User Manual

LucidControl DO4

4 Channel Digital Output USB Module

1 Introduction

This document describes the functionality of the LucidControl DO4 USB module providing 4 digital outputs controllable via Universal Serial Bus.

A basic description of the complete LucidControl product family can be found in the document *LucidControl User Manual*.

This document concentrates on module specific topics of the digital output module which is described here with all its details. In order to set up the module in a fast way please see the

LucidControl DO4 One Sheet Manual

which provides all information necessary to start working with the module out of the box without reading lots of documentation.

2 Setup and Installation

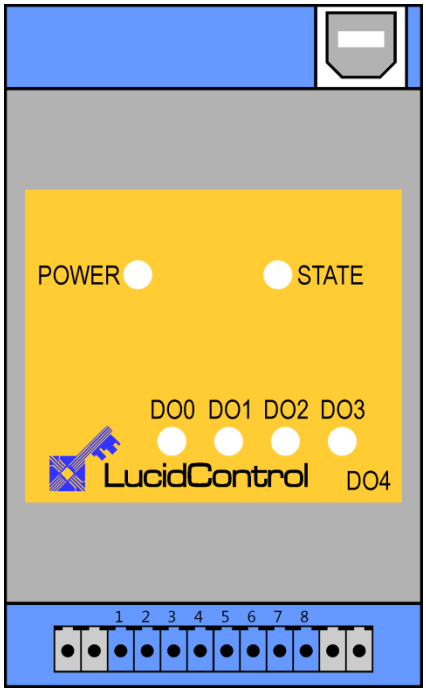

Fig. 1 Digital Output Module

Fig. 1 shows the sketch of the Digital Output DO4 module with 4 Digital Outputs (DO0 ~ DO3).

All LucidControl modules have two connectors, one USB connector and an IO- Connector which makes it easy to setup them.

While the upper USB connector is used for interconnection with the computer, the lower IO-Connector is used for inputs and outputs.

DO4 modules are available in different configurations (see 2.1) and because of this the IO Connector may have different pinouts.

2.1 Configurations

In order to fit most applications three different configurations of the DO4 module are available which are described in the following.

2.1.1 4 Solid State Relay Outputs (DO4-I)

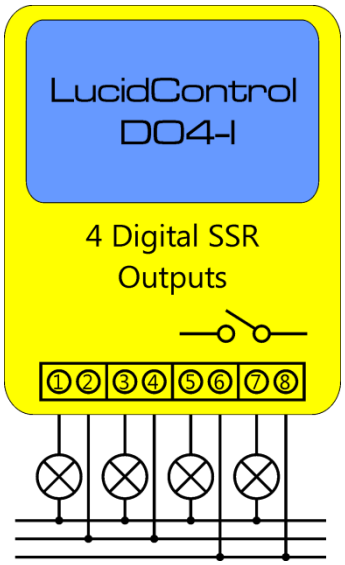

Fig. 2 DO4 Module with Solid State Relays

Fig. 2 shows the DO4-I module which is recommended for standard applicatons. The versatile module can control lamps as well as pumps and it can be used to generate general purpose opto-insulated and potential-free digital outputs.

The emploied solid state relays (SSR) are perfect to generate pulse-width-modulation (PWM) which allows e.g. controlling the power of a pump by switching power on and off periodically.

Despite to mechanical relays SSR are not limited in switching cycles and are suited for periodical switching as well as for static switching.

A detailed description of solid state relay outputs can be found in section 2.2.2.1.

2.1.2 4 Transistor Outputs with Open Collector (DO4-O)

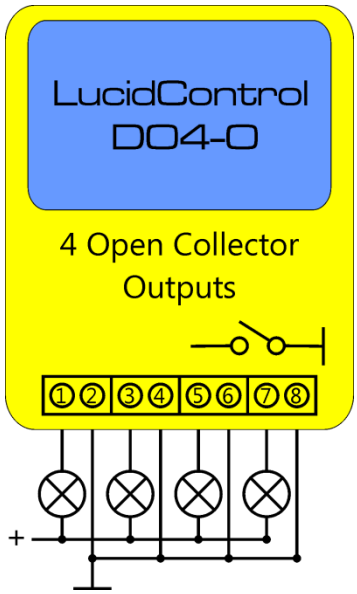

Fig. 3 DO4 Open Collector Module

While DO4-I modules are preferable for many applications because of their opto-insulation they are limited in switching timing.

The DO4-O module shown in Fig. 3 is similar to the DO4-I module but uses transistors instead of solid state relays which allow faster switching cycle times.

A detailed description of open-collector outputs can be found in section 2.2.2.2.

2.1.3 4 Mechanical Relay SPDT Outputs (DO4-S)

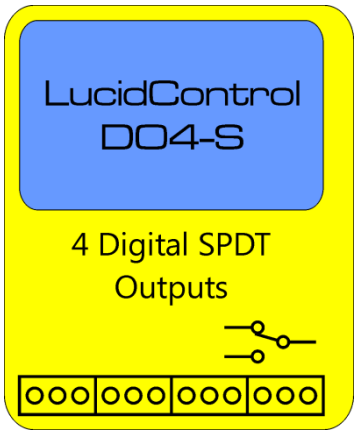

Fig. 4 DO4 Module with relays

The DO4-S module uses 4 mechanical "single pole double throw" (SPDT) relays. This relays have the advantage of behaving like mechanical switches closing a circuit. This allows not only switching of electrical power but also switching of measurement signals e.g. from a temperature sensor which would be distorted by using solid state relays.

An additional advantage of the DO4-S module is that it can toggle between two signals.

The DO4-S module should not be considered for periodical switching (e.g. PWM) since the relays are limited in number of switching cycles. Because of this the DO4-S module does not support the Duty-Cycle Mode (see 3.1.2).

A detailed description of SPDT outputs can be found in section 2.2.2.3.

2.2 Interface and Interconnection

2.2.1 USB Connection

LucidControl USB modules are connected to the computer by using a standard USB cable which must not extend a length of 5 m. They are "bus powered" which means that the host computer supplies the module with power.

Most LucidControl modules are rated with a load current of less than 50 mA. For the DO4-S module which drives the mechanical relays a maximum current of 250 mA must be considered.

Note:
Supplying USB devices with power is not critical using a desktop computer or notebooks but it must be considered that the total power of one USB port is limited to 500 mA.

Note:
The USB ports of the Raspberry Pi® are limited to 100 mA. This means that maximum two devices can be connected to a port directly.

