电容电感传感器 (LC Sensor)

NuMicro® 32 位系列微控制器范例代码介绍

文件信息

代码简述	使用 LC 电路对导电材料进行非接触式感应，以进行旋转量测
BSP 版本	Nano100B_Series_BSP_CMSIS_v3.02.002
开发平台	NuTiny-Nano100K

The information described in this document is the exclusive intellectual property of Nuvoton Technology Corporation and shall not be reproduced without permission from Nuvoton.

Nuvoton is providing this document only for reference purposes of NuMicro microcontroller based system design. Nuvoton assumes no responsibility for errors or omissions.

All data and specifications are subject to change without notice.

For additional information or questions, please contact: Nuvoton Technology Corporation.

www.nuvoton.com

1 功能介绍

1.1 简介

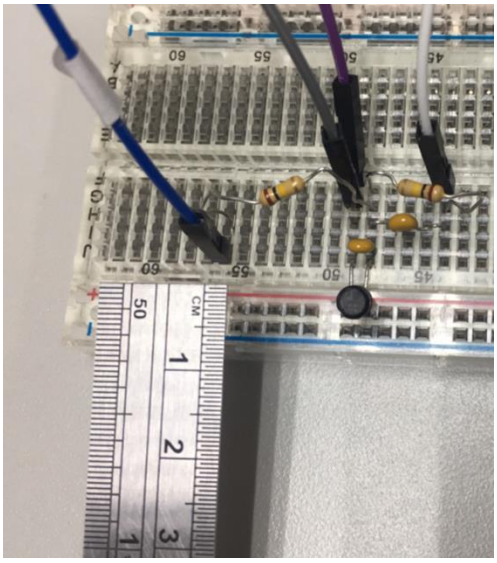
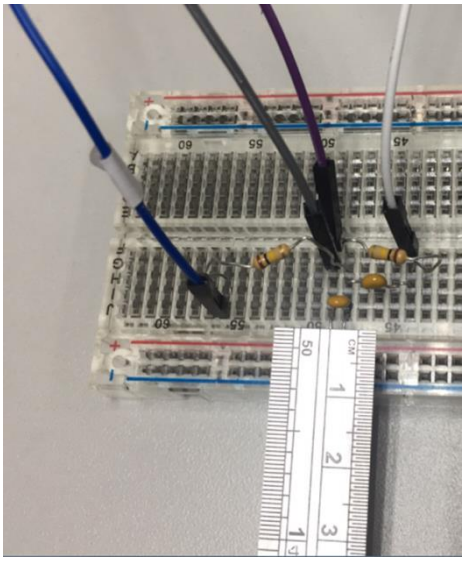
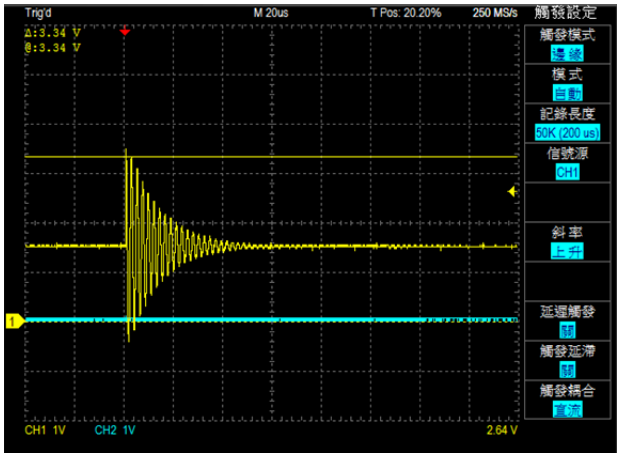
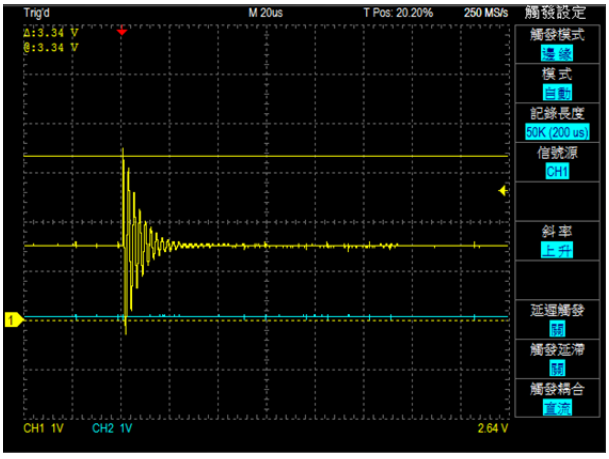
电容电感传感器(L-C Sensor)是透过电容电感并联的LC电路对导电材料进行非接触式感应以进行旋转量测的一种装置。

