OPTO ENGINEERING

LTDV6CH

Strobe controller 6 channel

ACCESSORIES

General index

1. Disclaimer

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2. Safety notes

Please read the following notes before using this controller. Contact your distributor or dealer for any doubts or further advice.

This device must not be used in an application where its failure could cause a hazard to human health or damage to other equipment. Keep in mind that if the device is used in a manner not foreseen by the manufacturer, the protection provided by its circuits and by its enclosure may be impaired.

This is a low voltage device. As such, the potential difference between any combination of applied signals must not exceed, at all times, the supply voltage. Higher voltages may cause a fault and can be dangerous to human health.

This device has limited protection against transients caused by inductive loads. If necessary, use external protection devices like fast diodes or, better, specific transient protectors.

The controller outputs pulses with high energy content. The user must be careful to connect the inputs and outputs correctly and to protect the output wiring and load from unintentional short-circuits. When the device is switched off, there is still energy stored in the internal capacitors for at least 5 minutes.

When operating the controller at the maximum ratings it can get very hot. The controller should be positioned where personnel cannot accidentally touch it and away from flammable materials. Never exceed the power ratings stated in the manual.

3. General description

Any machine vision application employs some kind of light controller. Light controllers are widely used to both optimize illumination intensity and obtain repeatable trigger sequencing between lights and vision cameras.

This controller is a compact unit that includes power supply conditioning, intensity control, timing generation and advanced triggering functions.

The controller can be set up using a PC with serial interface. Configurations are saved in nonvolatile memory so that the controller will resume operation after a power cycle.

Throughout this manual, references to the controller cover all variants in the LTDV6CH series unless otherwise noted. As usual symbol "s" is used to indicate seconds, "ms" for milliseconds and "µs" for microseconds.

3.1. Benefits of current control

Most LED manufacturers suggest their products to be driven using a constant current source, not a constant voltage source. This is because, using a constant voltage driving, small variations in temperature or voltage at the LEDs can cause a noticeable change in their brightness.

Brightness control with voltage is also very difficult because of the non-linearity of brightness with voltage. On the contrary, the brightness is approximately linear with current, so by driving the LEDs with a known current, intensity control is linear.

This strobe controller has six independent, programmable, current-controlled pulsed outputs with currents ranging from 3.5A to 17.0A.

3.2. Pulsed mode

This controller operates in pulsed mode. In this mode the lighting is switched on only when necessary. A digital input is used as a trigger. When a rising edge on the trigger signal is detected the output is pulsed for the programmed amount of time.

Using this technique it is possible to obtain excellent steady images of moving objects. The camera can be set for an arbitrary long exposure time and the light turned on for a shorter time, just enough to freeze the motion. This helps to overcome the problems usually related with integration start uncertainty which, to some degree, afflict most commercial cameras.

The delay from the trigger to the output pulse, the width of the output pulse and the intensity of the output pulse are all independently configurable. The pulse delay can range from 0µs to 65535µs in steps of 1µs. The pulse width can range from 10µs to 65535µs in steps of 1µs. The intensity of the pulse can range from 3.5A to 17.0A in steps of 98mA.

4. Getting started

Carefully read the sections on Safety Notes and Heat Dissipation and check the product fits your needs. Mount the controller using a DIN rail as described in the section on Mechanical fixing.

Connect the controller as in the section on Connections. When the controller powers up it should show the PWR LED lit with a stable green and the RUN LED lit with a pulsing green.

Read the section on Operation. Use the configuration software (available from our web site) to configure the unit using the RS485 communication port. Depending on purchasing options, a small USB/RS485 converter (product code ADPT001) could be shipped with the controller.

5. Mechanical fixing

The controller must be mounted on a DIN rail. Allow free flow of air around the unit. The controller has an IP rating of 20 and should be installed so that moisture and dirt cannot enter it.

An enclosure may also be required for other parts of the system such as power supplies. That enclosure would provide both mechanical and environmental protection in industrial applications.

6. Heat dissipation

The controller includes several linear circuits to produce the constant current outputs. This means that it generates heat which needs to be dissipated. The operating temperature range is 0°C to 40°C.

The controller has an internal 24V to 48V DC step-up converter. This widens the range of lighting systems it can drive. Take care of this higher voltage when calculating the generated heat.

6.1. Calculating generated heat per channel

For a pulsed output the heat generated is given by:

$$Heat[W] = LightingCurrent[A] * (InternalVoltage[V] - LightingVoltage[V]) * DutyCycle$$

Where:

$$InternalVoltage = 48V \text{ (internally generated)}$$

The duty cycle is given by:

$$DutyCycle = PulseWidth[s] * TriggerFrequency[Hz]$$

The term *LightingCurrent* stands for the nominal lighting current, while the term *LightingVoltage* is its corresponding lighting voltage. Both of them are stated in the lighting documentation.

6.2. Reducing generated heat

The total heat generated by the controller is simply given by adding the generated heat for each of the six channels, as calculated in the previous section.

There are several ways to reduce the heat generated by the controller. The simplest would be to turn the light off when not needed. If the light is on only when necessary the generated heat can be drastically diminished. Another opportunity would be to reduce pulse width or output current, if permitted by the application.

Another strategy to reduce the generated heat would be to connect lights in series instead of parallel, if possible. If you have several lights connected in parallel then changing the arrangement to series will increase the voltage across them but also reduce the overall current.

The last option, feasible with this six channel controller, would be to use two or more controllers and use few channels from each. For high power applications this may be the only solution.

With no air flow, the controller can approximately dissipate the following powers:

→   7W per channel at 20°C ambient

→   6W per channel at 30°C ambient

→   5W per channel at 40°C ambient

No fan cooling is required if the generated heat is no greater than these limits.

7. Connections

See the section on Specifications for information on connection ratings. All connections are made via screw terminals on the top panel of the controller. Check all connections carefully before switching on the equipment.

The controller has two independent 24V DC supplies for the power and logic sections. This choice is aimed at increasing versatility. Supply to the logic section must always be present, while supply to the power section can be cut off at any time. Supply to the power section can be removed to protect the end user from photo-biological hazard and other hazardous situations that may happen during fault conditions.

These two supplies can be connected together if convenient.

7.1. Layout of connectors

The following diagram depicts all the controller connections. Connectors are identified by their designators (P1, P2, P3, P4, P5, P6, P8 and P9).
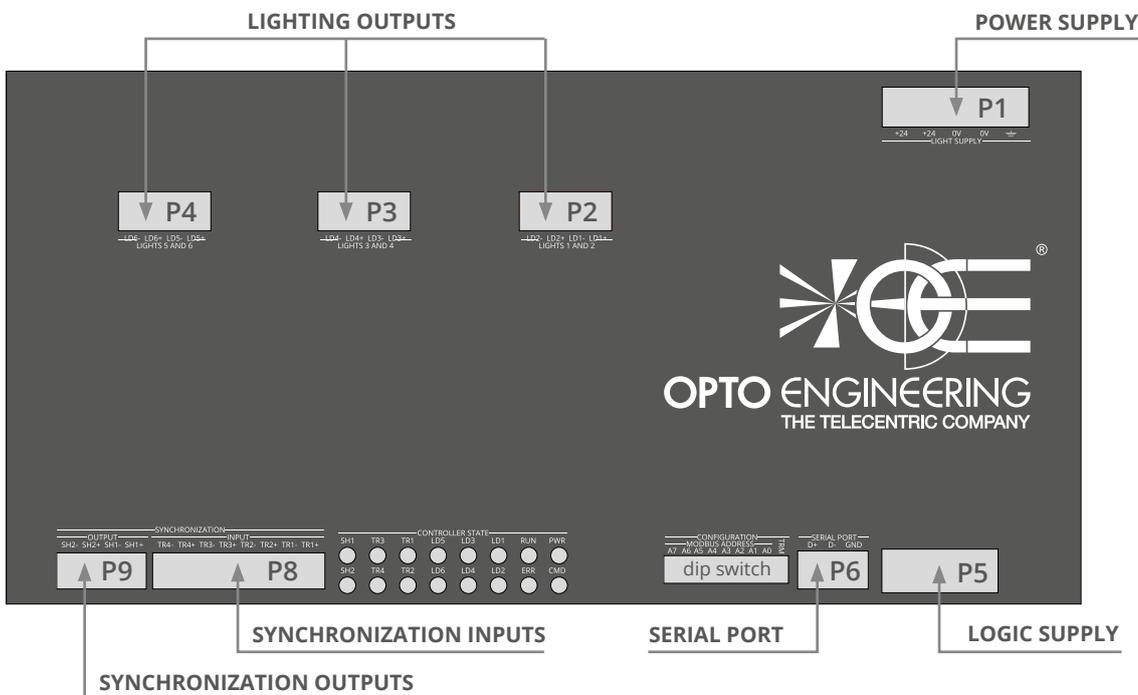
Illustration 1: connectors on front panel

These connectors are all standard Phoenix Contact parts. For each one a mating plug is provided in the controller package; for convenience the relevant manufacturer part numbers are listed in the following table.

Connector designator	Manufacturer	Mating plug part number
P1	Phoenix Contact	1757048
P2, P3, P4 and P9	Phoenix Contact	1803594
P5	Phoenix Contact	1757035
P6	Phoenix Contact	1803581
P8	Phoenix Contact	1803633

Table 1: connector mating plugs

7.2. Power supply

A regulated 24V DC±10% 4A supply is recommended. Maximum startup/inrush current is limited by an internal soft start feature to be no greater than 2.5A. The external power supply must be capable of supplying at least the average output power for all active lighting channels.

Choose a power supply unit that limits its output current by design or use protecting fuses. The fuses should be appropriately de-rated if mounted in an enclosure, as the inside temperature can be higher than the ambient temperature.