Note:
Using an active USB-Hub with its own power supply allows the connection of additional devices in the case that the host is not able to supply them.

The DO4-S module must not be connected to the Raspberry Pi® directly.

2.2.2 IO Connection

2.2.2.1 DO4-I (SSR)

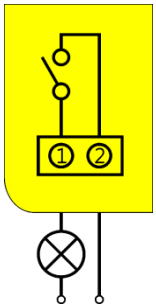

Fig. 5 SSR Output

Fig. 5 shows the connection of the first of the four solid state relay (SSR) outputs as they are used in the DO4-I module.

When the output is activated the SSR connects terminal 1 with terminal 2, closing the circuit and switching the lamp in the depicted application on.

For the DO4-I module the polarity of the signal does not play a role. The positive polarity can be connected to either terminal 1 or terminal 2.

One characteristic of the SSR output is the opto-insulation protecting the electronic behind the SSR (e.g. the host computer). Moreover the outputs are potential-free i.e. the terminals 1 and 2 are not related to the terminals of any other output.

The outputs connected to the terminals 3/4, 5/6 and 7/8 are identical to 1/2 and each is able to switch 0,75A / 30V DC.

The outputs are not protected against overcurrent. It must be ensured that the current does not extend I_{SSRMax}. Otherwise the output may be damaged.

The DO4-I module supports the Reflect Mode, Duty-Cycle Mode and On-Off Mode.

For Duty-Cycle and On-Off Modes the minimum on and off times are limited to T_{SSRMin}.

2.2.2.2 DO4-O (OC)

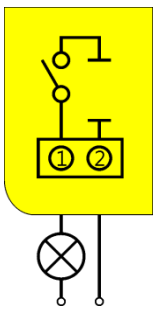

Fig. 6 Open Collector Output

Fig. 6 shows the connection of the first of the four open collector (OC) outputs of the DO4-O module.

When the output is activated the transistor connects terminal 1 with ground and switches the lamp of this application on.

The outputs are not opto-isolated and not potential-free and it is important that the positive polarity is connected to the terminals 1, 3, 5 or 7. The terminals 2, 4, 6 and 8 are internally connected to ground which means that all Outputs are connected to the same ground namely the ground of the host computer.

Due to this characteristic it is possible to switch the outputs much faster on and off.

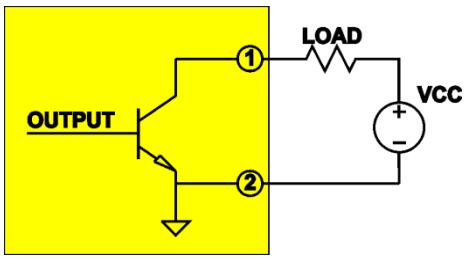

Fig. 7 Open Collector Principle

The principal of open collector outputs is shown in Fig. 7. While solid state relays create a connection between two terminals of the IO-Connector (e.g. 1 and 2) an open collector output connects one terminal (e.g. 1) to ground.

In this application an external power supply VCC and an external load are connected to terminal 1 and 2 of an output. The negative Terminal of the power supply VCC must be connected to the terminal 2 (resp. 4, 6 or 8) of the DO4-O module. The load must be connected to terminal 1 (resp. 3, 5 or 7) of the DO4-O module.

If the physical output is set, the transistor is switched on, connecting terminal 1 to ground.

The biggest advantage of Open Collector outputs is the very fast switching time. DO4-O modules are best suited for applications where fast switching is required e.g. switching or dimming of lamps especially LEDs with PWM cycles of 100 Hz or faster.

Note:
As Fig. 7 shows the output is not floating, but it is connected to internal ground. In contrast to solid state relays it must be considered that there is one common ground for all outputs.

The output is not protected against overcurrent. It must be ensured that the current does not extend I_{OCMax}. Otherwise the output may be damaged.

The output is not protected against wrong polarization of the input voltages. Connecting a negative voltage to a positive output pin may damage the output.

The DO4-O module supports Reflect Mode, Duty-Cycle Mode and On-Off Mode.

For Duty Cycle and On-Off Modes the minimum on and off times are limited to T_{OCMin}.

2.2.2.3 DO4-S (SPDT)

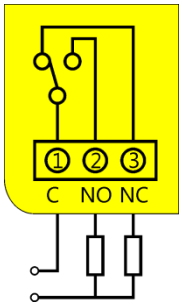

Fig. 8 Relay Output

Fig. 8 shows the connection of the first of the four single pole rouble throw (SPDT) relay outputs with its terminals 1, 2 and 3. The DO4-S module has 12 IO terminals instead of 8.

In the example the common contact “C” can be toggled between two resistors. While the output is deactivated the contact “C” is connected to

the contact “NC” (Normally Close). When the output is activated the Contact “C” is connected to the contact “NO” (Normally Open).

The terminals 1/4/7/10, 2/5/8/11 and 3/6/9/12 are identical.

All outputs of the DO4-S modules are galvanically-insulated and potential-insulated and therefore can be seen as separate units without interference.

The polarity can be disregarded i.e. it does not play a role which IO is connected to positive or negative polarity.

If an output is cleared it disconnects the C contact from the NO contact and connects it with the NC contact. This behavior is called “single pole double throw” (SPDT) and allows the selection of two different signals (toggling).

Fig. 4 shows that the IO-Connector of the module has not 8 but 12 terminals.

The output is not protected against overcurrent. It must be ensured that the current does not extend $I_{SPDTMax}$. Otherwise the output may be damaged.

The DO4-S module supports Reflect Mode and On-Off Mode only. Because of limited number of switching Duty-Cycle Mode is not supported.

For On-Off Mode the minimum on and off times are limited to T_{SSRMin}.

2.3 Setup of Hard- and Software

Setting up LucidControl hardware is extremely easy:

1. Ensure that no signal is applied to the IO Connector
2. Connect LucidControl via USB with the computer
3. Applies for Microsoft windows only: The system asks for an installation file. This is not a driver but only an information file (INF). The file can be downloaded from our website www.lucid-control.com/downloads
4. That’s all. LucidControl switches the green power LED on and the module is ready for usage.

2.3.1 Microsoft Windows®

As mentioned the installation under Microsoft Windows requires the information file.

After finished installation the Windows Device Manager contains a new serial port (COM). The module can be accessed using this port.

Note:
Even if more than one module is connected to a computer Windows ensures that the same serial port number is assigned to the module(s) after restart.

