$$K^A_TEX \; MarkDown \; HTML \; VsCode \; PicGo \; MyEasyPicBedMain \; Prince \; PADS$$

Logic重要设置

选项

设置"选项->常规->光标：全屏"，方便对齐元件

打开"选项->常规->在备份文件名中使用设计名称；在设计目录下创建备份文件"

取消勾选"选项->设计->允许命名子网无标签"

取消勾选"选项->设计->允许使用库中的空值覆盖设计中的属性值"

勾选"选项->设计->跨图页标签->显示页间链接图页编号"，通过"设置->网页"就可以添加多个网页，从而让电路原理图跨页，每行页码数可以指定最大页码位数(根据页数量设置)，页间连接符可以让引脚跨页，显示页间链接图页编号就会让元件连接符成对的显示编号

勾选"选项->设计->粘贴时保留参考编号"

勾选"选项->设计->允许悬浮连线"(不开启，则无法通过双击结束连线，同时右击没有结束连线选项)

图页尺寸是整个图纸的大小；图页边界线是有效图纸大小

在图页中"右键->字段"可以编辑图页的用户信息

"设置->显示颜色"可以设置显示颜色

设计技巧

模块化设计：通过页间连接符实现，多页面分模块设计，比如下表：

图页编号	图页标题	图页内容
1	POWER	稳压电源
2	MCU	STM32、STLINK、晶振、复位、BOOT
3	KEY&LED	按键、发光二极管
4	RELAY&BUZZER	继电器、蜂鸣器
5	ARDUINO	Arduino接口
6	USB/UART	USB转UART电路

原理图绘制

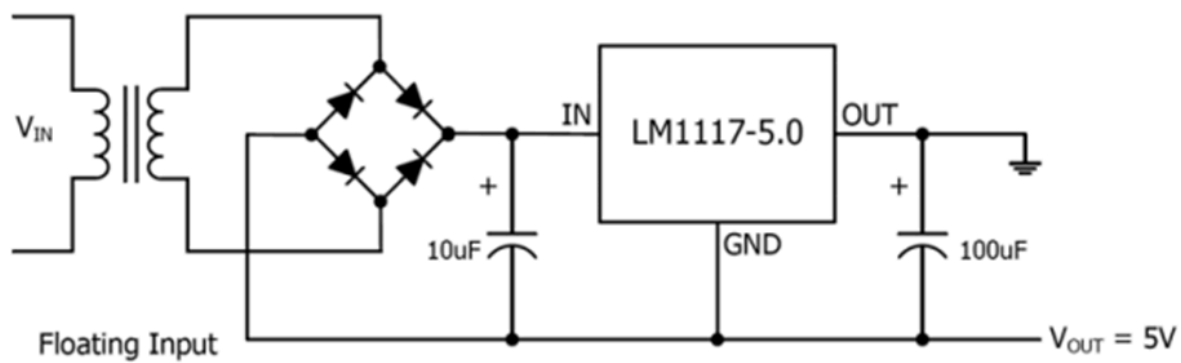一般参考元件数据手册的推荐电路完成

供电

比如M1117数据手册：
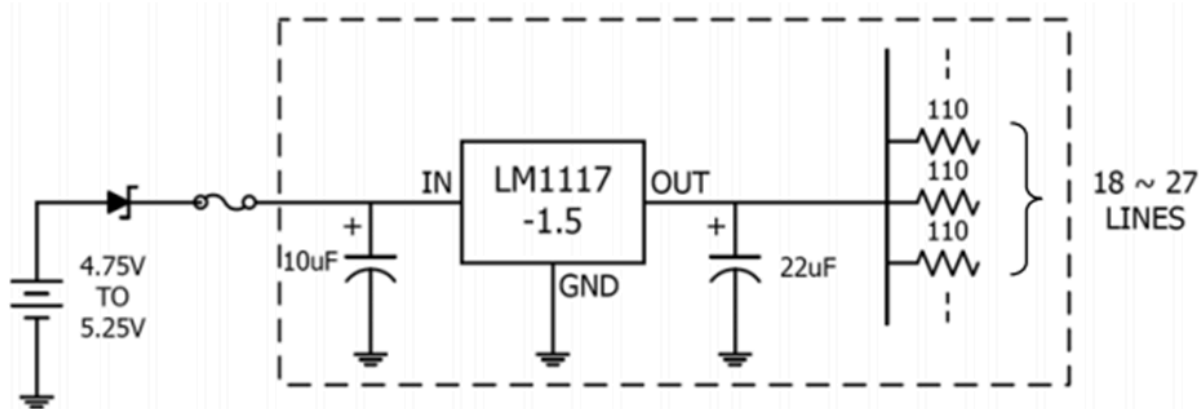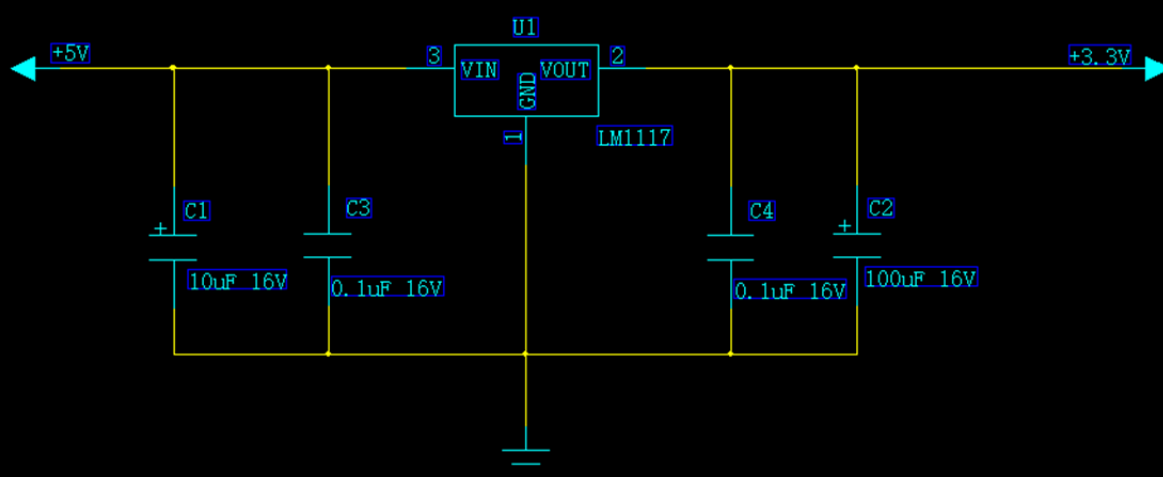
Fig.3 Negative Supply

**Fig.4 Active Terminator for SCSI-2BUS**

增加了两个小电容 大电容滤低频，小电容滤高频

晶振

晶振数据手册:

For C_{L1} and C_{L2}, it is recommended to use high-quality external ceramic capacitors in the 5 pF to 20 pF range (Typ.), designed for high-frequency applications, and selected to match the requirements of the crystal or resonator (see *Figure 17*). C_{L1} and C_{L2} are usually the same size. The crystal manufacturer typically specifies a load capacitance which is the series combination of C_{L1} and C_{L2}. PCB and MCU pin capacitance must be included (10 pF can be used as a rough estimate of the combined pin and board capacitance) when sizing C_{L1} and C_{L2}.

Figure 17. Typical application with an 8 MHz crystal
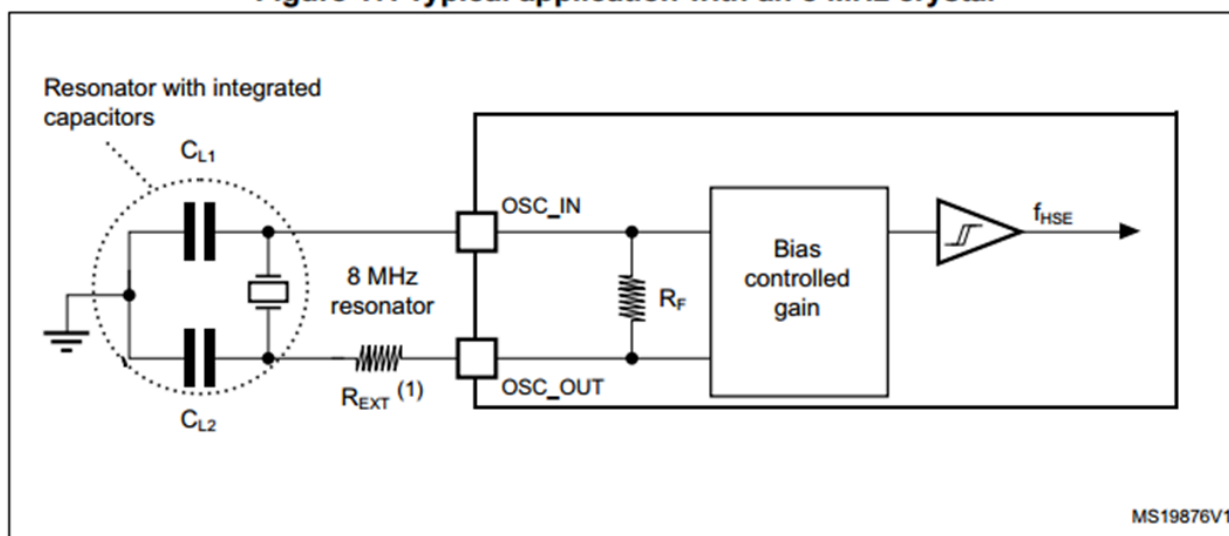
1. R_{EXT} value depends on the crystal characteristics.

