Interfacing the EC1000 to IPG Fiber Lasers

The EC1000 laser timing control has features designed specifically to ease the integration of IPG Photonics fiber lasers with type "B" interfaces. This application note details how to create cabling that can connect the IPG laser to the EC1000-IO module. It also defines the proper entries for the EC1000 configuration files that enable this interface, and provides examples of EC1000 job commands to control the laser behavior.

Cabling requirements

The IPG laser provides a 25-pin D-SUB male connector to interface the laser to a suitable control system like an EC1000. The EC1000-IO module uses Molex 3mm modular connectors to provide access to functional groups of signals. Unfortunately the signal naming conventions used by IPG and CTI do not necessarily lead to an unambiguous connection scheme.

The table below relates the signals available at the EC1000-IO board to the equivalent IPG signals. Not all of the IPG interface signals are directly supported, but where possible, a work-around solution is described. This document assumes that the reader already has an IPG Type "B" interface manual and an EC1000 OEM Integrators manual in his or her possession.

Table 1 IPG and EC1000 signal name correlation

IPG Signal Name	Pin number(s)	EC1000-IO Signal Name	EC1000-IO Connector & Pin Number(s)	Comment
D0-D7	1-8	DATAOUT0-DATAOUT7	J9 Pins 3,9,4,10,5,11,6,12	These signals are optically isolated on the EC1000 and need to be enabled to drive the IPG interface. This is done by connecting J9 pins 1&7 together and J9 pins 2&8 together.
DLATCH	9	LASERMOD2 or DATAOUT0	J8 Pin 2 J9 Pin 3	LASERMOD2 normally serves as a laser Q-Switch signal which is driven 180 degrees phase-shifted relative to LASERMOD1. It serves a different purpose here by continuously "latching" the laser power level into the IPG interface. This is normally OK because the EC1000 holds the power level value constant until changed via a job instruction. Continuously latching the value is not harmful. Alternatively, a special mode of operation permits the use of data bit 0 as the latch signal. When configured for this mode, the EC1000 automatically toggles D0 from logic "0" to "1" and back to "0" after the DATAOUTn signals have stabilized. This happens whenever the laser power changes from a previously different value. In this mode, only 7 bits of power level control are available (D7..D1). This still provides up to 128 settings. Using this mode, however, requires a more aggressive pull-up resistor (at least 1K) be applied to this signal than is used on the EC1000-I/O board in order to improve the rise-

				time of the signal.
GND	10-13, 24 14, 15	GND	J8 Pins 9-12, 14 J6 Pins 9, 10	IPG GND pins 14 and 15 are not connected.
ALARMSTAT1- ALARMSTAT0	16, 21	USERIN2_NEG, USERIN1_NEG *	J6 Pins 9, 10	The EC1000 is not currently explicitly configured to handle these IPG outputs. But if desired they could be connected to a pair of the USERIN signals on J6 (as indicated here for instance). These signals can then be periodically queried by an application for state information via Priority messages. See the following section for details.
+5V	17	FUSED_5V	J9 Pin 7	
MO	18	LASERENABLE	J8 Pin 6	
PA	19	LASERON1	J8 Pin 13	
PRR	20	LASERMOD1	J8 Pin 3	
GUIDELASER	22	LASERON2	J8 Pin 5	The LASERON2 signal of the EC1000 can be programmed for several different behaviors in conjunction with the master laser enable state of the EC1000. When the master laser enable state is “enabled”, the system operates normally with the laser timing signals being asserted as expected when the job is run. If the master laser enabled state is “disabled”, then only the PRR signal will have activity on it and it will stay at the idle frequency and pulse width. If programmed to do so while in this mode, LASERON2 will be asserted at the same time as when LASERON1 *would have been asserted.* This allows the GUIDELASER signal to be asserted only where “marks” would have occurred. Other modes of operation permit more direct control of the assertion of LASERON2.
EMERGSTOP	23	N/A	N/A	This should be connected to an external EMO switch circuit. If not used, it should be pulled up with a 10K resistor to +5V.

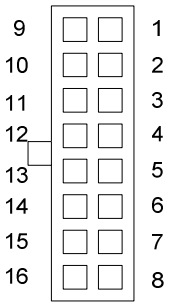
* The USERIN signals are optically isolated on the EC1000 module and the circuit must be completed to make use of them. This is done by applying +5V to the USERIN(n)_POS input which provides a current path through the optical isolator. The isolator is turned “ON” when the IPG interface drives the USERIN(n)_NEG input low, and “OFF” when the signal is driven high. Connect J6 Pins 19 & 20 to J6 Pin 2 to enable this capability.

