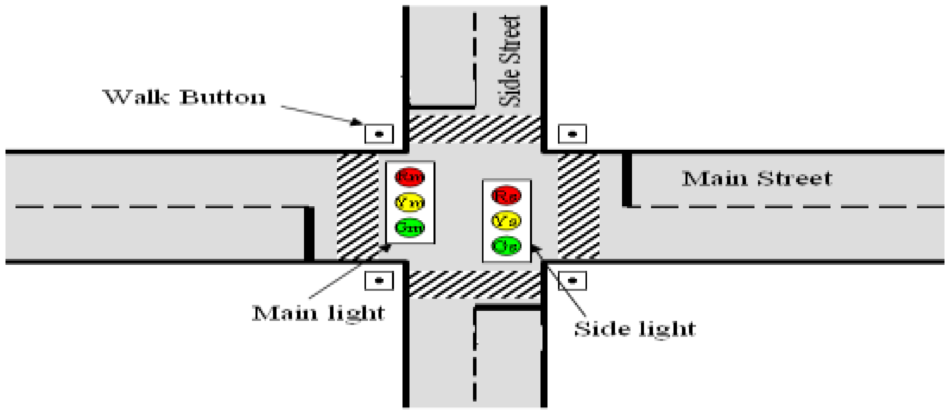
COE 306, Term 171

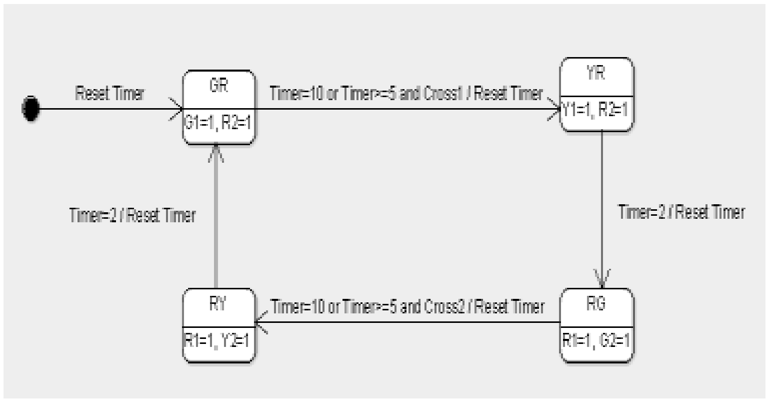
Introduction to Embedded Systems

Assignment# 4 Solution
Due date: Saturday, Nov. 25, 2017

Q.1. It is required to design a digital system that controls the traffic lights at an intersection. It receives inputs from all four corners indicating pedestrians that want to cross. In absence of crossing requests, it should allow each direction 10 seconds of green light, followed by 2 seconds of yellow light while the other traffic light will be red light (i.e., for 12 seconds). In presence of crossing requests at or after 5 seconds, immediately proceed with yellow. Use two buttons Cross1 and Cross2 to indicate request for crossing across the main street and side street respectively. Use a pair of Red, Yellow and Green leds for each street.



(i) Show the state diagram of your traffic light controller.



(ii) Implement your traffic light controller and include your code along with a link for a video demo illustrating its correct functionality.

Two solutions are done one based on using two timers and interrupts and the other is based on using one timer and timer polling in addition to displaying the waiting time on seven segment display.

