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A Study of Programmable System on Chip (PSoC) Technology for Engineering Education

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Abstract. This paper obtain the introducing of Programmable System on Chip (PSoC) technology for Engineering Education, consisting of 2 types of PSoC, i.e, CyPress Semiconductor CY8CKIT-049-42xx, and PSoC 6 Bluetooth Low Energy (BLE), in this paper it focuses on learning at the level basic and introduction to these 2 types of PSoC. moreover, Learning consists of introducing the PSoC input-output with a block diagram of a typical MCU, PSoC Creator features, installation, and testing using Light Emitting Diode (LED). It is hoped that students in the engineering field can understand PSoC as one of the competing microcontrollers of the Arduino or ATmega328p, therefore, that obtains the gain knowledge about the MCU extensively.

Keywords : chips, program, semiconductor, system, education, engineering

1. Introduction

Recently, the development of the Microcontroller or MCU field is increasingly rapid and Sophisticated, with the current development of the Internet of Things (IoT), the microcontroller (MCU) is made as small as possible, and develop of Artificial Intelligence (AI) in the recent research [1, 2, 3, 4], in research [5] Leafony Board uses the MCU Micro ATmega M328p which is compatible with Arduino Integrated Development of Environment (IDE). Leafony Board is made compatible with a variety of wireless devices e.g., Bluetooth, ESP32 Wi-Fi, LoRa and extension boards. Furthermore, PSoC or Programmable System on Chip is an integrated circuit Microcontroller device developed by Cypress Semiconductor, PSoC consists of CPU and Mixed-signal arrays with analog and digital peripheral configuration and integration. Moreover, PSoC has developed from PSoC 4 to PSoC 6. accordingly, PSoC 4, the features used are 32-bit ARM Cortex-M0 CPU using Operational Amplifier (Op-Amp) and Comparator. PSoC 4 is integrated with BLE or Bluetooth Low Energy with a Cortex-M0 CPU based SoC in a single, furthermore, 2016, PSoC 4 with ARM Cortex-M0 + CPU, and currently PSoC 6 with Bluetooth Low Energy technology and the new features e.g., CapSense (IDACs, Comparators, Touch

Sensing). PsoC is also combined with Radio Frequency (RFs) devices [6], applicable case studies (QuadCopters, Wireless Elevator) [7], [8], Genomic data [9], Electrical discharge machining (EDM) [10], Grammar tools [11], and Robot [12]. The first PSoC that will be described in this paper is CY8CKIT-049-42xx use PSoC Creator 3.0, in figure 1. As there are 2 separate parts, i.e., the head and body, these 2 parts are actually connected to each other on the 4 pins shown in table 1. And 8 The main parts of the PSoC CY8CKIT-049-42xx are shown in figure 1. ie, (1) PCB USB Connector (J8), (2) USB-Serial Bridge Controller (U2), (3) Power LED (LED2), (4) Current Measurement jumper (J4), (5) User LED (LED1), (6) PSoC 4 MCU (U1), (7) Programming Header, and (8) Push Button (SW1). In the LED test, the 2 parts of the PSoC were separated and connected using a cable. This is done when the PSoC experiences an error or there is no response when entering the program into PSoC 4.
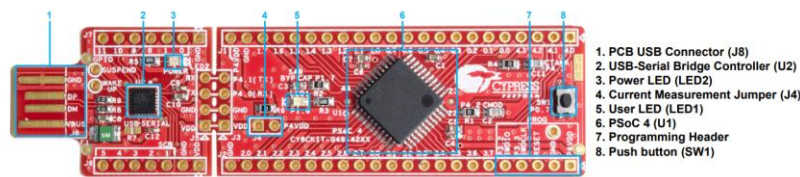

