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Electrical Lens Driver 4

Lens Driver Manual

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The Electrical Lens Driver offers a simple yet precise way to control Optotune's electrical lenses. There are two types of lens drivers available. The Electrical Lens Driver 4 is used to drive the EL-6-18 and EL-10-30-C lens series and comes in a plastic housing. The second Lens Driver 4i is suited to drive the EL-10-30-Ci industrial version and is contained in a steel housing. Both drivers can be used as a standalone solution or integrated into OEM designs. The main features are:

- Current control range up to -290 to +290 mA with 12 bit precision
- Drive frequencies from 0.2 to 2000 Hz (rectangular, triangular or sinusoidal)
- I2C sensor read-out e.g. for temperature compensation
- USB powered
- Driver software in Windows 7 and Windows 8
- Available with or without housing

Mechanical specifications	**Lens Driver 4**	**Lens Driver 4i**	
Dimensions (L x W x H)	77 x 19 x 13	99.05 x 19 x 13.5	mm
Weight	11	41	g
Interface to lens	0.5mm pitch 6 way FPC connector	6-pin Hirose connector	
Interface to PC	USB Type A		

Electrical specifications	**Lens Driver 4**	**Lens Driver 4i**	
Maximum output current	Up to 290mA, depending on resistance (see Figure 7)		
Drive current range for EL-6-18	-290 to +290		mA
Drive current range for EL-10-30-C, -Ci	-200 to +200		mA
Maximum output update frequency	>100		kHz
USB input voltage	5		V
Power consumption	50-1100		mW
Digital to analog converter	12 bit Analog Devices ADN8810		
Microcontroller	8-bit, 16 MHz with 32 KB Flash (Atmel ATmega32U4)		
Connector	6-way FPC (Molex 503480-0600)	6-way Hirose HR 10 G	

Thermal specifications	**Lens Driver 4**	**Lens Driver 4i**	
Operating temperature	-20 to +65		°C
Storage temperature	-40 to +85		°C

Integration into OEM systems

Both Lens Drivers are easily integrated into OEM systems. The microcontroller that is used offers serial interfaces over USB, RS-232 or SPI. Also, analog input from 0-5V is available. Schematics and part list of the Lens Drivers are available on request. Documentation of the firmware is presented at the end of this document. For more information please contact sales@optotune.com.

System requirements

- Windows 7 or Windows 8.1, 32/64 bit
- Lens driver: USB 2.0 port
- uEye camera: USB 2.0 port (preferably 3.0)

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Lens Driver Controller Software

Software Installation

- Run Setup.exe
- Follow the installation wizard

Installation of the Windows driver in Windows XP and Windows 7

- Start Lens Driver Controller. Should the Windows driver not yet be installed, you will be shown a window describing a detailed installation procedure.

Installation of the Windows driver in Windows 8.1

- Installation of the Windows driver in Windows 8.1 requires disabling the driver signature enforcement first. The following steps explain this procedure.
- Press the **Win + C** keyboard combination to bring up the charms bar, then click on the **Settings** charm.
- Click on **Change PC settings**.
- In Control Panel, click on **Update and recovery**.
- Now click on **Recovery**.
- On the right hand side in the **Advanced Startup** section click on **Restart now**.
- Once your computer has rebooted click on **Troubleshoot**.
- Now click on **Advanced Options**, then **Startup Settings** and finally **Restart**.
- Your computer will now restart again and show you a list of options. Select option **7) Disable driver signature enforcement** by pressing **F7** on your keyboard.
- Your computer will now restart with driver signature enforcement disabled and you may continue with the normal driver installation procedure. In order to do so, start Lens Driver Controller. Should the Windows driver not yet be installed, you will be shown a window describing a detailed installation procedure.

Operating Lens Driver Controller

Launch Optotune Lens Driver Controller and click on **Connect.** This will establish the hardware connection and open the main window with the current control and the temperature readout.

Controls

Figure 4 shows the main window. The output current can be changed, either by shifting the arrow or by using the +/- buttons. Using the +/- buttons together with the Shift key increases the step size. Alternatively, the desired value can be written in the gray box.

Figure 4: Screenshot of the main window of the Lens Driver software with the current control

The drive signal can be chosen to be a DC, sinusoidal, rectangular or triangular signal with the possibility to set the upper and the lower signal level as well as the driving frequency. This is indicated in Figure 5.

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Figure5: The drive signal can be chosen to be a DC, sinusoidal, rectangular or triangular signal

Limiting the maximum current

The limits for the current are set in the **Hardware** tab, shown in Figure 6.

Figure6: Settingthe current limits.

The maximum current of the driver is limited to either 290mA, see Figure 7, or 2.8V divided by the resistance applied.

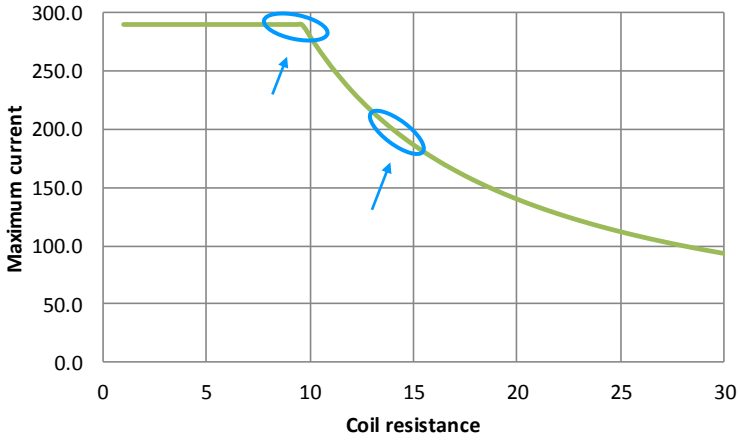

Figure7: Dependence of maximum current on coil resistance

Temperature compensation

When heating up the lens, the fluid expands in volume and therefore, the focal length of the lens decreases. The focal length decreases linearly by approximately 0.67 diopters per 10°C temperature increase. This temperature

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effect is systematic and reproducible and is therefore accurately compensated via a temperature sensor SE97B with an I^2C sensor read-out, integrated in the lens (not in the compact EL-10-30). This allows controlling the focal power directly.

