User Manual

Lucid485 DO16

16 Open Collector Digital Output Serial Module

Table of Content

1 Introduction

This document describes the functionality of the Lucid485 DO16 USB IO module with 16 digital outputs controllable by the Universal Serial Bus.

A basic description of the Lucid485 product family can be found in the general *Lucid485 User Manual*.

2 Setup and Installation

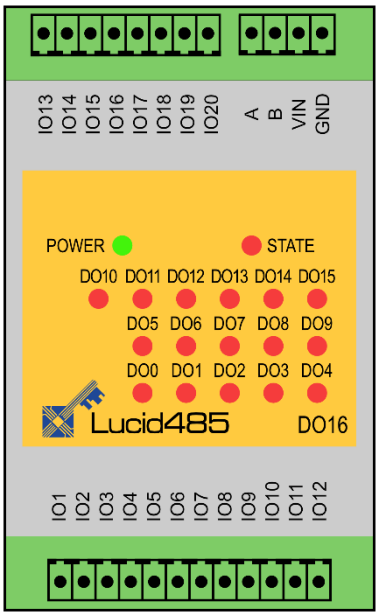

Fig. 1 Lucid485 DO16 Module

Fig. 1 shows the drawing of the DO16 digital output module with 16 digital outputs channels.

The IO signals are connected to the lower (IO1 – IO12) and the upper (IO13 – IO20) IO terminals.

2.1 Safety Information

Lucid485 complies with regulations and industrial standards active in the EU. To keep the device functional, the following safety and maintenance information must be adhered.

The device must only be used for the intended purpose.

The device must not be used under the following conditions:

- It is obviously damaged
- An error was detected
- Outside humidity and temperature limits
- Unauthorized personnel

Never apply voltages higher than 30V to any IO terminal. This would damage the device.

All contacts of the modules are protected against ESD but not necessarily against overload, which is especially relevant for output modules.

2.2 RS-485 bus and Power Connection

Please see the general *Lucid485 User Manual*.

2.3 LucidIoCtrl Command Line Tool

The LucidIoCtrl command line tool gives full access to all Lucid485 modules operating with Frame Protocol enabled. Executables for different architectures and can be downloaded from our website:

https://www.lucid-control.com/downloads

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

Please see the general *Lucid485 User Manual* for more information.

2.3.1 First Steps

When the module is powered, the green power LED is switched on, signaling that the module is ready.

The following examples demonstrate the functionality of the module by using the LucidIoCtrl command line tool.
It is assumed that the module is configured with default address 11, 9600 baud, 8N1.
The serial to RS-485 adapter is connected to COM1 of the host.

Windows Examples

Setting output channel number 0 to "1"

```
      LucidIoCtrl -drs485:COM1:11 -tL -c0 -w1
```

Resetting output channel number 0 to "0"

```
      LucidIoCtrl -drs485:COM1:11 -tL -c0 -w0
```

Reading the output states of the first 4 channels.

```
      LucidIoCtrl -drs485:COM1:11 -tL -c0,1,2,3 -r
->    CH0:00  CH1:00  CH2:00  CH3:00
```

Windows requires a different argument for comport numbers 10 and higher.

```
      LucidIoCtrl -drs485:\\.\COM10:11 -tL -c0,1,2,3 -r
->    CH0:00  CH1:00  CH2:00  CH3:00
```

Linux Examples

Reading the output states of the first 4 channels.

```
      LucidIoCtrl -drs485:/dev/ttyACM0:11 -tL -c0,1,2,3 -r
->    CH0:00  CH1:00  CH2:00  CH3:00
```

2.4 IO Configurations

Function Class	Value	Channels
DO16	0x9030	16

Tab. 1 Digital Output Function Class

Function Class Type	Value	Output Type
O	0x1200	Open Collector

Tab. 2 Digital Output Function Class Type

Tab. 1 and Tab. 2 lists the Function Class and the Function Class Type of the DO16-O module.

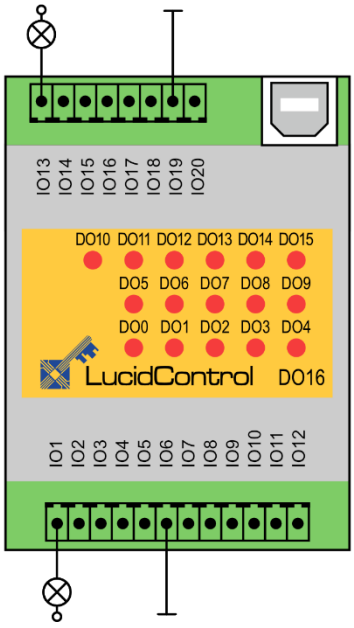

Fig. 2 DO16-O IO Connection

Fig. 2 shows the DO16-O module connection in detail.

Power loads (e.g. a lamp) are connected to IO1 (DO0) and IO13 (DO10).

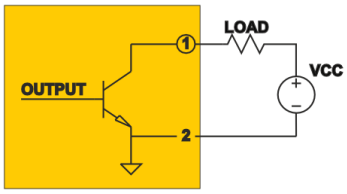

Fig. 3 Open Collector Circuit

The internal circuit of the open collector output is shown in Fig. 3. When the OUTPUT control signal is high, the transistor closes the circuit. This means that IO terminal 1 is connected to ground and the externally applied voltage source VCC powers the load.

