Мікропроцесорна техніка

(лекція 6)
Благітко Б.Я.
2019 р.

PSoC Creator 4.2
Designing with PSoC 3/5

Мікропроцесорна техніка

ADC+LCD

PSoC Creator 4.2
Designing with PSoC 3/5

Зміст

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

Що всередині PSoC 3/5 ?

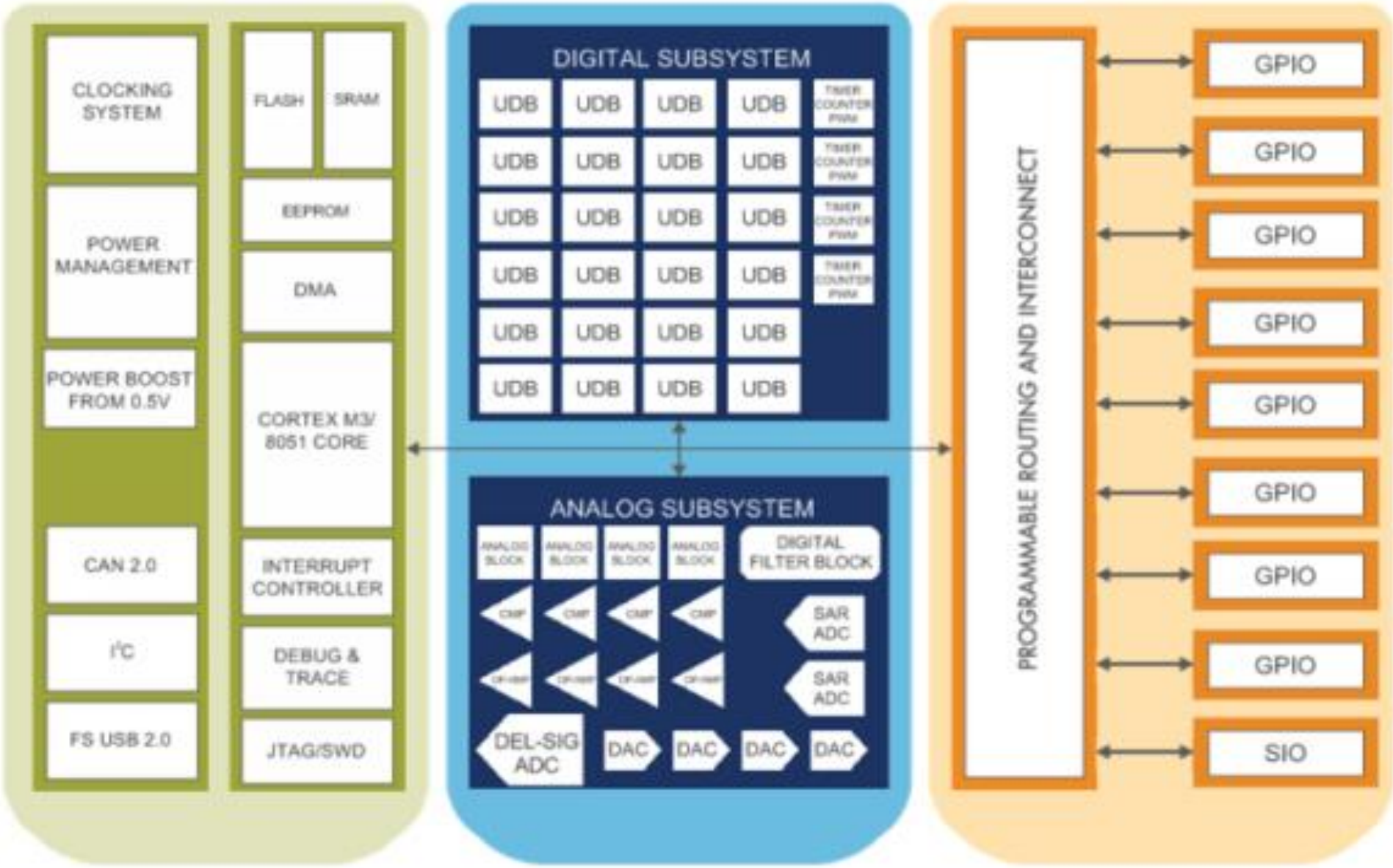
- **Особливості PSoC 3/5:**
  - Реконфігуровувані ***Аналогові модулі:***
  - Вбудовані АЦП і ЦАП, аналогові фільтри різних типів, підсилювачі аналогових сигналів, компаратори, аналогові модулятори і т. д.
  - Реконфігуровувані ***Цифрові модулі:***
  - Вбудовані таймери, лічильники, PWM, UART, SPI, IrDA, I2C і т. д.
  - *Flash* від 4KB до 32KB для зберігання програми
  - *SRAM* от 256B до 2KB для зберігання даних
  - *Процесорне ядро* - MK8051, CISC, 4MIPS

Оптимальні області застосування МК PSoC

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

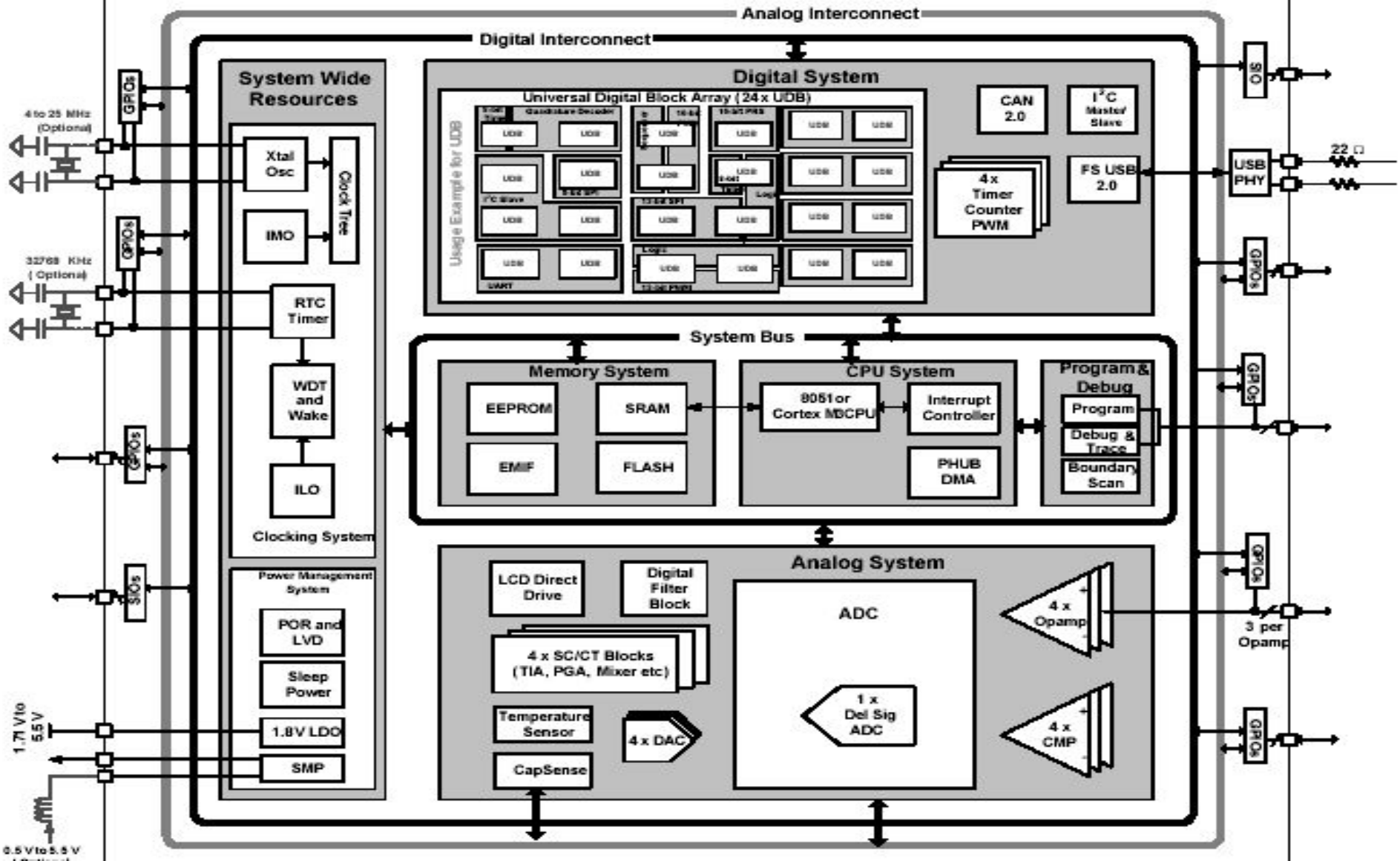
Виграш полягає в переносі зовнішніх дискретних компонентів у середину процесора.

Цифрові та аналогові модулі



Цифрові та аналогові модулі

Figure 1-1. Simplified Block Diagram



ADC

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.

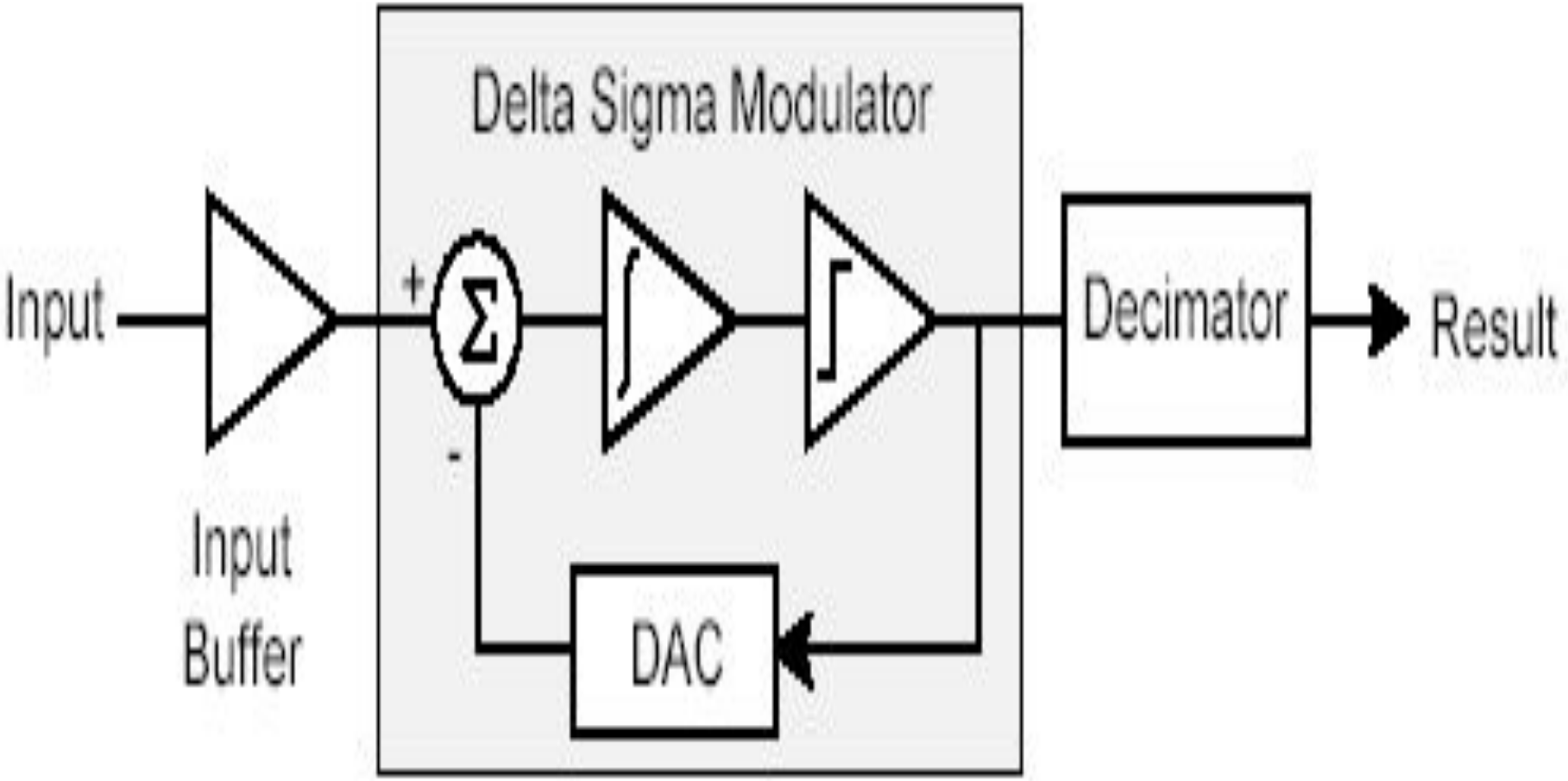
На вхід інтегратора подаються імпульси позитивної чи від'ємної полярності, в залежності від результату порівняння.