Ensure that the wire gauge used for these power connections is appropriate for the current to be drawn. The low voltage and mains wiring should be separately routed.

The power supply is connected on the +24 (positive) and 0V (negative) screw terminals of connector P1. Connector pinout, ordered from left to right, is listed in the following table.

Number	Name	Description	Note
1	+24	Power supply. Positive terminal	Pins have same potential. Use any
2	+24		
3	0V	Power supply. Negative terminal	Pins have same potential. Use any
4	0V		
5	Earth	Protection earth	

Table 2: pinout of connector P1

Ensure that the polarity of +24 and 0V is correct.

7.3. Logic supply

The logic supply must 24V DC. Maximum current consumption is below 200mA.

The logic supply is connected on the +24 (positive) and 0V (negative) screw terminals of connector P5. Connector pinout, ordered from left to right, is listed in the following table.

Number	Name	Description	Note
1	+24	Power supply. Positive terminal	Pins have same potential. Use any
2	+24		
3	0V	Power supply. Negative terminal	Pins have same potential. Use any
4	0V		

Table 3: pinout of connector P2

Ensure that the polarity of +24 and 0V is correct.

7.4. Lighting outputs

The IEC standard 61010-1 defines an internationally recognised safe voltage level which can be touched by a user. A certain voltage is considered safe if, at all times, its peak value is no greater than 46.7V or its DC value is no greater than 70V.

According to the standard pulse peak voltages above 46.7V are considered hazardous to the human body. For this reason the lighting connections must be shielded from being touched along the whole length of the cable and in the light.

Make sure you set the current rating for a light before connecting it. See the lighting datasheet and manual for details on this topic.

Light outputs are paired on 4-way pluggable screw terminal sockets. It is not possible to use two 2-way connectors in a 4-way socket. The lighting output connections must not be commoned or grounded in any way.

The state of each output is shown by a yellow LED indicator.

7.4.1. Lighting outputs 1 and 2

Lighting outputs 1 and 2 are connected on the LD1+, LD1-, LD2+ and LD2- screw terminals of connector P2. Connector pinout, ordered from left to right, is listed in the following table.

Number	Name	Description	Note
1	LD2-	Power channel 2 output. LED cathode	
2	LD2+	Power channel 2 output. LED anode	
3	LD1-	Power channel 1 output. LED cathode	
4	LD1+	Power channel 1 output. LED anode	

Table 4: pinout of connector P2

Please note that LD1- and LD2- are not the same as 0V.

7.4.2. Lighting outputs 3 and 4

Lighting outputs 3 and 4 are connected on the LD3+, LD3-, LD4+ and LD4- screw terminals of connector P3. Connector pinout, ordered from left to right, is listed in the following table.

Number	Name	Description	Note
1	LD4-	Power channel 4 output. LED cathode	
2	LD4+	Power channel 4 output. LED anode	
3	LD3-	Power channel 3 output. LED cathode	
4	LD3+	Power channel 3 output. LED anode	

Table 5: pinout of connector P3

Please note that LD3- and LD4- are not the same as 0V.

7.4.3. Lighting outputs 5 and 6

Lighting outputs 5 and 6 are connected on the LD5+, LD5-, LD6+ and LD6- screw terminals of connector P4. Connector pinout, ordered from left to right, is listed in the following table.

Number	Name	Description	Note
1	LD6-	Power channel 6 output. LED cathode	
2	LD6+	Power channel 6 output. LED anode	
3	LD5-	Power channel 5 output. LED cathode	
4	LD5+	Power channel 5 output. LED anode	

Table 6: pinout of connector P4

Please note that LD5- and LD6- are not the same as 0V.

7.5. Synchronization inputs

There are four independent, galvanically isolated synchronization inputs. These inputs can be connected directly to the system for voltages up to 24V DC. An external series resistor is not necessary. Synchronization inputs may be left unconnected when not used.

The state of each input is shown on an LED next to the connector.

Synchronization inputs are connected on the TR1+, TR1-, TR2+, TR2-, TR3+, TR3-, TR4+ and TR4- screw terminals of connector P8. Connector pinout, ordered from left to right, is listed in the following table.

Number	Name	Description
1	TR4-	Input 4. Negative terminal
2	TR4+	Input 4. Positive terminal
3	TR3-	Input 3. Negative terminal
4	TR3+	Input 3. Positive terminal
5	TR2-	Input 2. Negative terminal
6	TR2+	Input 2. Positive terminal
7	TR1-	Input 1. Negative terminal
8	TR1+	Input 1. Positive terminal

Table 7: pinout of connectorP8

The following diagram depicts the internal input circuit. The constant current source connected in series with each input allows for a broad range of input voltages without any need for a series resistor.
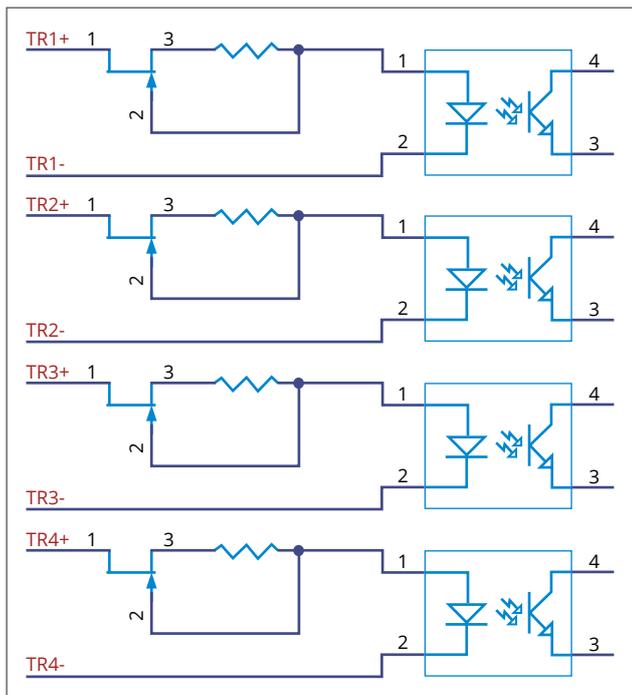
Illustration 2: input synchronization circuit

Circuit specifications are summarized in the following table.

Parameter	Value	Unit	Note
Uin (low)	0–1	V	
Uin (high)	4–24	V	
Current (constant-current source)	6–8	mA	

Table 8: specifications of input synchronization circuit

7.6. Synchronization outputs

There are two galvanically isolated synchronization outputs. These outputs can be used, for example, to trigger a camera or a slave lighting controller.

The state of each output is shown by an LED indicator next to the connector.

Synchronization outputs are connected on the SH1+, SH1-, SH2+ and SH2- screw terminals of connector P9. Connector pinout, ordered from left to right, is listed in the following table.

Number	Name	Description
1	SH2-	Output 2. Emitter terminal
2	SH2+	Output 2. Collector terminal
3	SH1-	Output 1. Emitter terminal
4	SH1+	Output 1. Collector terminal

Table 9: pinout of connectorP9

The following diagram depicts the internal output circuit.
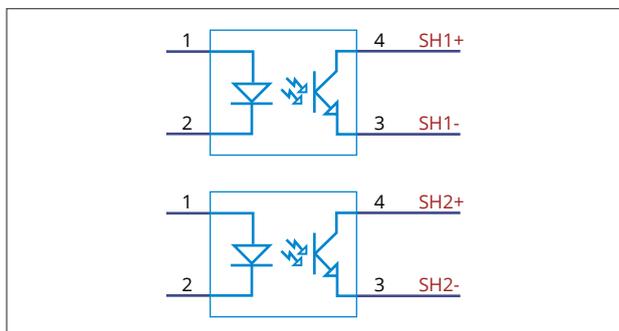
Illustration 3: output synchronization circuit

Circuit specifications are summarized in the following table.

Parameter	Value	Unit	Note
Imax	50	mA	
Umax	30	V	

Table 10: specifications of output synchronization circuit

7.7. Serial port

The controller can be quickly configured using an easy-to-use configuration software (which can be downloaded from our web site).

The controller implements a subset of the Modbus RTU slave protocol and, as such, can also be configured and managed by any programmable logic controller (PLC) with a proper interface.

All the settings are stored in non-volatile memory; the controller will retain these settings even when the supply is removed.

7.7.1. Serial port connections

The activity of the serial port is shown by an LED indicator next to the connector.

The serial port is connected on the D+, D- and GND screw terminals of connector P6. Connector pinout, ordered from left to right, is listed in the following table.

Number	Name	Description	Note
1	D+	RS485 data signal. Positive terminal	
2	D-	RS485 data signal. Negative terminal	
3	GND	RS485 reference ground	

Table 11: pinout of connector P6

Please note that GND is not the same as 0V.

7.7.2. Serial port settings

There is a 9-way dip switch in a hollow accessible from the top panel of the controller. The rightmost switch is used to enable (when ON) or disable (when OFF) the internal RS485 termination, while the eight leftmost switches are used to set the Modbus address of the controller.

The exact meaning of each of the switches is listed in the following table.

