電容電感傳感器 (LC Sensor)

NuMicro® 32 位系列微控制器範例代碼介紹

文件資訊

代碼簡述	使用 LC 電路對導電材料進行非接觸式感應，以進行旋轉量測
BSP 版本	Nano100B_Series_BSP_CMSIS_v3.02.002
開發平台	NuTiny-Nano100K

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1 功能介紹

1.1 簡介

電容電感傳感器(L-C Sensor)是透過電容電感並聯的LC電路對導電材料進行非接觸式感應以進行旋轉量測的一種裝置。

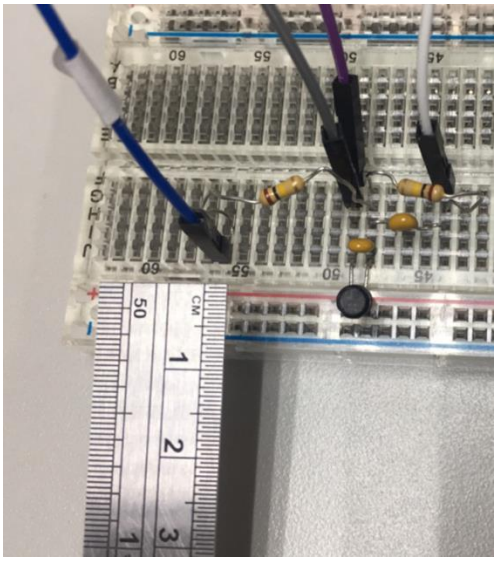
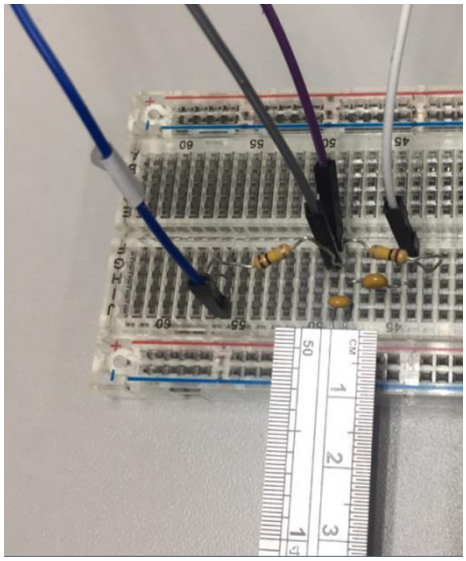
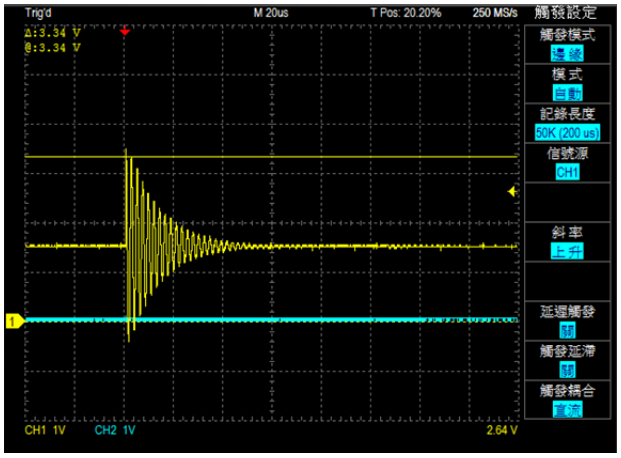
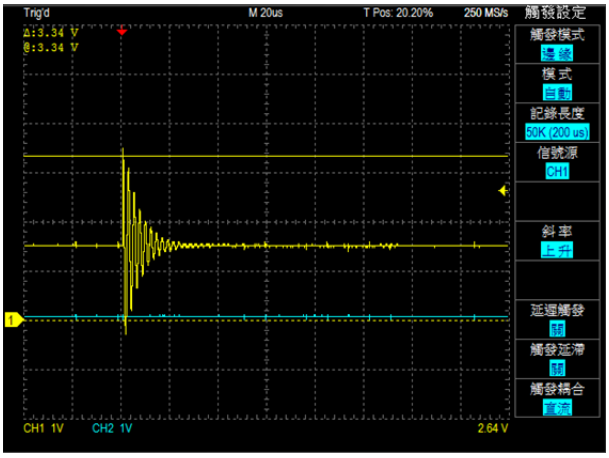
1.2 原理

電容與電感並聯的LC電路充電後，能夠產生固定頻率的諧振訊號，此訊號經過一段時間後會衰減至零，假如線圈電感的周圍有導電材料接近或存在，會導致諧振訊號的能量快速衰減。設定一個閥值(Threshold)，並觀察諧振訊號在閥值之上的時間，或是計算其震盪次數，即可判斷外部是否有導電材料接近或存在。本範例電路中，會將LC電路偏壓在一半的輸入電壓，由於類比數位轉換器(ADC)轉換出來的最大數值為4095 (0xFFF)，一半的輸入電壓會轉換出2047(0x7FF)的數值，因此建議使用者將閥值的範圍設定在0x850~0x8A0之間，使用者可自行調整至合適的範圍以符合自己的應用電路。

本文的LC振盪電路使用220 pF的電容以及470 uH的電感組合而成，其諧振頻率為494,948 Hz，但由於線路阻抗等周邊因素影響，通常頻率會稍微低一些。

$$F = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{220p * 470u}} = 494{,}948\ Hz$$

1.3 執行結果

無鐵磁性材質靠近	有鐵磁性材質靠近
	
	