■ 标准规格 (STANDARD SPECIFICATION)

Item \ Model	HC-49SM
频率范围 (Frequency Range)	3.5–30.0MHz(Fund.)
	30.0–70.0MHz(3rd Overtone)
调整频差 (Frequency Tolerance)	±30ppm
温度频差 (Freq. Tol. Over Temp)	±30ppm or ±50ppm
工作温度范围 (Operating Temp. Range)	−20~+70℃ or −40~+85℃
保存温度范围 (Storage Temp. Range)	−40~+85℃
谐振电阻 (Series Resistance)	Refer to the table as below
负载电容 (Motional Capacitance)	20pF
静态电容 (Shunt Capacitance)	7.0pF Max.
激励电平 (Drive Level)	100μw typical
年老化率 (Aging)	±5ppm Max.
绝缘阻抗 (Insulation Resistance)	500Mohm Min.

负载电容要求$20pF$

C_L load capacitance

The load capacitance is the terminal capacitance of the circuit connected to the crystal oscillator. This value is determined by the external capacitors C_{L1} and C_{L2} and the stray capacitance of the printed circuit board and connections (C_s). The C_L value is specified by the crystal manufacturer. For the frequency to be accurate, the oscillator circuit has to show the same load capacitance to the crystal as the one the crystal was adjusted for. Frequency stability mainly requires that the load capacitance be constant. The external capacitors C_{L1} and C_{L2} are used to tune the desired value of C_L to reach the value specified by the crystal manufacturer.

The following equation gives the expression of C_L:

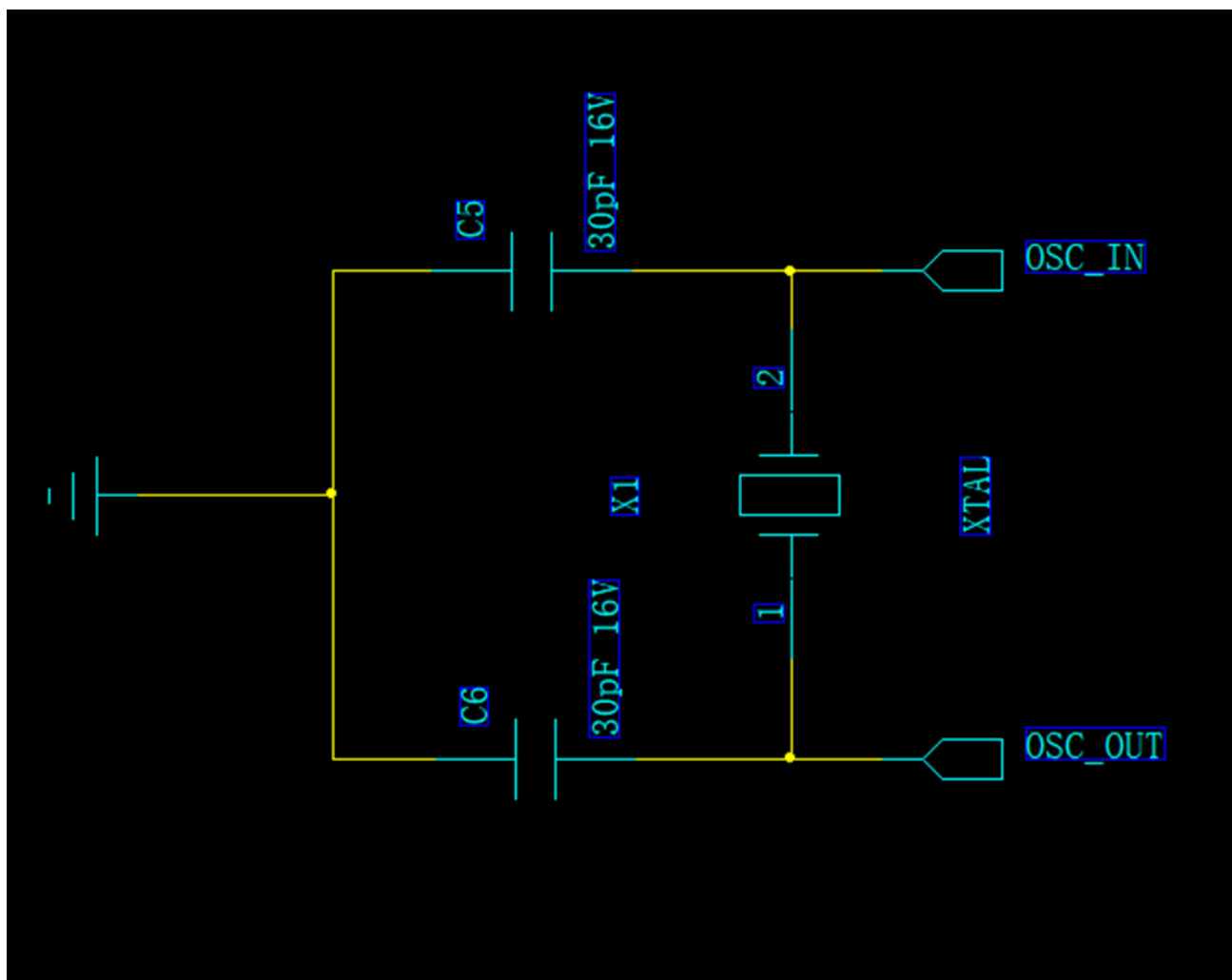$$C_L = \frac{C_{L1} \times C_{L2}}{C_{L1} + C_{L2}} + C_s$$

DocID15287 Rev 11

C_L是负载电容，这个电容的计算公式如上图

C_S是板间电容，一般是$5pF$
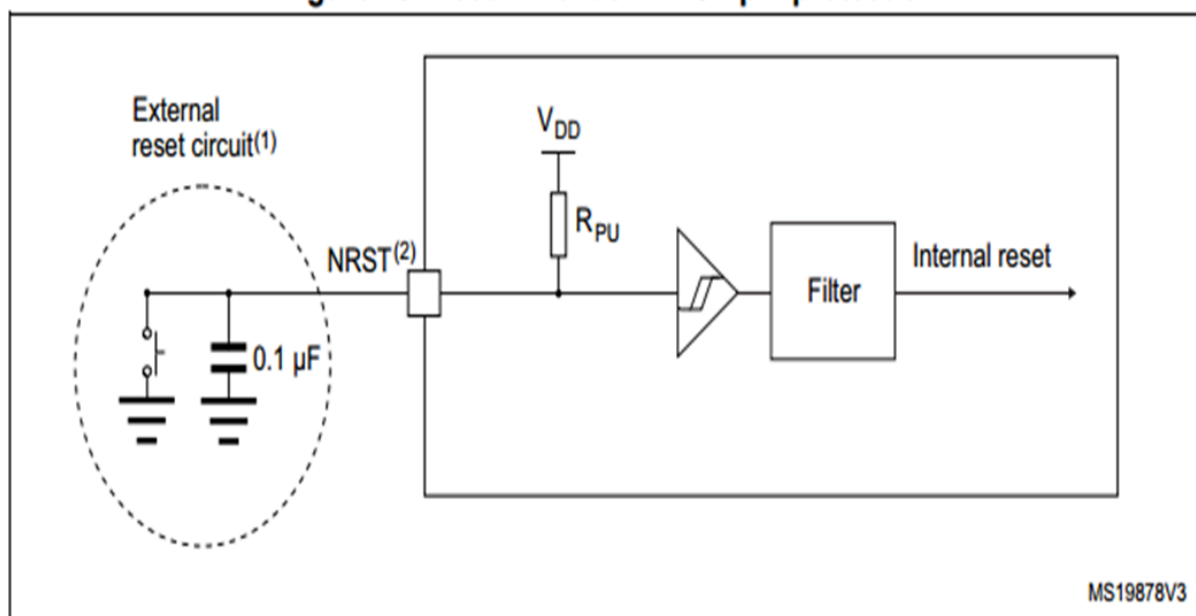
C_{L1}和C_{L1}可以同时取$30pF$

