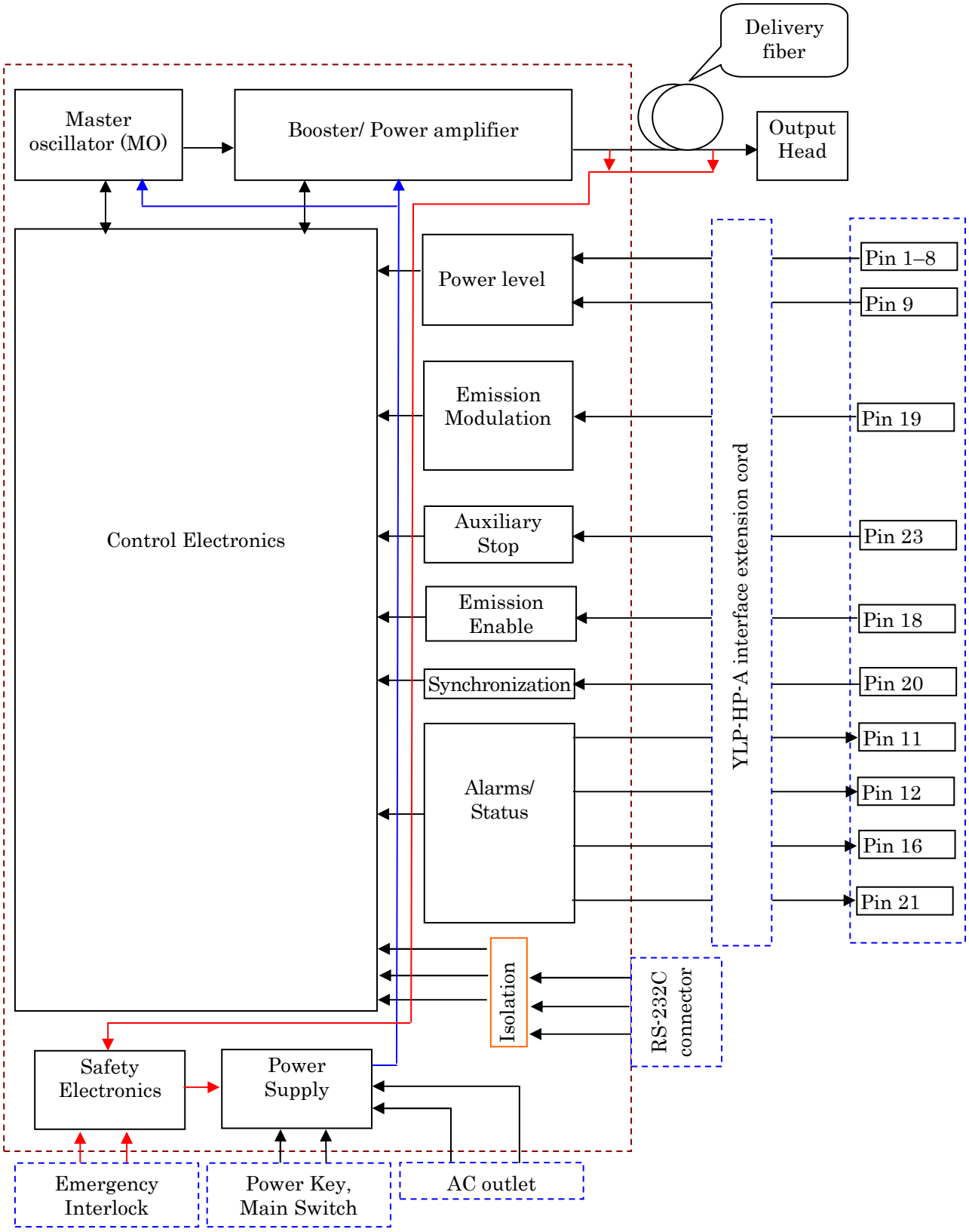
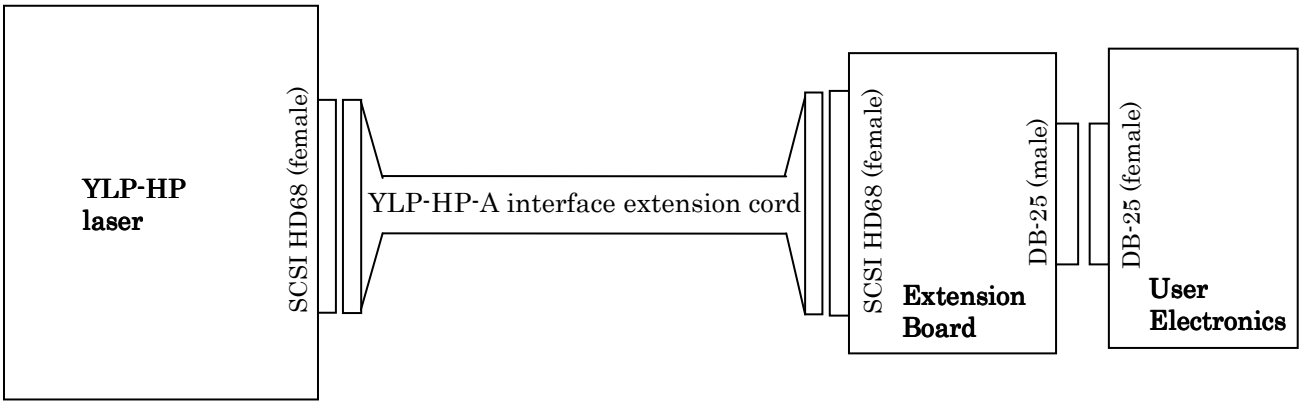
The document describes connection and control basics of YLP-HP series pulsed lasers equipped with digital interface "type YLP-HP-A" manufactured by IPG Laser GmbH and its sister companies.