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 получається N-бітний результат.

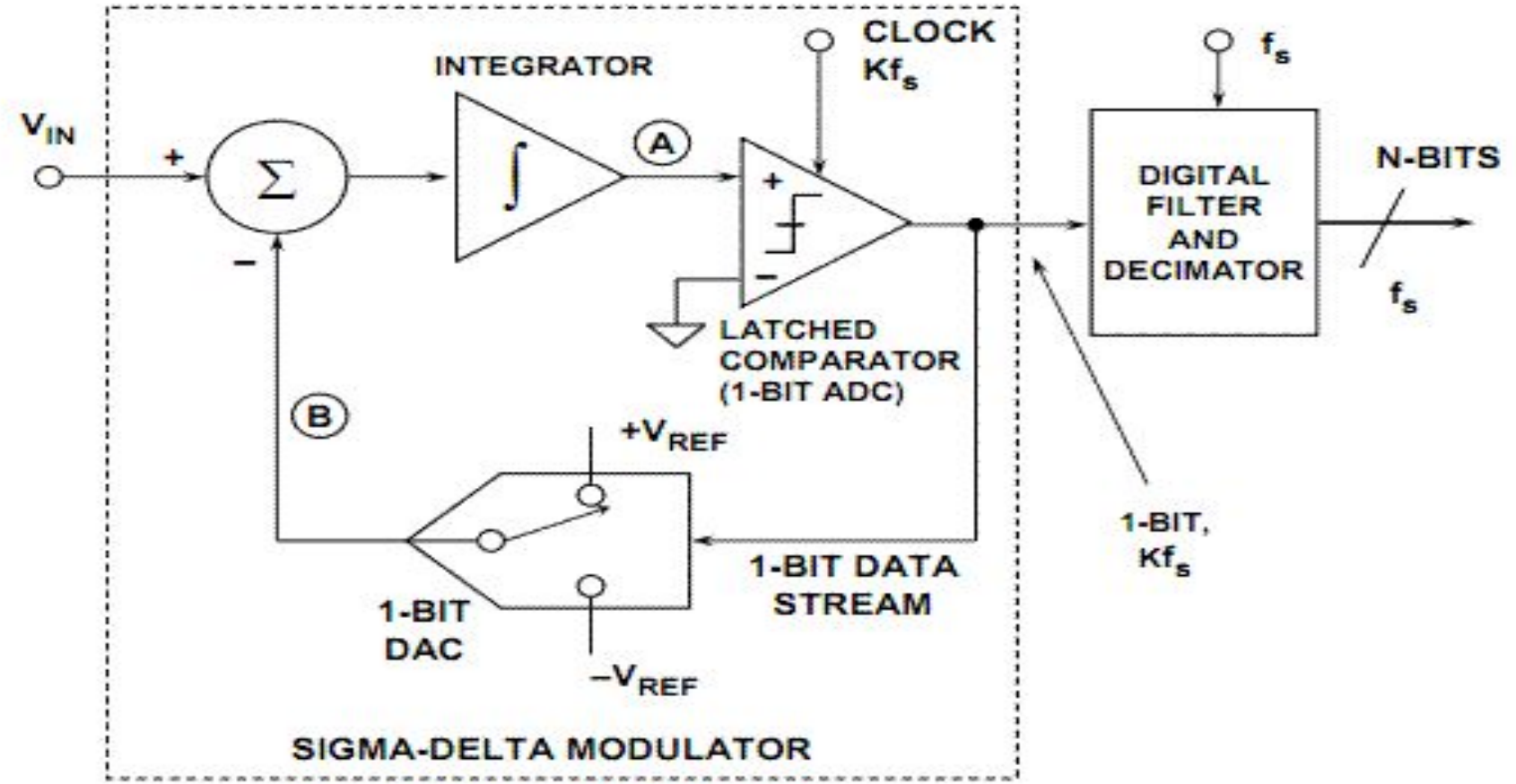
ФНЧ на рис. об'єднаний з «дециматором», пристроєм, який понижує частоту слідування відліків шляхом їх «проріджування».

Delta Sigma Analog to Digital Converter (ADC_DelSig)



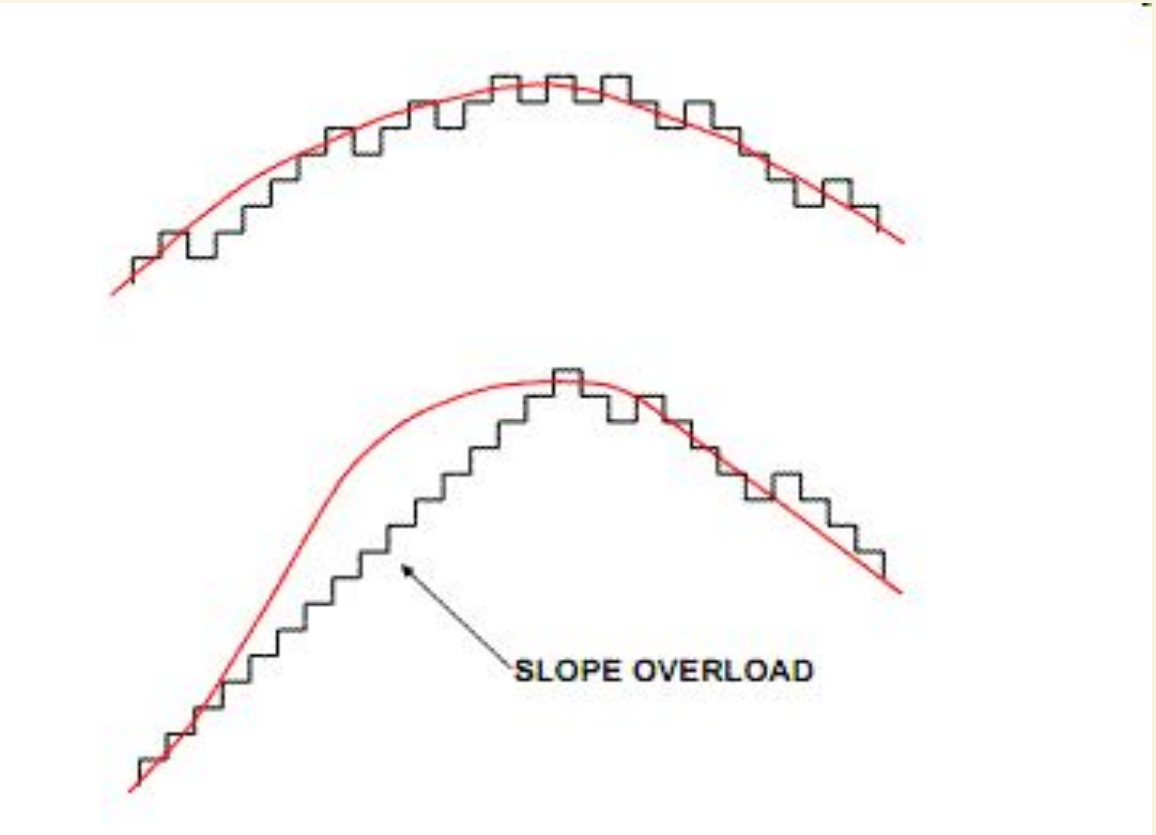
ADC_DelSig Block Diagram

Delta Sigma Analog to Digital Converter (ADC_DelSig)



Структурна схема сигма-дельта АЦП.

Delta Sigma Analog to Digital Converter (ADC_DelSig)