Figure 1. CY8CKIT-049-42xx

Table 1. Pin Connectivity of PSoC CY8CKIT-049-42xx

The Pin Left side	The Pin Right side
RX	P 4.1 (TX)
TX	P4.0 (RX)
GND	GND
VDD	VDD

Furthermore, the next generation PSoC is PSoC 6 which is equipped with Bluetooth Low Energy 5.0, this PSoC 6 is also tested in this paper, as an ingredient in engineering education for engineering students, especially for electrical engineering. Furthermore, Cypress also issued a new version, namely PSoC 6. Which is equipped with Bluetooth Low Energy (BLE) 5.0.
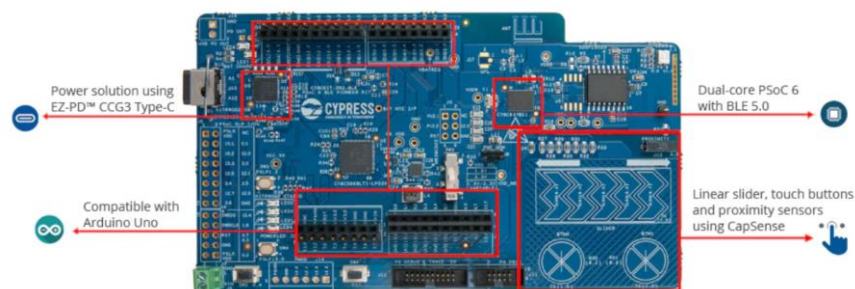

Figure 2. PSoC 6 BLE 5.0

As shown in figure 2. PSoC 6 BLE 5.0 consists of several parts, i.e., (1) Dual Core PSoC 6 with Bluetooth Low Energy 5.0, (2) Linear Slider, touch buttons, and proximity sensors using Capsense, (3) Power Solution using EZ- PDTM CCG3 Type-C, and (4) Compatible Port Arduino Uno. The Lower Power Consumption of CapSense with as low as 1.71 volt and 150 nA Current consumption in hibernate mode [13], [14]. Figure 3 is the architecture on the PSoC 4100 has three states or Power modes in Figure

3, i.e., Active / Sleep, Deep Sleep, and Hibernate. This situation determines the quality of the Power Consumption to get a longer lifetime, even though each PSoC test uses a USB Port to Laptop or Personal Computer (PC) to measure the Voltage and Current parameters on the PSoC.
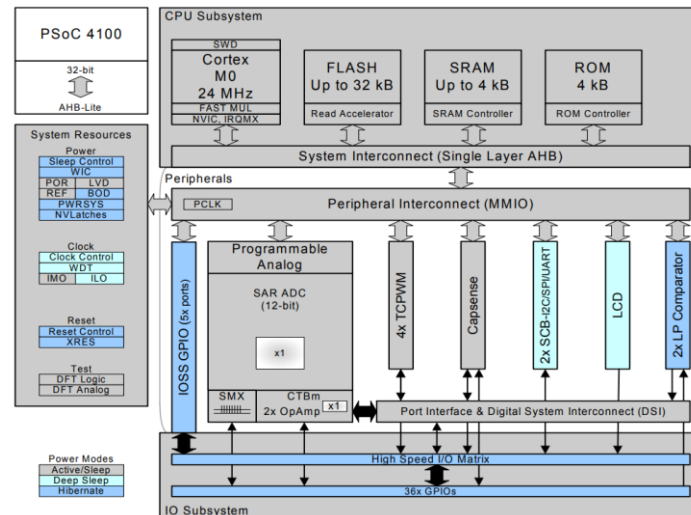