2.3.2 Linux

Despite to Windows installation under Linux the module is usable immediately after connection without any additional steps. Linux installs /dev/ttyACM devices for any module connected to the computer.

Note:
By default Linux cannot ensure that the same /dev/ttyACM device is assigned to the same module on restart. But as long as only one module is connected to the computer it is ensured that it is accessible via /dev/ttyACM0.

This problem can be solved by the LucidIoCtrl command line tool which can create static devices always pointing to a specific module. Moreover the device can be given useful names e.g. dev/digitalIoKitchen.

Please see the section … of the general LucidIo User Manual for more information..

2.3.3 Get command line LucidIoCtrl

LucidIoCtrl command line tool can be downloaded from our website:

www.lucid-control.com/downloads

This page provides the command line tool LucidIoCtrl for different architectures.

After downloading the program can be stored in a folder of choice.

Please see the section … of the general LucidControl User Manual for more information about this helpful tool..

2.3.4 Ready for Take-Off

After the module was installed successfully (if it was necessary at all) the green Power LED is switched on signaling that the module is ready for use.

Since the module was preconfigured for standard input mode (see ...) it can be used without further configuration. The following examples demonstrate the functionality of the module by using the LucidIoCtrl command line tool.

.

Windows Examples
For all examples it is assumed that the module is connected to COM1.

Setting output channel number 0 to "1"

```
      LucidIoCtrl –dCOM1 –tL –c0 –w1 [ENTER]
```

Resetting output channel number 0 to "0"

```
      LucidIoCtrl –dCOM1 –tL –c0 –w0 [ENTER]
```

Reading the outputs of all 4 channels back

```
      LucidIoCtrl –dCOM1 –tL –c0,1,2,3 –r [ENTER]
->    CH0:00  CH1:00  CH2:00  CH3:00
```

Linux Examples:
For all examples it is assumed that the module is connected to /dev/ttyACM0.

Setting output channel number 0 to "1"

```
      LucidIoCtrl –d/dev/ttyACM0 –tL –c0 –w1 [ENTER]
```

Resetting output channel number 0 to "0"

```
      LucidIoCtrl –d/dev/ttyACM0 –tL –c0 –w0 [ENTER]
```

Reading the outputs of all 4 channels back

```
      LucidIoCtrl –d/dev/ttyACM0 –tL –c0,1,2,3 –r [ENTER]
->    CH0:00  CH1:00  CH2:00  CH3:00
```

3 Module Usage

3.1 Output Modes

This section describes the operation of the different output modes and gives examples how the outputs can be controlled.

Each of the outputs of the module can work in one of the following modes:

- Reflect Mode
- Duty-Cycle Mode
- On-Off Mode

Physical output value inversion:
Digital outputs distinguish between physical and logical state. The logical state is the current internal state of the output which can be "0" (cleared) or "1" (set). The logical state is calculated by the output handling and is normally identical to the physical output state.

Normally, setting the logical output state to "1" sets the physical output state to "1" which results in an output being enabled.

In the case that the output inversion is activated by setting *outDiInverted* to "on" the logical and physical states are inverted which means that the physical output is inverted in relation to the logical output value. Setting the logical output to "1" clears the physical output state to "0" which results in an output being disabled.

All output modes support inversion of physical state.

3.1.1 Reflect Mode

Reflect Mode is the simplest output mode and links the value written to an output with the physical output directly.

Writing "1" to the output causes the output being set immediately.

Writing "0" to the output causes the output being cleared immediately.

By setting and clearing outputs in Reflect Mode any pattern of the output signal can be generated, but the timing is limited by the communication protocol and the host computer.

This means e.g. that switching an output on and off every 1ms would need 1000 commands per second. This is not realistic because common operating systems do not

allow such a fast timing. Moreover the communication (e.g. via USB) takes some time. Altogether this would lead into an inaccurate and non-deterministic timing of the signal.

Duty-Cycle Mode and On-Off Mode prevent this by implementing the critical timing in the module.

LucidIoCtrl Command Line Tool Example:
Configure output channel 0 for Reflect mode

```
LucidIoCtrl -dCOM4 -c0 -soutDiMode=reflect [ENTER]
```

Set output channel 0 to "1"

```
LucidIoCtrl -dCOM4 -c0 -tL -w1 [ENTER]
```

… and Set the channel 0 back to "0"

```
LucidIoCtrl -dCOM4 -c0 -tL -w0 [ENTER]
```

3.1.2 Duty-Cycle Mode and Generation of PWM

In Duty-Cylce Mode the module switches outputs on and off in a periodical sequence which is also referred to as PWM (pulse-width-modulation).

By switching an output on and off periodically it is e.g. possible to control the power consumed by a device and can be used for e.g. controlling the power of a pump or a heating element. By adding a temperature sensor connected to a LucidControl RI4 module a temperature control loop can be realized.

Switching a lamp or a LED very fast (T_{Cycle} < 10 ms) allows the dimming of them very easily.

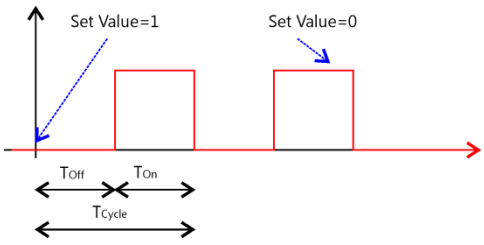

Fig. 9 Duty-Cycle Mode

Fig. 9 shows the typical periodical signal generated in Duty-Cycle Mode.

Setting the output value to "1" starts the processing of output handling until the output value is set to "0" which ends the processing after finishing the running cycle.

The timing of the generated signal is configured by two parameters:

- T_{Cycle} defines the cycle time (period) of the signal and can be configured by the IO Configuration Parameter *outDiCycleTime*.
- The IO Configuration Parameter *outDiDutyCycle* defines the relation of the on-time T_{On} and the off-time T_{Off}
  - On-time equals to $T_{On} = \frac{T_{Cycle}}{1000} * DutyCycle$

- Off-time equals to $T_{Off} = T_{Cycle} - \frac{T_{Cycle}}{1000} * DutyCycle$

The resolution of the generated signal is $\frac{T_{Cycle}}{1000}$ which means that on-time and off-time have a resolution of 1 ‰.

Changing the parameters *outDiCycleTime* or *outDiDutyCylce* while processing of the Duty-Cycle outputs is running updates the values immediately.

