中国石油大学(北京)

课程设计报告

课程名：　硬件综合实践

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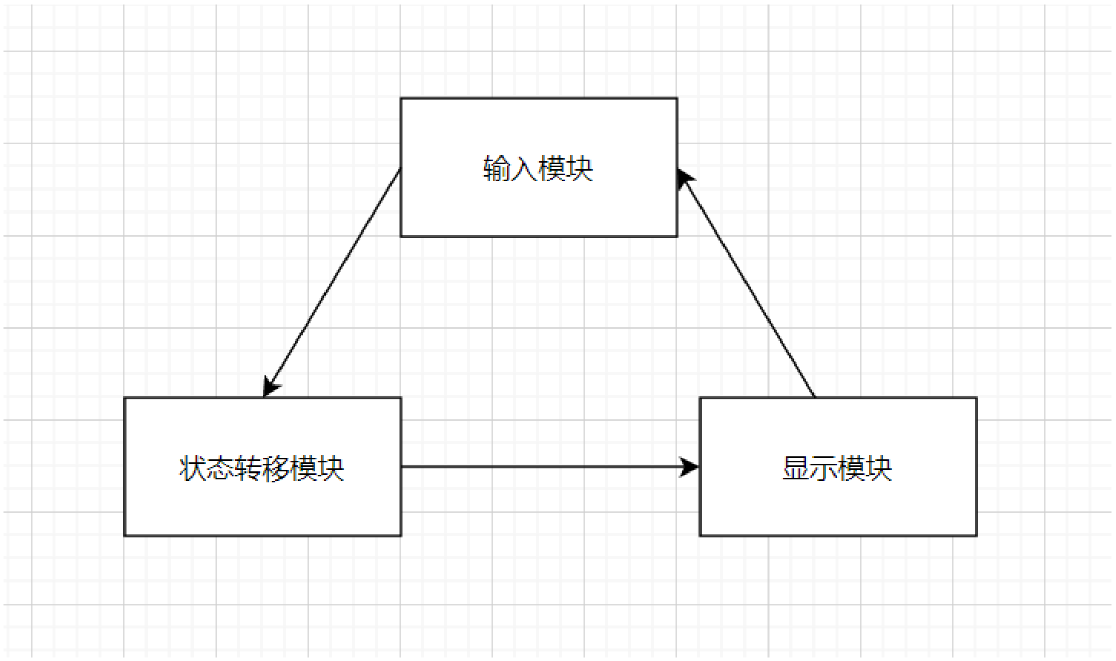
设计时间	2021.1.4

一、设计内容

实现 10 位以内的带括弧的四则混合运算，支持实数运算。

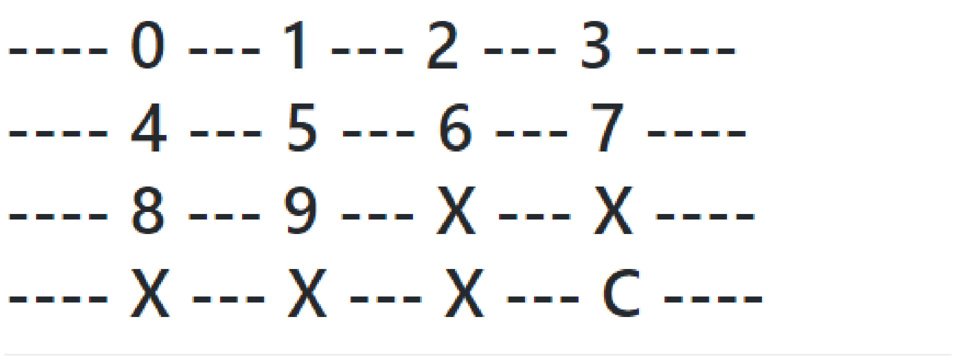
二、设计思路

将整个程序分为输入模块，状态转移模块，显示模块



输入模块使用矩阵键盘和独立按键，布局如下：

矩阵键盘：



```
---- 0 --- 1 --- 2 --- 3 ----
---- 4 --- 5 --- 6 --- 7 ----
---- 8 --- 9 --- X --- X ----
---- X --- X --- X --- C ----
```