Number	Name	Description
1	A7	Bit 7 of the Modbus address (1 when ON, 0 when OFF)
2	A6	Bit 6 of the Modbus address (1 when ON, 0 when OFF)
3	A5	Bit 5 of the Modbus address (1 when ON, 0 when OFF)
4	A4	Bit 4 of the Modbus address (1 when ON, 0 when OFF)
5	A3	Bit 3 of the Modbus address (1 when ON, 0 when OFF)
6	A2	Bit 2 of the Modbus address (1 when ON, 0 when OFF)
7	A1	Bit 1 of the Modbus address (1 when ON, 0 when OFF)
8	A0	Bit 0 of the Modbus address (1 when ON, 0 when OFF)
9	TRM	Internal RS485 termination (enabled when ON, disabled when OFF)

Table 12: meaning of the dip switches
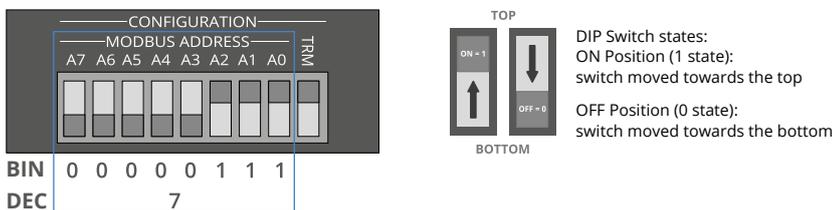
Illustration 4: serial port setting example

Please note valid Modbus addresses for slave devices are in the range 1 to 247; remaining addresses are reserved by the standard for special purposes and must not be used. It is of great importance to ensure, at the time of assigning the slave address, that there are not two devices with the same address. In such a case, an abnormal behavior of the whole serial bus can occur, the master being then in the impossibility to communicate with all slaves present on the bus.

The controller operates at 9600 bits per second, with even parity. These speed and parity settings are not modifiable in any way.

These switches should be operated only when the controller is switched off.

8. Visual indicators

There are sixteen LEDs on the top panel of the controller. Some of them are used to show that power supplies are present, others are pulsed when inputs and output are activated, while others are used to indicate serial port activity or fault conditions.

The exact meaning of each of the LEDs is listed in the following table.

Number	Name	Color	Description
1	PWR	Green	Stable when logic supply is present
2	RUN	Green	Blinks continuously during normal operation
3	CMD	Yellow	Pulses when there is activity on the serial port
4	ERR	Red	Stable when power supply missing, blinks in thermal trip condition
5	LD1	Yellow	Pulses when lighting output 1 is activated
6	LD2	Yellow	Pulses when lighting output 2 is activated
7	LD3	Yellow	Pulses when lighting output 3 is activated
8	LD4	Yellow	Pulses when lighting output 4 is activated
9	LD5	Yellow	Pulses when lighting output 5 is activated
10	LD6	Yellow	Pulses when lighting output 6 is activated
11	TR1	Green	Pulses when synchronization input 1 is activated
12	TR2	Green	Pulses when synchronization input 2 is activated
13	TR3	Green	Pulses when synchronization input 3 is activated
14	TR4	Green	Pulses when synchronization input 4 is activated
15	SH1	Yellow	Pulses when synchronization output 1 is activated
16	SH2	Yellow	Pulses when synchronization output 2 is activated

Table 13: meaning of the LEDs

Please note logic supply must be present in order for all the LEDs to turn on.

9. Pulse shaping logic

Each of the six channels can be individually configured to output pulses based either on a discrete external trigger signal or an internally-generated trigger. A wide variety of internal triggers can be produced by configuring the internal pulse shaping logic.

This logic includes eight pulse generators and several multiplexers. The pulse generators allow pulse delay and width control down to 1μsec resolution. The multiplexers, organized as two routing matrices, allow for the flexible selection of the pulse generators inputs and outputs.

An output protection circuit, used to prevent the lighting from getting overheated and thus damaged, is also included in this logic.

9.1. Diagram of internal logic

The following diagram depicts the logic network built in the controller.
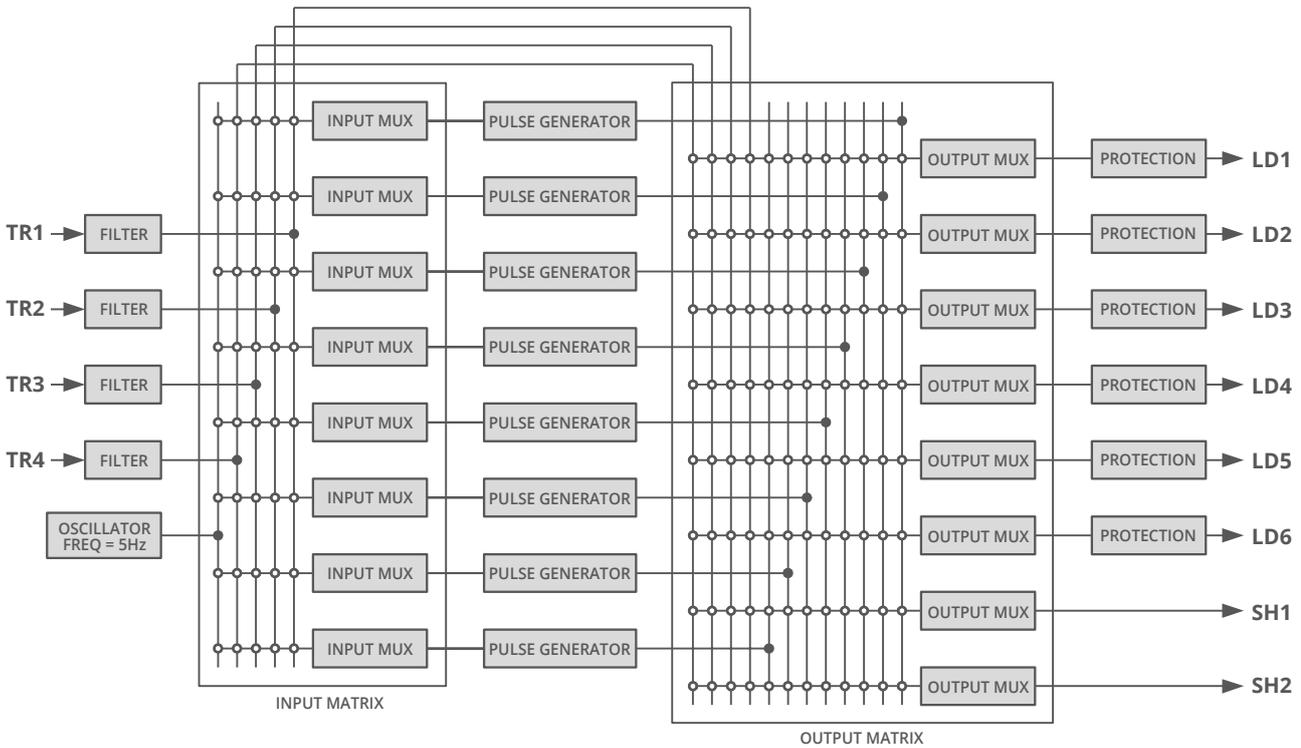
Illustration 5: diagram of internal logic network

The four synchronization inputs are shown at the left (TR1, TR2, TR3 and TR4), while the six lighting outputs (LD1, LD2, LD3, LD4, LD5 and LD6) and the two synchronization outputs (SH1 and SH2) are drawn at the right.

A description of each of the blocks is given in the next sections.

9.2. Input filters

The input filters are used to debounce and remove glitches from the incoming synchronization inputs. Each of the four synchronization inputs has a dedicated, independent filter.

The algorithm implemented in each of the filters processes the relevant synchronization input with a finite state machine. A change in the filter output is performed only when the input signal has remained constant for a defined period of time, called filter time constant. Any pulses shorter than the filter time constant are thus removed and not passed through.

The following time diagram shows the filter operation on a random input signal.
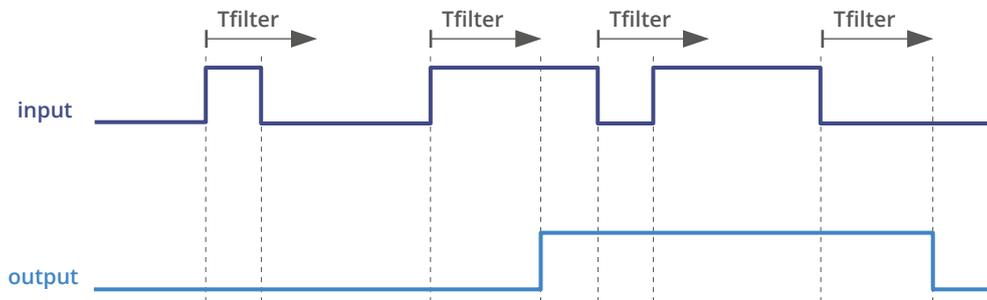
Illustration 6: operation of the input filter

As visible, the input signal is filtered by looking for pulses that hold the same state for a time of at least Tfilter before the change in state is passed to the output. Please note there is a fixed input to output delay equal to this filter time constant.

Each of the four filters can be set as follows:

→ No filtering (pass through)

→ Filtering with a 10µs time constant

→ Filtering with a 20µs time constant

→ Filtering with a 50µs time constant

→ Filtering with a 100µs time constant

→ Filtering with a 200µs time constant

→ Filtering with a 500µs time constant

Setting of the filters can be done graphically using the configuration software.

9.3. Input multiplexers

The input multiplexers are used to send the filtered inputs to the pulse generators. There are eight input multiplexers organized in a 5x8 routing matrix.

Each multiplexer can have its output selected from one of the following sources:

→ No selection

→ Filtered synchronization input 1 (TR1)

→ Filtered synchronization input 2 (TR2)

→ Filtered synchronization input 3 (TR3)

→ Filtered synchronization input 4 (TR4)

→ Free running oscillator

The free running oscillator is an autonomous asynchronous trigger source described in detail in the next sections. Setting of the input multiplexers can be done graphically using the configuration software.

9.4. Pulse generator

There are eight pulse generators. Each of them is characterized by two parameters: pulse delay and pulse width. The pulse delay can range from 0μs to 65535μs in steps of 1μs. The pulse width can range from 10μs to 65535μs in steps of 1μs.

