ADC with Differential Preamplifier Example Project

1.0

Features

- CTBm Opamps are used as Differential Preamplifier
- ADC is used in differential mode to cancel common mode voltage
- HyperTerminal displays ADC results sent via UART
- LED indicates when ADC input is outside defined voltage window

General Description

This example project is a PSoC Creator starter design for the PSoC 4 device. It demonstrates the PSoC 4's unique analog capability to use Opamps along with an ADC to form a Differential preamplifier frontend. In this project, SAR Sequencer automatically scans four input channels and places results into a SRAM buffer when complete. The user can change the channel selected for displaying on HyperTerminal by pressing switch SW2 on PSoC 4 Pioneer Kit.

Development Kit Configuration

This example project is designed to run on the CY8CKIT-042 kit from Cypress Semiconductor. A description of the kit, along with more example programs and ordering information, can be found at http://www.cypress.com/go/cy8ckit-042.

The project requires configuration settings changes to run on other kits from Cypress Semiconductor. Table 1 is the list of the supported kits. To switch from CY8CKIT-042 to any other kit, change the project's device with the help of Device Selector called from the project's context menu.

Table 1. Development Kits vs Parts

Development Kit	Device
CY8CKIT-042	CY8C4245AXI-483
CY8CKIT-042-BLE	CY8C4247LQI-BL483
CY8CKIT-044	CY8C4247AZI-M485

The pin assignments for the supported kits are in Table 2.

Table 2. Pin Assignment

Pin Name	Development Kit		
	CY8CKIT-042	CY8CKIT-042 BLE	CY8CKIT-044
Out_1	P1[2]	P2[2]	P1[2]
Out_2	P1[3]	P2[3]	P1[3]
Differential_In_1	P2[0]	P3[0]	P2[0]
Differential_In_2	P2[1]	P3[1]	P2[1]
Input_3	P2[2]	P3[2]	P2[2]
Input_4	P2[3]	P3[3]	P2[3]
\UART:tx\	P0[5]*	P1[5]	P7[1]
Preamp_In_1	P1[0]	P2[0]	P1[0]
Preamp_In_2	P1[5]	P2[5]	P1[7]
Inv_1	P1[1]	P2[1]	P1[1]
Inv_2	P1[4]	P2[4]	P2[4]
SW2	P0[7]	P2[7]	P0[7]
LED	P1[6]	P2[6]	P0[6]

* Connect P0[5] (\UART:tx\) to the Tx terminal (P12[6]) on header J8.

The following steps should be performed to observe the project's operation:

1. Set jumper J9 (J16 for CY8CKIT-042-BLE) to 5.0V position.
2. Connect all the external resistors (R1=10K, R2=10K and Rg=2.2K) as shown in the top design schematic.
3. Connect input signals as shown in the top design schematic.
4. Connect a USB cable to the PSoC 4 Pioneer Kit DVK and PC with the HyperTerminal program.

Note A warning about a bonded P1[4] pin appears during project compilation for the CY8CKIT-044 kit, which is expected taking into account the pins available for the user on this kit.

Project Configuration

This example project consists of SAR ADC with Sequencer, Opamp, and UART components. The top design schematic is shown in Figure 1. The hardware sequencer in the SAR ADC component continuously scans through four input channels. Two of these channels are configured in the differential mode and the remaining two are configured in the single ended mode. The first differential channel is connected to a preamplifier output and the remaining channels are directly connected to input signals. Switch SW2 is used to change the displayed channel on HyperTerminal.

The UART component sends the ADC output of the active channel along with the channel number on HyperTerminal. The Opamps form a differential amplifier front end. This preamplifier circuit, when used with a differential input ADC, provides gain and common mode rejection to input signal. The ADC result is displayed on HyperTerminal. The ADC also generates an interrupt when the input is outside the set voltage window (250mV – 750mV).

