Micro-Controller Experiment

Week3

Teacher: 廖裕評 Yu-Ping Liao

TA: 陳大荃 Da-chuan Chen, 陳恩妮 En-ni Chen

Class Rules

1. No drink besides water.
2. Bring a laptop and breadboard if needed.
3. Ask us TAs to sign and borrow development boards. Do not sign or ask others to sign for you without TAs' permission.
4. Arriving 10 minutes after the bell rings will be regarded as absent.
5. If you damage any borrowed equipment, you have to pay for it.

Homework Rules

1. Includes: A. Class content, B. Class exercise, C. Homework (screenshot or video)
2. Editing software: MS PowerPoint
3. File format: PDF
4. Filename: "date_group_studentID_name.pdf", like "0916_第1組_11028XXX_陳OO.pdf"
5. The homework deadline is 23:59 of the day before the next class. If you are late, then your grade will be deducted.

Contact

If you encounter any problems with this class, please get in touch with us with the following

E-mails:

1. Teacher, Prof. Yu-Ping Liao 廖裕評： lyp@cycu.org.tw
2. TA, Da-chuan Chen 陳大荃： dachuan516@gmail.com
3. TA, En-ni Chen 陳恩妮： anna7125867@gmail.com

Or visit 篤信 Lab353 for further questions.

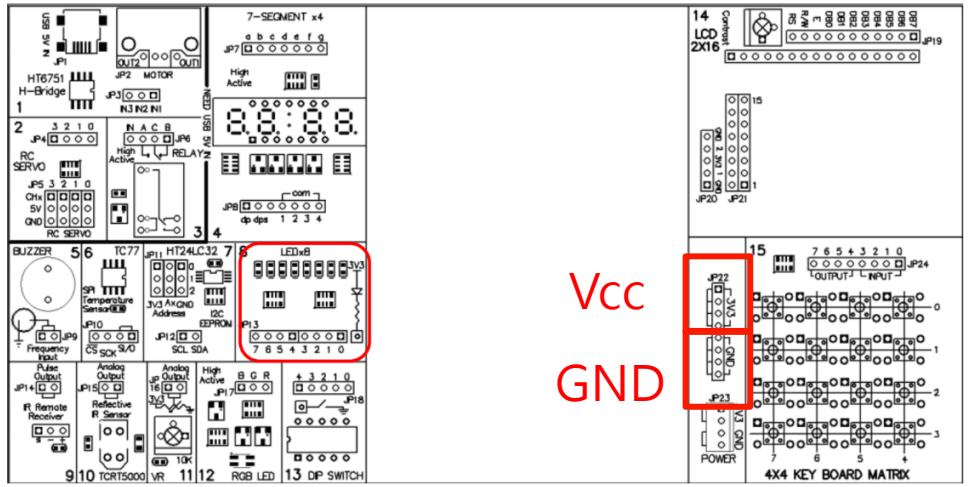
Outline of the Week

1. Last Week Homework W2-3.
2. ADC Introduction.
3. ADC Project.
4. Homework 3-1.
5. Homework 3-2 Bonus Question.

Last Week Homework W2-3.

https://github.com/CYCU-AIoT-System-Lab/Microcontroller-Experiment/blob/main/w2/GPIO-InputOutput-Experiment_Steps.md

Control LED



- Objective: Make LED lights flash using the delay function.
- Hint:

1. Use PC14、PC15、PB0、PB1、PB2、PB3、PB4、PB5 attach to JP13[0:7].
2. Add Delay function, modify the main function.
3. Draw the wiring diagram and explain how to turn the LEDs on.

Open Clock

```
101  void CKCU_Configuration(void)
102  {
103    CKCU_PeripClockConfig_TypeDef CKCUClock = {{0}};
104    CKCUClock.Bit.PB = 1;
105    CKCUClock.Bit.PC = 1;
106    CKCUClock.Bit.AFIO       = 1;
107    CKCU_PeripClockConfig(CKCUClock, ENABLE);
108  }
```

Clock of Port B and Port C is enable

Edit GPIO_OUT_Configuration

```
140  void GPIO_OUT_Configuration(void)
141  {
142    /* Configure LED1, LED2 pins as output function
143    /* Configure AFIO mode of output pins
144    AFIO_GPxConfig(HTCFG_OUTPUT_LED1_ID, HTCFG_OUTPUT_LED1_AFIO_PIN, AFIO_FUN_GPIO);
145    AFIO_GPxConfig(HTCFG_OUTPUT_LED2_ID, HTCFG_OUTPUT_LED2_AFIO_PIN, AFIO_FUN_GPIO);
146
147    /* Configure GPIO direction of output pins
148    GPIO_DirectionConfig(HTCFG_LED1, HTCFG_OUTPUT_LED1_GPIO_PIN, GPIO_DIR_OUT);
149    GPIO_DirectionConfig(HTCFG_LED2, HTCFG_OUTPUT_LED2_GPIO_PIN, GPIO_DIR_OUT);
150  }
151
```

F12

```
172  #if defined(USE_HT32F52352_SK)
173    #define HTCFG_OUTPUT_LED1_ID                    (GPIO_PC)
174    #define HTCFG_OUTPUT_LED2_ID                    (GPIO_PC)
175    #define HTCFG_INPUT_WAKE_ID                     (GPIO_PB)
176    #define HTCFG_INPUT_KEY1_ID                     (GPIO_PD)
177
178    #define HTCFG_OUTPUT_LED1_CLK(CK)               (CK.Bit.PC)
179    #define HTCFG_OUTPUT_LED2_CLK(CK)               (CK.Bit.PC)
180    #define HTCFG_INPUT_WAKE_CLK(CK)                (CK.Bit.PB)
181    #define HTCFG_INPUT_KEY1_CLK(CK)                (CK.Bit.PD)
182
183    #define HTCFG_LED1                              (HT_GPIOC)
184    #define HTCFG_LED2                              (HT_GPIOC)
185    #define HTCFG_WAKE                              (HT_GPIOB)
186    #define HTCFG_KEY1                              (HT_GPIOD)
187
188    #define HTCFG_OUTPUT_LED1_AFIO_PIN              (AFIO_PIN_14)
189    #define HTCFG_OUTPUT_LED2_AFIO_PIN              (AFIO_PIN_15)
190    #define HTCFG_INPUT_WAKE_AFIO_PIN               (AFIO_PIN_12)
```

```
137  void GPIO_OUT_Configuration(void)
138  {
139    /* Configure LED1, LED2 pins as output function
140    /* Configure AFIO mode of output pins
141    AFIO_GPxConfig(GPIO_PC, AFIO_PIN_14, AFIO_FUN_GPIO);
142    AFIO_GPxConfig(HTCFG_OUTPUT_LED2_ID, HTCFG_OUTPUT_LED2_AFIO_PIN, AFIO_FUN_GPIO);
143
144    /* Configure GPIO direction of output pins
145    GPIO_DirectionConfig(HTCFG_LED1, HTCFG_OUTPUT_LED1_GPIO_PIN, GPIO_DIR_OUT);
146    GPIO_DirectionConfig(HTCFG_LED2, HTCFG_OUTPUT_LED2_GPIO_PIN, GPIO_DIR_OUT);
147  }
148
```

Copy/Past

Edit GPIO_MainRoutine

```
153  void GPIO_MainRoutine(void)
154  {
155    /* Read WAKEUP and then output to LED1
156    GPIO_WriteOutBits(HTCFG_LED1, HTCFG_OUTPUT_LED1_GPIO_PIN, SET);
157    _Delay(1000);
158    /* Read KEY1 and then output to LED2
159    GPIO_WriteOutBits(HTCFG_LED2, HTCFG_OUTPUT_LED2_GPIO_PIN, RESET);
160    _Delay(1000);
161  }
```

F12

```
178    #define HTCFG_OUTPUT_LED1_CLK(CK)                (CK.Bit.PC)
179    #define HTCFG_OUTPUT_LED2_CLK(CK)                (CK.Bit.PC)
180    #define HTCFG_INPUT_WAKE_CLK(CK)                 (CK.Bit.PB)
181    #define HTCFG_INPUT_KEY1_CLK(CK)                 (CK.Bit.PD)
182
183    #define HTCFG_LED1                               (HT_GPIOC)
184    #define HTCFG_LED2                               (HT_GPIOC)
185    #define HTCFG_WAKE                               (HT_GPIOB)
186    #define HTCFG_KEY1                               (HT_GPIOD)
187
188    #define HTCFG_OUTPUT_LED1_AFIO_PIN               (AFIO_PIN_14)
189    #define HTCFG_OUTPUT_LED2_AFIO_PIN               (AFIO_PIN_15)
190    #define HTCFG_INPUT_WAKE_AFIO_PIN                (AFIO_PIN_12)
191    #define HTCFG_INPUT_KEY1_AFIO_PIN                (AFIO_PIN_1)
192
193    #define HTCFG_OUTPUT_LED1_GPIO_PIN               (GPIO_PIN_14)
194    #define HTCFG_OUTPUT_LED2_GPIO_PIN               (GPIO_PIN_15)
195    #define HTCFG_INPUT_WAKE_GPIO_PIN                (GPIO_PIN_12)
```

```
153  void GPIO_MainRoutine(void)
154  {
155    /* Read WAKEUP and then output to LED1
156    GPIO_WriteOutBits(HT_GPIOC, GPIO_PIN_14, 0);
157    _Delay(1000);
158    /* Read KEY1 and then output to LED2
159    GPIO_WriteOutBits(HTCFG_LED2, HTCFG_OUTPUT_LED2_GPIO_PIN, RESET);
160    _Delay(1000);
161  }
```

output is high(1)/low(0)

Copy/Past

GPIO_MainRoutine

- GPIO_ReadInBit（Port PA ~ PD、PIN number）

  Read in the input data from a specified pin.