同一个页面也可以用页连接符

复位电路

复位电路参考：

Figure 25. Recommended NRST pin protection

MS19878V3

1. The external capacitor protects the device against parasitic resets.

2. The user must ensure that the level on the NRST pin can go below the $V_{IL(NRST)}$ max level specified in *Table 56: NRST pin characteristics*. Otherwise the reset will not be taken into account by the device.
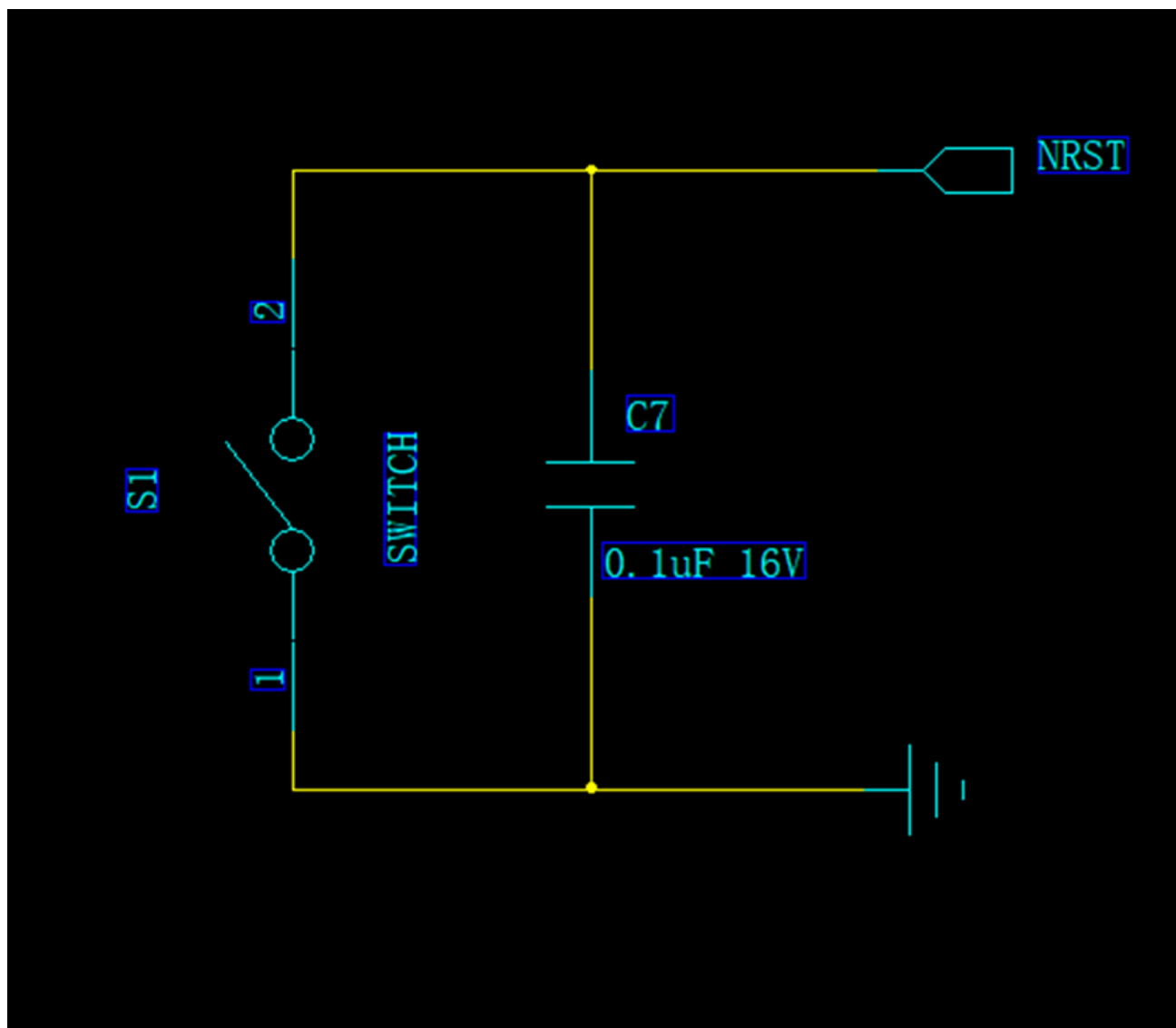
BOOT0&SWD

BOOT0电路参考：

Boot configuration

In the STM32F0x0, three different boot modes can be selected through the BOOT0 pin and boot configuration bits nBOOT1 in the User option byte, as shown in the following table.

Table 3. Boot modes

Boot mode configuration		Mode
nBOOT1 bit	BOOT0 pin	
x	0	**Main Flash memory** is selected as boot area[1]
1	1	**System memory** is selected as boot area
0	1	**Embedded SRAM** is selected as boot area

