CE97634 - PSoC® 4 Breathing LED

Objective

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

Overview

The code example shows how to use the flexibility of a PSoC 4 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 Design section for details on the implementation.

Note This example is supported ONLY in PSoC 4 devices with at least two PWMs and one universal digital block (UDB) for implementing the XOR and AND gate logic functions.

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:

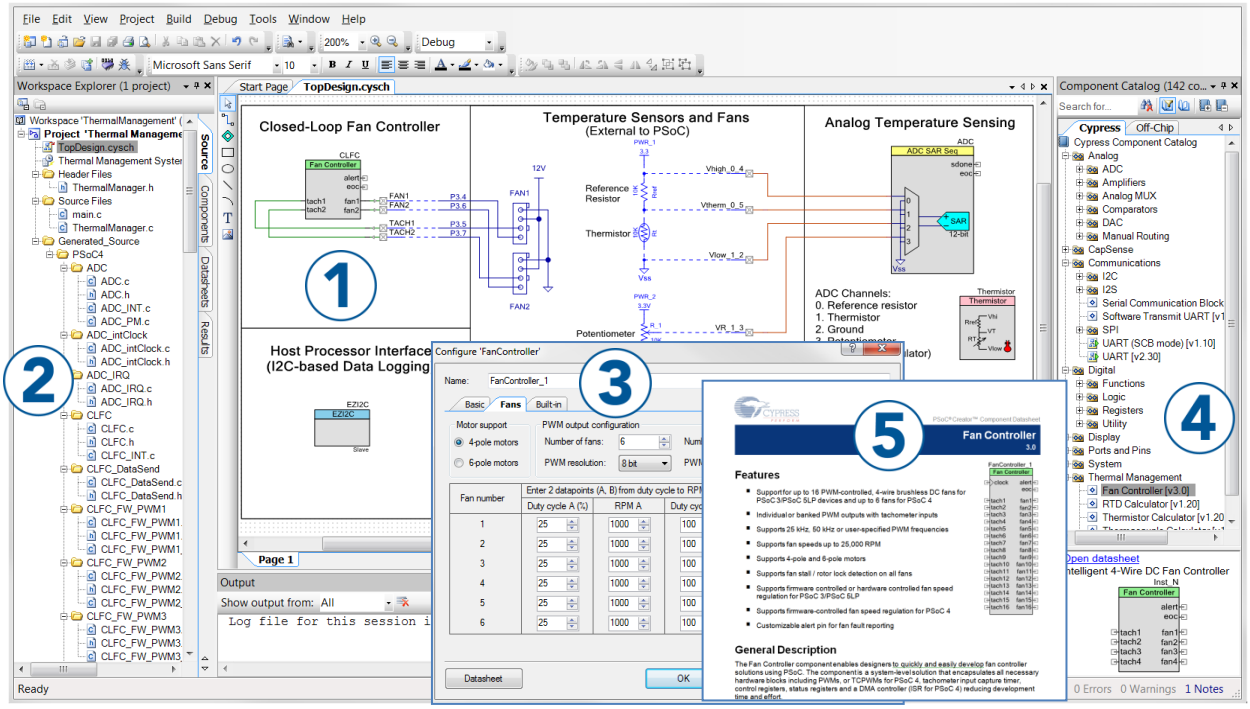
- **Overview:** PSoC Portfolio, PSoC Roadmap
- **Product Selectors:** PSoC 1, PSoC 3, PSoC 4, or PSoC 5LP. In addition, PSoC Creator includes a device selection tool.
- **Datasheets**: Describe and provide electrical specifications for the PSoC 4 device family
- **CapSense Design Guide:** Learn how to 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.
- **Technical Reference Manuals (TRM):** Provide detailed descriptions of the architecture and registers in each PSoC 4 device family.
- **Development Kits:**
  - CY8CKIT-040, CY8CKIT-042, and CY8CKIT-044 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, and PSoC 5LP. See Figure 1 – 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 1. PSoC Creator Features



Requirements

Tool: PSoC Creator 3.2 or later

Programming Language: C (GCC 4.8.4)

