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CE97634 - PSoC® 4 Breathing LED

Objective

This example demonstrates an implementation of an LED breathing effect using PWMs and XOR gates without CPU involvement.

Overview

The code example shows how to use the flexibility of a PSoC 4200DS device to implement a breathing LED effect exclusively in hardware without any CPU usage. The example uses two PWMs and an XOR gate to implement the design. A user switch is also used in the example to gate the breathing LED effect. Refer to the Design section for details on the implementation.

Note: This example is supported ONLY in PSoC 4200DS devices with at least two PWMs and one universal digital block (UDB) for implementing the XOR and AND gate logic functions.

Requirements

Tool: PSoC Creator 4.1 or later

Programming Language: C (ARM® GCC 5.4.1)

Associated Parts: PSoC 4 parts with at least two PWMs and one UDB

Related Hardware: CY8CKIT-146, CY8CKIT-042, CY8CKIT-044, CY8CKIT-042-BLE, and CY8CKIT-043

Design

Breathing LED

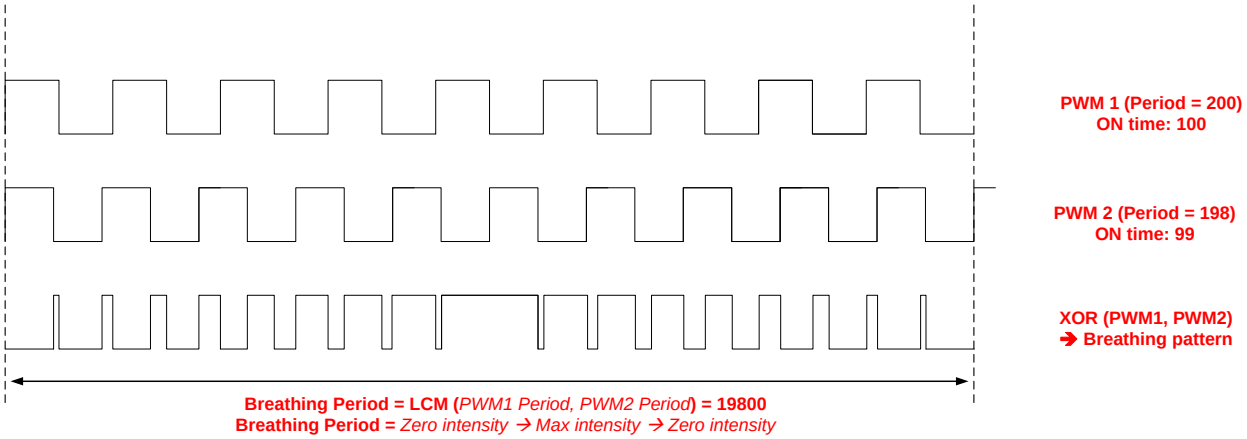
When the intensity of an LED is gradually varied from zero to maximum and then from maximum to zero in a periodic fashion, a breathing LED effect is generated. This effect is analogous to the human breathing pattern – inhale (zero to max intensity) and exhale (max to zero intensity).

To create this breathing effect on the LED, a PWM signal whose duty cycle varies gradually from zero to max and vice-versa (shown in Figure 1) is required. The gradual increase and decrease in the duty cycle can be linear or exponential depending on the aesthetic preference. A method of generating a linearly varying PWM using PSoC is presented in this example. The implementation uses hardware blocks available in PSoC and does not involve any CPU usage. This PWM output can also be generated using a single PWM but with firmware controlling the duty cycle and period.

Figure 1: PWM to Generate a Breathing LED Pattern

The PWM waveform shown in Figure 1 can be easily generated in hardware using two PWMs and a simple XOR gate. Take two PWMs, one with period 200, another with period 198 and both having a duty cycle of 50%. XOR the two PWM outputs to generate a waveform that provides a breathing LED output, as shown in Figure 2.