The IO terminals of the DO16-O module and their IO channel numbers are listed in Tab. 3.

IO Terminal	Signal	IO Channel Number
1	DO0 +	0
2	DO1 +	1
3	DO2 +	2
4	DO3 +	3
5	DO4 +	4
6	GND	
7	DO5 +	5
8	DO6 +	6
9	DO7 +	7
10	DO8 +	8
11	DO9 +	9
12	GND	
13	DO10 +	10
14	DO11 +	11
15	DO12 +	12
16	DO13 +	13
17	DO14 +	14
18	DO15 +	15
19	GND	
20	+ 5V	V_{USB}

Tab. 3 DO16-O IO Terminal Connector

The open collector outputs are not protected against overcurrent and overvoltage. I_{OCMax} and U_{OCMax} limits must be considered in. Otherwise, the device may be damaged.

The open collector outputs are not protected against wrong polarization of the applied voltages.

The DO16-O module is not insulated, the GND signals are connected to the system ground of the host computer.

2.4.1 Pull-Up Configuration

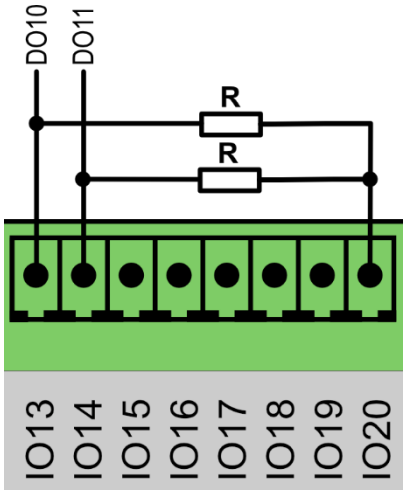

Fig. 4 Pull-Up Configuration

IO20 of the upper IO terminal connector provides the U_P voltage (5V). This voltage can be used in order to make a pull-up configuration as shown for DO10 and DO11 in Fig. 4.

The pull-up resistors R are connected between IO20 and the output IO pin.

If an output channel with pull-up is inactive, the output signal becomes high (+5V), if the output channel is active, the output signal is switched to GND.

When dimensioning the pull-up resistor, values of 1 kΩ – 10kΩ are a good starting point.

Max. I_P must be considered when pull-up resistors are dimensioned.

3 Module Operation

3.1 Output Signal Value Inversion

Digital output channels have an output signal value and a logical output value. The logical output value is the current state of the output which can be "0" (cleared) or "1" (set). The output signal value is calculated by the output handling.

Read and write commands give access to the logical output value.

In the case that *outDiInverted* is set to "off", output signal value inversion is disabled and the output signal values and logical output values are identical.

In the case that inversion is enabled by setting *outDiInverted* to "on" the output signal value is the inverted logical value. Writing "1" to the output channel value clears the output.

All output modes support output signal value inversion.

3.2 Timing Limits

The timing resolution t_{Res} (→ 4) specifies the minimum interval for an on-phase or off-phase. If an on-time or off-time is lower than t_{Res}, the phase is skipped.

Output channels 12 – 15 have limited timing resolution $t_{Res12,15}$.

3.3 Operation 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

3.3.1 Reflect Mode

Reflect Mode gives direct access to the logical output value of the output channel.

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 and USB latency do not allow such a fast and deterministic timing.

Duty-Cycle Mode and On-Off Mode improves this by handling the critical timing in the module.

LucidIoCtrl Command Line Tool Example

Configure output channel 0 for Reflect Mode

```
LucidIoCtrl -drs485:COM4:11 -c0 -soutDiMode=reflect
```

Set output channel 0 to “1”

```
LucidIoCtrl -drs485:COM4:11 -c0 -tL -w1
```

Set the channel 0 back to “0”

```
LucidIoCtrl -drs485:COM4:11 -c0 -tL -w0
```

3.3.2 Duty-Cycle Mode and PWM

In Duty-Cycle Mode the module switches outputs on and off in a periodical PWM (pulse-width-modulation) sequence.

By switching an output periodically on and off it is e.g., possible to control the power consumed by a device and can be used for controlling the power of a pump or a heating element.

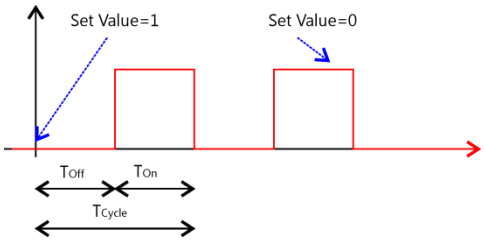

Fig. 5 Duty-Cycle Mode

Fig. 5 shows a periodical signal generated by Duty-Cycle Mode.

Setting the logical output value to “1” starts processing until it is set back to "0".

If the logical output value is set to "0" in off-phase, processing is stopped.

If the value of the output is set to "0" in on-phase, behavior depends on IO Configuration Parameter *outDiCanCancel*.

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 IO Configuration Parameters *outDiCycleTime* or *outDiDutyCylce* while processing is running updates the values immediately.

The calculated values of T_{on} and T_{off} must be in the limits of t_{Res}. Values outside the limits result in permanent off or on state.