The following time diagram describes the relationship between input and output. As depicted, the rising edge of the input signal triggers the generator, while the falling edge has no special meaning and can happen anywhere in time.
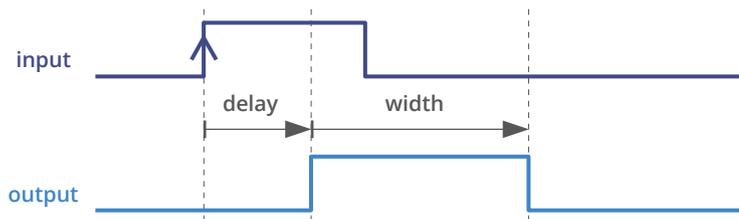
Illustration 7: pulse generator time diagram

Setting of the pulse generators can be done graphically using the configuration software.

9.5. Output multiplexers

The output multiplexers are used to send the inner signals to the output stages. There are eight output multiplexers organized in a 12x8 routing matrix.

Each multiplexer can have its output selected from one of the following sources:

→ No selection

→ Pulse generator 0 output

→ Pulse generator 1 output

→ Pulse generator 2 output

→ Pulse generator 3 output

→ Pulse generator 4 output

→ Pulse generator 5 output

→ Pulse generator 6 output

→ Pulse generator 7 output

→ Filtered synchronization input 1 (TR1)

→ Filtered synchronization input 2 (TR2)

→ Filtered synchronization input 3 (TR3)

→ Filtered synchronization input 4 (TR4)

As visible in the internal logic network diagram, the eight pulse generators can be bypassed entirely by selecting one of the last four choices. Setting of the output multiplexers can be done graphically using the configuration software.

9.6. Output protection

The output protection logic is used to prevent the lighting from getting overheated and thus damaged.

Inside each of the six protection blocks there is state machine with a couple of timers. The first timer is used to check the activation time (Ton) of the lighting is short enough (i.e. lesser than or equal to a programmable TonMAX). The second timer is used to check the deactivation time (Toff) of the lighting is long enough (i.e. greater than or equal to a programmable ToffMIN).

The following time diagram shows what happens when both time constraints are satisfied. As visible in the diagram, the output follows the input.
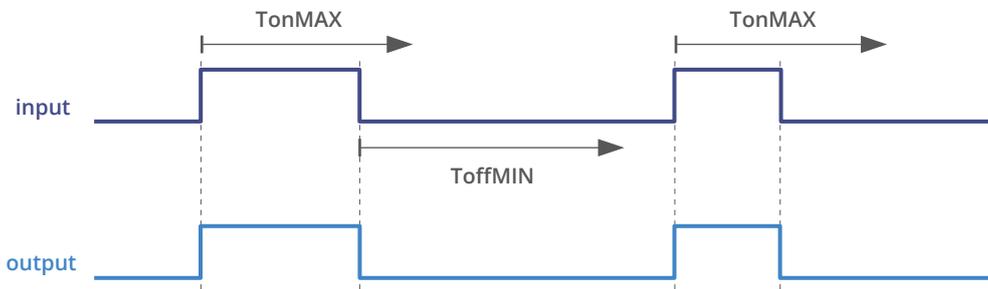
Illustration 8: activation and deactivation times within limits

The following time diagram shows what happens when activation time is too long. As visible in the diagram, the lighting is switched off earlier than required.
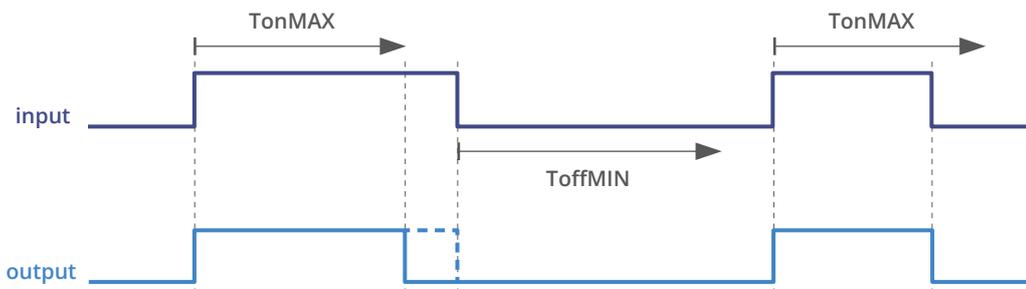
Illustration 9: protection prevents too long activation time

The following time diagram shows what happens when deactivation time is too short. As visible in the diagram, the lighting is turned on later then required.
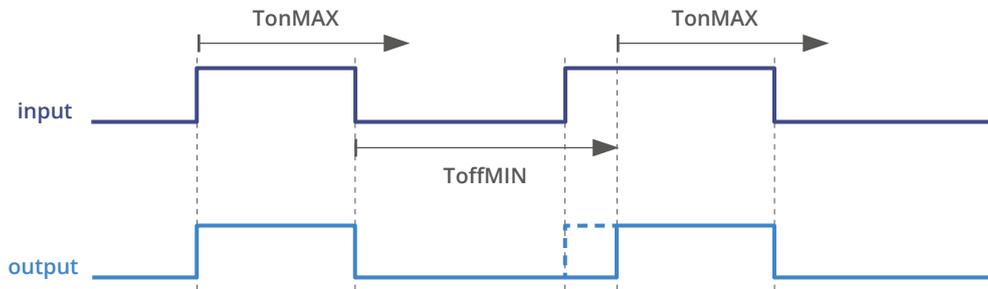
Illustration 10: protection prevents too short deactivation time

The six protection blocks have their own state machines and timers. They are completely independent but share the same settings regarding TonMAX (maximum activation time) and ToffMIN (minimum deactivation time). Both these time intervals can range from 1ms to 255ms in steps of 1ms.

The deactivation time check can be inhibited on select outputs if required by the application.

Setting of the output protection logic can be done graphically using the configuration software.

9.7. Free running oscillator

The free running oscillator is an autonomous asynchronous trigger source with a constant frequency of 5Hz. It can be selected as an input to the input multiplexers.

Common usage of the oscillator is to test the lighting during assembly and deployment.

10. Wiring diagrams

As discussed in the previous sections the controller is quite flexible and many configurations can be envisioned. The following wiring diagrams describe some of the most common.

10.1. Wiring example

In the following schematic the controller is driven by two input triggers, powers a total of six lights and triggers two cameras.
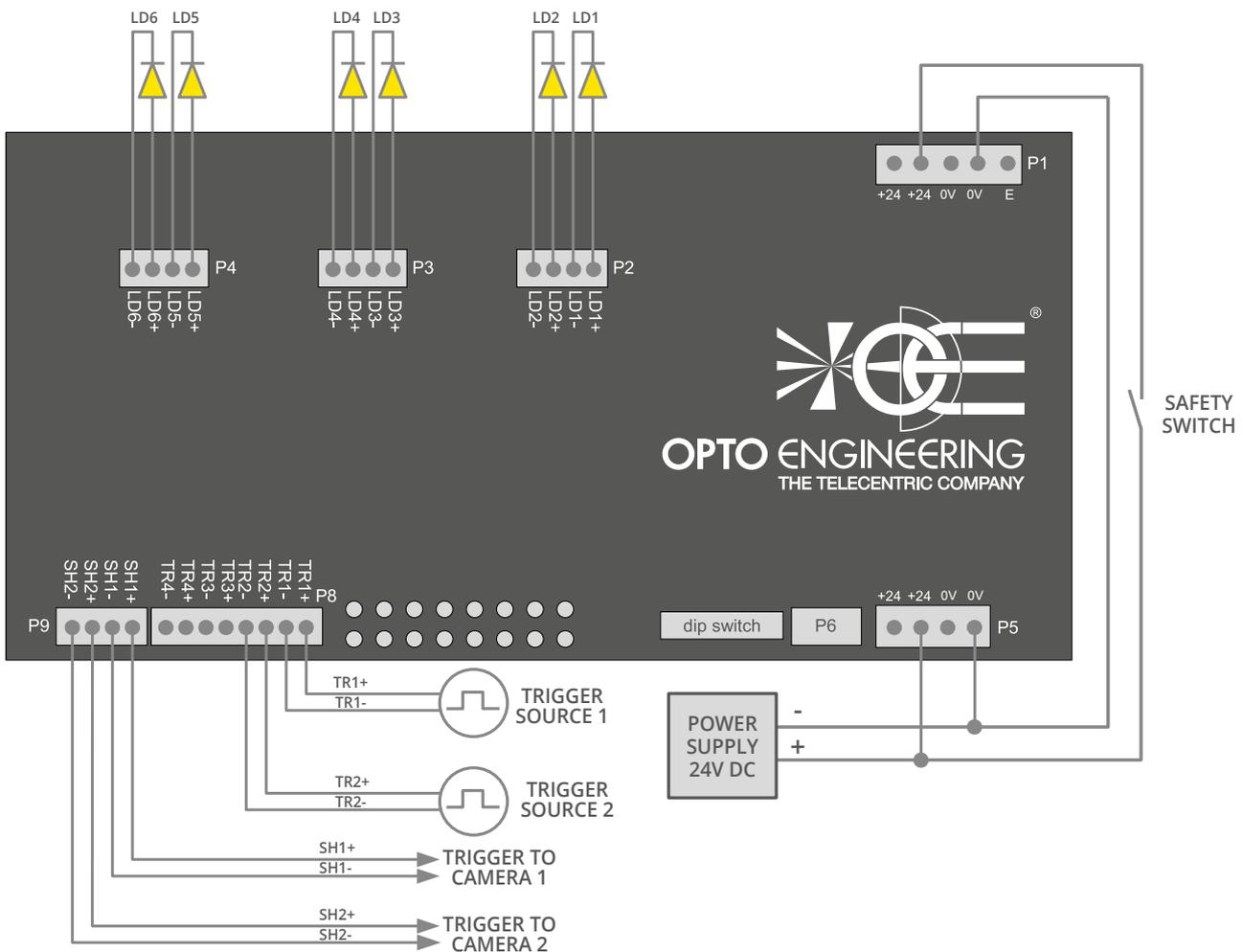
Illustration 11: example schematic

As shown the power and logic supplies are derived from a common 24V DC power source.