Physical Output Value Inversion:

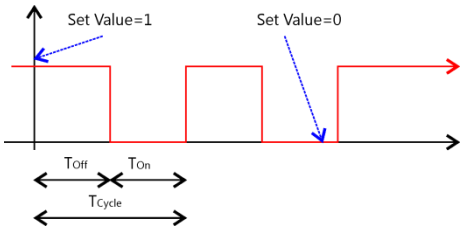

Fig. 10 Duty-Cycle Mode Output Inversion

Fig. 10 shows the physical output state of the example above in the case that physical output inversion is activated by setting the IO Configuration Parameter *outDiInverted* to "on".

While the processing of the outputs of both examples is identical, the figure shows the inverted physical output.

Cancelation of On-Phase:

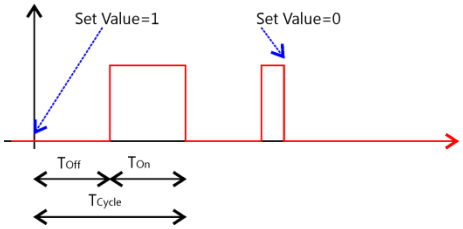

Fig. 11 Duty-Cycle Mode Cancel On-Phase

In the examples above setting the output value to "0" causes the end of the Duty-Cycle processing.

As long as the logic output is "0" value the running cycle can be interrupted immediately by setting the logic value to "0". But in the case that the logic output value is "1" the processing can earliest stop after the on-state has finished as shown in Fig. 9.

Fig. 11 shows the behavior of the output if the IO Configuration Parameter *outDiCanCancel* is set to "on". This allows stopping the logic on-phase immediately returning to "0" when the output processing is stopped by setting the output value to "0".

Updating of Parameters

While output processing is running the IO Configuration Parameters *outDiCycleTime* and *outDiDutyCycle* can be updated at any time. The changed values will be used immediately i.e. for the running cycle also.

Note:

Mechanical relays have a limited switching capability of approx. 1.000.000 on-off cycles. Because of this the Duty-Cycle Mode is not available for DO4-S module.

LucidIoCtrl Command Line Tool Example

Configure output channel 0 for Duty-Cycle mode

```
LucidIoCtrl -dCOM4 -c0 -soutDiMode=dutyCycle [ENTER]
```

Start processing of PWM signal for output channel 0

```
LucidIoCtrl -dCOM4 -c0 -tT -w1 [ENTER]
```

Since the module was preconfigured with T_{Cycle} = 1 s and DutyCycle = 50% the output is switchted 500 ms to "1" and 500 ms to "0"

Changing T_{Cycle} to 2 s

```
LucidIoCtrl -dCOM4 -c0 -soutCycleTime=2000000 [ENTER]
```

The output is now 1 s switched on and 1 s switched of

Increase DutyCycle = 75%

```
LucidIoCtrl -dCOM4 -c0 -soutDutyCycle=750 [ENTER]
```

... and disable processing of output channel 0

```
LucidIoCtrl -dCOM4 -c0 -tT -w0 [ENTER]
```

3.1.3 On-Off Mode

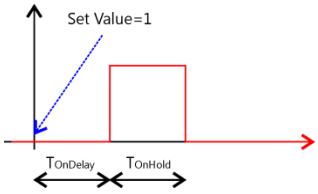

Fig. 12 On-Off Mode

In On-Off Mode the output generates a one-time sequence pattern shown in Fig. 12.

By using On-Off Mode time controlled switching functions (e.g. used in timing relays) can be realized.

Setting the logic value of the output to "1" starts processing of the output handling by starting the $T_{OnDelay}$ interval. After $T_{OnDelay}$ has passed the logic output value changes to "1" and T_{OnHold} interval starts. After T_{OnHold} time has passed the logic value returns to initial "0" state and the sequence finishes.

In On-Off Mode the following two IO Configuration Parameters are relevant for timing configuration:

- Time $T_{OnDelay}$ is specified by the parameter *outDiOnDelay*
- Time T_{OnHold} is specified by the parameter *outDiOnHold*

Physical Output Value Inversion:

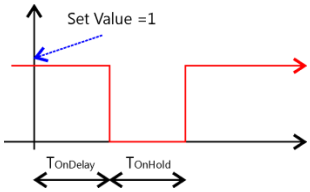

Fig. 13 On-Off Mode Output Inversion

Fig. 13 shows the inverted physical output value of the example above in the case that physical output inversion is activated by setting the IO Configuration Parameter *outDiInverted* to "on".

Cancelation of On-Phase:

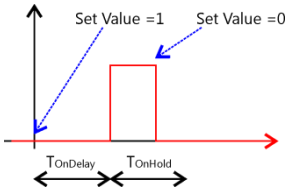

Fig. 14 On-Off Mode Cancel On Phase

Fig. 14 shows the behavior of the output value in the case that IO Configuration Parameter *outDiCanCancel* is set to "on" and the logical output value is set to "0" before T_{OnHold} has passed.

While in the previous Figures the on-phase finishes after T_{OnHold} has passed *outDiCanCancel* allows canceling the on-phase immediately by setting the output value to "0".

Retrigger of On-Phase:

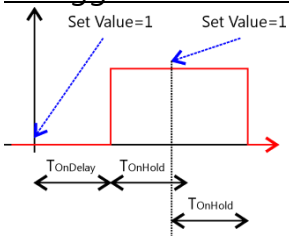

Fig. 15 On-Off Mode Retrigger

Fig. 15 shows the output timing sequence with IO Configuration Parameter *outDiCanRetrigger* set to "on".

This setting allows retriggering the on-phase before the logical output returns to initial "0" value.

Setting the logical output value to "1" before T_{OnHold} has passed restarts the T_{OnHold} interval again.

Note:

It is save to combine IO Configuration Parameters *outDiCanRetrigger*="on" and *outDiCanCancel*="on". This allows retriggering of on-phase as well as on-phase cancelation.

LucidIoCtrl Command Line Tool Example

Configure output channel 0 for On-Off mode

```
LucidIoCtrl -dCOM4 -c0 -soutDiMode=onOff [ENTER]
```

Since the module was preconfigured with $T_{OnDelay}$ = 1 s and T_{OnHold} = 1 after writing a "1" to output value of channel 0 will set the output after 1 s for 1 sec returning to "0" finally.

Start processing of output channel 0

```
LucidIoCtrl -dCOM4 -c0 -tT -w1 [ENTER]
```

3.2 Timing Limits

Duty-Cycle Mode and On-Off Mode use fast internal timers providing a high resolution and accuracy.

