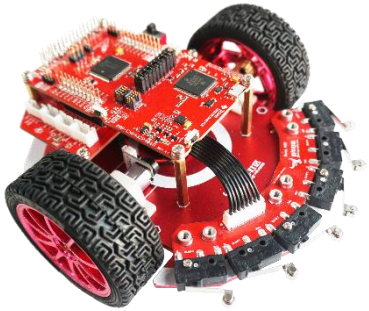

# ADC
# 采集数据

北京匠牛科技

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# 概要

采集电位器模块数值，显示输出结果：

1.介绍电位器模块的构成和作用；

2.介绍什么是ADC；

3.电位器模块与MSP432主控板连接引脚；

4.设置初始化MSP432 ADC功能的函数，
设置获取ADC数值采集函数；

5.演示效果；

# 电位器简介

电压范围0-3.3V


电位器模块

电位器: （英文：Potentiometer）
是可变电阻器的一种,通常是由电阻体和可移动的电刷组成。
当电刷沿电阻体移动时，在输出端即获得与位移量成一定关系的电压值。

电位器的作用：

1.用作分压器

电位器是一个连续可调的电阻器，当调节电位器的转柄或滑柄时，动触点在电阻体上滑动。此时在电位器的输出端可获得与电位器外加电压和可动臂转角或行程成一定关系的输出电压。

2.用作变阻器

电位器用作变阻器时，应把它接成两端器件，这样花电位器的行程范围内，便可获得一个平滑连续变化的电阻值。

3.用作电流控制器

当电位器作为电流控制器使用时，其中一个选定的电流输出端必须是滑动触点引出端。

# ADC 简介

**ADC名词简介：**

Analog-to-Digital Converter的缩写，指模/数转换器或者模数转换器。是指将连续变化的模拟信号转换为离散的数字信号的器件。真实世界的模拟信号，例如温度、压力、声音或者图像等，需要转换成更容易储存、处理和发射的数字形式。模/数转换器可以实现这个功能，在各种不同的产品中都可以找到它的身影。

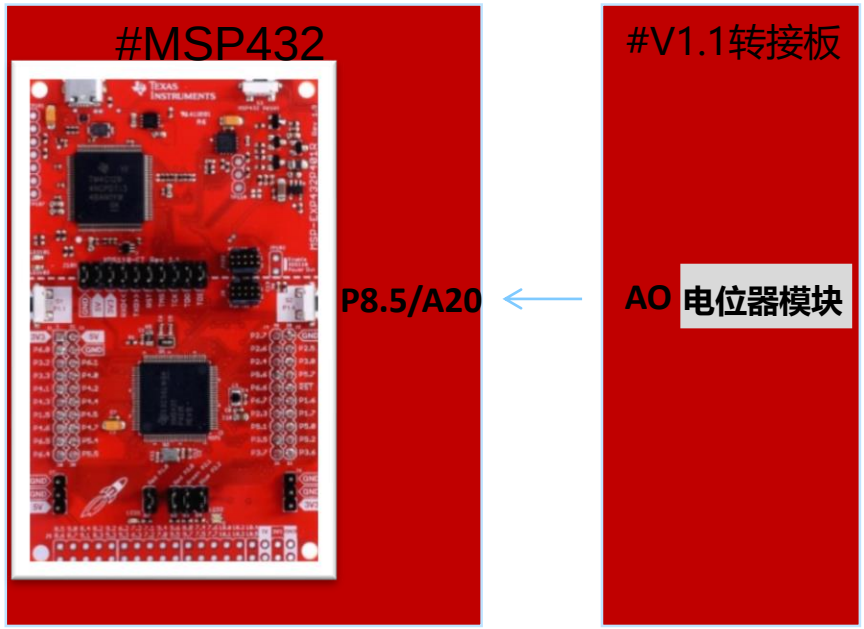
DAC
与之相对应，Digital-to-Analog Converter，它是ADC模数转换的逆向过程。

**MSP432 内部ADC简介：**


ADC是MSP432本机14位SAR（逐次逼近寄存器型）模数转换器，通过软件过采样支持最高16位精度。该模块实现了一个14位SAR内核，样本选择控制以及多达32个独立的转换和控制缓存器。 转换和控制缓存器允许多达32个独立的模数转换器（ADC）样本被转换和存储，而无需任何CPU干预。

