully turn the "OFFSET" screw (pictured above) so the voltage between pins 6 and 7 is at its most minimal point. This minimum voltage will generally be between 5 and 10 mV.

9. Now, set the analog spindle RPM to the max value, 4095.

10. Turn the "GAIN 1" screw so that the voltage is stable at 10 volts. (Gain 2 currently not used)

11. You have now calibrated the I/O Expansion board for use with analog spindle control.

5. Specifications

In this section are compiled relevant attributes of the USB I/O Expansion Board and information about accessories.

Board Dimensions:

7.92 x 4.59 inches (201 x 117 mm)

Digital Inputs

32 each (4 banks of 8), optically isolated;
1 each quadrature, differential encoder input
    including A, B and INDEX

Digital Outputs

32 each (4 banks of 8) 24V low-side relay
    driver, 250 mA each
8 each ACT logic (TTL/CMOS) 5V 24mA
each
2 each (SPON & SPDIR) 24V push-pull
    driver, 250 mA each

Analog Inputs

2 each, 10 bit ADC, 0-10V,
    50 kΩ input impedance

Analog Outputs

2 each 12-bit DAC, 0-10 V

Power Requirements:

0.7 W to 3 W depending on output states,
power supply configuration and load; board is
powered by Signal Generator host board.

Mating Connectors - Rear Panel I/O:

Molex-Waldom Mini-Fit Jr. Series
INPUTS (16-pin): p/n 39-01-2160
OUTPUTS (10-pin) p/n 39-01-2100
plus both fit female pins p/n 39-00-0039
or 39-00-0047 for 22 AWG or thinner wires

ANALOG & ENCODER: any standard 8/8
RJ-45 plug as for 10/100-Base-T Ethernet

Mating Connectors - Internal I/O:

JP20-22: 50-pin headers are 3M brand 0.100"
low-profile, four-wall 2500 series; mating
connectors include 3000 series wiremount
socket for ribbon cable.

JP40, JP50, JP60-61: 2 mm headers are
Molex/Waldom Milli-Grid™ 87831 series;
mating connectors include series 87568 for
ribbon cable, series 51110 for discrete
terminals (series 50394).

TB70, TB71: 2-pin terminal blocks accept 16-
26 AWG wire

USB I/O Expansion Board Kit Contents

1 each USB I/O Expansion Board
3 each #4-40 x 7/8" Nylon Standoff
6 each #4-40 x 1/4" Phillips Pan Screws
2 each #6-32 x 1/4" Phillips Pan Screws
1 each Right angle mount bracket #6-32 holes
1 each Aluminum Rear Panel with
        USB I/O Expansion Board cutouts

Available Accessories

OH-01 FlashCut I/O Adapter Kit

p/n? FlashCut Encoder Kit
    U.S. Digital 500 CPR S/E Encoder

Revision History

Revision	Date	Description of Revision
--	1-22-07	Draft
A	6/26/08	Updated
B	9/25/08	Updated
C	10/17/2008	Replaced/added diagrams; analog input, internal conn's, jumpers & spec's sections; TOC