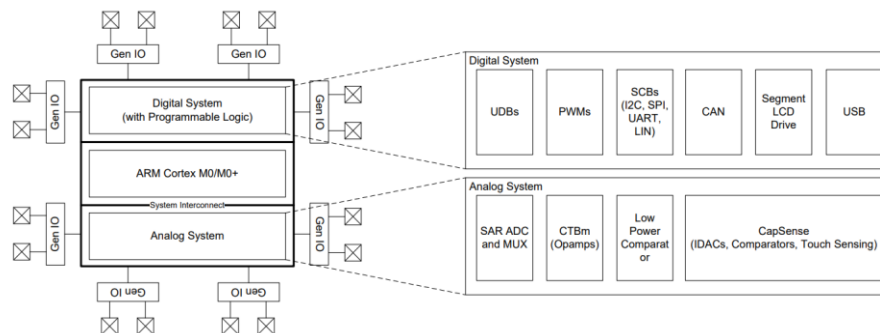**Figure 3.** PSoC 4 Architecture

Figure 4. PsoC 6 BLE 5.0 Block Diagram

To be more specific, figure 4 is a block diagram to get a deeper understanding of the PSoC description, two systems in the PSoC, i.e., Digital System and Analog System. This system shows the components that are part of the PSoC. e.g., CapSense is PSoC Analog System, CapSense (IDACs, Comparators, Touch Sensing). Figure 5 is the connection between the ARM Micro controller type and all the ports on the PSoC i.e. ADC, Port A, B, C, and D, timer, UART, SPI, I2C, and PWM. Pin settings are made so that no pins are reused or double on a PySoC machine or devices [8]. for examples figure 4, P1 [10] 43 is Pin Output LED (LED Emitting Diode), P1 [9] or 42, P1 [8] or 41 pins for another Output, etc.

2. Methods

The New projects are done with an initialize, create, and build the design on PSoC and PSoC creators. The engineering students can following the step by step on the starting project and CapSense technology. CapSense Technology is one of the new technologies owned by Cypress PSoC CapSense is a technology that uses touch as input to determine the output, e.g., Light Emitting Diode (LED).

Teaching 1. Step by step the PsoC project
1. Start the PsoC Project

2. Install and Initialize of The PsoC Creator
3. Create the Design
4. Design Component Categories i.e., Digital, ADC, CapSense, DAC, LCD, System, My Design
5. Ex.Initialize of Pulse Width Modulation (PWM), i.e., initialize of PWM (Clock) and Line_n (Pins)
6. Initialize pins on the Design Wide Resources
7. Build, Edit the design, and add the code in the PsoC Creator
8. Run and debug the Program or Code.
9. Finish the PsoC Project

Teaching 2. Step by step the CapSense Technology in PsoC for engineering student
1. Understanding CapSense Technology
2. CapSense Schematic Design
3. CapSense Layout and Mechanical Design
4. Component Configuration
5. CapSense Tuning
6. Design Validation : Test and Evaluate System Functionality and CapSense Performance

3. Results
This chapter discusses how to get output on the two types of PSoC, namely CY8CKIT-049-42xx and
PSoC 6 BLE. This output uses an LED as a test on both types of PSoC boards.

CY8CKIT-049-42xx PsoC Programming for LED test

There is no significant difference between Arduino and PSoC Microcontrollers. In this code, the
difference lies in the Library delay is represented by CyDelay (Cypress_Delay) in ms. The LED blinking
a same with command at programming, delay is 0,1 second, off and on.

```
12  #include "project.h"
13
14  int main(void)
15  {
16      CyGlobalIntEnable; /* Enable global interrupts. */
17
18      /* Place your initialization/startup code here (e.g. MyInst_Start()) */
19
20      for(;;)
21      {
22        Lampu_Kedap_Kedip_Write(1);
23        CyDelay(100);
24        Lampu_Kedap_Kedip_Write(0);
25        CyDelay(100);
26      }
27  }
28
29  /* [] END OF FILE */
30
```