Contents:

Laser Internal Structure.



Interface Extension Cord.



1. Digital interface type YLP-HP-A is provided oneself with interface extension board and interface extension cord as shown on connection above. User electronics controls the laser through DB-25 connector according pins specification.

2. Extension board transfers DB-25 plug input-output signals into differential signal format that is being transmitted to the laser through the extension cord. Such connection ensures noisy free operation with different cord lengths that allows laser and control interface to be standing separately for customer usability.

3. Typical cord length may be varied between 5 and 20 meters. Extension Board should be arranged side by side with User Electronics to minimize plug to plug cable length between DB-25 connectors.

Control Connector Pin Assignment, DB-25 plug on Extension Board

All control pins are TTL compatible, unless otherwise noted in the pin description. For the interface designs level ranges of the TTL standard should be taken into consideration. All control pins of Extension Board are galvanically isolated from laser control electronics.

PIN No.	Name	Description
1-8 (D0-D7)	Power Setting	8-bit bus. 0-FFh in hexadecimal or 0..255 in decimal formats. Least significant bit (lsb) (D0) corresponds to Pin number 1, Most significant bit (msb) (D7) corresponds to pin 8. 00h (0): Minimum output power FFh (255): Maximum output power Disconnected corresponds to 00h.
9	Latch	Latches power setting into the laser by the rising edge
10	Ground	Ground
11,12,16,21		Laser alarms status (see alarm codes in the table below).
13, 15, 17, 24, 25		Reserved, customer connection is not allowed.
14	Ground	Ground
18	EE	Emission Enable (EE) signal. HIGH: Emission Enable LOW or disconnected: Emission Disable
19	EM	Emission Modulation (EM) input. HIGH (>3V): Emission ON LOW or disconnected (<1V): Emission OFF
20	Sync	Pulse Repetition Rate (Synchronization) input, square wave.
22	Guide	Guide Laser (red diode) ON/OFF input. Additional functionality for type D1 interface (see corresponding section). HIGH: ON LOW or disconnected OFF
23	AStop	Auxiliary Stop Input HIGH: OK (Normal operation) LOW or disconnected: STOP (Laser automatically switches OFF MO and Booster)

Digital Control Interface type YLP-HP-A Description.

1. The laser equipped with digital interface may be controlled via signals applied to the DB-25 connector on Extension Board. Please refer to the connector interface description table above for pin designation and operating levels. The digital interface should be activated (set in configuration by RS-232) before it is being used.