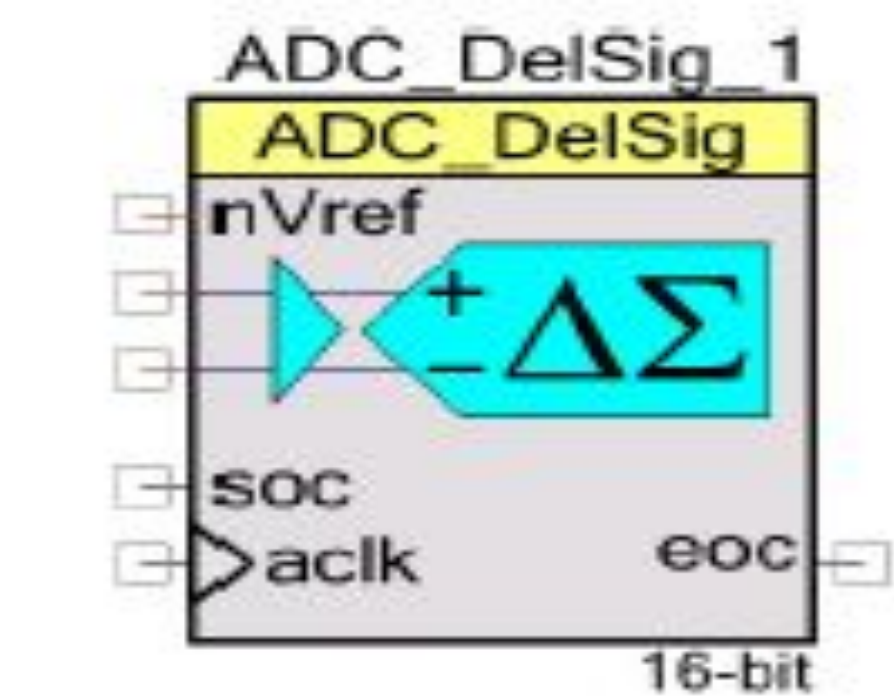


Сигма-дельта АЦП як слідкуюча система

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.**

ADC+LCD

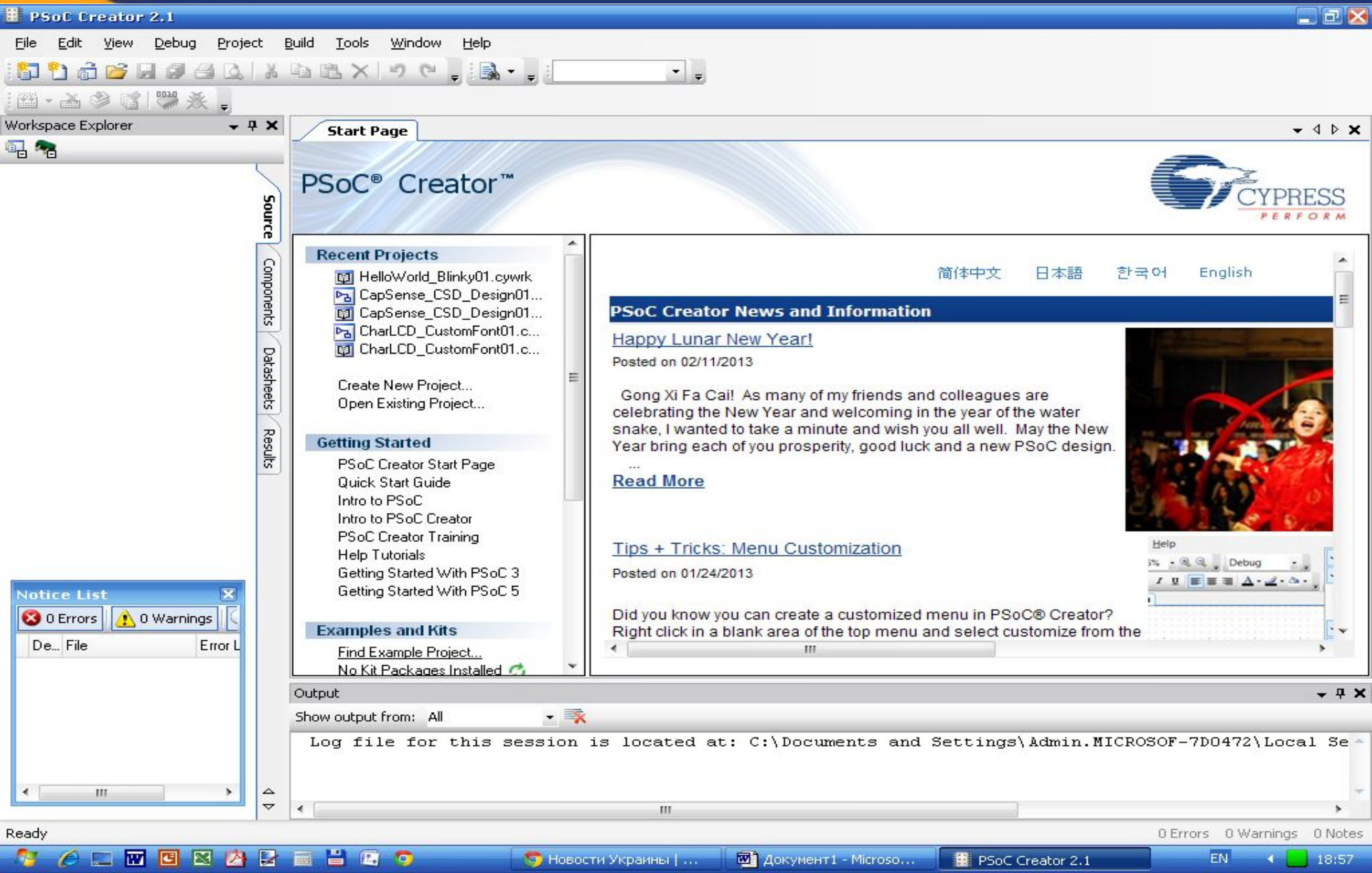
This example project shows how you can use **PSoC** to transfer data from one peripheral (**ADC**) to another (**LDC**),

ADC+LCD

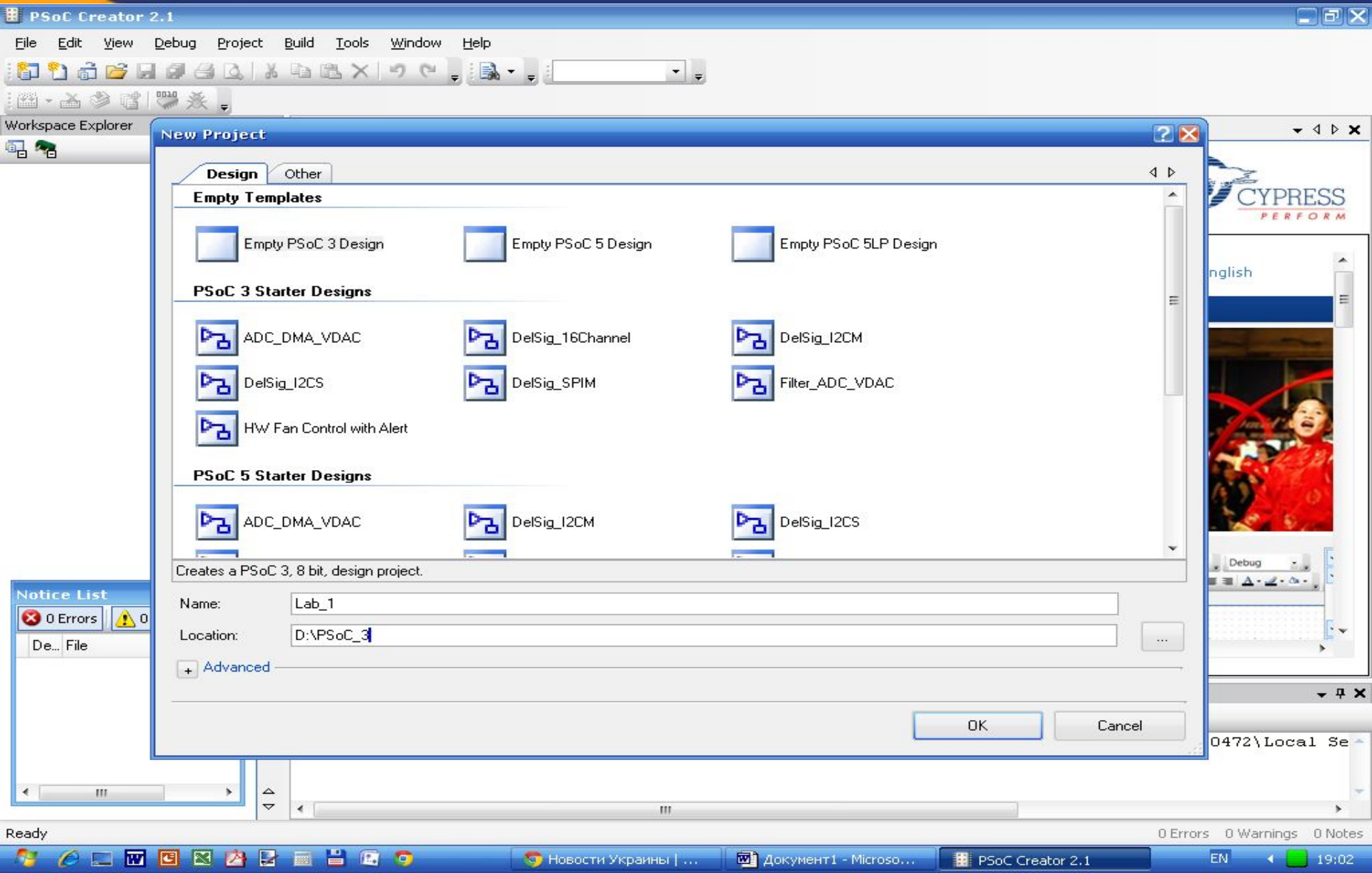
Features

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

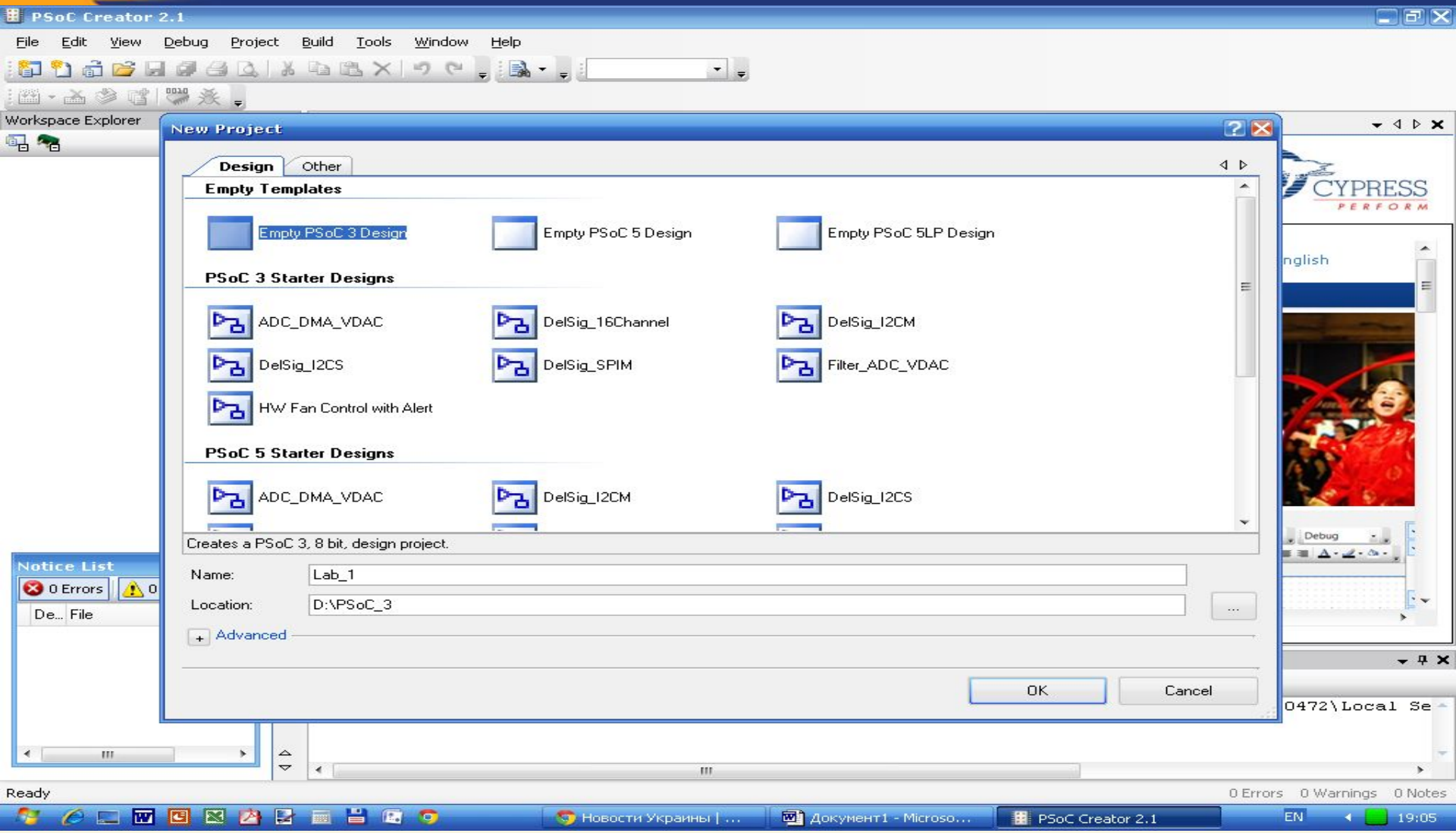
Creator


PSoC Creator 2.1
File Edit View Debug Project Build Tools Window Help
Workspace Explorer
Source
Components
Datasheets
Results
Start Page
PSoC® Creator™
CYPRESS PERFORM
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
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
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.MICROSOF-7D0472\Local Se
Ready
0 Errors 0 Warnings 0 Notes
Новости Украины | ...
Документ1 - Microso...
PSoC Creator 2.1
EN
18:57

