Application Note

Driving LEDs using Pulse Width Modulation

This technical note is intended to provide an introduction to the pulse width modulation technique (PWM) which can be used to drive Violumas LEDs.

Driving LEDs Using Pulse Width Modulation

Overview

This technical note is intended to provide an introduction to the pulse width modulation technique (PWM) which can be used to drive Violumas LEDs.

Intended Audience

- Product developers intending to use Violumas LED products
- Violumas technical Sales Engineers providing support to potential customers

Scope

This technical note is aimed to provide product designers with an introduction to pulse width modulation technique, the factors which need to be understood to use PWM with UV LED systems, and how such a system can be implemented.

Disclaimer

This resource is intended for engineers using Violumas LED products. Product designers are solely responsible for selecting the appropriate Violumas products and ensuring that the applicable standards and safety requirements are met. Violumas cannot be held responsible for any damage caused by following these guidelines.

Introduction to Pulse Width Modulation

Pulse-width modulation (PWM) refers to switching a device ON and OFF at a high frequency for dimming LEDs. It is a very well-known technique which has been used with visible LEDs to attain an average irradiance level. The fundamentals which govern PWM for UV LEDs remain the same as the visible LEDs. However, the perception of PWM in the case of visible LEDs is governed by the flicker levels, which is not necessarily concerning for UV LEDs, since such LEDs are not meant to be seen directly, and human eye exposure should be always avoided.
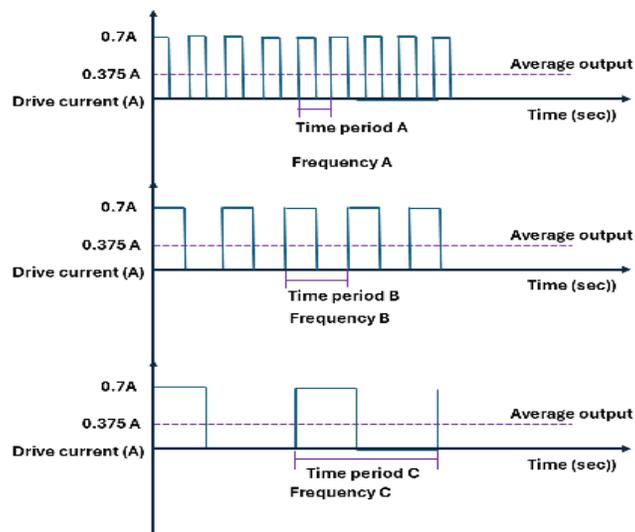

Figure 1: PWM signals at different frequencies.
Frequency is the inverse of time period so Frequency A > Frequency B > Frequency C

PWM provides more control over the output level and is ideally suited for applications needing high efficiency and a controlled temperature. Pulsed operation of UV LEDs is already used in many industries such as curing [1]. When compared to a constant current control, PWM provides a wider dimming range.
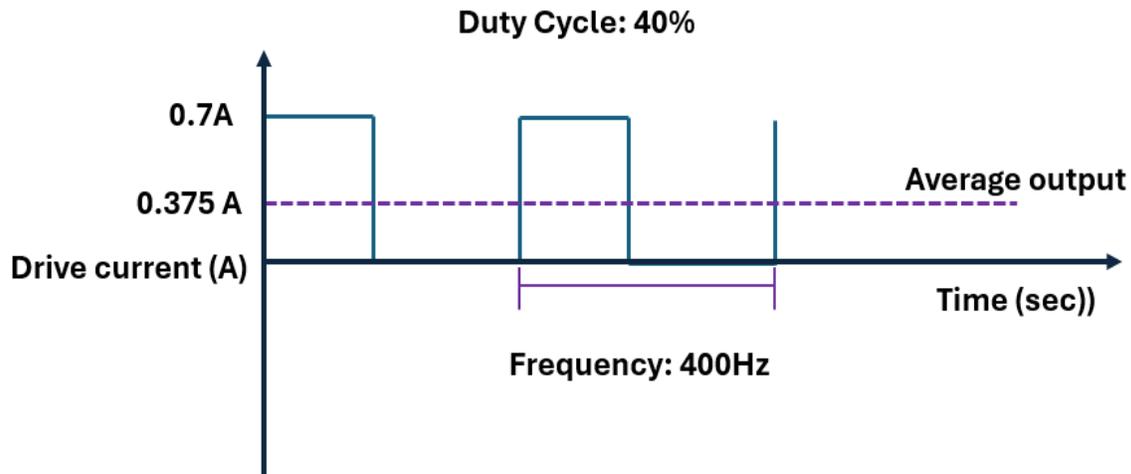
PWM Tuning Parameters

