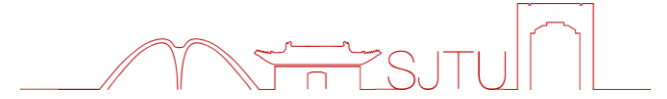




上海交通大学
SHANGHAI JIAO TONG UNIVERSITY



EE系统大作业

2022年12月23日

饮水思源 · 爱国荣校



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简单入门

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基础任务

3

进阶任务

4





01

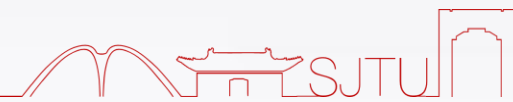
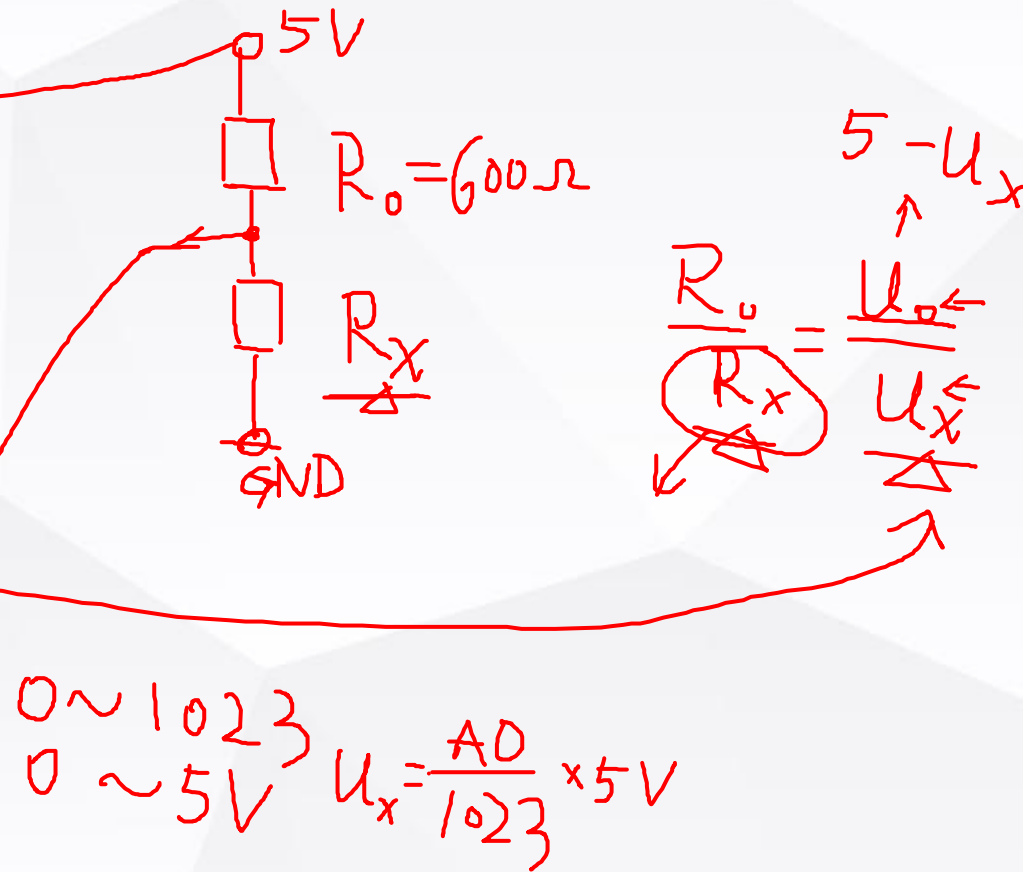
简单入门



测量电阻

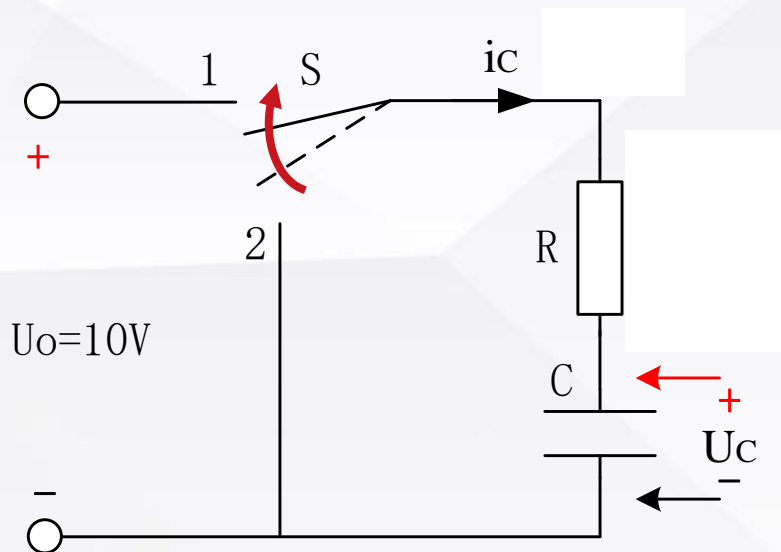


数字IO	单片机本	单片机本身	ADC
D0	PD0		VIN
D1	PD1		GND
Reset	PC6	PC6	Reset
GND	GND		+5V
D2	PD2	ADC7	A7
~D3	PD3	ADC6	A6
D4	PD4	PC0(ADC5)	A5
~D5	PD5	PC4(ADC4)	A4
~D6	PD6	PC3(ADC3)	A3
D7	PD7	PC2(ADC2)	A2
D8	PB0	PC1(ADC1)	A1
~D9	PB1	PC0(ADC0)	A0
~D10	PB2	AREF	AREF
~D11	PB3		+3V3
D12	PB4	PB5	D13





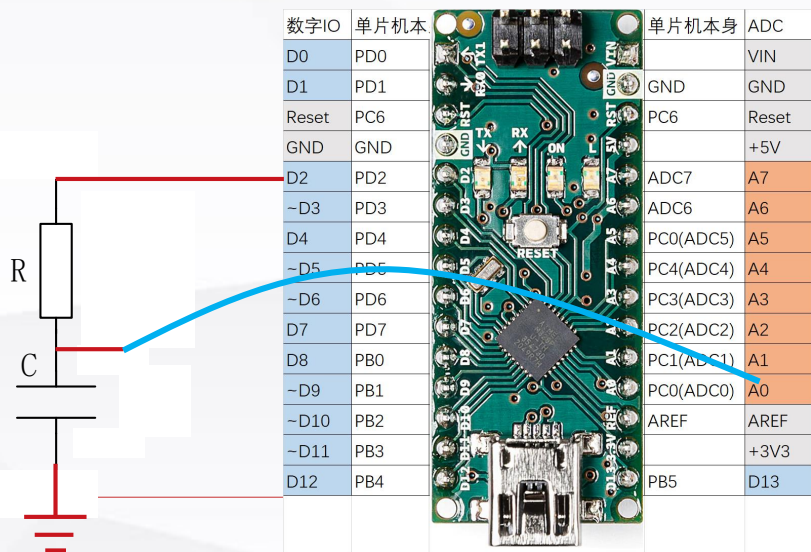
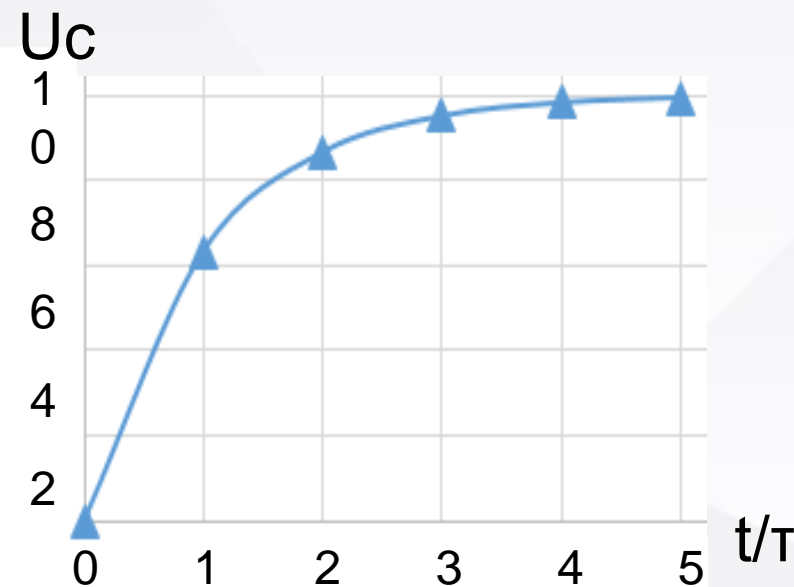
测量电容



$$u_c(t) = U_0(1 - e^{-t/\tau})$$

其中 $\tau = RC$

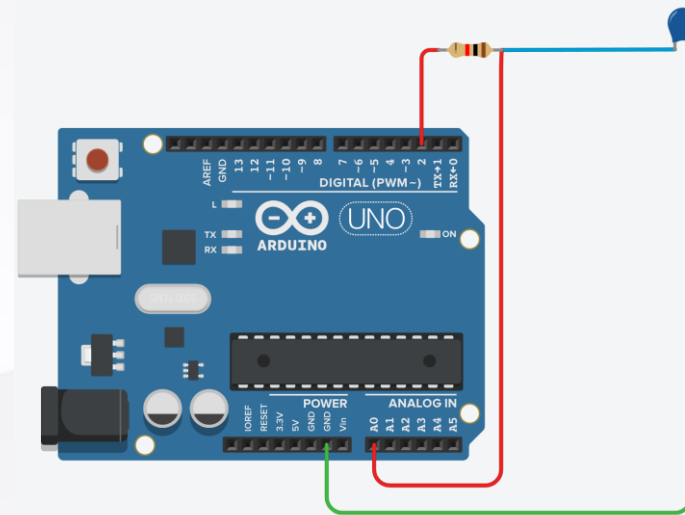
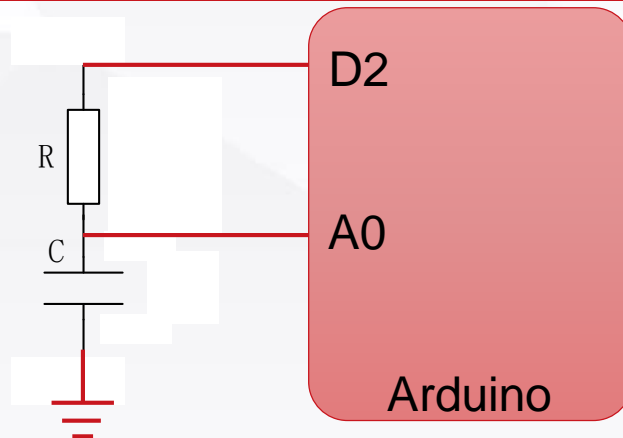
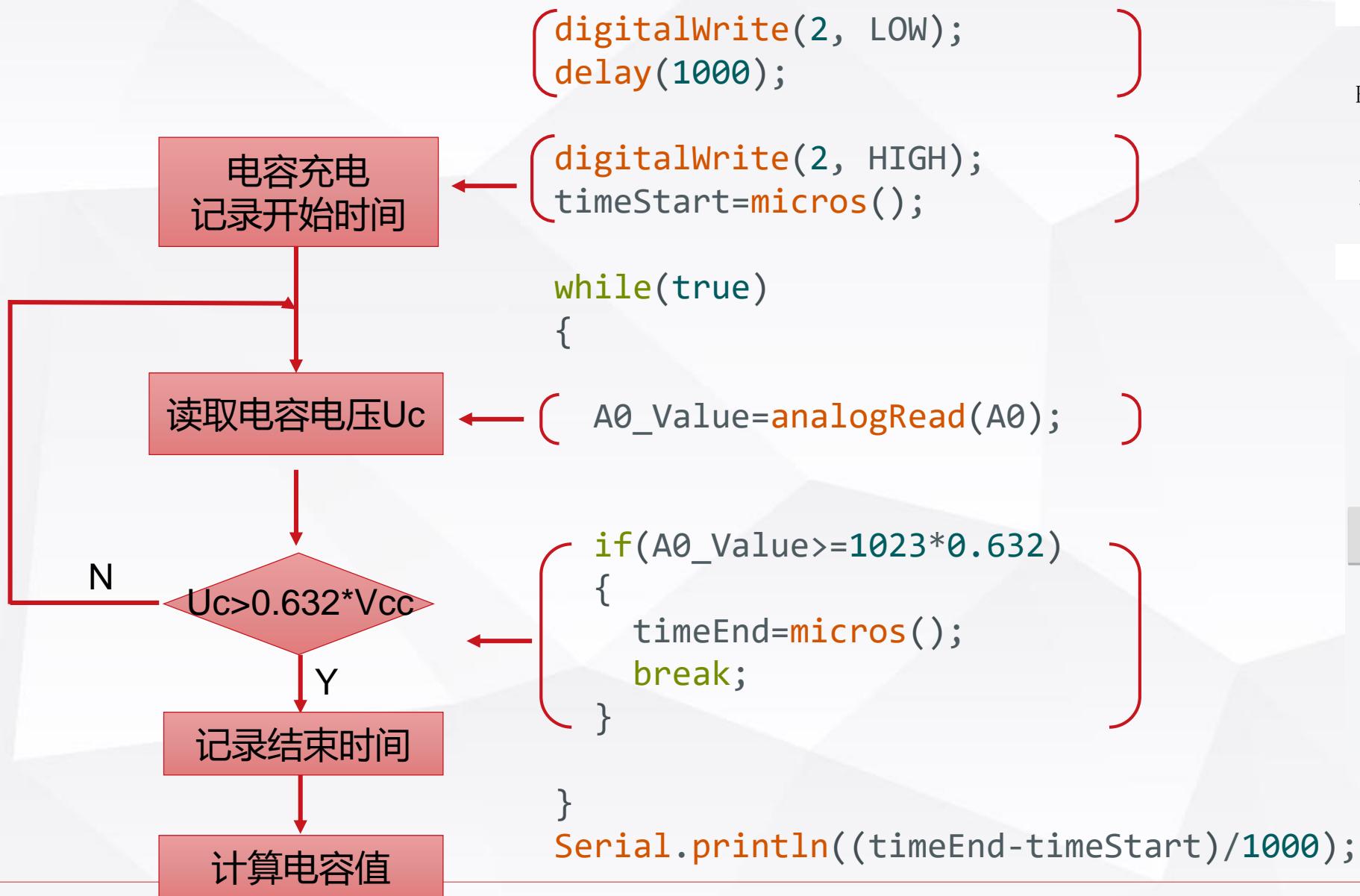
当开关S由“2”转向接通“1”时，电源通过R对电容充电。



