INTRODUCTION

DALI (**D**igital **A**ddressable **L**ighting **I**nterface) is a standard digital communication protocol, used to link electronic light units. It is a standard spotlight management system.

A DALI network can be used to drive building lighting systems or more simple lighting networks like some spotlights in a single room or in a shop where it is useful to drive each light source individually.

A DALI system is cheap, simple and flexible. Minimal wiring and user-friendly functions are the main characteristics of this digital communication protocol. It is used to close the gap between simpler analogic dimming techniques (like 0-10 V or Triac) and more complex digital bus communications.
It could be also implemented as a subsystem in a more complex digital bus building network.

The DALI standard is defined in the IEC 62386 international norm, which guarantees compatibility between products from different manufacturers and various types of devices.

Ozone LED Drivers equipped with the DALI Option are compatible with DALI STANDARD (IEC 62386) and can be used in a DALI network.

TYPICAL APPLICATIONS

Every Place where energy optimization and lighting scenes are required, such as:

- Shopping Centre
- Conference Rooms
- Sports Centres
- Home
- Outdoor Applications

- Theatres
- Daylight public system management
- Presence detection lighting systems
- Aesthetic light effects

DALI MAIN FEATURES

- **Easy Wiring:** Standard low-cost wires can be used, the control line (2 wires) can laid together with the power AC line (same multi wires cable or sheath) without risks.

- **No polarity:** No need to distinguish wires polarity, there is not polarity on the DALI control line.

- **Flexibility:** Devices can be removed or added at any time from/in an existing network. Devices connection can be serial, parallel, or mixed. Each device can be managed independently or in groups, set by software. Lighting scenes can be created.

- **ON/OFF and Dimming:** All devices can be managed as slaves by a control unit (master), and can be turned on/off or dimmed independently or in groups. It is also possible to select Logarithmic or linear dimming curves.

- **Device status:** Fault feedback can be released from OZONE-DALI faulty devices.

DALI Technical & Electrical Features

Max. n. of DALI units in a network:	64
Max. n. of DALI device's group in a network:	16
Max. n. of scenes in a DALI system:	16
DALI bus voltage:	9.5 V ÷ 22.5 V 16 V typ.
DALI bus current:	250 mA MAX.
DALI control gear Max current consumption:	2 mA
Data transfer rate:	1200 bit/sec.
Max. DALI bus cable length:	300 m for 1.5 mm² cable section (2 V drop must not be exceeded along the bus line under any condition).

Ozone-DALI Connection

Ozone-DALI LED Driver versatility, allows the user to approach different connections and management solutions as shown in the example below.

Each Ozone-DALI control gear can be part of more groups at the same time, without conflicts.
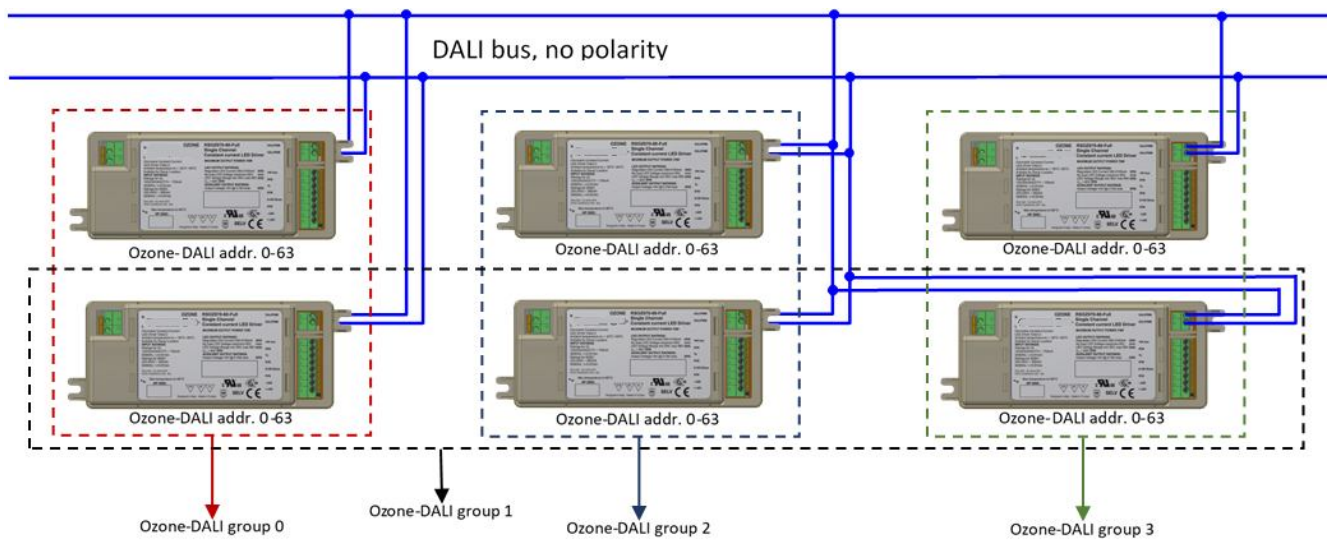