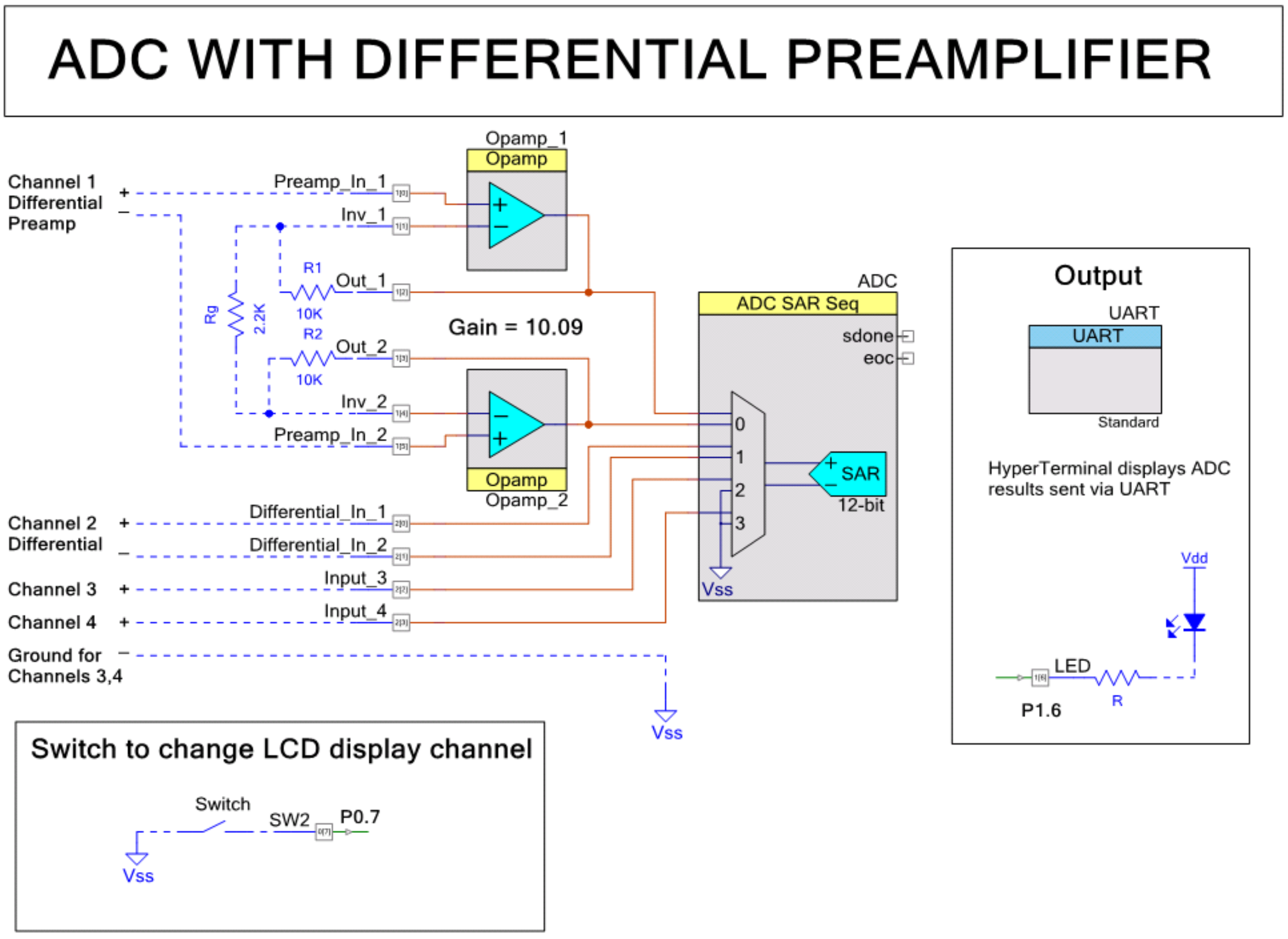
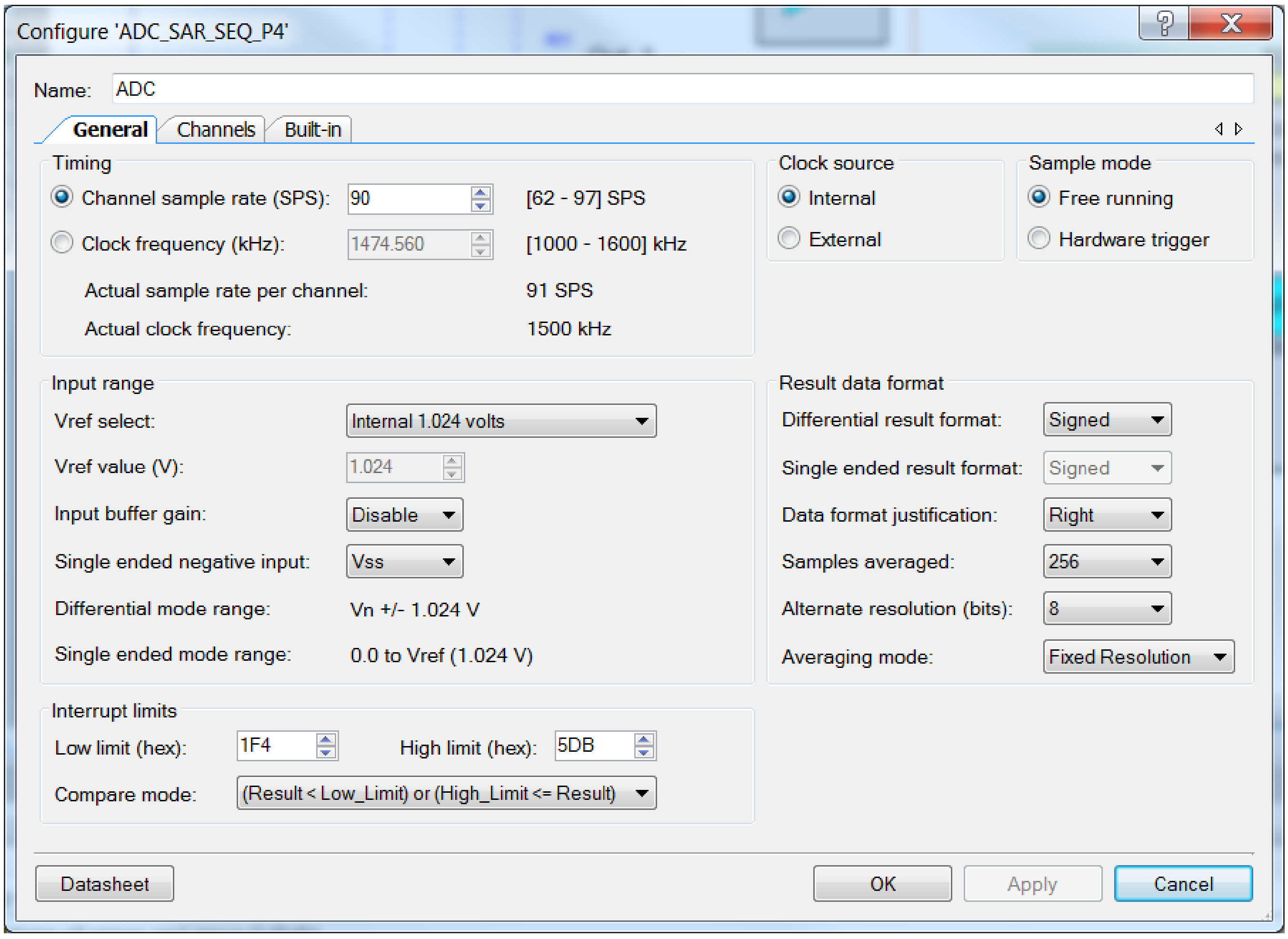