t	0 τ	τ	2 τ	3 τ	4 τ	5 τ
Uc	0	0.632	0.865	0.95	0.982	0.993

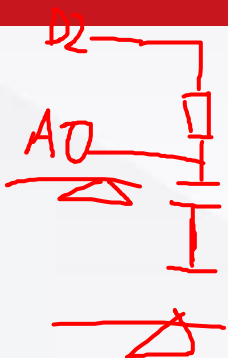
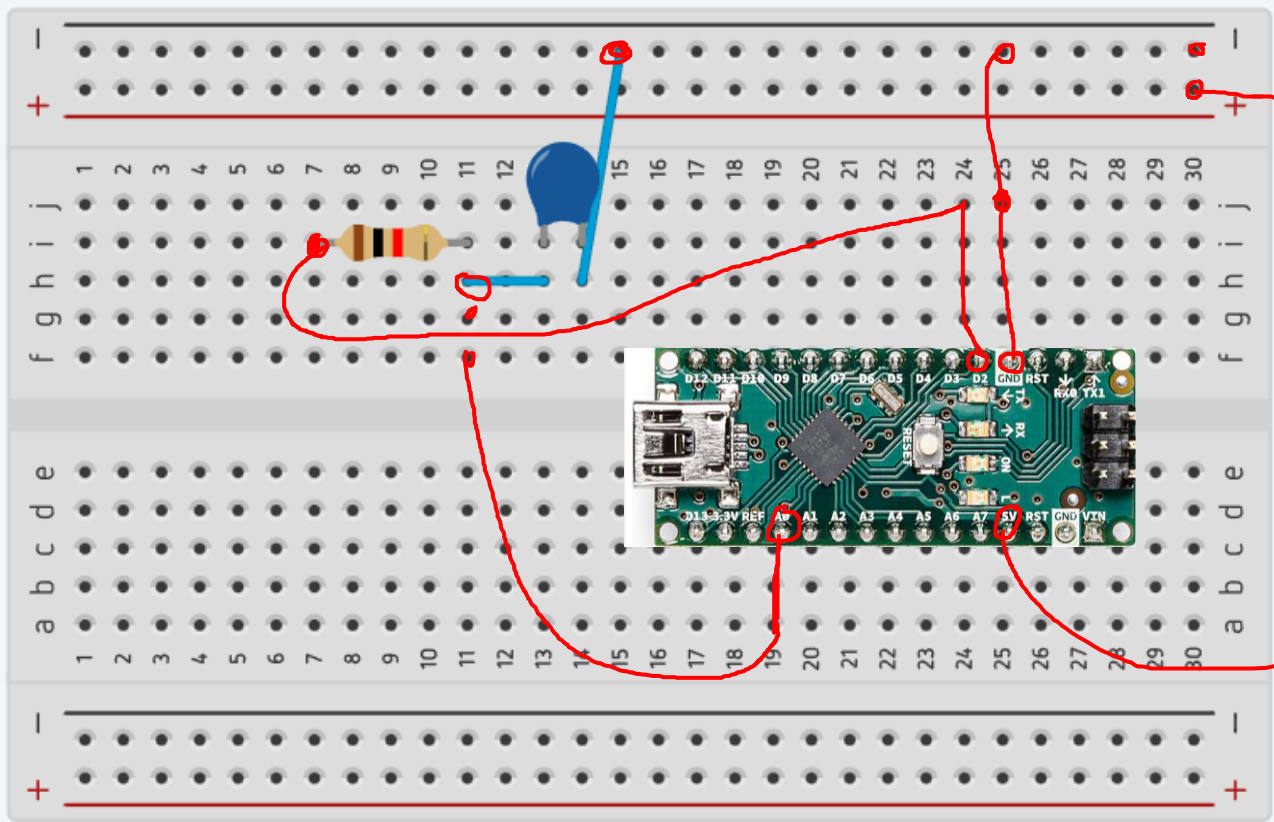


测量电容





面包板连线





测量电容

```
digitalWrite(2, LOW);  
delay(1000);
```

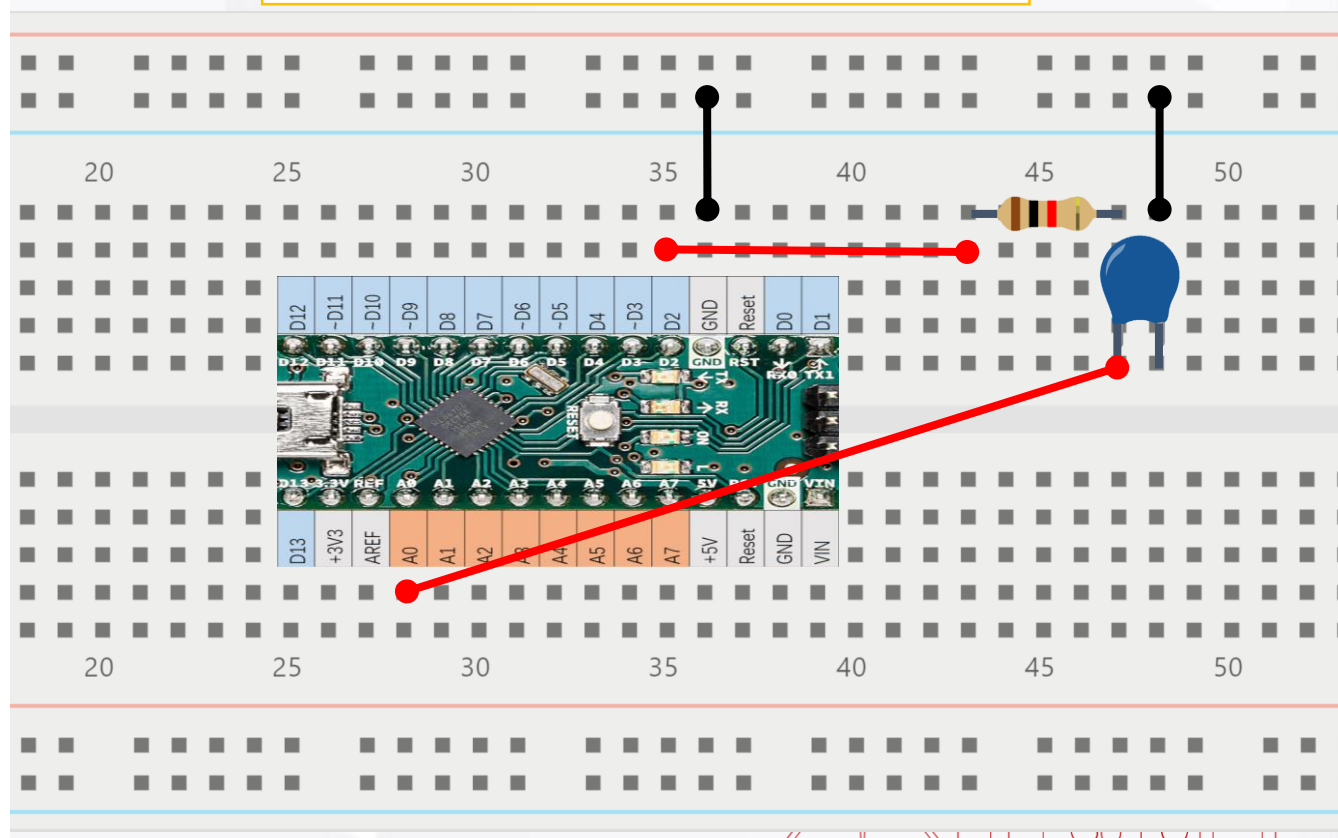
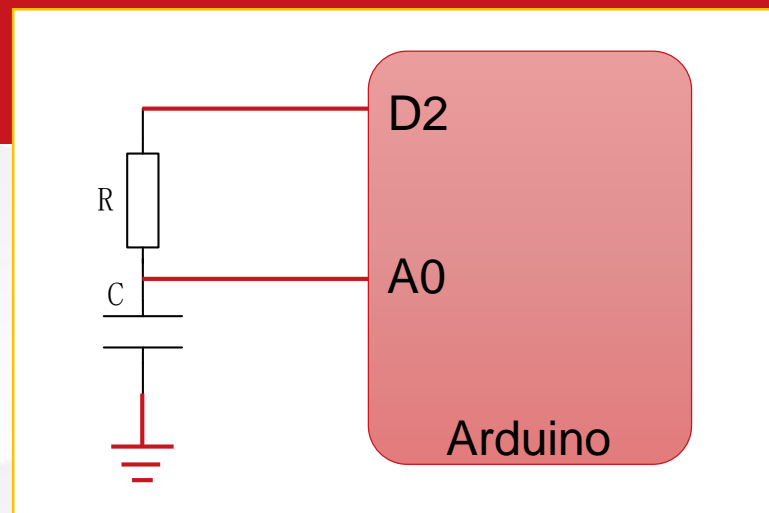
```
digitalWrite(2, HIGH);  
timeStart=micros();
```

```
while(true)  
{
```

```
    A0_Value=analogRead(A0);
```

```
    if(A0_Value>=1023*0.632)  
    {  
        timeEnd=micros();  
        break;  
    }
```

```
}  
Serial.println((timeEnd-timeStart)/1000);
```





02

元件参数测量（基础任务）



实验器材

电子电路系统实验器材

名称	数量	
单片机	1	
数据线	1	
面包板	1	
硬导线	1m	
电阻680欧	6	
电阻510千欧(替代原理图中470K, 计算请注意)	6	
被测电阻360欧	2	
被测电阻5.6千欧	2	
被测电阻100千欧	2	
被测电容47pF	2	
被测电容0.1uF/104	2	
被测电容10uF	2	
被测NPN三极管9013	2	
被测PNP三极管9012	2	
饭盒	1	
剥线钳	1	

面包板

待测元件

所有器材均回收

色环电阻值查询



<https://www.digikey.cn/zh/resources/conversion-calculators/conversion-calculator-resistor-color-code>

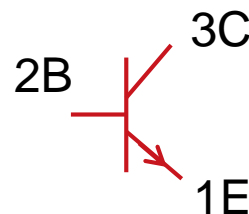
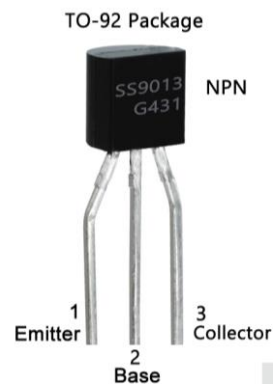
电容值查询