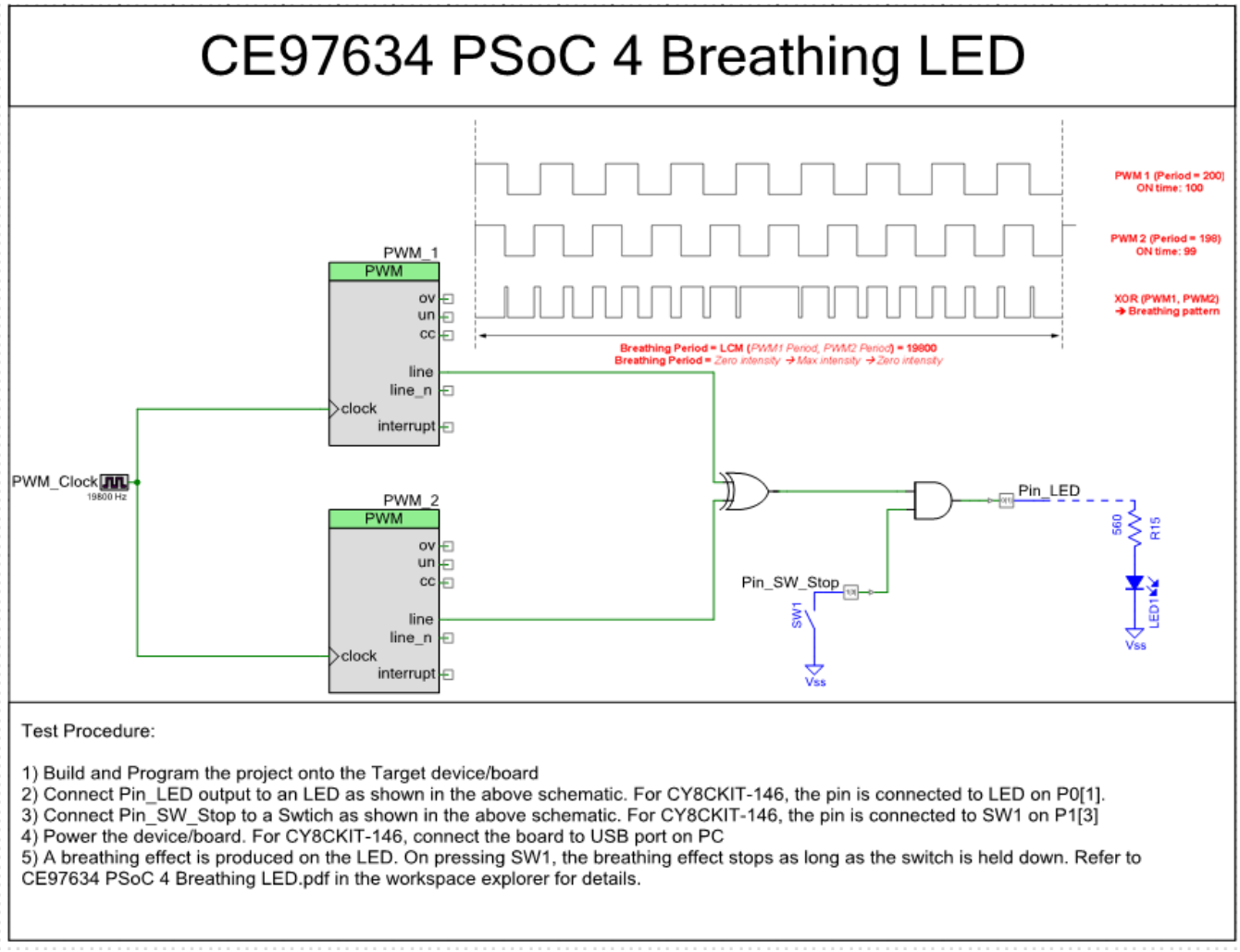
Figure 2: Generating Breathing PWM Output Using PWMs and XOR



As can be seen from the Figure 2, the breathing period of the LED is given by the least common multiple (LCM) of the two periods.

PSoC 4 Implementation

Figure 3. Top Design Schematic of the Example



Firmware starts the PWM clock and the PWMs. After that, the CPU is put into sleep mode because it is not required for any other operations. This complete implementation is with respect to CY8CKIT-146. In order to use the CE for other kits one can refer Table 1 for port mapping.