<u>**First Solution**</u>:

```
#ifdef __USE_CMSIS
#include "LPC17xx.h"
#endif

#include <cr_section_macros.h>


#define GR 0
#define YR 1
#define RG 2
#define RY 3
int state=0;
int Cross1=0, Cross2=0;
int timer0=0; timer1=0;

void TIMER0_IRQHandler() {
   timer0=1;
   LPC_TIM0->IR |= 1;
}

void TIMER1_IRQHandler() {
   timer1=1;
   LPC_TIM1->IR |= 1;
}

void EINT0_IRQHandler()
{
    if (state==GR) Cross1=1;
    printf("Cross1 pressed\n");
    for (int j=0; j<1000000; j++); // to avoid effect of bouncing
    LPC_SC->EXTINT |= 1;
}

void EINT1_IRQHandler()
{
      if (state==RG) Cross2=1;
      printf("Cross2 pressed\n");
      for (int j=0; j<1000000; j++); // to avoid effect of bouncing
      LPC_SC->EXTINT |= 2;
}


void SetTimer0(uint32_t delayInSec) {
      LPC_TIM0->TCR = 0x02; /* reset timer */
      LPC_TIM0->MR0 = delayInSec*2000 * (12500000 / 1000 - 1);
      LPC_TIM0->MCR = 0x05; /* stop timer on match and enable
interrupt*/
      LPC_TIM0->TCR = 0x01; /* start timer */
}

void SetTimer1(uint32_t delayInSec) {
      LPC_TIM1->TCR = 0x02; /* reset timer */
      LPC_TIM1->MR0 = delayInSec*2000 * (12500000 / 1000 - 1);
      LPC_TIM1->MCR = 0x05; /* stop timer on match and enable
interrupt*/
      LPC_TIM1->TCR = 0x01; /* start timer */
}


int main(void) {


      LPC_GPIO0->FIODIR |= 7<<7;    // set pins 0.7, 0.8, 0.9 for GYR
for Main Street TL
      LPC_GPIO0->FIODIR |= 7<<23;    // set pins 0.23, 0.24, 0.25 for
GYR for Side Street TL

      LPC_PINCON->PINSEL4     |=    (1<<20); // using pin p2.10 for
cross1
      LPC_PINCON->PINSEL4     |=    (1<<22); // using pin p2.11 for
cross2

      LPC_SC->EXTMODE  |= 3;
      LPC_SC->EXTPOLAR |= 3;

      NVIC_EnableIRQ(EINT0_IRQn);
      NVIC_EnableIRQ(EINT1_IRQn);
      NVIC_EnableIRQ(TIMER0_IRQn);  // Enable interrupt for timer 0
      NVIC_EnableIRQ(TIMER1_IRQn);  // Enable interrupt for timer 1

      Cross1=0; Cross2=0;

      LPC_TIM0->PR = 0x00; /* set prescaler to zero */
      SetTimer0(10);
      timer0=0;

      LPC_TIM1->PR = 0x00; /* set prescaler to zero */
      SetTimer1(5);
      timer1=0;

    while(1) {

      switch(state){

      case GR:
            printf("state GR\n");
            LPC_GPIO0->FIOSET |= (1<<7); LPC_GPIO0->FIOCLR |= (1<<8);
            LPC_GPIO0->FIOCLR |= (1<<9);
            LPC_GPIO0->FIOCLR |= (1<<23); LPC_GPIO0->FIOCLR |= (1<<24);
            LPC_GPIO0->FIOSET |= (1<<25);

            if (timer0 || (timer1 && Cross1)){
                  state = YR; Cross1=0;
                  SetTimer0(2);
                  timer0=0;
            }
            else
                  state = GR;
            break;
      case YR:
            printf("state YR\n");
            LPC_GPIO0->FIOCLR |= (1<<7); LPC_GPIO0->FIOSET |= (1<<8);
            LPC_GPIO0->FIOCLR |= (1<<9);
            LPC_GPIO0->FIOCLR |= (1<<23); LPC_GPIO0->FIOCLR |= (1<<24);
            LPC_GPIO0->FIOSET |= (1<<25);
            if (timer0){
                  state = RG;
                  SetTimer0(10);
                  timer0=0;
                  SetTimer1(5);
                  timer1=0;
            }
            else
                  state = YR;
            break;
      case RG:
            printf("state RG\n");

            LPC_GPIO0->FIOCLR |= (1<<7); LPC_GPIO0->FIOCLR |= (1<<8);
            LPC_GPIO0->FIOSET |= (1<<9);
            LPC_GPIO0->FIOSET |= (1<<23); LPC_GPIO0->FIOCLR |= (1<<24);
            LPC_GPIO0->FIOCLR |= (1<<25);

            if (timer0 || (timer1 && Cross2)){
                  state = RY; Cross2 = 0;
                  SetTimer0(2);
                  timer0=0;
            }
            else
                  state = RG;
            break;
      case RY:
            printf("state RY\n");
            LPC_GPIO0->FIOCLR |= (1<<7); LPC_GPIO0->FIOCLR |= (1<<8);
            LPC_GPIO0->FIOSET |= (1<<9);
            LPC_GPIO0->FIOCLR |= (1<<23); LPC_GPIO0->FIOSET |= (1<<24);
            LPC_GPIO0->FIOCLR |= (1<<25);
            if (timer0){
                  state = GR;
                  SetTimer0(10);
                  timer0=0;
                  SetTimer1(5);
                  timer1=0;
            }
            else
                  state = RY;
            break;
      }
    }
    return 0 ;
}
```