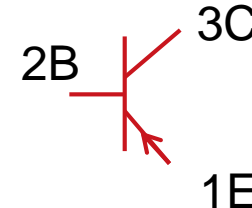
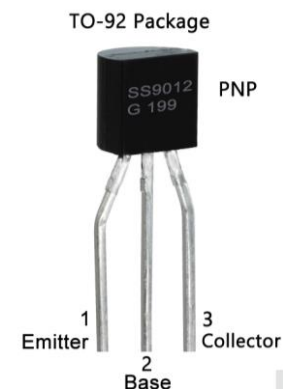
<https://www.digikey.cn/zh/resources/conversion-calculators/conversion-calculator-smd-capacitor-code>

三极管

NPN-9013



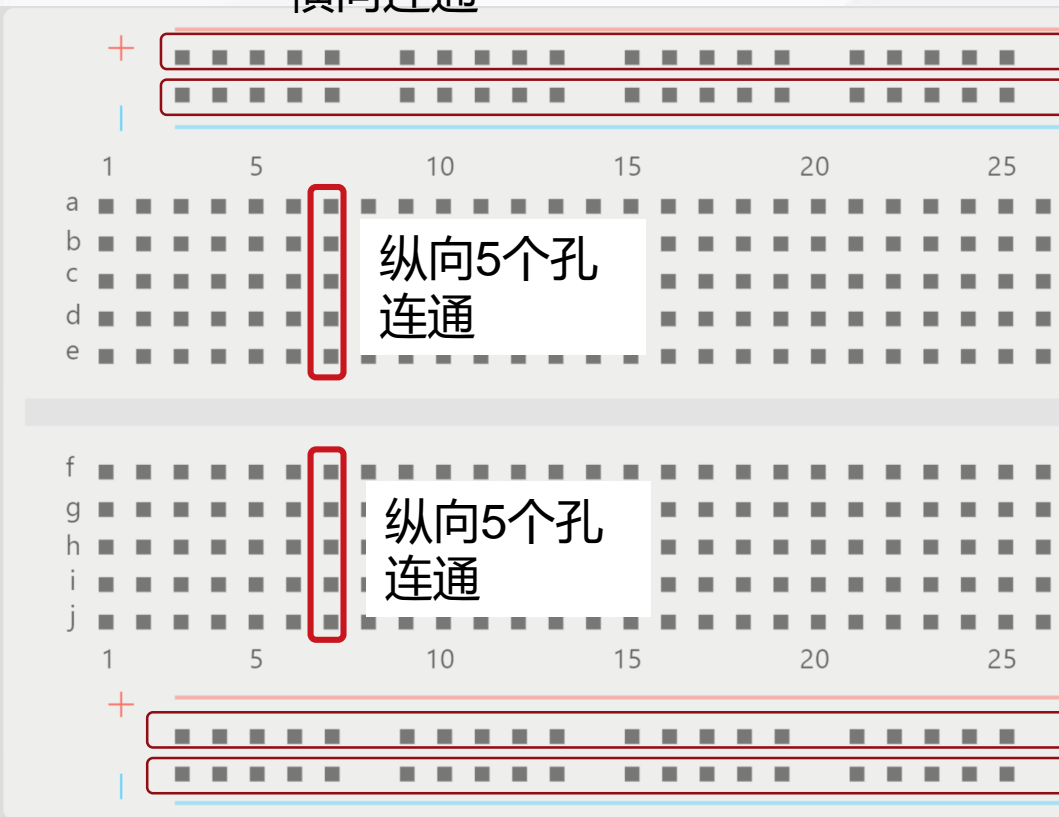
PNP-9012





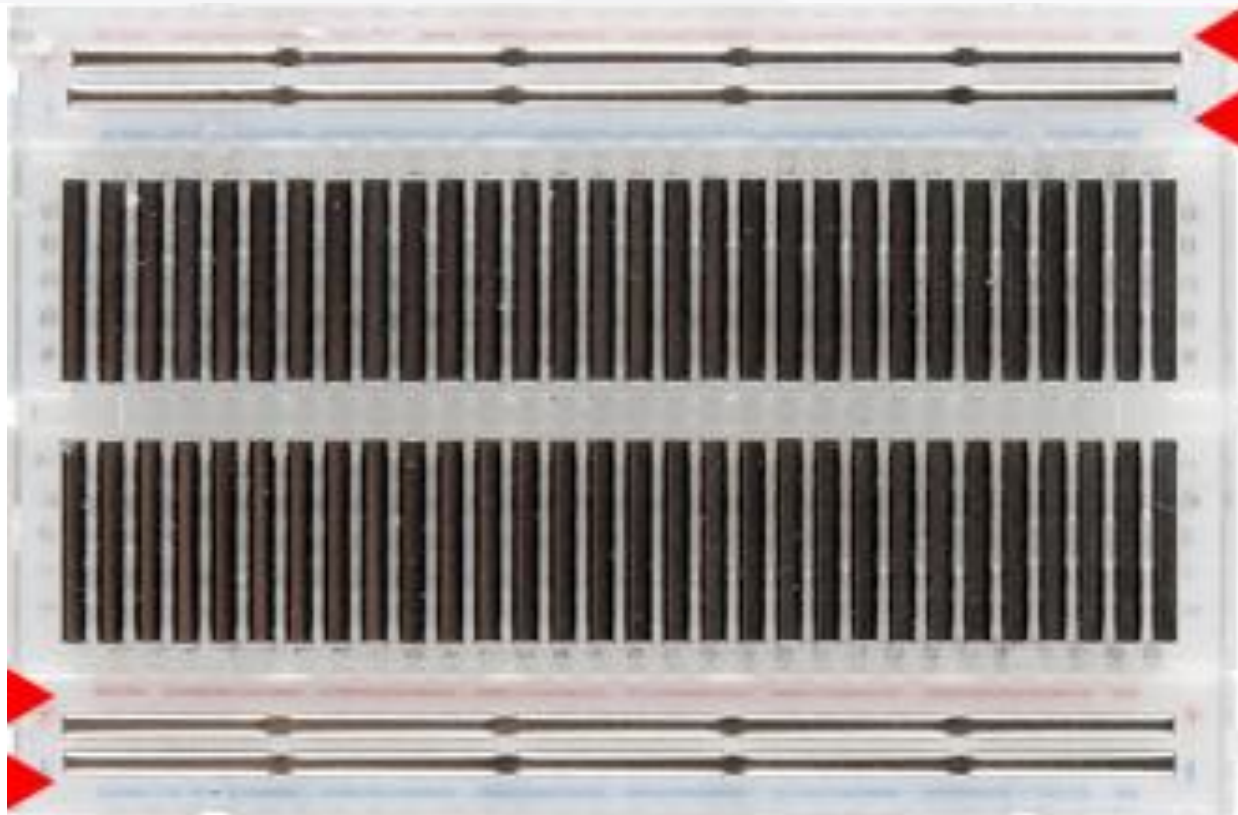
实验器材-面包板

横向连通



横向连通

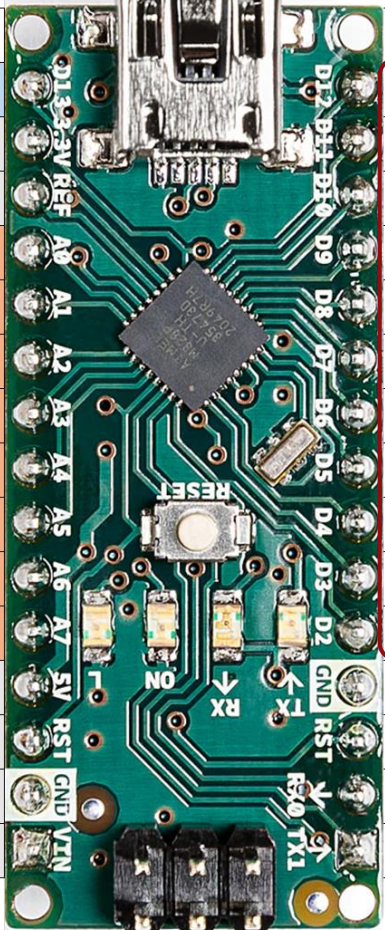
面包板正面



面包板内部构造



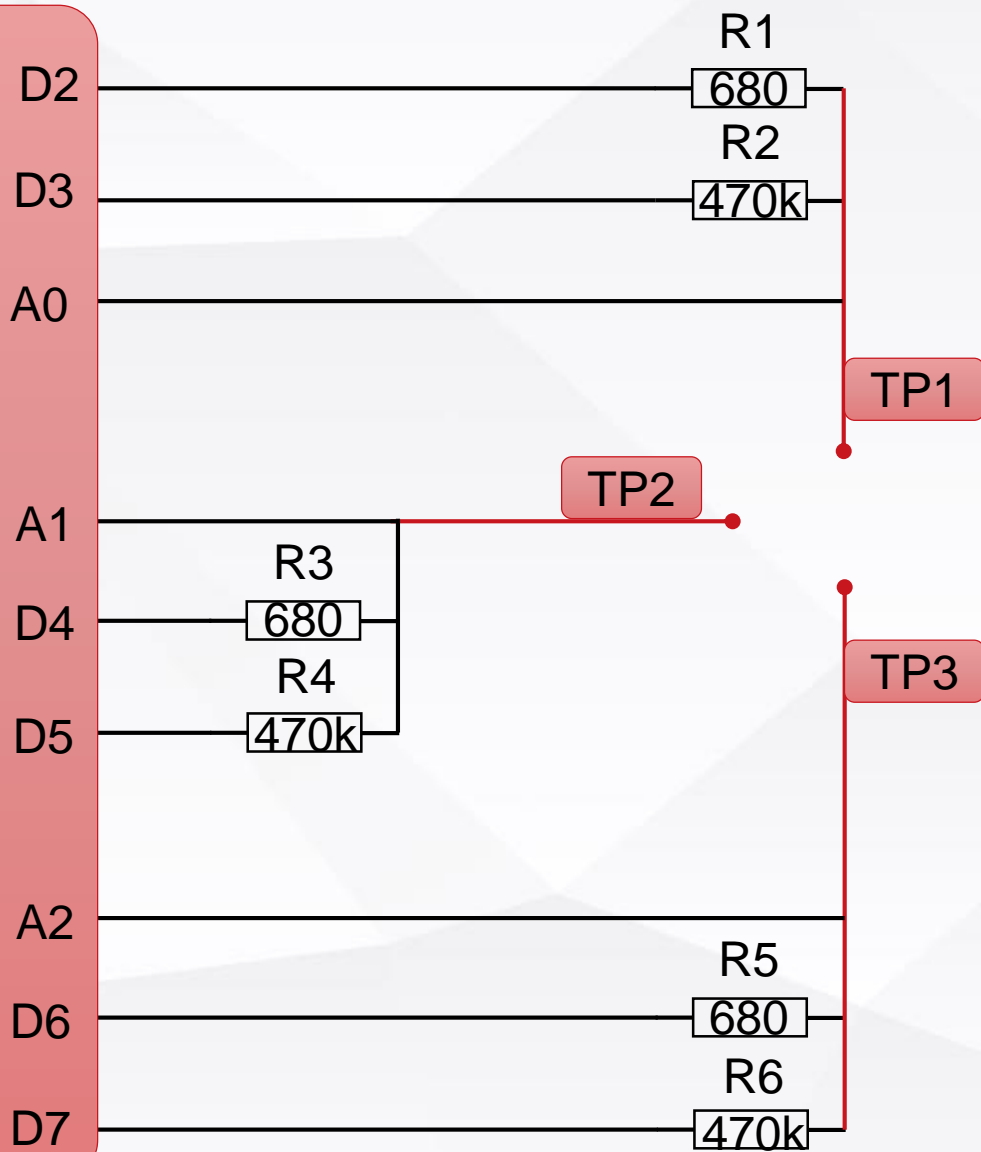
实验器材-Arduino

					
数字IO	模拟IO		数字IO	PWM	通信
	D13		D12		MISO
	+3V3		~D11	Timer2A	MOSI
	AREF		~D10	Timer1B	SS
D14	A0		~D9	Timer1A	
D15	A1		D8		
D16	A2		D7		
D17	A3		~D6	Timer0A	
D18	A4		~D5	Timer0B	
D19	A5		D4		
	A6		~D3	Timer2B	
	A7		D2		
	+5V		GND		
	Reset		Reset		
	GND		D0		TXD
	VIN		D1		RXD

digitalRead digitalWrite		PWM输出 analogWrite		电压测量 analogRead	串口输出 Serial.println
数字IO	PWM	数字IO	AD		UART
D0		D14	A0		RXD
D1		D15	A1		TXD
D2		D16	A2		
~D3	~D3	D17	A3		
D4		D18	A4		
~D5	~D5	D19	A5		
~D6	~D6		A6		
D7			A7		
D8					
~D9	~D9				
~D10	~D10				
D11					
D12					
D13					