In **Focal Power mode**, see drop down menu in Figure 5, temperature independent lens operation is ensured. Depending on the present temperature, the current applied to the lens is adjusted for compensation of the temperature drift. A look-up table with the calibration data for the temperature compensation are stored directly on the EEPROM of each individual lens. With the temperature compensation enabled, the absolute reproducibility achieved over an operating temperature range of 10 to 50°C amounts to typically 0.1 diopters.

Achievable Range of Focal Power

If the focal power is outside the allowed diopter range then a warning message will appear in yellow “warning focal power outside guaranteed range” and the panel has a yellow background, see Figure 8. The user can then change the focal power until the displayed focal power no longer has a yellow color and is within the diopter range.

Figure 8: On the left, the focal power is outside the achievable range and the panel is yellow. On the right, the focal power is within the range.

The limits for the range of focal power are determined by the temperature limits and the maximum and minimum current. The maximum diopter limit is located at lowest encoded temperature limit and maximum current and the minimum diopter limit is located at the highest encoded temperature and the minimum current. This is explained in Figure 9. The highest and lowest temperature, indicated by the gray and green lines, are adjustable in **File → Options** under **Temperature Settings**. The closer together the minimum and maximum values are the larger is the achievable range in focal power.

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Exemplary focal power set command

Command type: Set focal power
Channel: A
Focal power value: 2000 (5 diopters)

Resulting command:
Byte 0: 0x50 (corresponds to ASCII "P")
Byte 1: 0x77 (corresponds to ASCII "w")
Byte2: 0x44 (corresponds to ASCII "D")
Byte 3: 0x41 (corresponds to ASCII "A")
Byte 4: 0x07 (high current byte) / 0b00000111
Byte 5: 0xb2 (low current byte) / 0b11010000 -> with byte 1 the total current bits are 0b 0000011111010000 which equals to 2000 dec
Byte 3: 0xBF (low CRC byte)
Byte 4: 0x13 (high CRC byte)

Mode commands

Mode commands allow to access frequency modes (see table). A mode change command always starts with "M", followed by a "w" to write the command. Reading commands back is by sending an "r" instead of a "w" is possible but not tested and recommended. The "w" is followed by a char identifier that selects the mode type ("S", "Q", "T","C" or "D", see table) and finally a char selecting the channel ("A"). The command is finished by a 16bit CRC calculated from the four command bytes. The low byte of the CRC is sent first.

To set the property of the selected mode (i.e. frequency and currents) a signal property change command is used. This command starts with a "P" followed by a "w" to write the command. Again, reading commands back is by sending an "r" instead of a "w" is possible but not tested and recommended. The "w" is followed by a char identifier that selects the property to be changed ("U", "L" or "F", see table). Next a char selecting the channel ("A") is sent. The next four bytes sent represent the data for the command. It is a 32-bit unsigned integer for the frequency or a 16bit signed integer followed by two dummy bytes for the current. The frequency needs to be multiplied by 1000 (fixed comma representation). Example: For a frequency of 12Hz the integer sent out needs to be 12000 (0x00002EE0 as a 32bit hex). The bytes to be sent out (in this order) are: 0x00, 0x00, 0x2E, 0xE0. The command is finished by a 16bit CRC calculated from the eight command bytes. The low byte of the CRC is sent first.

The mode "C", or Controlled Mode, allows the driver to maintain the focal power of a connected lens. This mode must be enabled in order to use focal power set commands.

Char coding for the mode change command:

"A"	Channel A
"w"	Write Identifier
"S"	Sinusoidal signal
"Q"	Square signal
"D"	DC signal
"T"	Triangular signal
"C"	Controlled Mode

Char coding for the signal property change command:

"U"	upper swing current [-4095 to 4095]
"L"	lower swing current [-4095 to 4095]
"F"	Frequency (in 'value in [mHz] = value in [Hz] *1000')

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```
public class CRC16IBM
{
	const ushort polynomial = 0xA001;
	ushort[] table = new ushort[256];

	public ushort ComputeChecksum(byte[] bytes)
	{
		ushort crc = 0; // initial CRC value
		for (int i = 0; i < bytes.Length; ++i)
		{
			byte index = (byte)(crc ^ bytes[i]);
			crc = (ushort)((crc >> 8) ^ table[index]);
		}
		return crc;
	}

	public byte[] ComputeChecksumBytes(byte[] bytes)
	{
		ushort crc = ComputeChecksum(bytes);
		return BitConverter.GetBytes(crc);
	}

	public CRC16IBM()
	{
		ushort value;
		ushort temp;
		for(ushort i = 0; i < table.Length; ++i) {
			value = 0;
			temp = i;
			for(byte j = 0; j < 8; ++j) {
				if(((value ^ temp) & 0x0001) != 0) {
					value = (ushort)((value >> 1) ^ polynomial);
				}else {
					value >>= 1;
				}
				temp >>= 1;
			}
			table[i] = value;
		}
	}
}
```


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