If required for the application, a safety switch may be included in the circuit to cut off supply to the power section in order to protect the end user from photo-biological hazard. That switch would be appropriately placed on the machine chassis.

The cameras are triggered using the two available synchronization outputs. In general it is not possible to provide the details of the connections to the cameras because these are often vendor specific. Please see the camera hardware manual for more information.

11. Operation

The controller is set up using the configuration software (available from our web site). The set up is non-volatile, so the controller will resume the same operation after a power cycle.

12. Configuration software

The controller can be configured using a single PC running the configuration software (available from our web site). The PC must have a native RS485 communication interface or a suitable converter must be used. Depending on purchasing options, a small USB/RS485 converter (product code ADPT001) could be shipped with the controller.

In order to run the configuration software the following requirements must be satisfied:

→ Windows XP operating system or better

→ Java Runtime Environment version 6 or better

→ 10Mbyte of available disk space

→ 512Mbyte of system RAM

12.1. Software installation

Unpack the software archive downloaded from our web site and run the main application executable named "LTDV6CH_Config.exe". At the first run administrator privileges are required.

12.2. Main window

The following picture shows the configuration software main window just after start up.
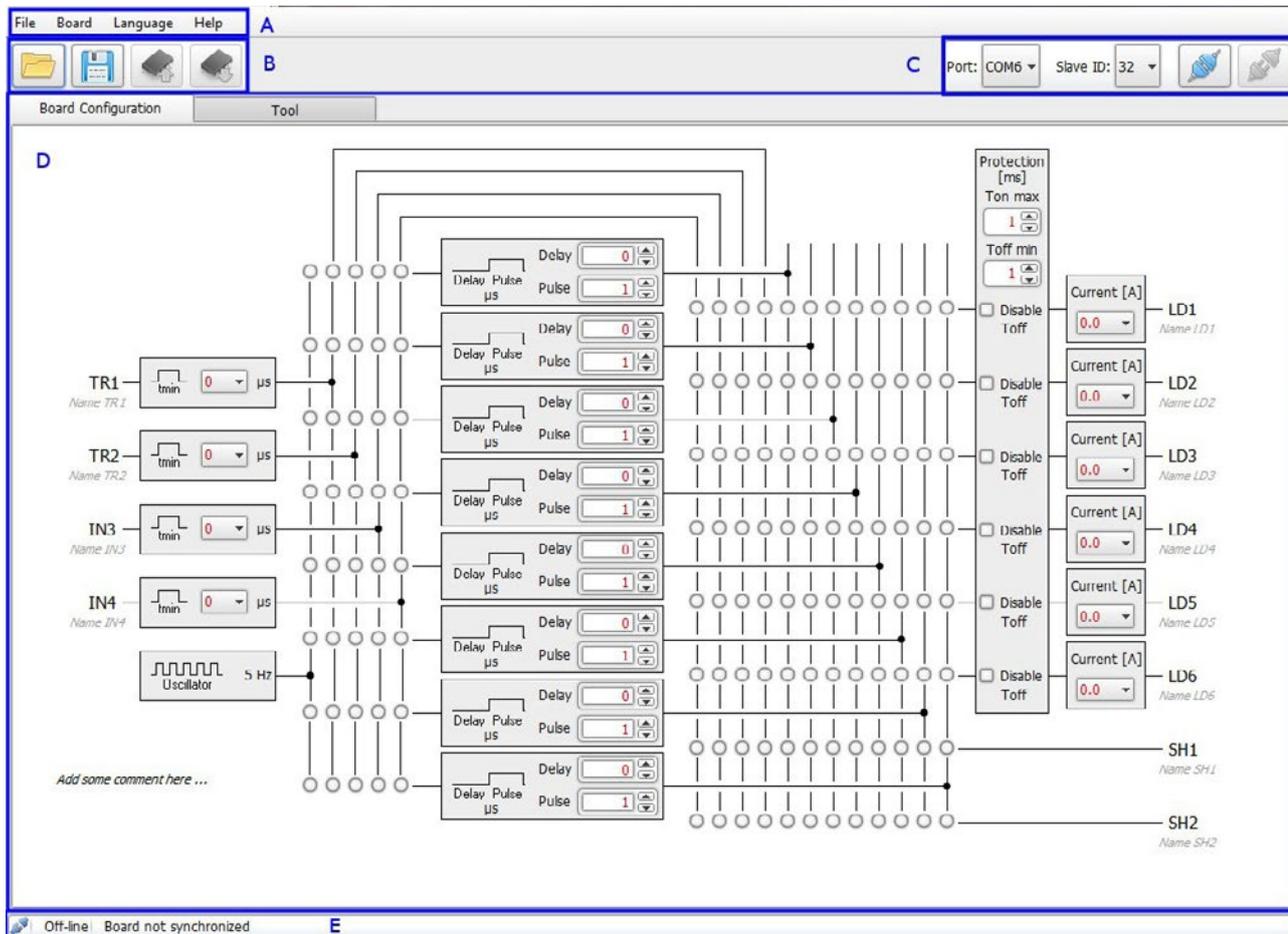
Illustration 12: main window of configuration software

As indicated in the screenshot the main window is divided into five parts:

→   Part A contains the main menu

→   Part B is the main toolbar that allows quick access to most common functionalities

→   Part C is the connection toolbar

→   Part D shows a diagram with a graphical representation of the controller internal logic

→   Part E is the status toolbar that shows the status of the connected controller

12.3. Connect the controller

The first step after launching the software is to enable communication between the computer and the controller. The connection toolbar at the upper right corner shows

the currently selected serial port and Modbus address.

Set both these fields to appropriate values and then press the connect button:

The status bar will be updated to display the successful connection.

12.4. Read the configuration

Press the read button to read the configuration from the controller:

In a few seconds the software will populate the diagram with the current configuration and the status bar will be updated to display "board synchronized" with the current date and time.

12.5. Write the configuration

After reading the configuration proceed to modify it as appropriate. It is possible to specify a label for each input and output signals, and a comment on the configuration itself. Any change from the saved configuration is highlighted in red.

When editing is complete press the write button to transfer the new parameters back to the controller:

The software will store the configuration in the controller non-volatile memory.

12.6. Save the configuration to a file

The software allows to save the current configuration to a file. This is useful if you need to program a number of controllers with the same configuration.

Press the save button:

A dialog will ask about the path and name for the configuration file.

12.7. Open a saved configuration

After saving the configuration, you can open it and transfer it to the controller.

Press the open button:

A dialog will ask about the path and name for the configuration file.

12.8. Disconnect the controller

After configuration is written in the controller non-volatile memory, the device itself can be disconnected by pressing the disconnect button:

At this point a new controller could be connected in order to be configured.

12.9. Change the language

To change the language, select "Language" from the main menu and then choose the preferred language. Next close and reopen the application in order to get the translated texts.

12.10. Tool tab usage

The tool tab can be used to perform several tasks. Its contents are shown in the following picture.
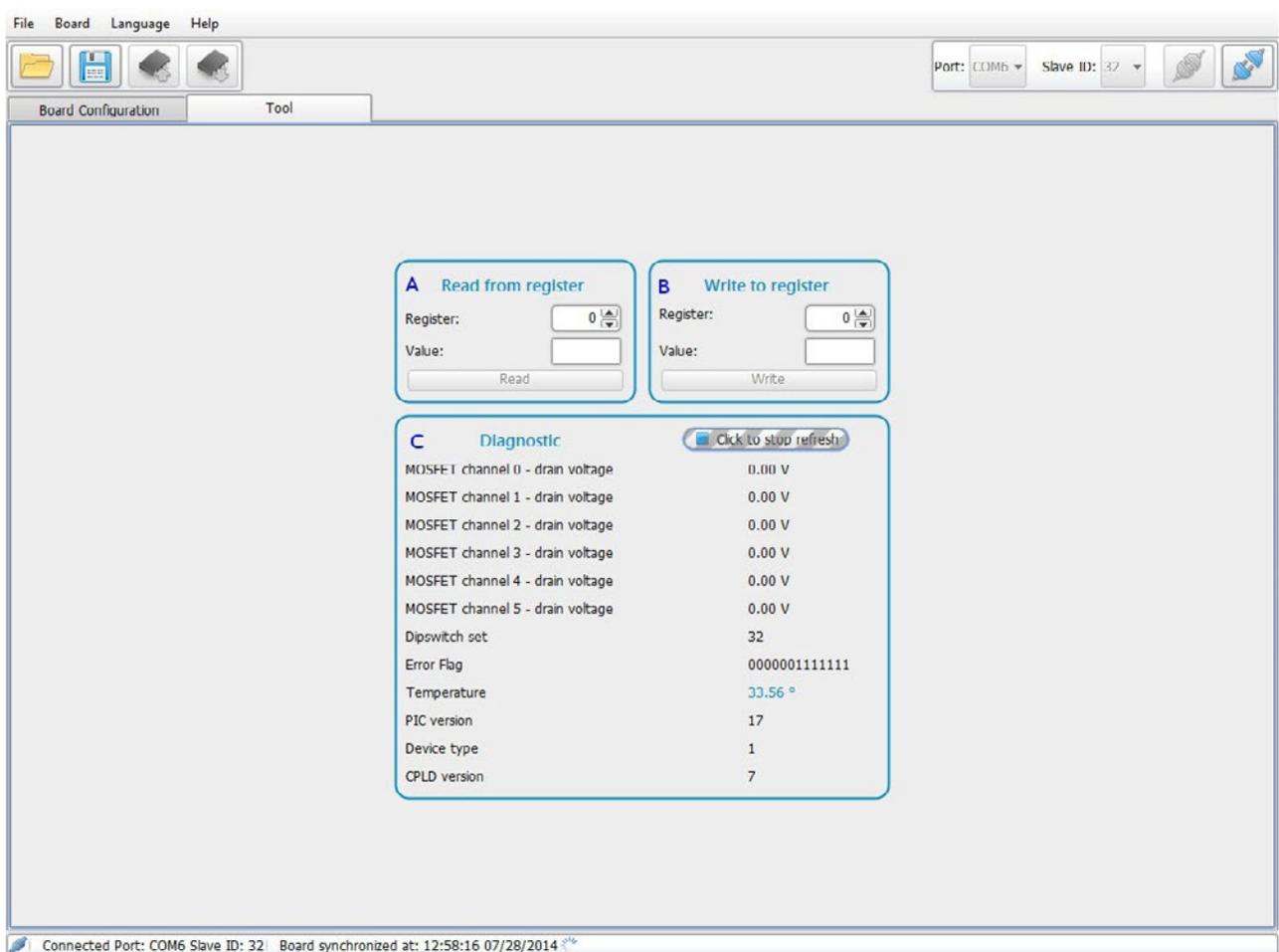
Illustration 13: contents of the tool tab