2. Pins 1 to 8 are the 8 bit bus for the output power setting. Pin 1 is the least significant bit and pin 8 is the most significant bit. Codes in the range 0...255 (0...FFh) should be applied to these pins, which correspond to the power setting of 0...100% of the specified nominal value.

   Note: optical output power is directly proportional to the power setting (see specification for the power adjustment range).

3. Pin 9 is the "Latch" control line to store power settings (pin1-8) into the laser. The data is stored to the laser by the rising edge of the signal on the pin 9. Data on the pins 1-8 should be stable for 1µs before and 1µs after the rising edge on pin 9.

   Stability of the data on the Pin 1-9 out of the above mentioned time frames is not required. IPG recommends supplying single positive pulse with duration longer than 2µs to latch the data into the laser. Time interval between adjacent latching pulses should be longer than 100µs (latching frequency less than 10 kHz).

4. Pin 18 is the Emission Enable (EE) signal. The Emission Enable input should be switched ON at least 5ms before switching ON the Emission. After switching ON Emission Enable input, the laser starts to consume more electrical power and emits residual optical power to the output even when EM pin 19 is LOW (Emission). The optical power value (pulsed and CW parts) depends on model and operating mode of the laser. High contrast (HC option) ensures low residual optical power.

   Note: the EE switches ON simultaneously with the rising edge on the pin. If the HIGH level was applied to the pin before supplying electrical power to the laser, the laser does not recognize that EE has ON state. In order to enable emission the pin 18 (EE) should be dropped and set to HIGH level again after completing of warm-up phase. If the pin 19 (EM) was also in the HIGH state before supplying electrical power to the laser it should be also dropped to the LOW state at the same time.

5. Pin 19 is the Emission Modulation (EM) control input. Apply HIGH to switch ON the Emission and LOW to switch it OFF. The laser starts to emit optical power within specified delay after setting the pin to the HIGH level and stops to emit with specified delay after setting to the LOW level. Refer to the laser optical specification for the laser average power rise and fall times. Modulation with a period shorter than sum of the rise and fall times (the laser response time) may lead to the non adequate laser power behavior and optical over/undershoot.

   Note 1: the EE input should be switched ON at least 5ms before switching ON the Emission. In case of switching ON EM while the EE is OFF, the laser does not start to emit. In case of switching ON the EM and later the EE, the laser starts to emit in less than 5ms after switching ON the EE.

   Note 2: Emission switches ON simultaneously with rising edge on the pin. If the HIGH level was applied to the pin before supplying the laser, the laser does not recognize that as the Emission switching ON signal. The pin should be dropped and set to HIGH level again. If the pin 18 was also in the HIGH state before supplying voltage to the laser it should be also dropped at the same time.

   Note 3: The laser may be equipped with secondary emission modulation input (implemented as plug or connector pin, for example BNC connector for some models) which acts similar to EM pin. This secondary modulation input is combined with EM control pin by "OR" logic. That means the HIGH state any of modulation inputs will generate emission ON signal. All operation description over this document supposes that secondary modulation input is LOW or disconnected.

6. Pin 20 is the Synchronization input. Pulse train with a repetition rate (PRR) within specified operating range should be applied to the pin (refer to the optical specification for PRR limits). The laser emits pulses simultaneously with the rising edge of the signal. The square wave input signal with duty cycle 0.1 to 0.9 is allowed. Variation of the duty cycle does not affect to the laser characteristics.

   Note: In case of the PRR supplied being out of the specified range (or no PRR signal supplied) the laser safety circuit substitutes missing pulses or limits the PRR.

7. Pin 22 is the guide laser (red diode/ pointer) control line. Apply HIGH to switch the guide laser ON and LOW to switch the guide laser OFF. If the guide laser option is not installed, pin 22 can either be connected to ground (pin14) or left floating.

Note: the laser emission is not allowed simultaneously with the guide laser operation. MO and Booster are blocked internally during the guide laser operation. If the Emission Modulation (pin 19) or Emission Enable (pin18) were set to HIGH level during guide laser operation, the laser will not emit power, and will not start to emit it even after switching OFF the guide laser. It is necessary to drop both Emission Modulation (pin 19) and Emission Enable (pin 18) to restart the laser emission. Until the restart is done the state "Laser is not ready for emission" will be active on appropriate alarm/status pins.