Figure 1
Ozone-DALI network (example connection)

OZONE-DALI DECLARATION OF FACTORY VARIABLES

Variable	Default Value (Factory pre-set)	Reset Value
ACTUAL LEVEL	Max Level (254)	254
POWER ON LEVEL	Max Level (254)	254
SYSTEM FAILURE LEVEL	Max Level (254)	254
MIN LEVEL	Physical min. level	Physical min. level
MAX LEVEL	254	254
FADE RATE	7	7
FADE TIME	0	0
SHORT ADDRESS	255 (no address)	No change
GROUP 0-7	No group	No group
GROUP 8-15	No group	No group
SCENE 0-15	No scene	No scene
VERSION NUMBER	1	No change
PHISICAL MIN. LEVEL	1	No change

For any additional details please refer to the IEC 62386 international standard.

OZONE-DALI IMPLEMENTED COMMANDS

Direct arc power control command		
Number	**Command Name**	**Description**
-	DIRECT ARC POWER CONTROL	The actual light level will be set to the value given by the data byte using the actual FADE TIME.

Indirect arc power control commands		
Number	**Command Name**	**Description**
0	OFF	The lamp goes to OFF without fading.
1	UP	The lamp is dimmed up for 200ms using the selected FADE RATE. If the lamp is already at the MAX LEVEL, no change will be implemented. If this command is received again while it is being executed, it will be retriggered. If the lamp is in OFF state, this command shall not cause the lamp turn ON.
2	DOWN	The lamp is dimmed down for 200ms using the selected FADE RATE. If the lamp is already at the MIN LEVEL, no change will be implemented. If this command is received again while it is being executed, it will be retriggered. This command shall not cause the lamp turn OFF.
3	STEP_UP	The actual light level will be set one step higher without fading. There shall be no change if the light level is already at the MAX LEVEL. This command shall not cause lamps to be switched ON.
4	STEP_DOWN	The actual light level will be set one step lower without fading. There shall be no change if the light level is already at the MIN LEVEL. This command shall not cause lamps to be switched OFF.
5	RECALL_MAX_LEVEL	The actual light level will be set to the MAX LEVEL without fading. If the lamp is OFF it shall be switched ON with this command.
6	RECALL_MIN_LEVEL	The actual light level will be set to the MIN LEVEL without fading. If the lamp is OFF it shall be switched ON with this command.
7	STEP_DOWN_AND_OFF	The actual light level will be set one step lower without fading. If the actual light level is already at the MIN LEVEL, the lamp shall be switched OFF by this command.
8	ON_AND_STEP_UP	The actual light level will be set one step higher without fading. If the lamp is switched OFF, the lamp shall be switched ON by this command and shall be set to the MIN LEVEL.
16-31	GO_TO_SCENE	Set the actual light level to the value stored for scene xx (0 to 15) using the actual fade time. If a control gear (a lamp) does not belong to the called scene x, its status shall remain unchanged.