原件参数测试原理图



$$R1 = R3 = R5 = 680\Omega$$

$$R2 = R4 = R6 = 470k\Omega$$

数字IO引脚状态

悬空

`pinMode(D2, INPUT)`

输出5V

`pinMode(D2, OUTPUT)`

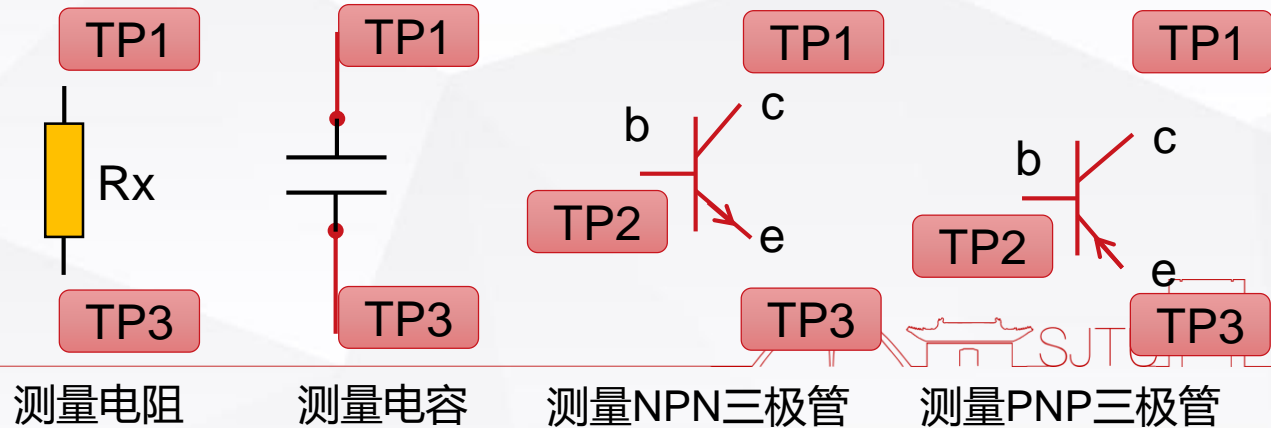
`digitalWrite(D2, HIGH)`

输出0V

`pinMode(D2, OUTPUT)`

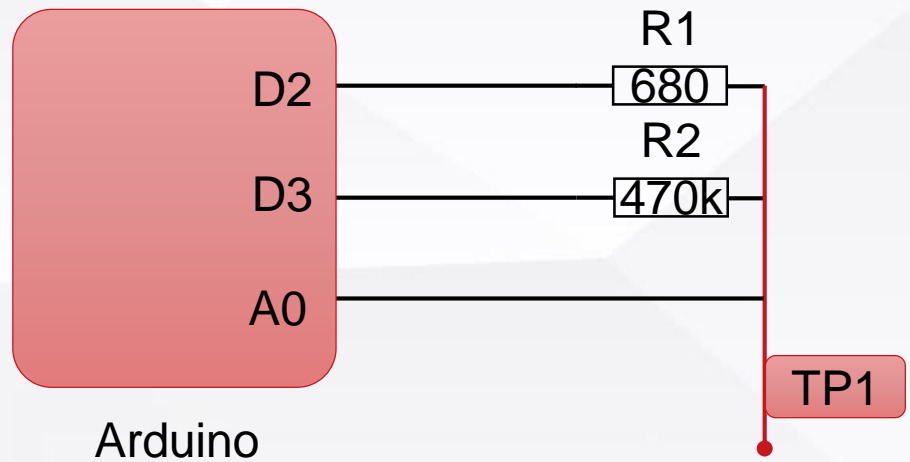
`digitalWrite(D2, LOW)`

Arduino





TestPoint状态切换



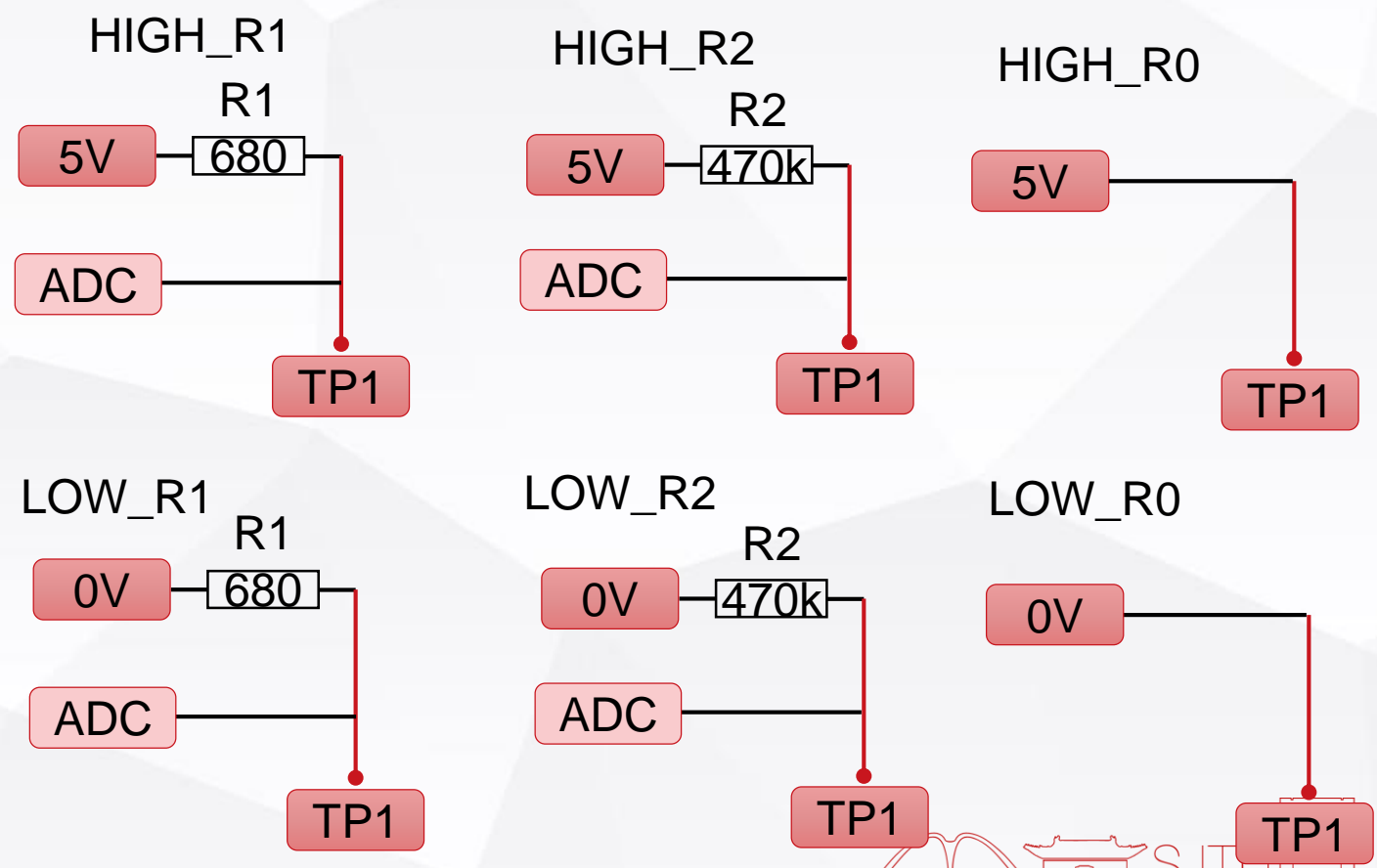
```
HIGH_R1
{
//D3输出5V, R2接入
pinMode(D3,OUTPUT)
digitalWrite(D3,HIGH)
//D2悬空
pinMode(D2,INPUT)
}
```

```
HIGH_R2
{
//D2输出5V, R1接入
pinMode(D2,OUTPUT)
digitalWrite(D2,HIGH)
//D3悬空
pinMode(D3,INPUT)
}
```

```
LOW_R1
{
//D3输出5V, R2接入
pinMode(D3,OUTPUT)
digitalWrite(D3,? )
//D2悬空
pinMode(D2,INPUT)
}
```

```
LOW_R2
{
//D2输出5V, R1接入
pinMode(D2,OUTPUT)
digitalWrite(D2,? )
//D3悬空
pinMode(D3,INPUT)
}
```

TestPoint		TestPoint状态					
Arduino 引脚	电阻	HIGH_R1	LOW_R1	HIGH_R2	LOW_R2	HIGH_R0	LOW_R0
D2	680	1	0	悬空	悬空	悬空	悬空
D3	470k	悬空	悬空	1	0	悬空	悬空
A0	0Ω	ADC	ADC	ADC	ADC	1	0