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

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

Design

Breathing LED

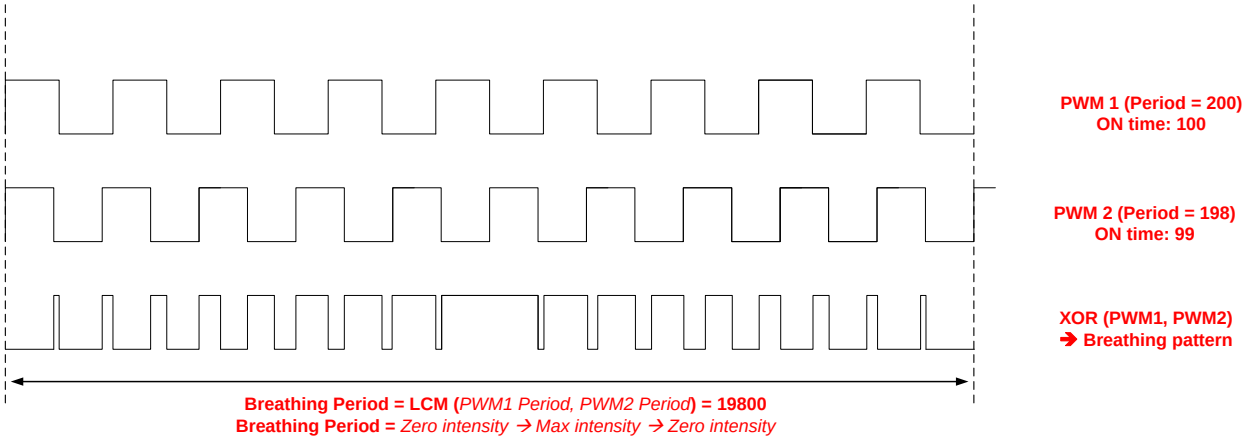
When the intensity of an LED is gradually varied from zero to maximum and then from maximum to zero in a periodic fashion, a breathing LED effect is generated. This effect is analogous to the human breathing pattern – inhale (zero to max intensity) and exhale (max to zero intensity).

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 2) is required. This PWM output can be generated using a single PWM but with firmware controlling the duty cycle every period. The gradual increase and decrease in 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.

Figure 2: PWM to Generate a Breathing LED Pattern

The PWM waveform shown in Figure 2 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%. If you XOR the two PWM's outputs, you will end up with a waveform that provides a breathing LED output, as shown in Figure 3.