Configuration commands

Number	Command Name	Description
32	RESET	The variables in the memory shall be changed to their reset values.
33	STORE_ACTUAL_LEVEL_IN_THE_DTR	The actual light level shall be stored in the DTR (Data Transfer Register).
42	STORE_THE_DTR_AS_MAX_LEVEL	The value in the DTR shall be saved as the new MAX LEVEL. If this value is below the MIN LEVEL of the control gear then the MIN LEVEL shall be stored as the new MAX LEVEL. If the ACTUAL LEVEL is above the new MAX LEVEL it should be set to the new MAX LEVEL without fading. If the DTR is MASK then 254 shall be stored as MAX LEVEL.
43	STORE_THE_DTR_AS_MIN_LEVEL	The value in the DTR shall be saved as the new MIN LEVEL. If the ACTUAL LEVEL is below the new MIN LEVEL it should be set to the new MIN LEVEL without fading, but if the ACTUAL LEVEL is "0" (OFF) it should not be affected by this command.
44	STORE_THE_DTR_AS_SYSTEM_FAILURE_LEVEL	The value in DTR shall be saved as new SYSTEM FAILURE LEVEL.
45	STORE_THE_DTR_AS_POWER_ON_LEVEL	The value in DTR shall be saved as the new POWER ON LEVEL.
46	STORE_THE_DTR_AS_FADE_TIME	The FADE TIME "T", will be set to a value given by formula: $T = \frac{1}{2} \cdot \sqrt{2^X} \cdot 1s$ with X=1-15 (X=0 means no fade). FADE TIME: Time for changing the actual light level to the requested level. The FADE TIME is used by the DIRECT ARC POWER CONTROL and GO TO SCENE commands.
47	STORE_THE_DTR_AS_FADE_RATE	The FADE RATE "F" will be set to a value given by the formula: $F = \frac{506}{\sqrt{2^X}}$ steps/s with X=1-15 FADE RATE: Rate in steps/s for changing the actual light level to the requested level. The FADE RATE is used by the UP and DOWN commands.
64-79	STORE_THE_DTR_AS_SCENE_XXXX	The value in the Data Transfer Register will be stored as a new level for the scene X (0-15).

System parameters settings

Number	Command Name	Description
80-95	REMOVE_FROM_SCENE_XX	The control gear will be removed from scene XX
96-111	ADD_TO_GROUP_XX	The control gear will be added to group XX
112-127	REMOVE_FROM_GROUP_XX	The control gear shall be removed from group XX
128	STORE_DTR_AS_SHORT_ADDRESS	The value in the DTR shall be saved as new short address.

Query commands: Queries related to status information

Number	Command Name	Description
144	QUERY_STATUS	Status information request.
145	QUERY_CONTROL_GEAR	Ask if there is a control gear with the given address that is able to communicate. The answer is YES or NO.
146	QUERY_LAMP_FAILURE	Ask if there is a lamp problem at the given address. The answer is YES or NO.
147	QUERY_LAMP_POWER_ON	Ask if there is a lamp operating at the given address. The answer is YES or NO.
148	QUERY_LIMIT_ERROR	Ask if the last requested light level at the given address could not be met, because it is above the MAX LEVEL or below the MIN LEVEL. The answer is YES or NO.
149	QUERY_RESET_STATE	Ask if the control gear is in RESET STATE. The answer is YES or NO.
150	QUERY_MISSING_SHORT_ADDRESS	Ask if the control gear has no short address. The answer is YES (no short address) or NO.
151	QUERY_VERSION_NUMBER	The answer is 1.
152	QUERY_CONTENT_DTR	The answer is the content of the DTR as an 8-bit number.
153	QUERY_DEVICE_TYPE	The answer is the devise type as an 8-bit number (6).
154	QUERY_PHYSICAL_MINIMUM_LEVEL	The answer is the PHISICAL MINIMUM LEVEL as an 8-bit number.
155	QUERY_POWER_FAILURE	The answer will be YES if the control gear has not received a RESET or one of the following arc power control commands since the last power-on: DIRECT ARC POWER CONTROL, OFF, RECALL MAX LEVEL, RECAL MIN LEVEL, STEP DOWN AND OFF, ON AND STEP UP, GOTO SCENE.

Queries related to arc power parameter settings		
Number	**Command Name**	**Description**
160	QUERY_ACTUAL_LEVEL	The answer will be the actual light level.
161	QUERY_MAX_LEVEL	The answer will be this level as an 8-bit number.
162	QUERY_MIN_LEVEL	The answer will be this level as an 8-bit number.
163	QUERY_POWER_ON_LEVEL	The answer will be this level as an 8-bit number.
164	QUERY_SYSTEM_FAILURE_LEVEL	The answer will be this level as an 8-bit number.
165	QUERY_FADE_TIME_AND_RATE	The answer will be xxxx yyyy where xxxxis the FADE TIME and yyyy the FADE RATE.