Module	Timing resolution (t_{Res})
DO4-I	10 ms
DO4-O	0.5 ms
DO4-S	100 ms

Tab. 1 Timing Resolution

The time t_{Res} given in Tab. 1 defines the minimum timing resolution which is necessary in order to fulfill the output restrictions of the different output types.

The timing resolution defines the minimum interval for a single on-phase or off-phase of the output. If a specified or calculated on-time or off-time is lower than t_{Res} the void phase is skipped.

Example:
The output 0 of DO4-S module is configured for mode Duty-Cycle with T_{Cycle}=1 s (1.000.000 µs) and a DutyCyle of 50‰.

The resulting times are T_{On}=50 ms and T_{Off}=950 ms. Since T_{On} violates the t_{Res} constraint requesting more than 100 ms as minimum interval the on-phase of the output is skipped, causing the output staying low permanently.

Maximum timing interval
T_{Cycle}, $T_{OnDelay}$ and T_{OnHold} have a common maximum limit of 3.600.000 µs (1 hour) for all modules.

3.3 Commands

After an output was set up correctly and configured it is possible to set the output value or to read back its state.

Accessing inputs and outputs is a very common task which is mostly identical for all Lucid Control modules. Please refer to the section 3.2.1.1, 3.2.1.2 and 4.3 of the general LucidControl manual for comprehensive information covering reading and writing of inputs and outputs in general.

The following sections describe in detail the commands which are supported by the DO4 module.

3.3.1 SetIo

This command sets one output value.

Mode	Value
Reflect	Value reflects the logic state to the output
Duty-Cycle	Status of the Duty-Cycle Mode processing. "1" refers to enabled processing, "0" to disabled processing.
On-Off	Status of the On-Off Mode processing. "1" refers to enabled processing, "0" to disabled processing.

Tab. 2 Output Values

Command	SetIo	**Access**	Write
Opcode	0x40		
LucidIoControl Command Line Tool			
Call (-tL)	`LucidIoCtrl –d[COMx] –c[Channel] –tL –w[Value]`		

Note:
When using the LucidIoCtrl command line tool the distinction between the SetIo and SetIoGroup commands is not necessary since LucidIoCtrl command line tool handles this automatically.

LucidIoCtrl Command Line Tool Example
Set output channel 0 to "1":

```
LucidIoCtrl –dCOM4 –c0 –tL –w1 [ENTER]
```

Accordingly to Tab. 2 writing of "1" means to set the output in Reflect Mode. In Duty-Cycle and On-Off Mode writing of "1" means starting of output processing.

Request Frame

OPC	P1	P2	LEN	Data Field
0x40	Channel	Value Type	Length	Value

Value	Description
Channel	Number of input or output channel (Range: 0 ~ 3)
Value Type	Value Type Supported Value ypes **Value Type** / **Value Range** / **Length** Digital Logic Value (0x00) / 0x00 oder 0x01 / 1 Byte
Length	Length of the Values in the Data Field
Value	Values accordingly to the Value Type

Tab. 3 SetIo Request

Response Frame

Status	Length
Status	0

The command does not return any data. In the case of an error the command returns Execution Status Code documented in section 4.4 of the LucidControl User Manual.

3.3.2 SetIoGroup

This command sets the output values of multiple outputs at once at the same type.

Command	SetIoGroup	**Access**	Write
Opcode	0x42		
LucidIoControl Command Line Tool			
Call (-tL)	`LucidIoCtrl –d[COMx] –c[Channels] –tL –w[Values]` Channels: Comma separated list of channels e.g. –c0,1,3 Values: Comma separated list of values to set e.g. -w1,1,0		

LucidIoCtrl Command Line Tool Example

Set output channel 0 to “1”, output channel 2 to “1” and output channel 3 to “0”:

```
LucidIoCtrl –dCOM4 –c0,2,3 –tL –w1,1,0 [ENTER]
```

Request Frame:

OPC	P1	P2	LEN	Data Field
0x40	Channel Mask	Value Type	Length	Values

Value	Description
Channel Mask	Channel Mask Specifies the output channels to access **Channel / Bit Position / Value** 0 / 0 / 0x01 1 / 1 / 0x02 2 / 2 / 0x04 3 / 3 / 0x08 Values are bitwise or combined Examples: Accessing channel 0 and 3 Value = 0x01 OR 0x08 = 0x09 Accessing channel 1 and 2 Value = 0x02 OR 0x04 = 0x06
Value Type	Value Type Supported Value Types **Value Type / Value Range / Length** Digital Logic Value (0x00) / 0x00 oder 0x01 / 1 Byte
Length	Length of the Values in the Data Field (One Value for every channel)
Values	Values accordingly to the Value Type

Tab. 4 SetIoGroup Request

Response Frame

Status	Length
Status	0

The command does not return any data. In the case of an error the command returns Execution Status Code documented in section 4.4 of the LucidControl User Manual.

Example of SetIoGroup

The following request frame sets:

- outputs 0 to “1”; output 1 to “1” and output 3 to “0”

Request Frame

OPC	P1	P2	LEN	Data Field
0x42	0x0B	0x00	0x03	Byte: 0 = 0x01, 1 = 0x01, 2 = 0x00

Channel Mask for Param1: 0x01 OR 0x02 OR 0x08 = 0x0B
Output Values in Data Field are sorted: Channel 0, Channel 1, Channel3

Response Frame:

Status	Length
0x00	0x00

3.3.3 GetIo

Command	GetIo	**Access**	Read
Opcode	0x46		
LucidIoControl Command Line Tool			
Call (-tL)	`LucidIoCtrl –d[COMx] –c[Channel] –tL –r`		
Return	CHn:ll n – Input Channel ll – Input Digital Value		

Note
When using the LucidIoCtrl command line tool the distinction between GetIo and GetIoGroup commands is not necessary since the program handles this automatically.

LucidIoCtrl Command Line Tool Example
Read output channel 0:

```
      LucidIoCtrl –dCOM4 –c0 –tL -r [ENTER]
->    CH0:01
```

Request Frame

OPC	P1	P2	LEN
0x46	Channel	Value Type	0

<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>Channel</td><td>Number of input or output channel (Range: 0 ~ 3)</td></tr>
<tr><td>Value Type</td><td>Supported Value Types
<table>
<tr><th>Value Type</th><th>Value Range</th><th>Response Len</th></tr>
<tr><td>Digital Logic Value (0x00)</td><td>0x00 oder 0x01</td><td>1 Byte</td></tr>
</table>
</td></tr>
</table>

Tab. 5 GetIo Request

Response Frame:
In case of successful execution the command returns the value of the specified channel number.

