

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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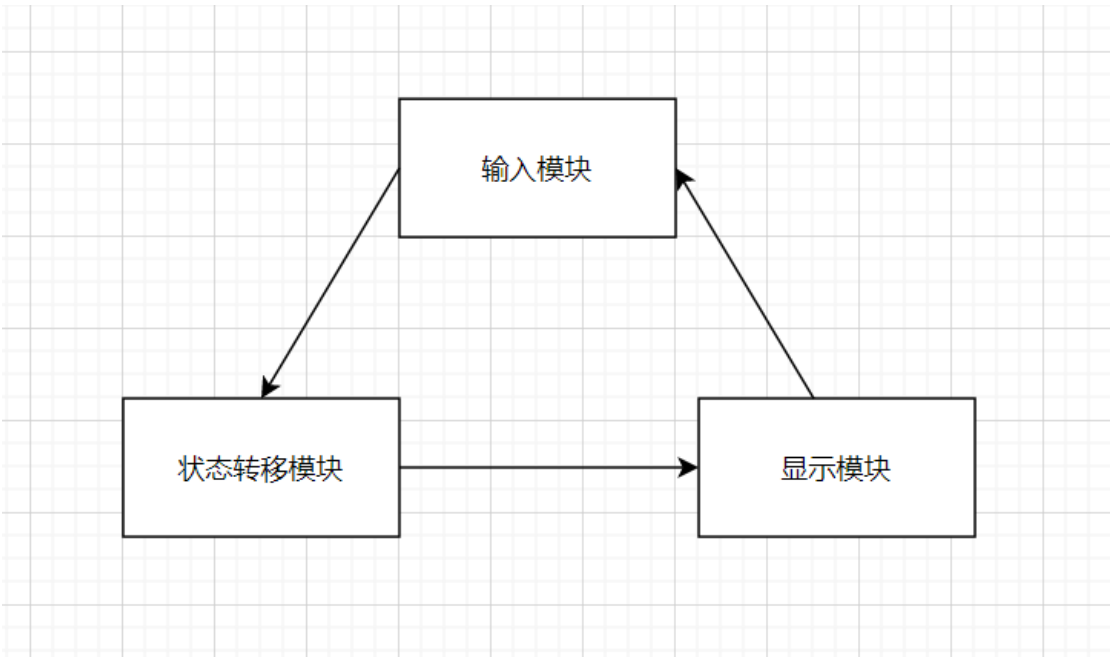
设计时间 2021.1.4

# 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：

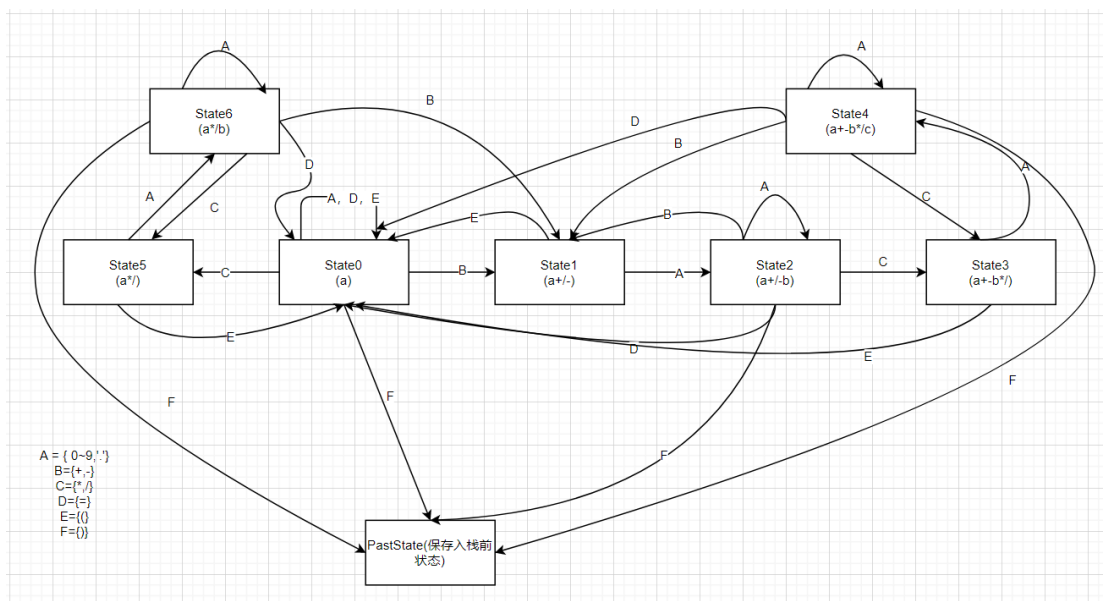
----- + ----- \* ----- / -----  
 ----- ( ----- ) ----- . ----- = -----

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  $A=\{0\sim9,.\}$ ,  $B=\{+,-\}$ ,  $C=\{*,/\}$ ,  $D=\{=\}$ ,  $E=\{(\}$ ,  $F=\{)\}$

状态图:



小数点处理：使用全局变量，为 a,b,c 设置一个标记变量，当未标记时为整数更新方式，标记后为浮点更新方式。

+/-状态用一个状态表示，使用 add\_sub\_flag 全局变量进行标记区分。\*/状态同理使用 multi\_div\_flag 来标记区分。

‘(’运算用堆栈完成，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。