As indicated in the screenshot the tool tab is divided into three parts:

→ Part A is used to read a single value from a Modbus register

→ Part B is used to write a single value to a Modbus register

→ Part C is used to display diagnostic information

The diagnostic panel shows diagnostic information collected from the controller. Its contents may be automatically updated in real-time by pressing the "Click to start refresh" button.

12.11. Getting help

Enable help pop-ups from the "Help" menu to get more information. The main window will be populated as it is shown in the following picture.
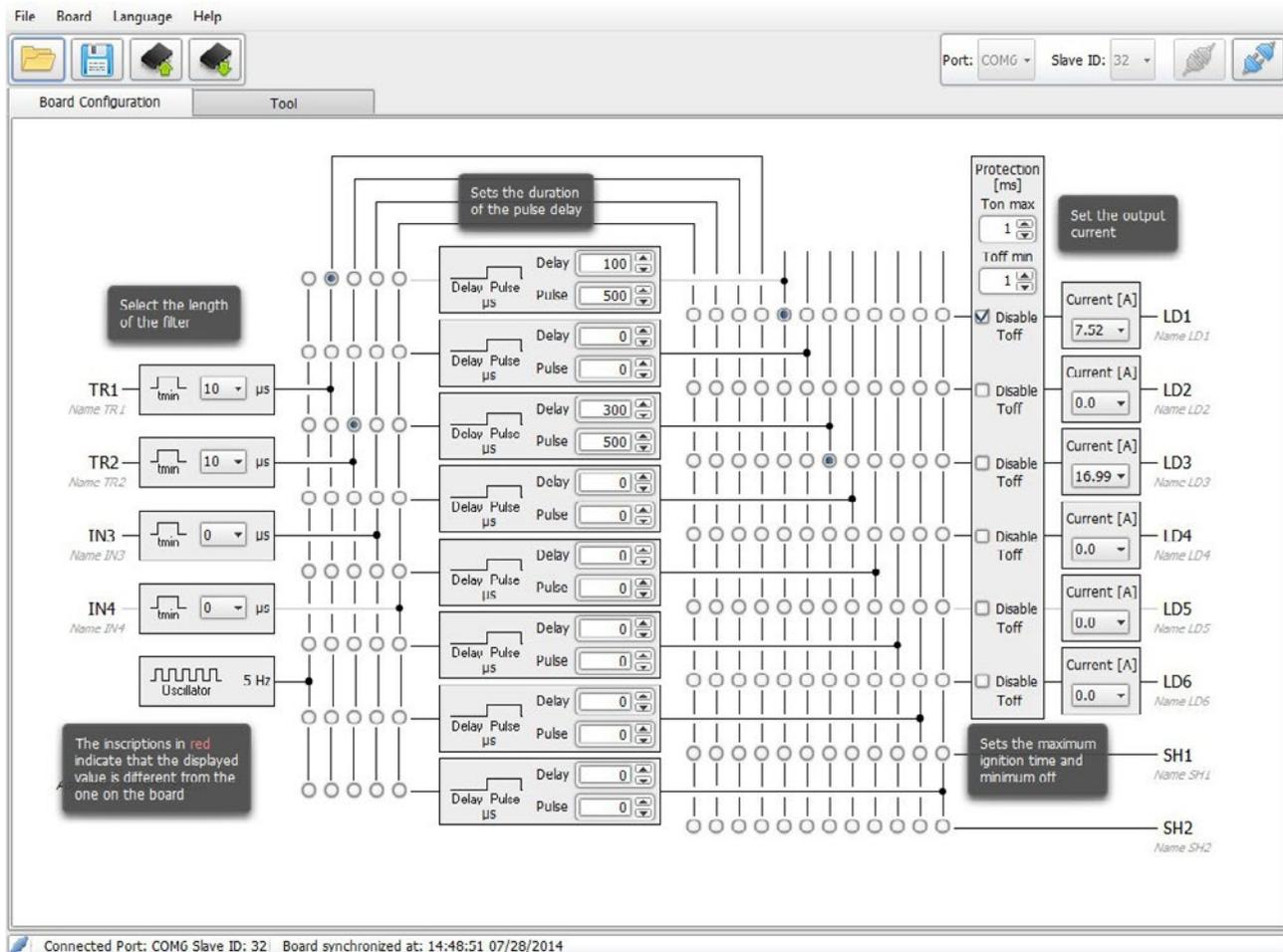
Illustration 14: main window with help shown

The help pop-ups can be disabled from the same "Help" menu.

12.12. Configuration example

The following picture shows an example configuration for the internal logic network.
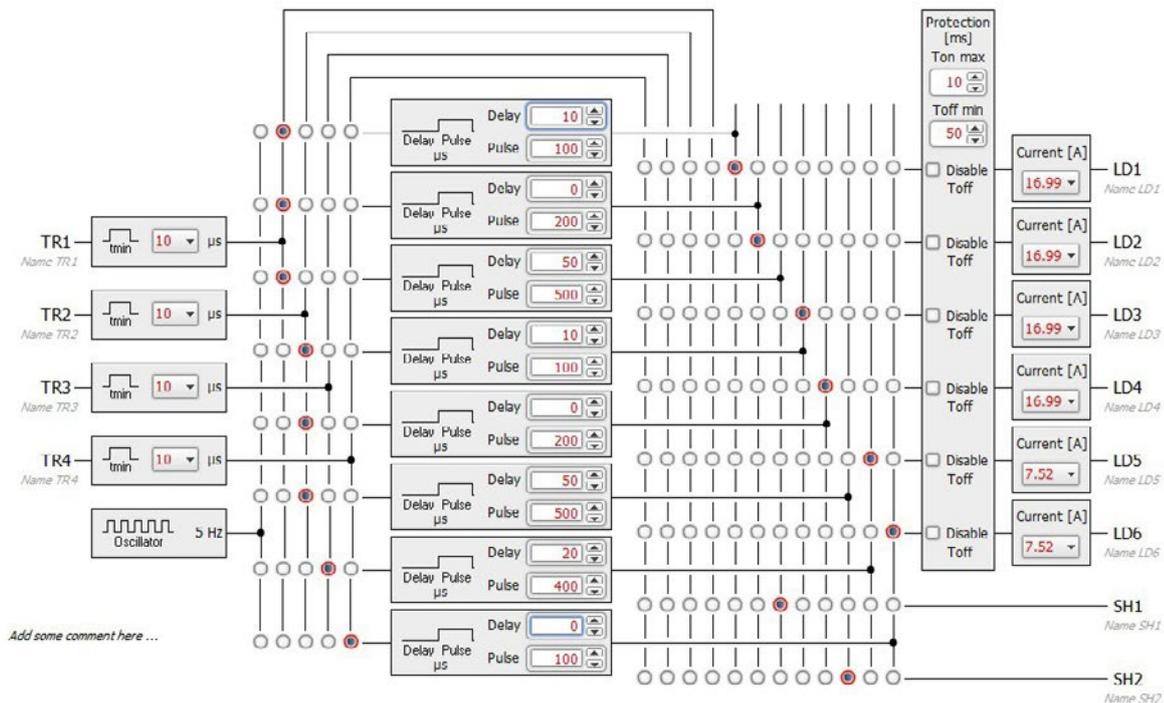
Illustration 15: example configuration for the internal logic network

Here the four input filters are all set for a time constant of 10µs.

The four filtered inputs are directed as follows:

> → Filtered signal TR1 feeds pulse generators 1, 2 and 3
>
> → Filtered signal TR2 feeds pulse generators 4, 5 and 6
>
> → Filtered signal TR3 feeds pulse generator 7
>
> → Filtered signal TR4 feeds pulse generator 8

As depicted, the eight pulse generators are set with different values for pulse delay and pulse width, as can be requested by the application.