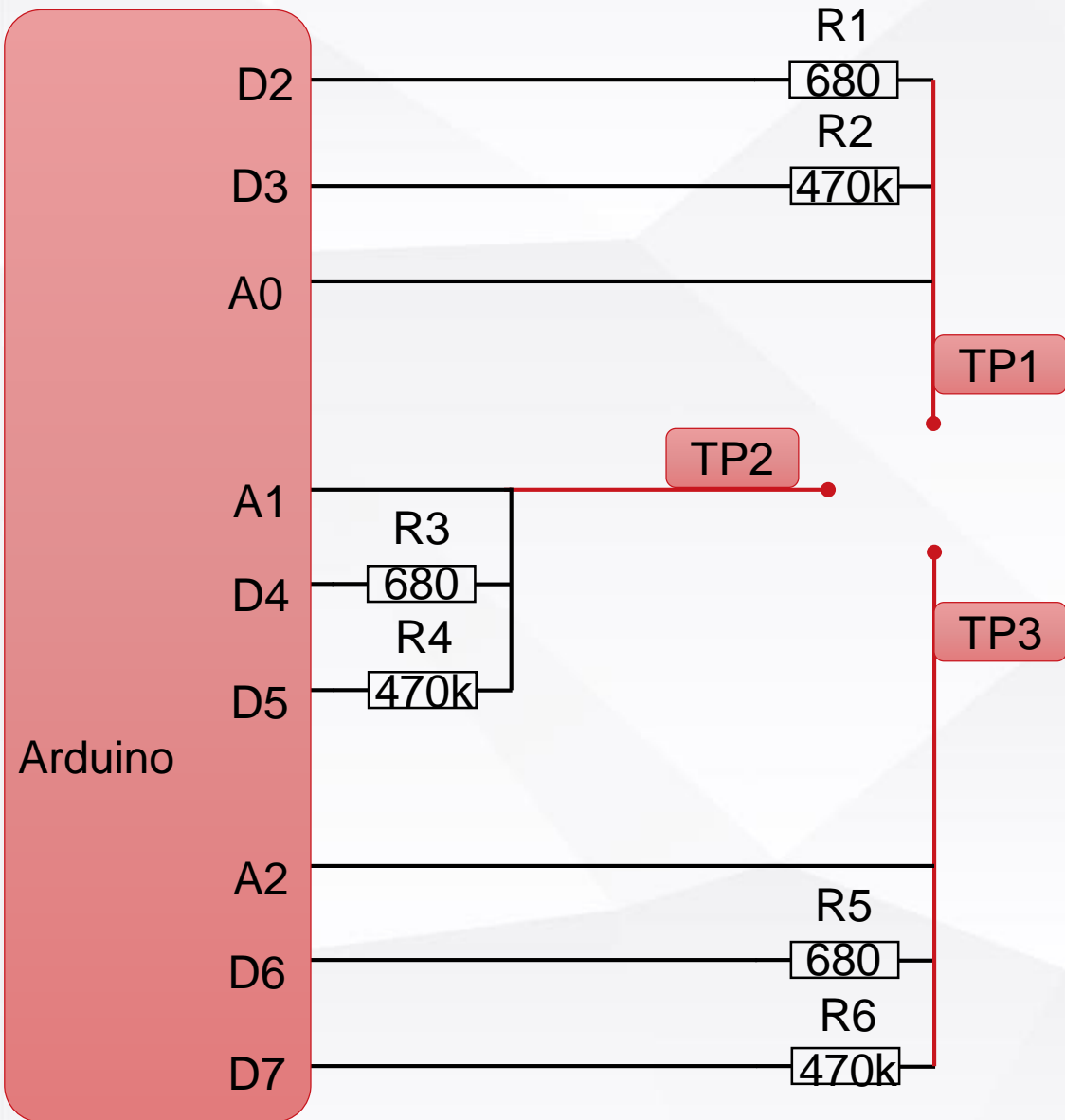
TestPoint类

尝试实现TestPoint类，为原件测量提供支撑

```
class TestPoint
{
    public:
        TestPoint(int R1_pin, int R2_pin, int ADC_Pin);
        void SetState(int TPState); //设置TestPoint状态
        int analogRead(); //读取TP电压ADC原始值, 范围0-1023
        double ReadVoltage(); //读取TP电压值, 范围0-5V

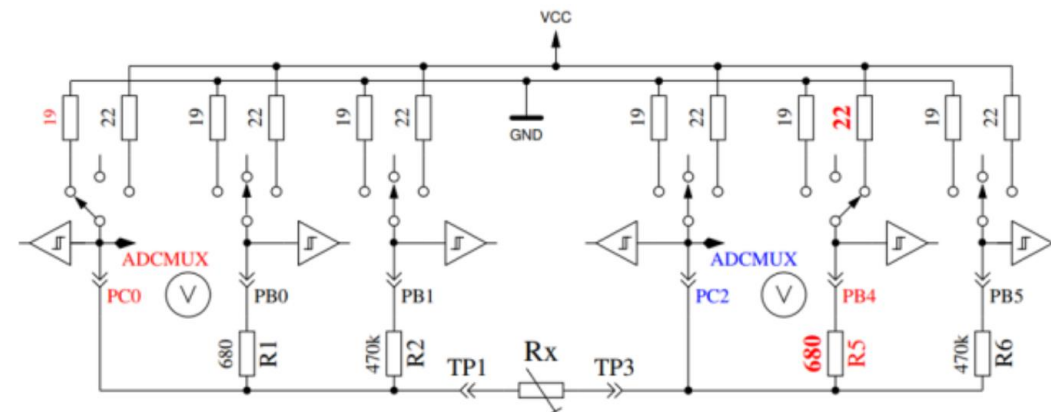
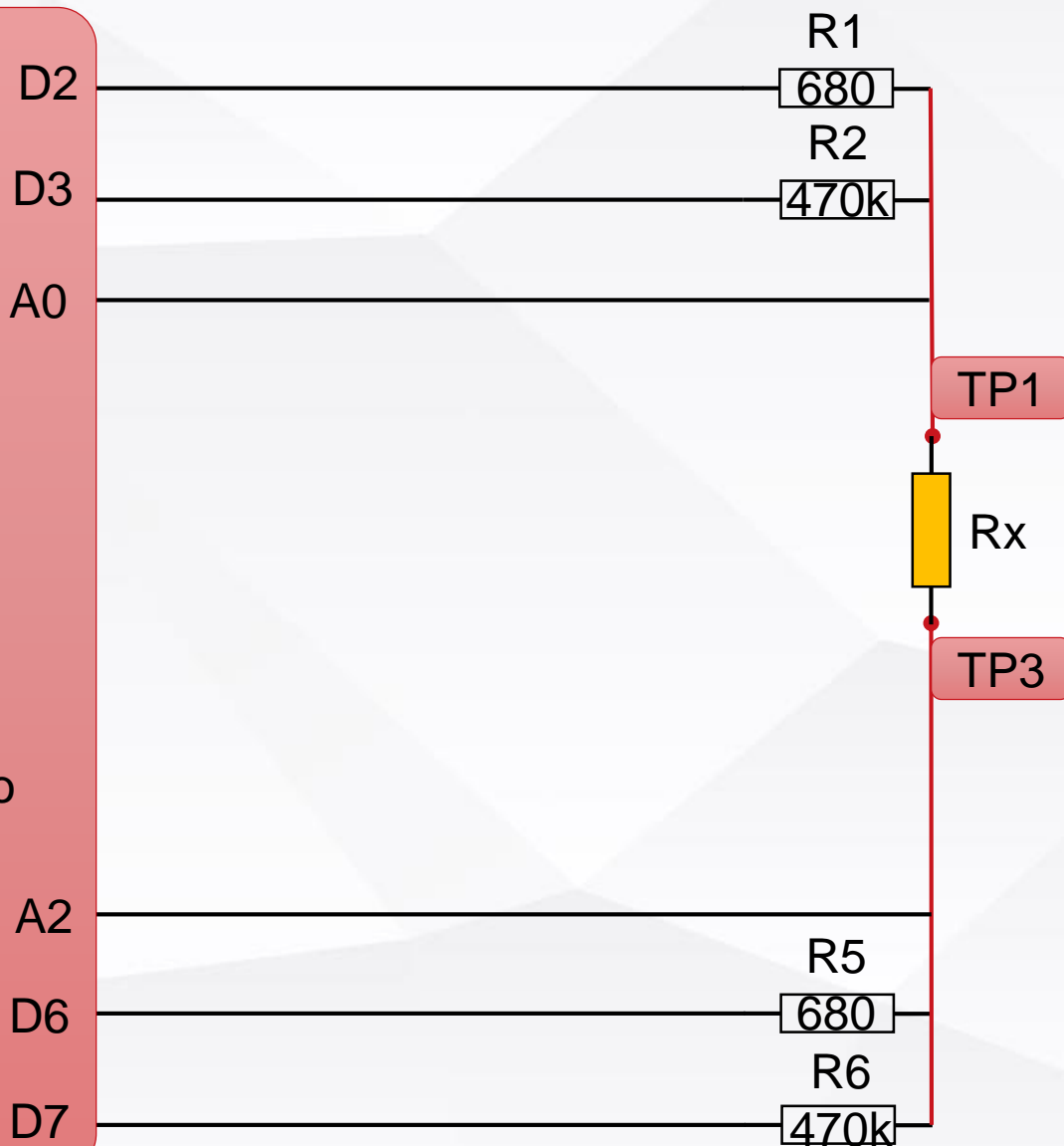
    private:
        int R1_pin, R2_pin, ADC_Pin;
};

//TP1, TP2, TP3实例化
class TestPoint TP1(2, 3, A0);
class TestPoint TP2(4, 5, A1);
class TestPoint TP3(6, 7, A2);
```

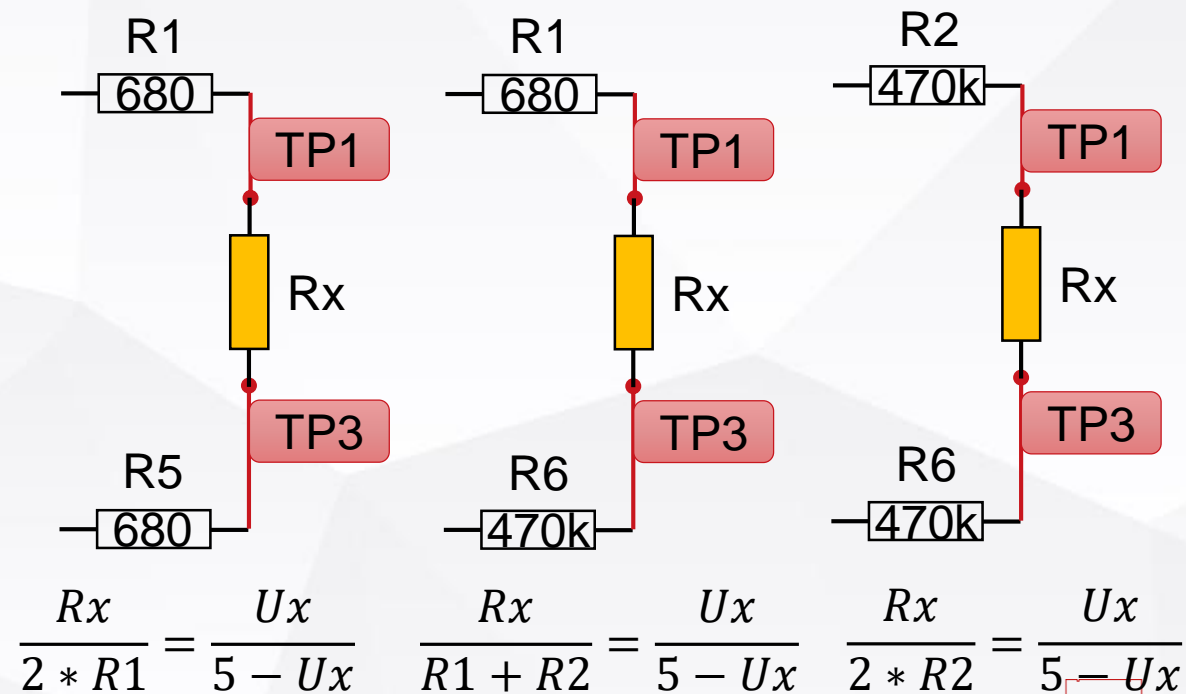




测量电阻



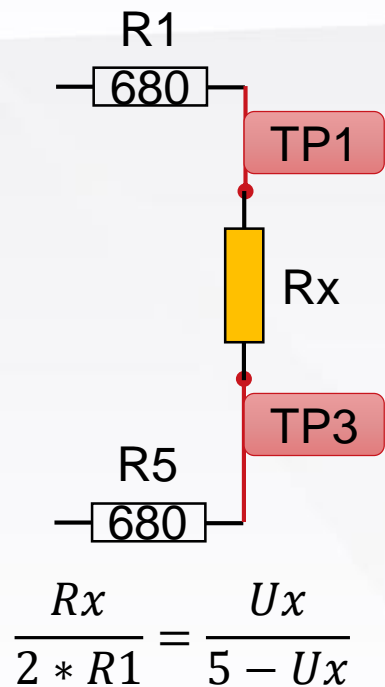
R	680*2	680+470k	470K*2
TP1	HIGH_R1	HIGH_R1	HIGH_R2
TP3	LOW_R1	LOW_R2	LOW_R2





测量电阻

R	680*2
TP1	HIGH_R1
TP3	LOW_R1



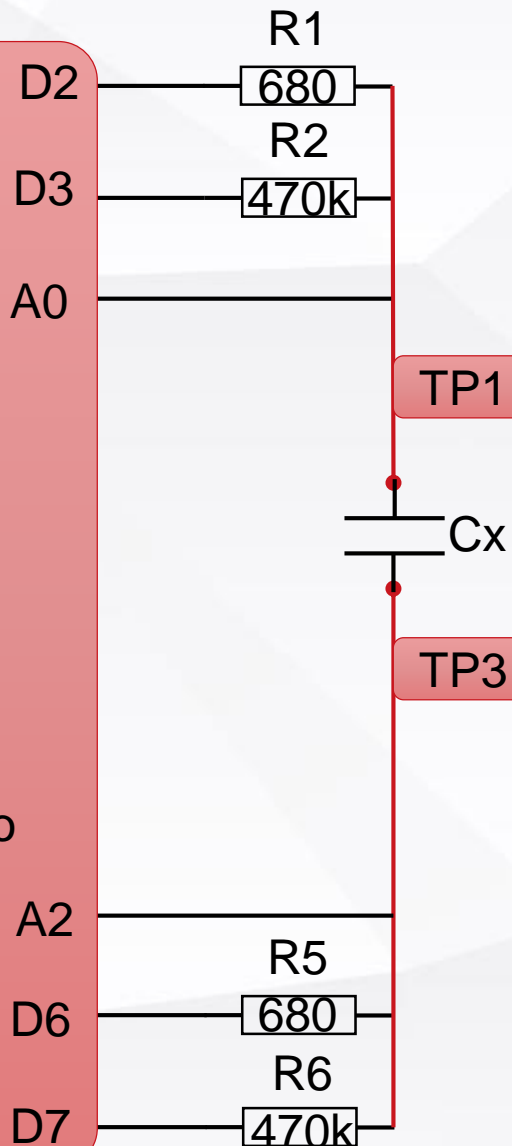
TP1.SetState(HIGH_R1)
TP3.SetState(LOW_R1)

U(TP1)=TP1.analogRead();
U(TP1)=TP1.analogRead();
U(Rx)=U(TP1,TP3)