- GPIO_WriteOutBits（Port PA ~ PD、PIN number，0 or 1 ）

  Write out the output data with a specified pin.

Delay function

Add Delay function

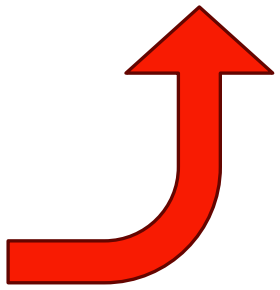
```
165  static void _Delay(vu32 count)
166  {
167    vu32 i;
168    for(i=0; i<5000*count; i++)
169    {
170    }
171  }
```

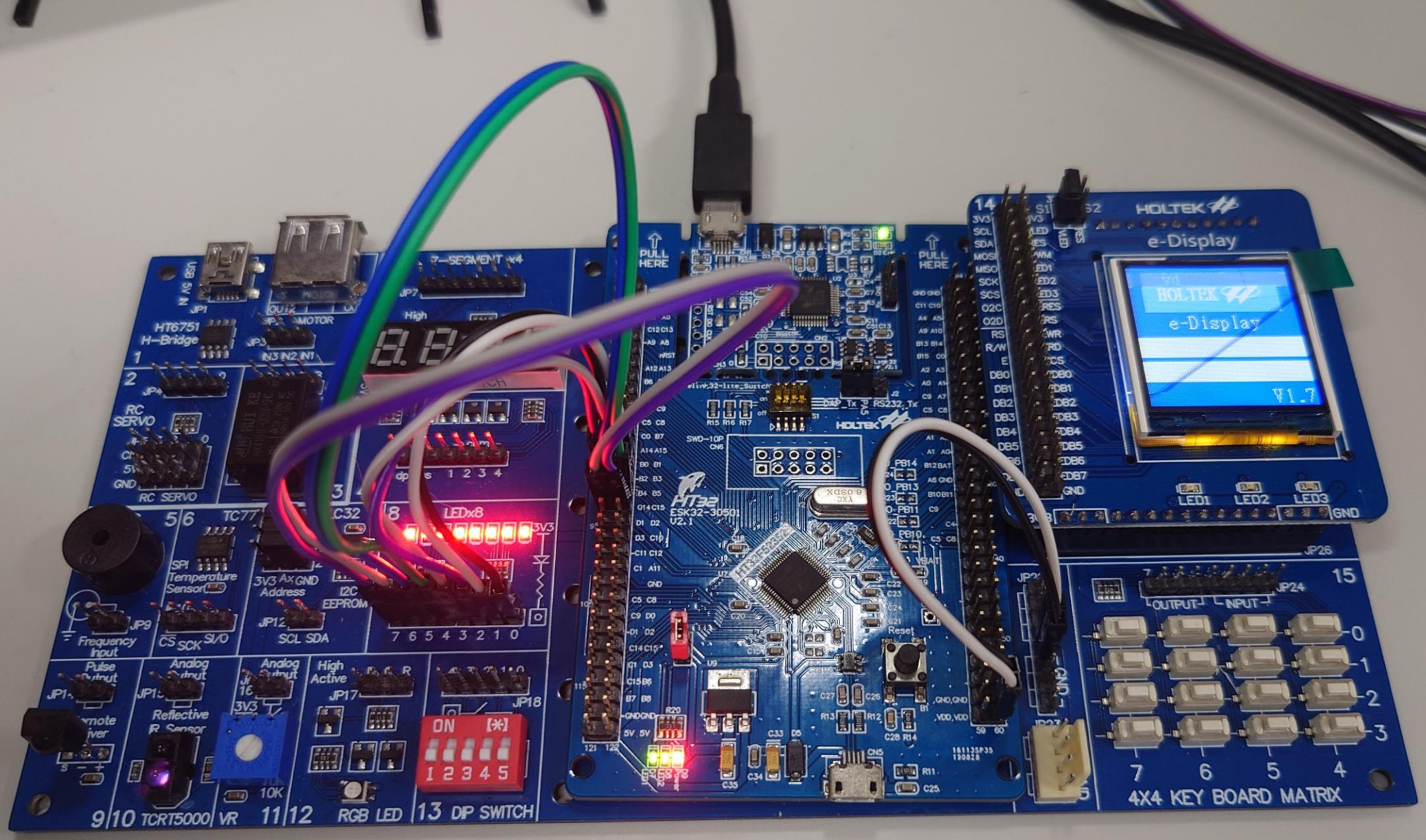
Function Declaration at the Beginning

```
45  /* Private function prototypes ---
46  void CKCU_Configuration(void);
47  void GPIO_IN_Configuration(void);
48  void GPIO_OUT_Configuration(void);
49  void GPIO_MainRoutine(void);
50  static void _Delay(vu32 count);
```

Modify GPIO_MainRoutine

```
156  void GPIO_MainRoutine(void)
157  {
158    /* Read WAKEUP and then output to LED1
159    GPIO_WriteOutBits(HTCFG_LED1, HTCFG_OUTPUT_LED1_GPIO_PIN, SET);
160    _Delay(1000);
161    /* Read KEY1 and then output to LED2
162    GPIO_WriteOutBits(HTCFG_LED2, HTCFG_OUTPUT_LED2_GPIO_PIN, RESET);
163    _Delay(1000);
164  }
```



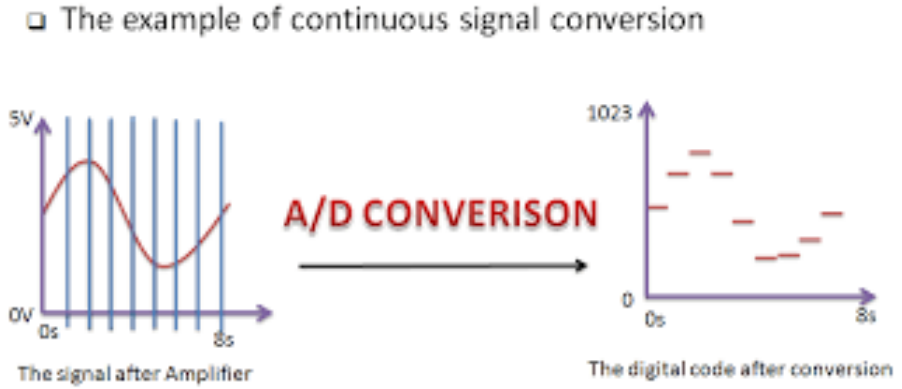


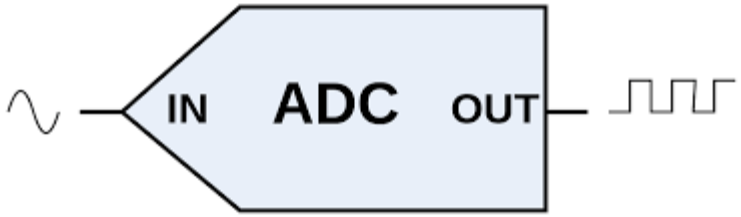
https://youtu.be/s0h11k8fy1w

ADC Introduction

What is ADC?

- 類比數位轉換器（英語：Analog-to-digital converter, ADC, A/D 或 A to D）是用於將連續的類比訊號轉換為離散的數位訊號。
- Analog-to-digital converter plays a crucial role in enabling digital systems to interface with the analog world by converting continuous analog signals into discrete digital values.