Queries related to system parameter settings		
Number	**Command Name**	**Description**
176-191	QUERY_SCENE_LEVEL_XXXX	The answer will be the light level of scene XX as an 8-bit number.
192	QUERY_GROUPS_0_7	The answer will be the membership of groups 0-7 as an 8-bit value.
193	QUERY_GROUPS_8_15	The answer will be the membership of groups 8-15 as an 8-bit value.
194	QUERY_RANDOM_ADDRESS_H	The answer will be the 8 high bits of the random address.
195	QUERY_RANDOM_ADDRESS_M	The answer will be the 8 mid bits of the random address.
196	QUERY_RANDOM_ADDRESS_L	The answer will be the 8 low bits of the random address.

Application extended commands for LED drivers		
Number	**Command Name**	**Description**
227	SELECT_DIMMING_CURVE	Set the dimming curve to linear or to logarithmic.
228	STORE_THE_DTR_AS_FAST_FADE_TIME	The DTR content will be stored as fast fade time value.
237	QUERY_GEAR_TYPE	Answer will be "Led power supply integrated" and "a.c. supply possible".
238	QUERY_DIMMING_CURVE	Answer will be the dimming curve currently in use.
239	QUERY_POSSIBLE_OPERATING_MODES	Answer will be an 8-bit code that identifies the following possible operating modes: PWM mode, AM mode, C.C. output.
240	QUERY_FEATURES	Answer will be an 8-bit code, giving information about implemented optional features.
241	QUERY_FAILURE_STATUS	Answer will be an 8-bit code identifying the actual failure status.
242	QUERY_SHORT_CIRCUIT	Ask if there is a short circuit detected at the given address. Answer shall be yes or no.
243	QUERY_OPEN_CIRCUIT	Ask if there is an open circuit detected at the given address. Answer shall be yes or no.
247	QUERY_THERMAL_SHUTDOWN	Ask if there is a thermal shut down detected at the given address. Answer shall be yes or no.
248	QUERY_THERMAL_OVERLOAD	Ask if there is a thermal overload with light level reduction detected at the given address. Answer shall be yes or no.
252	QUERY_OPERATING_MODE	Answer will be an 8-bit code that identifies the following possible operating modes: PWM mode, AM mode, C.C. output.
253	QUERY_FAST_FADE_TIME	Answer shall be the Fast Fade Time as an 8-bit value.
254	QUERY_MIN_FAST_FADE_TIME	Answer shall be the Minimum Fast Fade Time as an 8-bit value.
255	QUERY_EXTENDED_VERSION_NUMBER	Answer will be1.

Special commands: Terminate special processes		
Number	**Command Name**	**Description**
256	TERMINATE	Special mode processes shall be terminated.

Download information to the DTR		
Number	**Command Name**	**Description**
257	DATA_TRANSFER_REGISTER (DTR)	The 8-bit value xxxx xxxx shall be stored to the DTR.

Addressing commands		
Number	**Command Name**	**Description**
258	INITIALISE	This command will start a 15min. timer, the addressing commands 259 to 270 shall only be processed whilst this timer is running. The other commands shall still be processed during this period.
259	RANDOMISE	The control gear shall generate a new random address on receipt of this command.
260	COMPARE	The control gear shall compare its random address with the 24-bit search address. If its random address is less or equal the search address then the control gear shell answer YES.
261	WITHDRAW	The control gear whose random address is equal to the search address shall be excluded from the compare process, but not from the initialization process.
264	SEARCHADDR_H	The 8 high bits of the search address.
265	SEARCHADDR_M	The 8 mid bits of the search address.
266	SEARCHADDR_L	The 8 low bits of the search address.
267	PROGRAM_SHORT_ADDRESS	The control gear shall store the received 6-bit address as its short address if it is selected. Selected means that the control gear's random address is equal to the 24-bit search address.
268	VERIFY_SHORT_ADDRESS	The control gear shall answer YES if the received 6-bit short address is equal to its own short address.
269	QUERY_SHORT_ADDRESS	The control gear shall answer its short address if the random address is equal to the search address or the control gear is physically selected.

Extended special commands		
Number	**Command Name**	**Description**
272	ENABLE_DEVICE_TYPE_X	This command shall select the device type for witch the next following application extended command (227 to 255) is valid.

Any command not shown in this document has not been implemented. For any additional details, please, refer to the IEC 62386 international standard.