Cable Structure

The following diagram illustrates how to construct a cable to interface the EC1000-IO board to an IPG Type "B" interface. All EC1000-IO module connectors are Molex 3mm Micro-fit series connectors.

EC1000-IO Module Connector | Connection Table | IPG Interface

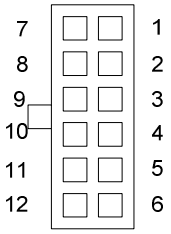
Laser Control
J8 (P8)



Connections

CTI Signal	P8		P1	IPG Signal
LASERMOD2	2	→	9	DLATCH
LASERMOD1	3	→	20	PRR
LASERON2	5	→	22	GUIDELASER
LASERENABLE	6	→	18	MO
GND	9	→	10	GND
GND	10	→	11	GND
GND	11	→	12	GND
GND	12	→	13	GND
LASERON1	13	→	19	PA
GND	14	→	24	GND

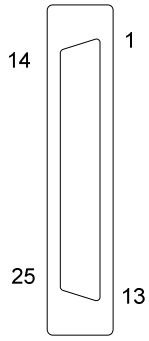
Laser Digital
J9 (P9)



Connections

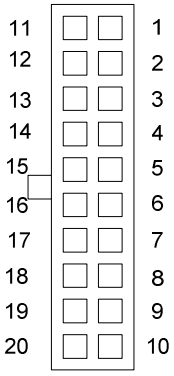
EC1000 Signal	P9		P1	IPG Signal
DATAVPOS	1	~	23	EMERGSTOP*
FUSED_5V	7	→	17	+5V
GND	2			
DATACOMMON	8			
DATAOUT0	3	→	1	D0
DATAOUT1	9	→	2	D1
DATAOUT2	4	→	3	D2
DATAOUT3	10	→	4	D3
DATAOUT4	5	→	5	D4
DATAOUT5	11	→	6	D5
DATAOUT6	6	→	7	D6
DATAOUT7	12	→	8	D7

IPG Control
J1 (P1)



NOTE: The EMERGSTOP connection shown is for convenience and is not considered to be a safe configuration.

User I/O
J6 (P6)



Connections

EC1000 Signal	P6		P1	IPG Signal
USERIN2_NEG	9	→	16	ALARMSTAT1
USERIN1_NEG	10	→	21	ALARMSTAT0
USERIN2_POS	19			
FUSED_5V	2			
USERIN1_POS	20			

Laser Configuration File

The EC1000 initializes the marking engine with base-line laser timing control parameters specified in the LaserConfig.xml control file located on the EC1000 Flash file system. On power-up, the EC1000 holds the laser control signals in tri-state until the parameters are internally applied. The expectation here is that the laser system is well behaved with what would appear to be a disconnected cable. Once the parameters are applied and the timing engine started, the drivers are taken out of tri-state and the cable is actively driven by the EC1000.

The parameter file sets the polarity of each of the laser control signals and the basic timing of the modulation signals and laser gating signals. Section 6.3.3 of the EC1000 OEM Integrators Manual explains each of the file settings. These parameters can be altered using the CTI supplied Configuration Editor.

For a typical IPG laser setup, the following values can be used:

Laser Config File XML Entry	Comment
<LsrTiming>50</LsrTiming>	The number of 20ns intervals that make up a laser timing "tick". In this case, a laser tick is set to 1usec.
<LsrEnaDly>8000</LsrEnaDly>	Minimum master oscillator startup time (8ms). This is the minimum time that the MO signal will be asserted prior to asserting the Power Amplifier (PA) signal in marking sequence.
<LsrEnaTmo>20000</LsrEnaTmo>	The laser master oscillator signal is deactivated if no laser activity is requested for 20msec.
<LsrModDly>0</LsrModDly>	No modulation delay required.
<FpsPos>0</FpsPos> <FpsWidth>0</FpsWidth>	No First Pulse Suppression is required.
<TickleWidth1>25</TickleWidth1> <TickleFreq1>20000</TickleFreq1>	Laser 1 stand-by: pulse width == 25 laser timing ticks (25usec); pulse frequency == 20.0KHz. This is a 50% duty cycle waveform. *
<TickleWidth2>25</TickleWidth2> <TickleFreq2>20000</TickleFreq2>	Laser 2 stand-by: Settings the same as Laser 1
<LENAHigh>true</LENAHigh>	Set the LASERENA (MO) signal polarity to active high
<LONHigh>true</LONHigh>	Set the LASERON (PA) signal polarity to active high
<LON2High>true</LON2High>	Set the LASERON2 (GUIDELASER) signal polarity to active high
<LON2Cfg>1</LON2Cfg>	Set the LASERON2 configuration to be active only while the laser master enable state is "disabled" (drawing mode)
<LMOD1High>true</LMOD1High>	Set the LASERMOD1 (PRR) signal polarity to active high
<LMOD2High>true</LMOD2High>	Set the LASERMOD2 signal polarity to active high (not used)
<LFPKHigh>true</LFPKHigh>	Set the LASERFPK (N/A) signal polarity to active high (not used)
<LsrPwrMode>8bit</LsrPwrMode>	Sets the laser digital power word to 8bits

* These values are nominal values for when the laser signals are activated. IPG recommends that the idle pulse parameters be set to the same as the laser on parameters. This is done in the job programming (see below).