ADC specifications

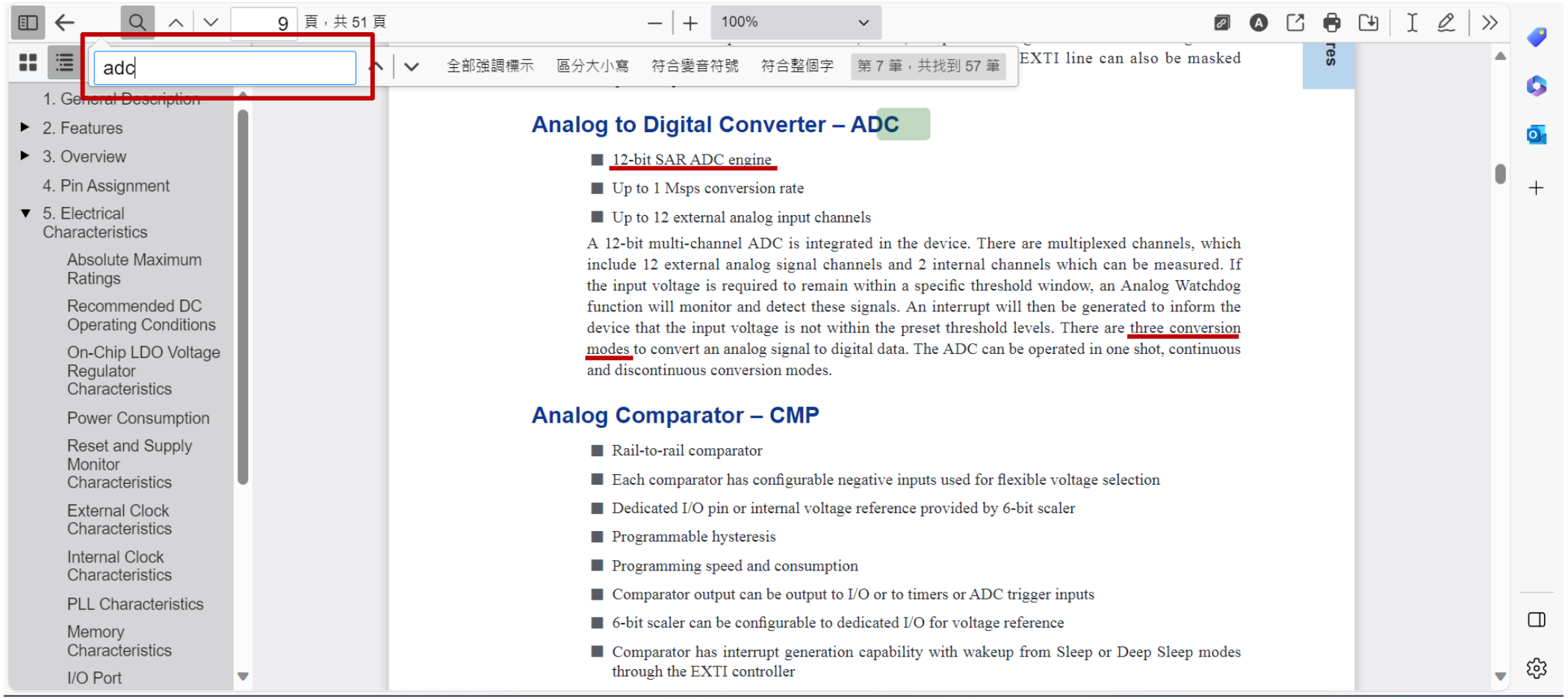
- Sampling rate: How often should we do the sampling?
- Resolution: How many storage bits can we use?
- ADC Conversion Equation:

$$ConvertedVoltage = ConvertedValue \times \frac{V_{ref}}{2^n - 1}$$

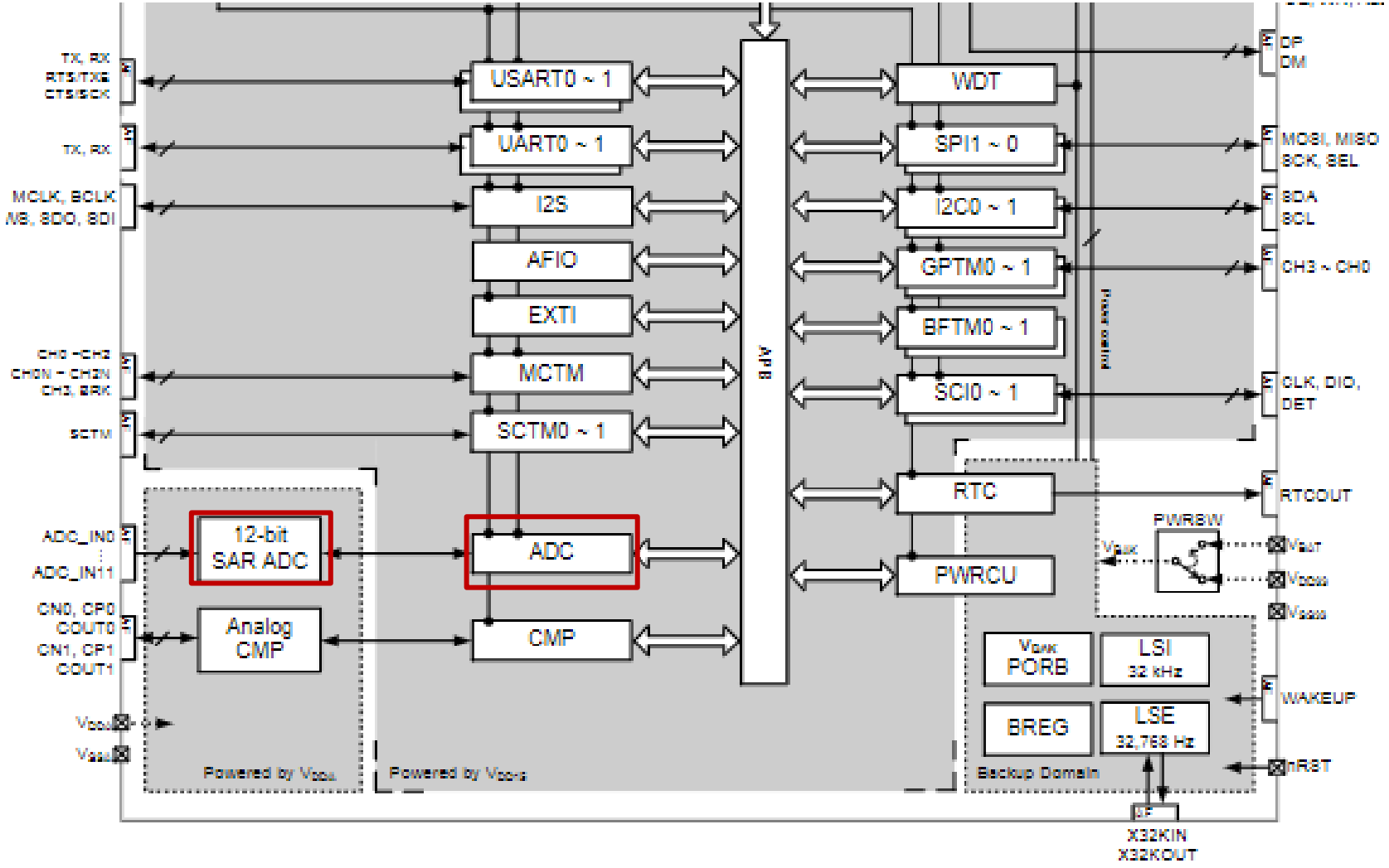
- Vref: referaence voltage, usually between V_{DD} and V_{SS}
- n: number of bits

Datasheet

Ctrl+f: search for “ADC”