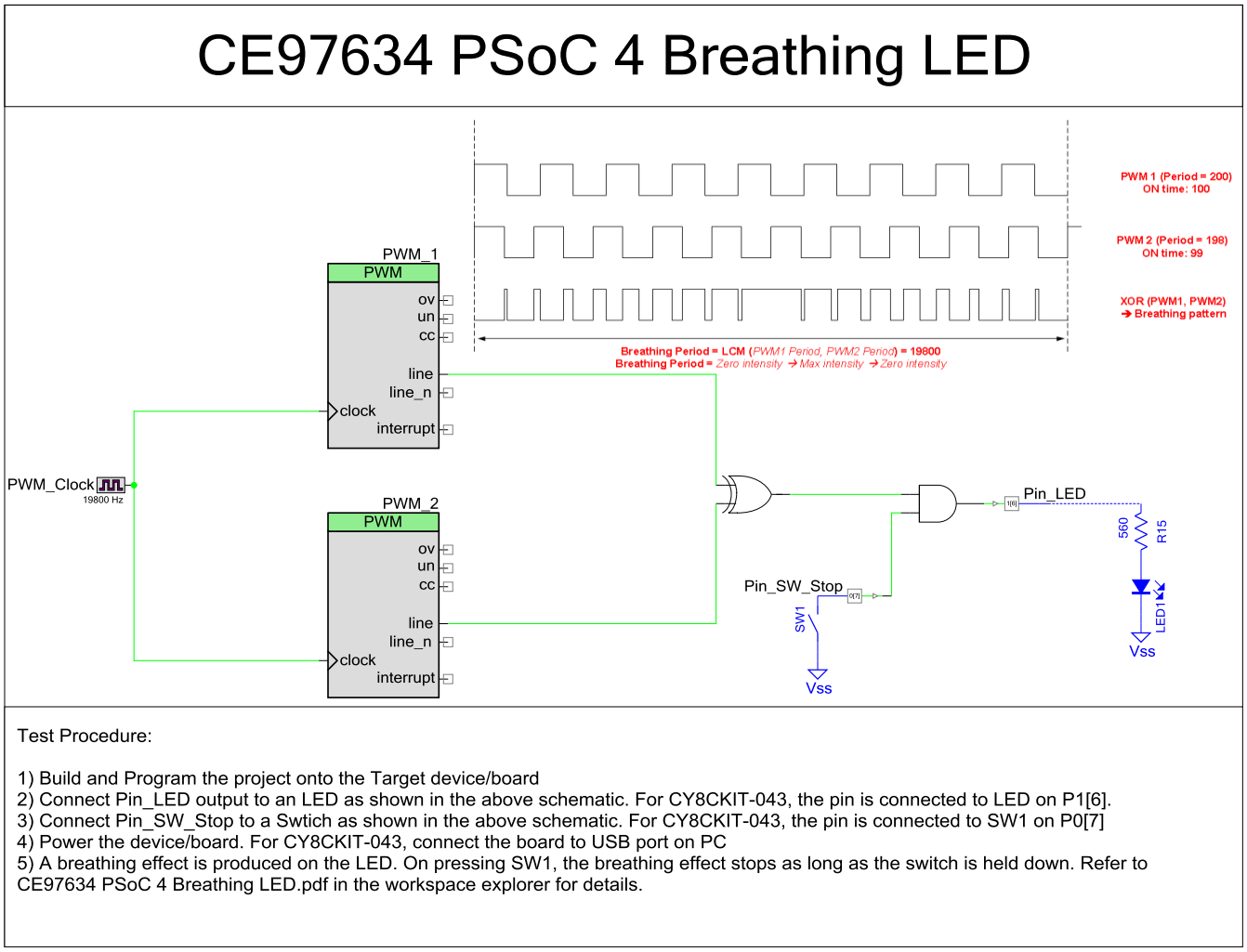
Figure 3: Generating Breathing PWM Output Using PWMs and XOR



As can be seen from the Figure 3, the breathing period of the LED is given by the least common multiple (LCM) of the two periods.

PSoC 4 Implementation

Figure 4. TopDesign Schematic of the Example



Test Procedure:

1) Build and Program the project onto the Target device/board
2) Connect Pin_LED output to an LED as shown in the above schematic. For CY8CKIT-043, the pin is connected to LED on P1[6].
3) Connect Pin_SW_Stop to a Swtich as shown in the above schematic. For CY8CKIT-043, the pin is connected to SW1 on P0[7]
4) Power the device/board. For CY8CKIT-043, connect the board to USB port on PC
5) A breathing effect is produced on the LED. On pressing SW1, the breathing effect stops as long as the switch is held down. Refer to CE97634 PSoC 4 Breathing LED.pdf in the workspace explorer for details.

Firmware starts the PWM clock and the PWMs. After that, the CPU is put into sleep mode since it is not required for any other operations.

Design Extensions

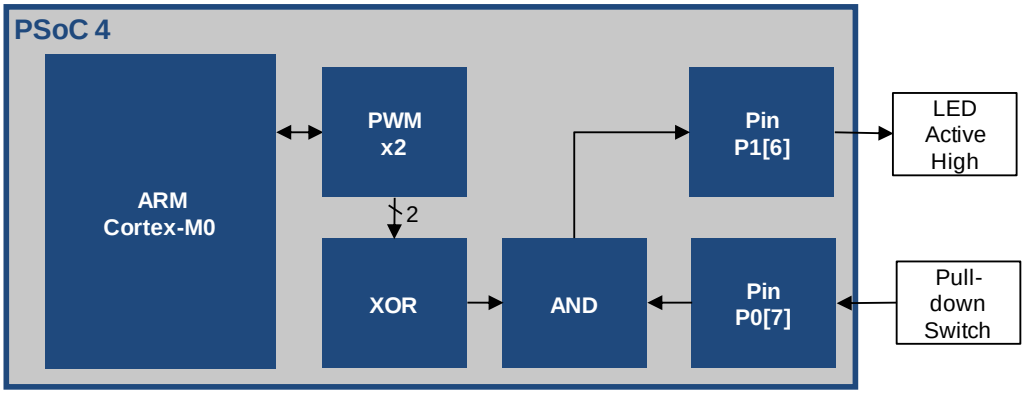
The example can be extended to generate any desired breathing effect with the desired breathing period and step size. The breathing period and step size at which the LED intensity is varied can be derived using the below relationship.