独立按键：

---- + --- - --- * --- / ----

---- (---) --- . --- = ----

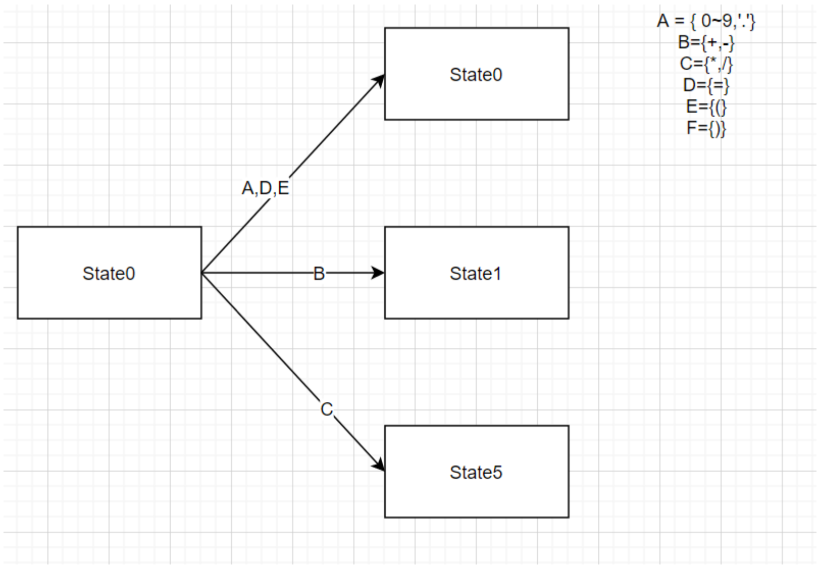
显示模块使用 Lcd1602 用来输出。

根据计算的状态图，通过构想最终划分为 7 种状态。

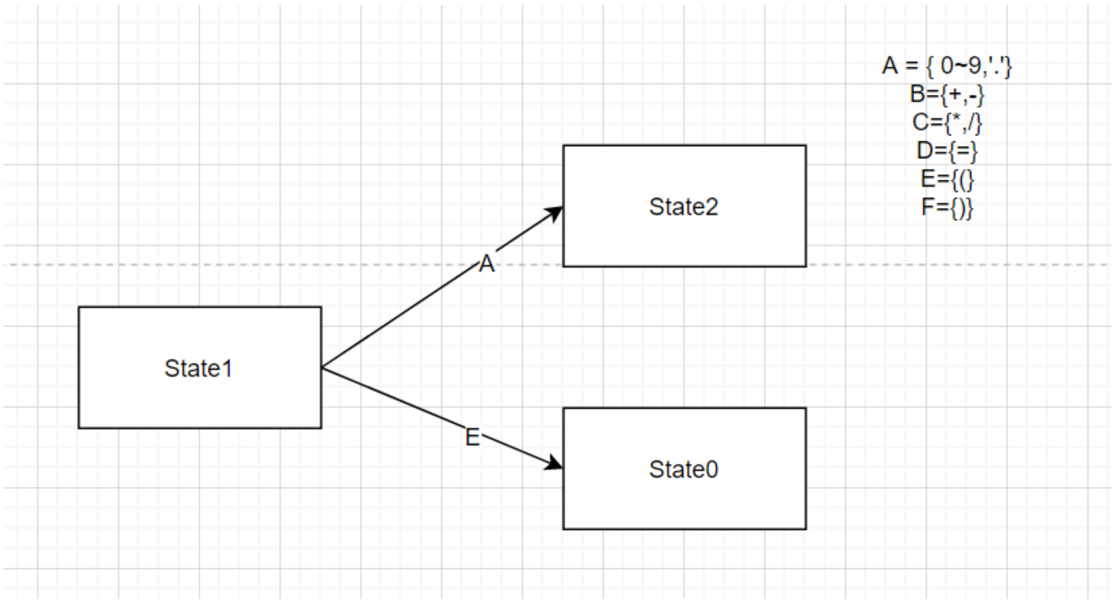
定义 A={0~9,.},B={+,-},C={*,/},D={=},E={(},F={)}

状态图:

