# Sequencing SAR ADC and Die Temperature Sensor with PSoC 4

## About this document

### Scope and purpose

This code example demonstrates the usage of the Sequencing PSoC® 4 SAR ADC Component with an injection channel and the Die Temperature Component.

### Requirements

**Tool:** PSoC® Creator™ 4.4

**Programming Language:** C (Arm® GCC 5.4.1 and Arm MDK 5.22)

**Associated Parts:** PSoC 4100, PSoC 4200, PSoC 4100 BLE, PSoC 4100M, PSoC 4200 BLE, PSoC 4200M, PSoC 4200L, PSoC 4100S, PSoC 4100S Plus, PSoC 4500S

**Related Hardware:** CY8CKIT-042, CY8CKIT-042-BLE, CY8CKIT-042-BLE-A, CY8CKIT-043, CY8CKIT-044, CY8CKIT-046, CY8CKIT-041-41XX, CY8CKIT-149, CY8CKIT-045S

## Table of Contents

# 1 Overview

This code example uses the Sequencing PSoC 4 SAR ADC Component to measure input voltages and die temperature. The measurement results are shown in the terminal program on a PC.

# 2 Hardware and Software Setup

## 2.1 Hardware Setup

This code example supports kits shown in **Table 1**. By default, this example project is configured to run on the CY8CKIT-045S development kit. The project can be migrated to any supported kit by changing the target device with **Device Selector** called from the project's context menu. See **Table 1** for the target device name of your kit.

For all supported kits, the project includes control files to automatically assign pins with respect to the kit hardware connections during the project build. To change pin assignments, override the control file selections in the Pin Editor of the Design Wide Resources by selecting the new port or pin number.

To run this example, you will need two external voltage sources in range from 0 to the PSoC 4 $V_{DD}$ voltage. You can use a voltage divider, potentiometer, etc.

For CY8CKIT-042 kit, connect the /UART_Tx/ pin (P0.5) of PSoC 4 to the UART Rx pin of KitProg (P12.6) with a jumper wire to use the KitProg USB-UART bridge. For other kits, the UART lines between PSoC 4 and KitProg are hard-wired on the kit's board.

**Table 1 Supported Kits, Devices, Pin Assignments**

| Kit | Series | Device | Pin Assignments | | |
|---|---|---|---|---|---|
| | | | Pin_Vin0 | Pin_Vin1 | /UART_tx/ |
| CY8CKIT-042 | PSoC 4200 | CY8C4245AXI-483 | P2[0] | P2[1] | P0[5] |
| CY8CKIT-042-BLE | PSoC 4200 BLE | CY8C4247LQI-BL483 | P3[0] | P3[1] | P1[5] |
| CY8CKIT-042-BLE-A | PSoC 4200 BLE | CY8C4248LQI-BL583 | | | |
| CY8CKIT-043 | PSoC 4200M | CY8C4247AZI-M485 | P2[0] | P2[1] | P7[1] |
| CY8CKIT-044 | PSoC 4200M | CY8C4247AZI-M485 | P2[0] | P2[1] | P7[1] |
| CY8CKIT-046 | PSoC 4200L | CY8C4248BZI-L489 | P2[0] | P2[1] | P3[1] |
| CY8CKIT-041-41XX | PSoC 4100S | CY8C4146AZI-S433 | P2[3] | P2[4] | P0[5] |
| CY8CKIT-149 | PSoC 4100S Plus | CY8C4147AZI-S475 | P2[3] | P2[4] | P7[1] |
| CY8CKIT-045S | PSoC 4500S | CY8C4548AZI-S485 | P2[0] | P2[1] | P2[5] |

## 2.2 Software Setup

For this code example, any terminal software can be used: Tera Term, PuTTY, etc.

# 3 Operation

1. Connect the board into your computer's USB port using the provided USB cable.
2. Build the project and program it onto the PSoC 4 device. Choose **Debug** > **Program**. For more information on the device programming, see the PSoC Creator Help.

