Universal
laser controller and testunit
for
SPI Laser Systems
and
laser units enabled by PWM or analog control

LCT3001 is a universal laser controller / testunit for laser systems controlled by pulse width modulation (PWM) or controlled by analog voltage 0-10 V. Laser control by means of serial protocol via RS232 port is also possible. BNC connector outputs a positive PWM signal. DB15F (Laser Control) connector is used to output positive and inverted PWM signal or positive / negative trigger signal for analog control and the 0-10V analog control voltage. The LCT3001 offers a 1 Hz - 100KHz PWM or trigger signal in following selectable ranges:

1	-	100 KHz	in 1 KHz steps
0.1	-	10KHz	in 100 Hz steps
10	-	1000 Hz	in 10 Hz steps
1	-	100 Hz	in 1 Hz steps

Above description is called **CO2 MODE** and usable for laser systems from UNIVERSAL, SYNRAD, JENOPTIK and others.

CO2 Mode of operation can be recognized in the display as follows:

Line 1:	output:	10 Khz	0%	(example)
Line 2:		* MCA * LCT3001*		

Note: output: and a % value indicates CO2 mode of operation.
Laser power is controlled by a pulse width in % in relation to a set frequeny in the range of 1 Hz to 100 Khz. Laser power in % PWM can be set in above display indication by direct entry of number keys followed by ENTER or by arrow keys in 10% increments. Key MENUE entered before numberkeys show display als follows:

Line 1:		5 KHz 13%	(example)
Line 2:	frequency	KHz	

Enter a new frequency by number keys and confirm by ENTER. Key BACK allows corrections. If arrow up key is used before number entry, an analog output value with one digit behind comma can be entered (ex. 8.4V). Arrowkey down allows input of % power. If arrow keys are input several times, SETUP menues are stepped through (Setup menues see below).

In addition LCT3001 has special functions which are called **SPI MODE** of operation. These functions are used to control laser system from SPI Southhampton GB. If this mode of ooperation is selected one additional frequency range of 0.2ms to 6.5 seconds with an accuracy of 4 digits behind comma (ex. 5.1862S).

SPI mode of operation is displayed as follows:

	Line 1:	4.3V	6.8KHz	0.024ms	(example values)
or	Line 1:	4.3V	3.4876s	2.8982s	
	Line 2:	* MCA * LCT 3001 *			

Laser power in SPI mode is controlled by 3 variables:

1. Selected analog voltage (ex. 4.3V)
2. Selected frequency (ex: 6.8 Khz, or a periode value in the seconds range)
3. Selected pulse width (ex. 0.024 ms)

Key MENUE and number keys again allows direct entry of a frequeny or period. Arrow up key before number entry allows setting of an analog value, arrow down key allow entry of a pulse width. Arrow keys operated several times leads to SETUP menue. BACK key allows for corrections and return to basic setting.
In SPI mode LCT3001 also allows a frequency pulsed analog 0-10V output voltage mode.

In the same time the LCT3001 functions as an analog in to PWM out converter. As input a 0-10V analog voltage or a 4-20mA current loop can be used. The trigger signal needed for this function is edge triggered and selectable as a rising or falling signal (DB9F, analog in, gate in). Only in this function pulse width limit can be set to 95%, 99%, 100%.

In PWM mode a tickle pulse at 5 KHz with app. 1usec width can be output with the PWM signal. The tickle pulse functions in such way, that the PWM signal accuracy is not affected.

RS232 Port: (DB9M, RS232 CONTROL): The LCT3001 can be remote controlled by PC or PLC (see annex 2).

Graphic User Interface (GUI):
A GUI under windows 98 - XP is under development and will be available for download under www.mcamicro.de to remote control LCT3001 via PC.

In addition LCT3001 can control laser systems with RS232 serial protocol.
Following protocolls a momentarely supported:
1: Diode pumped disk lasers from JENOPTIK (see annex 3).
2: SPECTRON laser systems (in preparation)
Other protocols can be implemented on demand.

Additional useful features:

4-20 mA to 0-10V converter.
A 4-20mA current loop input signal from a PLC etc. is converted to a 0-10 Volt output for laser power control. Sliding window technique is used for this purpose.

SETUP menue:

At first power up LCT3001 operates in default mode i.e. PWM output at 10KHz and 0% pulswidth in CO2 mode. Reset to default mode: keep key BACK depressed at power up.

With key MENUE LCT3001 goes in SETUP mode. Arrow up/down keys are used to scroll through menue points and key ENTER/YES selects the choosen menue point. Again arrow keys are used to subselect within a selected menue point. Key BACK(NO,EXIT) quits SETUP mode.
Number keys are used to input numerical values.