Design Extensions

The example can be extended to generate any desired breathing effect by changing the breathing period and step size. The breathing period and step size at which the LED intensity is varied can be derived using the below relationship.

If
PWM1 Period ➔ N clock cycles
Desired Step Size every N/2 cycles ➔ x cycles; 0 < x < N/4
PWM1 ON time ➔ N/2 cycles

Then,
PWM2 Period ➔ N – 2x cycles,
PWM2 ON time ➔ N/2 – x,
Breathing Period ➔ LCM (N, N-2x) clock cycles

Hardware Setup

No Additional Hardware setup is required.

Software Setup

No Additional software setup is required.

PSoC Creator Components

Table 1 lists the PSoC Creator Components used in this example, as well as the hardware resources used by each.

Table 1. List of PSoC Creator Components

Component	Version of the Components	Instance Name	Hardware Resources	Non-default Parameter settings
PWM (TCPWM Mode)	2.10	PWM_1	One TCPWM block	**Period:** *200* **Compare:** *100*
		PWM_2	One TCPWM block	**Period:** *198* **Compare:** *99*
Clock	2.20	PWM_Clock	One Clock Divider	**Frequency:** *19800 Hz* **Use fractional divider:** *Checked*
XOR	1.0	-	Part of one UDB	None
AND	1.0	-	Part of one UDB	None
Digital Output Pin	2.20	Pin_LED	CY8CKIT-146 -> P0[1] CY8CKIT-043 -> P1[6] CY8CKIT-044 -> P0[6] CY8CKIT-042 -> P0[3]	None
Digital Input Pin	2.20	Pin_SW_Stop	CY8CKIT-146 -> P1[3] CY8CKIT-043 -> P0[7] CY8CKIT-044 -> P0[7] CY8CKIT-042 -> P0[7]	**Drive mode:** *Resistive pull up* **Initial drive state:** *1*

Design-Wide / Global Resources

Figure 4. Pin Tab for CY8CKIT-146 4200DS Prototyping board in Design Wide Resources (.cydwr file)

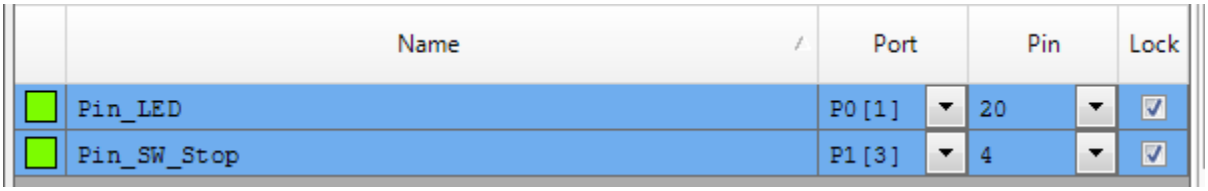
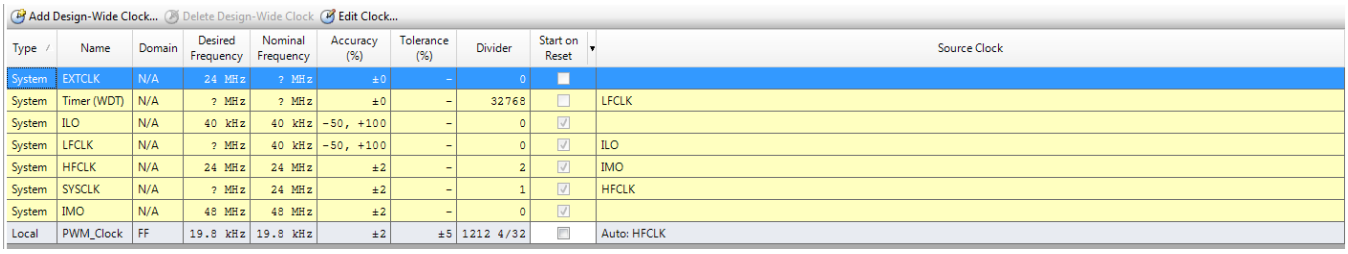