Figure 1. Top Design Schematic

The Opamps are configured in the high stability, high power, 10mA output current mode. The ADC averages 256 consecutive samples to produce a final result. The ADC_SAR component configuration window is shown in Figure 2. Switch SW2 and pin Channel_Sel is used to change the channel to be sent to HyperTerminal using a UART.



Configure 'ADC_SAR_SEQ_P4'

Name: ADC

General | Channels | Built-in

Timing

- [✓ Channel sample rate (SPS):] 90 [62 - 97] SPS
- Clock frequency (kHz): 1474.560 [1000 - 1600] kHz

Actual sample rate per channel: 91 SPS

Actual clock frequency: 1500 kHz

Clock source: [✓ Internal] External

Sample mode: [✓ Free running] Hardware trigger

Input range

Vref select:	Internal 1.024 volts
Vref value (V):	1.024
Input buffer gain:	Disable
Single ended negative input:	Vss
Differential mode range:	Vn +/- 1.024 V
Single ended mode range:	0.0 to Vref (1.024 V)

Result data format

Differential result format:	Signed
Single ended result format:	Signed
Data format justification:	Right
Samples averaged:	256
Alternate resolution (bits):	8
Averaging mode:	Fixed Resolution

Interrupt limits

Low limit (hex): 1F4 High limit (hex): 5DB

Compare mode: (Result < Low_Limit) or (High_Limit <= Result)

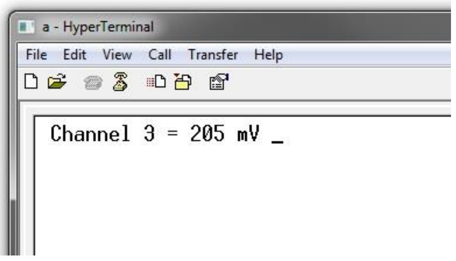
Figure 2. ADC Configuration Window

Project Description

In the main function all the components are started, SAR Sequencer is configured and ADC conversion is started. The “for” loop in main.c waits for the ADC to finish conversion. When an ADC result is available, data corresponding to the selected channel is sent to HyperTerminal using a UART. An interrupt is generated if the result from channel one falls outside the voltage window of 250mV to 750mV. This interrupt drives an LED. This LED turns ON when the output is outside the defined window.