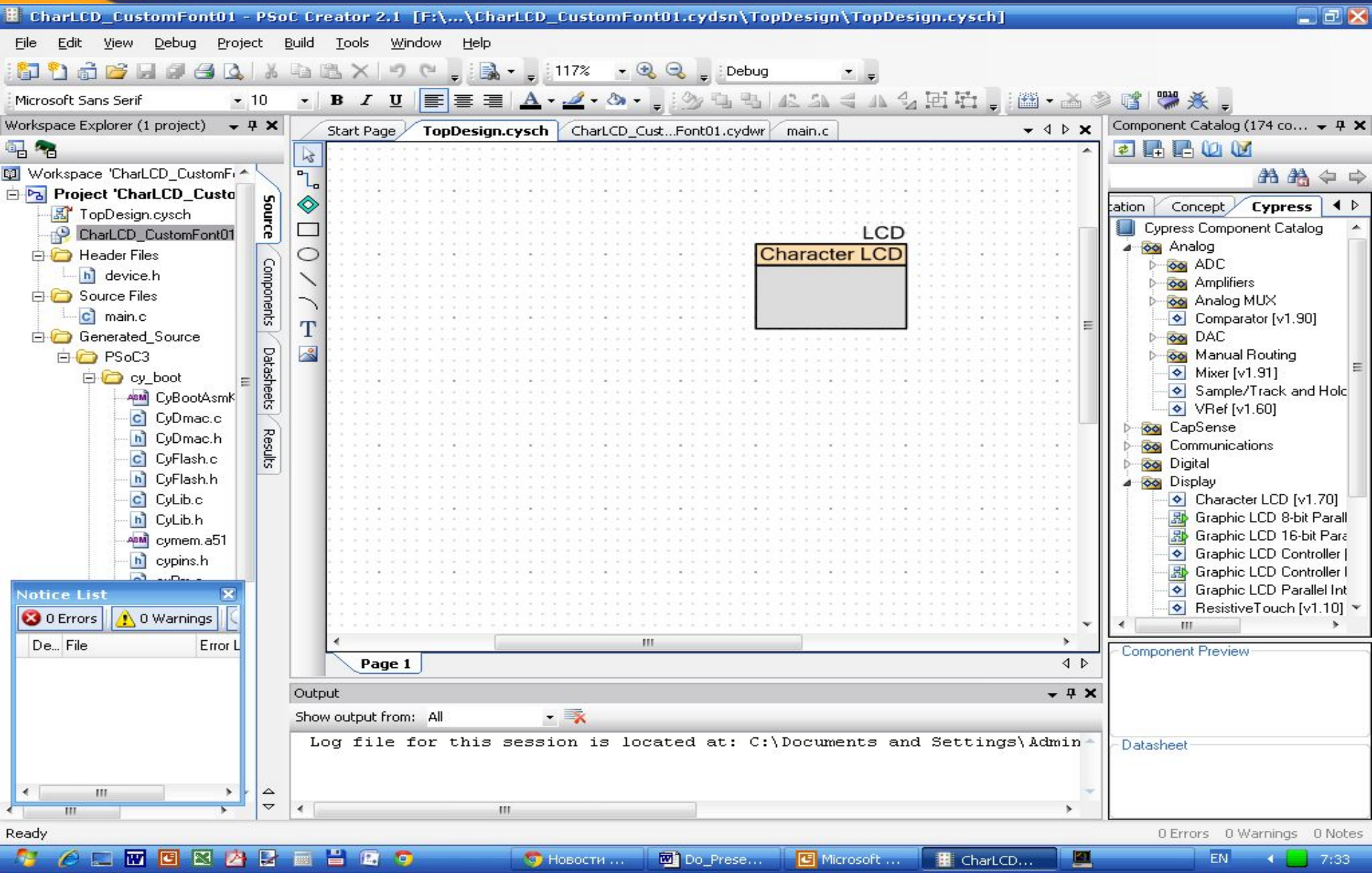
File – New - Projekt



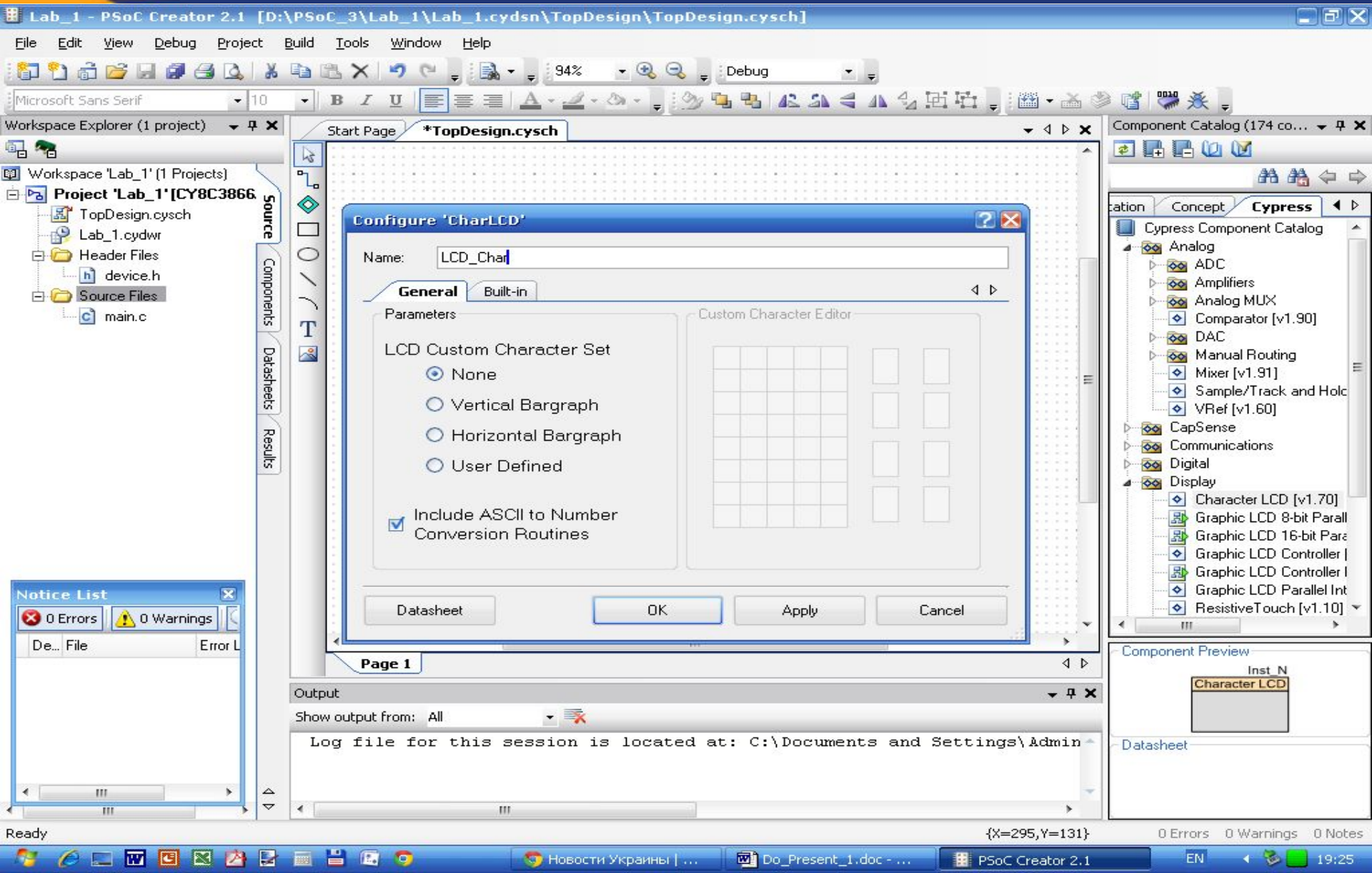
Empty PSoC 3/5 Design



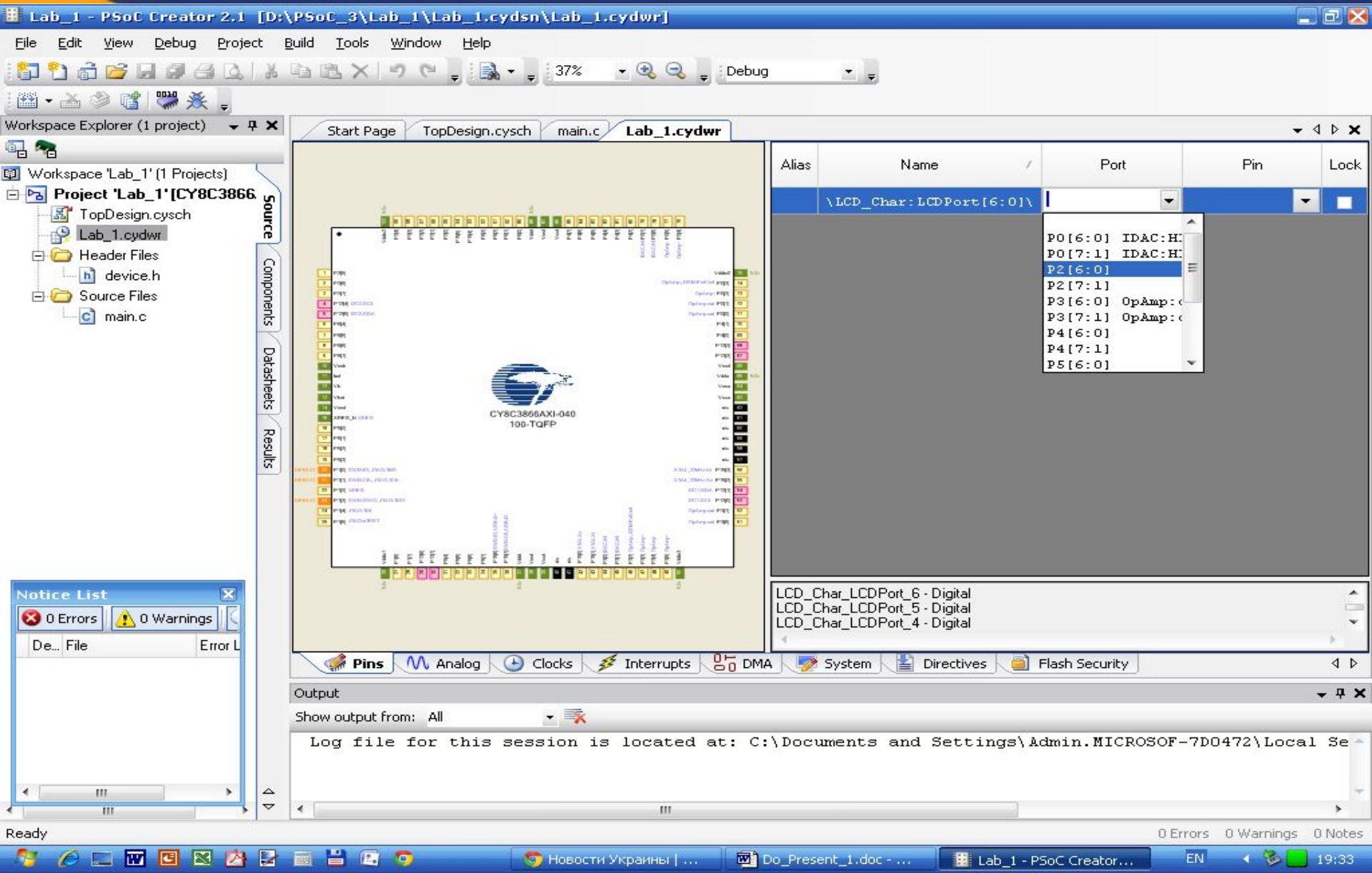
Lab_6 ADC+LCD


CharLCD_CustomFont01 - PSoC Creator 2.1 [F:\...\CharLCD_CustomFont01.cydsn\TopDesign\TopDesign.cysch]
File Edit View Debug Project Build Tools Window Help
Workspace Explorer (1 project)
Workspace 'CharLCD_CustomF
Project 'CharLCD_Custo
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
Source
Components
Datasheets
Results
Notice List
0 Errors
0 Warnings
De...
File
Error L
Start Page
TopDesign.cysch
CharLCD_Cust...Font01.cydwr
main.c
LCD
Character LCD
Page 1
Output
Show output from: All
Log file for this session is located at: C:\Documents and Settings\Admin
Component Catalog (174 co...
Concept
Cypress
Cypress Component Catalog
Analog
ADC
Amplifiers
Analog MUX
Comparator [v1.90]
DAC
Manual Routing
Mixer [v1.91]
Sample/Track and Holc
VRef [v1.60]
CapSense
Communications
Digital
Display
Character LCD [v1.70]
Graphic LCD 8-bit Parall
Graphic LCD 16-bit Para
Graphic LCD Controller
Graphic LCD Controller
Graphic LCD Parallel Int
ResistiveTouch [v1.10]
Component Preview
Datasheet
Ready
0 Errors 0 Warnings 0 Notes
Новости ...
Do_Prese...
Microsoft ...
CharLCD...
EN
7:33

Configure LCD



Lab_6 ADC+LCD


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
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:H
P0[7:1] IDAC:H
P2[6:0]
P2[7:1]
P3[6:0] OpAmp:
P3[7:1] OpAmp:
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
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.MICROSOF-7D0472\Local Se
Ready
0 Errors 0 Warnings 0 Notes
Новости Украины | ...
Do_Present_1.doc - ...
Lab_1 - PSoC Creator...
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.