Figure 5. CY8CKIT-049-42xx PsoC Programming Code for LED test

CapSense Pseodocode

1. Start the project.
2. Open the cm4.c.
3. Library initialization [include "project.h"].
4. CapSense initialization [CapSense_Start and ScanAllWidgets].
5. Pulse Width Modulation (PWM) start.
6. Starting the Programming code for CapSense on PsoC 6 BLE.

```
if(!CapSense_IsBusy())
{
CapSense_ProcessAllWidgets();
int pos;
pos=CapSense_GetCentroidPos(CapSense_LINEARSLIDER0_WDGT_ID);
if(pos<0xFFFF)
    Cy_TCPWM_PWM_SetCompare0(PWM_HW,PWM_CNT_NUM,pos);
if(CapSense_IsWidgetActive(CapSense_BUTTON0_WDGT_ID))
{
    Cy_TCPWM_PWM_Disable(PWM_HW,PWM_CNT_NUM);
    Cy_GPIO_Write(BLUE_PORT,BLUE_NUM,0);
}
if(CapSense_IsWidgetActive(CapSense_BUTTON1_WDGT_ID))
{
    Cy_TCPWM_PWM_Enable(PWM_HW,PWM_CNT_NUM);
    Cy_TCPWM_TriggerStart(PWM_HW, PWM_CNT_MASK);
    Cy_GPIO_Write(BLUE_PORT,BLUE_NUM,1);
}
```
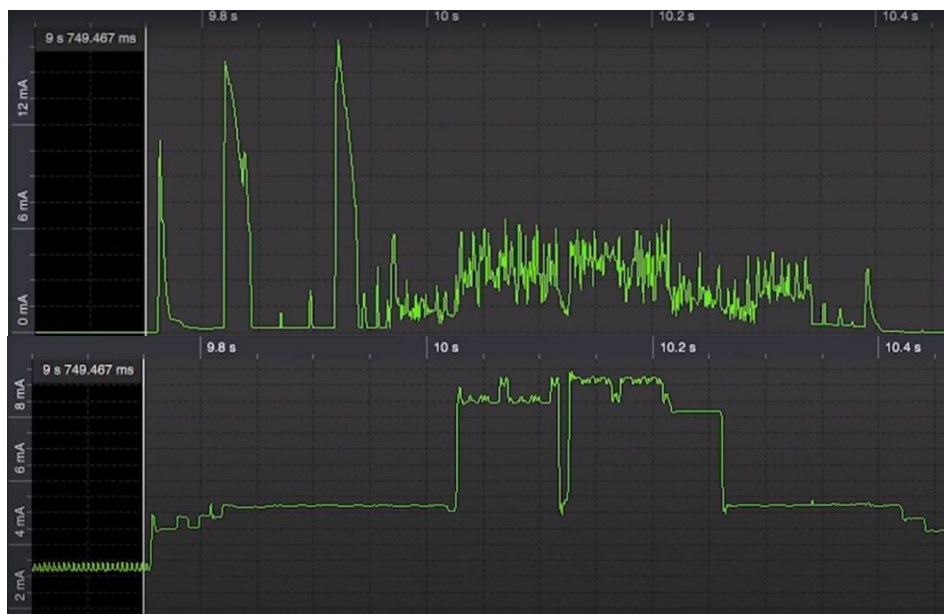7. CapSense Initialize [CapSense_UpdateAllBaselines, CapSense_ScanAllWidgets]

Figure 6. Current (mA) Analysis of PsoC 6 BLE

From the modification of the circuit, the results of the Reference (Qoitech) Current Measurement from the PSoC 6 are obtained, the resulting analysis of PsoC 6 BLE is an average of 6 mA, smaller than the PSoC 6 specification which is 30 mA.

4. Discussion and Conclusion

The learning process at PSoC is carried out in several stages such as initialization of the PSoC Creator, Design Component, initialization of PWM, initialization of Wide Resources, and introduction to hardware and programming in PSoC, there are 2 learning modules, namely PSoC programming In the simple case (LED) and touching the sensor technology on PSoC is CapSense. It is hoped that this paper can   provide   instructions   in   starting   PSoC   learning   for   engineering   students. Furthermore, the development can be carried out by combining Arduino and PsoC on the socket

available on the PSoC 6 BLE, then testing the telecommunication equipment e.g, LoRa, ZigBee, etc. By comparing its capabilities with Bluetooth Low Energy (BLE) on the PSoC 6 BLE.

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