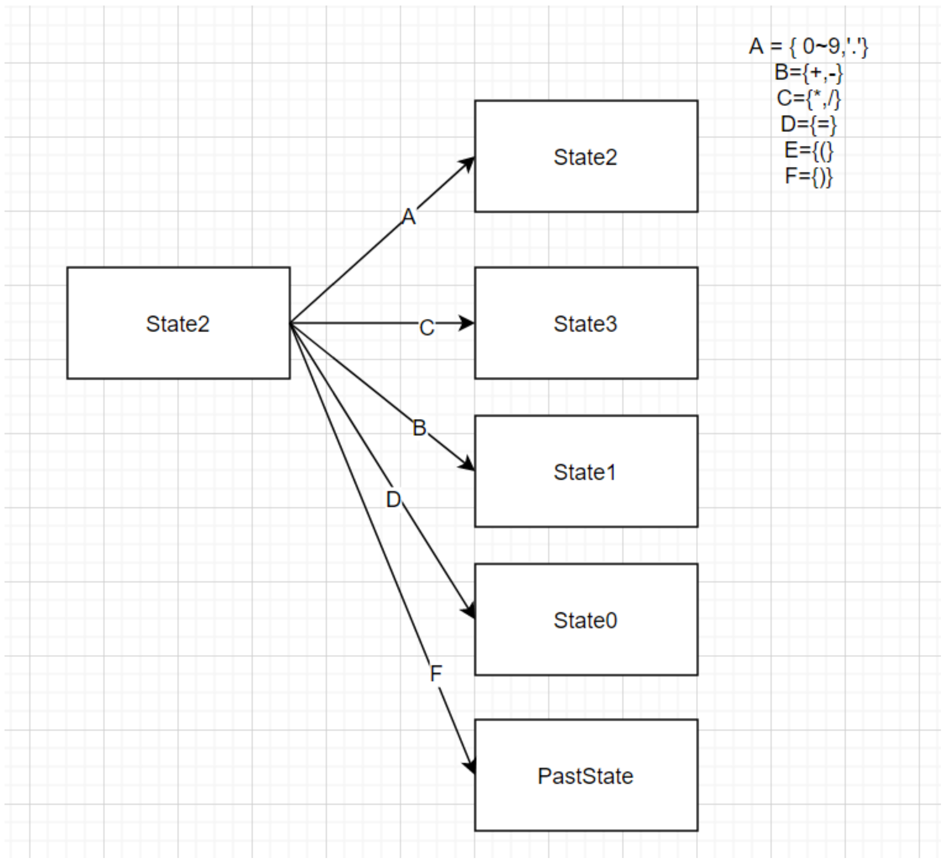
0：初始状态



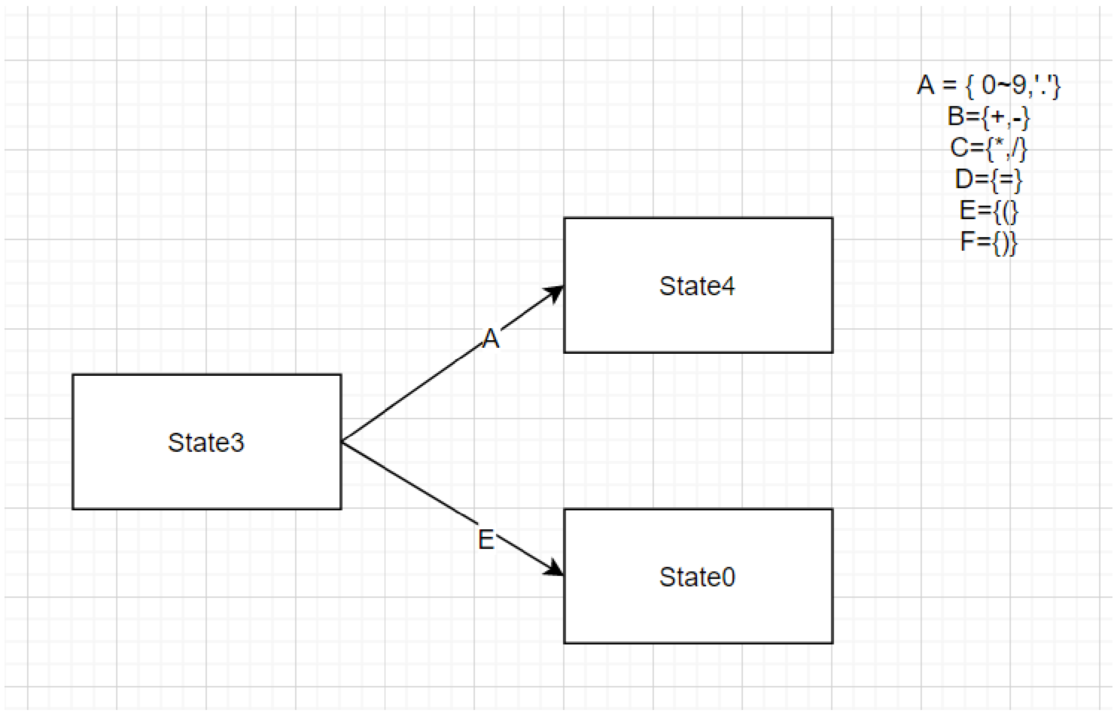
1： a +-状态