2 代碼介紹

2.1 定義與全域變數

定義電壓的閥值，並宣告全域變數給ADC計算次數。

```
/*---------------------------------------------------------*/
/* Define                                                  */
/*---------------------------------------------------------*/
#define Threshold 0x850

/*---------------------------------------------------------*/
/* Global variables                                        */
/*---------------------------------------------------------*/
uint32_t g_u32ADCCount = 0;
```

2.2 ADC 中斷函數

ADC每轉換完成一次就會進入此函數，累加超過閥值的次數。

```
void ADC_IRQHandler(void)
{
    uint32_t u32Flag;
    // Get ADC comparator interrupt flag
    u32Flag = ADC_GET_INT_FLAG(ADC, ADC_CMP0_INT);
    // Add the count for calculate that how long the signal is bigger than threshold
    if(u32Flag & ADC_CMP0_INT)
        g_u32ADCCount++;
    ADC_CLR_INT_FLAG(ADC, u32Flag);
}
```

2.3 Main 函數

設定PC6為輸出模式以產生電阻所需的偏壓。設定PA0為開漏模式，以保持I/O處於浮接狀態。ADC將會轉換PA0的電壓，以計算超過閥值的次數，判斷外部是否有金屬物質接近。

```
int32_t main (void)
{
    …
    GPIO_SetMode(PC,BIT6,GPIO_PMD_OUTPUT);
    PC6 = 1;//Output high level to generate bias voltage at resistor
    GPIO_SetMode(PA,BIT0,GPIO_PMD_OPEN_DRAIN);
    PA0 = 1;//Initial IO as floating state when PA0 is open drain mode

    // Enable channel 0
    ADC_Open(ADC, ADC_INPUT_MODE_SINGLE_END, ADC_OPERATION_MODE_CONTINUOUS,
ADC_CH_0_MASK);
    // Set reference voltage to AVDD
    ADC_SET_REF_VOLTAGE(ADC, ADC_REFSEL_POWER);

    while(1)
    {
        //Open ADC
        ADC_POWER_ON(ADC);
        //Start ADC Convertion
        ADC_START_CONV(ADC);

        //Open ADC comparator and set the threshold
        ADC_ENABLE_CMP0(ADC, 0, ADC_CMP_GREATER_OR_EQUAL_TO, Threshold, 1);
        //Enable ADC interrupt
        ADC_EnableInt(ADC, ADC_CMP0_INT);
        NVIC_EnableIRQ(ADC_IRQn);

        PA0 = 0; //Set PA.0 as Output low
        __NOP(); //Delay for capacitor charge
        __NOP();
        PA0 = 1; //Set PA.0 as floating state

        CLK_SysTickDelay(100); // Delay for LC sensor detection

        ADC_STOP_CONV(ADC);

        //Print the counter that bigger than threshold
```

```
        printf("g_u32ADCCount=%d\n",g_u32ADCCount);
        g_u32ADCCount = 0;
    }
}
```

3 軟體與硬體環境

● 軟體環境

■ BSP 版本

- ◆ Nano100B_Series_BSP_CMSIS_v3.02.002

■ IDE 版本

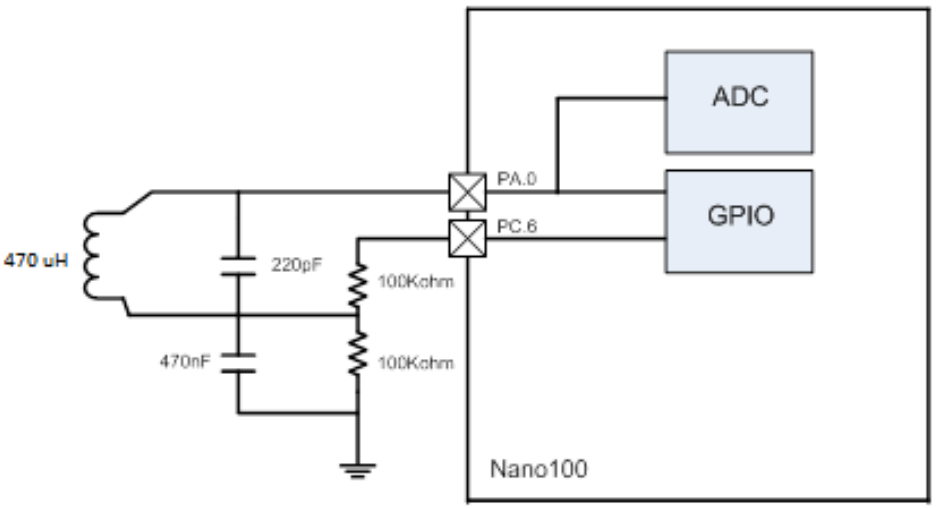
- ◆ Keil uVersion 5.26

● 硬體環境

■ 電路元件

- ◆ NuTiny-Nano100K
- ◆ Capacitor : 470 nF *1, 220 pF *1
- ◆ Inductance : 470 uH *1 (Inductance coil)
- ◆ Resistor : 100 kOhm *2

■ 示意圖



4 目錄資訊

- EC_Nano100_LC_Sensor_V1.00
  - Library — Sample code header and source files
    - CMSIS — Cortex® Microcontroller Software Interface Standard (CMSIS) by Arm® Corp.
    - Device — CMSIS compliant device header file
    - StdDriver — All peripheral driver header and source files
  - SampleCode
    - ExampleCode — Source file of example code

5 如何執行範例程式

1. 根據目錄資訊章節進入 ExampleCode 路徑中的 KEIL 資料夾，雙擊 LC_Sensor.uvproj。
2. 進入編譯模式介面
   a. 編譯
   b. 下載代碼至記憶體
   c. 進入 / 離開除錯模式
3. 進入除錯模式介面
   a. 執行代碼

6 修訂紀錄

Date	Revision	Description
Jun. 24, 2019	1.00	1. 初版

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