Block Diagram



Three conversion modes

- One shot conversion mode

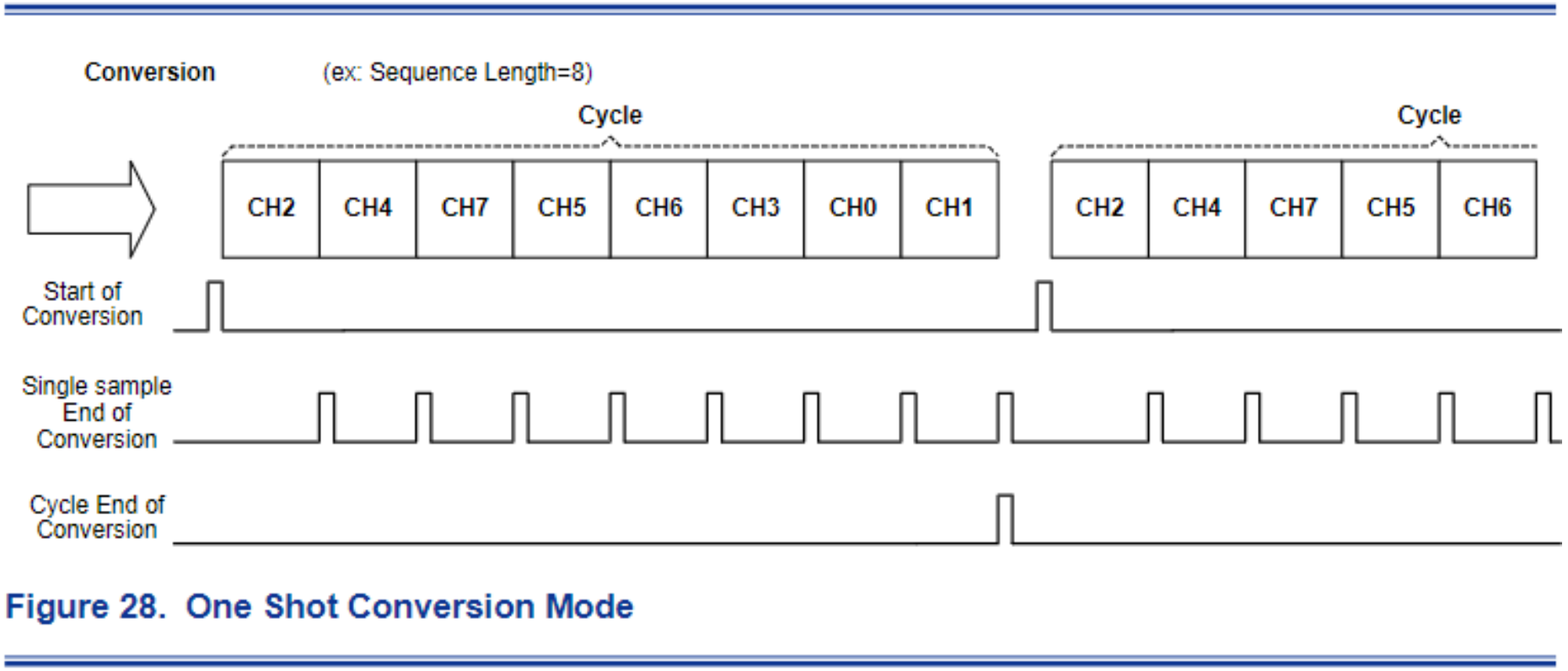


Figure 28. One Shot Conversion Mode

Three conversion modes

- Continuous conversion mode

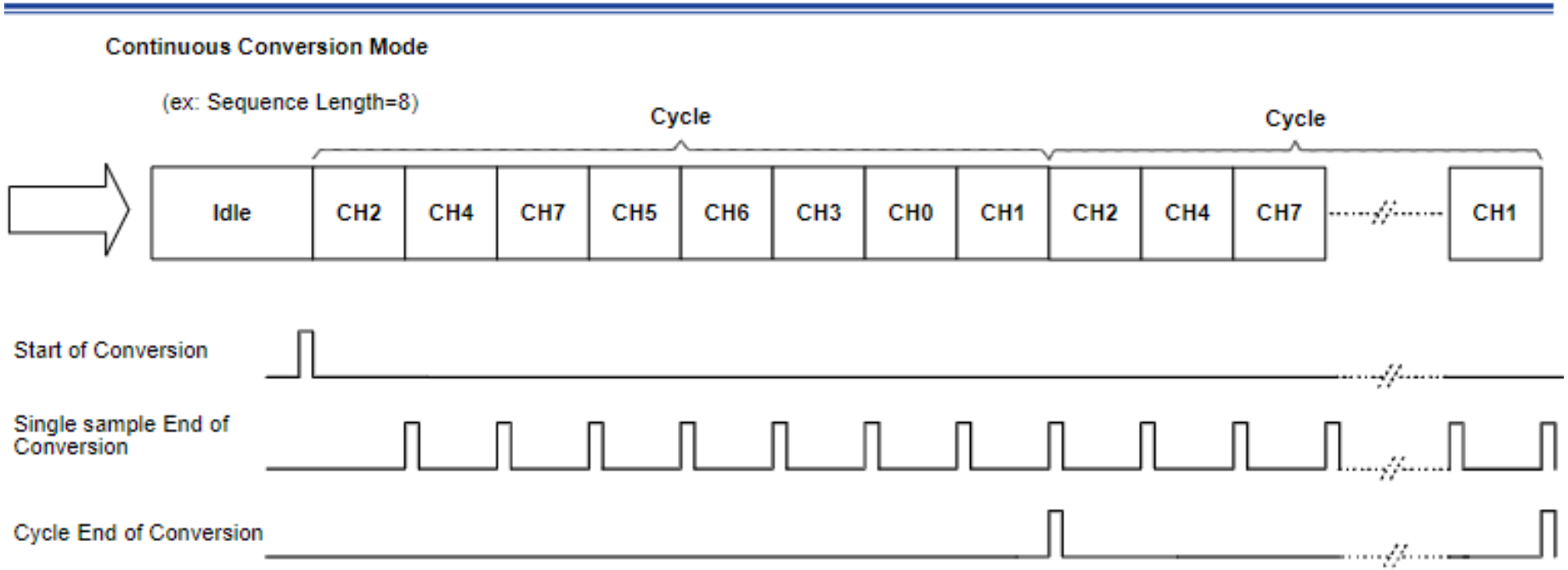


Figure 29. Continuous Conversion Mode

Three conversion modes

- Discontinuous conversion mode

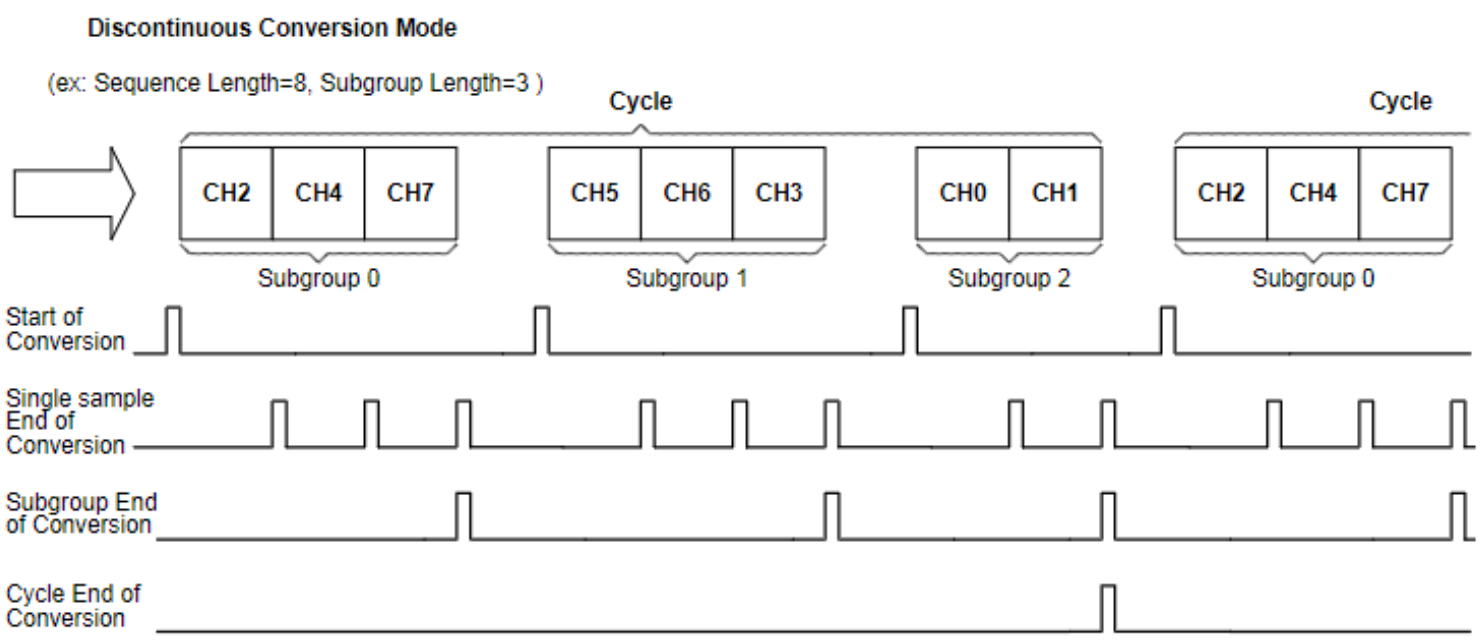


Figure 30. Discontinuous Conversion Mode

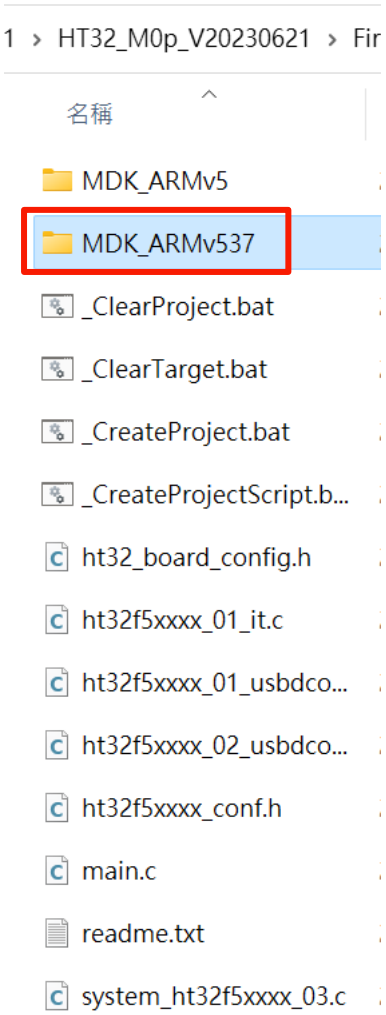
ADC Project

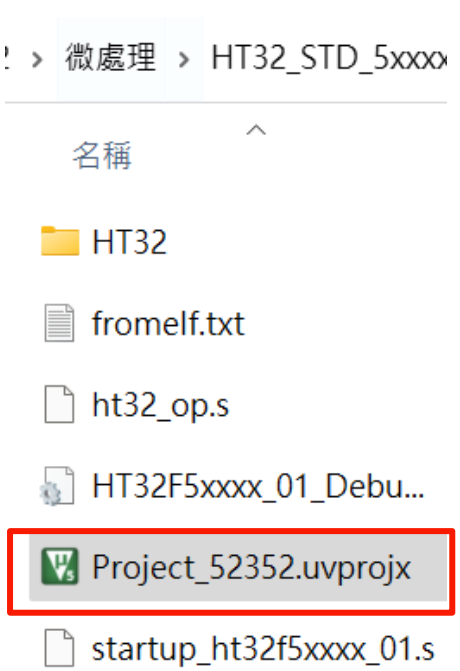
1. Execute “_CreatProject”

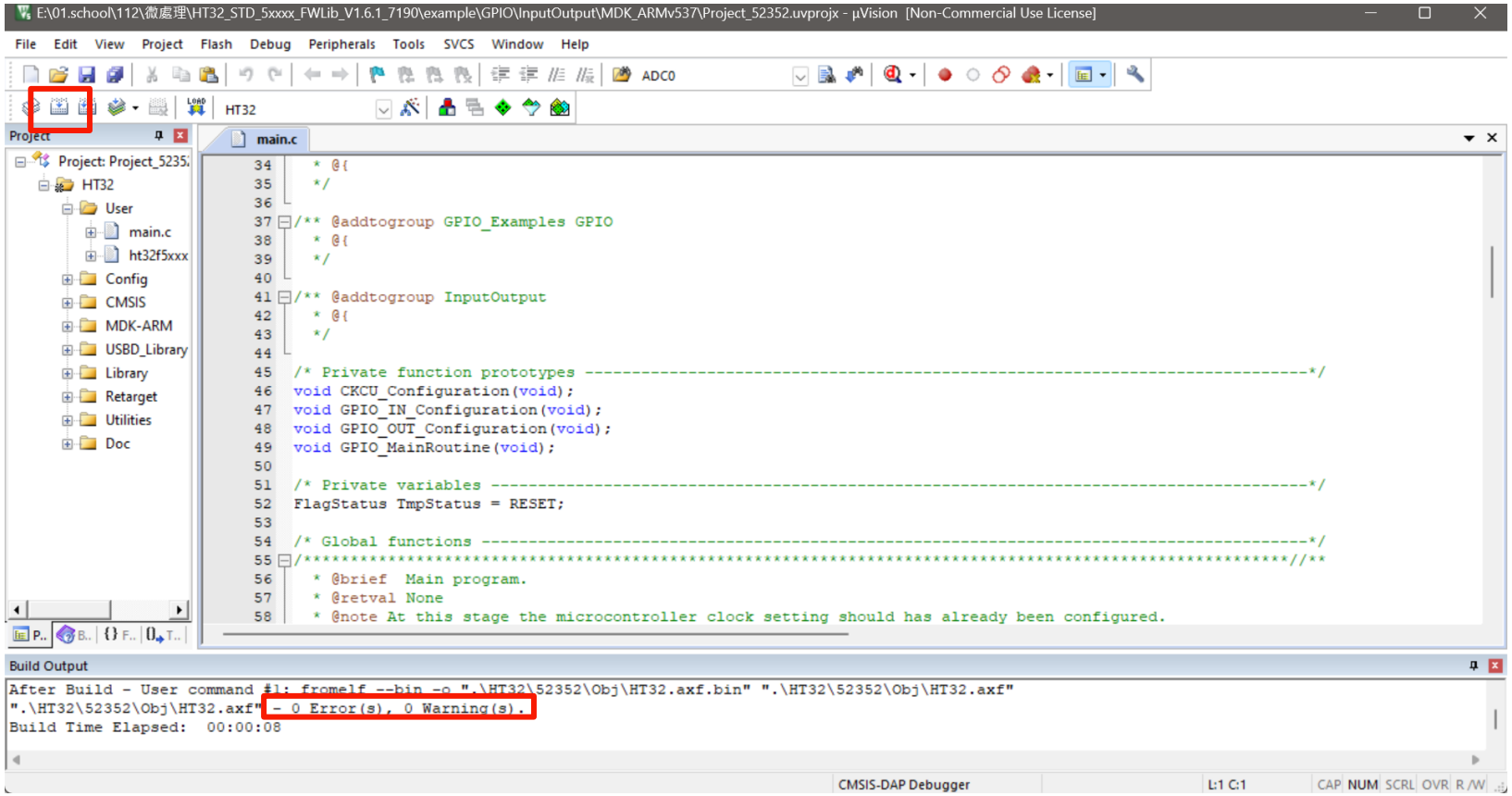
1. Go to “~/HT32_STD_5xxxx_FWLib_V1.5.1_7084/example/ADC/Continuous_Pontentiometer”.

2. Double click “_CreateProject.bat”.

2. Launch project







main

```
58  int main(void)
59  {
60    RETARGET_Configuration();
61
62    ADC_Configuration();
63
64    /* Enable ADC
65    ADC_Cmd(HTCFG_ADC_PORT, ENABLE);
66
67    /* Software trigger to start ADC conversion
68    ADC_SoftwareStartConvCmd(HTCFG_ADC_PORT, ENABLE);
69
70    while (1)
71    {
72      if (gADC_SingleEndOfConversion)
73      {
74        printf("\rPotentiometer level is %04d", (int)gPotentiometerLevel);
75      }
76    }
77  }
```

ADC_Configuration

```
83  void ADC_Configuration(void)
84  {
85    { /* Enable peripheral clock
86      CKCU_PeripClockConfig_TypeDef CKCUClock = {{ 0 }};
87      CKCUClock.Bit.AFIO = 1;
88      CKCUClock.Bit.HTCFG_ADC_IPN = 1;
89      CKCU_PeripClockConfig(CKCUClock, ENABLE);
90    }
```

Open the clock that will be used

Before edit

```
92    /* Configure AFIO mode as ADC function                                                    */