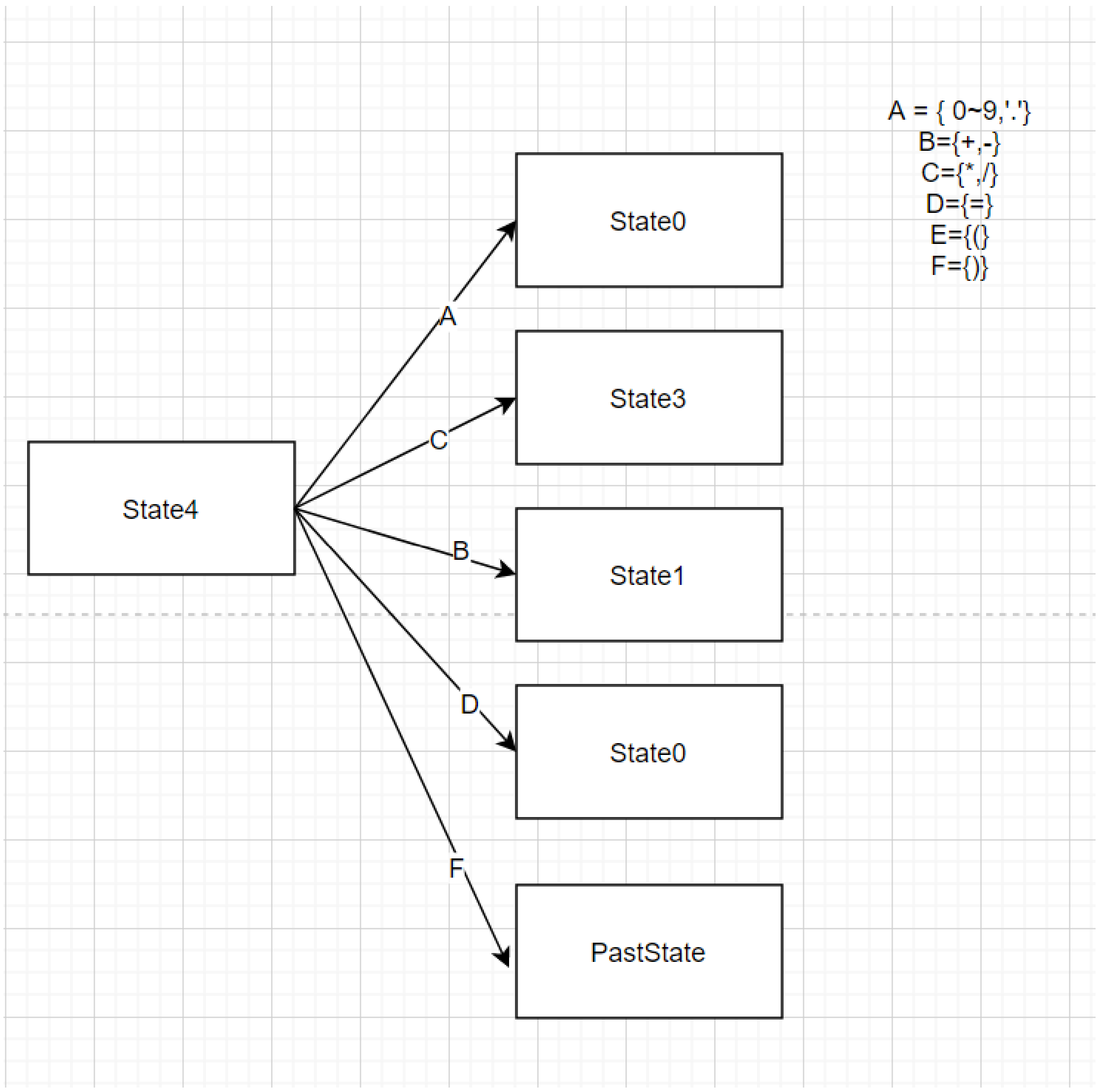
2：a+-b 状态



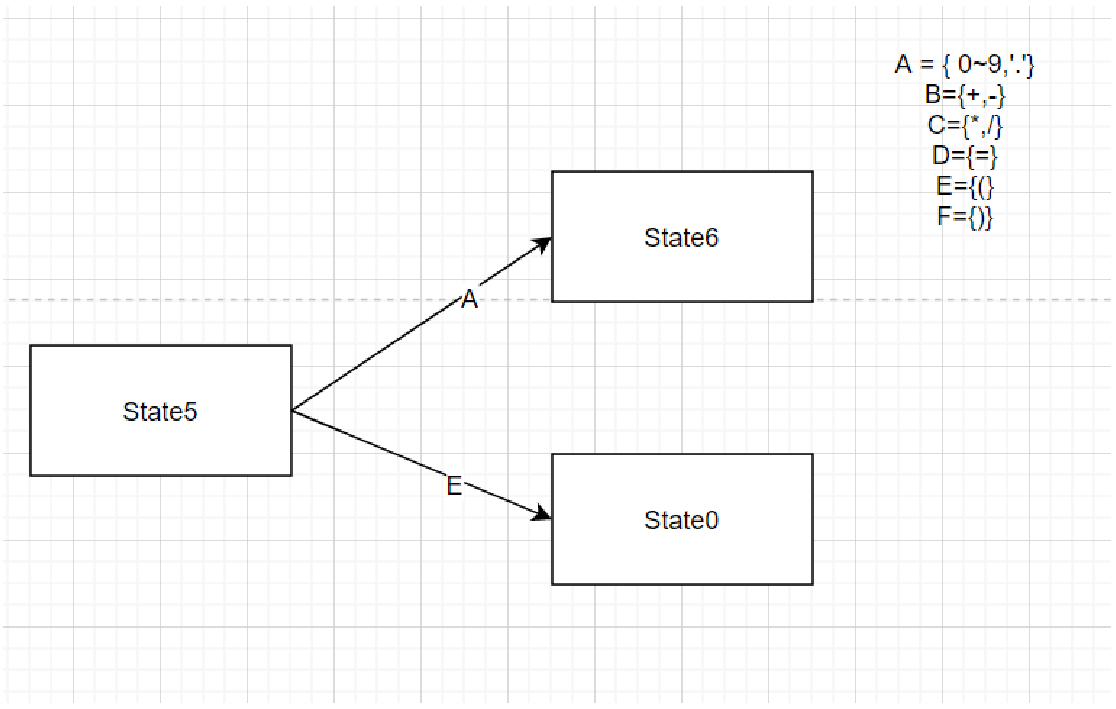
3：a+-b*/状态



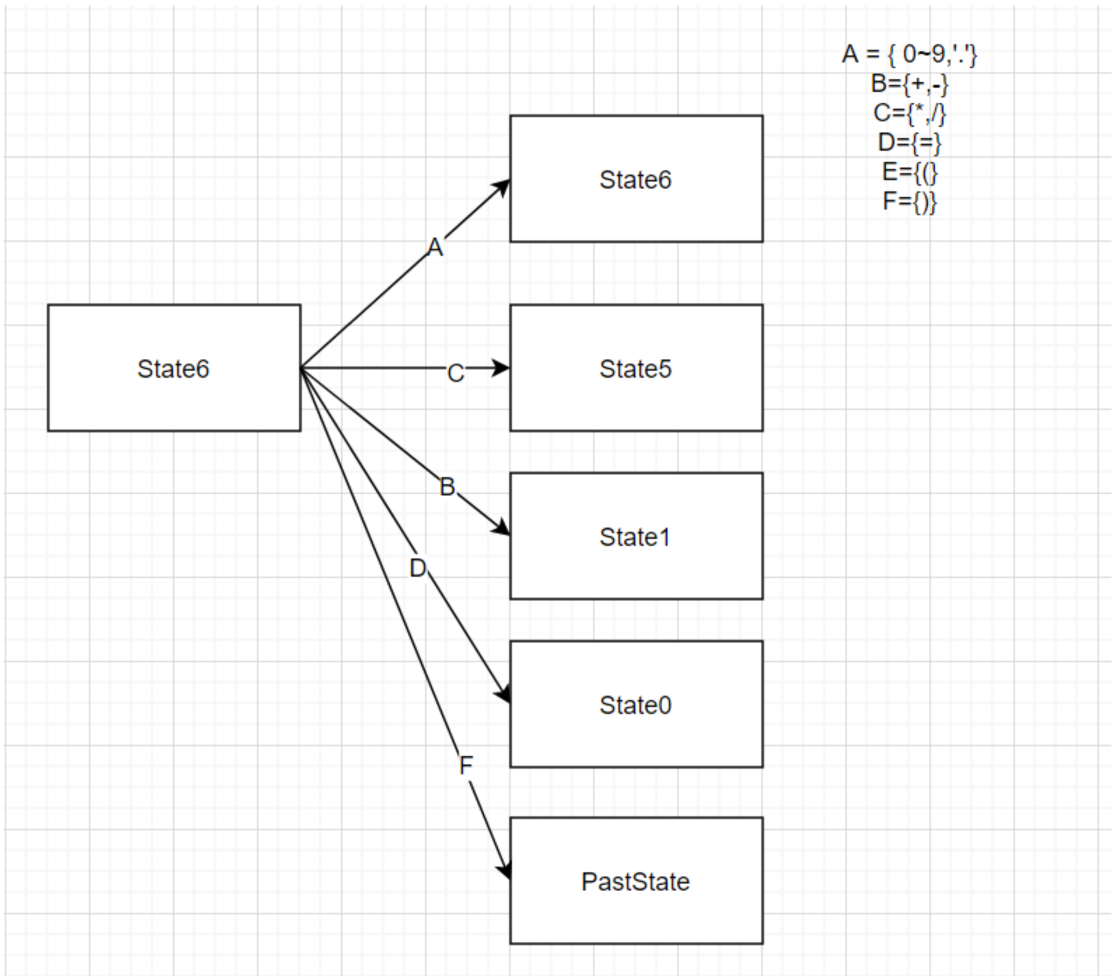
4：a+-b*/c 状态


A = { 0~9,'.'}
B={+,-}
C={*,/}
D={=}
E={(}
F={)}
State4
State0
State3
State1
State0
PastState
A
C
B
D
F