Figure 5. Clock Tab Settings in CY8CKIT-146 Design-Wide Resources



Operation

1. Build the example project by navigating to **Build** > **Build <*Project Name*>** in PSoC Creator.
2. Program the example to the device by navigating to **Debug** > **Program**.
3. The **User LED (LED1)** connected to **P0[1]** should start displaying the breathing effect.
4. Press the **User Switch (SW1)** connected to **P1[3]** and as long as it is held down, the LED will be OFF. On releasing the switch, the LED will start displaying the breathing effect again. Note that the PWM component is not stopped when the switch is pressed; only the LED output is gated.

Upgrade Information

N/A

Related Documents

Table 2 lists all relevant application notes, code examples, knowledge base articles, device datasheets, and component datasheets.

Table 2. Related Documents and Resources

Application Notes		
AN79953	Getting Started with PSoC® 4	Provides details on getting started resources for PSoC 4
PSoC Creator Component Datasheets		
TCPWM	PSoC 4 Timer Counter Pulse Width Modulator (TCPWM) component	
Digital Logic Gates	Supports boolean operation with configurable number of inputs	
Device Documentation		
PSoC 4200DS Datasheets		
PSoC 4200DS Technical Reference Manuals		
Development Kits		
PSoC 4 Kits		
Software		
PSoC Creator Training		
PSoC 3/4/5 Code Examples		
Video Library		

PSoC Resources

Cypress provides a wealth of data at www.cypress.com to help you to select the right PSoC device for your design, and quickly and effectively integrate the device into your design. For a comprehensive list of resources, see KBA86521, How to Design with PSoC 3, PSoC 4, and PSoC 5LP. Refer to AN79953 - Getting Started with PSoC® 4 to get started with PSoC 4**.** The following is an abbreviated list of resources to get started with PSoC 4:

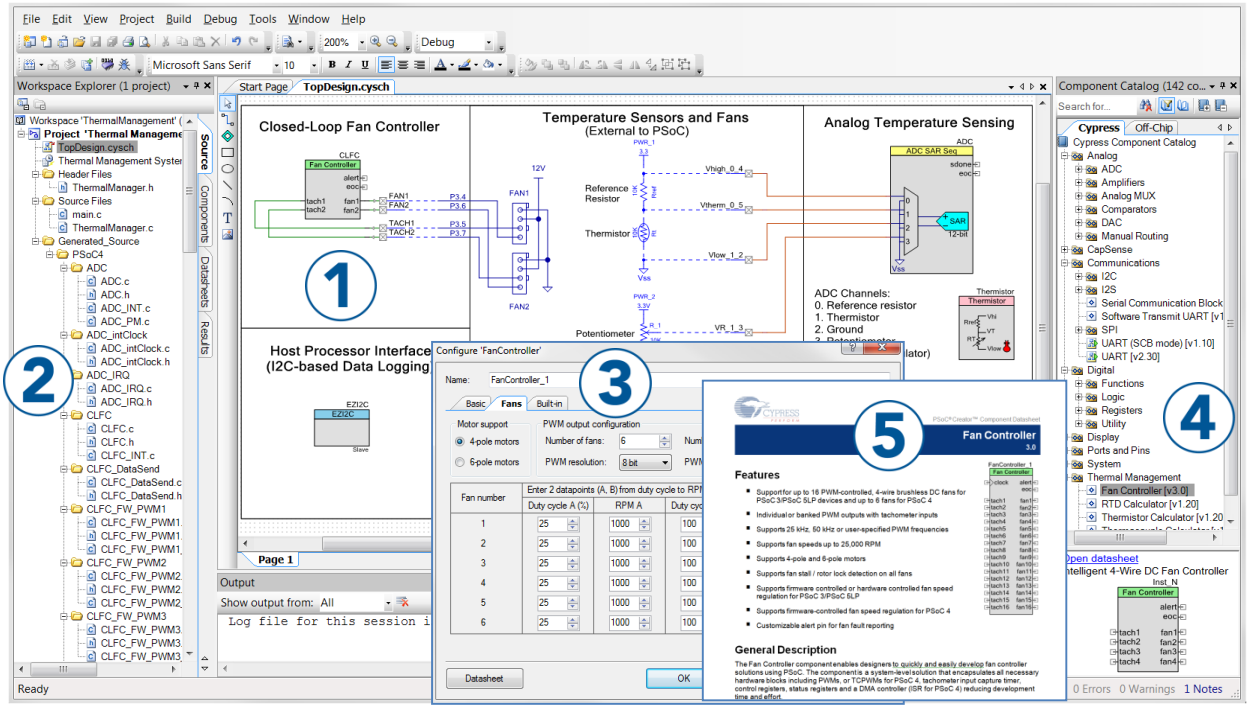
- **Overview:** PSoC Portfolio, PSoC Roadmap
- **Product Selectors:** PSoC 1, PSoC 3, PSoC 4, PSoC 5LP. In addition, PSoC Creator includes a device selection tool.
- **Datasheets**: Describe and provide electrical specifications for the PSoC 4 device family
- **CapSense Design Guide:** Learn how to design capacitive touch-sensing applications with the PSoC 4 family of devices.
- **Application Notes and Code Examples:** Cover a broad range of topics, from basic to advanced level. Many of the application notes include code examples. Visit the PSoC 3/4/5 Code Examples page for a complete list of PSoC Creator code examples available across application notes, kits, and PSoC Creator.
- **PSoC Training Videos**: These videos provide step-by-step instructions on getting started building complex designs with PSoC.
- **Technical Reference Manuals (TRM):** Provide detailed descriptions of the architecture and registers in each PSoC 4 device family.
- **Development Kits:**
  - CY8CKIT-040, CY8CKIT-042, CY8CKIT-044, CY8CKIT-046, CY8CKIT-041-40XX, and CY8CKIT-041-41XX PSoC 4 Kits, are easy-to-use and inexpensive development platforms. These kits include connectors for Arduino™ compatible shields and Digilent® Pmod™ daughter cards.
  - CY8CKIT-049 and CY8CKIT-043 are very low-cost prototyping platforms for sampling PSoC 4 devices.
  - CY8CKIT-001 is a common development platform for all PSoC family devices.
- The MiniProg3 device provides an interface for flash programming and debug. The same functionality is built into most kits through the KitProg present on-board.

PSoC Creator

PSoC Creator is a free Windows-based Integrated Design Environment (IDE). It enables concurrent hardware and firmware design of systems based on PSoC 3, PSoC 4, PSoC 5LP, and PSoC 4200DS. See Figure 6 – with PSoC Creator, you can:

1. Drag and drop Components to build your hardware system design in the main design workspace
2. Codesign your application firmware with the PSoC hardware
3. Configure Components using configuration tools
4. Explore the library of 100+ Components
5. Review Component datasheets

Figure 6. PSoC Creator Features



Document History

Document Title: CE97634 - PSoC® 4 Breathing LED

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Revision	ECN	Orig. of Change	Submission Date	Description of Change
**	4777393	MSUR	05/26/2015	New spec.
*A	4795367	MSUR	06/12/2015	Minor text edits.
*B	5629922	NMIT	02/16/2017	Updated Overview: Updated description. Updated Design: Updated Breathing LED: Updated description. Updated PSoC 4 Implementation: Updated Figure 3. Updated Hardware Setup: Updated Figure “Hardware Block Diagram for CY8CKIT-146 4200DS Prototyping Board”. Updated description. Updated PSoC Creator Components: Replaced “Components” with “PSoC Creator Components” in heading. Updated Table 1. Updated Design-Wide / Global Resources: Updated Figure 4. Updated Figure 5. Updated Operation: Updated description. Updated Related Documents: Updated Table 2. Updated PSoC Resources: Updated description. Updated PSoC Creator: Updated description. Updated to new template.
*C	5665948	NMIT	03/20/2017	Updated Hardware Setup: Removed Figure “Hardware Block Diagram for CY8CKIT-146 4200DS Prototyping Board”. Updated description. Added Software Setup. Updated to new template. Completing Sunset Review.

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