The eight outputs are set as follows:

> → Output LD1 is fed from pulse generator 1 and is set for a current of 17.0A
>
> → Output LD2 is fed from pulse generator 2 and is set for a current of 17.0A
>
> → Output LD3 is fed from pulse generator 4 and is set for a current of 17.0A
>
> → Output LD4 is fed from pulse generator 5 and is set for a current of 17.0A

→ Output LD5 is fed from pulse generator 7 and is set for a current of 7.5A

→ Output LD6 is fed from pulse generator 8 and is set for a current of 7.5A

→ Output SH1 is fed from pulse generator 3

→ Output SH2 is fed from pulse generator 6

The protection circuits are set for a maximum activation time (TonMAX) of 10ms and a minimum deactivation time (ToffMIN) of 50ms. Deactivation time check is enabled for all the outputs.

13. Communication protocol

The controller has a RS485 communication port that implements a subset of the Modbus RTU slave protocol. It can be configured and managed by any PC and programmable logic controller (PLC) with a suitable interface.

Being simple and robust, over the years Modbus became a well known communication protocol and it is now a commonly available means of connecting industrial electronic devices. The development and update of Modbus protocols has been managed by the Modbus Organization since April 2004. The Modbus Organization is an association of users and suppliers of Modbus compliant devices that seeks to drive the adoption and evolution of Modbus.

The organization web site is:

>   http://www.modbus.org

More information, including Modbus specifications, implementation guides and code fragments can be downloaded from:

>   http://www.modbus.org/specs.php

The user may choose from a wide variety of libraries to implement the low level aspects of the Modbus protocol needed to control LTDV6CH. They are available for the majority of Operating Systems and programming languages. Additionally most of them are free.

13.1. Communication parameters

The controller operates at 9600 bits per second, with even parity. Speed and parity are not modifiable. Valid Modbus addresses for slave devices are in the range 1 to 247; remaining addresses are reserved by the standard for special purposes and must not be used.

13.2. Supported function codes

Modbus is a request/reply protocol and offers services specified by function codes. The following table lists the Modbus function codes supported by the controller with the current firmware.

Function name	Function code	Note
Read Holding Registers	0 x 03	
Write Single Register	0 x 06	
Write Multiple Registers	0 x 10	

Table 14: function codes supported by the controller

Any Modbus request containing an unimplemented function code is silently ignored by the controller and no response, of any kind, is given back to the master.
These supported function codes can be used to access the controller internal register file, organized as an array of two-byte values. These function codes are briefly described in the following sections.

13.2.1. Read Holding Registers (0x03)

This function code is used to read the contents of a contiguous block of registers from the controller register file. The master specifies the starting register address and the number of registers to be read. Registers are addressed starting at zero.
The register data in the response message are packed as two bytes per register.
For each register, the first byte contains the high order bits and the second contains the low order bits.

13.2.2. Write Single Register (0x06)

This function code is used to write a single register in the controller register file.
The master specifies the address of the register to be written and the actual data to be written. Registers are addressed starting at zero. The register data in the request message are packed as two bytes per register. For each register, the first byte contains the high order bits and the second contains the low order bits. The normal response is an echo of the request, returned after the register contents have been written.

13.2.3. Write Multiple registers (0x10)

This function code is used to write a block of contiguous registers (1 to 123 registers) in the controller register file. The master specifies the starting register address, the number of registers and the actual data to be written. Registers are addressed starting at zero. The register data in the request message are packed as two bytes per register. For each register, the first byte contains the high order bits and the second contains the low order bits. The normal response returns the function code, starting address, and quantity of registers written.

13.3. Register file

The following table lists all the Modbus registers implemented in the controller.
There are 64 registers, each of two bytes in size. The registers are mapped at addresses from 0 to 63.

Address	Name	Type	Range	Description
0	INP_FLT0	RW	0 - 6	Filter setting for input TR1
1	INP_FLT1	RW	0 - 6	Filter setting for input TR2
2	INP_FLT2	RW	0 - 6	Filter setting for input TR3
3	INP_FLT3	RW	0 - 6	Filter setting for input TR4
4	INP_SEL0	RW	0 - 31	Setting of input multiplexer 0
5	INP_SEL1	RW	0 - 31	Setting of input multiplexer 1
6	INP_SEL2	RW	0 - 31	Setting of input multiplexer 2
7	INP_SEL3	RW	0 - 31	Setting of input multiplexer 3
8	INP_SEL4	RW	0 - 31	Setting of input multiplexer 4

Address	Name	Type	Range	Description
9	INP_SEL5	RW	0 - 31	Setting of input multiplexer 5
10	INP_SEL6	RW	0 - 31	Setting of input multiplexer 6
11	INP_SEL7	RW	0 - 31	Setting of input multiplexer 7
12	GEN_DELAY0	RW	0 - 65535	Pulse delay setting for generator 0
13	GEN_PULSE0	RW	10 - 65535	Pulse width setting for generator 0
14	GEN_DELAY1	RW	0 - 65535	Pulse delay setting for generator 1
15	GEN_PULSE1	RW	10 - 65535	Pulse width setting for generator 1
16	GEN_DELAY2	RW	0 - 65535	Pulse delay setting for generator 2
17	GEN_PULSE2	RW	10 - 65535	Pulse width setting for generator 2
18	GEN_DELAY3	RW	0 - 65535	Pulse delay setting for generator 3
19	GEN_PULSE3	RW	10 - 65535	Pulse width setting for generator 3
20	GEN_DELAY4	RW	0 - 65535	Pulse delay setting for generator 4
21	GEN_PULSE4	RW	10 - 65535	Pulse width setting for generator 4
22	GEN_DELAY5	RW	0 - 65535	Pulse delay setting for generator 5
23	GEN_PULSE5	RW	10 - 65535	Pulse width setting for generator 5
24	GEN_DELAY6	RW	0 - 65535	Pulse delay setting for generator 6
25	GEN_PULSE6	RW	10 - 65535	Pulse width setting for generator 6
26	GEN_DELAY7	RW	0 - 65535	Pulse delay setting for generator 7
27	GEN_PULSE7	RW	10 - 65535	Pulse width setting for generator 7
28	OUT_SEL0	RW	0 - 8191	Setting of output multiplexer 0 (light LD1)
29	OUT_SEL1	RW	0 - 8191	Setting of output multiplexer 1 (light LD2)
30	OUT_SEL2	RW	0 - 8191	Setting of output multiplexer 2 (light LD3)
31	OUT_SEL3	RW	0 - 8191	Setting of output multiplexer 3 (light LD4)
32	OUT_SEL4	RW	0 - 8191	Setting of output multiplexer 4 (light LD5)
33	OUT_SEL5	RW	0 - 8191	Setting of output multiplexer 5 (light LD6)
34	OUT_SEL6	RW	0 - 4095	Setting of output multiplexer 6 (signal SH1)
35	OUT_SEL7	RW	0 - 4095	Setting of output multiplexer 7 (signal SH2)
36	CUR_SET0	RW	35 - 175	Current setting for LD1
37	CUR_SET1	RW	35 - 175	Current setting for LD2
38	CUR_SET2	RW	35 - 175	Current setting for LD3
39	CUR_SET3	RW	35 - 175	Current setting for LD4
40	CUR_SET4	RW	35 - 175	Current setting for LD5
41	CUR_SET5	RW	35 - 175	Current setting for LD6
42	VOL_THR0	N/A	N/A	Reserved
43	VOL_THR1	N/A	N/A	Reserved
44	VOL_THR2	N/A	N/A	Reserved

Address	Name	Type	Range	Description
45	VOL_THR3	N/A	N/A	Reserved
46	VOL_THR4	N/A	N/A	Reserved
47	VOL_THR5	N/A	N/A	Reserved
48	TON_MAX	RW	1 - 255	Maximum activation time for LD[1:6]
49	TOFF_MIN	RW	1 - 255	Minimum deactivation time for LD[1:6]
50	DRN_VOL0	R	0 - 255	Measured drain voltage for LD1
51	DRN_VOL1	R	0 - 255	Measured drain voltage for LD2
52	DRN_VOL2	R	0 - 255	Measured drain voltage for LD3
53	DRN_VOL3	R	0 - 255	Measured drain voltage for LD4
54	DRN_VOL4	R	0 - 255	Measured drain voltage for LD5
55	DRN_VOL5	R	0 - 255	Measured drain voltage for LD6
56	SPARE	N/A	N/A	Reserved
57	DIP_VAL	N/A	N/A	Reserved
58	ERR_FLG	R	0 - 16383	Error flags
59	BRD_TMP	R	0 - 8191	Board temperature
60	MCU_VER	R	0 - 255	Microcontroller firmware version
61	DEV_TYPE	R	0 - 255	Device type
62	FPGA_VER	R	0 - 255	FPGA firmware version
63	BRD_CMD	RW	0 - 3	Board command

Table 15: controller register file

As indicated in the table, most of the registers can be both read and written (type RW), some registers are read only (type R) and a few others are reserved (type N/A). Registers marked as reserved must not be accessed, either in reading and writing, at any time. The accessible registers are described in the following sections.

Changes to the register file are not saved in non-volatile memory until a specific command is issued to the controller. See the description of register BRD_CMD in the next sections for more information on this subject.

13.3.1. Registers INP_FLT[0:3]

These registers hold the settings for the input filters.

→ INP_FLT0: filter setting for input TR1

→ INP_FLT1: filter setting for input TR2

→ INP_FLT2: filter setting for input TR3

→ INP_FLT3: filter setting for input TR4

Each bit field [2:0] of these four registers selects the time constant for filtering the relevant input signal. Allowed values are in the range from 0 to 6 and are listed below. Avoid operation with non-listed values.

→ When 0 filter is disabled (pass through)

→ When 1 filter is enabled with a 10μs time constant

→ When 2 filter is enabled with a 20μs time constant

→ When 3 filter is enabled with a 50μs time constant

→ When 4 filter is enabled with a 100μs time constant

→ When 5 filter is enabled with a 200μs time constant

→ When 6 filter is enabled with a 500μs time constant

Bits fields [15:3] of these registers are unused. When writing they must be set to zero.