1. For STM32F070x6 and STM32F030xC devices, see also Empty check description.
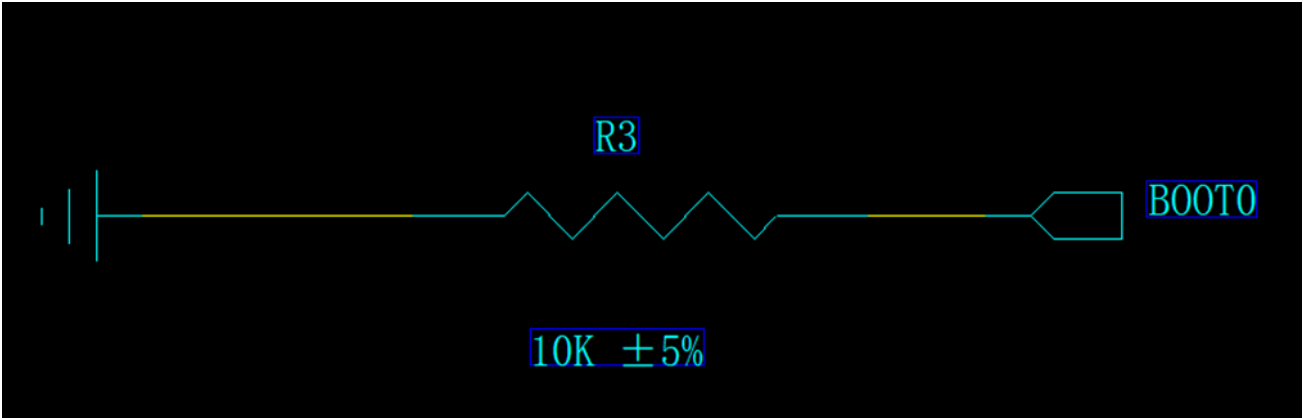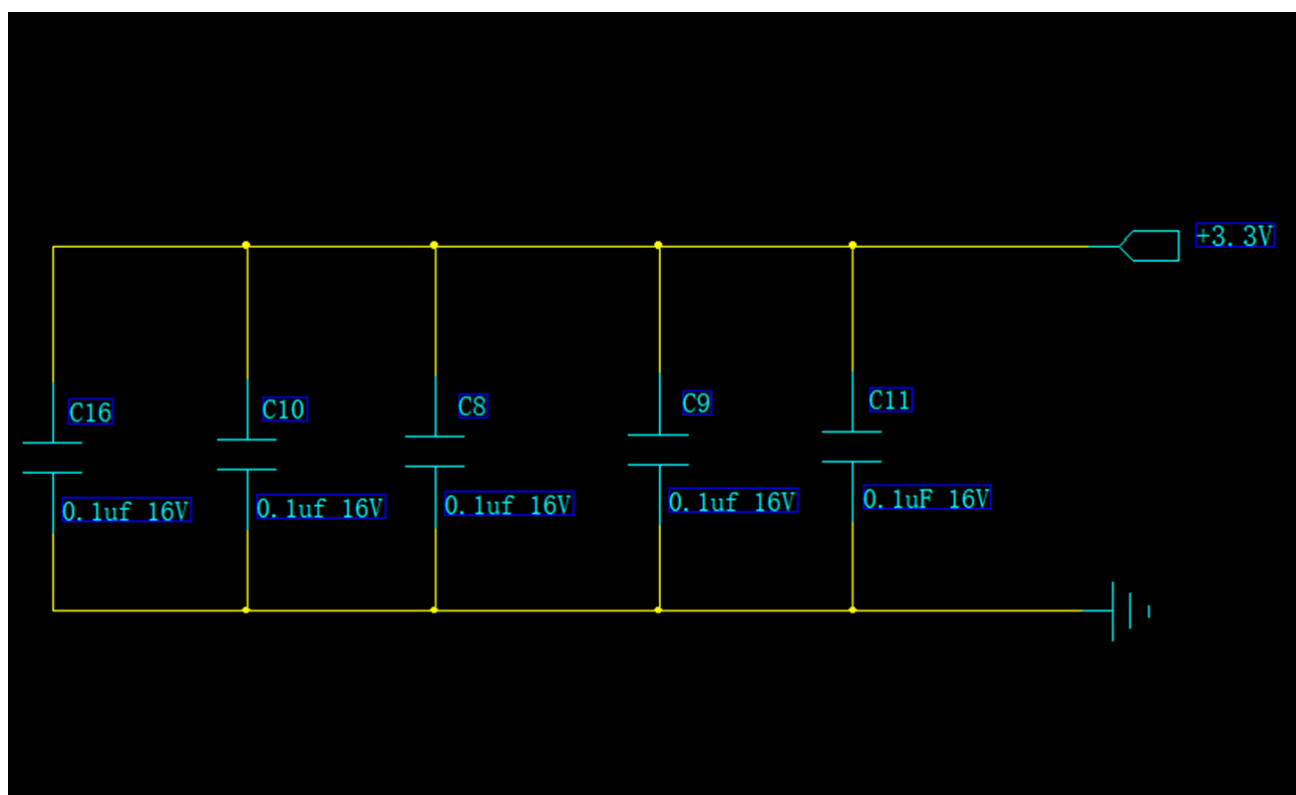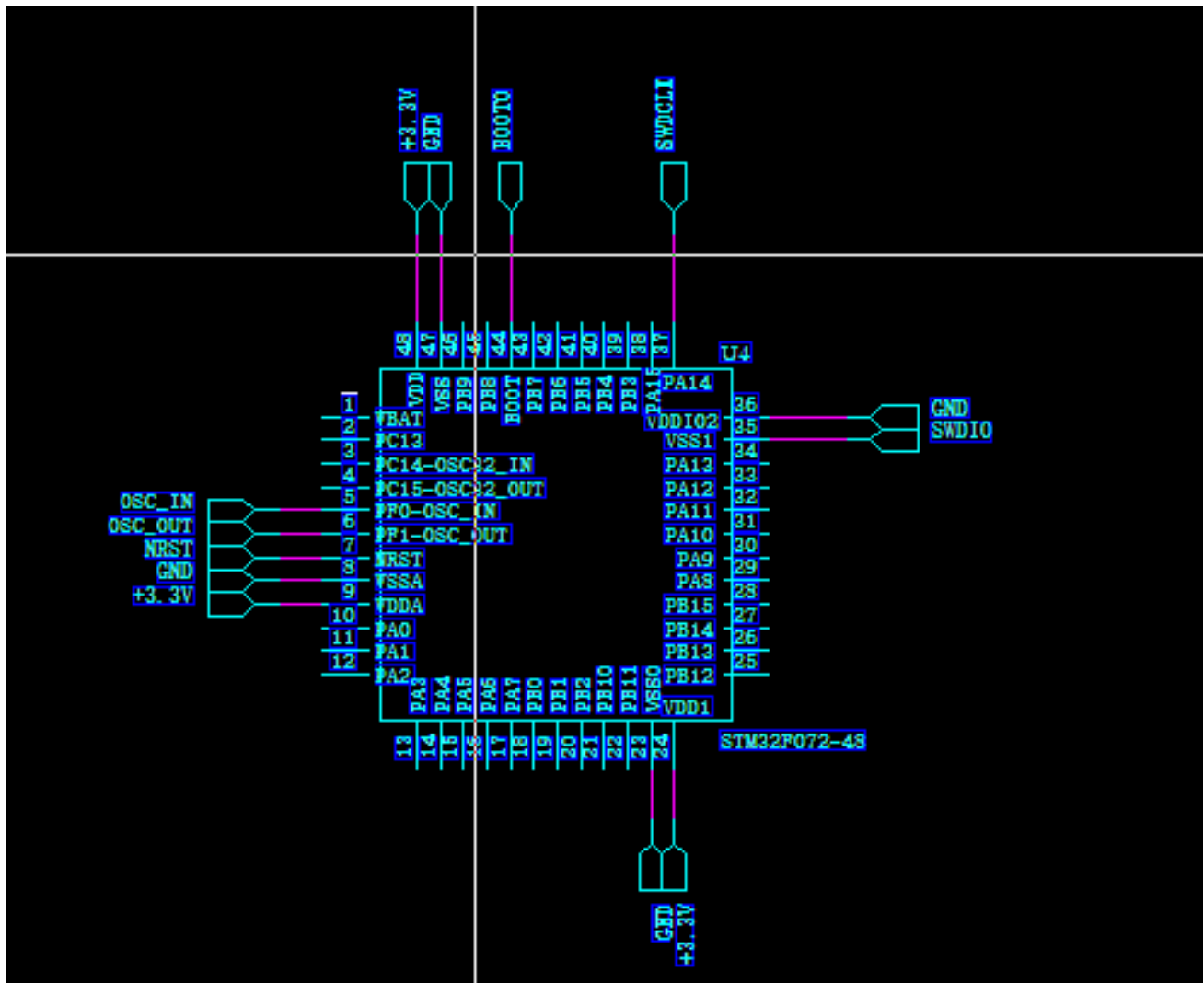

