

# Мікропроцесорна техніка

(лекція 6)  
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2019 р.

**PSoC Creator 4.2**  
**Designing with PSoC 3/5**



# Мікропроцесорн а техніка

## ADC+LCD

PSoC Creator 4.2  
Designing with PSoC 3/5



**PSoC 3/5 включає в себе можливість обробки аналогових, цифрових і змішаних сигналів, а також можливість формування аналогових і цифрових сигналів, охоплюючи широкий спектр прикладних задач**

- **Особливості PSoC 3/5:**
  - Реконфігуровувані Аналогові модулі:
  - Вбудовані АЦП і ЦАП, аналогові фільтри різних типів, підсилювачі аналогових сигналів, компаратори, аналогові модулятори і т. д.
  - Реконфігуровувані Цифрові модулі:
  - Вбудовані таймери, лічильники, PWM, UART, SPI, IrDA, I2C і т. д.
  - Flash від 4КВ до 32КВ для зберігання програми
  - SRAM от 256В до 2КВ для зберігання даних
  - Процесорне ядро - МК8051, CISC, 4MIPS

**Оптимальними для PSoC являються задачі, коли необхідна обробка аналогових сигналів на апаратному рівні (підсилення, фільтрація, АМ/ФМ модуляція, демодуляція) із наступним перетворенням в цифрову форму в смузі аналогових сигналів до 100 кГц.**

**Виграш полягає в переносі зовнішніх дискретних компонентів у середину процесора.**

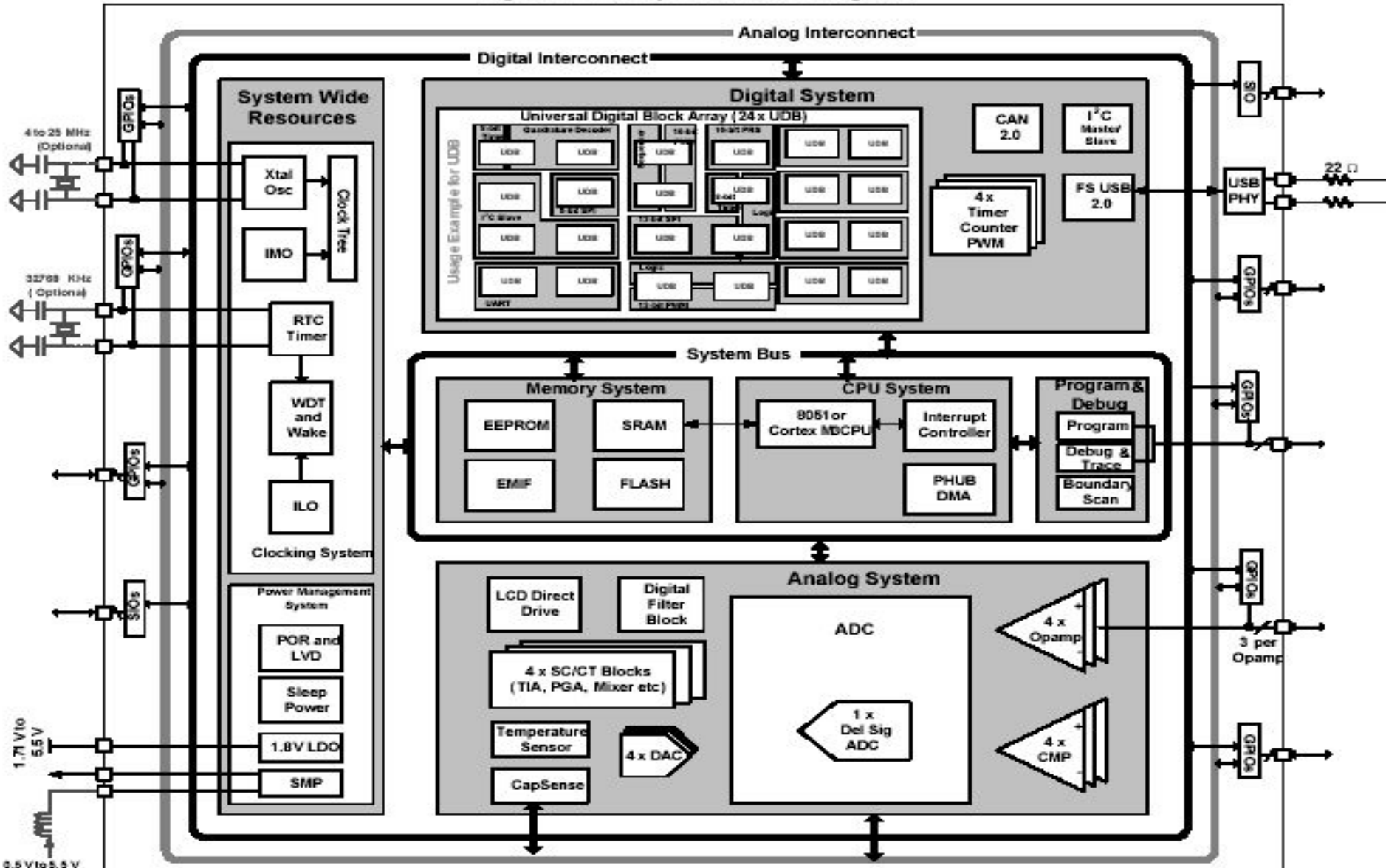






# Цифрові та аналогові модулі

Figure 1-1. Simplified Block Diagram



**Принцип дії даного АЦП дещо більш складний, ніж у інших типів АЦП.**

**Його суть в тому, що вхідна напруга порівнюється зі значенням напруги, накопиченим інтегратором.**

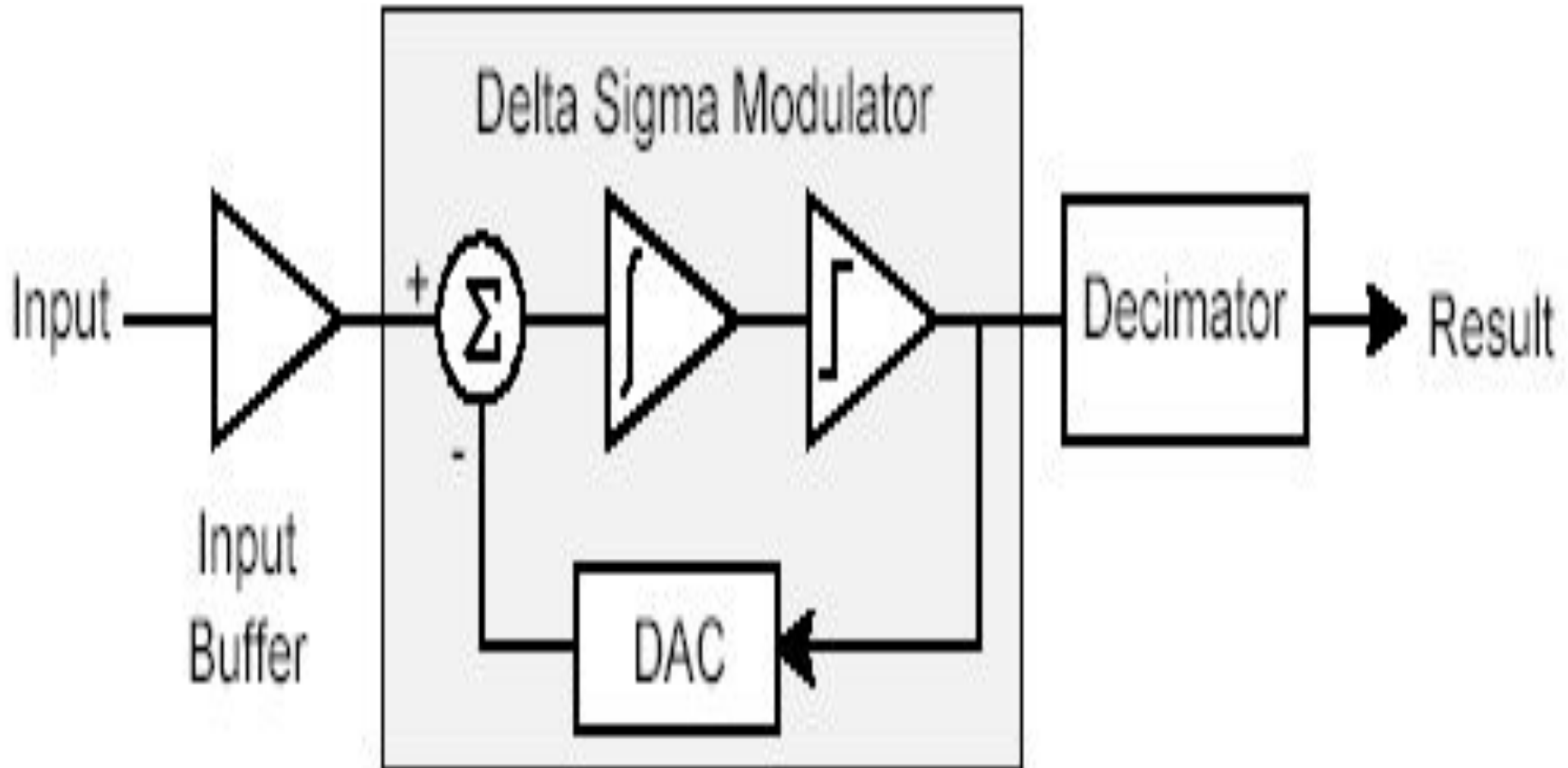
**На вхід інтегратора подаються імпульси позитивної чи від'ємної полярності, в залежності від результату порівняння.**