DALI DIMMING CURVES

Ozone-DALI ensures very high dimming performance, currently not achievable with analog dimming techniques such as 0-10 V_{DC} or 1-10 V_{DC}. Ozone-DALI L.E.D. driver provides 254 brightness level between min and max values, including linear and logarithmic (default) dimming possibilities.
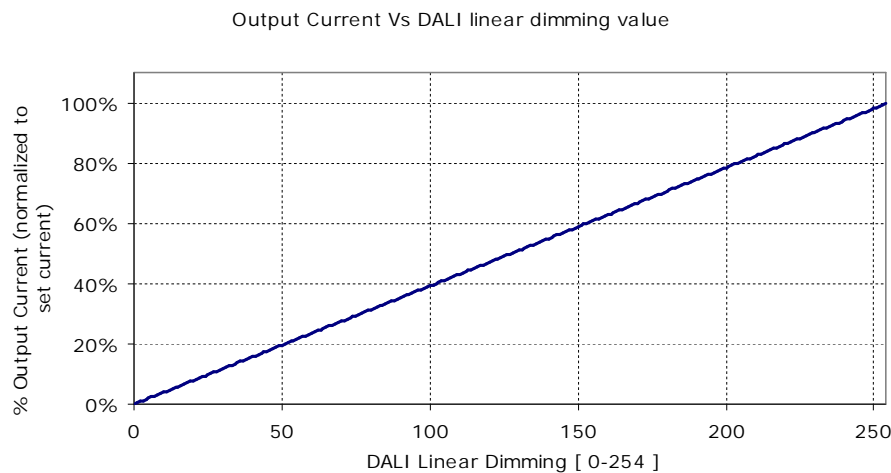

Figure 2
DALI linear dimming diagram

Logarithmic dimming technique gives larger brightness increments at high dim levels and smaller increments at low dim levels. The result is a better control of the lighting intensity in response to the human eye perception.
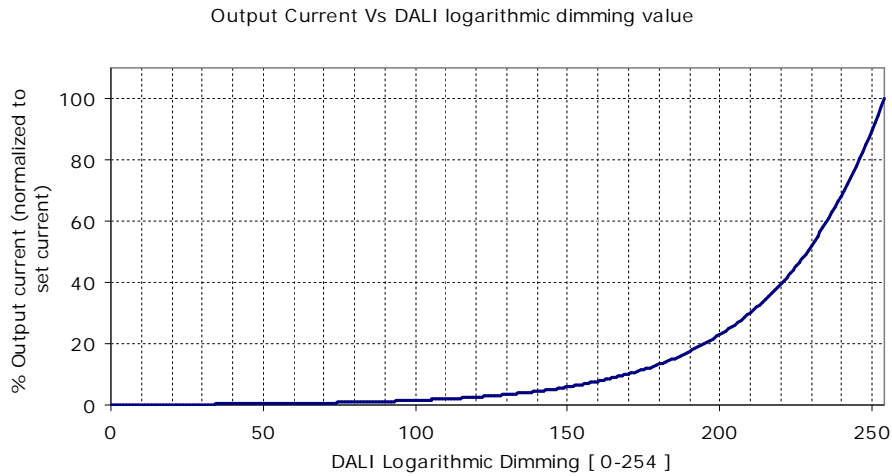
Output Current Vs DALI logarithmic dimming value

Figure 3: DALI logarithmic dimming diagram

PWM DIMMING

Ozone-DALI output current can also be dimmed using a PWM dimming signal applied on the same DALI connector.
Using the Ozone programming tool, available as optional (ordering code: **RSOZ070-PTOOL**), it is possible to set Ozone-DALI as DALI LED driver or PWM dimmable LED driver. Refer to "**AN3_Ozone setting**" for more device settings details.

Once set as PWM dimmable LED driver, Ozone can accept a PWM dimming signal, conforming to the EN60929 normative, to dim its nominal constant current output from 0 % to 10 0%.
The frequency of the output current is fixed at 150 Hz.