*Note:* *By default, the ADC_SAR_Seq Component customizer has the Vref select parameter set to **Internal Vref.** The devices other than PSoC 4500S, PSoC 4100S and PSoC 4100S Plus, have an internal reference of 1.024 volts; therefore, the Vref select parameter must be set to **Internal 1.024 volts**. Building an example project without changing the default Vref select parameter value for these devices will cause a building error – "Error in component: ADC_SAR_Seq. The selected type of voltage reference is not supported for the current device type".*

*In main.c file, this parameter needs to be configured according to the device.*

*For PSoC 4500S, PSoC 4100S and PSoC 4100S Plus, set DIETEMP_VREF_MV_VALUE to 1200*

```
#define DIETEMP_VREF_MV_VALUE    (1200)
```

*The device other than PSoC 4500S, PSoC 4100S and PSoC 4100S Plus, set DIETEMP_VREF_MV_VALUE to 1024*

```
#define DIETEMP_VREF_MV_VALUE    (1024)
```

3. Run any terminal program. Set the terminal parameters: **Baud Rate** – 115200, **Data Bits** – 8, **Parity** – none, **Stop Bits** – 1 and connect to the corresponding port.

*Note:* *To find COM port number, open the Device Manager in your PC, find the device **KitProg USBUART** or **KitProg2 USBUART** or **KitProg3 USBUART** under **Ports** (COM & LPT), and note the port number.*

4. Connect the voltage sources to the ADC voltage inputs: Pin_Vin0 and Pin_Vin1. For the CY8CKIT-041, use an on-board potentiometer to change the voltage value on the Pin_Vin1 input.

*Note:* *The ADC measurement result will be out of range (1024 mV) for a voltage larger than 1.024 V. You may use an external voltage divider to get the expected voltage in the range (0 - 1.024 V). For the PSoC 4500S, PSoC 4100S and PSoC 4100S Plus devices (CY8CKIT-045S, CY8CKIT-041-41XX and CY8CKIT-149 kits), the upper voltage limit will be 1.2 V.*

5. Observe the inputs voltage and device temperature values on the terminal program.

# 4 Design and Implementation

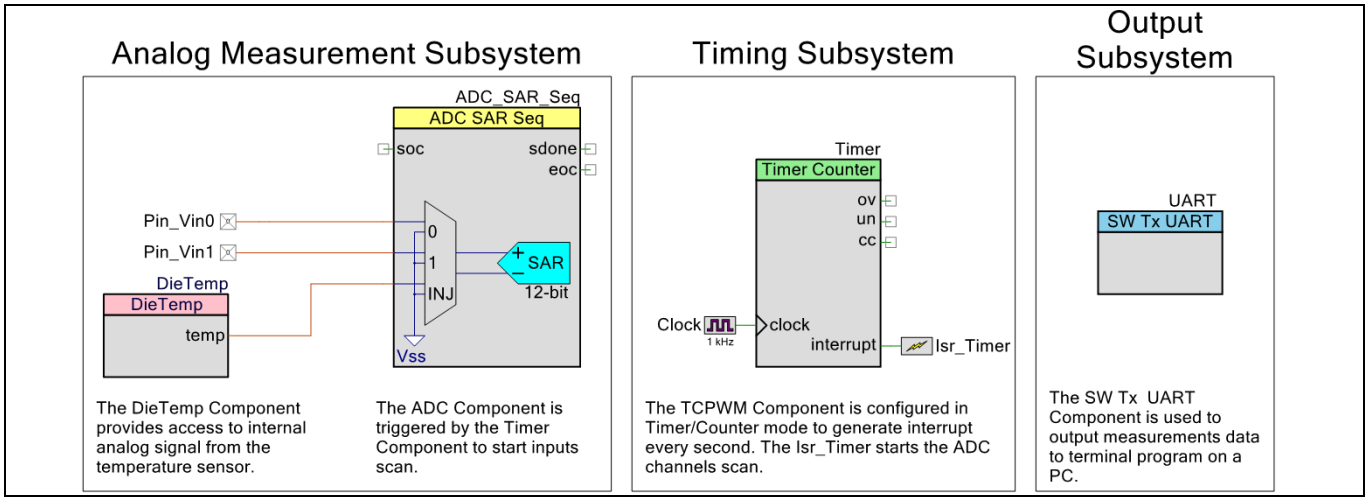


**Figure 1 PSoC Creator Project Schematic**

The ADC_SAR_Seq uses two sequenced channels to measure voltage values from the input pins and an injection channel to measure voltage values from the DieTemp Component. To increase the ADC measurement accuracy, Averaging Mode is used for all input channels.