**Таким чином, даний АЦП представляє собою просту слідкуючу систему: напруга на виході інтегратора «відслідковує» вхідну напругу (рис. ).**

**Результатом роботи даної схеми являється потік нулів та одиниць на виході компаратора, який потім пропускається через цифровий ФНЧ, в результаті отримується N-бітний результат.**

**ФНЧ на рис. об'єднаний з «дециматором», пристроєм, який понижує частоту слідування відліків шляхом їх «проріджування».**

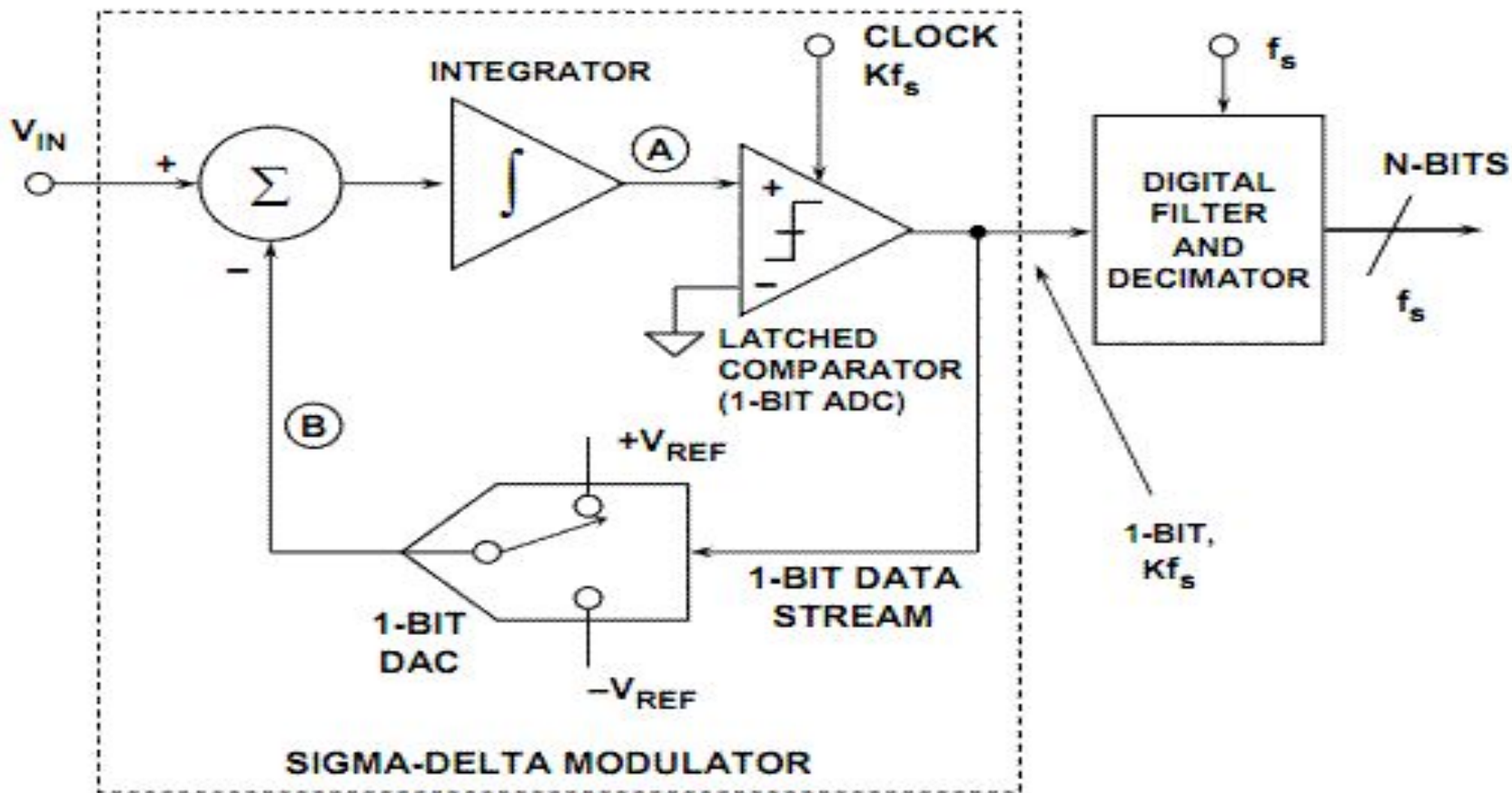




**ADC\_DelSig Block Diagram**



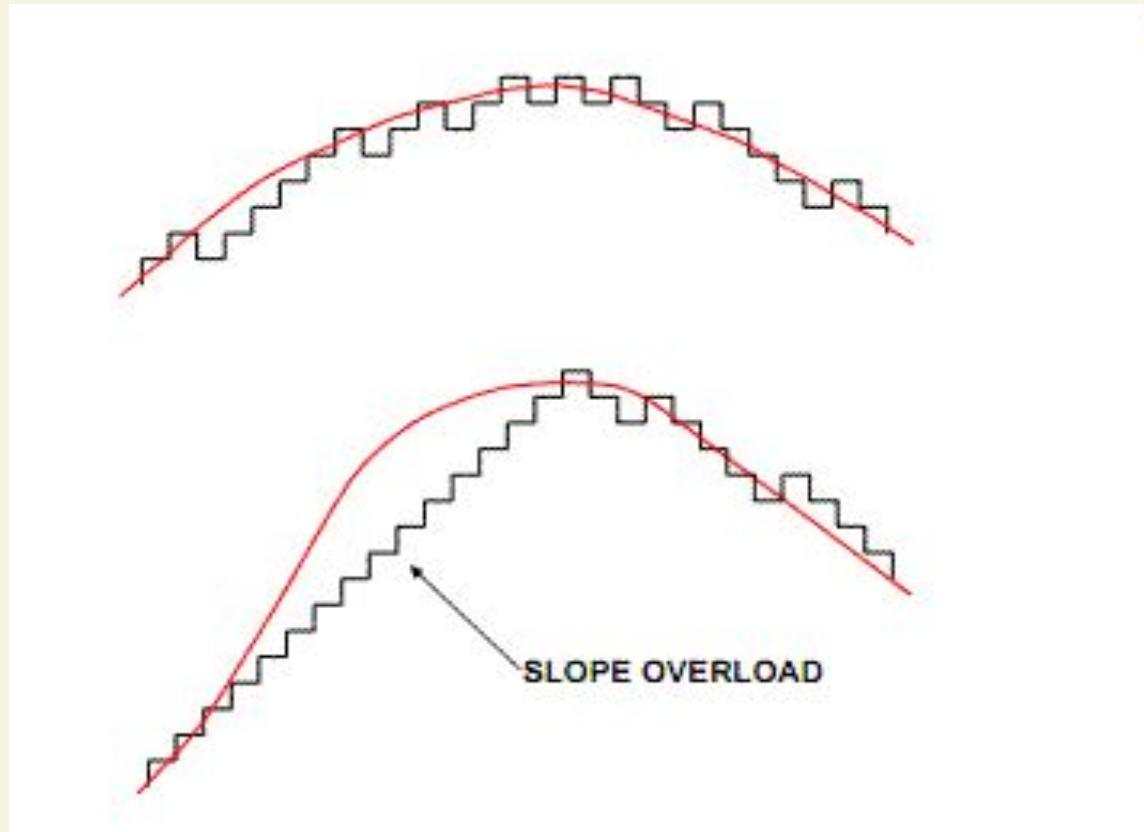
# Delta Sigma Analog to Digital Converter (ADC\_DelSig)