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

Figure 5. Hardware Block Diagram



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	Name	Hardware Resources	Non-default Parameter settings
PWM(TCPWM Mode) [v2.0]	PWM_1	One TCPWM block	**Period:** *200* **Compare:** *100*
PWM(TCPWM Mode) [v2.0]	PWM_2	One TCPWM block	**Period:** *198* **Compare:** *99*
Clock [v2.20]	PWM_Clock	Fixed function clock divider	**Frequency:** *19800 Hz* **Use fractional divider:** *Checked*
XOR [v1.0]	-	Part of one UDB	None
AND [v1.0]	-	Part of one UDB	None
Digital Output Pin [v2.10]	Pin_LED	P1[6]	None
Digital Input Pin [v2.10]	Pin_SW_Stop	P0[7]	**Drive mode:** *Resistive pull up* **Initial drive state:** *1*

Design-Wide / Global Resources

Figure 6. **Pins** Tab in Design Wide Resources (**.cydwr** file)

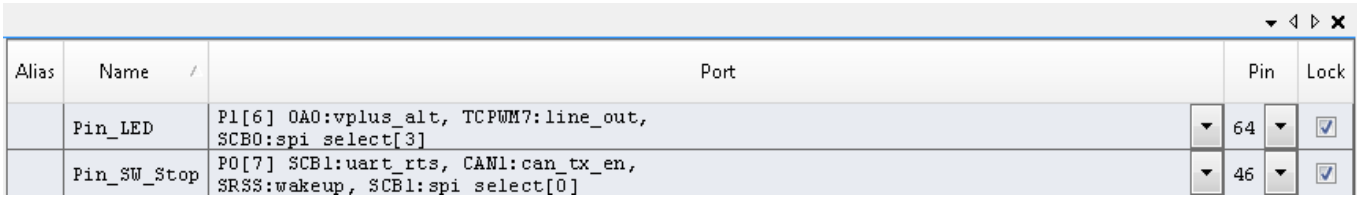
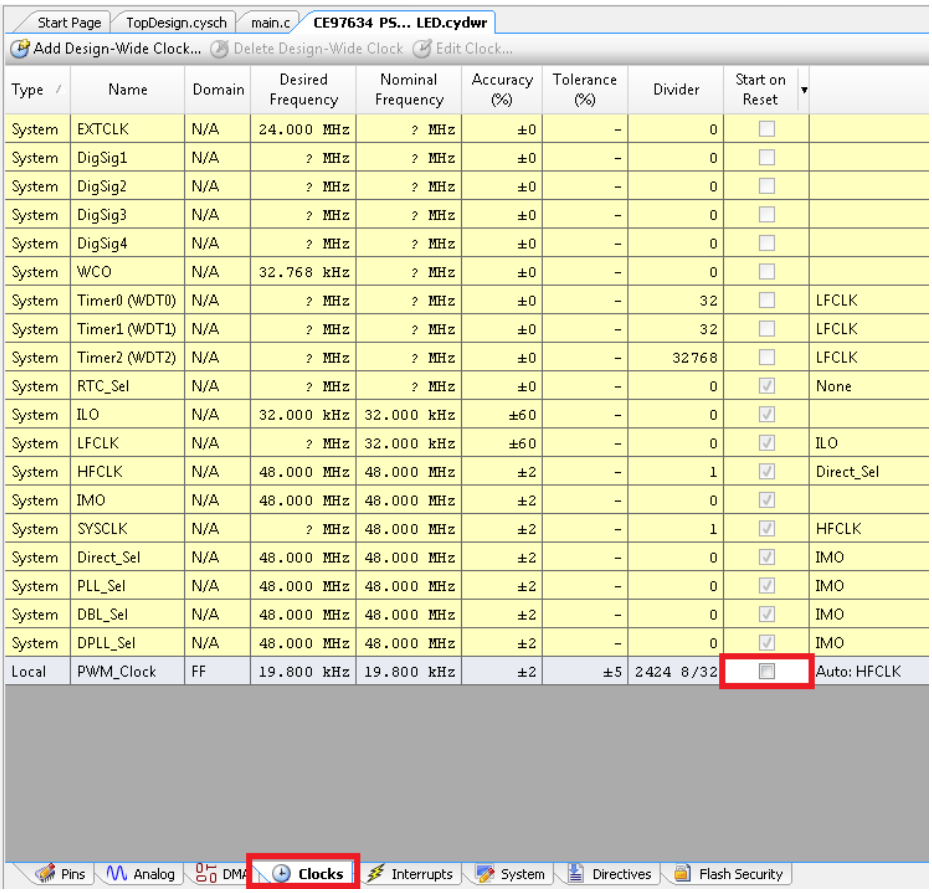