93    AFIO_GPxConfig(HTCFG_VR_GPIO_ID, HTCFG_VR_AFIO_PIN, HTCFG_ADC_AFIO_MODE);
94
95    { /* ADC related settings                                                                 */
96      /* CK_ADC frequency is set to (CK_AHB / 64)                                             */
97      CKCU_SetADCnPrescaler(HTCFG_ADC_CKCU_ADCPRE, CKCU_ADCPRE_DIV64);
98
99      /* Continuous mode, sequence length = 1                                                 */
100     ADC_RegularGroupConfig(HTCFG_ADC_PORT, CONTINUOUS_MODE, 1, 0);
101
102     /* ADC conversion time = (Sampling time + Latency) / CK_ADC = (1.5 + ADST + 12.5) / CK_ADC  */
103     /* Set ADST = 0, sampling time = 1.5 + ADST                                             */
104     #if (LIBCFG_ADC_SAMPLE_TIME_BY_CH)
105       // The sampling time is set by the last parameter of the function "ADC_RegularChannelConfig()".
106     #else
107     ADC_SamplingTimeConfig(HTCFG_ADC_PORT, 0);
108     #endif
109
110     /* Set ADC conversion sequence as channel n                                             */
111     ADC_RegularChannelConfig(HTCFG_ADC_PORT, HTCFG_VR_ADC_CH, 0, 0);
112
113     /* Set software trigger as ADC trigger source                                           */
114     ADC_RegularTrigConfig(HTCFG_ADC_PORT, ADC_TRIG_SOFTWARE);
115   }
116
117   /* Enable ADC single end of conversion interrupt                                          */
118   ADC_IntConfig(HTCFG_ADC_PORT, ADC_INT_SINGLE_EOC, ENABLE);
119
120   /* Enable the ADC interrupts                                                              */
121   NVIC_EnableIRQ(HTCFG_ADC_IRQn);
122 }
```