**Структурна схема сигма-дельта АЦП.**



# Delta Sigma Analog to Digital Converter (ADC\_DelSig)



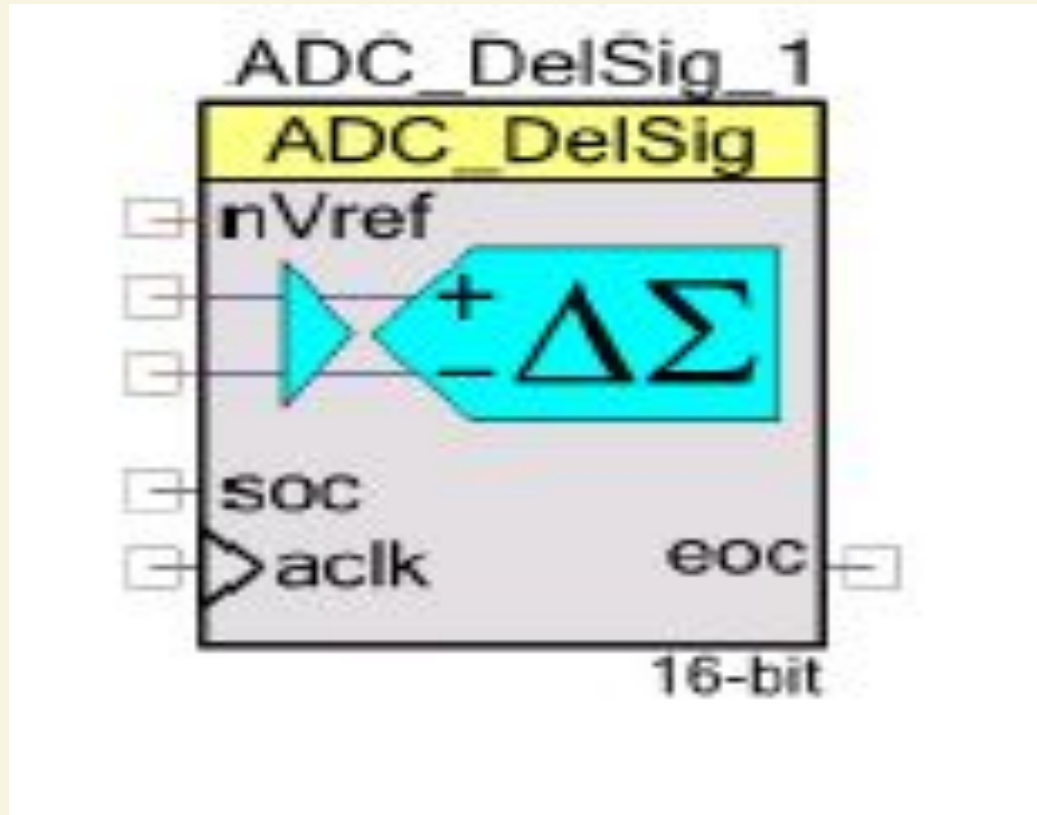
**Сигма-дельта АЦП як слідкуюча система**



# Delta Sigma Analog to Digital Converter (ADC\_DelSig)

- 1. When processing audio information, the ADC\_DelSig is used in a continuous operation mode.**
- 2. When used for scanning multiple sensors, the ADC\_DelSig is used in one of the multisample modes.**
- 3. When used for single-point high-resolution measurements, the ADC\_DelSig is used in single-sample mode.**
- 4. Delta-sigma converters are good for both high-speed medium-resolution (8 to 16 bits) applications, and low-speed high-resolution (16 to 20 bits) applications. The sample rate can be adjusted between 10 and 384000 samples per second, depending on mode and resolution.**

# Delta Sigma Analog to Digital Converter (ADC\_DelSig)



**It can produce 16-bit.**





# Delta Sigma Analog to Digital Converter (ADC\_DelSig)

- 1. When used for single-point high-resolution measurements, the ADC\_DelSig is used in single-sample mode.**
- 2. Delta-sigma converters are good for both high-speed medium-resolution (8 to 16 bits) applications.**
- 3. The sample rate can be adjusted between 2000 and 38400 samples per second, depending on mode and resolution.**

This example project shows how you can use **PSoC** to transfer data from one peripheral (**ADC**) to another (**LDC**),

## Features

- Delta-Sigma ADC in single-ended mode
- LCD used to verify output

PSoC Creator 2.1


File Edit View Debug Project Build Tools Window Help

Workspace Explorer

Source Components Datasheets Results

**Start Page**

PSoC® Creator™



简体中文 日本語 한국어 English

**PSoC Creator News and Information**

[Happy Lunar New Year!](#)  
Posted on 02/11/2013

Gong Xi Fa Cai! As many of my friends and colleagues are celebrating the New Year and welcoming in the year of the water snake, I wanted to take a minute and wish you all well. May the New Year bring each of you prosperity, good luck and a new PSoC design. ....  
[Read More](#)

[Tips + Tricks: Menu Customization](#)  
Posted on 01/24/2013

Did you know you can create a customized menu in PSoC® Creator? Right click in a blank area of the top menu and select customize from the

**Recent Projects**

- HelloWorld\_Blinky01.cywrk
- CapSense\_CSD\_Design01...
- CapSense\_CSD\_Design01...
- CharLCD\_CustomFont01.c...
- CharLCD\_CustomFont01.c...

Create New Project...  
Open Existing Project...

**Getting Started**

- PSoC Creator Start Page
- Quick Start Guide
- Intro to PSoC
- Intro to PSoC Creator
- PSoC Creator Training
- Help Tutorials
- Getting Started With PSoC 3
- Getting Started With PSoC 5

**Examples and Kits**

- Find Example Project...
- No Kit Packages Installed

**Notice List**

0 Errors 0 Warnings

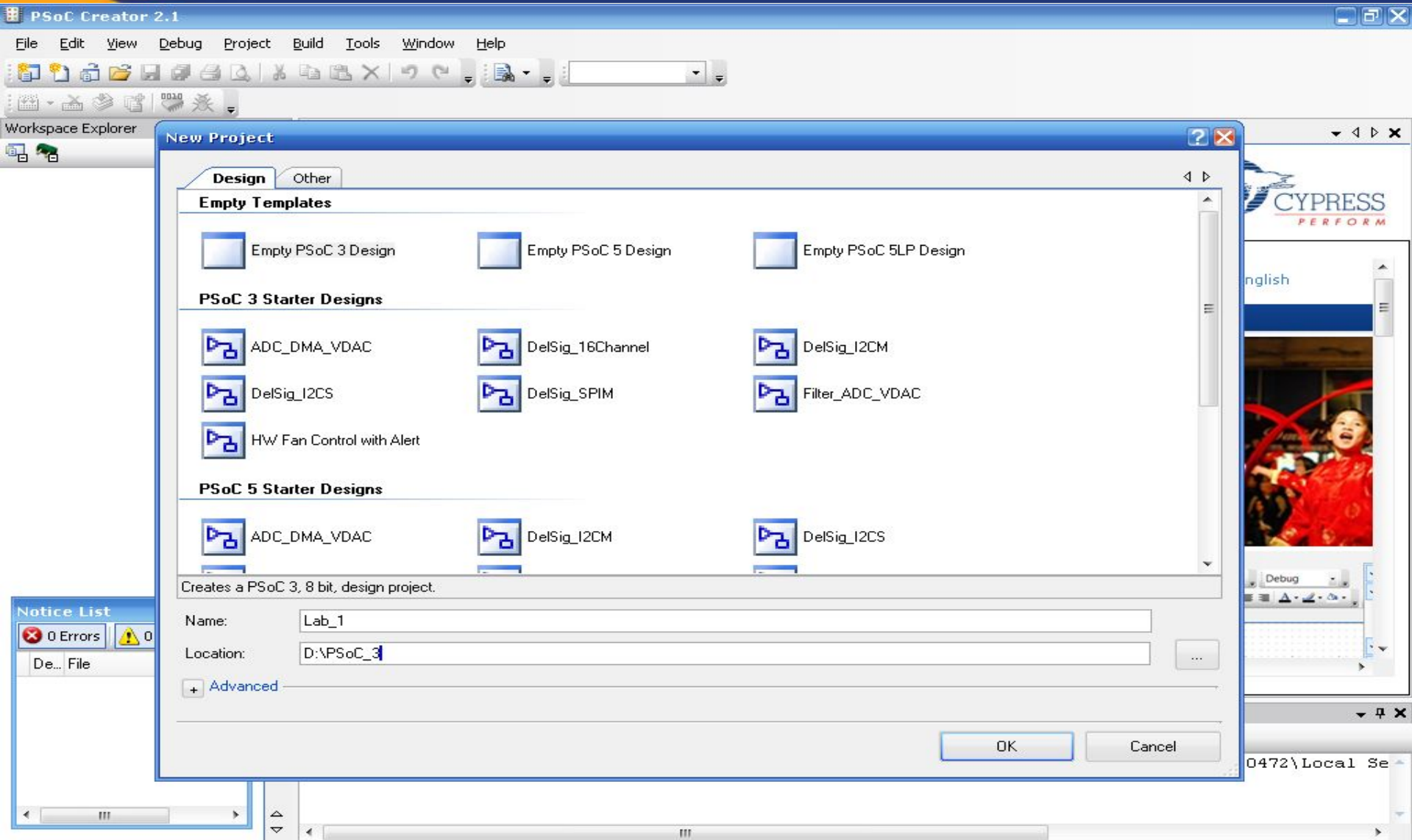
De...	File	Error L

**Output**

Show output from: All

Log file for this session is located at: C:\Documents and Settings\Admin.MICROSOFT-7D0472\Local Se