Expected Results

The analog input channel should change when switch SW2 is pressed. HyperTerminal displays the active channel and its input voltage. An LED will turn on when the ADC channel 0 input is outside the voltage window (250mV – 750mV).



```
Channel 3 = 205 mV _
```

Figure 3. Result

Schematic

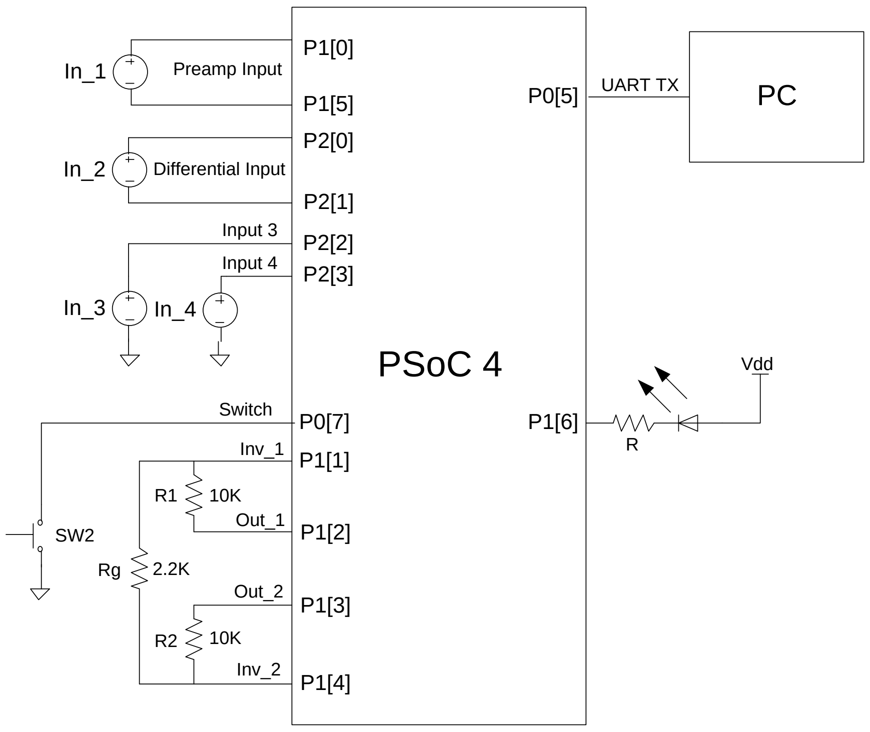


Figure 4. Connection Schematic

Note: If the LED is active HIGH, then please replace LOW with HIGH to turn LED ON and vice-versa. The Section of the code that needs to be changed in "main.c" is mentioned below:

```
/* Turn ON the LED when the input is outside the window (250mV - 750mV) */
    LED_Write(LOW);

/* Turn OFF the LED when the input is within the defined window (250mV - 750mV) */
    LED_Write(HIGH)
```

Using UART to communicate with PC Host

This example project communicates with a PC host using an UART. A HyperTerminal program is required in the PC to communicate with PSoC 4. If you don't have the HyperTerminal program installed, download and install any serial port communication program. Free wares such as HyperTerminal, Bray's Terminal etc. are available on the Web.

Follow these steps to communicate with the PC host.

1. Connect P0[5] to pin P12[6] on header J8.
2. Connect the USB cable between the PC and PSoC 4 Pioneer Kit.
3. Open the device manager program in your PC, find the COM port in which the PSoC 4 is connected, and note the port number.
4. Open the HyperTerminal program and select the COM port in which the PSoC 4 is connected.
5. Configure Baud rate, Parity, Stop bits and Flow control information in the HyperTerminal configuration window. These settings should match the configuration of the PSoC Creator UART component in the project
6. Start communicating with the device as explained in the project description.

Cypress Semiconductor	Phone	: 408-943-2600
198 Champion Court	Fax	: 408-943-4730
San Jose, CA 95134-1709	Website	: www.cypress.com