After edit

```
93   AFIO_GPxConfig(GPIO_PA, AFIO_PIN_6, HTCFG_ADC_AFIO_MODE);
94
95   { /* ADC related settings                                                */
96     /* CK_ADC frequency is set to (CK_AHB / 64)                          */
97     CKCU_SetADCnPrescaler(CKCU_ADCPRE_ADC0, CKCU_ADCPRE_DIV64);
98
99     /* Continuous mode, sequence length = 1                              */
100    ADC_RegularGroupConfig(HT_ADC0, CONTINUOUS_MODE, 1, 0);
101
102    /* ADC conversion time = (Sampling time + Latency) / CK_ADC = (1.5 + ADST + 12.5) / CK_ADC
103    /* Set ADST = 0, sampling time = 1.5 + ADST                          */
104    #if (LIBCFG_ADC_SAMPLE_TIME_BY_CH)
105      // The sampling time is set by the last parameter of the function "ADC_RegularChannelConfig()"
106    #else
107    ADC_SamplingTimeConfig(HT_ADC0, 0);
108    #endif
109
110    /* Set ADC conversion sequence as channel n                          */
111    ADC_RegularChannelConfig(HT_ADC0, ADC_CH_6, 0, 0);
112
113    /* Set software trigger as ADC trigger source                        */
114    ADC_RegularTrigConfig(HT_ADC0, ADC_TRIG_SOFTWARE);
115  }
116
117  /* Enable ADC single end of conversion interrupt                       */
118  ADC_IntConfig(HTCFG_ADC_PORT, ADC_INT_SINGLE_EOC, ENABLE);
119
120  /* Enable the ADC interrupts                                           */
121  NVIC_EnableIRQ(HTCFG_ADC_IRQn);
122 }
```

Set AFIO mode for the pins

Select the ADC sampling frequency

Set ADC mode :
1.Which ADC channel?
2.Which mode?
3.How many conversion times ?

Which register stores the read data?

Software triggering

Configure ADC interrupt mode

main

```
58  int main(void)
59  {
60    RETARGET_Configuration();
61
62    ADC_Configuration();
63
64    /* Enable ADC
65    ADC_Cmd(HTCFG_ADC_PORT, ENABLE);
66
67    /* Software trigger to start ADC conversion
68    ADC_SoftwareStartConvCmd(HTCFG_ADC_PORT, ENABLE);
69
70    while (1)
71    {
72      if (gADC_SingleEndOfConversion)
73      {
74        printf("\rPotentiometer level is %04d", (int)gPotentiometerLevel);
75      }
76    }
77  }
```

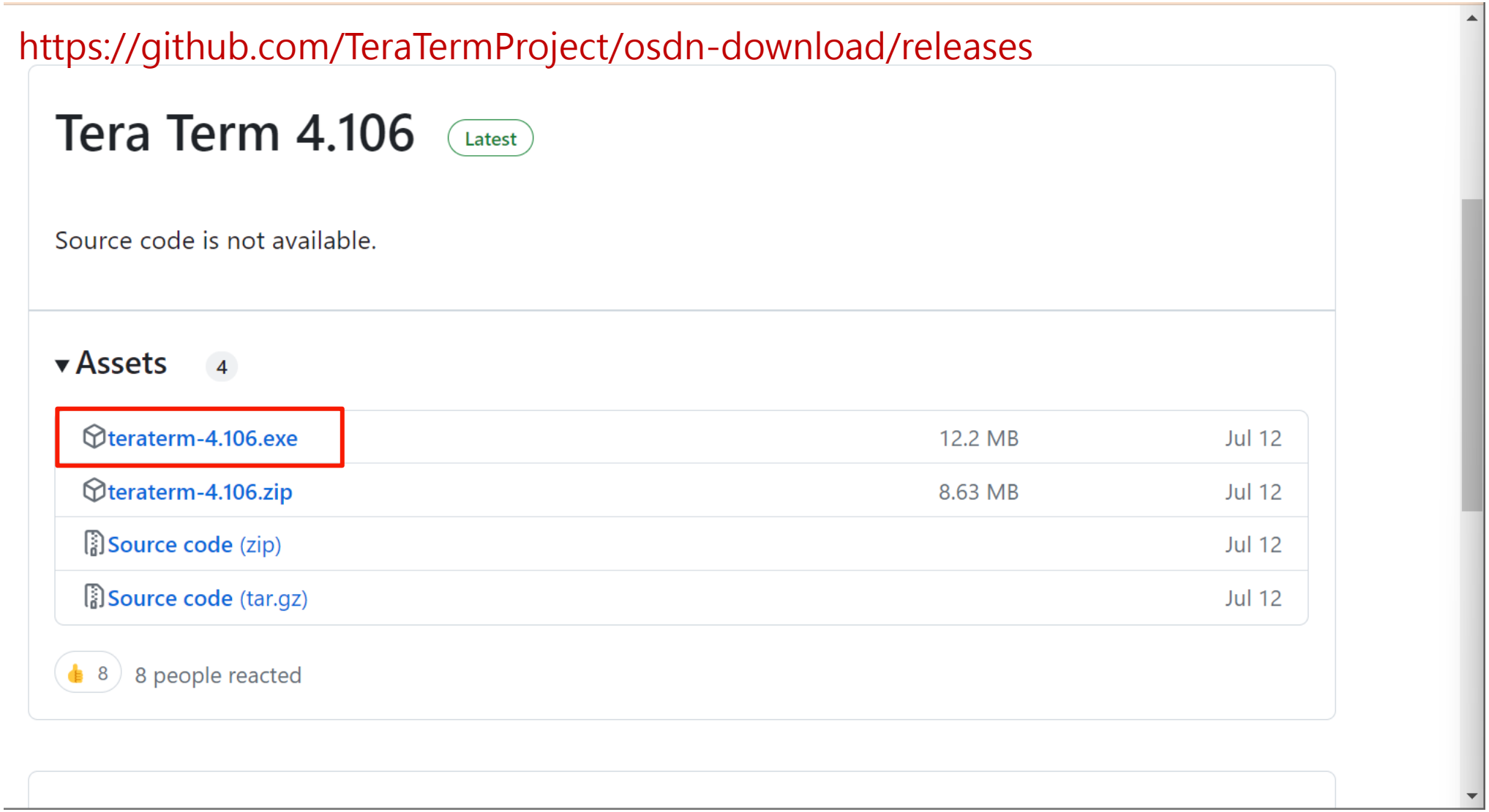
Retarget_Configuration

```
118 void RETARGET_Configuration(void)
119 {
120 #ifdef RETARGET_IS_UART
121   /* !!! NOTICE !!!
122      Notice that the local variable (structure) did not have an initial value.
123      Please confirm that there are no missing members in the parameter settings below in this function.
124   */
125   USART_InitTypeDef USART_InitStructure;
126   #ifdef RETARGET_UxART_BAUDRATE
127   USART_InitStructure.USART_BaudRate = RETARGET_UxART_BAUDRATE;
128   #else
129   USART_InitStructure.USART_BaudRate = 115200;
130   #endif
131   USART_InitStructure.USART_WordLength = USART_WORDLENGTH_8B;
132   USART_InitStructure.USART_StopBits = USART_STOPBITS_1;
133   USART_InitStructure.USART_Parity = USART_PARITY_NO;
134   USART_InitStructure.USART_Mode = USART_MODE_NORMAL;
```

BaudRate: 115200

Download Tera Term

https://github.com/TeraTermProject/osdn-download/releases



Tera Term

https://github.com/TeraTermProject/osdn-download/releases

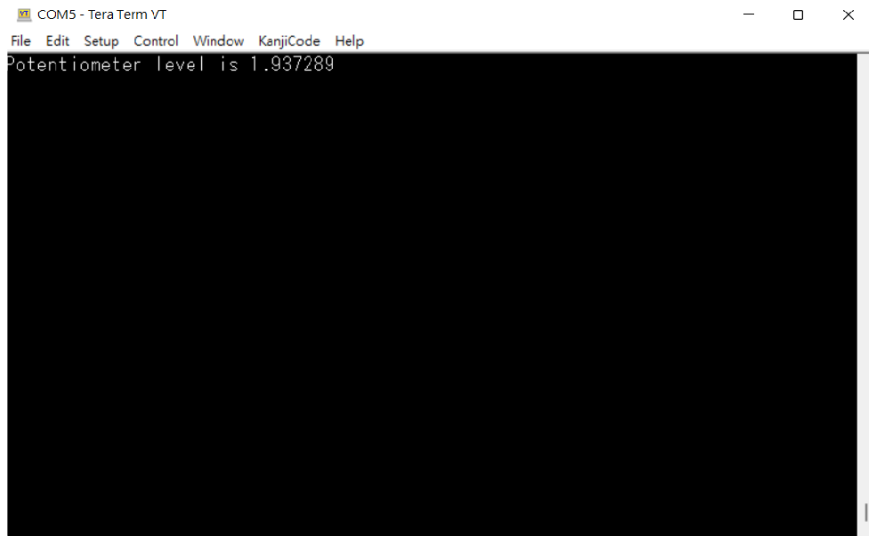
Homework W3-1.