Status	LEN	Data Field
Status	Length	Value(s)

In the case of an error the command returns Execution Status Code documented in section 4.4 of the LucidControl User Manual.

3.3.4 GetIoGroup

This command reads the logic output values of a group of outputs of the same Value Type. See also section 3.3.3.

Command	GetIoGroup	**Access**	Read
Opcode	0x48		
LucidIoControl Command Line Tool			
Call (-tL)	`LucidIoCtrl –d[COMx] –c[Channels] –tL –r` Channels: Comma separated list of channels e.g. –c0,1,3		
Return	List of values sorted from lower to higher channels CHn:xx n – Input Channel ll – Input Digital Value		

LucidIoCtrl Command Line Tool Example

Read output values of channel 0, 1 and 3:

```
LucidIoCtrl –dCOM4 –c0,1,3 –tL –r [ENTER]
CH0:00  CH1:01  CH3:01
```

Request Frame

OPC	P1	P2	LEN
0x48	Channel Mask	Value Type	0

<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>Channel Mask</td><td>Channel Mask
Specifies the output channels to access
<table>
<tr><th>Channel</th><th>Bit Position</th><th>Value</th></tr>
<tr><td>0</td><td>0</td><td>0x01</td></tr>
<tr><td>1</td><td>1</td><td>0x02</td></tr>
<tr><td>2</td><td>2</td><td>0x04</td></tr>
<tr><td>3</td><td>3</td><td>0x08</td></tr>
</table>
Values are bitwise or combined

Examples:
Accessing channel 0 and 3 Value = 0x01 OR 0x08 = 0x09
Accessing channel 1 and 2 Value = 0x02 OR 0x04 = 0x06</td></tr>
<tr><td>Value Type</td><td>Supported Value Types
<table>
<tr><th>Value Type</th><th>Value Range</th><th>Response Len</th></tr>
<tr><td>Digital Logic Value (0x00)</td><td>0x00 oder 0x01</td><td>1 Byte</td></tr>
</table></td></tr>
</table>

Tab. 6 GetIoGroup Request

Response Frame:
In case of successful execution the command returns the read values of the channels specified in the Channel Mask.

Status	LEN	Data Field
Status	Length	Value

In the case of an error the command returns Execution Status Code documented in section 4.4 of the LucidControl User Manual.

Example of GetIoGroup Request:
The following request frame reads outputs 0, 1 and 3

Opcode	P1	P2	Length
0x48	0x0B	0x00	0x00

Channel Mask (P1): 0x01 OR 0x02 OR 0x08 = 0x0B

Response Frame:
For input 0 = “0”, input 2 = “1” and input 3 = “1”

Values in Data Field are in ascending order Channel 0, Channel 1, Channel3.

Header Field		Data Field		
Status	LEN	Value Channel 0	Value Channel 1	Value Channel 3
0x00	0x03	0x00	0x01	0x01

3.4 Parameters

LucidControl modules allow configuration by a set of System Configuration Parameters and IO Configuration Parameters.

The Parameters are accessible via the SetParam and GetParam command which are described in sections 4.3.5 and 4.3.6 of the LucidControl User Manual.

The relevance of some parameter may depend on the operation mode described in section 3.1.

3.4.1 outDiValue

This IO Configuration Parameter reflects the value or the state of the output (see Tab. 2).

In the case the output is in Reflect mode the *outDiValue* contains the logic value of the output.

In the case that the output is in Duty-Cycle or On-Off mode *outDiValue* contains "1" in the case that the output processing is running and "0" in the case that the output processing is stopped.

Parameter	outDiValue	**Access**	Read / Write
Address	0x1000		
Values	Output Value		
Default Value	0x00	**Parameter Type**	1 Byte unsigned
LucidIoControl Command Line Tool			
Parameter Name	outDiValue	**Parameter Values**	0x00 or 0x01
Call (Set)	`LucidIoCtrl –d[COMx] –c[Channel] –soutDiValue=[Value] {-p} {--default}`		
Call (Set	`LucidIoCtrl –d[COMx] –c[Channel] –goutDiValue`		

LucidIoCtrl Command Line Tool Example

Set value of output channel 0 to "1" and make the setting persistent:

```
      LucidIoCtrl –dCOM4 –c0 –soutDiValue=1 –p [ENTER]
```

Read value or state of output channel 0:

```
      LucidIoCtrl –dCOM4 –c0 –goutDiValue [ENTER]
->    outDiValue=0
```

Note:
For normal operation it is recommended to use the functions SetIo (3.3.1) and GetIo (3.3.3) in order to write or read to an output.

Setting *outDiValue* allows making a value persistent by means that the output value is restored after the module is restarted.

3.4.2 outDiMode

This IO Configuration parameter configures the operation mode of the output.

<table>
<tr><td>Parameter</td><td>outDiMode</td><td>Access</td><td>Read / Write</td></tr>
<tr><td>Address</td><td>0x1100</td><td colspan="2"></td></tr>
<tr><td>Values</td><td colspan="3">Output Mode<table><tr><th>Byte</th><th>Mode</th></tr><tr><td>0x00</td><td>Inactive</td></tr><tr><td>0x01</td><td>Reflect</td></tr><tr><td>0x08</td><td>On-Off</td></tr><tr><td>0x0A</td><td>Duty-Cycle</td></tr></table></td></tr>
<tr><td>Default Value</td><td>0x00</td><td>Parameter Type</td><td>1 Byte unsigned</td></tr>
<tr><td colspan="4">LucidIoControl Command Line Tool</td></tr>
<tr><td>Parameter Name</td><td>outDiMode</td><td>Parameter Values</td><td>incactive / reflect / onOff / dutyCycle</td></tr>
<tr><td>Call (Set)</td><td colspan="3"><code>LucidIoCtrl –d[COMx] –c[Channel] –soutDiMode=[Value] {-p} {--default}</code></td></tr>
<tr><td>Call (Get)</td><td colspan="3"><code>LucidIoCtrl –d[COMx] –c[Channel] –goutDiMode</code></td></tr>
</table>

LucidIoCtrl Command Line Tool Example
Set operation mode of channel 0 to Duty-Cycle Mode and make the setting persistent.

```
LucidIoCtrl –dCOM4 –c0 –soutDiMode=dutyCycle –p [ENTER]
```

Read the operation mode of channel 0

```
LucidIoCtrl –dCOM4 –c0 –goutDiMode [ENTER]
outDiMode=dutyCycle
```

3.4.3 Bit Parameter outDiFlags

This IO Configuration Parameter groups parameters which are represented by one bit e.g. having an “on” or “off” state only).