BOOT0通过10K下拉电阻到地，限流电阻可以降低功耗
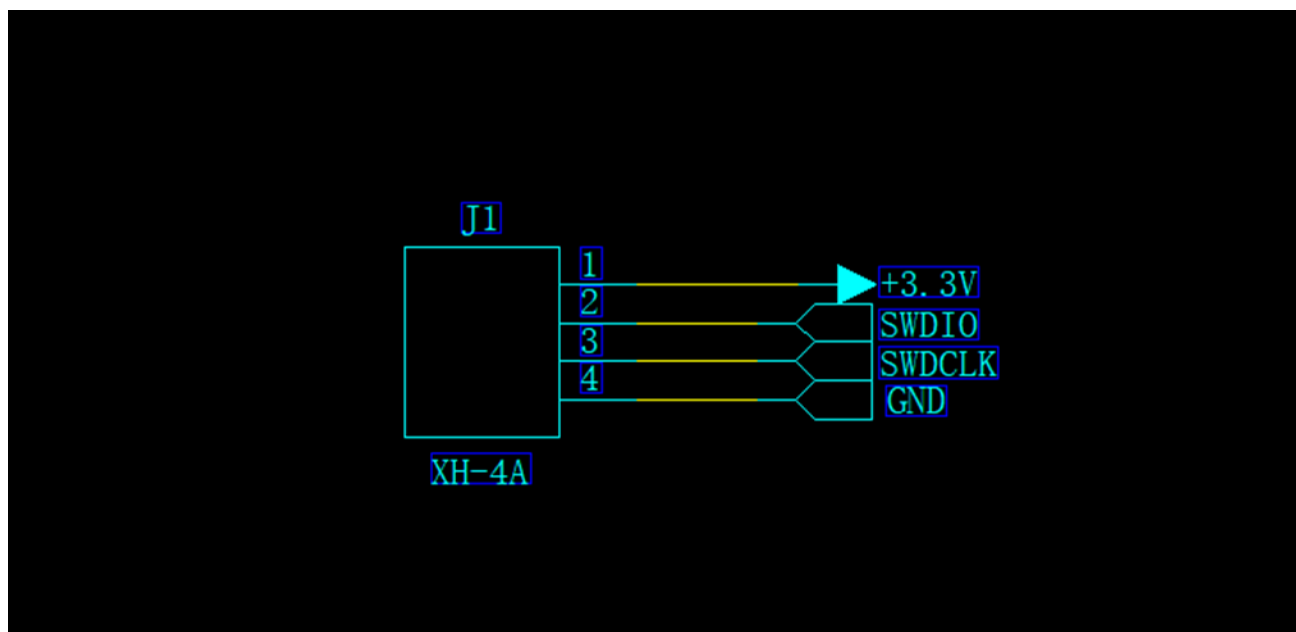
通过4P接口连接

电源滤波

MCU的每个电源引脚一般都要加滤波电容

所有的3.3v引脚都会接一个$0.1\mu F$的电容

10~50MHz的电路一般采用0.1μF的电容滤波效果最好，50MHz的电路一般采用0.01μF的电容

MCU

KEY
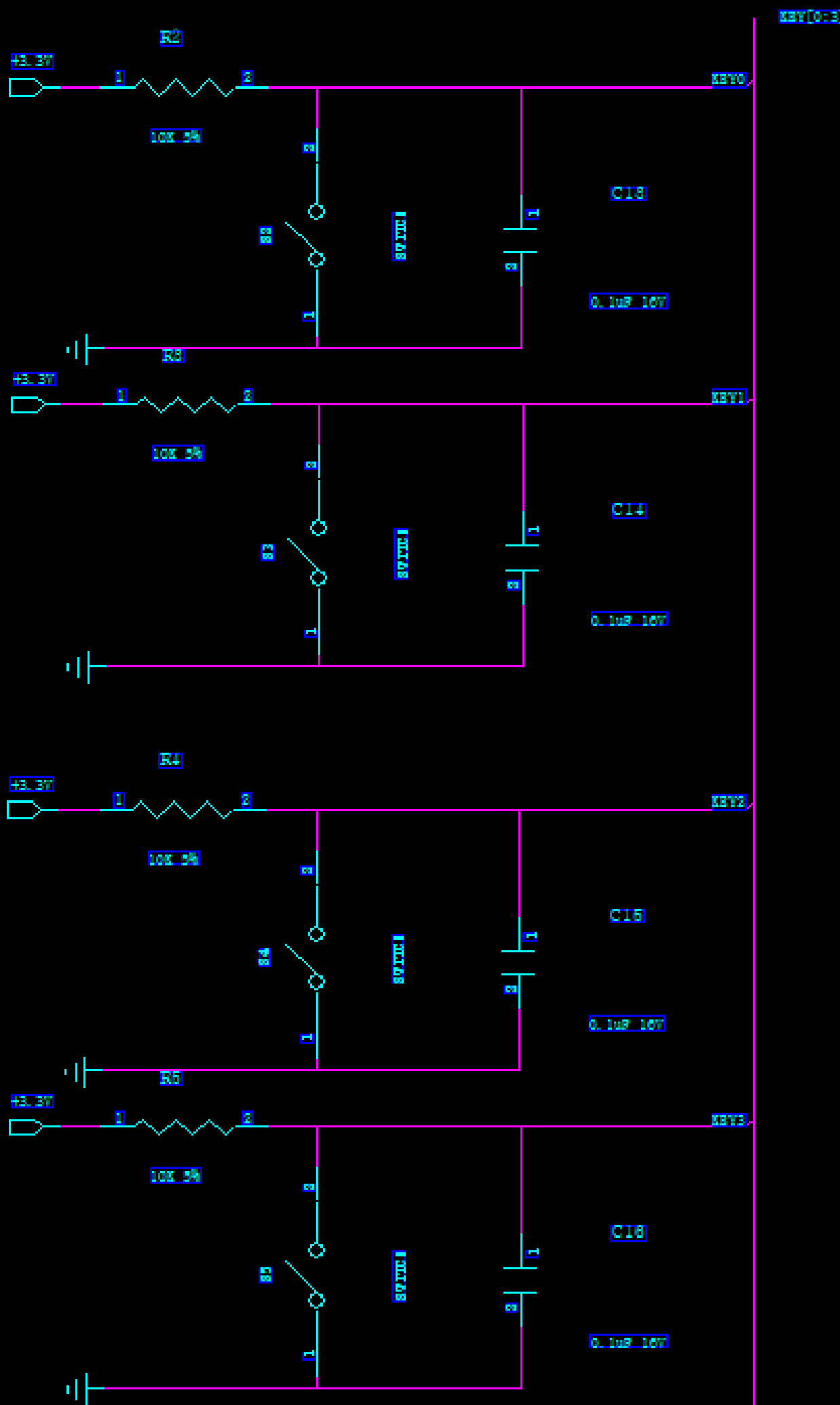
LED

LED数据手册：

Electro-Optical Characteristics(1)

✧ **极限参数**（温度=25℃）
Absolute Maximum Ratings (Temperature=25℃)

参数名称 Parameter	符号 Symbol	数值 Rating	单位 Unit
正向电流 Forward Current	I_F	25	mA
正向脉冲电流* Pulse Forward Current*	I_{FP}	50	mA
反向电压 Reverse Voltage	V_R	5	V
工作温度 Operating Temperature	T_{OPR}	-30 ~ +85	℃
贮存温度 Storage Temperature	Tstg	-40 ~ +100	℃
功耗 Power Dissipation	P_D	65	mW

* 注：脉冲宽度≤0.1ms，占空比≤1/10   * Note: Pulse Width≤0.1ms, Duty≤1/10

一般LED大于5ma就能发光，正向电流是LED发光最亮的电流值，二极管压降2V，电阻 $\dfrac{1.3}{0.005} = 260$
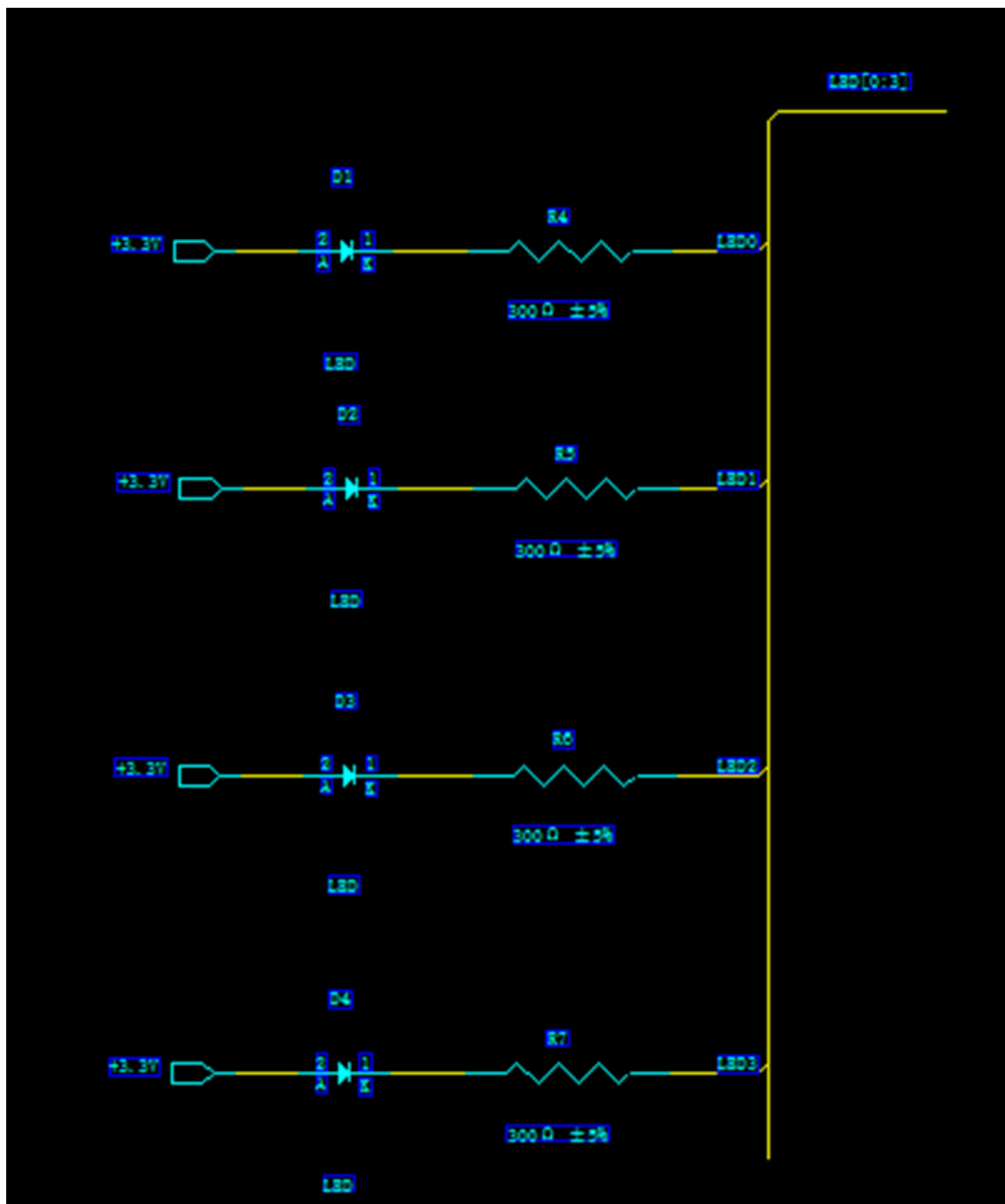
继电器

继电器数据手册：

线圈规格表   常温（20℃）

功 耗 W	电 压 VDC	电 流 mA	电 阻 Ω±10%	吸合电压	释放电压	过载电压
0.36W （L）	05	71.4	70	75%Max	10%Min	130%
	06	60	100			
	09	40	225			
	12	30	400			
	18	20	900			
	24	15	1600			
	36	10	3600			
	48	7.5	6400			
0.45W （D）	05	89.3	55	75%Max	10%Min	130%
	06	75	80			
	09	50	180			
	12	37.5	320			
	18	25	720			
	24	18.7	1280			
	36	12.5	2880			
	48	10	4500			