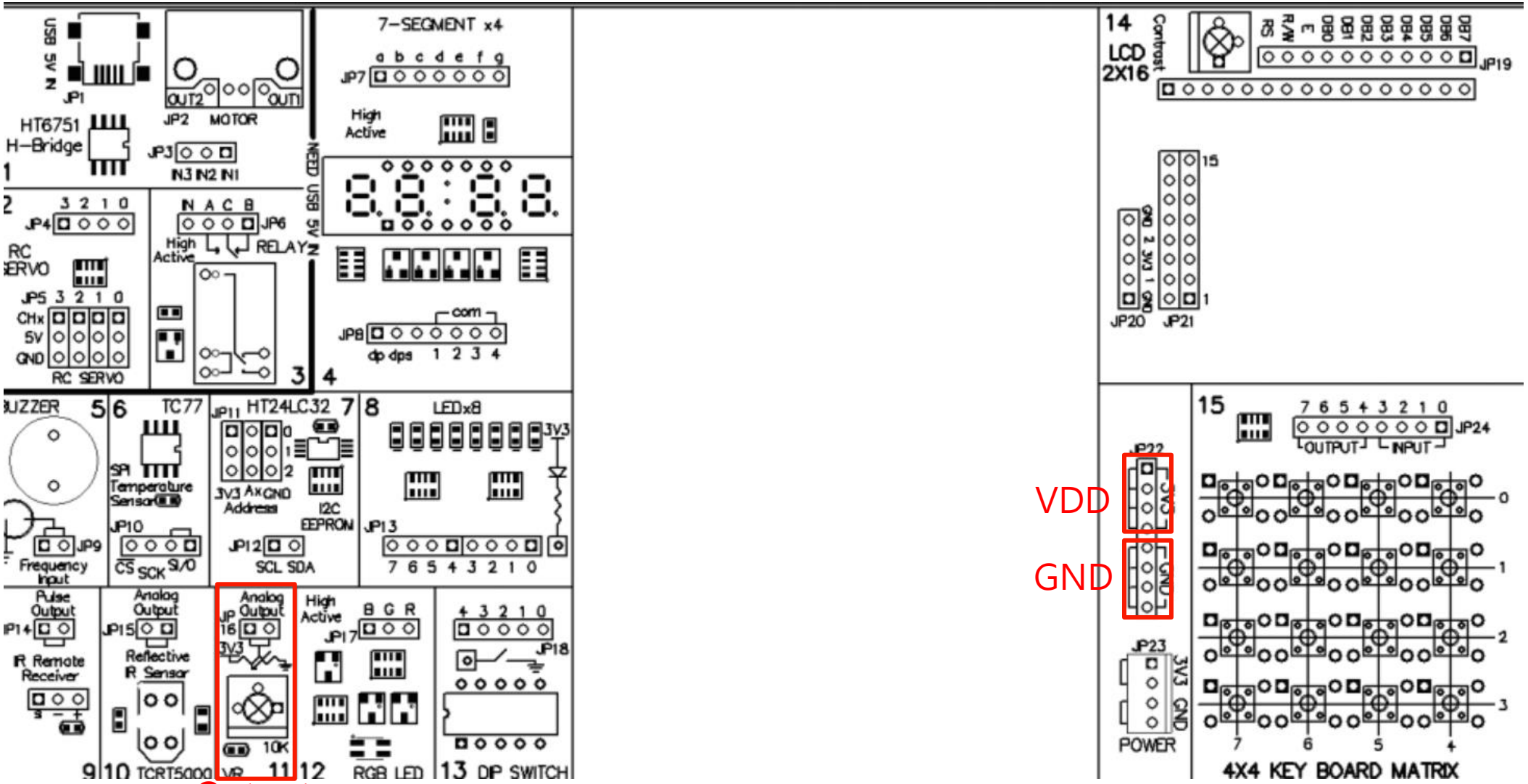
https://github.com/CYCU-AIoT-System-Lab/Microcontroller-Experiment/blob/main/w3/ADC-Continuous_Potentiometer-Experiment_Steps.md

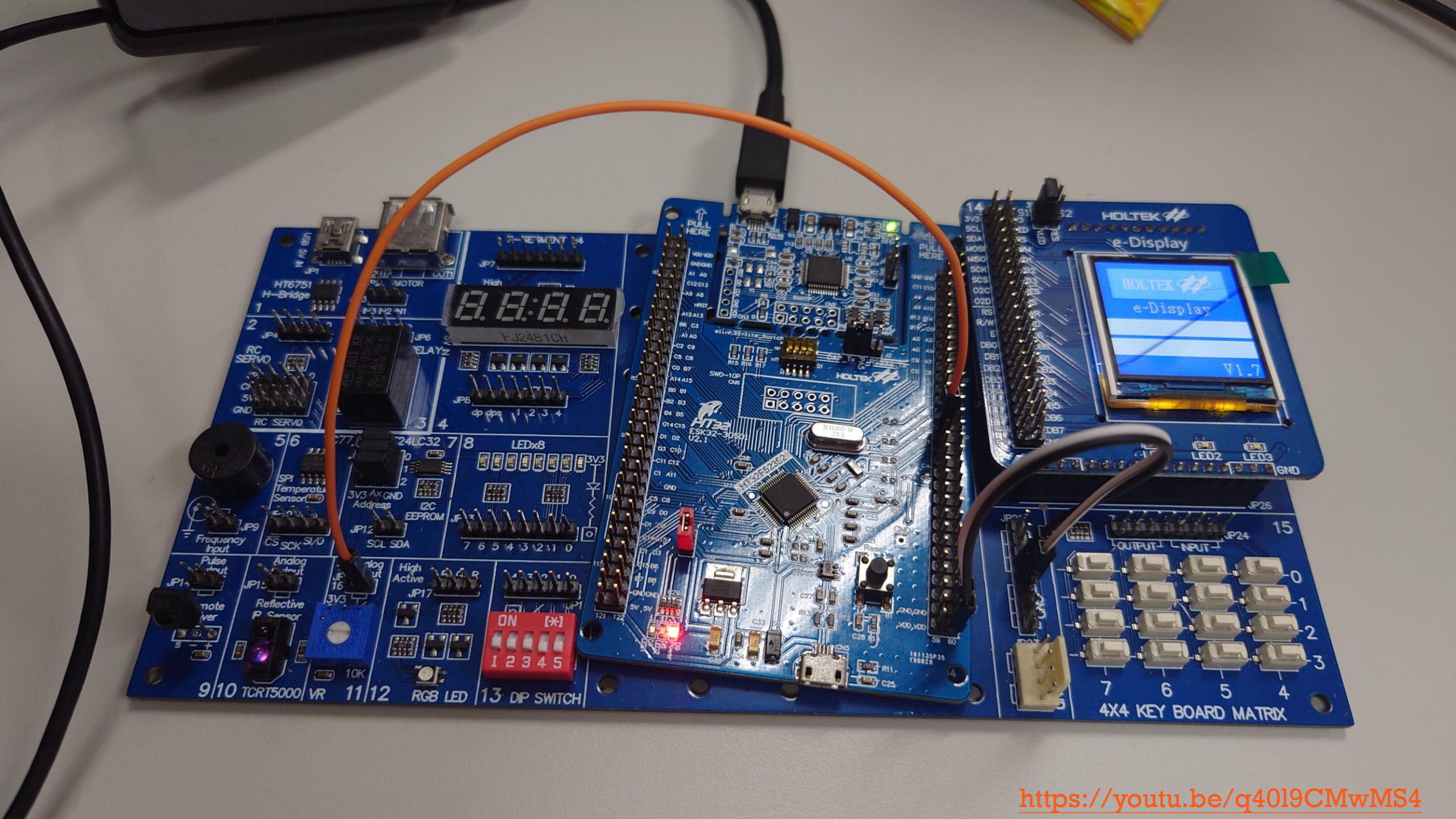
Use potentiometer to display measured voltage.