<u>**Second Solution**</u>:

```
#ifdef __USE_CMSIS
#include "LPC17xx.h"
#endif

#include <cr_section_macros.h>

#define GR 0
#define YR 1
#define RG 2
#define RY 3
int state=0;
int Cross1=0, Cross2=0;


void EINT0_IRQHandler()
{
      if (state==GR) Cross1=1;
      printf("Cross1 pressed\n");
      LPC_SC->EXTINT |= 1;
      for (int j=0; j<1000000; j++); // to avoid effect of bouncing
}

void EINT1_IRQHandler()
{
      if (state==RG) Cross2=1;
      printf("Cross2 pressed\n");
      LPC_SC->EXTINT |= 2;
      for (int j=0; j<1000000; j++); // to avoid effect of bouncing
}


int main(void) {



      LPC_GPIO2->FIODIR |= 0x7f;    // set pins 2.0 to 2.6 for 7-
segment display
      LPC_GPIO0->FIODIR |= 7<<7;    // set pins 0.7, 0.8, 0.9 for GYR
for Main Street TL
      LPC_GPIO0->FIODIR |= 7<<23;    // set pins 0.23, 0.24, 0.25 for
GYR for Side Street TL

      LPC_PINCON->PINSEL4     |=    (1<<20); // using pin p2.10 for
cross1
      LPC_PINCON->PINSEL4     |=    (1<<22); // using pin p2.11 for
cross2

      LPC_SC->EXTMODE  |= 3;
      LPC_SC->EXTPOLAR |= 3;

      NVIC_EnableIRQ(EINT0_IRQn);
      NVIC_EnableIRQ(EINT1_IRQn);




      Cross1=0; Cross2=0;
```

```
while(1) {

  switch(state){

  case GR:
        printf("state GR\n");
        LPC_GPIO0->FIOSET |= (1<<7); LPC_GPIO0->FIOCLR |= (1<<8);
        LPC_GPIO0->FIOCLR |= (1<<9);
        LPC_GPIO0->FIOCLR |= (1<<23); LPC_GPIO0->FIOCLR |= (1<<24);
        LPC_GPIO0->FIOSET |= (1<<25);
        for (i=1; i<=5; i++){
            Display(i);
            DelaySec(1);
        }
        for (i=6; i<=10; i++){
              if (Cross1) { Cross1=0; break;}
            Display(i);
            DelaySec(1);
        }
        state = YR;
        break;
  case YR:
        printf("state YR\n");
        LPC_GPIO0->FIOCLR |= (1<<7); LPC_GPIO0->FIOSET |= (1<<8);
        LPC_GPIO0->FIOCLR |= (1<<9);
        LPC_GPIO0->FIOCLR |= (1<<23); LPC_GPIO0->FIOCLR |= (1<<24);
        LPC_GPIO0->FIOSET |= (1<<25);
        for (i=1; i<=2; i++){
            Display(i);
            DelaySec(1);
        }
        state = RG;
        break;
  case RG:
        printf("state RG\n");
        LPC_GPIO0->FIOCLR |= (1<<7); LPC_GPIO0->FIOCLR |= (1<<8);
        LPC_GPIO0->FIOSET |= (1<<9);
        LPC_GPIO0->FIOSET |= (1<<23); LPC_GPIO0->FIOCLR |= (1<<24);
        LPC_GPIO0->FIOCLR |= (1<<25);
        for (i=1; i<=5; i++){
            Display(i);
            DelaySec(1);
        }
        for (i=6; i<=10; i++){
              if (Cross2) { Cross2=0; break;}
            Display(i);
            DelaySec(1);
        }
        state = RY;
        break;
  case RY:
        printf("state RY\n");
        LPC_GPIO0->FIOCLR |= (1<<7); LPC_GPIO0->FIOCLR |= (1<<8);
        LPC_GPIO0->FIOSET |= (1<<9);
        LPC_GPIO0->FIOCLR |= (1<<23); LPC_GPIO0->FIOSET |= (1<<24);
        LPC_GPIO0->FIOCLR |= (1<<25);
        for (i=1; i<=2; i++){
            Display(i);
```

```
                        DelaySec(1);
                    }
                    state = GR;
                    break;
            }
        }
        return 0 ;
}

void Display(int num){
        int res;            // GFEDCBA
        if(num == 0)
                res = 0x3F;
        else if(num == 1)
                res = 0x6;
        else if(num == 2)
                res = 0x5B;
        else if(num == 3)
                res = 0x4F;
        else if(num == 4)
                res = 0x66;
        else if(num == 5)
                res = 0x6D;
        else if(num == 6)
                res = 0x7D;
        else if(num == 7)
                res = 0x7;
        else if(num == 8)
                res = 0x7F;
        else if(num == 9)
                res = 0x6F;
        else res = 0x3F;
        LPC_GPIO2->FIOPIN = ~res;
}

void DelaySec(uint32_t delayInSec) {
        delayInSec = delayInSec * 2000;
        LPC_TIM0->TCR = 0x02; /* reset timer */
        LPC_TIM0->PR = 0x00; /* set prescaler to zero */
        LPC_TIM0->MR0 = delayInSec * (12500000 / 1000 - 1);
        LPC_TIM0->IR = 0xff; /* reset all interrrupts */
        LPC_TIM0->MCR = 0x04; /* stop timer on match */
        LPC_TIM0->TCR = 0x01; /* start timer */
        while (LPC_TIM0->TCR & 0x01);
}
```