Figure 2: Parameters of a PWM signal

Time Period and Frequency

The time taken for a PWM signal to complete a full ON-OFF cycle is called a time period. The inverse of the time period is the frequency.

$$Time\ period = T_{ON} + T_{OFF}$$

$$Frequency = {1}/{T}$$

Duty Cycle

A duty cycle is the fraction of one period when a system is switched to high (ON level). It is typically expressed as a ratio or percentage.

$$Duty\ cycle\ (\%) = \frac{T_{ON}}{T} \times 100$$

For example, if a PWM signal is in an ON-state half the time and in the OFF state for the other half, the duty cycle of this PWM signal would be 50%. In order to increase the duty cycle of the signal the ON time needs to be increased for the same time period.

True PWM Dimming For LEDs

True PWM dimming for constant current LED sources implies that the current is switched from high to low directly such that the LED power varies at every cycle. If the time period is the same and the pulses are narrow, implying that the ON time in a particular cycle is short, the average current will be lower as compared to a wider pulse within the same time period.
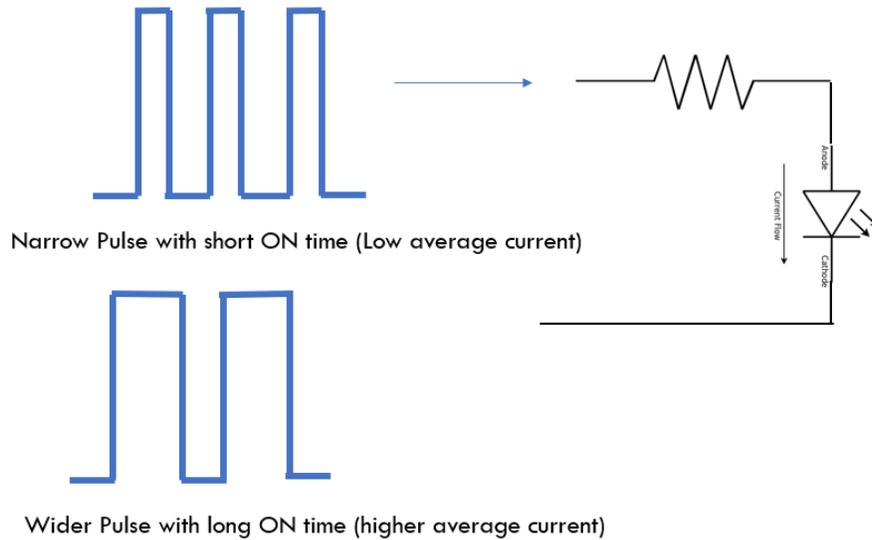

Narrow Pulse with short ON time (Low average current)

Wider Pulse with long ON time (higher average current)

Figure 3: True PWM dimming

Analog Dimming Using PWM

In some LED power supplies, PWM can be used to achieve constant current dimming. In this case, an RC filter is embedded into the PSU.

While the signal applied to the power supply is a PWM signal, the actual signal to the LEDs is not a PWM signal but a constant current signal, for which the current is determined based on the additive PWM signal. For example, in a Meanwell Power supply, PWM is one way to achieve constant current dimming.
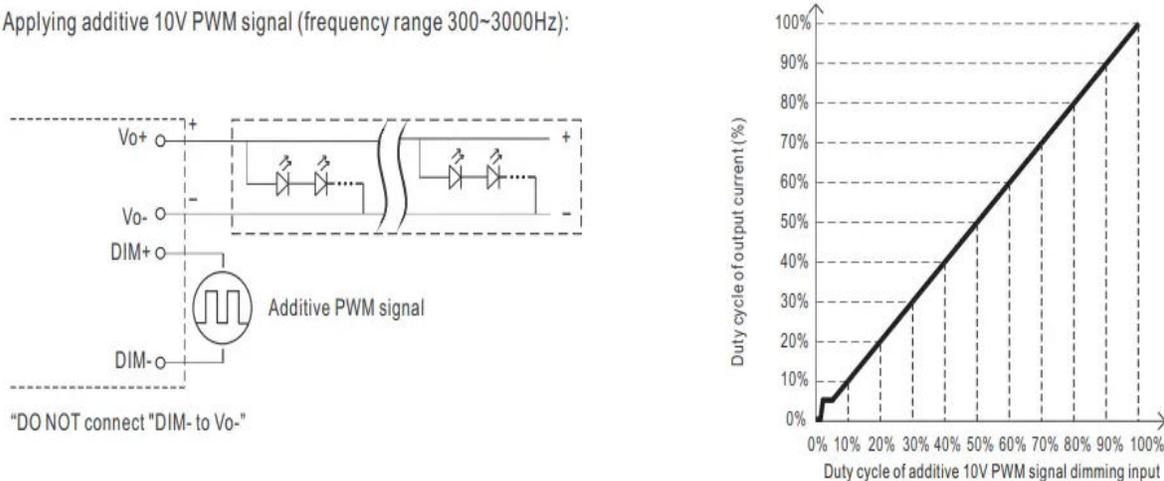