MCU输出电流一般是25ma，而继电器需要70ma的驱动电流，因此还需要使用NPN三极管进行驱动

三极管数据手册：

MAXIMUM RATINGS (T$_a$=25℃ unless otherwise noted)

Symbol	Parameter	Value	Unit
V$_{CBO}$	Collector-Base Voltage	40	V
V$_{CEO}$	Collector-Emitter Voltage	25	V
V$_{EBO}$	Emitter-Base Voltage	6	V
I$_C$	Collector Current	800	mA
P$_C$	Collector Power Dissipation	200	mW
R$_{\Theta JA}$	Thermal Resistance From Junction To Ambient	625	℃/W
T$_j$	Junction Temperature	150	℃
T$_{stg}$	Storage Temperature	-55～+150	℃

集电极-基极电压$V_{CBO} = 40V$

集电极-发射级电压$V_{CEO} = 25V$

发射级-基极电压$V_{CEO} = 6V$

集电极电流$I_C = 800mA$

ELECTRICAL CHARACTERISTICS (Ta=25℃ unless otherwise specified)

Parameter	Symbol	Test conditions	Min	Max	Unit
Collector-base breakdown voltage	$V_{(BR)CBO}$	I_C=100μA, I_E=0	40		V
Collector-emitter breakdown voltage	$V_{(BR)CEO}$*	I_C=1mA , I_B=0	25		V
Emitter-base breakdown voltage	$V_{(BR)EBO}$	I_E=100μA, I_C=0	6		V
Collector cut-off current	I_{CBO}	V_{CB}= 35V, I_E=0		0.1	μA
Collector cut-off current	I_{CEO}	V_{CE}= 20V, I_B=0		0.1	μA
DC current gain	$h_{FE(1)}$	V_{CE}=1V, I_C=5mA	45		
	$h_{FE(2)}$	V_{CE}=1V, I_C=100mA	80	400	
	$h_{FE(3)}$	V_{CE}=1V, I_C=800mA	40		
Collector-emitter saturation voltage	$V_{CE(sat)}$	I_C= 800mA, I_B=80mA		0.5	V
Base-emitter saturation voltage	$V_{BE(sat)}$	I_C=800mA, I_B= 80mA		1.2	V
Transition frequency	f_T	V_{CE}=6V, I_C= 20mA , f=30MHz	150		MHz

* Pulse Test : pulse width ≤ 300μs , duty cycle ≤2%.

放大倍数
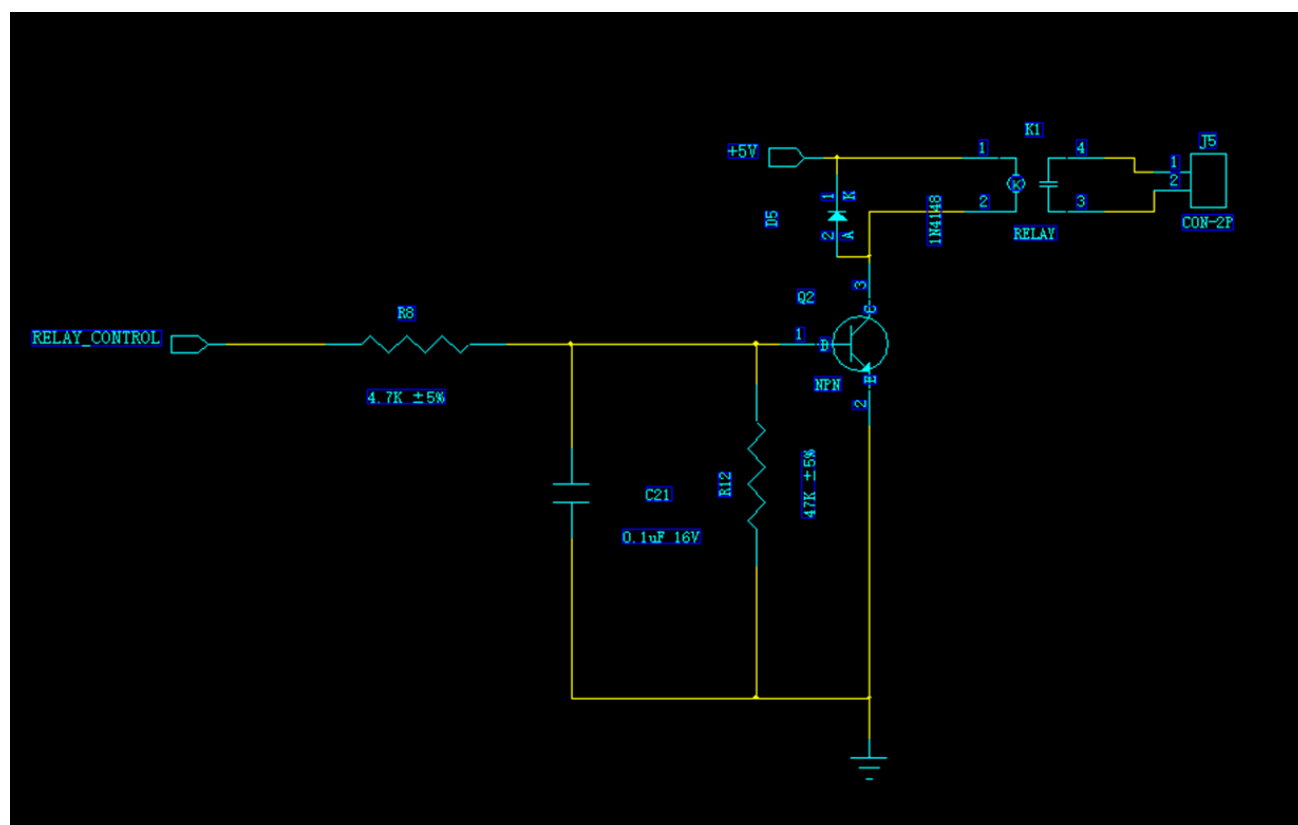
通过MCU的IO口控制三极管B极的电流，从而控制三极管的导通和截止，属于数字电路

当三极管导通时，5V经继电器线圈流过三极管，继电器工作

二极管作用是续流 [1]

继电器的线圈可以看作电感，电感两边的电流不能突变，当三极管从导通变为截止的时候，电感就会形成反向电动势，如果没有续流二极管，就会将三极管击穿

MCU的GPIO输出高低电平是3.3V和0V，输出高电平时，电流经三极管B到E(PN结)，导通电压是0.7V ，放大系数200，继电器的工作电流70mA

$$I_C = \beta \times I_B$$
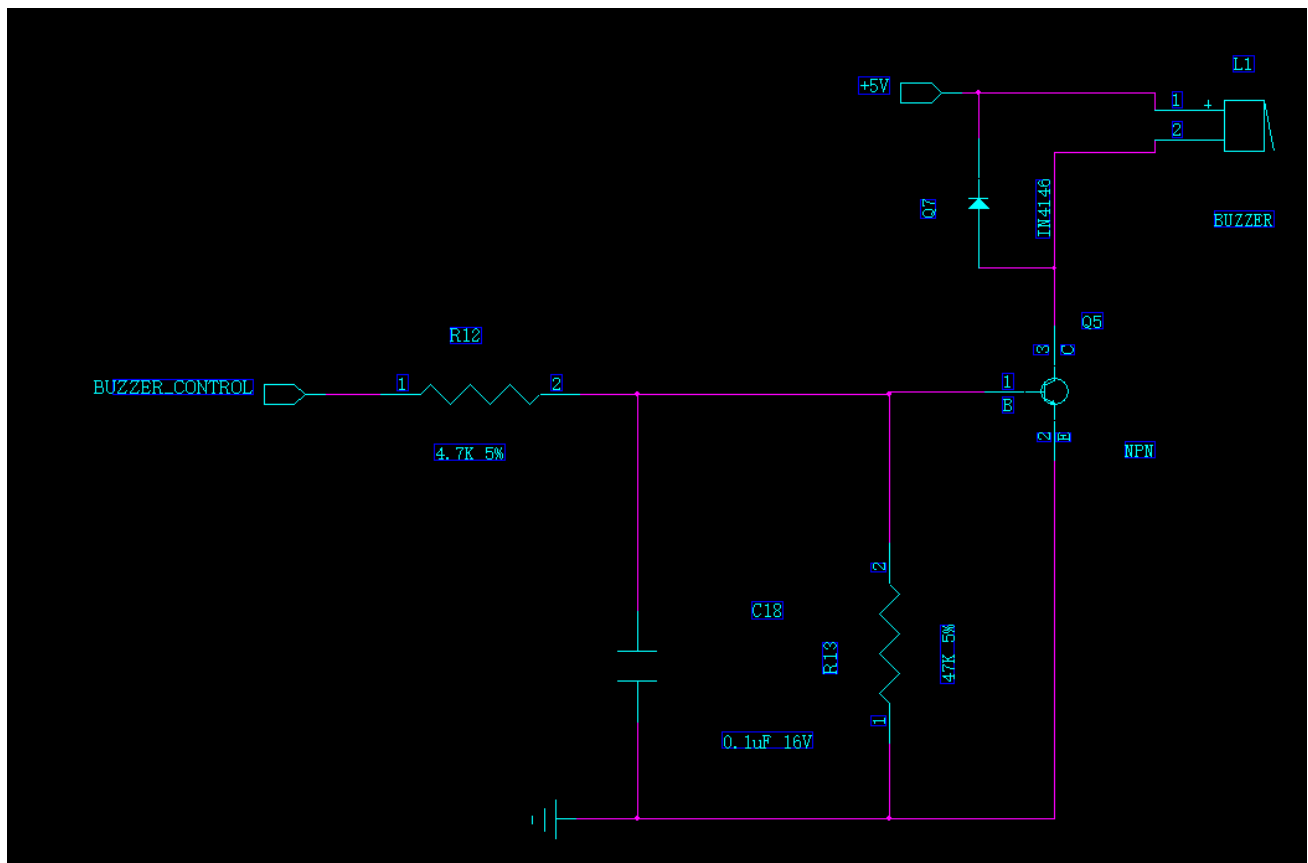
基极电流：$I_B = \dfrac{I_C}{\beta} = \dfrac{70ma}{200} = 0.35$