5：a*/状态



6：a*/c 状态



‘(’运算完成压栈操作，记录当前状态，同时回到状态 0。

‘）’运算完成出栈，还原压栈前状态。

三、设计解释

3.1、设计环境介绍

使用 Keil5 软件 C51 软件。普中自动下载软件完成烧录。STC89C516 芯片，LCD1602 显示。

3．2、程序解释（可含硬件部分）

```
#include "lcd.h"
#include <reg51.h>
#include <stdio.h>
#include <math.h>
typedef unsigned int u16;       //对数据类型进行声明定义
typedef unsigned char u8;
const char Outputchar[18]={48,49,50,51,52,53,54,55,56,57,43,45,42,47,40,41,46,61};
#define MAX_LEN 4
float a = 0.0 , b = 0.0, c =0.0 ;
float pastdata[MAX_LEN];
u8 Statestack[MAX_LEN];
u8 stackpoint = -1, pastpoint = -1;
u8 flag_a = 0 , flag_b = 0 , flag_c =0 ;
u8 State = 0; //最开始在初始状态
u8 add_sub_flag = 0 ; //1->'+' , 0->'-'
u8 multi_div_flag = 0 ; //1->'*' , 0->'/'
u8 count = 0 ; //对应括号的匹配

// State : 0 0 0 0 0 0 0 0 -> 128 64 32 16 8 4 2 1
void printans(float a);
void initA(){
    a = 0;
    flag_a = 0;
}
void initB(){
    b = 0 ;
    flag_b =0 ;
}
void initC(){
        c = 0 ;
        flag_c = 0;
}
void pushState(){
        switch(State){
                case 0:      // (
                        stackpoint ++;
                        Statestack[stackpoint] = State;
                        break;
                case 1:    // a +/- (
                        if(add_sub_flag == 1){
                                State += 128;
                        }
                        Statestack[++stackpoint]=State;
                        pastdata[++pastpoint] = a;
                        break;
                case 3: // a +/- b */ (
                        if(add_sub_flag == 1)
                                State+=128;
                        if(multi_div_flag == 1)
                                State+=64;
                        Statestack[++stackpoint]=State;
                        pastdata[++pastpoint] = a;
                        pastdata[++pastpoint] = b;
                        break;
                case 5: // a */ (
                        if(multi_div_flag == 1){
                                State += 64;
                        }
                        Statestack[++stackpoint]=State;
                        pastdata[++pastpoint] = a;
                        break;
        }
        initA();
}

void PopStack(){
        u8 past = Statestack[stackpoint--];
        switch(past&0x3F){ // 0011 1111
                case 0:
                        State       = 0;
                        a = a;
                        break;
                case 1:
```

```
                State = 2;
                if((past & 128) ==128){    // +
                    add_sub_flag = 1;
                }
                else
                    add_sub_flag = 0;
                b = a;
                a = pastdata[pastpoint--];
                break;
            case 3:
                State = 4;
                if((past & 128) == 128){
                    add_sub_flag= 1;
                }
                else
                    add_sub_flag = 0;
                if((past & 64) == 64){
                    multi_div_flag = 1;
                }
                else
                    multi_div_flag = 0;
                c = a;
                b = pastdata[pastpoint--];
                a = pastdata[pastpoint--];
                break;
            case 5:
                State = 6;
                if((past & 64) == 64){    // *
                    multi_div_flag = 1;
                }
                else
                    multi_div_flag = 0;
                c = a;
                a = pastdata[pastpoint--];
                break;
        }
}

void printans(float a){
    u8 i ;
    char str[8];
    sprintf(str,"%f",a);
    LcdWriteCom(0xc0); //定位到第二行
    for(i= 0 ; i< 8 ; i++){
```

```
		LcdWriteData(str[i]);
	}
}
void delay(u16 i){
	while(i--);
}
/*
	P17->H1
	P16->H2
	P15->H3
	P14->H4

	P13->L1
	P12->L2
	P11->L3
	P10->L4
*/
#define GPIO_KEY P1 //	0000 0000
#define GPIO_BUTTON P3 //独立按键使用 P3
sbit K1 = P3^0; sbit K2 = P3^1;
sbit K3 = P3^2; sbit K4 = P3^3;
sbit K5 = P3^4; sbit K6 = P3^5;
sbit K7 = P3^6; sbit K8 = P3^7;
u8 isNum(u8 num){
	if((num>=0)&&(num<=9))
		return 1;
	return 0;
}

u8 KeyDown(void)
{
	u8 KeyValue= 127;
	char adelay=0;
	GPIO_KEY=0x0f;
	if(GPIO_KEY!=0x0f)//读取按键是否按下
	{
		delay(1000);//延时 10ms 进行消抖
		if(GPIO_KEY!=0x0f)//再次检测键盘是否按下
		{
			//测试列
			GPIO_KEY=0X0F;
			switch(GPIO_KEY)
			{
				case(0X07):	KeyValue=0;break;
```

```
                case(0X0b):    KeyValue=1;break;
                case(0X0d): KeyValue=2;break;
                case(0X0e):    KeyValue=3;break;
            }
            //测试行
            GPIO_KEY=0XF0;
            switch(GPIO_KEY)
            {
                case(0X70):    KeyValue=KeyValue;break;
                case(0Xb0):    KeyValue=KeyValue+4;break;
                case(0Xd0): KeyValue=KeyValue+8;break;
                case(0Xe0):    KeyValue=KeyValue+12;break;
            }

        }
    }
    //delay(1000);
    while((adelay<50)&&(GPIO_KEY!=0xf0))      //检测按键松手检测
    {
        delay(160);
        adelay++;
    }
    if(KeyValue == 15)
        return 18;
    return KeyValue;
}


/*
从独立按键输入字符
*/
u8 keypros(){



    GPIO_BUTTON = 0xff;
    delay(1000);
    if(K1 == 0){
        while(!K1);
        return 10;    //'+'
    }
    if(K2 == 0){
        while(!K2);
        return 11;
    }
```

```
	if(K3 == 0){
		while(!K3);
		return 12;
	}
	if(K4 == 0){
		while(!K4);
		return 13;
	}