# 引脚框图

引脚连接：




引脚功能：

| PIN NAME (P8.x) | x | FUNCTION | CONTROL BITS OR SIGNALS(1) | | |
|---|---|---|---|---|---|
| | | | P8DIR.x | P8SEL1.x | P8SEL0.x |
| P8.5/A20(2) | 5 | P8.5 (I/O) | I: 0; O: 1 | 0 | 0 |
| | | N/A | 0 | 0 | 1 |
| | | DVSS | 1 | | |
| | | N/A | 0 | 1 | 0 |
| | | DVSS | 1 | | |
| | | A20(3) | X | 1 | 1 |



备注：位于msp432p401r手册第6.12.12章节

# 设置初始化ADC函数（上）

```
// channel 20, P8.5
// single conversion, 3.3V reference
void ADC0_InitSWTriggerCh20(void){
  ADC14->CTL0 &= ~0x00000002;         // 2) ADC14ENC = 0 to allow programming
  while(ADC14->CTL0&0x00010000){};    // 3) wait for BUSY to be zero
  ADC14->CTL0 = 0x04203310;           // 4) single, SMCLK, on, disabled, /1, 32 SHM
  // 31-30 ADC14PDIV  predivider,               00b = Predivide by 1
  // 29-27 ADC14SHSx  SHM source               000b = ADC14SC bit
  // 26    ADC14SHP   SHM pulse-mode             1b = SAMPCON the sampling timer
  // 25    ADC14ISSH  invert sample-and-hold     0b =  not inverted
  // 24-22 ADC14DIVx  clock divider            000b = /1
  // 21-19 ADC14SSELx clock source select      100b = SMCLK
  // 18-17 ADC14CONSEQx mode select             00b = Single-channel, single-conversion
  // 16    ADC14BUSY  ADC14 busy                0b (read only)
  // 15-12 ADC14SHT1x sample-and-hold time 0011b = 32 clocks
  // 11-8  ADC14SHT0x sample-and-hold time 0011b = 32 clocks
  // 7     ADC14MSC   multiple sample           0b = not multiple
  // 6-5   reserved                            00b (reserved)
  // 4     ADC14ON    ADC14 on                 1b = powered up
  // 3-2   reserved                            00b (reserved)
  // 1     ADC14ENC   enable conversion         0b = ADC14 disabled
  // 0     ADC14SC    ADC14 start               0b = No start (yet)
```

# 设置初始化ADC函数（下）

```
ADC14->CTL1 = 0x00000030;           // 5) ADC14MEM0, 14-bit, ref on, regular power
 // 20-16 STARTADDx  start addr           00000b = ADC14MEM0
 // 15-6  reserved                  0000000000b (reserved)
 // 5-4   ADC14RES   ADC14 resolution       11b = 14 bit, 16 clocks
 // 3     ADC14DF    data read-back format   0b = Binary unsigned
 // 2     REFBURST   reference buffer burst  0b = reference on continuously
 // 1-0   ADC14PWRMD ADC power modes        00b = Regular power mode
 ADC14->MCTL[0] = 0x00000094;         // 6) 0 to 3.3V, channel 20=0x14
 // 15   ADC14WINCTH Window comp threshold   0b = not used
 // 14   ADC14WINC   Comparator enable       0b = Comparator disabled
 // 13   ADC14DIF    Differential mode       0b = Single-ended mode enabled
 // 12   reserved                            0b (reserved)
 // 11-8 ADC14VRSEL  V(R+) and V(R-)      0000b = V(R+) = AVCC, V(R-) = AVSS
 // 7    ADC14EOS    End of sequence         1b = End of sequence
 // 6-5  reserved                           00b (reserved)
 // 4-0  ADC14INCHx  Input channel       10100b = A20, P8.5

 ADC14->IER0 = 0; // 7) no interrupts
 ADC14->IER1 = 0; // no interrupts
 P8->SEL1 |= 0x20;                   // 8) analog mode on A20, P8.5
 P8->SEL0 |= 0x20;
 ADC14->CTL0 |= 0x00000002;          // 9) enable
}
```