Please note: some SETUP menues are only available in the selected mode of operation, i.e CO2 Mode or SPI Mode.

Setup | laser operation: toggle with ENTER between enable and disable. Two relay contacts are closed at enable and green led ENABLE is on. Contacts can be used as interlock, enable laser etc.

Setup | manual fire button pressed, disabled, oneshot, on-off:
Button pressed: As long as key **Laser on** is depressed PWM signal (PWM mode) or output trigger out (analog mode) is on.
Oneshot: for every key depression a single PWM respectively analog trigger is released.
On-off: Each key depression toggles between on and off.

Setup | external fire control normal, disabled, oneshot: select with ENTER, choose with arrow key and confirm with ENTER again.
Function: In converter mode the analog input voltage which is converted to a pulse width is activated by a gate signal.
Normal: as long as gate signal is activated a PWM signal at selected frequency is generated. Pulswidth is determined by analog input value i.e 0-10V or 4-20mA.
Oneshot: for each trigger on the input gate a single PWM pulswidth is generated. Pulswidth again is determined by analog input value.

Setup | external trigger rising/falling: toggle with ENTER and confirm. This function is used to select trigger polarity in converter mode (see above).

Setup | maximum pulswidth: confirm with ENTER. With arrow keys 95%, 99% or 100% is selectable and value is again confirmed by ENTER.
Note: this function is only operational in the analog to PWM converter mode i.e. 0-10V or 4-20mA in --- PWM out.

Setup | remote control: enabled/disabled:
Activation of remote control via RS232 (see annex 1).

Setup | new boot configuration: select with ENTER. **Save new boot configuration?** Confirm with ENTER to store all settings. At power up LCT3001 operates now with preselected settings.

Setup | 0-10V trigger length: 1 - 9 usec set by number keys. Trigger width in analog mode.
If for test purposes a larger pulse width is required see annex 4.

Setup | tickle charge: toggle with ENTER on/off. Tickle pulse works at fixed frequency of 5 KHz at pulse width of 1 usec und is used to maintain plasma within laser tube. For laser systems with integrated tickle generator tickle should be off.
Note: If for test purposes a larger trigger width is desired proceed as follows:
1. Switch off tickle pulse (**setup | tickle charge** off).
2. Go to PWM mode (**setup | operating mode** PWM).
3. Select trigger frequency via **set frequency**. Trigger width is now adjustable between minimum and 100% by direct input of number keys or arrow keys in 10% steps.

Setup | CO2 power mode (pulswidth / 0 -10V):
This function selects laser operating mode.
Mode laser power control by pulse width modulation (PWM).
Set CO2 power to pulswidth mod.? confirmed by key ENTER means LCT3001 outputs a positive PWM signal on the BNC connector. DB15 connector also has the same signal on PIN9 and the inverted signal on PIN2
Mode laser power by 0-10V analog control.
Set CO2 power by 0-10V analog out? Confirmed by ENTER means LCT3001 outputs analog voltage on DB15 PIN13 . In the same time the positive and negative trigger pulse at a selectable frequency of 1Hz - 100 KHz and a selectable enable pulse (1 - 9 usec) to fire laser.
In 0 -10V analog out mode input of a % power value equal an analog voltage.
Example: 43% power equals 4.3V analog.

RS232 | JENOPTIK
Send RS232 command
Transmission of serial commands to a laser of JENOPTIK via RS232 port.

SETUP | enabled/disabled
SPI MODUS
Toggle with key ENTER between enabled and disabled. Leave SPI setting with key BACK.

SETUP | selected range
Frequency range
Select menue with ENTER, select frequency range with arrow keys, confirm selected range by ENTER and leave menue with key BACK.

SETUP | manual / 4-20mA / 0-10V
Pulsewidth control
Select menue with ENTER, select value with arrow keys, confirm by enter.

SETUP | manual / 0-10V
Frequency control
Select menue with ENTER, select by arrow keys and confirm by ENTER.

SETUP | enabled / disabled
Pulse analog
Select menue by ENTER and toggle with ENTER enable or disable.
This function is only in SPI mode available. The 0-10 Volt analog output signal at DB15/pin13 is pulsed by set frequency. Pulse analog enable signal envelope is available on DB15/pin10. Please note: Enable (DB15/pin10) can drive max. 20 mA loads only!

Annex 1: Technical notes:

Regulated 12V DC Power supply.
LTC3001 power reqirement: 12V DC/ 600mA min.