Parameter	outDiFlags	**Access**	Read / Write
Address	0x1101		
Values	The "bit container" consists of the following parameters. **Bit Parameter** / **Bit Postion** outDiCanRetrigger / Bit 0 outDiCanCancel / Bit 1 outDiInverted / Bit 2		
Default Value	0x00	**Parameter Type**	1 Byte unsigned

Note:
The parameter *outDiFlags* cannot be accessed by the Command Line Tool. The Bit Parameters should be used instead.

Note:
When *outDiFlags* is changed by the SetParam command which is described in section 4.3.5 of the LucidControl User Manual the current setting of *outDiFlags* must be read before updating it in order to prevent overwriting other Bit Parameters.

3.4.3.1 outDiInverted

This Bit Parameter configures the inversion of the physical output value.

See output modes descriptions in section 3.1 for more information.

Parameter	outDiFlags	**Access**	Read / Write
Address	0x1101	Bit Parameter outDiFlags	
Values	**Bit Parameter** / **Bit Postion** outDiInverted / Bit 2		
Default Value	Off	**Parameter Type**	1 Bit
LucidIoControl Command Line Tool			
Parameter Name	outDiInverted	**Parameter Values**	on / off
Call (Set)	`LucidIoCtrl -d[COMx] -c[Channel] -soutDiInverted=[Value] {-p} {--default}`		
Call (Get)	`LucidIoCtrl -d[COMx] -c[Channel] -goutDiInverted`		

LucidIoCtrl Command Line Tool Example
Enable inversion of physical output channel 0 and make the setting persistent.

```
      LucidIoCtrl -dCOM4 -c0 -soutDiInverted=on -p [ENTER]
```

Read inversion configuration of physical output channel 0

```
      LucidIoCtrl -dCOM4 -c0 -goutDiInverted [ENTER]
->    outDiInverted=on
```

3.4.3.2 outDiCanCancel

This Bit Parameter configures the output on-phase cancelation.

See the output modes descriptions in section 3.1 for more information.

Parameter	outDiFlags	**Access**	Read / Write
Address	0x1101	Bit Parameter outDiFlags	
Values	**Bit Parameter**: outDiCanCancel — **Bit Postion**: Bit 1		
Default Value	Off	**Parameter Type**	1 Bit
LucidIoControl Command Line Tool			
Parameter Name	outDiCanCancel	**Parameter Values**	on / off
Call (Set)	`LucidIoCtrl –d[COMx] –c[Channel] –soutDiCanCancel=[Value] {-p} {--default}`		
Call (Get)	`LucidIoCtrl –d[COMx] –c[Channel] –goutDiCanCancel`		

LucidIoCtrl Command Line Tool Example

Enable output cancelation output channel 0 and make the setting persistent.

```
LucidIoCtrl –dCOM4 –c0 –soutDiCanCancel=on –p [ENTER]
```

Read configuration of output cancelation of output channel 0

```
LucidIoCtrl –dCOM4 –c0 –goutDiCanCancel [ENTER]
->  outDiCanCancel=on
```

3.4.3.3 outDiCanRetrigger

This Bit Parameter configures the on-phase retrigger function of the output.

See the output modes descriptions in section 3.1 for more information.

Parameter	outDiFlags	**Access**	Read / Write
Address	0x1101	Bit Parameter outDiFlags	
Values	**Bit Parameter**: outDiCanRetrigger — **Bit Postion**: Bit 0		
Default Value	Off	**Parameter Type**	1 Bit
LucidIoControl Command Line Tool			
Parameter Name	outDiCanRetrigger	**Parameter Values**	on / off
Call (Set)	`LucidIoCtrl –d[COMx] –c[Channel] –soutDiCanRetrigger=[Value] {-p} {--default}`		
Call (Get)	`LucidIoCtrl –d[COMx] –c[Channel] –goutDiCanRetrigger`		

LucidIoCtrl Command Line Tool Example

Enable output retrigger of channel 0 and make the setting persistent.

```
LucidIoCtrl –dCOM4 –c0 –soutDiCanRetrigger=on –p [ENTER]
```

Read output retrigger configuration of output channel 0

```
      LucidIoCtrl –dCOM4 –c0 –goutDiCanRetrigger [ENTER]
->    outDiCanRetrigger=on
```

3.4.4 outDiCycleTime

This IO Configuration Parameter specifies the cycle time T_{Cycle} of an output in Duty-Cycle Mode.

Parameter	outDiCycleTime	**Access**	Read / Write
Address	0x1110		
Values	T_{Cycle} in µs (micro seconds) $T_{Res} \leq T_{Cycle} \leq 1$ h		
Default Value	1,000,000 (1 s)	**Parameter Type**	4 Bytes unsigned
LucidIoControl Command Line Tool			
Parameter Name	outDiCycleTime	**Parameter Values**	Time [µs]
Call (Set)	`LucidIoCtrl –d[COMx] –c[Channel] –sinDiCycleTime=[Time] {-p} {--default}`		
Call (Get)	`LucidIoCtrl –d[COMx] –c[Channel] –ginDiCycleTime`		

LucidIoCtrl Command Line Tool Example

Set T_{Cycle} of input channel 0 to 1.5 s and make the setting persistent.

```
      LucidIoCtrl –dCOM4 –c0 –sinDiCycleTime=1500000 –p [ENTER]
```

Read T_{Cycle} parameter of input channel 0

```
      LucidIoCtrl –dCOM4 –c0 –ginDiCycleTime [ENTER]
->    inDiCycleTime=1500000
```

Note:

Timing limits for T_{Res} (see 3.2) have to be considered.

3.4.5 outDiDutyCycle

This IO Configuration Parameter specifies the Duty-Cycle of an output in Duty-Cycle mode.