Lab_6 Assigning Pins

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.**

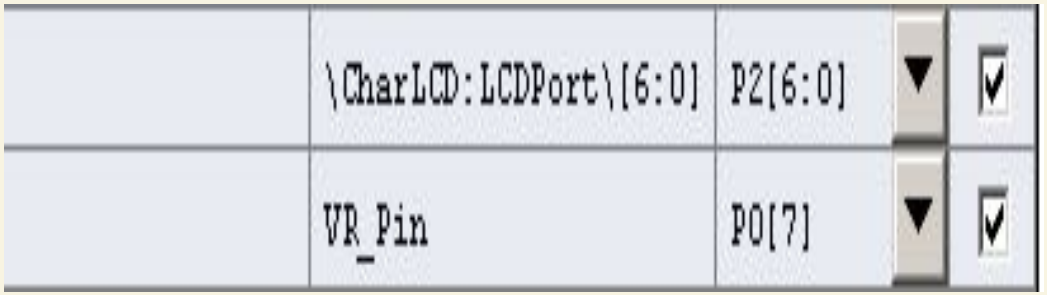
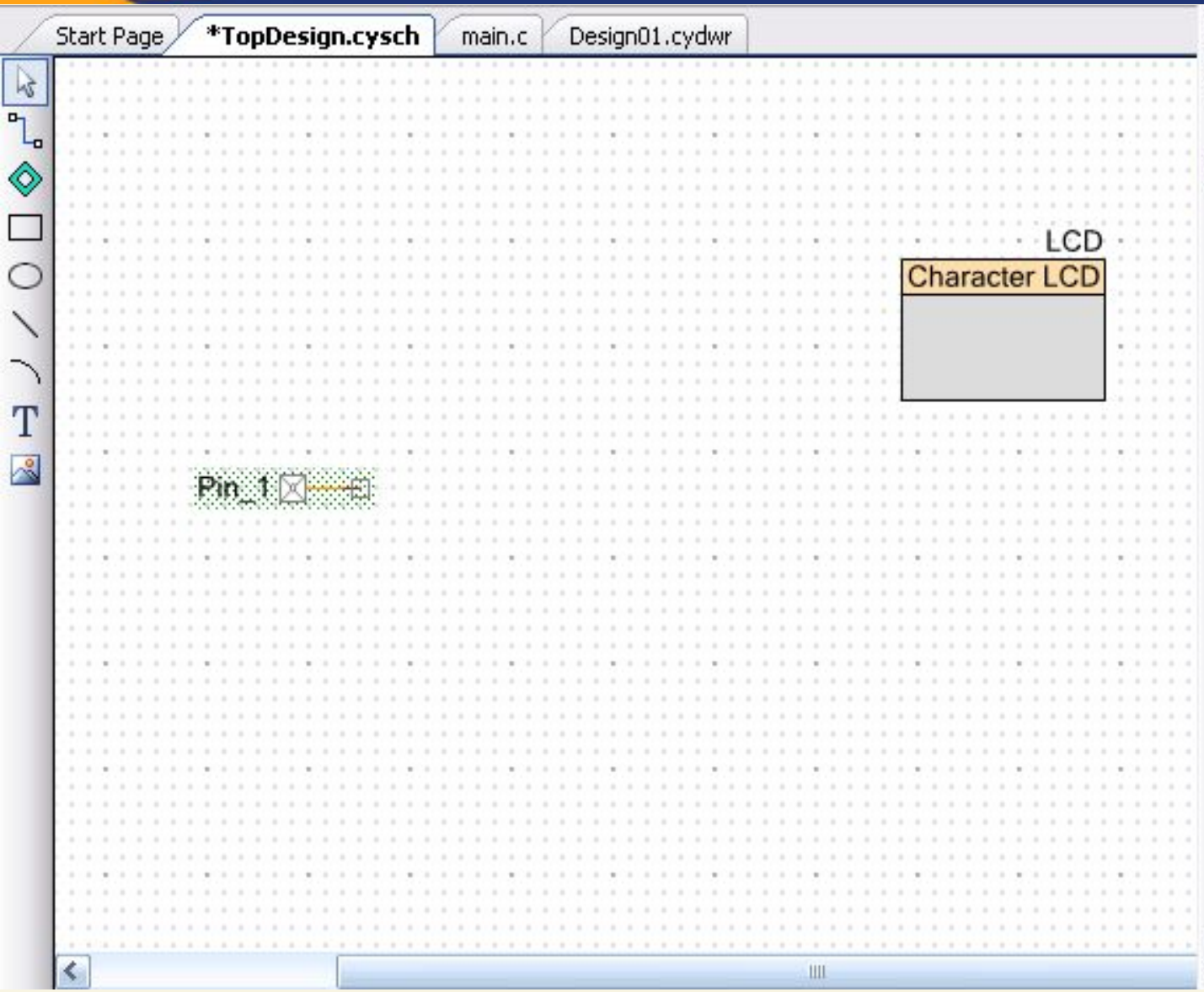
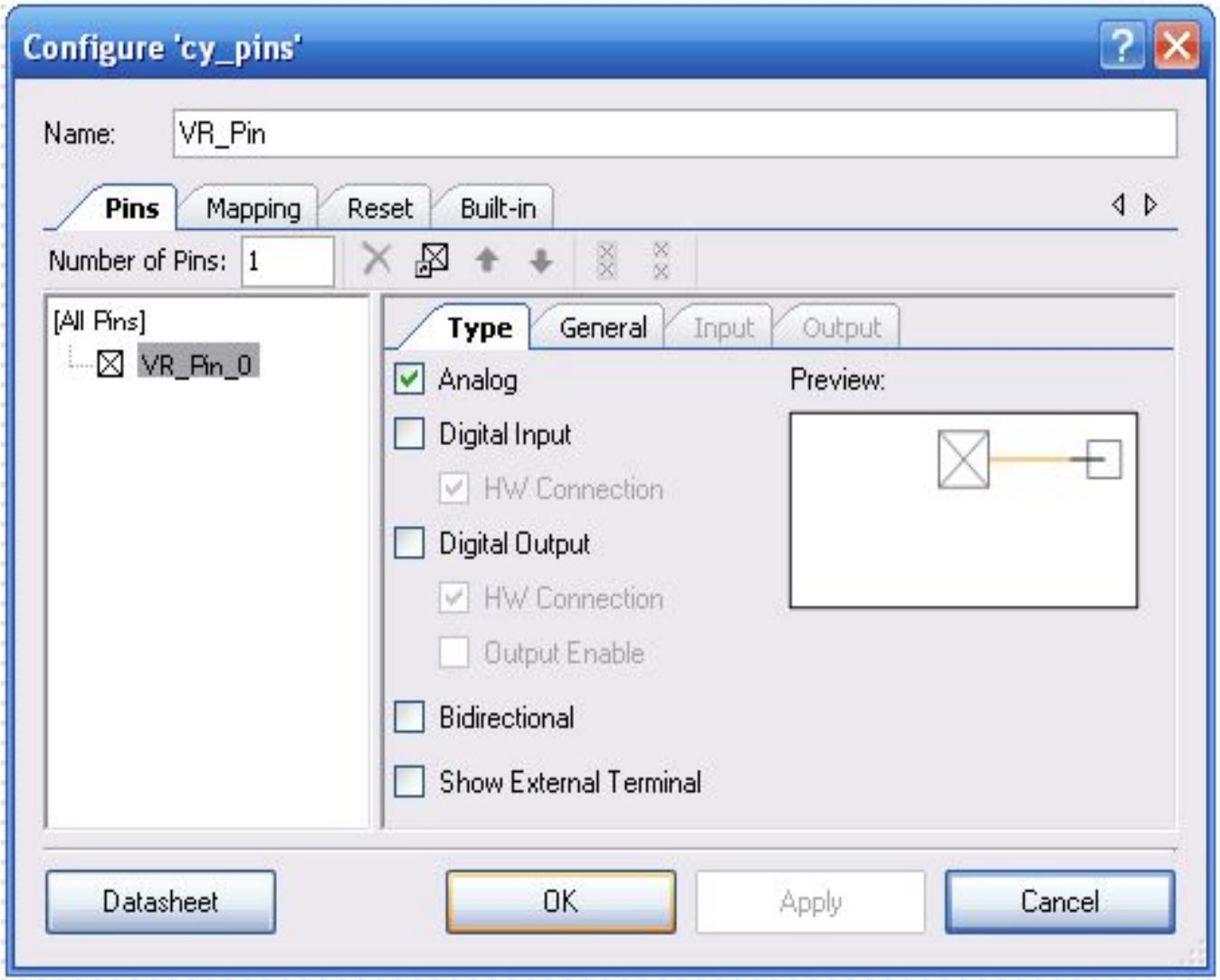


Рис.1

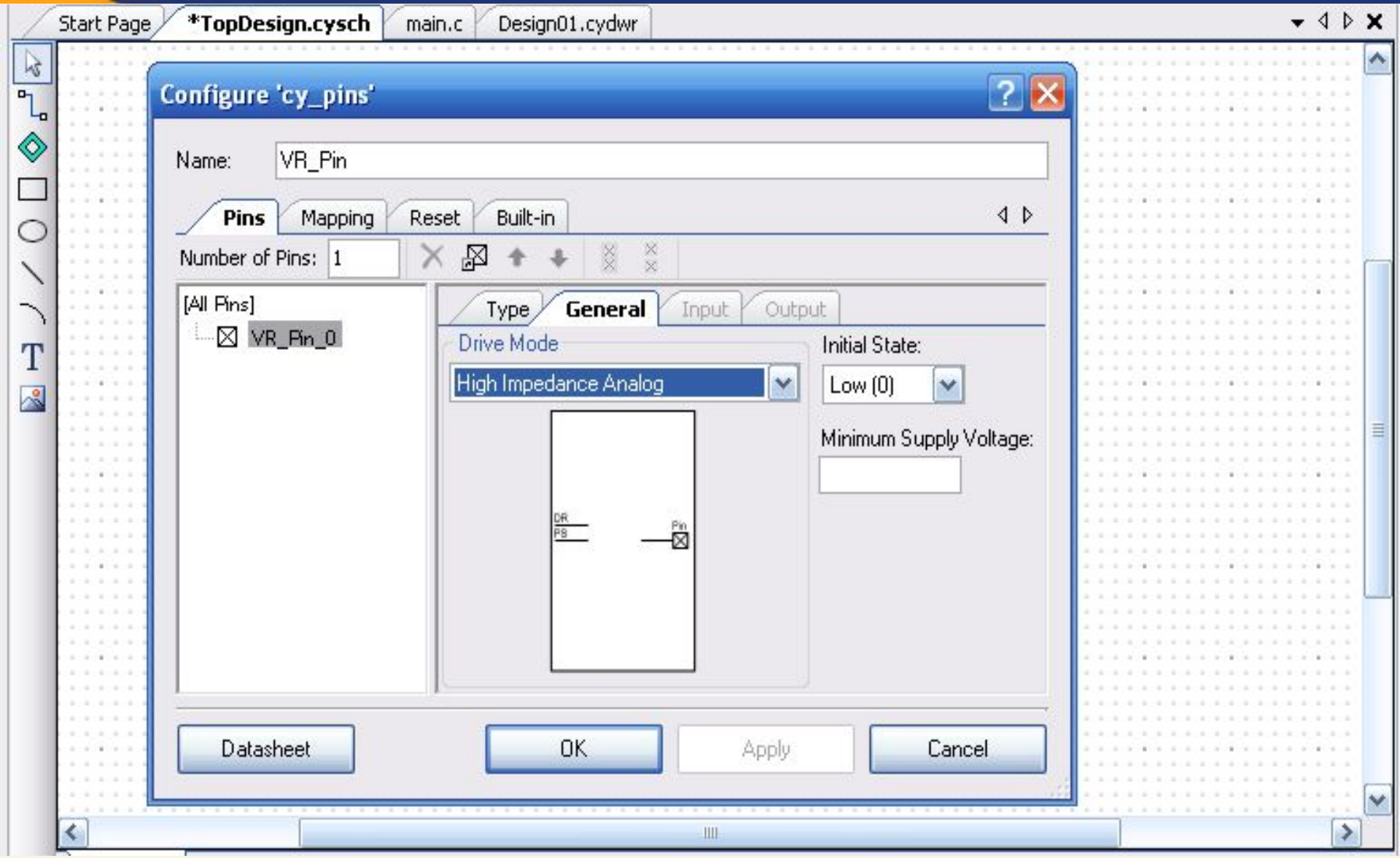
Lab_6 ADC+LCD


Start Page
*TopDesign.cysch
main.c
Design01.cydwr
LCD
Character LCD
Pin_1
Component Catalog (200 co...
Search for...
Cypress
Off-Chip
Cypress Component Catalog
Analog
CapSense
Communications
Digital
Display
Filters
Ports and Pins
Analog Pin [v2.5]
Digital Bidirectional Pin [v2.5
Digital Input Pin [v2.5]
Digital Output Pin [v2.5]
Power Supervision
System
Thermal Management