PWM outputs (BNC, DB15 pin 2 and pin 9) are CMOS outputs 5 Volts max. 150mA.
0 - 10V analog output drives a load of 500 Ohms**.**

Enable line for pulsed analog voltage (DB15 pin 10) : TTL 5 V **max. 20 mA.**

Annex 2: Protocol LCT3001 remote control:

RS232 configuration: 9600Bd, 8N1, no flow control.
Remote control of LCT3001 is only possible, if setup "Remote control" is previously enabled.
To issue a complete command, start byte 0xF5 must be sent.

Answer	Meaning
0xA0	One more Byte expected
0xA1	More Bytes follow (up to 12)
0xAA	command done correktly
0xAF	Error! command not done correktly

Function	Command	Answer
Start Byte	0xF5	0xA0

Function	Command	Answer
Analog in 1 is the 0 - 10V or the 4 - 20mA input controlling the pulswidth.		
Set analog in 1 maximum	0x50	0xA0
	High-Byte High-Nibble	0xA0
	High-Byte Low-Nibble	0xA0
	Low-Byte High-Nibble	0xA0
	Low-Byte Low-Nibble	0xAA / 0xAF
High-Byte, Low-Byte: 16 Bit value (n times timebase)		
Set analog in 1 offset	0x51	0xA0
	Offset1 High-Nibble	0xA0
	Offset1 Low-Nibble	0xA0
	Offset2 High-Byte High-Nibble	0xA0
	Offset2 High-Byte Low-Nibble	0xA0
	Offset2 Low-Byte High-Nibble	0xA0
	Offset2 Low-Byte Low-Nibble	0xAA / 0xAF
Set analog in 1 factor	0x52	0xA0
	High-Byte High-Nibble	0xA0
	High-Byte Low-Nibble	0xA0
	Low-Byte High-Nibble	0xA0
	Low-Byte Low-Nibble	0xAA / 0xAF

High-Byte, Low-Byte:
multiplication factor as 16 Bit value > 0, < 4, in 2.14 fix point format

formula: (required factor * 16384), as 16 bit integer
in hexadezimal format.

e.g. factor = 1:
High-Byte = 0x40, Low-Byte = 0x00
command: 0x52, value: 0x40, 0x00, 0x00, 0x00

e.g. factor = 1/10 (exactly: 0.0999756)
High-Byte = 0x06, Low-Byte = 0x66
command: 0x52, value: 0x00, 0x06, 0x60, 0x06

e.g. factor = 1/100 (exaktly 0.0100098)
High-Byte = 0x00, Low-Byte = 0xA4
command: 0x52, value: 0x00, 0x00, 0xA0, 0x04

e.g. factor = 1/1000 (exakt 0.0009766)
High-Byte = 0x00, Low-Byte = 0x10
command: 0x52, value: 0x00, 0x00, 0x10, 0x00

Function	Command	Answer
Analog in 2 is the 0 - 10V input controlling the frequency.		
Set analog in 2 maximum	0x53	0xA0
	High-Byte High-Nibble	0xA0
	High-Byte Low-Nibble	0xA0
	Low-Byte High-Nibble	0xA0
	Low-Byte Low-Nibble	0xAA / 0xAF
High-Byte: 8 Bit value (max. frequency * 2.5) Low-Byte: 8 Bit spare, e.g. 0.		
Set analog in 2 offset	0x54	0xA0
	Offset1 High-Nibble	0xA0
	Offset1 Low-Nibble	0xA0
	Offset2 High-Nibble	0xA0
	Offset2 Low-Nibble	0xAA / 0xAF
Set analog in 2 factor	0x55	0xA0
	High-Byte High-Nibble	0xA0
	High-Byte Low-Nibble	0xA0
	Low-Byte High-Nibble	0xA0
	Low-Byte Low-Nibble	0xAA / 0xAF
High-Byte, Low-Byte: multiplication factor as 16 Bit value > 0, < 4, in 2.14 fix point format (same as command: 0x52 = Set analog in 1 factor)		
Manual fire control Btn. pressed	0x56	0xAA / 0xAF
Manual fire control on - off	0x57	0xAA / 0xAF
Manual fire control oneshot	0x58	0xAA / 0xAF
Manual fire control disabled	0x59	0xAA / 0xAF
Pulse analog Out enabled (SPI)	0x5A	0xAA / 0xAF
Pulse analog Out disabled (SPI)	0x5B	0xAA / 0xAF
All analog in curves linear	0x5C	0xAA / 0xAF
Ask status 2	0x5D	(see below)
Ask status 3	0x5E	(see below)
PWM max. = 100 %	0x5F	0xAA / 0xAF
Enable CO2 Modus	0x60	0xAA / 0xAF
Enable SPI Modus	0x61	0xAA / 0xAF
Tickle charge enabled (CO2)	0x62	0xAA / 0xAF
Tickle charge disabled (CO2)	0x63	0xAA / 0xAF
CO2 Power Pulswidth mod. (CO2)	0x64	0xAA / 0xAF
CO2 Power by 0-10V out (CO2)	0x65	0xAA / 0xAF
Ext. fire control normal	0x66	0xAA / 0xAF
Ext. fire control oneshot	0x67	0xAA / 0xAF
Ext. fire control disabled	0x68	0xAA / 0xAF
An.2 Set frequency manual	0x69	0xAA / 0xAF
An.2 Set frequency by 0-10 V	0x6A	0xAA / 0xAF