Output Signal Value Inversion:

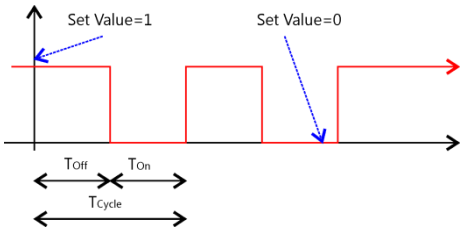

Fig. 6 Duty-Cycle Mode Output Inversion

Fig. 6 shows the output signal value in the case that output signal value inversion is enabled (*outDiInverted* is "on").

Cancelation of On-Phase:

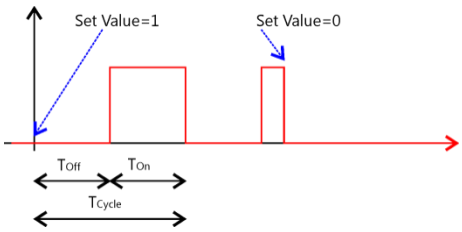

Fig. 7 Duty-Cycle Mode Cancel On-Phase

If output processing is stopped while the output is in on-phase (T_{on}), IO Configuration Parameter *outDiCanCancel* specifies the behavior of stopping.

If *outDiCanCancel* is set to "off" the sequence completes as shown in Fig. 5.

If *outDiCanCancel* is set to "on" the on-phase is interrupted immediately when the output value is set to "0" as shown in Fig. 7.

Updating Parameters
If output processing is running, updates of the IO Configuration Parameters *outDiCycleTime* and *outDiDutyCycle* are applied immediately.

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 -drs485:COM4:11 -c0 -soutDiMode=dutyCycle
```

Start processing of PWM signal for output channel 0

```
LucidIoCtrl -drs485:COM4:11 -c0 -tL -w1
```

By default, the module is configured with T_{Cycle} = 1 s and DutyCycle = 50%. The output channel is switched 500 ms to “1” and 500 ms to “0”.

Changing T_{Cycle} to 2 s

```
LucidIoCtrl -drs485:COM4:11 -c0 -soutDiCycleTime=2000000
```

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

Change DutyCycle to 75%

```
LucidIoCtrl -drs485:COM4:11 -c0 -soutDiDutyCycle=750
```

Disable processing of output channel 0

```
LucidIoCtrl -drs485:COM4:11 -c0 -tT -w0
```

3.3.3 On-Off Mode

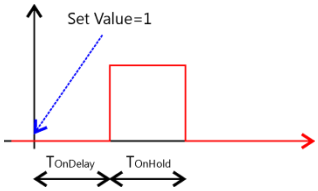

Fig. 8 On-Off Mode

In On-Off Mode the output channel generates a one-time sequence pattern shown in Fig. 8.

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

Setting the output value to “1” starts processing of the output handling by starting the $T_{OnDelay}$ interval (off-phase). After $T_{OnDelay}$ has passed the output changes to on-phase and T_{OnHold} interval starts. After T_{OnHold} time has passed output changes back to off-phase and the sequence finishes.

Writing "0" to the logical output value while being in off-phase stops the sequence in any case, preventing the output entering on-phase.

If the output value is set to "0" in on-phase, behavior depends on IO Configuration Parameter *outDiCanCancel*.

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*

If the values of T_{OnHold} or $T_{OnDelay}$ are outside the limits of t_{Res} off-phase or on-phase are skipped.

Output Signal Value Inversion

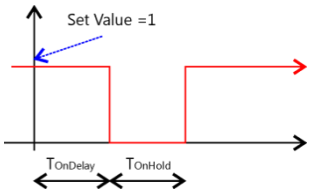

Fig. 9 On-Off Mode Output Inversion

Fig. 9 shows the output signal in case that the output signal inversion is enabled for the output channel (*outDiInverted* set to "on").

Cancelation of On-Phase

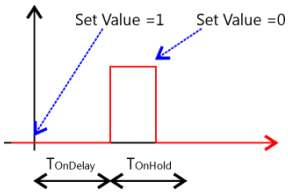

Fig. 10 On-Off Mode Cancel On Phase

If the IO Configuration Parameter *outDiCanCancel* is set to "on", output processing can be stopped by writing "0" to the output channel value. This is shown in Fig. 10 where the on-phase is immediately interrupted before T_{OnHold} has passed.

Writing "0" to the logical output value while being in on on-phase is ignored if *outDiCanCancel* is set to "off".

Retrigger of On-Phase

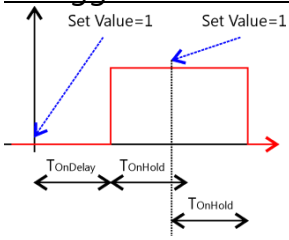

Fig. 11 On-Off Mode Retrigger

Fig. 11 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.

LucidIoCtrl Command Line Tool Example

Configure output channel 0 for On-Off mode

```
LucidIoCtrl –drs485:COM4:11 –c0 –soutDiMode=onoff
```

By default, $T_{OnDelay}$ and T_{OnHold} are set to 1s.
After writing a “1” to the output value of channel 0 the output will be set after 1s to “1” returning to “0” after 1s more.

Start processing of output channel 0