Figure 7. **Clocks** Tab Settings in Design-Wide Resources



Type	Name	Domain	Desired Frequency	Nominal Frequency	Accuracy (%)	Tolerance (%)	Divider	Start on Reset	
System	EXTCLK	N/A	24.000 MHz	? MHz	±0	-	0	☐	
System	DigSig1	N/A	? MHz	? MHz	±0	-	0	☐	
System	DigSig2	N/A	? MHz	? MHz	±0	-	0	☐	
System	DigSig3	N/A	? MHz	? MHz	±0	-	0	☐	
System	DigSig4	N/A	? MHz	? MHz	±0	-	0	☐	
System	WCO	N/A	32.768 kHz	? MHz	±0	-	0	☐	
System	Timer0 (WDT0)	N/A	? MHz	? MHz	±0	-	32	☐	LFCLK
System	Timer1 (WDT1)	N/A	? MHz	? MHz	±0	-	32	☐	LFCLK
System	Timer2 (WDT2)	N/A	? MHz	? MHz	±0	-	32768	☐	LFCLK
System	RTC_Sel	N/A	? MHz	? MHz	±0	-	0	☑	None
System	ILO	N/A	32.000 kHz	32.000 kHz	±60	-	0	☑	
System	LFCLK	N/A	? MHz	32.000 kHz	±60	-	0	☑	ILO
System	HFCLK	N/A	48.000 MHz	48.000 MHz	±2	-	1	☑	Direct_Sel
System	IMO	N/A	48.000 MHz	48.000 MHz	±2	-	0	☑	
System	SYSCLK	N/A	? MHz	48.000 MHz	±2	-	1	☑	HFCLK
System	Direct_Sel	N/A	48.000 MHz	48.000 MHz	±2	-	0	☑	IMO
System	PLL_Sel	N/A	48.000 MHz	48.000 MHz	±2	-	0	☑	IMO
System	DBL_Sel	N/A	48.000 MHz	48.000 MHz	±2	-	0	☑	IMO
System	DPLL_Sel	N/A	48.000 MHz	48.000 MHz	±2	-	0	☑	IMO
Local	PWM_Clock	FF	19.800 kHz	19.800 kHz	±2	±5	2424 8/32	☐	Auto: HFCLK

Operation

1. Build the example project by navigating to **Build** > **Build <*Project Name*>** in PSoC Creator.
2. Connect the device/board to a programmer connected to a PC. If the kit contains an on-board KitProg, then connect the KitProg to the PC. On-board KitProgs usually are connected to the programming pins of the device in the board itself.
3. Program the example to the device by navigating to **Debug** > **Program**.
4. Power the device, if not already powered.
5. The **LED** connected to **P1[6]** should start displaying the breathing effect.
6. Press the **switch** connected to **P0[7]** and as long as it is held down, the LED output will be OFF. On releasing the switch, the LED should 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	Digital logic gates for PSoC 3/4/5	
Device Documentation		
PSoC 4 Datasheets		
PSoC 4 Technical Reference Manuals		
Development Kits		
PSoC 4 Kits		
Software		
PSoC Creator Training		
PSoC 3/4/5 Code Examples		
Video Library		

Document History

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Revision	ECN	Orig. of Change	Submission Date	Description of Change
**	4777393	MSUR	05/26/15	New spec
*A	4795367	MSUR	06/11/15	Minor text edits

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