Figure 4: Dimming achieved using a PWM signal but not a true PWM dimming [2].

PWM Dimming vs. Constant Current Dimming

| PWM Dimming	Constant Current Dimming
Output power is modulated using a digital signal (ON/OFF cycle)	DC current is varied in a continuous manner
Possible lowering of LED junction temperature due to OFF times	Linear increase/decrease in current with fixed junction temperature
More precise control over dimming levels	Dimming level control not as precise
Higher instantaneous irradiance levels may be reached. However, junction temperature escalations may reduce lifetime.	Current levels have to be fixed based on maximum ratings

It should also be noted that switching the LEDs ON/OFF implies a lower energy dosage depending on the duty cycle, which might impact the performance of certain applications such as curing.

PSU Compatibility

When deciding to use PWM, it is essential to ensure that the LED driver is compatible and whether it would be a true PWM dimming or a constant current dimming using PWM.

For example, RECOM dc-dc driver, RCD-48, offers true PWM dimming as shown in the figure. Note that this driver requires an external PWM signal to be generated and applied to the PWM pin.
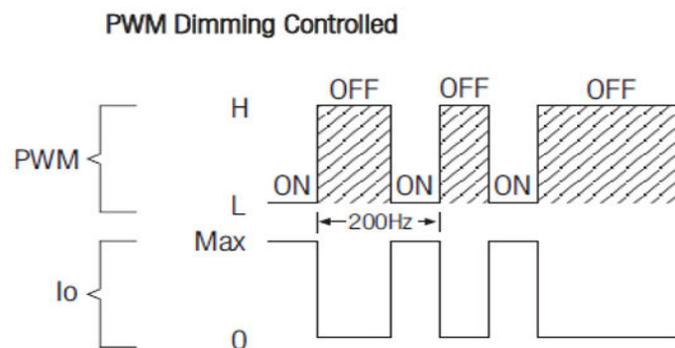
Figure 3: True PWM dimming

Many applications may directly benefit by pulsing the LEDs. For example, improved microbial reduction was observed for water disinfection by using pulsed UVC LED irradiation as compared to continuous ON operation [4]. Pulsed UVC light has also been used for fluorescence detection [5] as well as for oxidation processes, as shown in [6].

References

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2. https://led.meanwell.com/webapp/product/search.aspx?prod=HLG-240H

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4. Kai Song, Fariborz Taghipour, Madjid Mohseni, "Microorganisms inactivation by continuous and pulsed irradiation of ultraviolet light-emitting diodes (UV-LEDs)", Chemical Engineering Journal, Volume 343, 2018,Pages 362-370.

5. K. -C. Huang, C. -L. Chang, H. -C. Chang and C. -H. Chang, "The pulse exciation of UV LED source for fluorescence detection," 2011 IEEE International Instrumentation and Measurement Technology Conference, Hangzhou, China, 2011, pp. 1-4, doi: 10.1109/IMTC.2011.5944032.

6. Ismael Hajimiri, Mohammad Hossein Rasoulifard, Mir Saeed Seyed Dorraji, Mohammad Reza Eskandarian, "Study of controlled pulsed illumination (CPI) efficiency in the homogeneous UV-LED/S2O82− process for the removal of organic dye from contaminated water", Results in Engineering,Volume 21,2024.

Have more questions?

If you have questions that are not answered in this document, please contact the Violumas team.

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