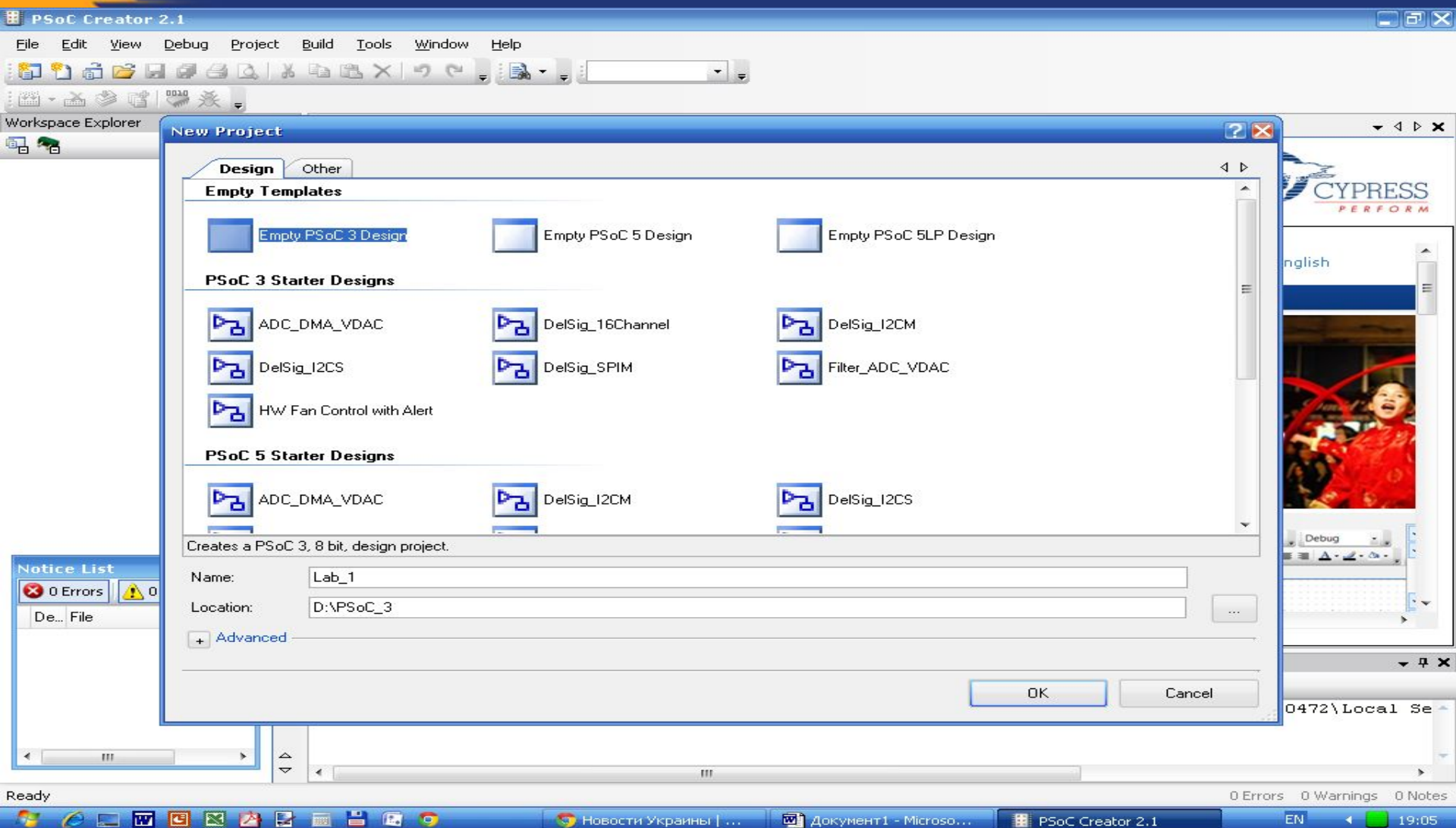
# File – New - Projekt



The screenshot shows the PSoC Creator 2.1 application window. The 'File' menu is open, and the 'New' option is selected, which has opened the 'New Project' dialog box. The dialog box has two tabs: 'Design' (selected) and 'Other'. Under the 'Design' tab, there are three sections: 'Empty Templates', 'PSoC 3 Starter Designs', and 'PSoC 5 Starter Designs'. Each section contains several project templates with a small icon to the left. Below the templates, there is a text description: 'Creates a PSoC 3, 8 bit, design project.' At the bottom of the dialog, there are two text input fields: 'Name:' with the value 'Lab\_1' and 'Location:' with the value 'D:\PSoC\_3'. There is also an 'Advanced' button with a plus sign. At the bottom right of the dialog are 'OK' and 'Cancel' buttons. In the background, the main application window is visible, showing the 'Workspace Explorer' on the left and a 'Notice List' at the bottom left. The 'Notice List' shows '0 Errors' and '0 Warnings'. The Windows taskbar at the bottom shows the system tray with '0 Errors 0 Warnings 0 Notes', the language 'EN', and the time '19:02'.



# Empty PSoC 3/5 Design



PSoC Creator 2.1

File Edit View Debug Project Build Tools Window Help

Workspace Explorer

**New Project**

Design Other

**Empty Templates**

- Empty PSoC 3 Design
- Empty PSoC 5 Design
- Empty PSoC 5LP Design

**PSoC 3 Starter Designs**

- ADC\_DMA\_VDAC
- DelSig\_I2CS
- DelSig\_I2CM
- DelSig\_16Channel
- DelSig\_SPIM
- Filter\_ADC\_VDAC
- HW Fan Control with Alert

**PSoC 5 Starter Designs**

- ADC\_DMA\_VDAC
- DelSig\_I2CM
- DelSig\_I2CS

Creates a PSoC 3, 8 bit, design project.

Name: Lab\_1

Location: D:\PSoC\_3

+ Advanced

OK Cancel

Notice List

- 0 Errors
- 0 Warnings
- 0 Notes

0472\Local Se

Ready

0 Errors 0 Warnings 0 Notes

EN 19:05



# Lab\_6 ADC+LCD

CharLCD\_CustomFont01 - PSoC Creator 2.1 [F:\...\CharLCD\_CustomFont01.cydsn\TopDesign\TopDesign.cysch]

File Edit View Debug Project Build Tools Window Help

Microsoft Sans Serif 10 B I U

Workspace Explorer (1 project)

Project 'CharLCD\_CustomFont01'

- TopDesign.cysch
- CharLCD\_CustomFont01
  - Header Files
    - device.h
  - Source Files
    - main.c
  - Generated\_Source
    - PSoC3
      - cy\_boot
        - CyBootAsmk
        - CyDmac.c
        - CyDmac.h
        - CyFlash.c
        - CyFlash.h
        - CyLib.c
        - CyLib.h
        - cymem.a51
        - cypins.h

Component Catalog (174 components)

Cypress Component Catalog

- Display
  - Character LCD [v1.70]

Notice List

0 Errors 0 Warnings

Output

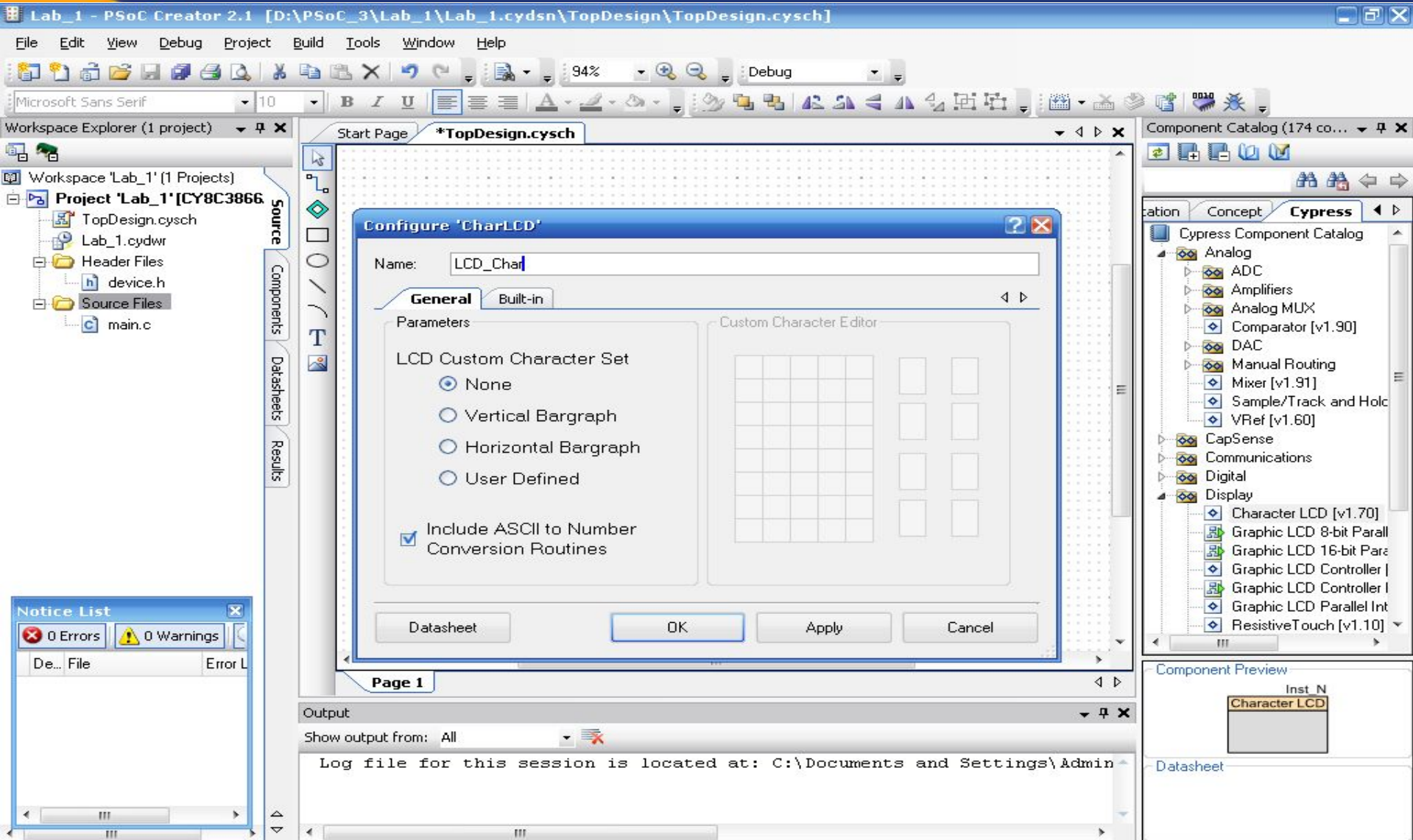
Show output from: All

Log file for this session is located at: C:\Documents and Settings\Admin...