13.3.2. Registers INP_SEL[0:7]

These registers hold the settings for the input multiplexers.

→ INP_SEL0: setting of input multiplexer 0

→ INP_SEL1: setting of input multiplexer 1

→ INP_SEL2: setting of input multiplexer 2

→ INP_SEL3: setting of input multiplexer 3

→ INP_SEL4: setting of input multiplexer 4

→ INP_SEL5: setting of input multiplexer 5

→ INP_SEL6: setting of input multiplexer 6

→ INP_SEL7: setting of input multiplexer 7

Each bit field [4:0] of these eight registers is the selector of the relevant input multiplexer. Each input multiplexer feeds the dedicated pulse generator. Allowed values are listed below. Avoid operation with non-listed values.

→ When 1 the filtered TR1 input is selected

→ When 2 the filtered TR2 input is selected

→ When 4 the filtered TR3 input is selected

→ When 8 the filtered TR4 input is selected

→ When 16 the free running oscillator is selected

Bits fields [15:5] of these registers are unused. When writing they must be set to zero.

13.3.3. Registers GEN_DELAY[0:7]

These registers hold the delay settings for the generators.

→   GEN_DELAY0: pulse delay setting for generator 0

→   GEN_DELAY1: pulse delay setting for generator 1

→   GEN_DELAY2: pulse delay setting for generator 2

→   GEN_DELAY3: pulse delay setting for generator 3

→   GEN_DELAY4: pulse delay setting for generator 4

→   GEN_DELAY5: pulse delay setting for generator 5

→   GEN_DELAY6: pulse delay setting for generator 6

→   GEN_DELAY7: pulse delay setting for generator 7

Each of these eight registers sets the pulse delay for the relevant generator.
Allowed values are in the range from 0 to 65535 and are expressed in μs, so the pulse
delay can range from 0μs to 65535μs with a resolution of 1μs.

13.3.4. Registers GEN_PULSE[0:7]

These registers hold the pulse settings for the generators.

→   GEN_PULSE0: pulse width setting for generator 0

→   GEN_PULSE1: pulse width setting for generator 1

→   GEN_PULSE2: pulse width setting for generator 2

→   GEN_PULSE3: pulse width setting for generator 3

→   GEN_PULSE4: pulse width setting for generator 4

→   GEN_PULSE5: pulse width setting for generator 5

→   GEN_PULSE6: pulse width setting for generator 6

→   GEN_PULSE7: pulse width setting for generator 7

Each of these eight registers sets the pulse width for the relevant generator.
Allowed values are in the range from 10 to 65535 and are expressed in μs, so the pulse
width can range from 10μs to 65535μs with a resolution of 1μs.
Avoid operation with non-allowed values.

13.3.5. Registers OUT_SEL[0:7]

These registers hold the settings for the outputs multiplexers.

→ OUT_SEL0: setting of output multiplexer 0 (light LD1)

→ OUT_SEL1: setting of output multiplexer 1 (light LD2)

→ OUT_SEL2: setting of output multiplexer 2 (light LD3)

→ OUT_SEL3: setting of output multiplexer 3 (light LD4)

→ OUT_SEL4: setting of output multiplexer 4 (light LD5)

→ OUT_SEL5: setting of output multiplexer 5 (light LD6)

→ OUT_SEL6: setting of output multiplexer 6 (signal SH1)

→ OUT_SEL7: setting of output multiplexer 7 (signal SH2)

Each bit field [11:0] of these eight registers is the selector of the relevant output multiplexer. Each output multiplexer feeds the dedicated output signal (either LD1, LD2, LD3, LD4, LD5, LD6, SH1 or SH2). Allowed values are listed below.
Avoid operation with non-listed values.

→ When 1 pulse generator 0 ouput is selected

→ When 2 pulse generator 1 ouput is selected

→ When 4 pulse generator 2 ouput is selected

→ When 8 pulse generator 3 ouput is selected

→ When 16 pulse generator 4 ouput is selected

→ When 32 pulse generator 5 ouput is selected

→ When 64 pulse generator 6 ouput is selected

→ When 128 pulse generator 7 ouput is selected

→ When 256 filtered input TR1 is selected

→ When 512 filtered input TR2 is selected

→ When 1024 filtered input TR3 is selected

→ When 2048 filtered input TR4 is selected

Bit 12 of registers OUT_SEL0, OUT_SEL1, OUT_SEL2, OUT_SEL3, OUT_SEL4 and OUT_SEL5, when set, inhibit deactivation time check on the relevant output.
Bits fields [15:13] of registers OUT_SEL0, OUT_SEL1, OUT_SEL2, OUT_SEL3, OUT_SEL4 and OUT_SEL5 are unused. When writing they must be set to zero.

Bits fields [15:12] of registers OUT_SEL6 and OUT_SEL7 are unused.
When writing they must be set to zero.

13.3.6. Registers CUR_SET[0:5]

These registers hold the current settings for the lighting outputs.

- → CUR_SET0: current setting for LD1
- → CUR_SET1: current setting for LD2
- → CUR_SET2: current setting for LD3
- → CUR_SET3: current setting for LD4
- → CUR_SET4: current setting for LD5
- → CUR_SET5: current setting for LD6

Each bit field [7:0] of these six registers defines the current for the relevant output.
Setting for a given current can be calculated as follows:

$$RegisterSetting = RequiredCurrent[A] * 10.24$$

Current for a given setting can be calculated as follows:

$$ActualCurrent[A] = RegisterSetting / 10.24$$

Minimum allowed value is 35, corresponding to an output current of 3.42A.
Maximum allowed value is 175, corresponding to a current of 17.09A.
Avoid operation with non-allowed values.

Bits fields [15:8] of these registers are unused. When writing they must be set to zero.

13.3.7. Registers TON_MAX

This register holds the maximum activation time for lighting outputs LD1, LD2, LD3, LD4, LD5 and LD6.

Allowed values are in the range from 1 to 255 and are expressed in ms, so the maximum activation time can range from 1ms to 255ms with a resolution of 1ms.
Avoid operation with non-allowed values.

Bit field [15:8] of this register is unused. When writing they must be set to zero.

13.3.8. Registers TOFF_MIN

This register holds the minimum deactivation time for lighting outputs LD1, LD2, LD3, LD4, LD5 and LD6.

Allowed values are in the range from 1 to 255 and are expressed in ms, so the minimum deactivation time can range from 1ms to 255ms with a resolution of 1ms.
Avoid operation with non-allowed values.

Bit field [15:8] of this register is unused. When writing they must be set to zero.

13.3.9. Registers DRN_VOL[0:5]

LD1, LD2, LD3, LD4, LD5 and LD6 lighting outputs.

→   DRN_VOL0: measured drain voltage for LD1

→   DRN_VOL1: measured drain voltage for LD2

→   DRN_VOL2: measured drain voltage for LD3

→   DRN_VOL3: measured drain voltage for LD4

→   DRN_VOL4: measured drain voltage for LD5

→   DRN_VOL5: measured drain voltage for LD6

Each bit field [7:0] of these six registers contains a rough measure of the drain voltage for the MOSFET driving the relevant lighting output. Given the register value, the corresponding actual voltage can be calculated as follows:

$$ActualVoltage[V] = RegisterValue / 5.12$$

The measurement is performed using an iterative, successive approximation algorithm. For this reason, from eight to nine activation pulses, at least 500ms apart, are necessary for each lighting output in order to update the reading in its corresponding register.

Bits fields [15:8] of these registers are unused.

13.3.10. Register ERR_FLG

This register contains a few error flags in bit field [7:6]. The register may be read and these flags then checked to evaluate the controller health. The meaning of each of the bits is as follows:

→   Bit 6 is set if the 24V power supply is missing, it is reset if power supply is present

→   Bit 7 is set if the controller is too hot, it is reset when temperature becomes acceptable

Thermal protection is tripped when heat sink temperature goes above about 80°C, while it is disengaged when heat sink temperatures go below about 70°C. Lighting outputs LD1, LD2, LD3, LD4, LD5 and LD6 are turned off as long as thermal protection is active. Synchronization outputs SH1 and SH2 are never disabled.

Bit field [15:14] of this register is unused. Bits fields [13:8] and [5:0] of this register are reserved.

13.3.11. Register BRD_TMP

This register contains the controller temperature in bit field [12:0].
Temperature is expressed as a signed 13-bit integer, with a resolution of 0.0625°C.
Given the register value, the corresponding actual temperature can be calculated as follows:

$$ActualTemperature[°C] = RegisterValue * 0.0625$$

Bit field [15:13] of this register is unused.

13.3.12. Register MCU_VER

This register contains the microcontroller firmware version in bit field [7:0].
This information is encoded as a two-digit hexadecimal number. Bit field [15:8] of this register is unused.

13.3.13. Register DEV_TYPE

This register contains the device type in bit field [7:0]. This information is encoded as a two-digit hexadecimal number. Bit field [15:8] of this register is unused.

13.3.14. Register FPGA_VER

This register contains the FPGA firmware version in bit field [7:0]. This information is encoded as a two-digit hexadecimal number. Bit field [15:8] of this register is unused.

13.3.15. Register BRD_CMD

This register is used to execute special actions. Allowed values are listed below.
Avoid operation with non-listed values.

→ When 0 no action to perform

→ When 1 register file is read from flash memory
   (current contents will be overridden)

→ When 2 register file is written to flash memory
   (current contents will not be affected)

→ When 3 the controller is rebooted

Changes to the register file are saved in non-volatile memory only when a specific command is issued to the controller using this register.
The register is automatically set back to zero after the requested action has been completed.

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