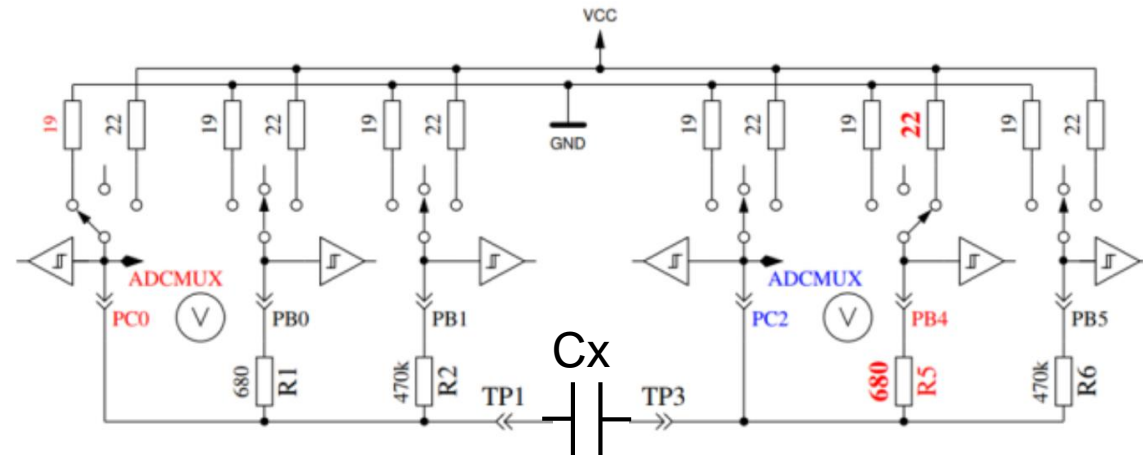
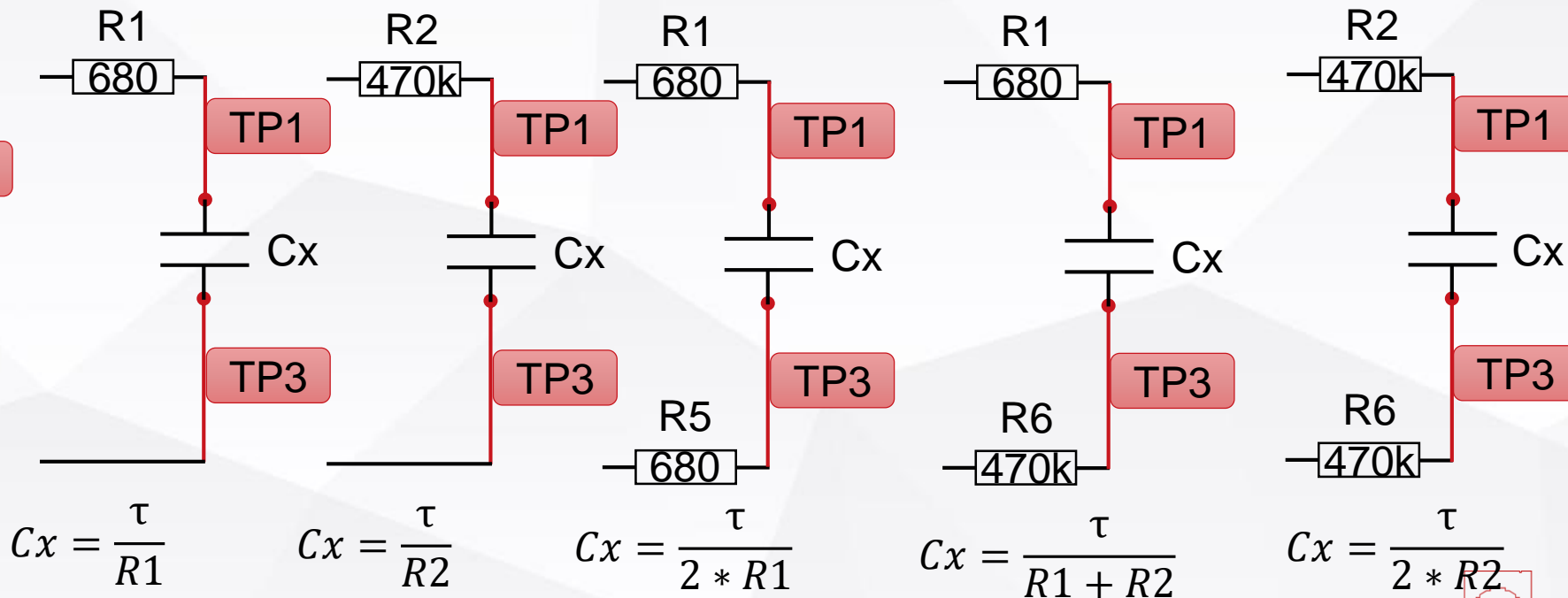
$$\frac{R_x}{2 * R1} = \frac{U(Rx)}{5 - U(Rx)}$$



测量电容

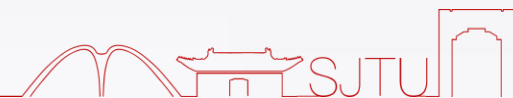
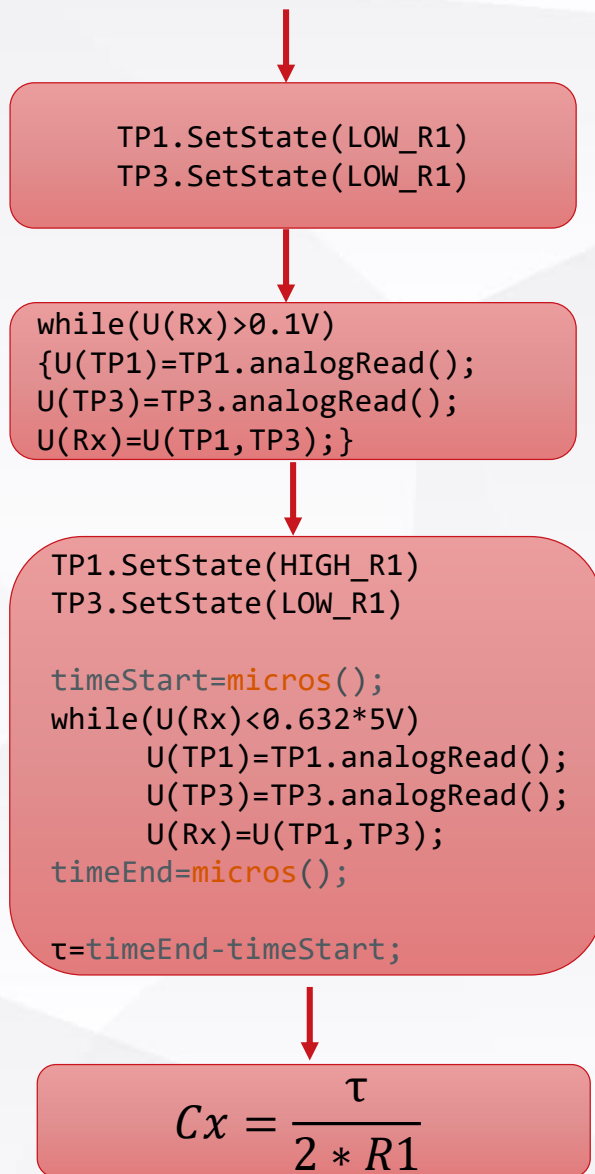
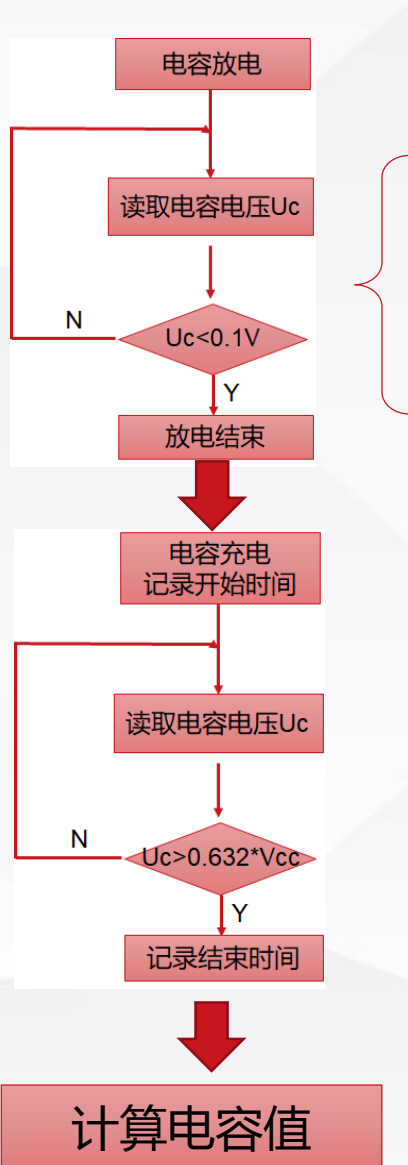
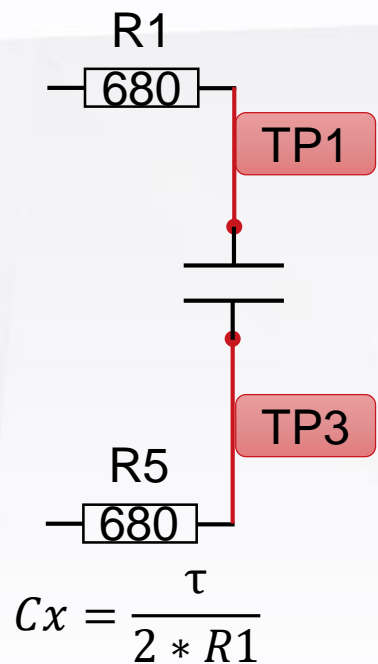