Page 1

Ready 0 Errors 0 Warnings 0 Notes

# Configure LCD



The screenshot shows the PSoC Creator 2.1 software interface. The main window displays the 'Configure CharLCD' dialog box for a component named 'LCD\_Char'. The dialog has two tabs: 'General' and 'Built-in'. Under the 'General' tab, there are two sections: 'Parameters' and 'Custom Character Editor'. In the 'Parameters' section, the 'LCD Custom Character Set' is set to 'None'. Other options include 'Vertical Bargraph', 'Horizontal Bargraph', and 'User Defined'. The 'Include ASCII to Number Conversion Routines' checkbox is checked. The 'Custom Character Editor' section contains a grid for defining characters. At the bottom of the dialog are buttons for 'Datasheet', 'OK', 'Apply', and 'Cancel'. The background shows the workspace explorer with project files, a component catalog on the right, and a notice list at the bottom left.



Lab\_1 - PSoC Creator 2.1 [D:\PSoc\_3\Lab\_1\Lab\_1.cydsn\Lab\_1.cydwr]

File Edit View Debug Project Build Tools Window Help

37% Debug

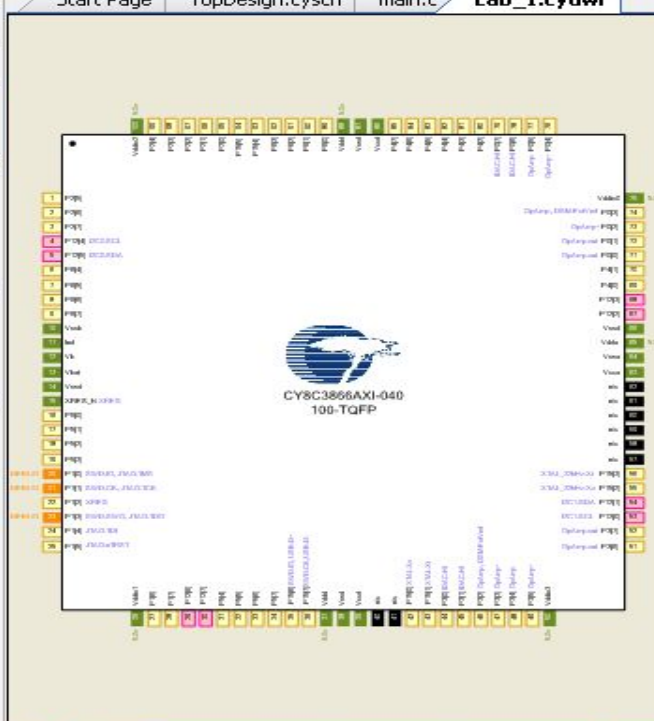
Workspace Explorer (1 project)

Workspace 'Lab\_1' (1 Projects)

- Project 'Lab\_1' [CY8C3866]
  - TopDesign.cysch
  - Lab\_1.cydwr
  - Header Files
    - device.h
  - Source Files
    - main.c

Source Components Datasheets Results

Start Page TopDesign.cysch main.c Lab\_1.cydwr



CY8C3866AXI-040  
100-TQFP

Alias	Name	Port	Pin	Lock
	\LCD_Char:LCDPort[6:0]\			
	P0[6:0]	IDAC:HC		
	P0[7:1]	IDAC:HC		
	P2[6:0]			
	P2[7:1]			
	P3[6:0]	OpAmp:c		
	P3[7:1]	OpAmp:c		
	P4[6:0]			
	P4[7:1]			
	P5[6:0]			

LCD\_Char\_LCDPort\_6 - Digital  
LCD\_Char\_LCDPort\_5 - Digital  
LCD\_Char\_LCDPort\_4 - Digital

Pins Analog Clocks Interrupts DMA System Directives Flash Security

Output

Show output from: All

Log file for this session is located at: C:\Documents and Settings\Admin.MICROSOFT-7D0472\Local Se

Notice List

0 Errors 0 Warnings

De... File Error L

Ready

0 Errors 0 Warnings 0 Notes

EN 19:33

## **Adding Components**

**To see how the ADC works we need an analog signal to convert. We're going to use a potentiometer to provide one analog signal. A basic potentiometer provides a great diagnostic tool for analog processing since you can slowly sweep the signal through the range of the potentiometer and observe the output. Char LCD to provide visual feedback.**

- 1. Drag an Analog Pin component onto your design.**
- 2. Name it VR\_Pin. This pin will be connected to the potentiometer on the DVK.**
- 3. The potentiometer output will send to the ADC.**



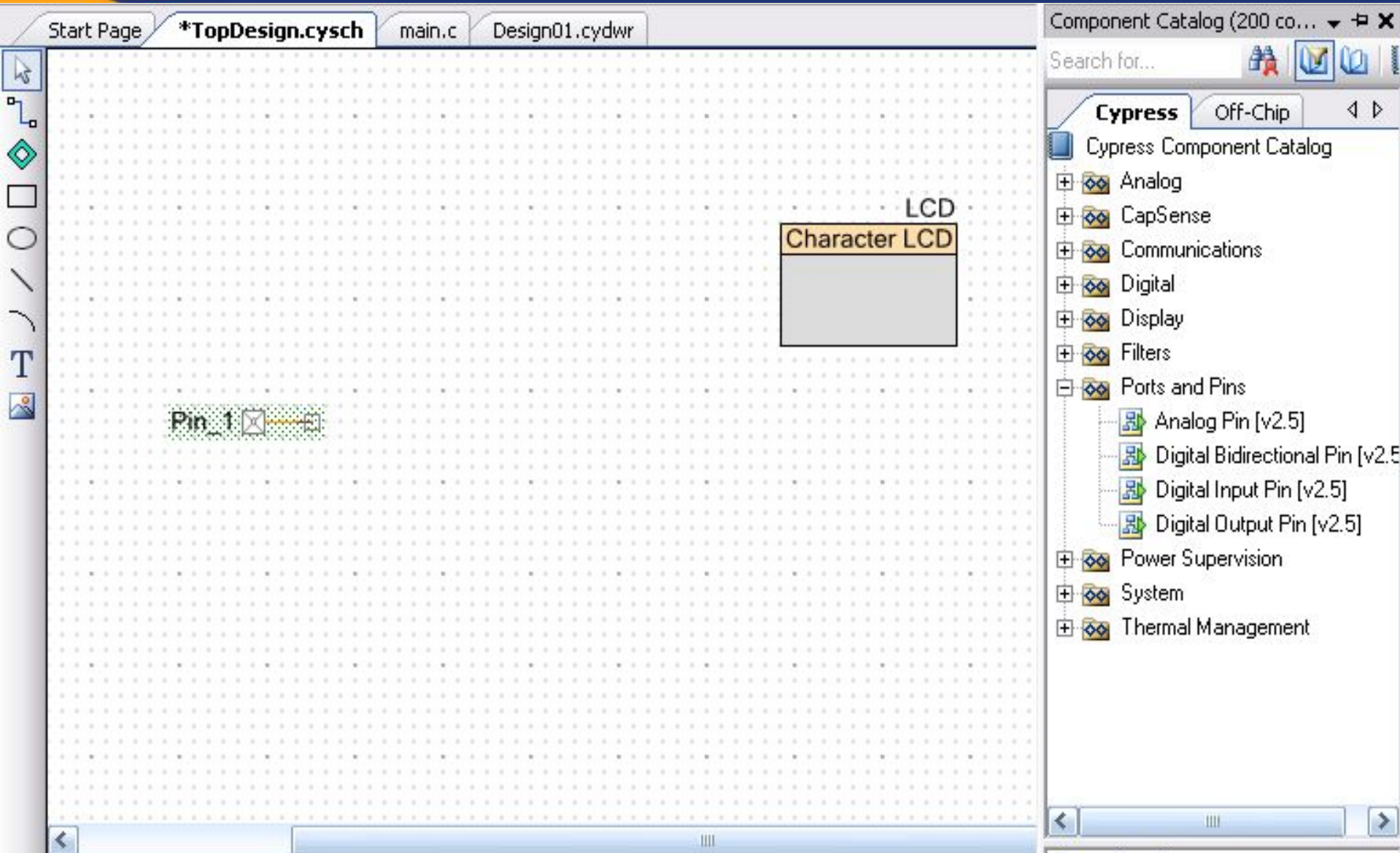
**This design adds only one external pin for the potentiometer.**