Laser Control Job Commands

The EC1000 software API uses XML to specify parameters and commands to instruct the module on how mark a substrate. The EC1000 hardware operates on these parameters as it receives them via the Streaming Data interface. The following examples illustrate how to change the laser power, modulation parameters, and on/off delays. It is possible at any time to change the parameters that are set in the Laser Config file via the streaming interface although the syntax for some of these commands differs.

Setting marking parameters

The following XML fragment changes various parameters in preparation for a new marking sequence. As specified below and sent as a single packet, all of the parameters will be applied in sequence. The hardware will hold these values until changed by another XML fragment.

Marking Job XML	Comment
<Data type="JobData" rev="1.0">	// Job packet identification
<set id="JumpDelay">150</set>	// 150usec jump delay
<set id="JumpSpeed">10,47</set>	// 10usec update rate, 47 counts per update (~4.5m/s)*
<set id="MarkDelay">150</set>	// 150usec mark delay
<set id="MarkSpeed">10,20</set>	// 10usec update rate, 20 counts per update (~2m/s)*
<set id="LaserOnDelay">100</set>	// 100usec laser on delay**
<set id="LaserOffDelay">100</set>	// 100usec laser off delay**
<set id="PolyDelay">50</set>	// 50usec polygon delay**
<set id="LaserPowerDelay">125</set>	// 125usec laser power chg delay (only if power chgs)
<set id="LaserPower">200</set>	// Laser power set to 200 (out of 255)
<set id="LaserPulse">1,6,13</set>	// Laser mod set to 77Khz at approx 50% duty cycle
<set id="LaserStandby">1,6,13</set>	// Same for Laser Standby
</Data>	// End of job packet

* Speed value in meters/sec assumes a 150mm marking field

** Laser delays are very much a function of the response time of the galvos and the laser. These times overlap with each other to a large extent leading to delays that are numerically smaller than the response time of either component.

Controlling the pointer laser

The EC1000 laser control activity can be disabled during the execution of a marking job to permit a non-marking "pointer" laser to illuminate the marking field in the pattern of the desired image. Disabling laser control is accomplished by sending the job command:

<Set id="EnableLaser">0</Set>

While in this mode of operation, the LASERENABLE (MO) and LASERON1 (PA) signals are disabled and the LASERMOD1 (PRR) signal is modulated using the "Tickle" frequency and pulse width parameters set in the Laser Config file. The <LON2Cfg>1</LON2Cfg> parameter setting in the Laser Config file enables the activation of the LASERON2 (GUIDELASER) signal while running a job, but only when the laser activity has been disabled with the "EnableLaser" command. This signal will be asserted at the same time as when the LASERON1 (PA) signal would have been asserted during normal job execution. LASERON2 will be unasserted at all other times.

Drawing preview images

The visualization of a image generated using the guide laser requires a rapid redraw of the image to reinforce the persistence effect of the human eye. If the preview image has too many vertices, the system will not be able to display it rapidly enough and flickering will result. Because of this, most applications generate a preview image that represents an outline of the desired image. This can range from a simple box, to an irregular polygon that hits selected boundary points of the image.

The EC1000 supports an additional mode of operation that facilitates drawing preview images. The <Draw> command permits the specification of preview images with up to 32 vertices. In the following XML job fragment, a bounding box 1000 counts on a side are repeatedly drawn until another command is sent to the EC1000:

```
…
<Set id=”EnableLaser”>0</Set>
<Set id=”MarkSpeed”>15, 120</Set>
<Set id=”PolyDelay”>0</Set>
<Set id=”MarkDelay”>0</Set>
<JumpAbs>-500, 500</JumpAbs>
<Draw>
<Vertex>500, 500</Vertex>
<Vertex>500, -500</Vertex>
<Vertex>-500, -500</Vertex>
<Vertex>-500, 500</Vertex>
</Draw>
```

These settings cause the system to draw the image very rapidly; care should be taken to avoid excessive speed for the galvos used in the marking head. The EC1000 will remain in this drawing state until it receives an Abort command, or if any other job command is sent. Normal laser control can be restored by just sending the command:

```
<Set id=”EnableLaser”>1</Set>
```