电阻：$\dfrac{3.3 - 0.7}{0.35ma} = 7.4k\Omega$

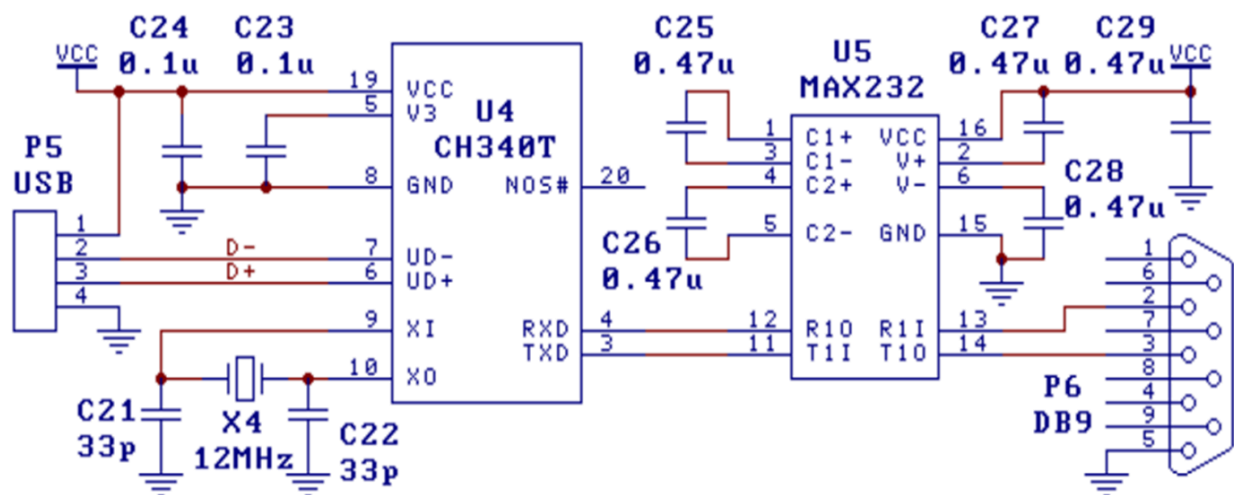在系统上电的时候MCU的GPIO口会出现不稳定的情况，有可能会让继电器误触发，因此需要使用一个$47K\Omega$的下拉电阻，所以左边电阻是$4.7K\Omega$

> 蜂鸣器驱动电路也类似

蜂鸣器

	项目/Item	规格/Spec	条件/Condition
1	额定电压 Rated voltage	5VDC	
2	工作电压 Operation voltage	4～8VDC	
3	声压 Sound Pressure Level=SPL	Min 85dB	测试环境：标准状态，标准驱动电路，额定电压 测试距离：0.1m Standard State,Standard Drive Circuit. Rated voltage,Distance at 0.1m
4	平均消费电流 Average consumption current	≤ 30mA	
5	振荡频率 Oscillation frequency	2300±300Hz	
6	响应时间 Response time	Max 50mS	最低工作电压 Lowest operation voltage
7	工作温度范围 Range of operation temperature	-20～+85℃	声压 ≥85dB SPL ≥85dB
8	保存温度范围 Range of preservation temperature	-20～+85℃	

USB/UART电路设计

ARDUINO电路设计

ARDUINO[0:15]

J2

P1	1	+5V
P2	2	ARDUINO0
P3	3	ARDUINO1
P4	4	ARDUINO2
P5	5	ARDUINO3
P6	6	ARDUINO4
P7	7	ARDUINO5
P8	8	ARDUINO6
P9	9	ARDUINO7
P10	10	GND