R	680	470k	680*2	680+470k	470K*2
TP1	HIGH_R1	HIGH_R2	HIGH_R1	HIGH_R1	HIGH_R2
TP3	LOW_R0	LOW_R0	LOW_R1	LOW_R2	LOW_R2



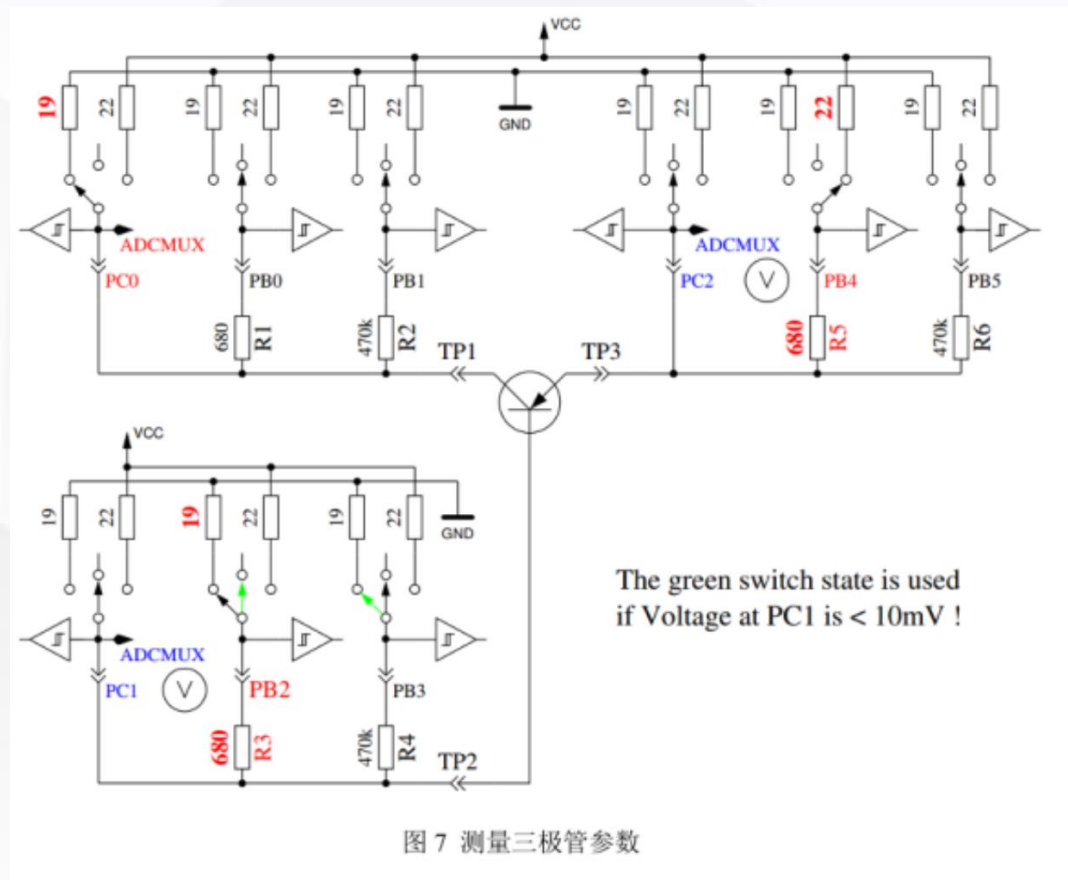
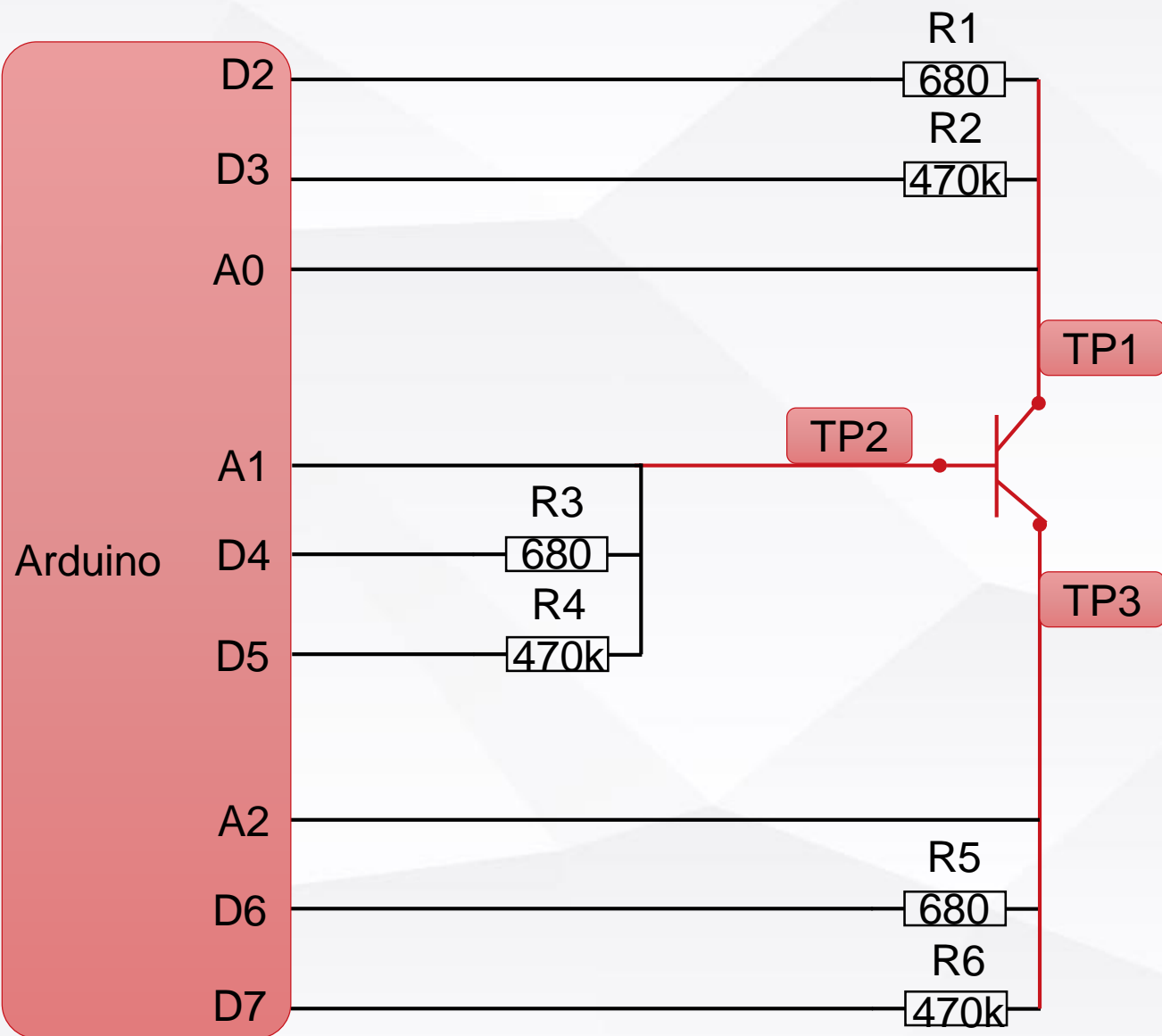


测量电容



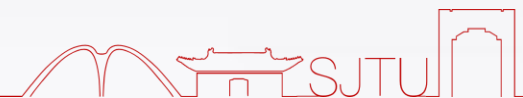
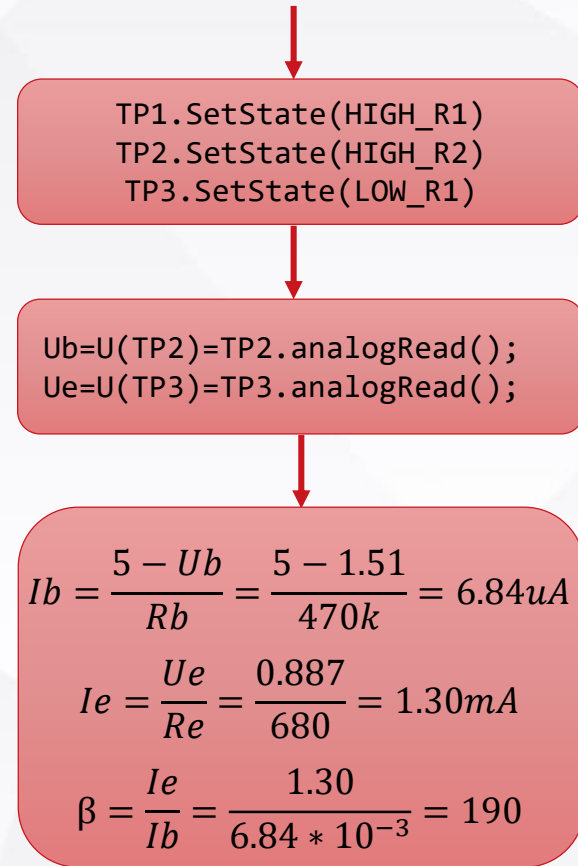
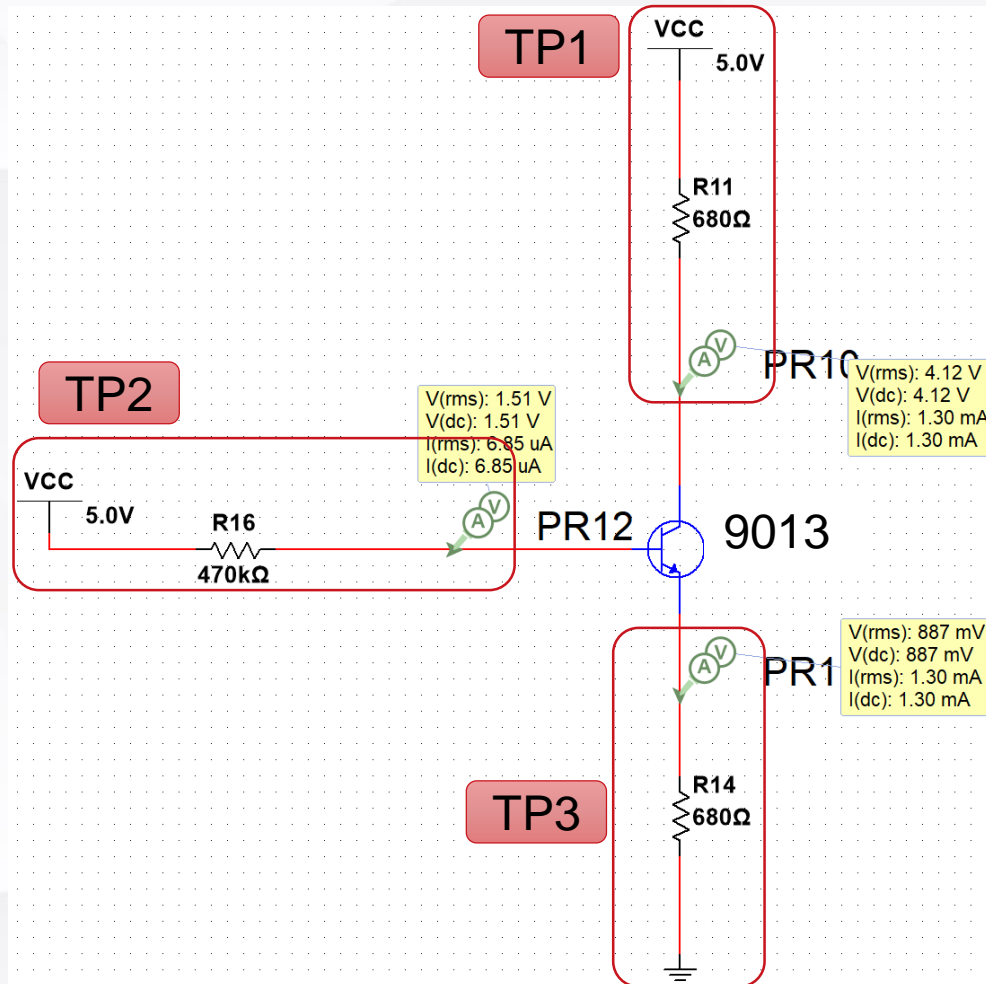
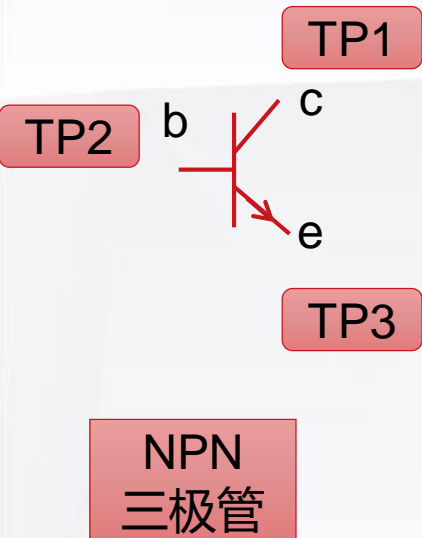


测量三极管



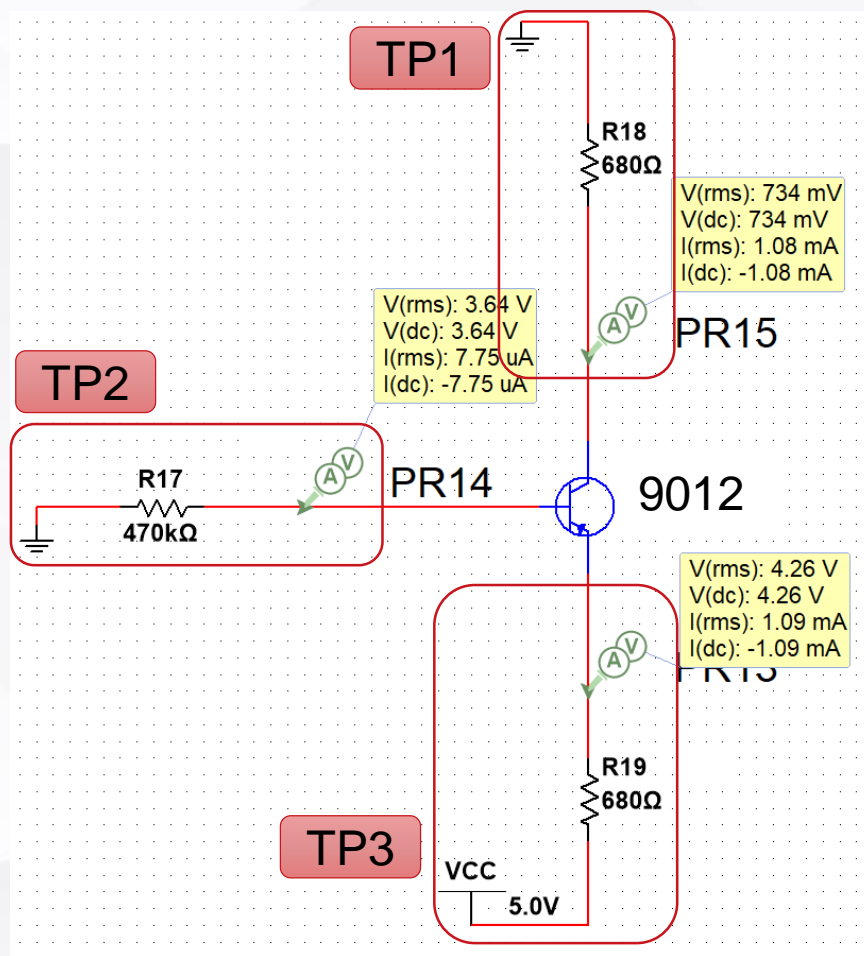
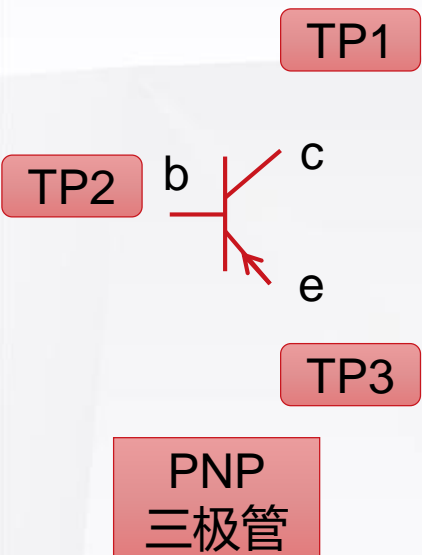