PWM signal NO polarity

V. high: 10 ÷ 25 V
V. low: 0 V ÷ 1.5 V

T. period: 1 to 10ms

PWM input current: ≈ 2 mA MAX
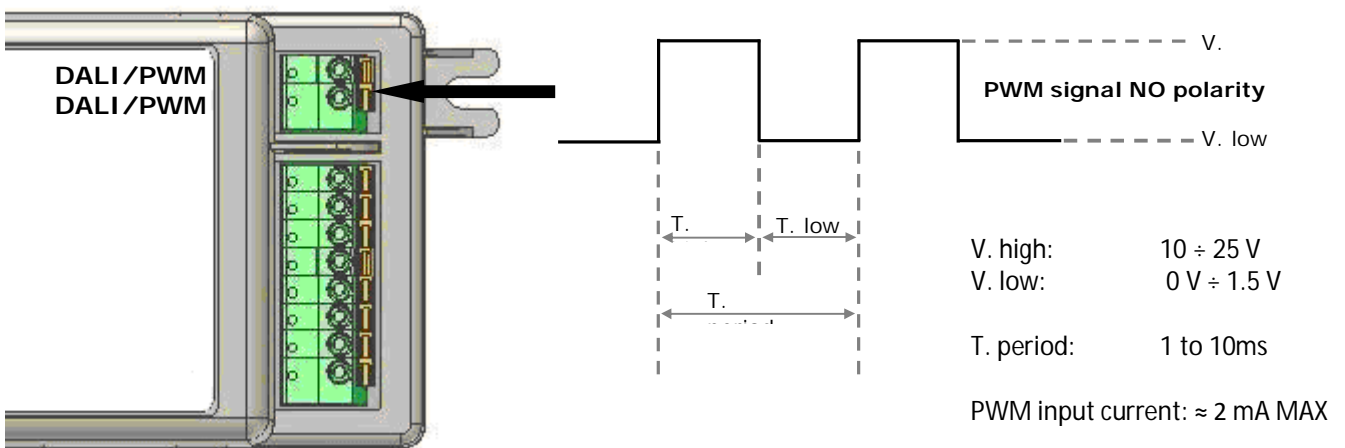
Figure 4
Ozone as PWM dimmable LED driver

Several Ozone LED drivers can be managed with the same PWM signal.
The PWM generator circuitry must be able to supply the current amount required by the all connected Ozone devices (I_{TOT}: 2 mA x number of Drivers connected).

PWM DIMMING CURVE

Using Ozone as PWM dimmable LED driver, the output current level will linearly correspond to the PWM signal duty cycle as shown in the curve represented in the **Figure 5**.

Output Current Vs PWM dimming duty
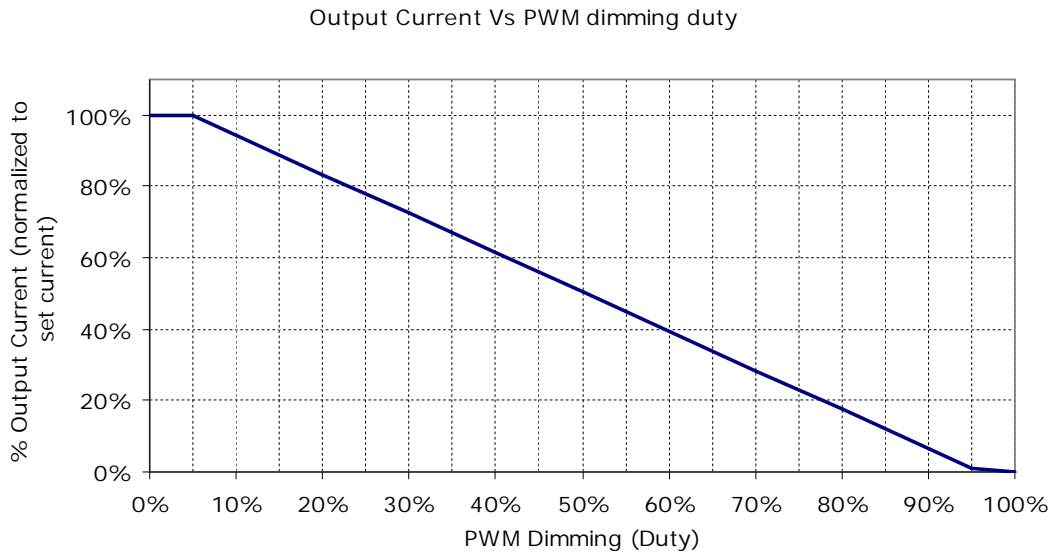
Min Light level: **0 %** (OFF) when PWM Duty cicle is more than 95 %
Max Light level: **100 %** when PWM Duty cicle is 0 ÷ 5 %

Figure 5
PWM dimming diagram