Lab_6 ADC+LCD


Configure 'cy_pins'
Name:
VR_Pin
Pins
Mapping
Reset
Built-in
Number of Pins:
1
[All Pins]
VR_Pin_0
Type
General
Input
Output
Analog
Digital Input
HW Connection
Digital Output
HW Connection
Output Enable
Bidirectional
Show External Terminal
Preview:
Datasheet
OK
Apply
Cancel

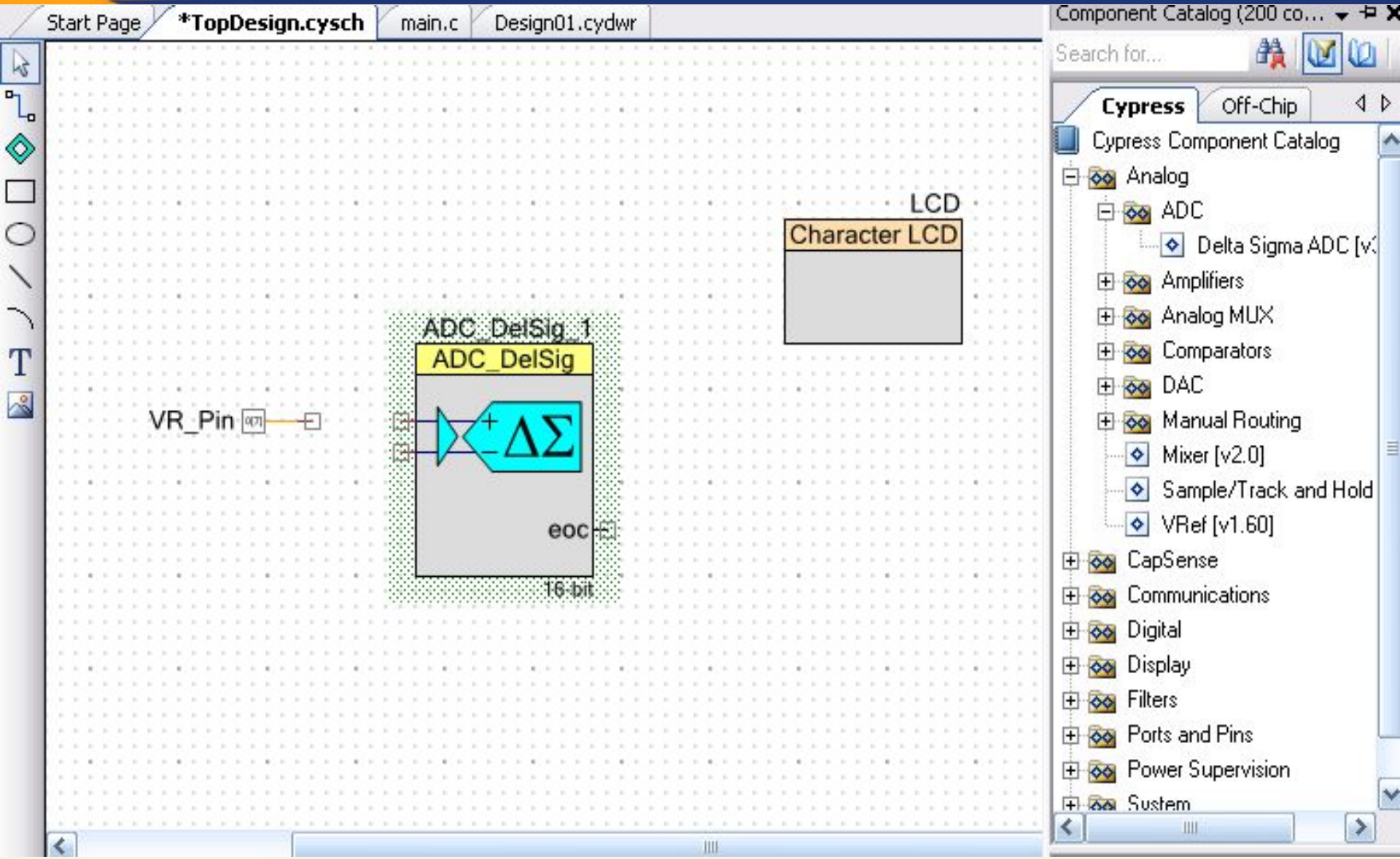
Lab_6 ADC+LCD


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:
DR
PS
Pin
Datasheet
OK
Apply
Cancel

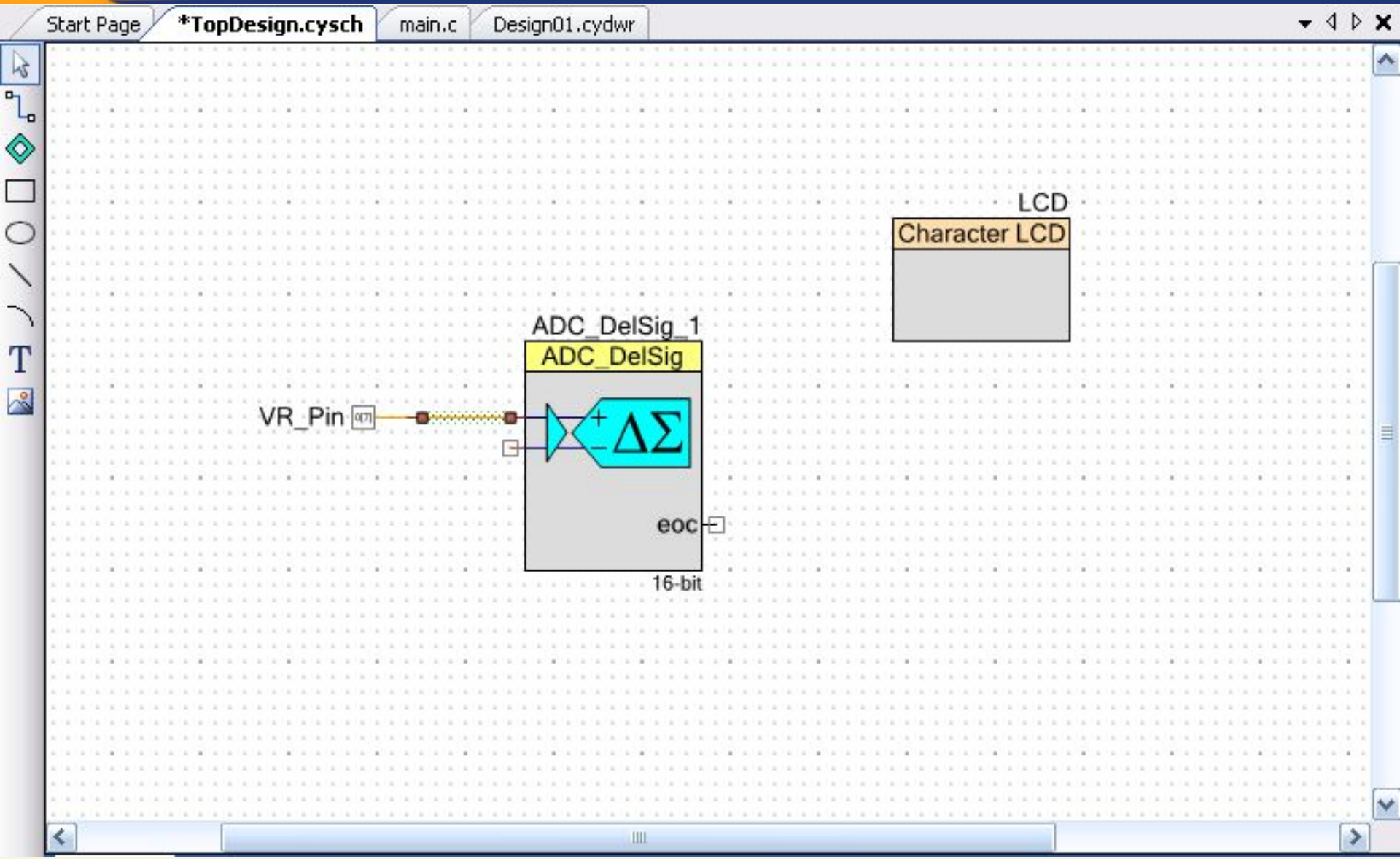
Lab_6 Adding Components

- 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

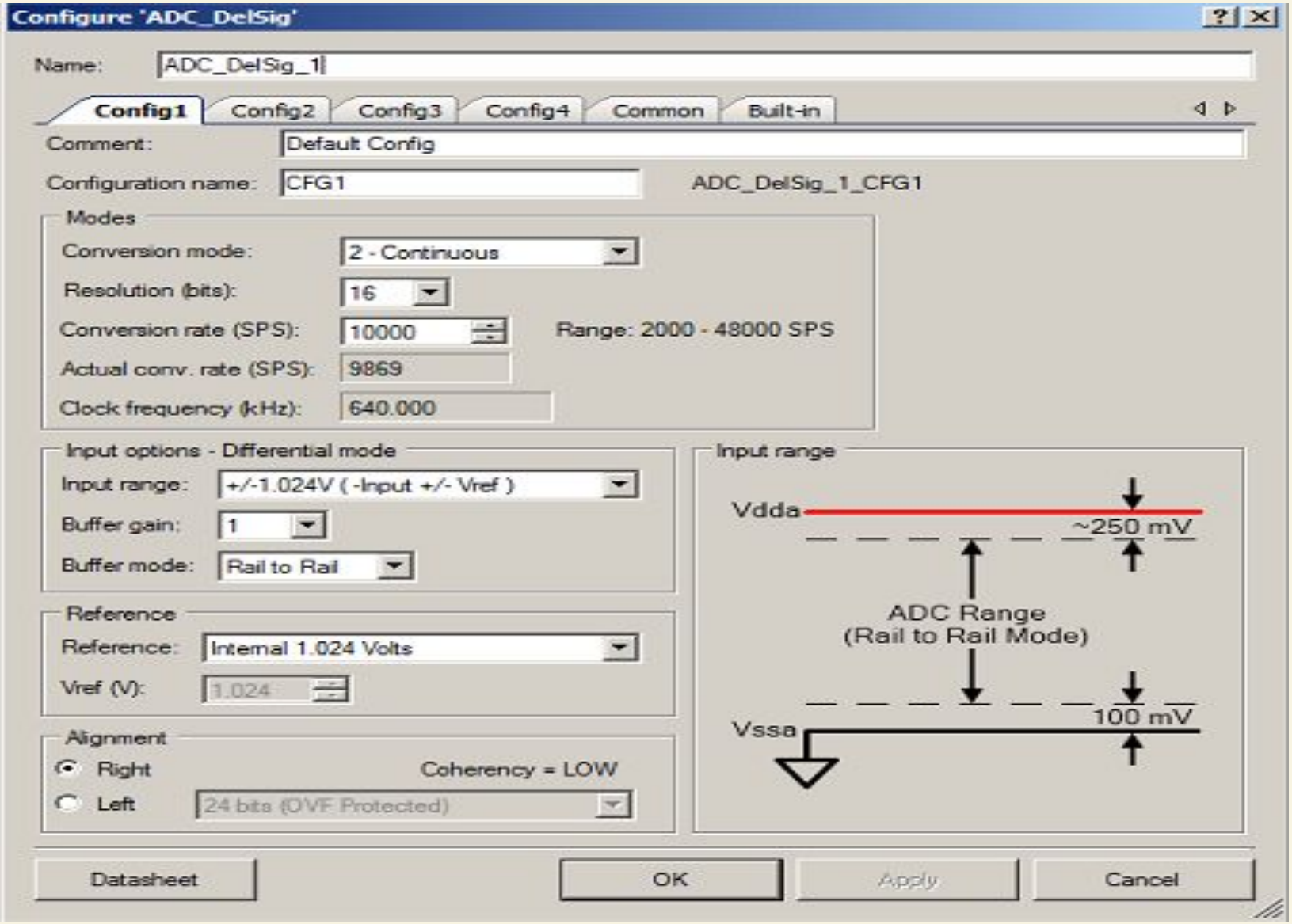
Lab_6 ADC+LCD


Start Page
*TopDesign.cysch
main.c
Design01.cydwr
LCD
Character LCD
ADC_DelSig_1
ADC_DelSig
VR_Pin
eoc
16-bit
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