```
LucidIoCtrl –drs485:COM4:11 –c0 –tL –w1
```

3.4 Commands

Lucid485 IO Modules can be accessed by the Frame Protocol which is documented in the general *Lucid485 User Manual*.

This section describes in detail the commands which are supported by the DO16 module.

3.4.1 SetIo

This command sets one output value.

Mode	Value
Reflect	Value reflects the logic state to the output
Duty-Cycle	**Value** | 0 | Processing disabled 1 | Processing enabled
On-Off	**Value** | 0 | Processing disabled 1 | Processing enabled, triggered

Tab. 4 SetIo Output Values

Command	SetIo	**Access**	Write
Opcode	0x40		
LucidIoCtrl Command Line Tool			
Call (-tL)	`LucidIoCtrl –drs485:[COMx:addr] –c[Channel] –tL –w[Value]`		

Tab. 5 SetIo Command

LucidIoCtrl Command Line Tool Example

Set output channel 0 to "1":

```
LucidIoCtrl –drs485:COM4:11 –c0 –tL –w1
```

Request Frame

DST	SRC	OPC	P1	P2	LEN	Data Field	CRC
DST	SRC	0x40	Channel	Value Type	Length	Value	CRC-16

Tab. 6 SetIo Network Request Frame

Value	Description
Channel	Number of input or output channel (Range: 0 - 15)
Value Type	Supported Value Types **Value Type** / **Value Range** / **Length** Digital Logic Value (0x00) / 0 / 1 / 1 Byte
Length	Length of the Values in the Data Field
Value	Values accordingly to the Value Type

Tab. 7 SetIo Request

Response Frame

DST	SRC	Status	LEN	CRC
DST	SRC	Status	0	CRC-16

Tab. 8 SetIo Response Frame

Returns Execution Status Code, documented in the general Lucid485 User Manual.

3.4.2 SetIoGroup

This command sets the output values of a group of outputs.

Command	SetIoGroup	**Access**	Write
Opcode	0x42		
LucidIoCtrl Command Line Tool			
Call (-tL)	`LucidIoCtrl –drs485:[COMx:addr] –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		

Tab. 9 SetIoGroup Command

LucidIoCtrl Command Line Tool Example

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

```
LucidIoCtrl –drs485:COM4:11 –c0,2,3 –tL –w1,1,0
```

Request Frame:

DST	SRC	OPC	P1	P2	LEN	Data Field	CRC
DST	SRC	0x42	Channel Mask	Value Type	Length	Values	CRC-16

Tab. 10 SetIoGroup Network Request Frame

<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 rowspan="2">Channel</th><th colspan="3">Bit Position P1</th></tr>
<tr><th>P1</th><th>P1A</th><th>P1B</th></tr>
<tr><td>0</td><td>0</td><td></td><td></td></tr>
<tr><td>1</td><td>1</td><td></td><td></td></tr>
<tr><td>2</td><td>2</td><td></td><td></td></tr>
<tr><td>3</td><td>3</td><td></td><td></td></tr>
<tr><td>4</td><td>4</td><td></td><td></td></tr>
<tr><td>5</td><td>5</td><td></td><td></td></tr>
<tr><td>6</td><td>6</td><td></td><td></td></tr>
<tr><td>7</td><td>7</td><td>0</td><td></td></tr>
<tr><td>8</td><td>7</td><td>1</td><td></td></tr>
<tr><td>9</td><td>7</td><td>2</td><td></td></tr>
<tr><td>10</td><td>7</td><td>3</td><td></td></tr>
<tr><td>11</td><td>7</td><td>4</td><td></td></tr>
<tr><td>12</td><td>7</td><td>5</td><td></td></tr>
<tr><td>13</td><td>7</td><td>6</td><td></td></tr>
<tr><td>14</td><td>7</td><td>7</td><td>0</td></tr>
<tr><td>15</td><td>7</td><td>7</td><td>1</td></tr>
</table>

Values are bitwise or combined
Size of P1 is 1 - 3 bytes. If Bit 7 of P1 is set, a subsequent P1 byte is present.

<u>Examples:</u>
Accessing channel numbers:
0 and 3 Value P1 = 0x01 OR 0x08 = 0x09
1 and 7 Value P1 = 0x02 OR 0x80 = 0x82
Value P1A = 0x01
1 and 15 Value P1 = 0x02 OR 0x80 = 0x82
Value P1A = 0x80 (no channel but P1B)
Value P1B = 0x02 (channel 15)
</td></tr>
<tr><td>Value Type</td><td>
Supported Value Types
<table>
<tr><th>Value Type</th><th>Value Range</th><th>Length</th></tr>
<tr><td>Digital Logic Value (0x00)</td><td>0x00 oder 0x01</td><td>1 Byte</td></tr>
</table>
</td></tr>
<tr><td>Length</td><td>Length of the Values in the Data Field (One Value for each channel)</td></tr>
<tr><td>Values</td><td>One or more values to set in channel number ascending order</td></tr>
</table>

Tab. 11 SetIoGroup Request

Response Frame

DST	SRC	Status	LEN	CRC
DST	SRC	Status	0	CRC-16

Tab. 12 SetIoGroup Network Response Frame

Returns Execution Status Code, documented in the general Lucid485 User Manual.

Example of SetIoGroup
Request frame sets output channel 0 to "1", channel 7 to "1" and channel 15 to "0"

Request Frame

DST	SRC	OPC	P1	P1A	P1B	P2	LEN	Data Field			CRC
								Byte			
								0	1	2	
0x11	0x10	0x42	0x81	0x81	0x02	0x00	0x03	0x01	0x01	0x00	CRC

Tab. 13 SetIoGroup Request Example

Response Frame:

DST	SRC	Status	LEN	CRC
0x10	0x11	0x00	0x00	CRC

Tab. 14 SetIoGroup Network Response Example

3.4.3 GetIo

This command reads the value or state of a digital output channel.

In the case that the output mode is Duty-Cycle or On-Off, the value returns the processing state of the output. "1" indicates processing running, "0" processing stopped.

Command	GetIo	**Access**	Read
Opcode	0x46		
LucidIoCtrl Command Line Tool			
Call (-tL)	`LucidIoCtrl -drs485:[COMx:addr] -c[Channel] -tL -r`		
Return	CHn:LL n: Input Channel LL: Input Digital Value		

Tab. 15 GetIo Command

LucidIoCtrl Command Line Tool Example
Read output channel 0:

```
      LucidIoCtrl -drs485:COM4:11 -c0 -tL -r
->    CH0:01
```

Request Frame

DST	SRC	OPC	P1	P2	LEN	CRC
DST	SRC	0x46	Channel	Value Type	0	CRC-16

Tab. 16 GetIo Network Request Frame

<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>Channel</td><td>Number of input or output channel (Range: 0 - 15)</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 or 0x01</td><td>1 Byte</td></tr>
</table>
</td></tr>
</table>

Tab. 17 GetIo Request

Response Frame:

DST	SRC	Status	LEN	Data Field	CRC
DST	SRC	Status	Length	Value	CRC-16

Tab. 18 GetIo Network Response Frame

Returns Execution Status Code, documented in the general *Lucid485 User Manual*.

In case of successful execution, the command returns the value of the specified channel number.

3.4.4 GetIoGroup

This command reads the logic output values of a group of outputs of the same Value Type.

Command	GetIoGroup	**Access**	Read
Opcode	0x48		
LucidIoCtrl Command Line Tool			
Call (-tL)	`LucidIoCtrl –drs485:[COMx:addr] –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:LL n – Channel LL – Digital Value		

Tab. 19 GetIoGroup Command

LucidIoCtrl Command Line Tool Example

Read output values of channel 0, 1 and 3:

```
      LucidIoCtrl –drs485:COM4:11 –c0,1,3 –tL –r
->    CH0:00  CH1:01  CH3:01
```

Request Frame

DST	SRC	OPC	P1	P2	LEN	CRC
DST	SRC	0x48	Channel Mask	Value Type	0	CRC-16

Tab. 20 GetIoGroup Network Request Frame

Value	Description
Channel Mask	Channel Mask Specifies the output channels to access (→ Tab. 11)
Value Type	Supported Value Types Value Type: Digital Logic Value (0x00) – Value Range: 0x00 or 0x01 – Response Len: 1 Byte

Tab. 21 GetIoGroup Command

Response Frame:

DST	SRC	Status	LEN	Data Field	CRC
DST	SRC	Status	Length	Value(s)	CRC-16

Tab. 22 GetIoGroup Network Response Frame

Returns Execution Status Code, documented in the general *Lucid485 User Manual*.

In case of successful execution, the command returns the read values of the channels specified in the Channel Mask in channel number ascending order.

Example of GetIoGroup Request:

Request frame reads output channels 0, 7 and 15

DST	SRC	OPC	P1	P1A	P1B	P2	LEN	CRC
0x11	0x10	0x48	0x81	0x81	0x02	0x00	0x00	CRC

Tab. 23 GetIoGroup Network Request Example

Response Frame:

For output 0 = “0”, output 7 = “1” and output 15 = “1”

Values in Data Field are in ascending order

DST	SRC	Status	LEN	Data Field			CRC
0x10	0x11	0x00	0x03	CH 0	CH 7	CH 15	CRC
				0x00	0x01	0x01	

Tab. 24 GetIoGroup Network Response Example

3.5 Parameters

Lucid485 modules are configured by a set of System Configuration Parameters and IO Configuration Parameters.

The parameters are accessible by the SetParam and GetParam command which are described in the *Lucid485 User Manual*.

Parameter values can be made persistent in the non-volatile memory of the microcontroller e.g., by adding the -p argument to LucidIoCtrl or by setting the persistent parameter in the API function to true. Values of persistent parameters are restored when Lucid485 is powered on.

The number of write cycles to the non-volatile memory is limited. Write operations wear out the non-volatile memory and periodical updates of persistent parameter values should be avoided in order not to destroy the device over time.

3.5.1 outDiValue

This IO Configuration Parameter reflects the value or the state of the output.

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

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

Parameter	outDiValue	**Access**	Read / Write
Address	0x1000		
Values	Output Value		
Default Value	0x00	**Parameter Type**	1 Byte unsigned
LucidIoCtrl Command Line Tool			
Parameter Name	*outDiValue*	**Parameter Values**	0 / 1
Call (Set)	`LucidIoCtrl –drs485:[COMx:addr] –c[Channel] –soutDiValue=[Value] {-p} {--default}`		
Call (Get)	`LucidIoCtrl –drs485:[COMx:addr] –c[Channel] –goutDiValue`		

Tab. 25 IO Configuration Parameter outDiValue

LucidIoCtrl Command Line Tool Example

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