Function	Command	Answer
Set frequency range	0x6B	0xA0
	Range-Byte	0xAA / 0xAF

Range-Byte:
0x31 = "1" Range 1 = 1 - 100 kHz
0x32 = "2" Range 2 = 0.1 - 10 kHz
0x33 = "3" Range 3 = 10 - 1000 Hz
0x34 = "4" Range 4 = 1 - 100 Hz

0x54 = "T" Range Tt = 0.2 - 6.5 S

Set Frequency	0x6C	0xA0
	Frequency-Byte	0xAA / 0xAF

Frequency-Byte:
1-100 (1-100 fuer Frequency value depending to Range in 1/10/100/1000Hz)

Set Analog Volt	0x6D	0xA0
	Volt-Byte	0xAA / 0xAF

Volt-Byte:
in 1/10V (0-100 for 0.0 to 10.0V)

Set duration (T) (SPI)	0x6E	0xA0
	High-Byte High-Nibble	0xA0
	High-Byte Low-Nibble	0xA0
	Low-Byte High-Nibble	0xA0
	Low-Byte Low-Nibble	0xAA / 0xAF

High-Byte, Low-Byte:
16 Bit value (T times timebase 0.1 mS)

e.g. for 2.5000 seconds: 25000 = 0x61A8
command: 0x6E, value: 0x60, 0x01, 0xA0, 0x08

Set Pulswidth (t) (SPI)	0x6F	0xA0
	High-Byte High-Nibble	0xA0
	High-Byte Low-Nibble	0xA0
	Low-Byte High-Nibble	0xA0
	Low-Byte Low-Nibble	0xAA / 0xAF

High-Byte, Low-Byte:
16 Bit value (t times timebase depending to Range)

z.B. for 0.1250 S in Range 4: 1250 * 100uS = 0x04E2
command: 0x6F, value: 0x00, 0x04, 0xE0, 0x02
z.B. for 80.14 mS in Range 3: 8014 * 10uS = 0x1F4E
command: 0x6F, value: 0x10, 0x0F, 0x40, 0x0E
z.B. for 6.783 mS in Range 2: 6783 * 1uS = 0x1A7F
command: 0x6F, value: 0x10, 0x0A, 0x70, 0x0F
z.B. for 0.0207 mS in Range 1: 207 * 0.1uS = 0x00CF
command: 0x6F, value: 0x00, 0x00, 0xC0, 0x0F

An.1 Set pulswidt manual	0x70	0xAA / 0xAF
An.1 Set pulswidt by 4-20 mA	0x71	0xAA / 0xAF
An.1 Set pulswidt by 0-10 V	0x72	0xAA / 0xAF
Enable Laser	0x75	0xAA / 0xAF
Disable Laser	0x76	0xAA / 0xAF
PWM Frequency = 5 kHz	0x77	0xAA / 0xAF
PWM Frequency = 10 kHz	0x78	0xAA / 0xAF
PWM Frequency = 20 kHz	0x79	0xAA / 0xAF
CO2 PWM max. = 95 %	0x7C	0xAA / 0xAF
CO2 PWM max. = 99 %	0x7D	0xAA / 0xAF
CO2 PWM max. = 100 %	0x5F	0xAA / 0xAF
Ask status 1	0x7E	(see below)
Set PWM % (CO2)	0x7F	0xAA / 0xAF
	PWM-Byte	

PWM-Byte:
% value * 2

e.g. fur 70 % PWM = 0x8C
command: 0x7F, value: 0x8C

Function	Command	Answer
Ask status 1	0x7E	0xA1,(!=0xAA !!!) Status-Byte 1, Status-Byte 2, PWM % Byte, PWM Power-Byte. 0xAA