- **Open the design-wide resource file and assign the pins (Рис.1).**
- **Build the project.**
- **Add a wire to the DVK board connecting P0\_7 to the VR.**
- **Make sure the VR\_PWR jumper on the DVK is placed properly to provide power to the potentiometer.**

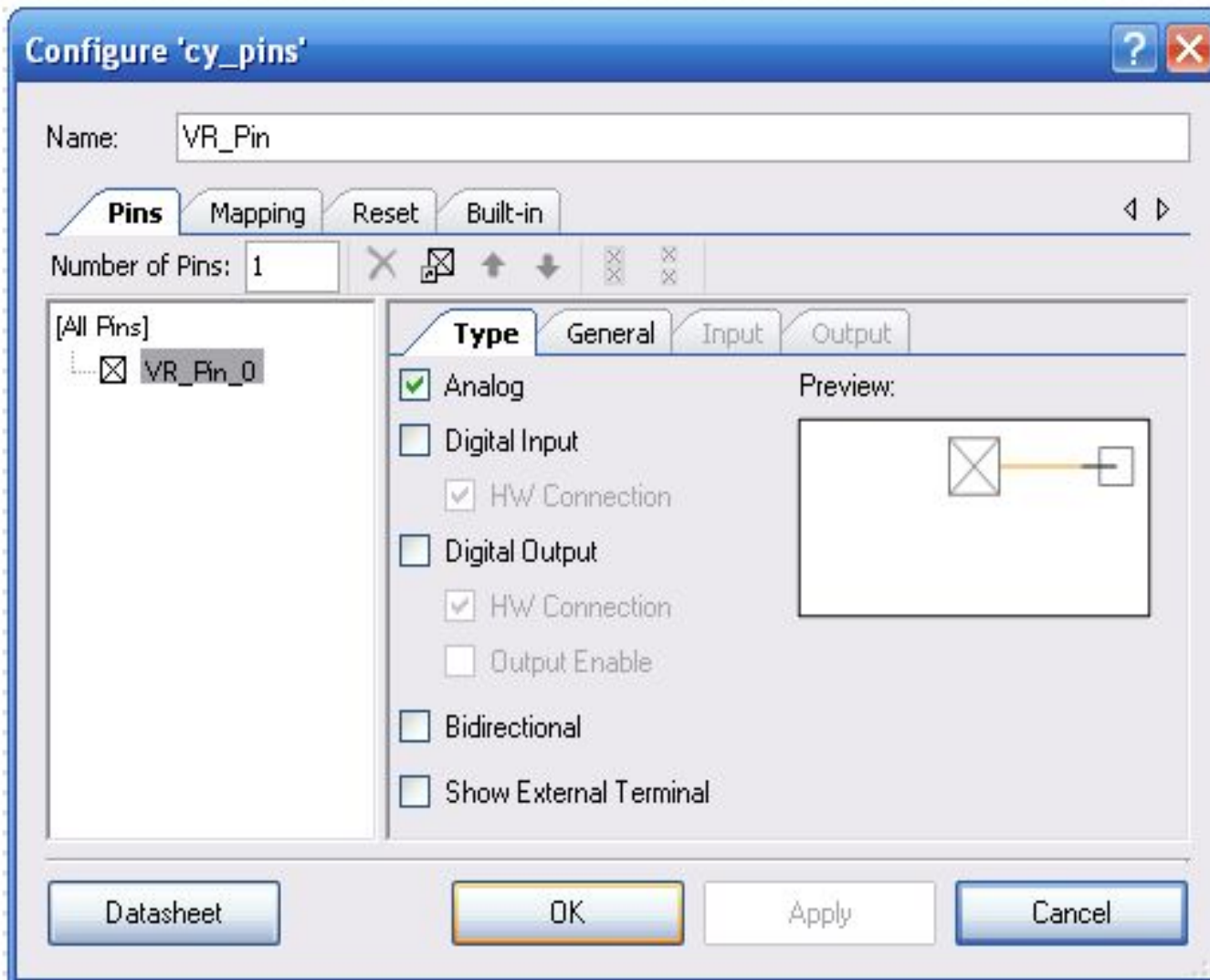
	\CharLCD:LCDPort\[6:0]	P2[6:0]	▼	☑
	VR_Pin	P0[7]	▼	☑

Рис.1

# Lab\_6 ADC+LCD



The screenshot shows the Cypress PSoC Designer IDE interface. The main workspace contains a schematic design on a grid. A component labeled "Character LCD" is placed on the right side, with the text "LCD" above it. On the left side, a component labeled "Pin\_1" is placed, with a small icon of a pin and a connection point. The top of the window shows the project name "\*TopDesign.cysch" and the design file "Design01.cydwr". The right-hand side features the "Component Catalog" window, which is currently displaying the "Cypress" category. The catalog lists various component types, including Analog, CapSense, Communications, Digital, Display, Filters, Ports and Pins, Power Supervision, System, and Thermal Management. Under "Ports and Pins", several specific pin types are listed, such as "Analog Pin [v2.5]", "Digital Bidirectional Pin [v2.5]", "Digital Input Pin [v2.5]", and "Digital Output Pin [v2.5]".



Start Page \*TopDesign.cysch main.c Design01.cydwr

## Configure 'cy\_pins'

Name: VR\_Pin

**Pins** Mapping Reset Built-in

Number of Pins: 1

[All Pins]

VR\_Pin\_0

Type

**General** Input Output

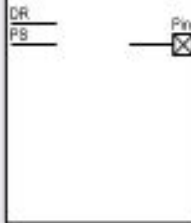
Drive Mode

High Impedance Analog

Initial State:

Low (0)

Minimum Supply Voltage:



Datasheet

OK

Apply

Cancel



## Lab\_6 Adding Components

- Drag an **Analog Pin** component onto your design  
Name it **VR\_Pin**.  
This pin will be connected to the potentiometer on the DVK
- Add a **Delta Sigma ADC** component from the Component Catalog to your design
- Double Click the **ADC** to configure it.  
Name the component **ADC**.
- Set the **Conversion Mode** to **Continuous**.
- Set the **Resolution** to be **14** bits and the **Conversion Rate** to be **5,000 SPS** (samples per second).
- Set the **Input Range** to be **Vssa to Vdda (Single Ended)**
- Set the **Input Buffer Gain** to **1**
- Select **Single Ended** Input mode



Start Page \*TopDesign.cysch main.c Design01.cydwr

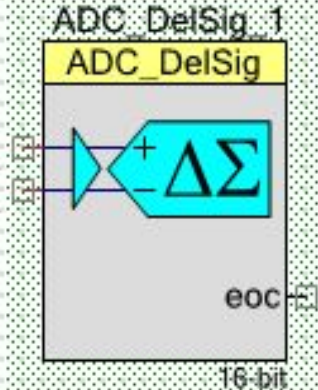
Component Catalog (200 co... Search for...

**Cypress** Off-Chip

- Cypress Component Catalog
  - Analog
    - ADC
      - Delta Sigma ADC [v...
    - Amplifiers
    - Analog MUX
    - Comparators
    - DAC
    - Manual Routing
    - Mixer [v2.0]
    - Sample/Track and Hold
    - VRef [v1.60]
  - CapSense
  - Communications
  - Digital
  - Display
  - Filters
  - Ports and Pins
  - Power Supervision
  - System