- Objective: Connect pin A7 to a variable resistor, rotate the variable resistor, and observe the change in voltage value.
- Hint: Look for the formula in page 10

```
58  int main(void)
59  {
60    RETARGET_Configuration();
61
62    ADC_Configuration();
63
64    /* Enable ADC
65    ADC_Cmd(HTCFG_ADC_PORT, ENABLE);
66
67    /* Software trigger to start ADC conversion
68    ADC_SoftwareStartConvCmd(HTCFG_ADC_PORT, ENABLE);
69
70    while (1)
71    {
72      if (gADC_SingleEndOfConversion)
73      {
74        printf("\rPotentiometer level is %04d", (int)gPotentiometerLevel*[redacted]);
75      }
76    }
77  }
78
```




7-SEGMENT x4
HT6751
H-Bridge
MOTOR
RELAY
RC SERVO
TC77
HT24LC32
LEDx8
Frequency Input
Pulse Output
IR Remote Receiver
Analog Output
Reflective IR Sensor
TCRT5000
RGB LED
DIP SWITCH
LCD 2X16
JP19
JP20
JP21
JP22
JP23
JP24
POWER
4X4 KEY BOARD MATRIX
VDD
GND
Output



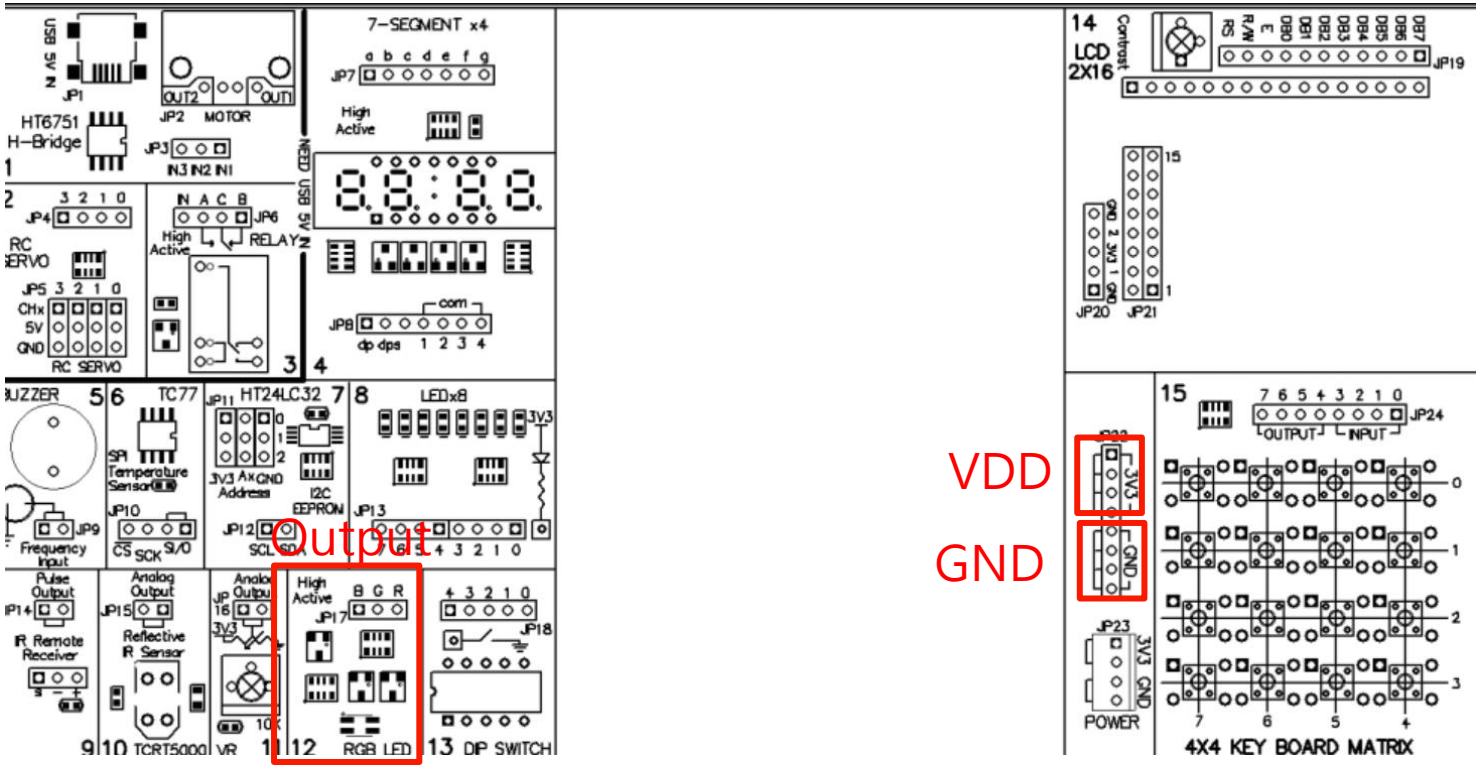
https://youtu.be/q40l9CMwMS4

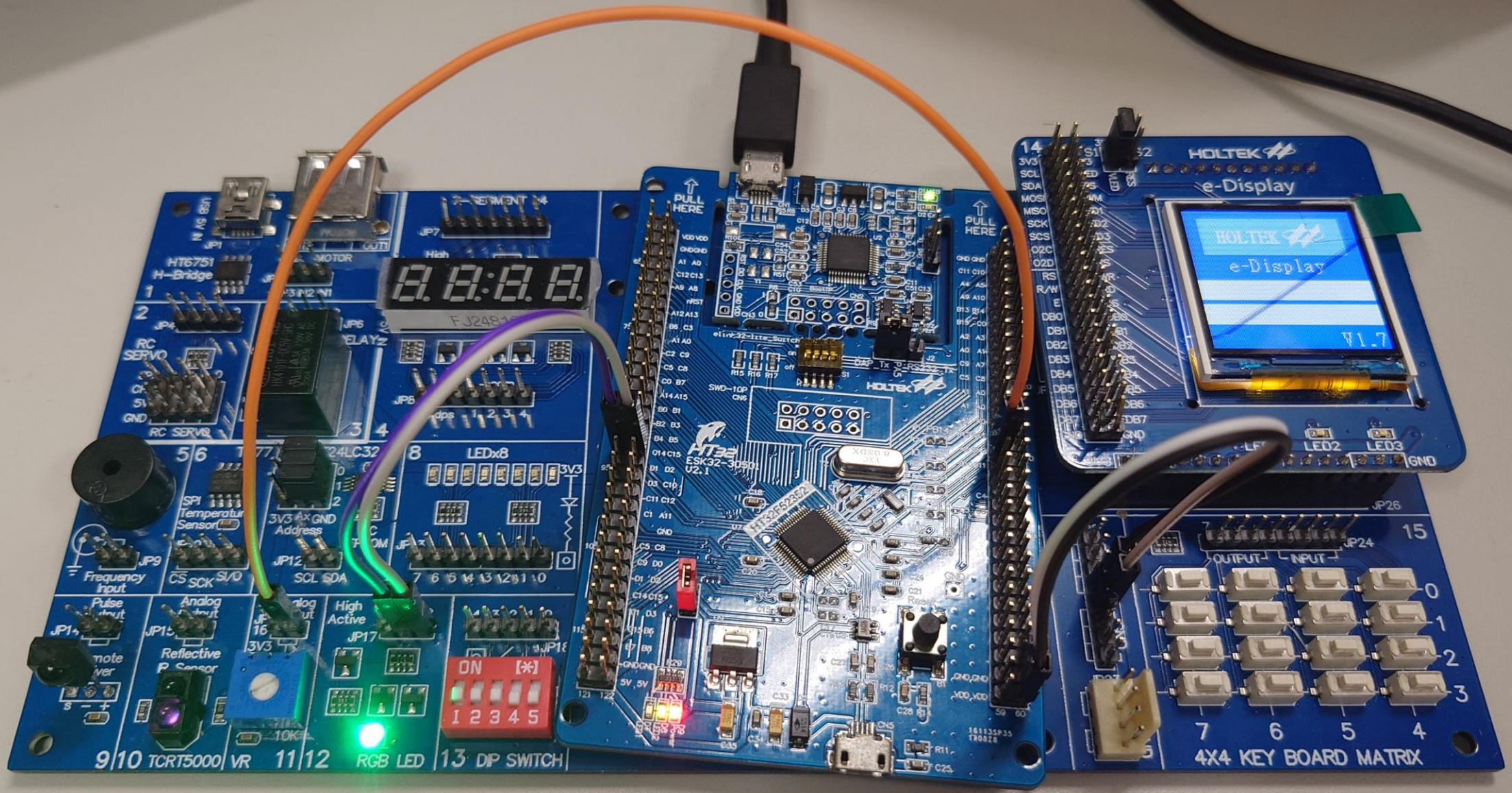
Homework W3-2 Bonus Question

Use potentiometer control RGB LED

- Objective: If measured value is larger than 2000, turn red light of RGB LED on; if it is smaller than 2000, turn green light on.
- Hint:

1. Output pins: PC14、PC15
2. Input pins: **PA7**





https://youtu.be/K4dNRj2S0x4

Class Dismissed