



## NXP 16-channel, 12-bit I<sup>2</sup>C-bus PWM/LED backlight controller PCA9685

# Build a better LCD backlighting unit for full-color RGBA displays

This flexible I<sup>2</sup>C-bus LED controller, optimized for full-color LCD RGBA backlighting units, can also be combined with switch-mode regulators to create high-efficiency LED displays with low in-rush current. The IC reduces EMI and offers 4,096-step LED dimming.

### Key features

- ▶ 16 LED outputs with 25-mA sink/10-mA source
- ▶ 400-mA device limit for direct LED drive or glueless connection to external, high-current FETs
- ▶ Independently programmable control for on, off, and staggered delay on each output
- ▶ Smooth backlight control with 4,096 user-programmable steps of individual LED brightness
- ▶ Integrated 25-MHz oscillator with optional external clock input pin for up to 50 MHz
- ▶ 16 independent PWMs programmable to a common frequency (40 to 1000 Hz)
- ▶ 1-MHz Fast-mode Plus I<sup>2</sup>C-bus interface
- ▶ Operating voltage: 2.3 to 5.5 V (all I/O tolerant to 5.5 V)
- ▶ Temperature range: -40 to +85 °C

### Key applications

- ▶ RGB or RGBA LED drivers
- ▶ LED status information
- ▶ LED displays
- ▶ LCD backlights
- ▶ Keypad backlights for cellular phones or handheld devices

Optimized for full-color LCD RGBA backlighting applications, the PCA9685 is a 16-channel LED controller based on the I<sup>2</sup>C-bus.

It is an upgrade of the PCA9635, adding a 4,096-step PWM, a lower PWM frequency (40 to 1000 Hz), programmable LED output delays, and an optional external-clock input. The PCA9685 also adds a default power-up state of outputs set to Low, to ensure that LEDs in systems that use an external driver power up in the off state.

Each LED output in the PCA9685 has its own fixed-frequency PWM controller with 12-bit resolution (4,096 steps). The PWMs operate at a programmable frequency (from 40 to 1000 Hz) with a duty cycle that can be adjusted from 0 to 100%, so the LEDs can be set to specific brightness values. All the outputs are set to the same PWM frequency.

Each LED output can be off or on (no PWM control), or set at its individual PWM controller value. The LED output driver is programmed to be either an open drain (with a 25-mA current sink capability at 5 V) or a totem pole (25-mA sink, 10-mA source capability at 5 V).



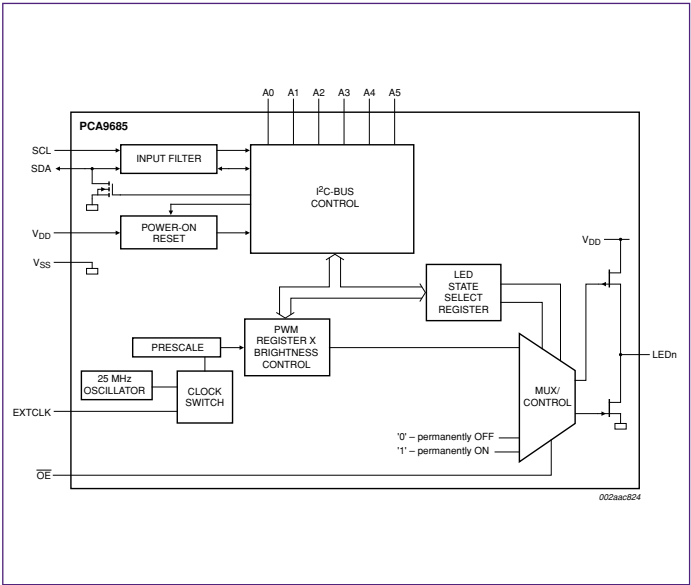
LEDs can be connected directly to the LED output (up to 25 mA, 5.5V). To support larger currents and higher voltages, a small number of discrete components can be used to drive the LEDs externally.

The PCA9685 has a built-in oscillator for low-cost PWM control but an external clock can be supplied when multiple PCA9685 devices are used in tandem and need to be synchronized.

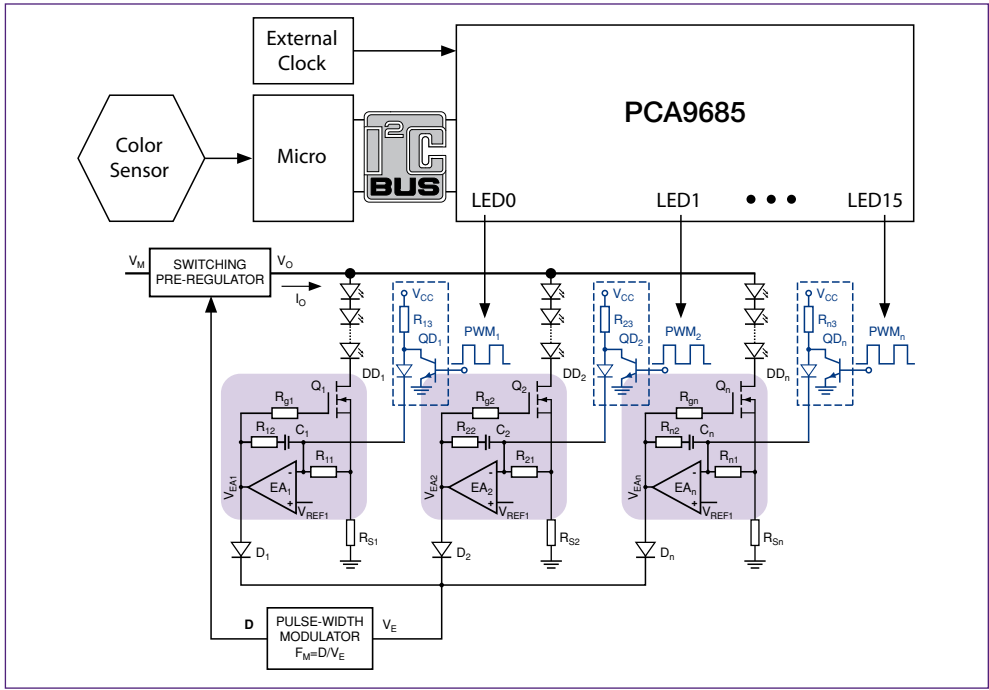
The PWM frequency and LED on and off positions within the duty cycle are programmable. This means the LED output pulses can be staggered, thus reducing EMI, and any in-rush currents caused by inductive LED loads are limited.

To improve the efficiency of LED dimming in LED backlighting units (BLUs), the PWM outputs can also be used to modulate switch-mode power supplies. At power-up, the LED PWM outputs default to Low to prevent external, high-current driver transistors from turning on.

PCA9685 block diagram



### LCD backlighting application



### Ordering Information

Type number	Package	Number of pins
PCA9685PW	TSSOP	28
PCA9685BS	HVQFN	28

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