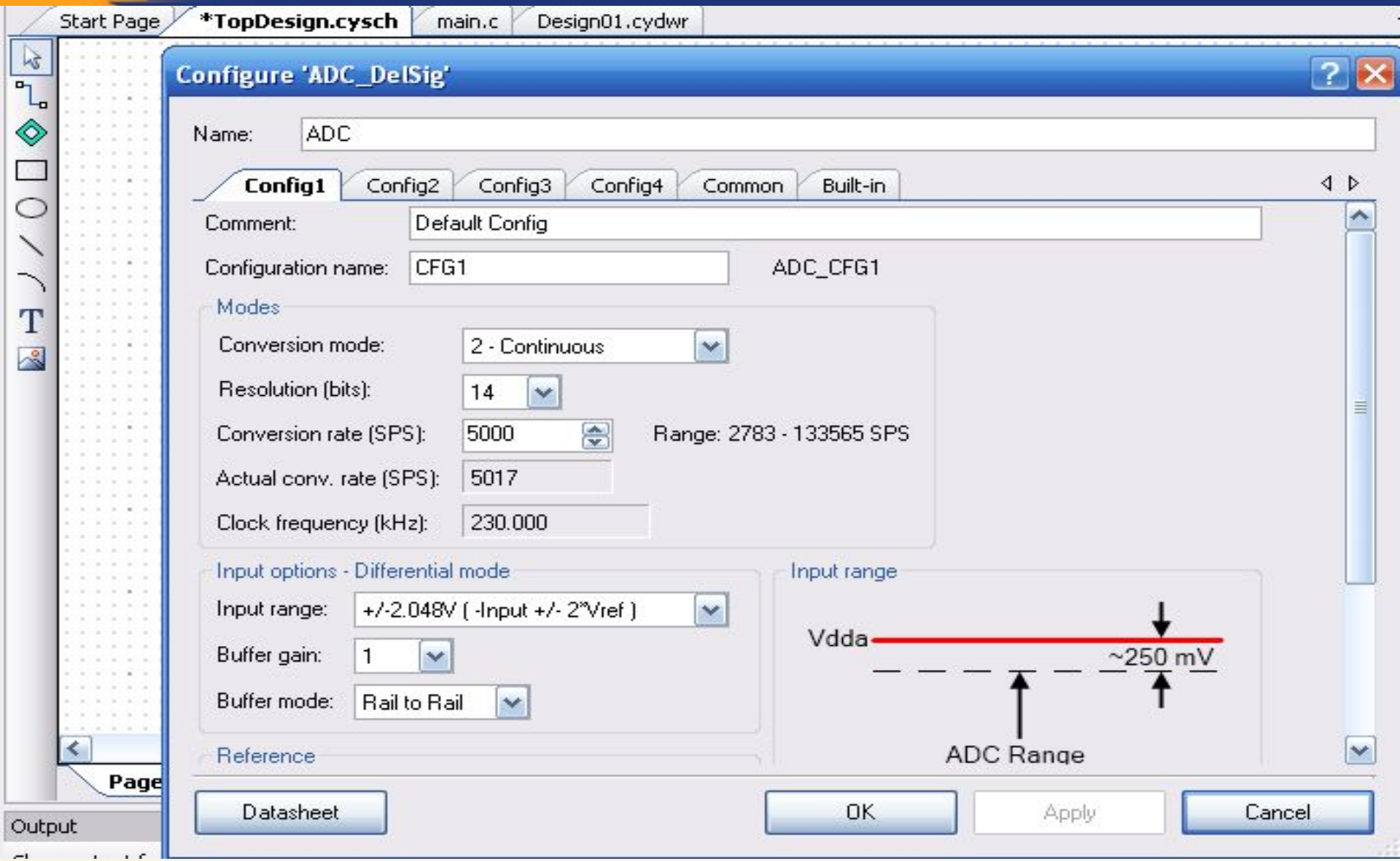
Lab_6 ADC+LCD


Start Page
*TopDesign.cysch
main.c
Design01.cydwr
LCD
Character LCD
ADC_DelSig_1
ADC_DelSig
VR_Pin
ΔΣ
eoc
16-bit

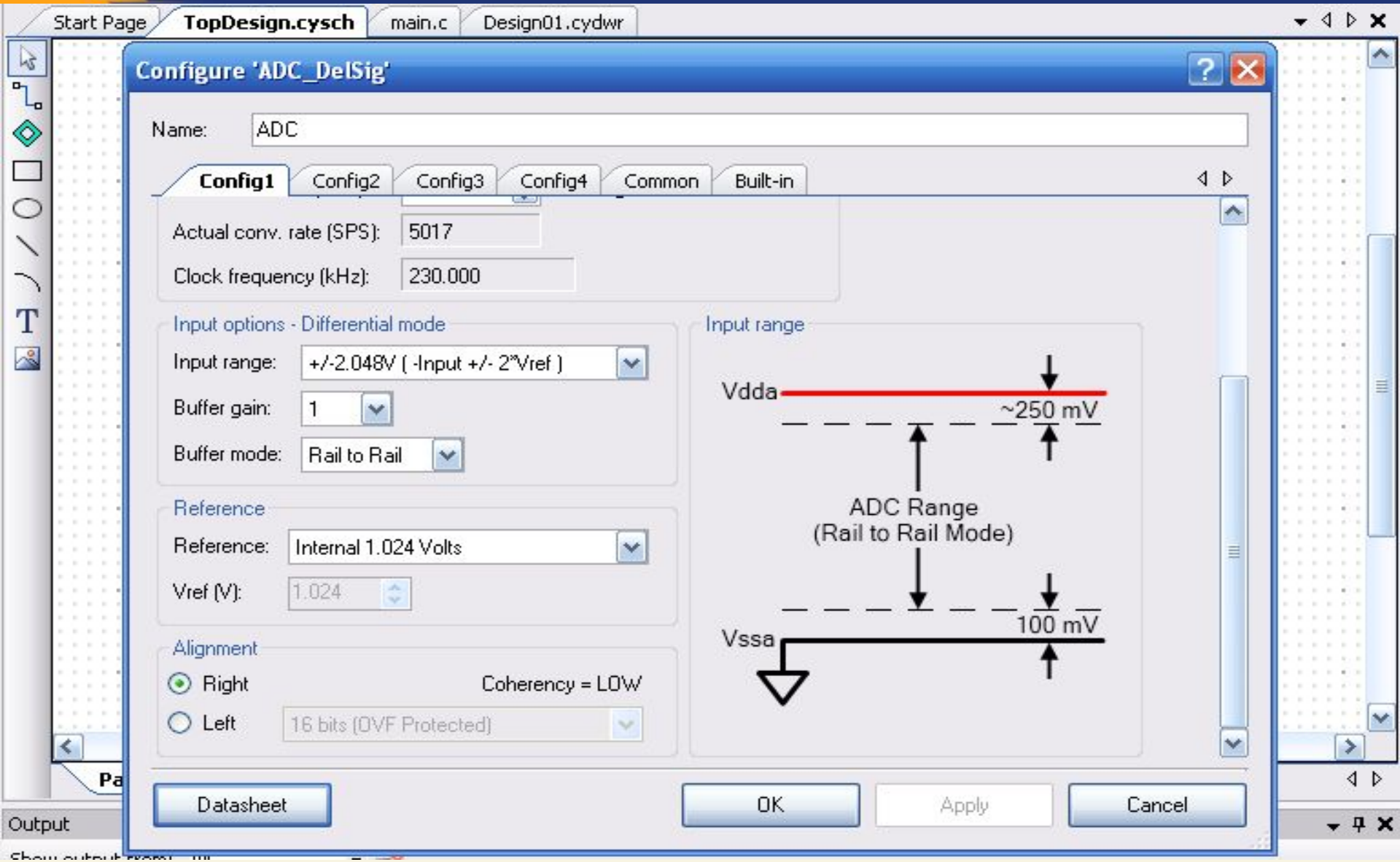
Lab_6 ADC+LCD


Configure 'ADC_DelSig'
Name: ADC_DelSig_1
Config1
Config2
Config3
Config4
Common
Built-in
Comment: Default Config
Configuration name: CFG1
ADC_DelSig_1_CFG1
Modes
Conversion mode: 2 - Continuous
Resolution (bits): 16
Conversion rate (SPS): 10000
Range: 2000 - 48000 SPS
Actual conv. rate (SPS): 9869
Clock frequency (kHz): 640.000
Input options - Differential mode
Input range: +/-1.024V (-Input +/- Vref)
Buffer gain: 1
Buffer mode: Rail to Rail
Reference
Reference: Internal 1.024 Volts
Vref (V): 1.024
Alignment
Right
Left
Coherency = LOW
24 bits (OVF Protected)
Input range
Vdda
~250 mV
ADC Range
(Rail to Rail Mode)
100 mV
Vssa
Datasheet
OK
Apply
Cancel