Parameter	outDiDutyCycle	**Access**	Read / Write
Address	0x1111		
Values	Duty Cycle in ‰ (1 / 1000)		
Default Value	500 (50%)	**Parameter Type**	2 Bytes unsigned
LucidIoControl Command Line Tool			
Parameter Name	outDiDutyCycle	**Parameter Values**	Duty Cycle [‰]
Call (Set)	`LucidIoCtrl –d[COMx] –c[Channel] –soutDiDutyCycle=[Time] {-p} {--default}`		
Call (Get)	`LucidIoCtrl –d[COMx] –c[Channel] –goutDiDutyCylce`		

LucidIoCtrl Command Line Tool Example

Set Duty Cycle ot output channel 0 to 20% and make the setting persistent.

```
LucidIoCtrl –dCOM4 –c0 –soutDiDutyCycle=200 –p [ENTER]
```

Read Duty Cycle setting for output channel 0

```
LucidIoCtrl –dCOM4 –c0 –goutDiDutyCycle [ENTER]
outDiDutyCycle=200
```

Note:

Timing limits (see 3.2) have to be considered.

3.4.6 outDiOnDelay

This IO Configuration Parameter specifies the on-delay time $T_{OnDelaye}$ of an output in On-Off Mode.

Parameter	outDiOnDelay	**Access**	Read / Write
Address	0x1112		
Values	$T_{OnDelay}$ in µs (micro seconds) $T_{Res} \leq T_{OnDelay} \leq 1$ h		
Default Value	1,000,000 (1 s)	**Parameter Type**	4 Bytes unsigned
LucidIoControl Command Line Tool			
Parameter Name	outDiOnDelay	**Parameter Values**	Time [µs]
Call (Set)	`LucidIoCtrl –d[COMx] –c[Channel] –soutDiOnDelay=[Time] {-p} {--default}`		
Call (Get)	`LucidIoCtrl –d[COMx] –c[Channel] –goutDiOnDelay`		

LucidIoCtrl Command Line Tool Example

Set $T_{OnDelay}$ for output channel 0 to 520 ms and make the setting persistent.

```
LucidIoCtrl –dCOM4 –c0 –soutDiOnDelay=520000 –p [ENTER]
```

Read $T_{OnDelay}$ setting for output channel 0

```
LucidIoCtrl –dCOM4 –c0 –goutDiOnDelay [ENTER]
->    outDiOnDelay=520000
```

Note:

Timing limits (see 3.2) have to be considered.

3.4.7 outDiOnHold

This IO Configuration Parameter specifies the on-hold time T_{OnHold} of an output in On-Off Mode.

Parameter	outDiOnHold	**Access**	Read / Write
Address	0x1113		
Values	T_{OnHold} in µs (micro seconds) $T_{Res} \leq T_{OnHold} \leq 1$ h		
Default Value	1,000,000 (1 s)	**Parameter Type**	4 Bytes unsigned
LucidIoControl Command Line Tool			
Parameter Name	outDiOnHold	**Parameter Values**	Time [µs]
Call (Set)	`LucidIoCtrl –d[COMx] –c[Channel] –soutDiOnHold=[Time] {-p} {--default}`		
Call (Get)	`LucidIoCtrl –d[COMx] –c[Channel] –goutDiOnHold`		

LucidIoCtrl Command Line Tool Example

Set T_{OnHold} for output channel 0 to 1200 ms and make the setting persistent.

```
LucidIoCtrl –dCOM4 –c0 –soutDiOnHold=1200000 –p [ENTER]
```

Read T_{OnHold} setting for output channel 0

```
LucidIoCtrl –dCOM4 –c0 –goutDiOnHold [ENTER]
->   outDiOnHold=1200000
```

Note:

Timing limits (see 3.2) have to be considered.

4 Specification

Parameter		Condition	Value	
Outputs				
	No of Output Channels		4	
Outputs - Electrical Characteristics				
	Maximum Rated Load Current	DO4-I	I_{SSRMax}	750 mA
		DO4-O	I_{OCMax}	750 mA
		DO4-S	$I_{SPDTMax}$	750 mA
	Maximum Rated Load Voltage	DO4-I	U_{SSRMax}	30 V
		DO4-O	U_{OCMax}	30 V
		DO4-S	$U_{SPDTMax}$	30 V
	Maximum On Resistance	DO4-I	R_{SSR}	0.25 Ω
		DO4-O	R_{OC}	tbd
		DO4-S	R_{SPDT}	0.1 Ω
	Insulation Resistance	DO4-S		1 GΩ
	Insulation Voltage	DO4-I		1,000 V
		DO4-S		400 V AC for 1 minute
Outputs – Timing Characteristic				
	Minimum Resolution t_{Res}	DO4-I		10 ms
		DO4-O		0.5 ms
		DO4-S		100 ms
	T_{Cycle}, $T_{OnDelay}$, T_{OnHold}			t_{Res} < T < 3600 s
Module – Communication				
	USB			2.0 Full Speed CDC Profil
Module – Electrical Characteristics				
	Power Supply			Supplied with +5V by USB No additional Power Supply needed.
	Maximum Rated Supply Current	DO4-I	40 mA	
		DO4-O	40 mA	
		DO4-S	250 mA	
Module – Environment				
	Temperature	Storage		-20 °C … +70 °C
		Operation		0 °C … +55 °C
	Humidity			< 85 % RH, non-condensing
Module – Housing				
	Dimensions L x W x H			90 x 54 x 62 mm
	Weight (in total)			120 g
	Assembly			Rail-Mount (EN 50022, TS35)
	Protection Class (DIN 40050)			IP20

Module - Interconnection			
	Terminal Clamp	DO4-I	Plug-In Terminal 8-way 1,5 mm² wire
		DO4-O	Plug-In Terminal 8-way 1,5 mm² wire
		DO4-S	Plug-In Terminal 12-way 1,5 mm² wire
Module - Indicators			
	• Operation and Error Indicator • Communication Indicator • Indicator for Output State (Enabled / Disabled)		
Software			
	Supported Systems		Windows® XP, Windows® Vista, Windows® 7 Ubuntu, Raspbian, Debian

5 Order Information and Accessories

Digital Output Product Family

Order Code	Product
LCTR-DO4-I	LucidControl Digital Output USB Module 4-Channels with Solid State Relays (SSR)
LCTR-DO4-O	LucidControl Digital Output USB Module 4-Channels with Open Collectors (OC)
LCTR-DO4-S	LucidControl Digital Output USB Module 4-Channels with Relays (SPDT)

The following accessories are available:

Order Code	Product
LCTR-AK1710-8	Plug-In Terminal 8-way 1,5 mm² wire
LCTR-AK1710-12	Plug-In Terminal 12-way 1,5 mm² wire

deciphe it GmbH
Schäferstr. 5
87600 Kaufbeuren / Germany
www.lucid-control.com