```
LucidIoCtrl –drs485:COM4:11 –c0 –soutDiValue=1 –p
```

Read value or state of output channel 0:

```
LucidIoCtrl –drs485:COM4:11 –c0 –goutDiValue
->  outDiValue=1
```

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

3.5.2 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>0x01</td><td>Parameter Type</td><td>1 Byte unsigned</td></tr>
<tr><td colspan="4">LucidIoCtrl 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 –drs485:[COMx:addr] –c[Channel] –soutDiMode=[Value] {-p} {--default}</code></td></tr>
<tr><td>Call (Get)</td><td colspan="3"><code>LucidIoCtrl –drs485:[COMx:addr] –c[Channel] –goutDiMode</code></td></tr>
</table>

Tab. 26 IO Configuration Parameter outDiMode

LucidIoCtrl Command Line Tool Example

Set operation mode of channel 0 to Duty-Cycle Mode and make the setting persistent.

```
LucidIoCtrl –drs485:COM4:11 –c0 –soutDiMode=dutyCycle –p
```

Read the operation mode of channel 0

```
LucidIoCtrl –drs485:COM4:11 –c0 –goutDiMode
->  outDiMode=dutyCycle
```

3.5.3 Bit Parameter outDiFlags

This IO Configuration Parameter groups Bit Parameters which are represented by one bit only (e.g. having an "on" or "off" state).

Parameter	*outDiFlags*	**Access**	Read / Write
Address	0x1101		
Values	The value consists of these bit parameters **Bit Parameter** / **Bit Position** *outDiCanRetrigger* / Bit 0 *outDiCanCancel* / Bit 1 *outDiInverted* / Bit 2		
Default Value	0x00	**Parameter Type**	1 Byte unsigned

Tab. 27 IO Configuration Parameter outDiFlags

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

If *outDiFlags* is changed by the SetParam command this must be done in a read-modify-write sequence in order to prevent overwriting other bit parameters.

3.5.3.1 outDiInverted

This Bit Parameter configures the output signal value inversion.

Parameter	*outDiFlags*	**Access**	Read / Write
Address	0x1101	Bit Parameter outDiFlags	
Values	**Bit Parameter** / **Bit Position** *outDiInverted* / Bit 2		
Default Value	Off	**Parameter Type**	1 Bit
LucidIoCtrl Command Line Tool			
Parameter Name	*outDiInverted*	**Parameter Values**	on / off
Call (Set)	`LucidIoCtrl -d[COMx] -c[Channel] -soutDiInverted=[Value] {-p} {--default}`		
Call (Get)	`LucidIoCtrl -drs485:[COMx:addr] -c[Channel] -goutDiInverted`		

Tab. 28 IO Configuration Parameter Bit outDiInverted

LucidIoCtrl Command Line Tool Example

Enable output signal value inversion of output channel 0 and make the setting persistent.

```
LucidIoCtrl -drs485:COM4:11 -c0 -soutDiInverted=on -p
```

Read output signal value inversion flag of output channel 0.

```
LucidIoCtrl -drs485:COM4:11 -c0 -goutDiInverted
->  outDiInverted=on
```

3.5.3.2 outDiCanCancel

This Bit Parameter configures the output on-phase cancelation.

Parameter	*outDiFlags*	**Access**	Read / Write
Address	0x1101	Bit Parameter outDiFlags	
Values	**Bit Parameter**: *outDiCanCancel* — **Bit Position**: Bit 1		
Default Value	Off	**Parameter Type**	1 Bit
LucidIoCtrl Command Line Tool			
Parameter Name	*outDiCanCancel*	**Parameter Values**	on / off
Call (Set)	`LucidIoCtrl –drs485:[COMx:addr] –c[Channel] –soutDiCanCancel=[Value] {-p} {--default}`		
Call (Get)	`LucidIoCtrl –drs485:[COMx:addr] –c[Channel] –goutDiCanCancel`		

Tab. 29 IO Configuration Parameter Bit outDiCanCancel

LucidIoCtrl Command Line Tool Example

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

```
LucidIoCtrl –drs485:COM4:11 –c0 –soutDiCanCancel=on –p
```

Read configuration of output cancelation of output channel 0

```
      LucidIoCtrl –drs485:COM4:11 –goutDiCanCancel
->    outDiCanCancel=on
```

3.5.3.3 outDiCanRetrigger

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

Parameter	*outDiFlags*	**Access**	Read / Write
Address	0x1101	Bit Parameter outDiFlags	
Values	**Bit Parameter**: *outDiCanRetrigger* — **Bit Position**: Bit 0		
Default Value	Off	**Parameter Type**	1 Bit
LucidIoCtrl Command Line Tool			
Parameter Name	*outDiCanRetrigger*	**Parameter Values**	on / off
Call (Set)	`LucidIoCtrl –drs485:[COMx:addr] –c[Channel] –soutDiCanRetrigger=[Value] {-p} {--default}`		
Call (Get)	`LucidIoCtrl –drs485:[COMx:addr] –c[Channel] –goutDiCanRetrigger`		

Tab. 30 IO Configuration Parameter Bit outDiCanRetrigger

LucidIoCtrl Command Line Tool Example

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

```
LucidIoCtrl –drs485:COM4:11 –c0 –soutDiCanRetrigger=on –p
```

Read output retrigger configuration of output channel 0

```
      LucidIoCtrl –drs485:COM4:11 –c0 –goutDiCanRetrigger
->    outDiCanRetrigger=on
```

3.5.4 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
LucidIoCtrl Command Line Tool			
Parameter Name	*outDiCycleTime*	**Parameter Values**	Time [µs]
Call (Set)	`LucidIoCtrl –drs485:[COMx:addr] –c[Channel] –soutDiCycleTime=[Time] {-p} {--default}`		
Call (Get)	`LucidIoCtrl –drs485:[COMx:addr] –c[Channel] –goutDiCycleTime`		

Tab. 31 IO Configuration Parameter outDiCycleTime

LucidIoCtrl Command Line Tool Example

Set T_{Cycle} of output channel 0 to 1.5s.