8. Pin 23 is the "Auxiliary stop" input. It should be set to HIGH for normal operation. In case of dropping this pin to LOW state (even for a short period) the laser automatically switches OFF (similar state when both EE and EM are OFF) independently of other control signals. It is necessary to drop both EE and EM pins (if they were in HIGH state) to restart laser operation. Until the restart is done state "Laser is not ready for emission" will be active on appropriate alarm/status pins. Pin 23 should be set to HIGH at least 2μs before supplying ON signals to EE and EM pins.

9. Pins 11, 12, 16 and 21 are the alarm and status outputs. Pin 12 is reserved for future alarm codes expansion. These pins indicate the following device states:

Pin 12	Pin 11	Pin 16	Pin 21	Alarm description
X	LOW	LOW	LOW	**Temperature alarm** Laser temperature is out of the operating temperature range.
X	HIGH	LOW	LOW	**Fiber alarm** Processing or Feeding fiber alarm
X	LOW	LOW	HIGH	**Normal operation**
X	HIGH	LOW	HIGH	**Laser is not ready for emission**
X	LOW	HIGH	LOW	**Back reflection alarm** Laser automatically switches OFF due to high optical power reflected back to the laser.
X	HIGH	HIGH	LOW	Reserved
X	LOW	HIGH	HIGH	**System alarm** Laser protection system detects internal failure.
X	HIGH	HIGH	HIGH	Reserved

In the case of any alarm the laser will be automatically switched OFF and sets internal Alarm flag. To continue operation after alarm event the internal Alarm flag should be reset. To reset Alarm flag pin 18 and 19 should be set to LOW. Alarm outputs (pins 11, 12, 16 and 21) will be recovered to the normal state simultaneously with the reset of Alarm flag signal (except Back Reflection alarm).

Back reflection alarm: Alarm flag may be dropped when at least one second passes after the alarm activation. If reset was done earlier, the flag will be dropped when 1 second passes after alarm activation.

Laser is not ready for emission state: Laser is not ready to emit power. That may be a result of Emergency Stop and Guide Laser activation without following reset or not – activated main power supply.

Fiber alarm: This alarm may be a result of opened interlock of processing fiber connector or broken integrity of processing or feeding fiber. More information may be received through RS-232 by reading of laser status bits.

Laser Operation using Digital Interface.

1. Follow all the procedures described in User's Guide to prepare laser to operation.

2. Connect the laser using extension cord and extension board to the control system via DB-25 connector. Use pins according to the description above.

   Note: Described laser interface is compatible with the IPG provided YLP-RC-USB remote control drivers. Consult IPG concerning suitable model of remote control and its software.

3. Recommended initial state of control pins:

   Pins 18, 19, 22 are LOW

   Pin 23 HIGH

   Pin 20 with repetition rate within specified range

4. Activate housekeeping and main power supply of the laser as described in User's Guide.

5. Make sure that the laser is configured to use digital interface. Read operation mode of the laser through RS-232 interface. Set digital DB-25 interface mode bit if required (more information is provided in User's Guide).

6. In 10 seconds after activating of main power supply (warm-up time) the laser is ready for operation.

7. Set desired power via pin 1-8. Apply the latch pulse to the pin 9 to store the power settings into the laser.

8. Switch the EE ON applying HIGH to the pin 18.

9. Wait 5ms.

10. Laser is ready for fast modulation via Pin 19. It is possible to apply HIGH and LOW sequence to switch the laser ON and OFF correspondingly. The laser has finite ON/OFF rise/fall times (refer to the specification for the particular model). The speed of the modulation should not be faster than sum of rise and fall times, otherwise laser optical response may not be as expected.

11. If the EM OFF time between subsequent ON/OFF batches (jobs) is more than 500ms, it is recommended to switch OFF the Emission Enable pin. This will spare power consumption, avoid unnecessary wear out of the laser and exclude residual MO power at the laser output.

12. After finishing laser operation, switch OFF the EM and EE (set LOW to pin 18 and pin 19).

13. Switch of power supply.

Operation Features.