1.2 原理

电容与电感并联的LC电路充电后，能够产生固定频率的谐振讯号，此讯号经过一段时间后会衰减至零，假如线圈电感的周围有导电材料接近或存在，会导致谐振讯号的能量快速衰减。设定一个阀值(Threshold)，并观察谐振讯号在阀值之上的时间，或是计算其震荡次数，即可判断外部是否有导电材料接近或存在。本范例电路中，会将LC电路偏压在一半的输入电压，由于模拟数字转换器(ADC)转换出来的最大数值为4095 (0xFFF)，一半的输入电压会转换出2047(0x7FF)的数值，因此建议使用者将阀值的范围设定在0x850~0x8A0之间，使用者可自行调整至合适的范围以符合自己的应用电路。
本文的LC振荡电路使用220 pF的电容以及470 uH的电感组合而成，其谐振频率为494,948 Hz，但由于线路阻抗等周边因素影响，通常频率会稍微低一些。

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

1.3 执行结果

无铁磁性材质靠近	有铁磁性材质靠近
	
	

2 代码介绍

2.1 定义与全局变量

定义电压的阀值，并宣告全局变量给ADC计算次数。

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

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

2.2 ADC 中断函数

ADC每转换完成一次，就会进入此函数，并累加超过阀值的次数。

```
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 函数

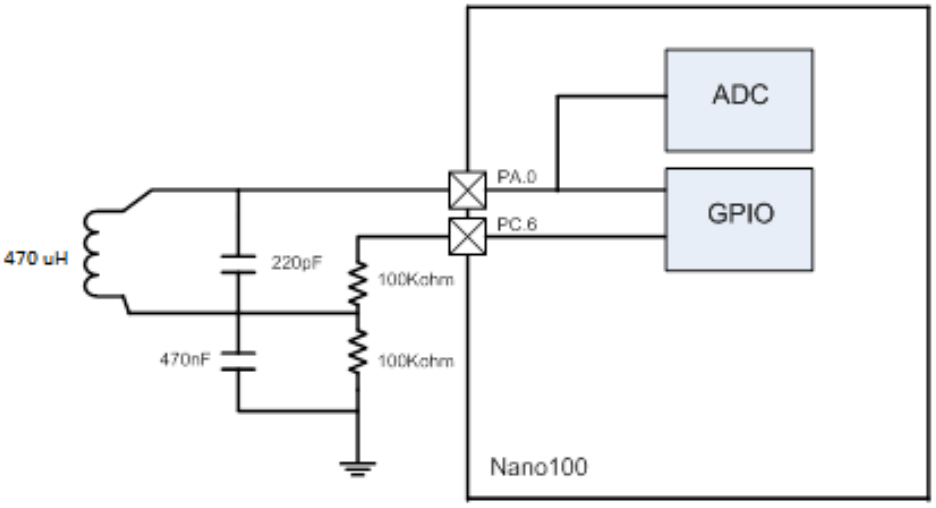
设定PC6为输出模式以产生电阻所需的偏压。设定PA0为开漏模式，以保持I/O处于浮接状态。ADC将会转换PA0的电压，以计算超过阀值的次数，判断外部是否有金属物质接近。

```
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 软件与硬件环境

- 软件环境
  - BSP 版本
    - Nano100B_Series_BSP_CMSIS_v3.02.002
  - IDE 版本
    - Keil uVersion 5.26
- 硬件环境
  - 电路组件
    - NuTiny-Nano100K
    - Capacitor : 470 nF *1, 220 pF *1
    - Inductance : 470 uH *1 (Inductance coil)
    - Resistor : 100 kOhm *2
  - 示意图



4 目录信息

- 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 如何执行范例程序

1. 根据目录信息章节进入 ExampleCode 路径中的 KEIL 文件夹，双击 LC_Sensor.uvproj。
2. 进入编译模式接口
   a. 编译
   b. 下载代码至内存
   c. 进入 / 离开除错模式
3. 进入除错模式接口
   a. 执行代码

6 修订纪录

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

Important Notice

Nuvoton Products are neither intended nor warranted for usage in systems or equipment, any malfunction or failure of which may cause loss of human life, bodily injury or severe property damage. Such applications are deemed, "Insecure Usage".

Insecure usage includes, but is not limited to: equipment for surgical implementation, atomic energy control instruments, airplane or spaceship instruments, the control or operation of dynamic, brake or safety systems designed for vehicular use, traffic signal instruments, all types of safety devices, and other applications intended to support or sustain life.

All Insecure Usage shall be made at customer's risk, and in the event that third parties lay claims to Nuvoton as a result of customer's Insecure Usage, customer shall indemnify the damages and liabilities thus incurred by Nuvoton.

Please note that all data and specifications are subject to change without notice.
All the trademarks of products and companies mentioned in this datasheet belong to their respective owners.