```
      LucidIoCtrl –drs485:COM4:11 –c0 –soutDiCycleTime=1500000
```

Read T_{Cycle} parameter of output channel 0

```
      LucidIoCtrl –drs485:COM4:11 –c0 –goutDiCycleTime
->    outDiCycleTime=1500000
```

If the cycle time is changed frequently, the value must not be made persistent in order to avoid wear-out of non-volatile memory.

The IO Configuration Parameter is accessible by Modbus holding registers *Param 0*. Values are not stored in non-volatile memory.

Note:
Timing limits for t_{Res} (→ 3.2) have to be considered.

3.5.5 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
LucidIoCtrl Command Line Tool			
Parameter Name	*outDiDutyCycle*	**Parameter Values**	Duty Cycle [‰]
Call (Set)	`LucidIoCtrl –drs485:[COMx:addr] –c[Channel] –soutDiDutyCycle=[Value] {-p} {--default}`		
Call (Get)	`LucidIoCtrl –drs485:[COMx:addr] –c[Channel] –goutDiDutyCylce`		

Tab. 32 IO Configuration Parameter outDiDutyCycle

LucidIoCtrl Command Line Tool Example

Set Duty Cycle of output channel 0 to 20%.

```
LucidIoCtrl –drs485:COM4:11 –c0 –soutDiDutyCycle=200
```

Read Duty Cycle setting for output channel 0

```
LucidIoCtrl –drs485:COM4:11 –c0 –goutDiDutyCycle
->  outDiDutyCycle=200
```

If the duty-cycle is changed frequently, the value must not be made persistent in order to avoid wear-out of non-volatile memory (→ 3.5).

The IO Configuration Parameter is accessible by Modbus holding registers *Param 1*. Values are not stored in non-volatile memory.

Note:
Timing limits (→ 3.2) have to be considered.

3.5.6 outDiOnDelay

This IO Configuration Parameter specifies the on-delay time $T_{OnDelay}$ 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
LucidIoCtrl Command Line Tool			
Parameter Name	*outDiOnDelay*	**Parameter Values**	Time [µs]
Call (Set)	`LucidIoCtrl –drs485:[COMx:addr] –c[Channel] –soutDiOnDelay=[Time] {-p} {--default}`		
Call (Get)	`LucidIoCtrl –drs485:[COMx:addr] –c[Channel] –goutDiOnDelay`		

Tab. 33 IO Configuration Parameter outDiOnDelay

LucidIoCtrl Command Line Tool Example

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

```
      LucidIoCtrl -drs485:COM4:11 -c0 -soutDiOnDelay=520000 -p
```

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

```
      LucidIoCtrl -drs485:COM4:11 -c0 -goutDiOnDelay
->    outDiOnDelay=520000
```

The IO Configuration Parameter is accessible by Modbus holding registers *Param 0*. Values are not stored in non-volatile memory.

Note:
Timing limits (→ 3.2) have to be considered.

3.5.7 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
LucidIoCtrl Command Line Tool			
Parameter Name	*outDiOnHold*	**Parameter Values**	Time [µs]
Call (Set)	`LucidIoCtrl -drs485:[COMx:addr] -c[Channel] -soutDiOnHold=[Time] {-p} {--default}`		
Call (Get)	`LucidIoCtrl -drs485:[COMx:addr] -c[Channel] -goutDiOnHold`		

Tab. 34 IO Configuration Parameter outDiOnHold

LucidIoCtrl Command Line Tool Example

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

```
      LucidIoCtrl -drs485:COM4:11 -c0 -soutDiOnHold=1200000 -p
```

Read T_{OnHold} setting of output channel 0