测量三极管(NPN)





测量三极管(PNP)



```
TP1.SetState(LOW_R1)  
TP2.SetState(LOW_R2)  
TP3.SetState(HIGH_R1)
```

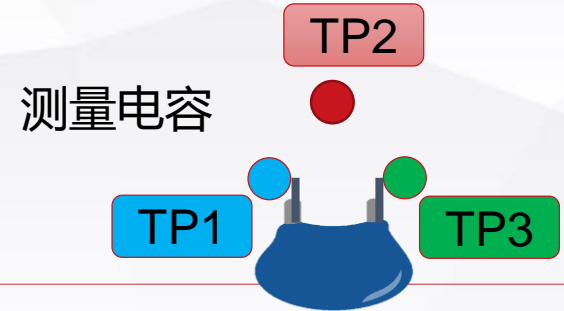
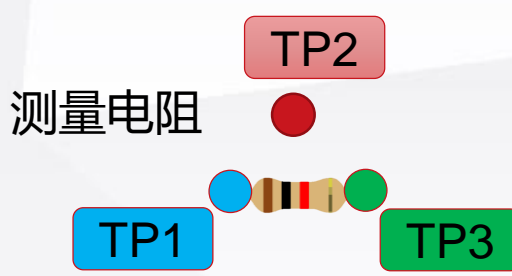
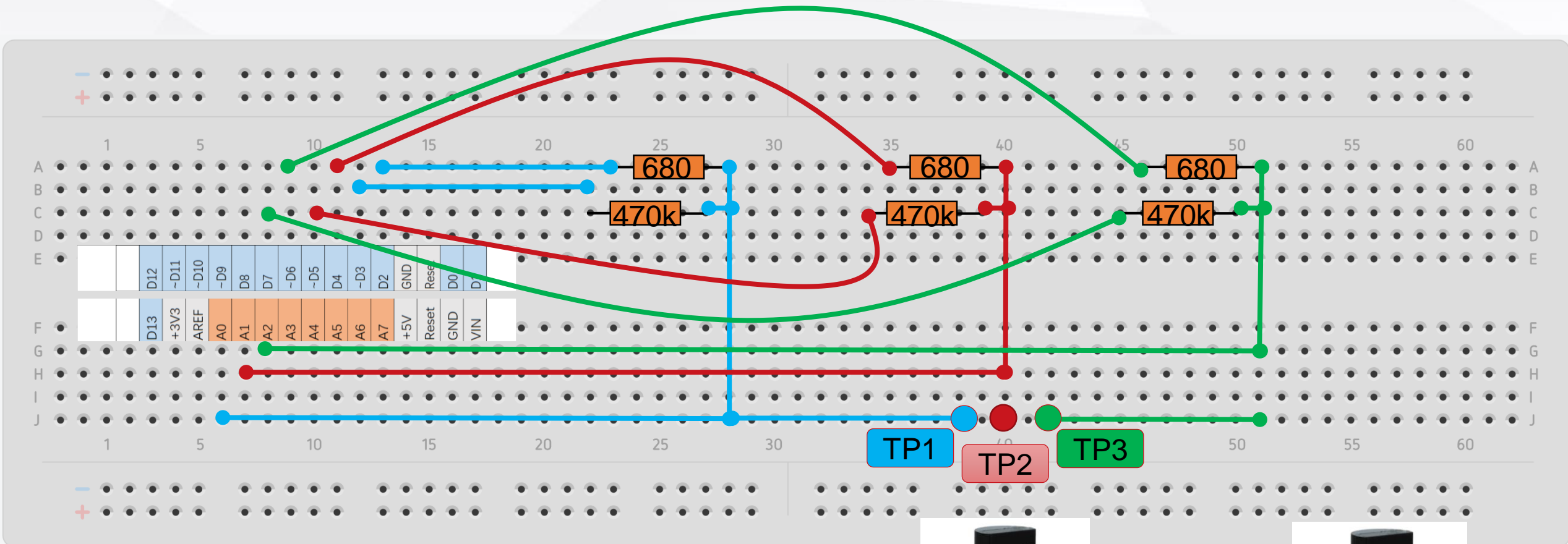
```
Ub=U(TP2)=TP2.analogRead();  
Ue=U(TP3)=TP3.analogRead();
```

$$I_b = \frac{U_b}{R_b} = \frac{3.64}{470k} = 7.74\mu A$$
$$I_e = \frac{5 - U_e}{R_e} = \frac{5 - 4.26}{680} = 1.09mA$$
$$\beta = \frac{I_e}{I_b} = \frac{1.09}{7.74 * 10^{-3}} = 141$$

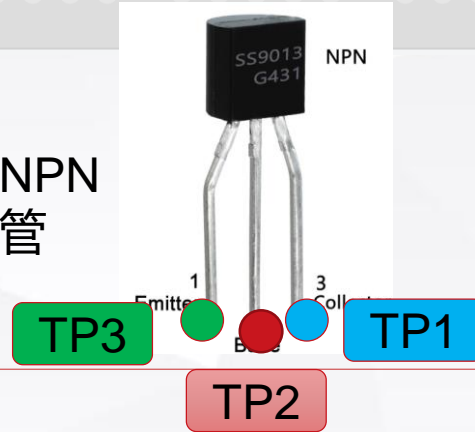




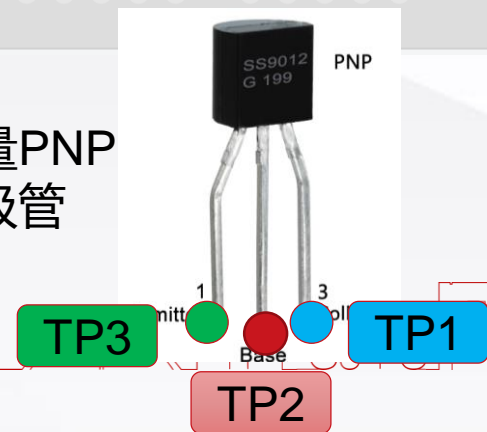
面包板连线示意图(完整)



测量NPN
三极管



测量PNP
三极管





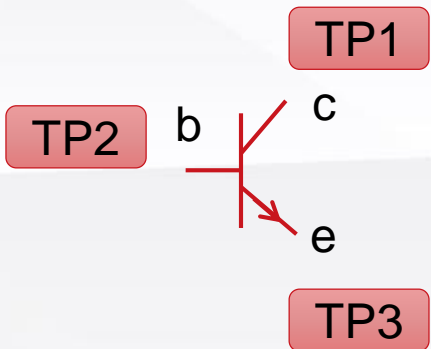
03

元件类型判别（进阶任务）



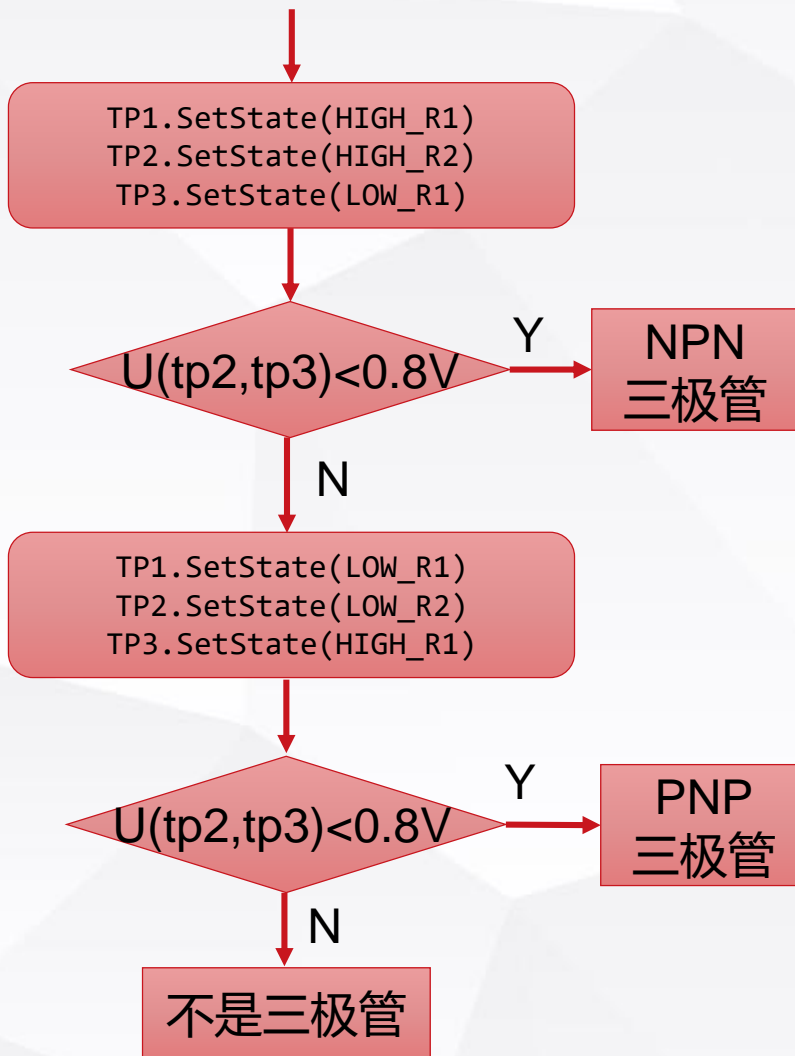
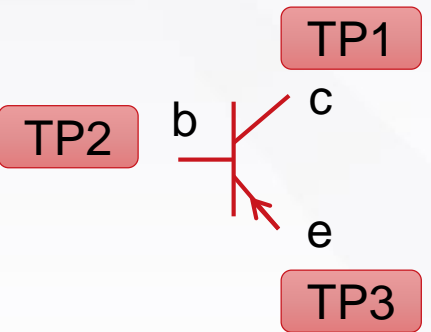
判断三极管

NPN
三极管



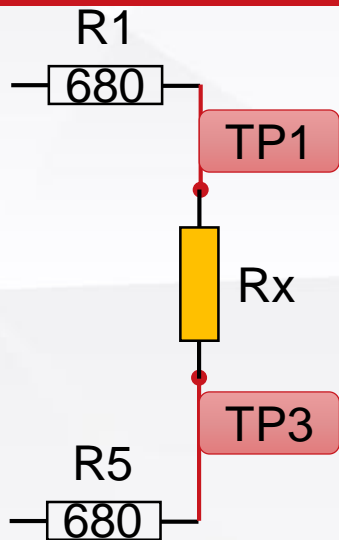
三极管BE间导通
电压约等于0.6V,
判断其导通电压
小于0.8V, 即可
认为是三极管。

PNP
三极管

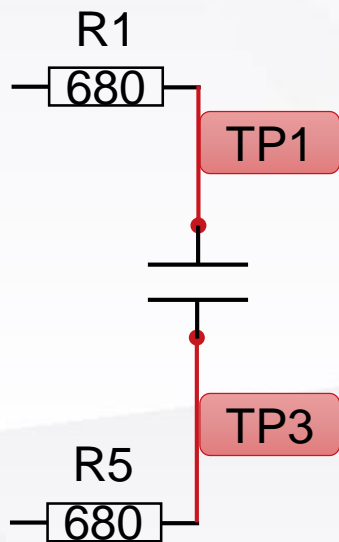




分辨电阻和电容



电容充放电时电压会变化，而电阻电压恒定。
采集一段时间内的 $U(TP1, TP3)$ ，如果恒定则为电阻，不恒定则为电容。



分辨电阻和电容

```
TP1.SetState(HIGH_R1)  
TP3.SetState(LOW_R1)
```

```
for(i=0;i<100;i++)  
    U(TP1)=TP1.analogRead();  
    U(TP3)=TP3.analogRead();  
    U[i]=U(TP1,TP3);  
    delay(10);
```

计算 $U[100]$ 中元素的方差，较小则为电阻，较大则为电容



元件类型判别流程