1. PRR can be changed during laser operation by the adjustment of the signal frequency at the pin 20. The laser has its own internal frequency generator to ensure correct optical PRR for driving MO. Internal generator is a “slave” circuit, that controlled by a “master” pulses applied to the pin 20. Control circuit attempts to synchronize frequency and phase of “slave” pulses with “master” pulses by an appropriate frequency tuning of internal generator. When synchronization pulses of a stable frequency within specified frequency range are applied to the pin 20, the laser synchronizes frequency and phase of the optical pulses with the “master” pulses at the pin 20.

2. A phase locking loop circuit attempts to compensate a delay between the supplied “master” pulses and the output optical pulses. Changing of the “master” pulses PRR causes tuning of the internal generator frequency and a drift of optical PRR to the new “master” frequency. There are two modes of the tuning depending on “Jump PRR” configuration state.

   Jump PRR is active. If the period of the “master” pulses is changed by less than 1us, the internal “slave” generator adjusts its period with speed of 10 ns per “master” pulse. If the period of “master” pulses is changed by more than 1us, the laser switches OFF

emission for typically 4 pulses and restores it with the "slave" generator operating at the new PRR. Delay compensation between "master" and "slave" generators follows this PRR jump and runs with a speed of 10ns per pulse. This frequency/phase locking mechanism provides stable laser operation and protects the laser from a random or a missing input signal on pin 20.

Jump PRR is not active. Phase locking loop starts to synchronize frequency and phase of the "master" and "slave" generators. The speed of the PRR drift equals to 10ns per "master" pulse period. This mechanism ensures smooth PRR tuning from a previous PRR to the final one.

Note: Jump PRR feature is available not for all laser models. Please refer to the laser specification for more details. If Jump PRR feature is not available, the laser operates like Jump PRR is not active.

3. If the "master" PRR (pin 20) is higher than the maximum allowed PRR, the laser will operate at the maximum specified PRR. If the "master" PRR (pin 20) is lower than the minimum allowed PRR, the laser will operate at the minimum specified PRR.

4. The power setting can be changed during the laser operation by applying updated levels to pin 1-8 and latching them into the laser via pin 9. Laser response time to the power setting change is within specified delays for rise/fall times (refer to the laser specification).

5. If pins 18 and 19 are in LOW state, there is no laser radiation at the operating wavelength.

6. If the EE is ON, and the EM is OFF, there is a residual power at the laser output. The value depends on the laser model and the operating mode.

7. If the EE is ON and the EM is ON with the zero power set (all pins 1-8 were LOW during the latching of the power into the laser) there is a residual power at the laser output. The value depends on the laser model and the operating mode.

8. The red diode can be switched ON during laser operation (if the option is installed) using pin 22. The guide laser should be turned ON when the EE and EM pins are OFF. If the one of EE or EM is ON, the emission is automatically stopped. To recover laser operation it is necessary to drop pins 18, 19 to LOW. Switching ON of EE and EM is enabled only after setting pin 22 to LOW.

9. Make sure that pin 22 is connected to the ground or left floating if the guide laser is not in use. Connection to the HIGH level disables laser emission.

10. The laser automatically switches OFF emission, if the module temperature rises above or drops below specified maximum/minimum operating temperatures (for operating temperature range refer to the laser specification). The internal Alarm flags set and appropriate alarm signal combination appears on the alarm pins 11, 12, 16 and 21. The laser does not recover the emission and holds the alarm pins unchanged until the reset of Alarm flag is done.

11. The laser has an internal back reflection sensor. It switches emission OFF if the reflected level is potentially dangerous for the laser. The internal Alarm flag is set and the appropriate alarm signal combination appears on the alarm pins 11, 12, 16 and 21. The laser does not recover the emission and holds the alarm pins unchanged until the reset of Alarm flag is done. It is possible to switch ON the EE and EM again in one second after the alarm was emerged.

12. All operation modes which are installed in the laser (like HC, ACON, ExtPRR etc., for complete list of modes and their operation refer to laser specification and User's Guide) are available with digital interface also. Control diagrams and operation description for each mode remain the same with the exception of corresponding control signals coming from DB-25 pins connector.