The DieTemp Component provides access only to the internal analog signal from the temperature sensor and must be used in conjunction with an ADC to produce a digital value. Temperature changes slowly; therefore, this signal is used with the injection channel. It samples values infrequently compared to the sequenced channel.

The TCPWM Component is configured in Timer/Counter mode to generate an interrupt every second. The Timer's interrupt handler starts the scan of the sequenced channels every second, and enables the injection channel every fifth sequenced scan. You can change sequenced and injection channel scan periods by changing the Timer Component period in the Component customizer and `ADC_INJ_PERIOD` value in the *main.c* file.

The UART Component is used to output voltage and temperature measurements.

The firmware performs these functions:

1. Initializes the UART, ADC, and Timer.
2. Starts the ADC conversion.
3. Waits for the converted results.
4. Calculates the voltage and temperature values.
5. Prints the calculated values into the UART.

**Design and Implementation**

## 4.1 Components and Settings

Table 2 lists the PSoC Creator Components used in this example, how they are used in the design, and the non-default settings required so they function as intended.

**Table 2 PSoC Creator Components**

| Component | Instance Name | Purpose | Non-default Settings |
|---|---|---|---|
| Sequencing SAR ADC | ADC_SAR_Seq | Measures the voltage values from the input pins and the DieTemp Component. | See Figure 2 and Figure 3 |
| Die Temperature | DieTemp | Provides access to internal analog signal from the temperature sensor. | None |
| Analog Pin | Pin_Vin0 | The input pins of the ADC. | None |
| | Pin_Vin1 | | |
| Timer Counter (TCPWM mode) | Timer | Starts the ADC scan with the desired period. | Period: 999 |
| Clock | Clock | Clock source for the Timer Component. | Frequency: 1 kHz |
| Software Transmit UART | UART | Sends measurement results to the terminal program on the PC. | None |

For information on the hardware resources used by a Component, see the Component datasheet.

Figure 2 and Figure 3 show the ADC_SAR_Seq Component configuration with the highlighted non-default settings.