VR\_Pin [07] →

ADC DelSig\_1  
ADC\_DelSig

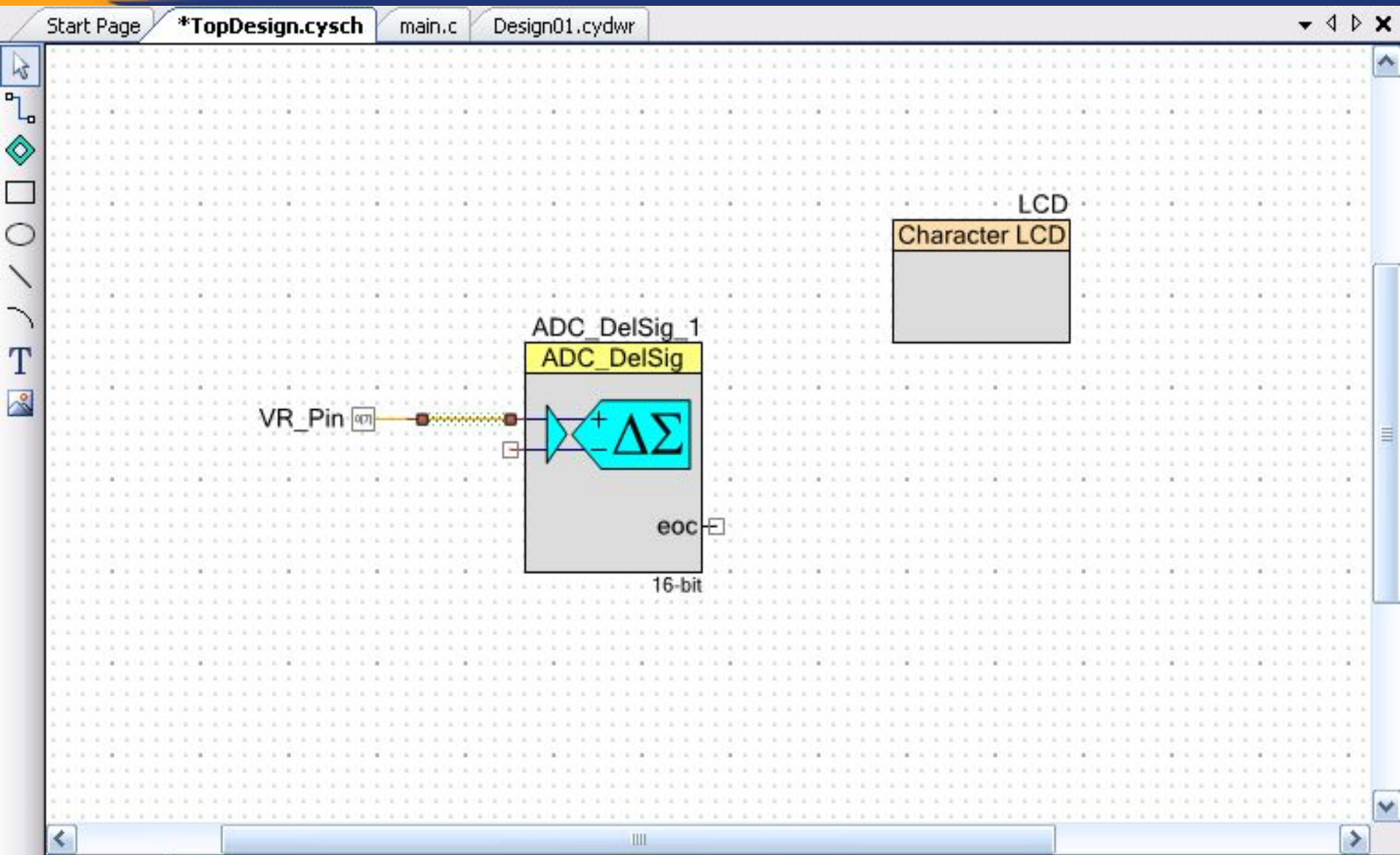


eoc

16-bit

LCD  
Character LCD

# Lab\_6 ADC+LCD



**Configure 'ADC\_DeISig'**

Name:

Config1 | Config2 | Config3 | Config4 | Common | Built-in

Comment:

Configuration name:  ADC\_DeISig\_1\_CFG1

**Modes**

Conversion mode:

Resolution (bits):

Conversion rate (SPS):  Range: 2000 - 48000 SPS

Actual conv. rate (SPS):

Clock frequency (kHz):

**Input options - Differential mode**

Input range:

Buffer gain:

Buffer mode:

**Reference**

Reference:

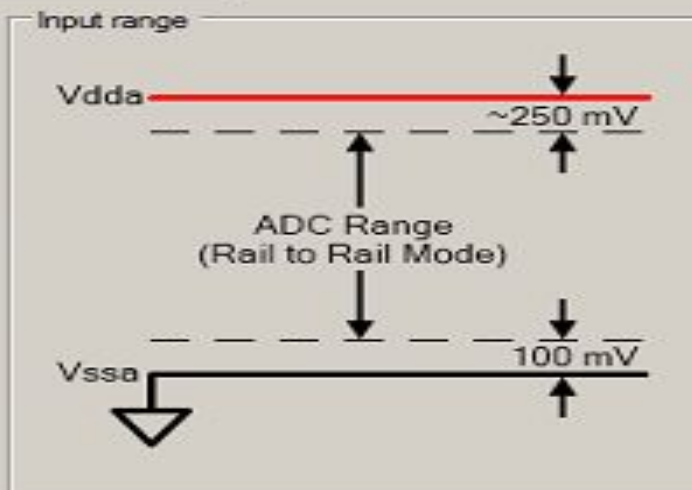
Vref (V):

**Alignment**

Right      Coherency = LOW

Left     

**Input range**



Datasheet      OK      Apply      Cancel

## Configure 'ADC\_DeISig'

Name: ADC

**Config1** Config2 Config3 Config4 Common Built-in

Comment: Default Config

Configuration name: CFG1 ADC\_CFG1

### Modes

Conversion mode: 2 - Continuous

Resolution (bits): 14

Conversion rate (SPS): 5000 Range: 2783 - 133565 SPS

Actual conv. rate (SPS): 5017

Clock frequency (kHz): 230.000

### Input options - Differential mode

Input range: +/-2.048V [ -Input +/- 2\*Vref ]

Buffer gain: 1

Buffer mode: Rail to Rail

### Input range



### Reference

Datasheet

OK

Apply

Cancel



Start Page | TopDesign.cysch | main.c | Design01.cydwr

### Configure 'ADC\_DeISig'

Name:

**Config1** | Config2 | Config3 | Config4 | Common | Built-in

Actual conv. rate (SPS):

Clock frequency (kHz):

Input options - Differential mode

Input range:

Buffer gain:

Buffer mode:

Reference

Reference:

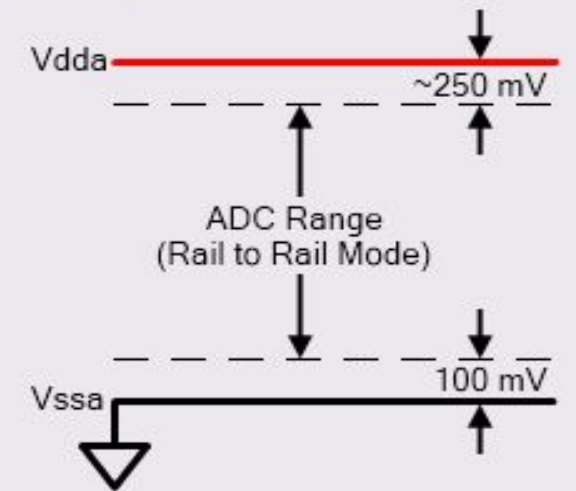
Vref (V):

Alignment

Right      Coherency = LOW

Left     

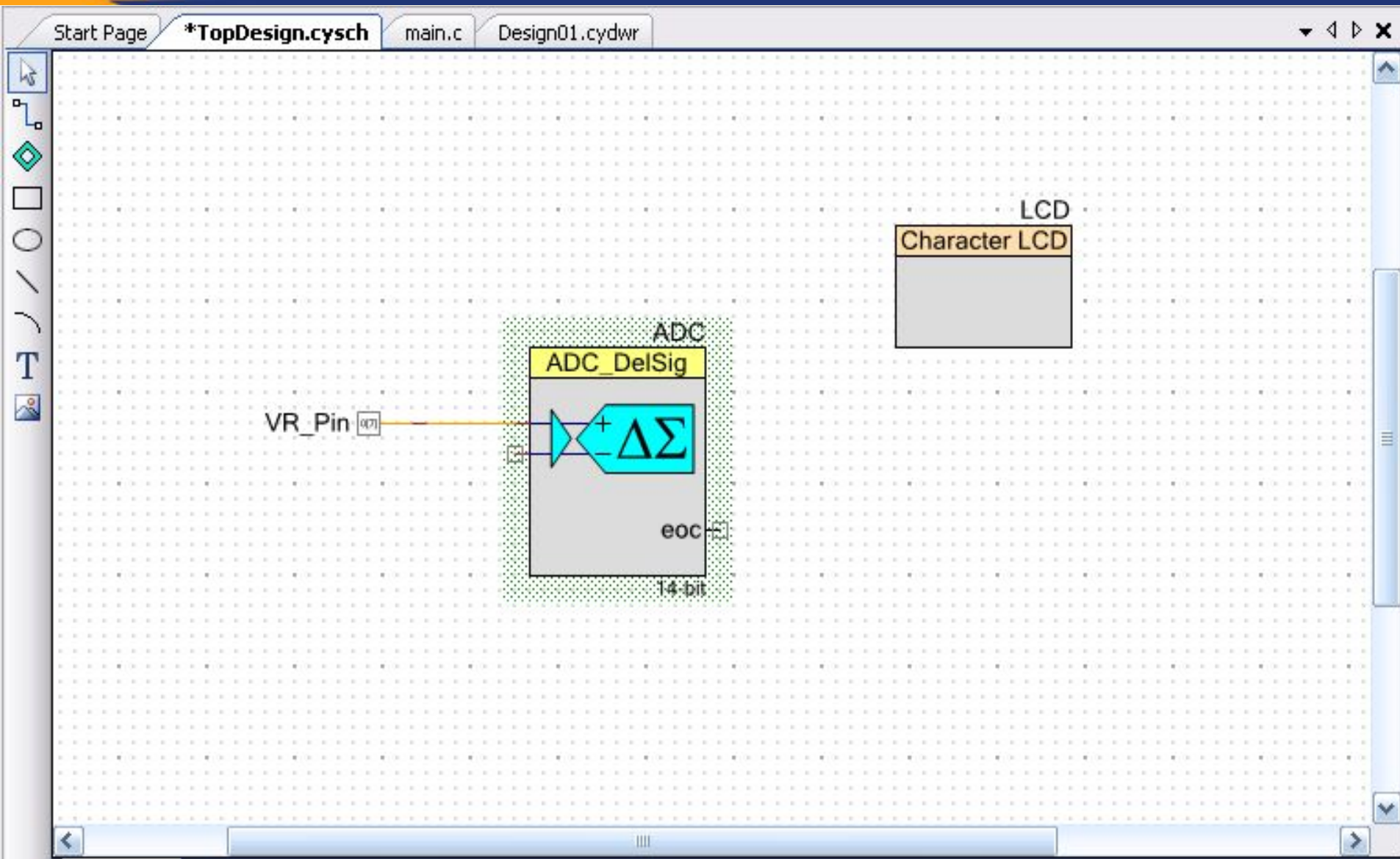
Input range diagram:



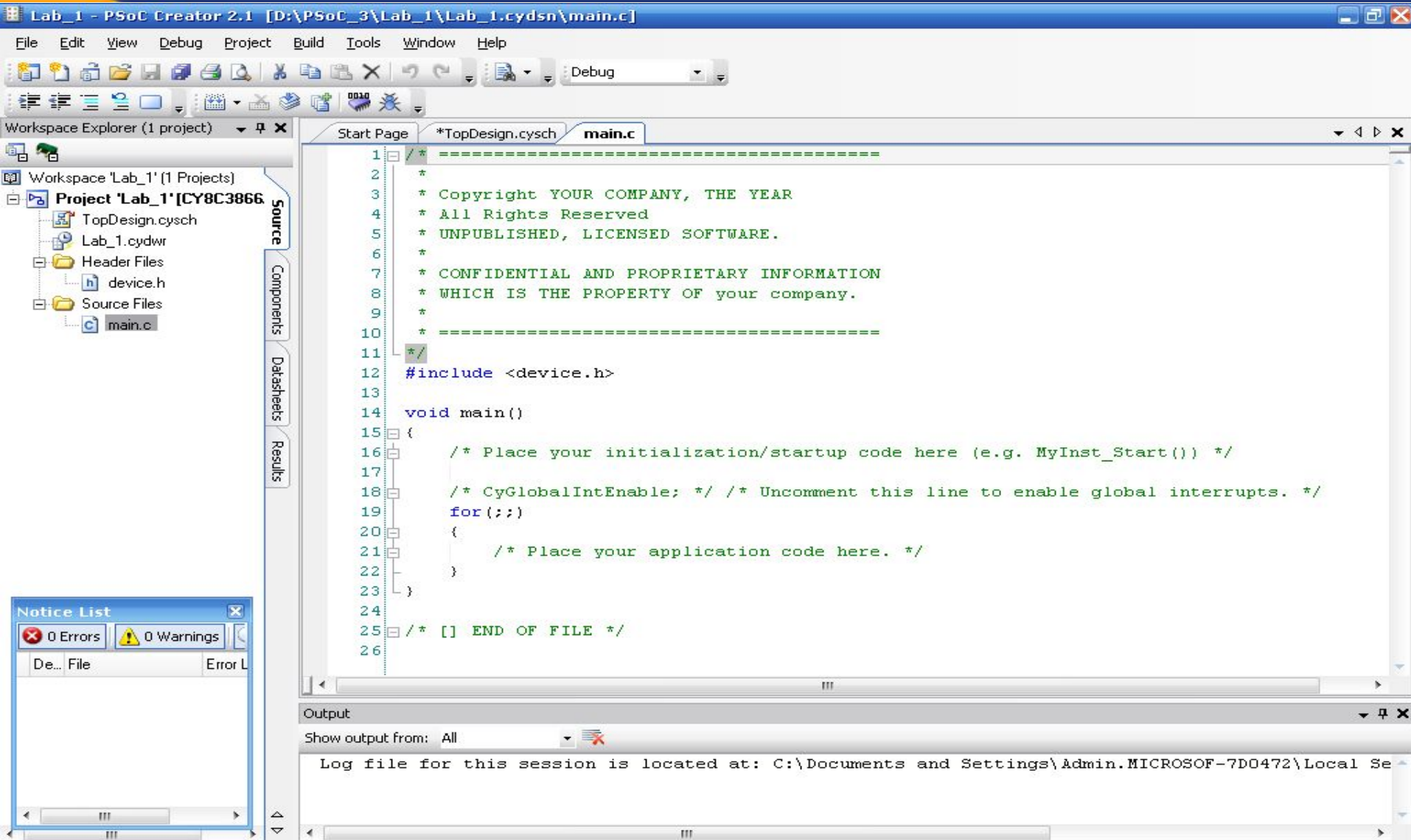
The diagram illustrates the ADC's input range. It shows two horizontal lines representing the supply rails: a red line for V<sub>dda</sub> at the top and a black line for V<sub>ssa</sub> at the bottom. A vertical double-headed arrow between these lines is labeled "ADC Range (Rail to Rail Mode)". A horizontal dashed line is drawn below the V<sub>dda</sub> line, and another horizontal dashed line is drawn above the V<sub>ssa</sub> line. The vertical distance between these two dashed lines is indicated by a vertical double-headed arrow and labeled "~250 mV". A vertical double-headed arrow between the V<sub>ssa</sub> line and the lower dashed line is labeled "100 mV".

Buttons: Datasheet | OK | Apply | Cancel

# Lab\_6 ADC+LCD







The screenshot shows the PSoC Creator 2.1 IDE interface. The main window displays the source code for `main.c`. The code includes a copyright notice, an include directive for `device.h`, and a `main()` function with several comments and a `for` loop. A `Notice List` window is open in the bottom-left corner, showing 0 Errors and 0 Warnings. The Output window at the bottom shows a message about the log file location.

```
1  /* -----  
2  *  
3  * Copyright YOUR COMPANY, THE YEAR  
4  * All Rights Reserved  
5  * UNPUBLISHED, LICENSED SOFTWARE.  
6  *  
7  * CONFIDENTIAL AND PROPRIETARY INFORMATION  
8  * WHICH IS THE PROPERTY OF your company.  
9  *  
10 * -----  
11 */  
12 #include <device.h>  
13  
14 void main()  
15 {  
16     /* Place your initialization/startup code here (e.g. MyInst_Start()) */  
17  
18     /* CyGlobalIntEnable; */ /* Uncomment this line to enable global interrupts. */  
19     for (;;)   
20     {  
21         /* Place your application code here. */  
22     }  
23 }  
24  
25 /* [] END OF FILE */  
26
```

Notice List  
0 Errors 0 Warnings  
De... File Error L

Output  
Show output from: All  
Log file for this session is located at: C:\Documents and Settings\Admin.MICROSOFT-7D0472\Local Se

**Make the following changes to the beginning of *main.c*.**

```
#include "myADC.h"
```

```
.....
```

```
void main()
```

```
{
```

```
    /* Components should be initialized in the following order:
```

```
    * 1. interrupts
```

```
    * 2. sources of interrupts (clocks are auto-initialized)
```

```
    * 3. global interrupt enable
```

```
    */
```

```
    InitAdc(); /* source of interrupt */
```

```
    CYGlobalIntEnable /* macro */
```

```
    /* Initialize other components, not associated with interrupts */
```

```
    CharLCD_Start();
```

Create a file called *myADC.c*.

Add the following code to the *myADC.c* file.

```
#include <device.h>
#include "myADC.h"
/*****
* Global Functions
*****/
/*****
* Function Name: InitAdc()
*****/
void InitAdc(void)
{
ADC_Start();
ADC_StartConvert(); /* Starts a continuous conversion process */
} /* end of InitAdc() */
```



```
/* **** */
* Function Name: UpdateAdc()
* **** */
void UpdateAdc(void)
{
if(ADC_IsEndConversion(ADC_RETURN_STATUS))
{
uint8 adcval8;
/* Get 14-bit conversion reported in a signed 16-bit result, and limit
* negative and positive overflow. */
int16 adcval16 = ADC_GetResult16();
if(adcval16 < 0)
{
adcval16 = 0;
}
else if(adcval16 > 0x3FFF)
{
adcval16 = 0x3FFF;
}
else {} /* value is in range, do nothing */
```



# myADC.c

```
/* Convert to an 8-bit result; grab the 8 MS bits. */
adcval8 = (uint8)(((uint16)adcval16 >> 6) & 0xFFU);
if(source != 0U)
{
    adcval8 *= 3U;
}
/* display the result on the char LCD */
CharLCD_Position(1U, 6U); /* row, column */
CharLCD_PrintHexUint8(adcval8);
/* Print (val / 4) (with rounding, add half the divisor) 'X' characters,
 * which creates a horizontal line whose length is proportional to the
 * ADC value.
 */
adcval8 = (uint8)(((uint16)adcval8 + 2U) / 4U);
if (adcval8 == 0U) /* make sure that at least one 'X' is printed */
{
    adcval8 = 1U;
}
} /* end of if (ADC_IsEndConversion(ADC_RETURN_STATUS)) */
} /* end of UpdateAdc() */
```

На сайті фірми Cypress знаходиться більше 200 Application Notes і Reference Designs, які ілюструють області застосування мікроконтролерів PSoC.

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