# ADC14寄存器列表

**Table 22-4. ADC14 Registers**

| Offset | Acronym | Register Name | Type | Reset | Section |
|---|---|---|---|---|---|
| 000h | ADC14CTL0 | Control 0 Register | Read/write | 00000000h | Section 22.3.1 |
| 004h | ADC14CTL1 | Control 1 Register | Read/write | 00000030h | Section 22.3.2 |
| 008h | ADC14LO0 | Window Comparator Low Threshold 0 Register | Read/write | 00000000h | Section 22.3.3 |
| 00Ch | ADC14HI0 | Window Comparator High Threshold 0 Register | Read/write | 00003FFFh | Section 22.3.4 |
| 010h | ADC14LO1 | Window Comparator Low Threshold 1 Register | Read/write | 00000000h | Section 22.3.5 |
| 014h | ADC14HI1 | Window Comparator High Threshold 1 Register | Read/write | 00003FFFh | Section 22.3.6 |
| 018h to 094h | ADC14MCTL0 to ADC14MCTL31 | Memory Control 0 to Memory Control 31 Register | Read/write | 00000000h | Section 22.3.7 |
| 098h to 114h | ADC14MEM0 to ADC14MEM31 | Memory 0 to Memory 31 Register | Read/write | undefined | Section 22.3.8 |
| 13Ch | ADC14IER0 | Interrupt Enable 0 Register | Read/write | 00000000h | Section 22.3.9 |
| 140h | ADC14IER1 | Interrupt Enable 1 Register | Read/write | 00000000h | Section 22.3.10 |
| 144h | ADC14IFGR0 | Interrupt Flag 0 Register | Read | 00000000h | Section 22.3.11 |
| 148h | ADC14IFGR1 | Interrupt Flag 1 Register | Read | 00000000h | Section 22.3.12 |
| 14Ch | ADC14CLRIFGR0 | Clear Interrupt Flag 0 Register | Write | 00000000h | Section 22.3.13 |
| 150h | ADC14CLRIFGR1 | Clear Interrupt Flag 1 Register | Write | 00000000h | Section 22.3.14 |
| 154h | ADC14IV | Interrupt Vector Register | Read | 00000000h | Section 22.3.15 |

备注：位于MSP432P4xx Technical Reference Manual手册22.3章节

# MCTL寄存器4-0Bit描述

**Table 22-11. ADC14MCTL0 to ADC14MCTL31 Register Description (continued)**

| Bit | Field | Type | Reset | Description |
|---|---|---|---|---|
| 4-0 | ADC14INCHx | RW | 0h | Input channel select. If even channels are set as differential then odd channel configuration is ignored.<br>Can be modified only when ADC14ENC = 0.<br>00000b = If ADC14DIF = 0: A0; If ADC14DIF = 1: Ain+ = A0, Ain- = A1<br>00001b = If ADC14DIF = 0: A1; If ADC14DIF = 1: Ain+ = A0, Ain- = A1<br>00010b = If ADC14DIF = 0: A2; If ADC14DIF = 1: Ain+ = A2, Ain- = A3<br>00011b = If ADC14DIF = 0: A3; If ADC14DIF = 1: Ain+ = A2, Ain- = A3<br>00100b = If ADC14DIF = 0: A4; If ADC14DIF = 1: Ain+ = A4, Ain- = A5<br>00101b = If ADC14DIF = 0: A5; If ADC14DIF = 1: Ain+ = A4, Ain- = A5<br>00110b = If ADC14DIF = 0: A6; If ADC14DIF = 1: Ain+ = A6, Ain- = A7<br>00111b = If ADC14DIF = 0: A7; If ADC14DIF = 1: Ain+ = A6, Ain- = A7<br>01000b = If ADC14DIF = 0: A8; If ADC14DIF = 1: Ain+ = A8, Ain- = A9<br>01001b = If ADC14DIF = 0: A9; If ADC14DIF = 1: Ain+ = A8, Ain- = A9<br>01010b = If ADC14DIF = 0: A10; If ADC14DIF = 1: Ain+ = A10, Ain- = A11<br>01011b = If ADC14DIF = 0: A11; If ADC14DIF = 1: Ain+ = A10, Ain- = A11<br>01100b = If ADC14DIF = 0: A12; If ADC14DIF = 1: Ain+ = A12, Ain- = A13<br>01101b = If ADC14DIF = 0: A13; If ADC14DIF = 1: Ain+ = A12, Ain- = A13<br>01110b = If ADC14DIF = 0: A14; If ADC14DIF = 1: Ain+ = A14, Ain- = A15<br>01111b = If ADC14DIF = 0: A15; If ADC14DIF = 1: Ain+ = A14, Ain- = A15<br>10000b = If ADC14DIF = 0: A16; If ADC14DIF = 1: Ain+ = A16, Ain- = A17<br>10001b = If ADC14DIF = 0: A17; If ADC14DIF = 1: Ain+ = A16, Ain- = A17<br>10010b = If ADC14DIF = 0: A18; If ADC14DIF = 1: Ain+ = A18, Ain- = A19<br>10011b = If ADC14DIF = 0: A19; If ADC14DIF = 1: Ain+ = A18, Ain- = A19<br>10100b = If ADC14DIF = 0: A20; If ADC14DIF = 1: Ain+ = A20, Ain- = A21<br>10101b = If ADC14DIF = 0: A21; If ADC14DIF = 1: Ain+ = A20, Ain- = A21<br>10110b = If ADC14DIF = 0: A22; If ADC14DIF = 1: Ain+ = A22, Ain- = A23<br>10111b = If ADC14DIF = 0: A23; If ADC14DIF = 1: Ain+ = A22, Ain- = A23<br>11000b = If ADC14DIF = 0: A24; If ADC14DIF = 1: Ain+ = A24, Ain- = A25<br>11001b = If ADC14DIF = 0: A25; If ADC14DIF = 1: Ain+ = A24, Ain- = A25<br>11010b = If ADC14DIF = 0: A26; If ADC14DIF = 1: Ain+ = A26, Ain- = A27<br>11011b = If ADC14DIF = 0: A27; If ADC14DIF = 1: Ain+ = A26, Ain- = A27<br>11100b = If ADC14DIF = 0: A28; If ADC14DIF = 1: Ain+ = A28, Ain- = A29<br>11101b = If ADC14DIF = 0: A29; If ADC14DIF = 1: Ain+ = A28, Ain- = A29<br>11110b = If ADC14DIF = 0: A30; If ADC14DIF = 1: Ain+ = A30, Ain- = A31<br>11111b = If ADC14DIF = 0: A31; If ADC14DIF = 1: Ain+ = A30, Ain- = A31 |