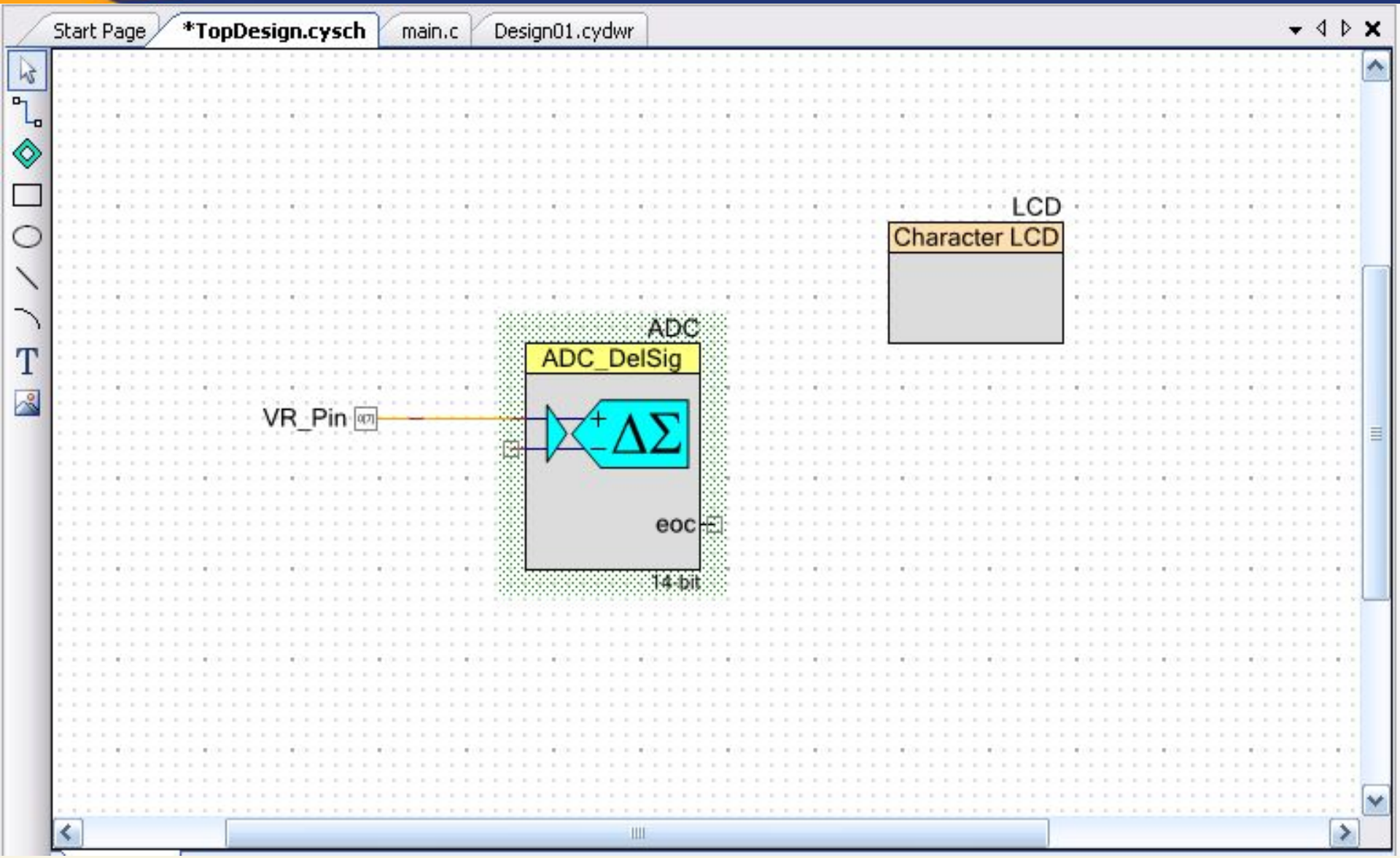
Lab_6 ADC+LCD


Start Page
*TopDesign.cysch
main.c
Design01.cydwr
Configure 'ADC_DelSig'
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
Reference
Input range
Vdda
~250 mV
ADC Range
Datasheet
OK
Apply
Cancel
Output

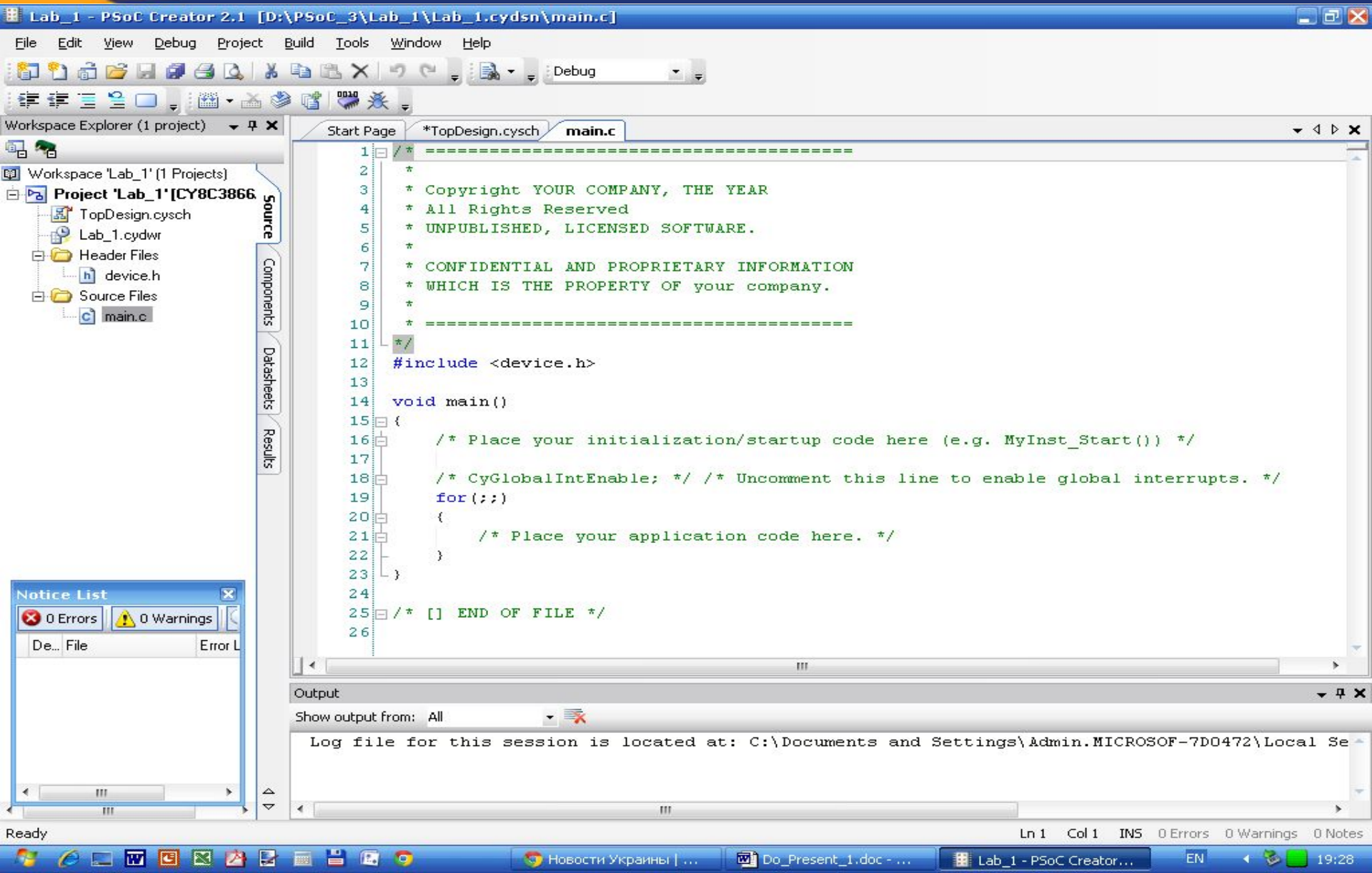
Lab_6 ADC+LCD


Start Page
TopDesign.cysch
main.c
Design01.cydwr
Configure 'ADC_DelSig'
Name:
ADC
Config1
Config2
Config3
Config4
Common
Built-in
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
Reference
Reference:
Internal 1.024 Volts
Vref (V):
1.024
Alignment
Right
Left
Coherency = LOW
16 bits (OVF Protected)
Input range
Vdda
~250 mV
ADC Range
(Rail to Rail Mode)
100 mV
Vssa
Datasheet
OK
Apply
Cancel
Output

Lab_6 ADC+LCD


Start Page
*TopDesign.cysch
main.c
Design01.cydwr
LCD
Character LCD
ADC
ADC_DelSig
VR_Pin
eoc
14 bit

Main.c


Lab_1 - PSoC Creator 2.1 [D:\PSoC_3\Lab_1\Lab_1.cydsn\main.c]
File Edit View Debug Project Build Tools Window Help
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
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.MICROSOF-7D0472\Local Se
Ready
Ln 1 Col 1 INS 0 Errors 0 Warnings 0 Notes
Новости Украины | ...
Do_Present_1.doc - ...
Lab_1 - PSoC Creator...
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19:28

Main.c

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();
```

myADC.c

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() */
```

myADC.c

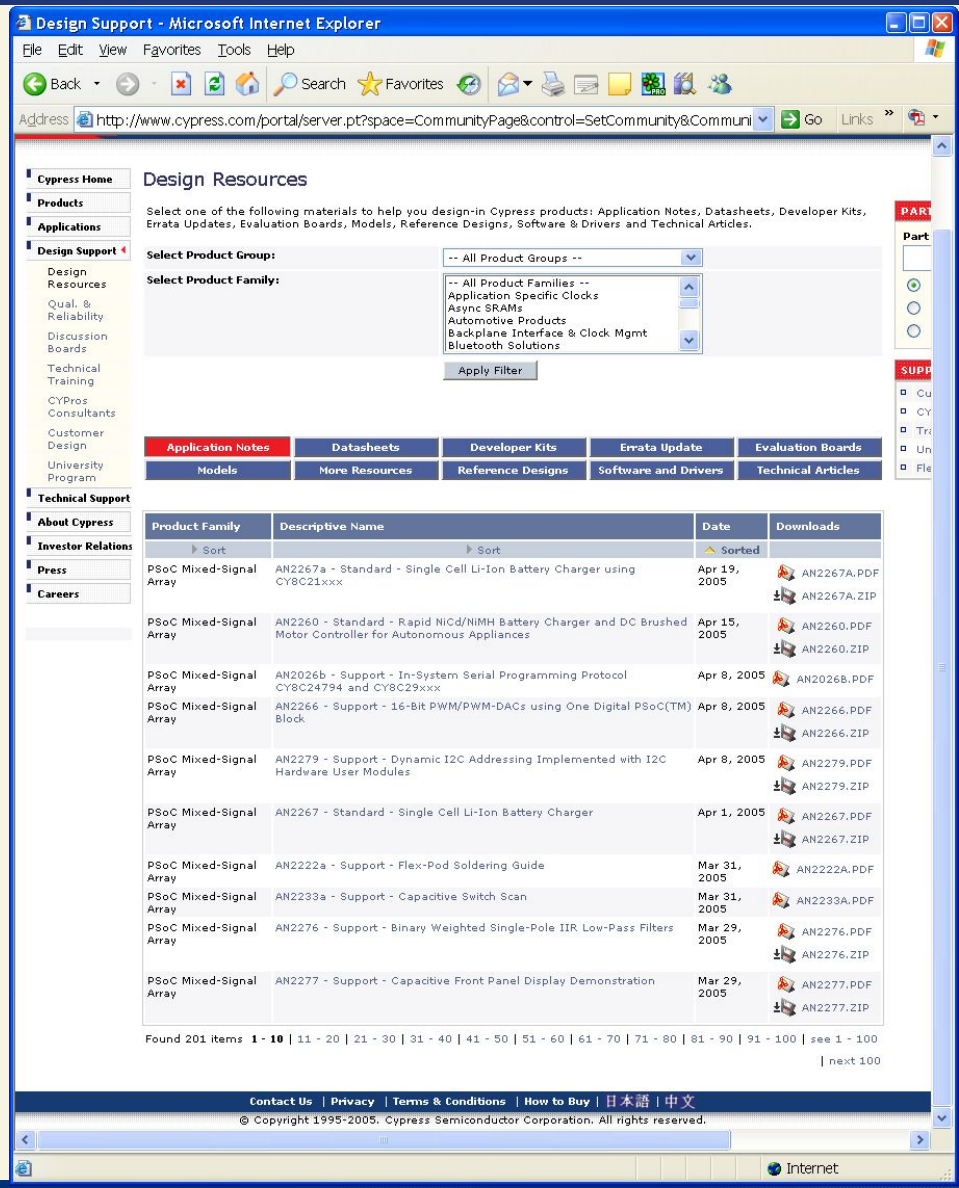
```
/*******************************************************************
* Function Name: UpdateAdc()
********************/
void UpdateAdc(void)
{
if(ADC_IsEndConversion(ADC_RETURN_STATUS))
{
uint8 adcval8;
/* Get 14-bit conversion reported in a signed 16-bit result, and limit
* negative and positive 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() */
```

Приклади застосування МК PSOC

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



Мікропроцесорна техніка

(лекція 6, кінець)

Благітко Б.Я.

2019 р.