CON

J3

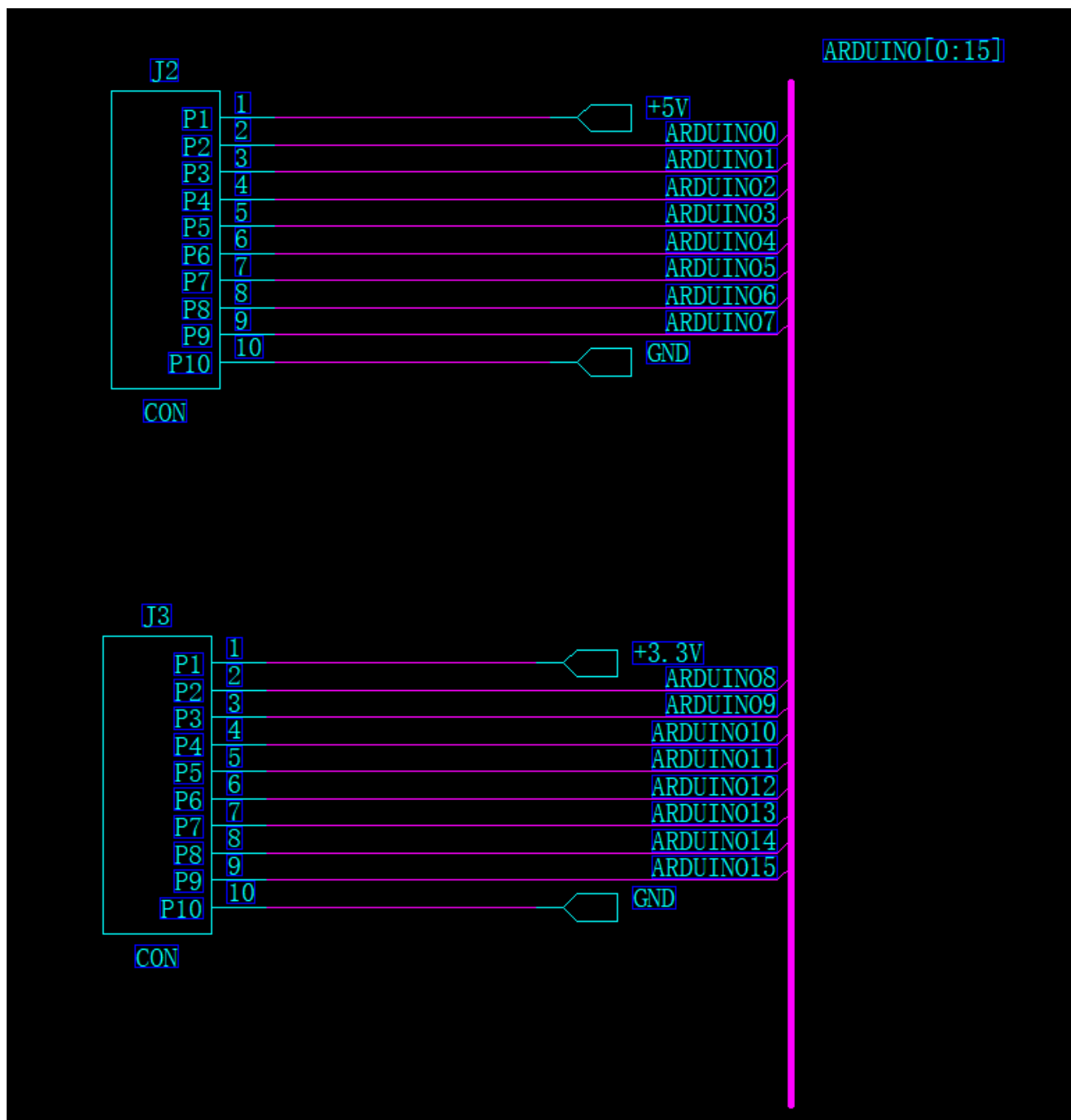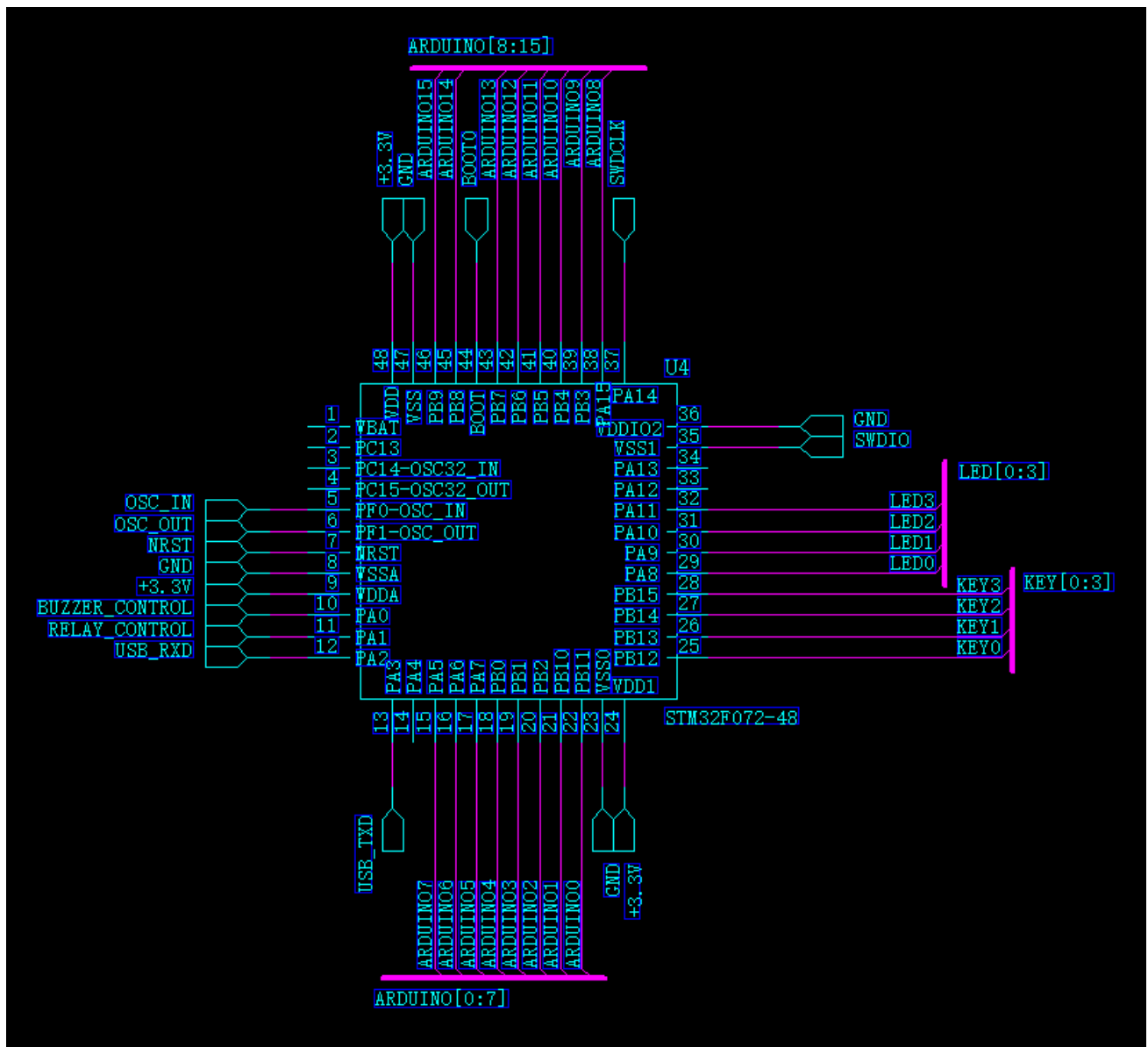|		
P1	1	+3.3V
P2	2	ARDUINO8
P3	3	ARDUINO9
P4	4	ARDUINO10
P5	5	ARDUINO11
P6	6	ARDUINO12
P7	7	ARDUINO13
P8	8	ARDUINO14
P9	9	ARDUINO15
P10	10	GND

CON
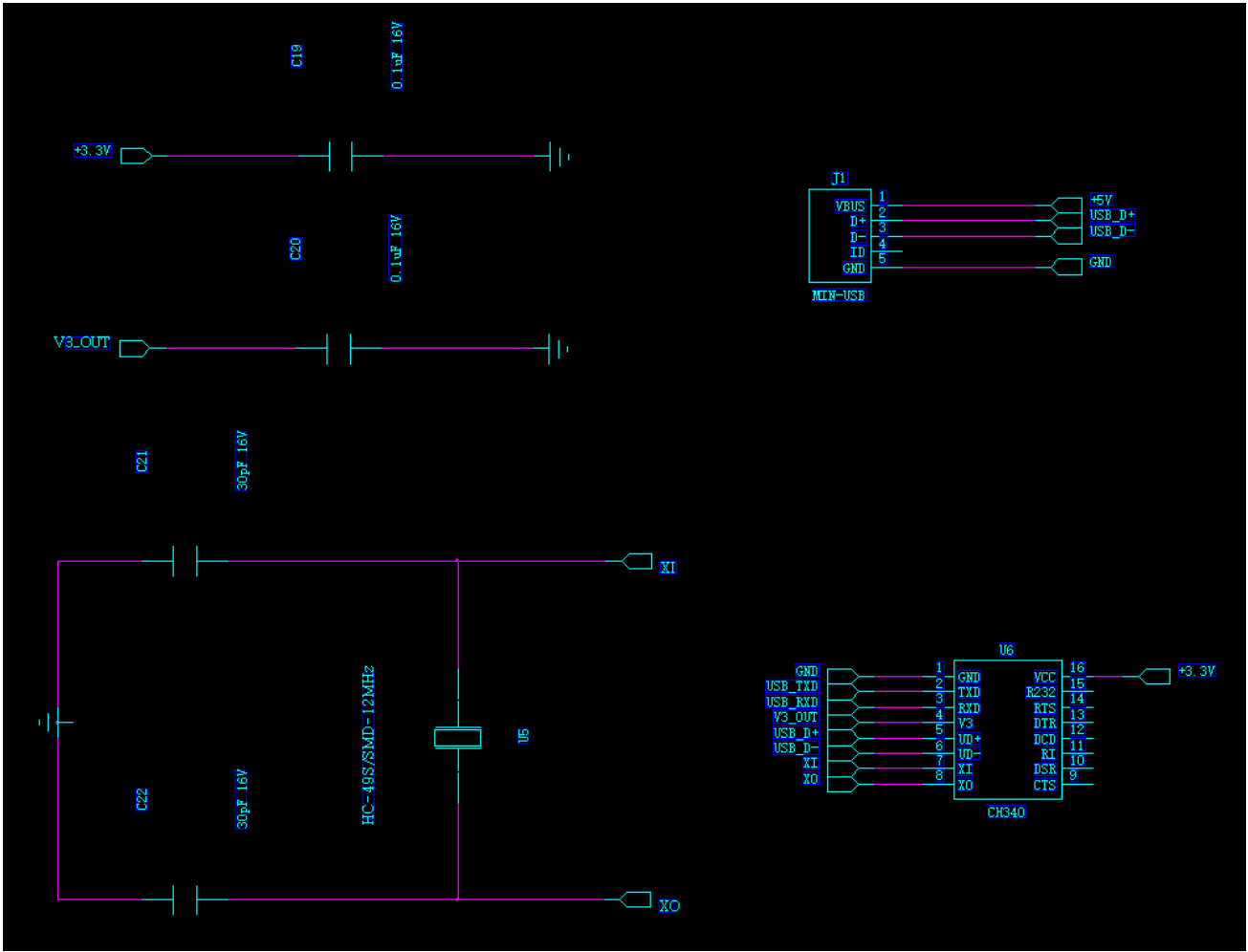
MCU电路集成

1. 续流二极管（Freewheeling Diode），也称为飞轮二极管或snubber二极管，是一种配合电感性负载使用的二极管。它的作用是在电感性负载的电流突然变化或减少时，提供一个通路，以避免因电感产生的突变电压而损坏电路中的其他元件。续流二极管通常并联在线圈的两端，当线圈中的电流消失时，线圈产生的感应电动势通过二极管和线圈构成的回路消耗掉，从而保护电路中的元件。在开关电源、电动机驱动、变换器和逆变器等电子设备中，续流二极管被广泛应用以提供稳定的电路操作。↵