Status-Byte 1:
- Bit 7,6 - PWM Frequency,
  - 00 = 0 - 7 kHz
  - 01 = 8 - 15 kHz
  - 10 = 16 - 29 kHz
  - 11 = 30 - 100 kHz
- Bit 5 - NC always 0
- Bit 4 - Laser enabled - 1 = enabled, 0 = disabled
- Bit 3 - remote control - 1 = enabled, 0 = disabled
- Bit 2,1,0 - Analog in 1
  - 000 = manuel
  - 001 = 4 - 20 mA
  - 010 = 0 - 10 V

Status-Byte 2:
- Bit 7 - 4 Software version
- Bit 3,2 NC allways 0,0
- Bit 1 PWM max.
- 0 = 99/100 %
- 1 = 95 %
- Bit 0 laser status at Power up in CO2 Modus
- 1 = laser enabled at boot
- 0 = laser disabled at boot

PWM % byte:
Das PWM % byte is % * 2 (like above).

PWM power byte:
same as PWM % byte.

Function	Command	Answer
Ask status 2	0x5D	0xA1, Status 2-1, Status 2-2, Status 2-3, Analog Volt Out, Pulsweite in % (CO2), Frequency, Puls Time High Byte (SPI), Puls Time Low Byte (SPI), Tt Time T High Byte (SPI Tt), Tt Time T Low Byte (SPI Tt), Maximale PW in % (CO2), 0-10V Trigger Length (CO2), 0xAA

Status 2-1:
- Bit 7,6 - Range
  - 00 = Range 1 = 1 - 100 kHz
  - 01 = Range 3 = 10 - 1000 Hz
  - 10 = Range 2 = 0.1 - 10 kHz
  - 11 = Range 4 = 1 - 100 Hz
- Bit 5 - Range Tt
- Bit 4 - Remotecontrol on
- Bit 3 - PORTG, 7 = !Pulse Analog
- Bit 2 - PORTF, 3 = External enabled
- Bit 1 - PORTF, 2 = Trigger rising edge / high
- Bit 0 - PORTG, 0 = Ist Laser enabled / Power an

Status 2-2:
- Bit 7 - Tickle Charge an
- Bit 6 - 0 bis 10V Analog out Modus (!pulswidth)
- Bit 5 - External 1 shot
- Bit 4 - ! pressed Mode (~= Manual On Off Mode)
- Bit 3 - Manual 1 shot
- Bit 2 - Manual Fire blocked
- Bit 1 - 0 ^= 0-10V, 1 ^= 4-20mA
- Bit 0 - Pulswide Control External

Status 2-3:
- Bit 7 - 3 - Firmware version
- Bit 2 - Frequenzy Control External
- Bit 1 - Range Tt (Eingabe)
- Bit 0 - SPI Modus on

Function	Command	Answer
Ask status 3	0x5E	0xA1, Downset1 Offset1High Offset1Low ADfact1High ADfact1Low Limit1High Limit1Low Downset2 Offset2 ADfact2High ADfact2Low Limit2High Limit2Low 0xAA

Note: For reasons of compatibility commands 0x73, 0x74,
0x7A, 0x7B, are acknoledged by 0xAA, but do have no other function.
For reasons of security RS232 command cannot:
- change boot configuration of LCT3001 (0x30, 0x31 gets no answer).
- change hardware configuration for raising or falling external trigger.
- alter trigger length in CO2 0-10V mode.
- logically activate or deactivate RS232 mode.

Annex 3: **Serial protocol LCT3001 for laser systems JENOPTIK:**
Please also refer to laser manual JENOPTIK.

RS232: control cmd.
Cmd:^BSS_ .00^C (^BSSccc.00^C)
(enter value and send string or scroll by arrow keys)

RS232: set current
Cmd:^BSJ_ . ^C (^BSSjjj.jj^C)
(enter value and send string or scroll by arrow keys)

RS232: get status
send: ^BRS^C
(send string or scroll by arrow keys)

RS232: error block 1
send: ^BE1^C
(send string or scroll by arrow keys)

RS232: error block 2
send: ^BE2^C
(send string or scroll by arrow keys)

RS232: first error
send: ^BR1^C
(send string or scroll by arrow keys)

In **control cmd.** and **set current** enter value with number keys.
Wrong entry: use BSP key (bent arrow)
If last number is entered display automatically shows **send:** before string
Now send string by ENTER
Display reads now: **RS232 response**
Second line shows returned values
Line is erasable by arrow keys.

Annex 4:

Note: If for test purposes a larger trigger width is desired proceed as follows:
1. Switch off tickle pulse (**setup | tickle charge** off).
2. Go to PWM mode (**setup | CO2 power mode**: PWM).
3. Select trigger frequency via **set frequency**. Trigger width is now adjustable between minimum and 100% by direct input of number keys or arrow keys in 10% steps.