# 获取通道A20的采样数据值

```
// ADC14IFGR0 bit 0 is set when P8.5 = A20 conversion done
//                  cleared on read ADC14MEM0
// ADC14CLRIFGR0 bit 0, write 1 to clear flag
// ADC14IVx is 0x0C when ADC14MEM0 interrupt flag; Interrupt Flag: ADC14IFG0
// ADC14MEM0 14-bit conversion in bits 13-0 (31-16 undefined, 15-14 zero)
uint32_t ADC_In20(void){
  while(ADC14->CTL0&0x00010000){};    // 1) wait for BUSY to be zero
  ADC14->CTL0 |= 0x00000001;          // 2) start single conversion
  while((ADC14->IFGR0&0x01) == 0){};  // 3) wait for ADC14IFG0
  return ADC14->MEM[0];      // 4) return result 0 to 16383
}
```

# 内容小结

1. 知道了ADC概念；
2. 学会了配置MSP432P401R 的ADC功能；

# 疑难解答

电位器模块不起作用：

1.安装电位器模块后，使用万用表测量电位器模块AO引脚的电压值，旋转电位器模块按钮，
电压值在0 – 3.3V之间变化；

# 课后练习&思考&本知识点延伸扩展

课后练习：
1.实现电位器模块的数据采集，并将该数据通过串口调试工具打印出来；

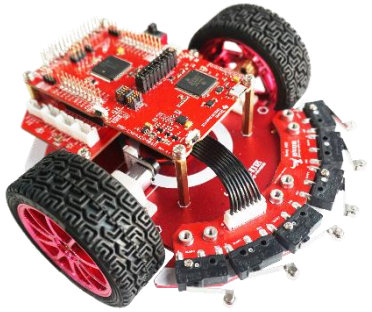
思考：
1.ADC输入电压和数字输出数之间的数学关系?
2.为什么本实验中需要中断?即，中断能使我们做什么?

本知识点延伸扩展:
1.添加上节课中的OLED屏，将数据输出到OLED屏，便于调试，校准和测试。
2.通过电位器的输入控制电机的速度。
3.添加三个红外测距传感器，使机器人走避障迷宫。

# 更多信息请关注

官方公众号

官方商城



# 谢谢

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