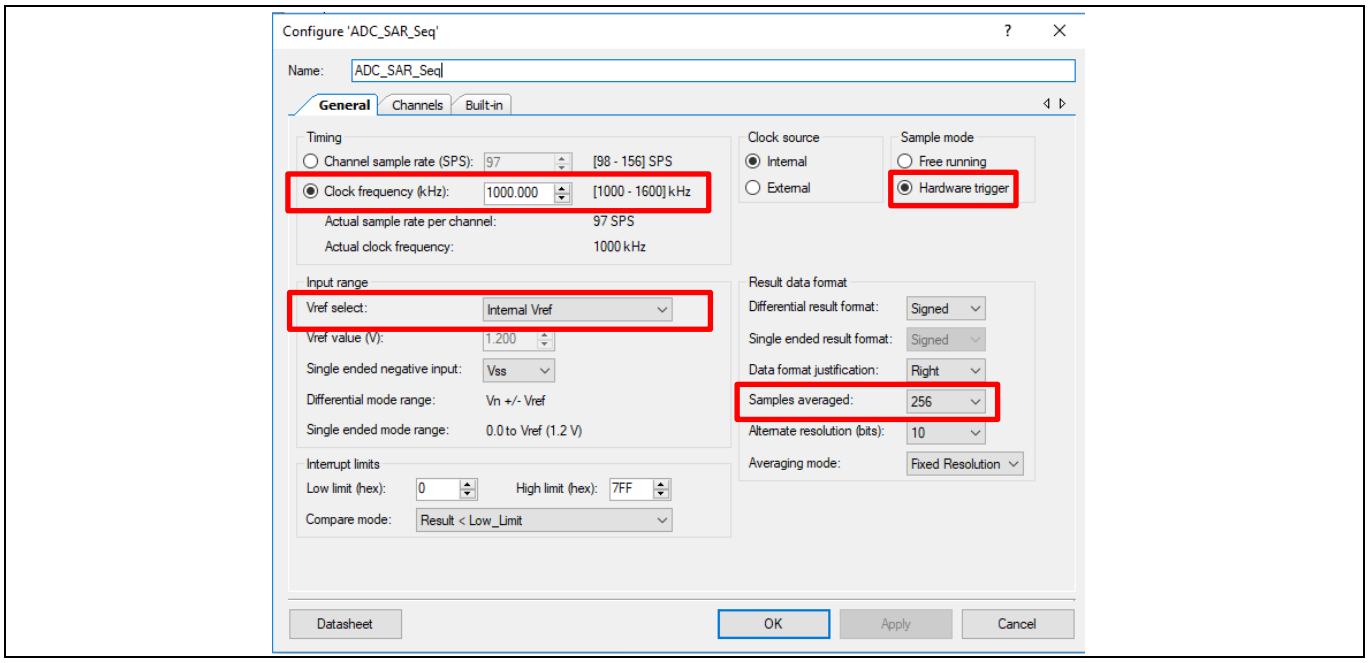


**Figure 2 ADC_SAR_Seq General Settings Tab**

**Design and Implementation**

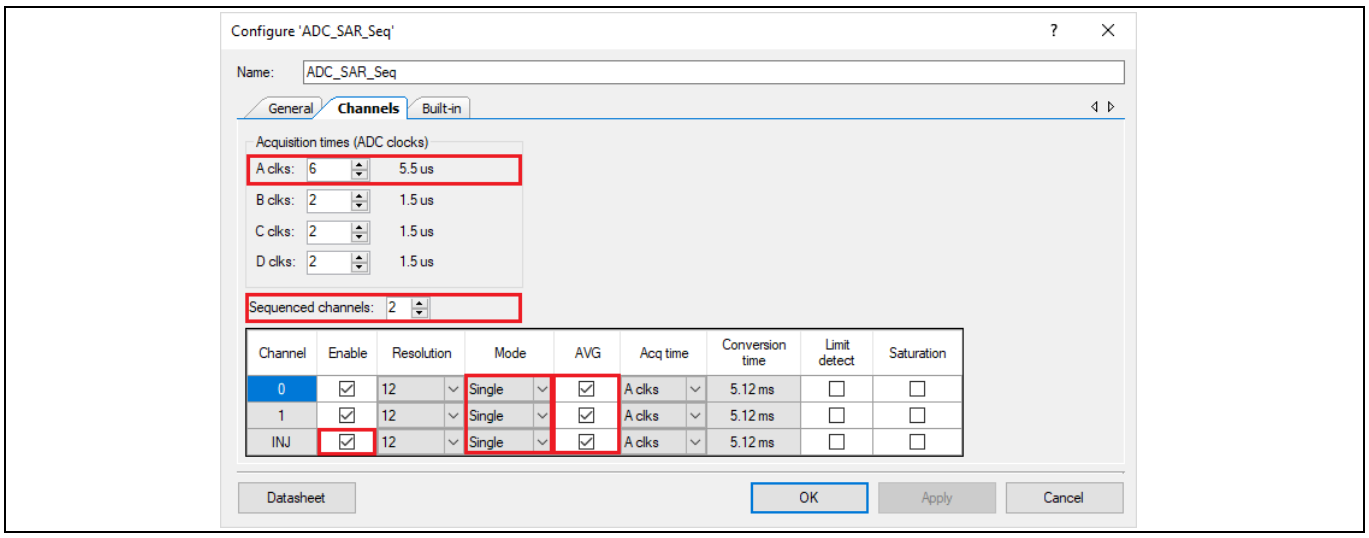


**Figure 3 ADC_SAR_Seq Channels Settings Tab**

## 4.2 Reusing This Example

This example is designed for the kits listed in **Table 1**. To port the design to a different PSoC 4 device and/or kit, change the target device using **Device Selector** and update the Tx pin assignment in the **Design Wide Resources Pins** settings as needed.

**Design and Implementation**

# References

### Application Notes

[1] **AN79953** – Getting Started with PSoC 4: Introduces the PSoC 4 architecture and development tools.

### PSoC Creator Component Datasheets

[2] **Sequencing SAR ADC:** Supports Sequencing SAR ADC to perform analog to digital conversions

[3] **Die Temperature:** Supports on-chip temperature sensor

[4] **Timer Counter (TCPWM mode):** Supports TCPWM blocks

[5] **Pins:** Supports connection of hardware resources to physical pins

### Device Documentation

[6] **PSoC 4 Datasheets**

[7] **PSoC 4 Technical Reference Manuals**

### Development Kit (DVK) Documentation

[8] **PSoC 4 Kits**

# Revision history

| Document version | Date of release | Description of changes |
|---|---|---|
| Rev. ** | 2018-04-06 | Initial version |
| Rev. *A | 2020-10-19 | Update the code example to support CY8CKIT-045S. |

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