	if(K5 == 0){
		while(!K5);
		return 14;
	}
	if(K6 == 0){
		while(!K6);
		return 15;
	}
	if(K7 == 0){
		while(!K7);
		return 16;
	}
	if(K8 == 0){
		while(!K8);
		return 17;
	}
	return 127;
}

u8 Getch(){
	u8 op = 127;
	while(op==127){
		op = keypros();
		if(op!=127)
			return op ;
		op = KeyDown();
		if(op!=127){
		return op;
		}
	}
	return 127;
}

/* if  不是小数
//		更新小数 flag
//	update
```

```
        if  不是小数
                *10 + nun
        是小数
                根据小数计算
//
*/

void clear(){
            //    LCD1602_E = 0;
            LcdWriteCom(0x01);
            initA();
            initB();
            initC();
            count = 0;
            State = 0;
            stackpoint = -1;
            pastpoint = -1;
}
void function_S0(){
      u8 num = Getch();
      if(num == 17){
            LcdWriteData(Outputchar[num]);
            printans(a);
      }
      else if(num == 18){
      clear();
      }
      else if(num == 15){
            if(count>0){
                        PopStack();
                        LcdWriteData(Outputchar[num]);
                        count --;
                  }
      }
      else if(num == 16){
                  if(flag_a == 0){
                        flag_a = 1;
                        LcdWriteData(Outputchar[num]);
                  }
      }
      else {
            if(isNum(num)==1){
                  if(flag_a == 0){
                              a = a*10 +num;
                }
                else{
                        a += num*(float)pow(0.1,flag_a);
                        flag_a ++;
                }
        }
        else if(num == 14){
                pushState();
                State = 0;
                count++;
        }
        else if(num == 10){    // + -
                add_sub_flag = 1;
                State = 1;
        }
        else if(num == 11){
                add_sub_flag = 0 ;
                State = 1;
        }
        else if(num ==12 ){
                State = 5;
                multi_div_flag = 1;
        }// * /
        else if(num == 13){
                State =5 ;
                multi_div_flag = 0;
        }
        LcdWriteData(Outputchar[num]);
    }
}



void function_S1(){
    u8 num = Getch();
    initB();
    if(isNum(num)==1){
        b = num;
        State = 2;
        LcdWriteData(Outputchar[num]);
    }
    else if(num == 14){
        pushState();
        count++;
        State = 0;
        LcdWriteData(Outputchar[num]);
    }
    else if(num == 18){
        clear();
    }
}

void function_S2(){
    u8 num = Getch();
    if(num==17){
        State = 0;
        if(add_sub_flag ==1){
            a = a+b;
        }
        else
            a = a-b;
        LcdWriteData(Outputchar[num]);
        printans(a);
    }
    else if(num == 18){
        clear();
    }
    else if(num == 16){
        if(flag_b == 0){
            flag_b = 1;
            LcdWriteData(Outputchar[num]);
            }
    }
    else if(num == 15){
        if(count>0){
                if(add_sub_flag == 1)
                a = a+b ;
                else a = a-b;
                PopStack();
                LcdWriteData(Outputchar[num]);
                count --;
            }
    }
    else{
        if(isNum(num) == 1){
            if(flag_b == 0){
                    b = b*10 +num;
            }
```

```
                else{
                        b += num*(float)pow(0.1,flag_b);
                        flag_b ++;
                }
            }
            else if (num== 12){    //*
                State = 3;
                multi_div_flag = 1;
            }

            else if (num == 13){ // /
                State = 3;
                multi_div_flag = 0;
            }
            else if (num == 10){
                if(add_sub_flag ==1){
                    a = a+b;
                }
                else
                    a = a-b;
                State = 1;
                add_sub_flag = 1;
            }
            else if (num == 11){
                if(add_sub_flag ==1){
                    a = a+b;
                }
                else
                    a = a-b;
                State = 1;
                add_sub_flag = 0;
                }
            LcdWriteData(Outputchar[num]);
        }
}

void function_S3(){
        u8 num = Getch();
        initC();
        if(isNum(num)==1){
            c = num;
            State = 4;
            LcdWriteData(Outputchar[num]);
        }
```

```
	else if(num == 14){
		pushState();
		State = 0;
		count++;
		LcdWriteData(Outputchar[num]);
	}
	else if(num == 18){
		clear();
	}
}

void function_S4(){
	u8 num = Getch();
	if(isNum(num)==1){
			if(flag_c == 0){
					c = c*10 +num;
			}
			else{
					c += num*(float)pow(0.1,flag_c);
					flag_c ++;
			}
	}
	else if(num == 16){
		if(flag_c == 0){
			flag_c = 1;
			LcdWriteData(Outputchar[num]);
		}
	}
	else if(num == 15){
		if(count > 0){
			if(add_sub_flag == 1){
				if(multi_div_flag ==1)
					a= a+b*c;
				else
					a= a+b/c;
			}
			else{
				if(multi_div_flag ==1)
					a= a-b*c;
				else
					a= a-b/c;
			}
			PopStack();
			LcdWriteData(Outputchar[num]);
```

```
            count --;
        }
}
else if(num == 10){ // +
        if(add_sub_flag == 1){
                if(multi_div_flag ==1)
                        a= a+b*c;
                else
                        a= a+b/c;