```
      LucidIoCtrl -drs485:COM4:11 -c0 -goutDiOnHold
->    outDiOnHold=1200000
```

The IO Configuration Parameter is accessible by Modbus holding registers *Param 1*. Values are not stored in non-volatile memory.

Note:
Timing limits (→ 3.2) have to be considered.

4 Modbus RTU Protocol

The IO values can be accessed by Modus holding registers listed in Tab. 36.

The function of the configuration parameters (→ Tab. 36) depends on the selected mode.

Mode	IO Config. Param.	Type	Modbus Register
on-off	*outDiCycleTime*	Unsigned 16 Bit	Param 0
	outDiDutyCycle	Unsigned 16 Bit	Param 1
duty-cycle	*outDiOnDelay*	Unsigned 16 Bit	Param 0
	outDiOnHold	Unsigned 16 Bit	Param 1

Tab. 35 Modbus IO Configuration Parameters

IO Channel Values registers contain either 0 or 1.

Address	Type	Width	Description
0x2000	Holding	16	IO Channel Number 0 Value (DO0)
0x2001	Holding	16	IO Channel Number 1 Value (DO1)
0x2002	Holding	16	IO Channel Number 2 Value (DO2)
0x2003	Holding	16	IO Channel Number 3 Value (DO3)
0x2004	Holding	16	IO Channel Number 4 Value (DO4)
0x2005	Holding	16	IO Channel Number 5 Value (DO5)
0x2006	Holding	16	IO Channel Number 6 Value (DO6)
0x2007	Holding	16	IO Channel Number 7 Value (DO7)
0x2008	Holding	16	IO Channel Number 8 Value (DO8)
0x2009	Holding	16	IO Channel Number 9 Value (DO9)
0x200A	Holding	16	IO Channel Number 10 Value (DO10)
0x200B	Holding	16	IO Channel Number 11 Value (DO11)
0x200C	Holding	16	IO Channel Number 12 Value (DO12)
0x200D	Holding	16	IO Channel Number 13 Value (DO13)
0x200E	Holding	16	IO Channel Number 14 Value (DO14)
0x200F	Holding	16	IO Channel Number 15 Value (DO15)
0x2100	Holding	16	IO Channel Number 0 Configuration Param 0
0x2101	Holding	16	IO Channel Number 1 Configuration Param 0
0x2102	Holding	16	IO Channel Number 2 Configuration Param 0
0x2103	Holding	16	IO Channel Number 3 Configuration Param 0
0x2104	Holding	16	IO Channel Number 4 Configuration Param 0
0x2105	Holding	16	IO Channel Number 5 Configuration Param 0
0x2106	Holding	16	IO Channel Number 6 Configuration Param 0
0x2107	Holding	16	IO Channel Number 7 Configuration Param 0
0x2108	Holding	16	IO Channel Number 8 Configuration Param 0
0x2109	Holding	16	IO Channel Number 9 Configuration Param 0
0x210A	Holding	16	IO Channel Number 10 Configuration Param 0
0x210B	Holding	16	IO Channel Number 11 Configuration Param 0

0x210C	Holding	16	IO Channel Number 12 Configuration Param 0
0x210D	Holding	16	IO Channel Number 13 Configuration Param 0
0x210E	Holding	16	IO Channel Number 14 Configuration Param 0
0x210F	Holding	16	IO Channel Number 15 Configuration Param 0
0x2200	Holding	16	IO Channel Number 0 Configuration Param 1
0x2201	Holding	16	IO Channel Number 1 Configuration Param 1
0x2202	Holding	16	IO Channel Number 2 Configuration Param 1
0x2203	Holding	16	IO Channel Number 3 Configuration Param 1
0x2204	Holding	16	IO Channel Number 4 Configuration Param 1
0x2205	Holding	16	IO Channel Number 5 Configuration Param 1
0x2206	Holding	16	IO Channel Number 6 Configuration Param 1
0x2207	Holding	16	IO Channel Number 7 Configuration Param 1
0x2208	Holding	16	IO Channel Number 8 Configuration Param 1
0x2209	Holding	16	IO Channel Number 9 Configuration Param 1
0x220A	Holding	16	IO Channel Number 10 Configuration Param 1
0x220B	Holding	16	IO Channel Number 11 Configuration Param 1
0x220C	Holding	16	IO Channel Number 12 Configuration Param 1
0x220D	Holding	16	IO Channel Number 13 Configuration Param 1
0x220E	Holding	16	IO Channel Number 14 Configuration Param 1
0x220F	Holding	16	IO Channel Number 15 Configuration Param 1

Tab. 36 Modbus RTU Registers

6 Specification

Parameter		Condition	Value
Outputs			
	No of Output Channels		16
Module - Electrical Characteristics			
	Supply Voltage		7-24 V
	Max. Supply Current		100 mA
Outputs - Electrical Characteristics @ 25°C			
	Maximum Rated Load Current Note1		I_{Max} 250 mA
	Maximum Rated Load Voltage		U_{Max} 24 V
	Maximum On Resistance		R_{On} 0.25 Ω
	IO20 Output Voltage		U_P 5 V
	Max. IO20 Output Current		I_P 80 mA
Outputs – Timing Characteristic			
	Min. Resolution		t_{Res} 1 ms
	Min. Resolution		$t_{Res12,15}$ 2 ms
	T_{Cycle}, $T_{OnDelay}$, T_{OnHold}		t_{Res} < T < 3600 s
Module – Communication			
	Baudrate		1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200 bps
	Parity		NONE, EVEN, ODD
	Stopbits		1 or 2
	Databits		8
	Bus Termination (If enabled)		120 Ω
Module – Environment			
	Temperature	Storage	-20 °C … +70 °C
		Operation	0 °C … +55 °C
	Humidity		< 85 % RH, non-condensing
Module – Housing			
	Dimension 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

Tab. 37 DO16 Device Specification

Note1 Output channels are able to control resistive loads only. For inductive loads additional protection is necessary.

Module is specified at environmental temperature of 25°C.

7 Order Information

Order Code	Product
L485-DO16-O	Lucid485 Digital Output Serial Module with 16 Open Collector (OC) Channels

Tab. 38 Digital Output Module Order Code

8 Document Revision

Date	Rev.	
2024/11/13	1.0	Initial document

Tab. 39 Document Revision

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