        }
        else{
                if(multi_div_flag ==1)
                        a= a-b*c;
                else
                        a= a-b/c;
        }
        add_sub_flag = 1;
        State = 1;
}
else if(num == 11){
        if(add_sub_flag == 1){
                if(multi_div_flag ==1)
                        a= a+b*c;
                else
                        a= a+b/c;
        }
        else{
                if(multi_div_flag ==1)
                        a= a-b*c;
                else
                        a= a-b/c;
        }
        add_sub_flag = 0;
        State = 1;
}
else if(num == 12){ //*
        if(multi_div_flag == 1){
                b = b*c ;
        }
        else
                b = b/c;
        State =3;
        multi_div_flag = 1;
}
```

```
        else if(num == 13){ // /
                if(multi_div_flag == 1){
                        b = b*c ;
                }
                else
                        b = b/c;
                State =3;
                multi_div_flag = 0;
        }
        else if(num == 17){
                if(add_sub_flag == 1){
                        if(multi_div_flag ==1)
                                a= a+b*c;
                        else
                                a= a+b/c;
                }
                else{
                        if(multi_div_flag ==1)
                                a= a-b*c;
                        else
                                a= a-b/c;
                }
                add_sub_flag = 0;
                State = 0;
        }
        if(num == 18){
                clear();
        }
        else if(num==17){
                LcdWriteData(Outputchar[num]);
                printans(a);
        }
        else if((num !=15)&&(num!=16)){
                LcdWriteData(Outputchar[num]);
        }
}

void function_S5(){
        u8 num = Getch();
        initC();
        if(isNum(num)==1){
                c = num;
                State = 6;
                LcdWriteData(Outputchar[num]);
        }
        else if(num == 14){
                pushState();
                State = 0;
                LcdWriteData(Outputchar[num]);
                count ++;
        }
        else if(num==18){
                clear();
        }
}

void function_S6(){
        u8 num = Getch();
        if(isNum(num)==1){
                if(flag_c == 0){
                                c = c*10 +num;
                }
                else{
                                c += num*(float)pow(0.1,flag_c);
                                flag_c ++;
                }
        }
        else if(num == 16){
                if(flag_c== 0){
                        flag_c = 1;
                        LcdWriteData(Outputchar[num]);
                }
        }
        else if(num == 10){ // +
                if(multi_div_flag==1){
                        a = a*c;
                        State = 1;
                        add_sub_flag = 1;
                }
                else{
                        a = a/c;
                        State = 1;
                        add_sub_flag = 1;
                }
        }
        else if (num == 11){ // -
                if(multi_div_flag==1){
                        a = a*c;
```

```
				State = 1;
				add_sub_flag = 0;
			}
			else{
				a = a/c;
				State = 1;
				add_sub_flag = 0;
			}
		}
		else if(num ==12){ // *
			if(multi_div_flag==1){
				a = a*c;
				multi_div_flag = 1;
			}
			else{
				a = a/c;
				multi_div_flag = 1;
			}
			State = 5;
		}
		else if (num == 13){ // /
			if(multi_div_flag==1){
				a = a*c;
				multi_div_flag = 0;
			}
			else{
				a = a/c;
				multi_div_flag = 0;
			}
			State = 5;
		}
		else if(num == 17){ // ==
			State = 0;
			if(multi_div_flag==1){
				a = a*c;
			}
			else{
				a = a/c;
			}
		}
		else if(num == 15){
			if(count >0){
				if(multi_div_flag==1){
					a = a*c;
```

```
            }
            else{
                a = a/c;
            }
            PopStack();
            LcdWriteData(Outputchar[num]);
            count--;
        }
    }
    if(num == 18){
        clear();
    }
    else if(num==17){
        LcdWriteData(Outputchar[num]);
        printans(a);
    }
    else if((num !=15) && (num !=16)){    //不为) , .
        LcdWriteData(Outputchar[num]);
    }
}

//todo : a  的 flag 没有更新过
void main(){
    LcdInit();
    while(1){
        switch(State){
            case 0:
                function_S0();
                break;
            case 1:
                function_S1();
                break;
            case 2:
                function_S2();
                break;
            case 3:
                function_S3();
                break;
            case 4:
                function_S4();
                break;
            case 5:
                function_S5();
                break;
                case 6:
                        function_S6();
                        break;
                }
        }
}
```

相关使用介绍可参照 https://github.com/Sun2018421/Hardware-integrated-design

四、设计体会与建议

经过两周的硬件综合实践，完成了简易计算器的设计。在这个过程中学习到了之前很多忽略的知识，在有限的 RAM 和 FLASH 上写程序让我对每一个字节，每一个地址的理解更加深入。通过查看 Lcd1602 的数据手册让我对时序有了新的理解。在调试设计中有着各自各式各样的 bug，比如按键抖动，运算符优先级等等让我不断的发现并解决一些隐蔽的问题。通过查阅了解状态图来完成整个计算器的设计拓展了我的新思路，对程序设计提供了新的思考角度。不仅感叹图灵机思维的巧妙性。在老师的讲解下对 51 单片机这一鼻祖级的单片机掌握的更加熟练。在疫情期间，课程圆满的结束感谢老师的教学付出。