Q.2. Write an embedded software that computes the moving average of the last five samples using a circular buffer. Assume that each sample is 4-bit. Whenever a sample is entered by the user, your program should print the average of the last five samples. Use interrupt to indicate that a new sample is entered. Include your code along with a video link illustrating correct functionality of your program for 10 entered samples.

```
ifdef __USE_CMSIS
#include "LPC17xx.h"
#endif

#include <cr_section_macros.h>
```

```
int x;
#define SIZE 5
int buffer[SIZE];
int pos;


void init() {
  for (int i = 0; i < SIZE; i++)
     buffer[i] = 0;
  pos = SIZE - 1;
}

void put(int value) {
  pos = (pos + 1) % SIZE;
  buffer[pos] = value;
}

/* get the ith value earlier from the circular buffer; zero being the
newest value */
int get(int i) {
int index = (pos - i) % SIZE;
if (index >=0)
   return buffer[index];
else return buffer[SIZE+index];
}


void EINT0_IRQHandler()
{
        x = LPC_GPIO2->FIOPIN & 0xf; // Using pins 2.0, 2.1, 2.2 and
2.3 for 4-bit input
        printf("Entered new value = %d \n", x);
        put(x);
        int sum=0;
        printf("Buffer Content: ");
        for (int k=0; k<SIZE;k++){
            printf("%d ", buffer[k]);
            sum += get(k);
        }
        printf("\n");
        float avg = (float) sum /SIZE;
        printf("Average = %f \n", avg);

        LPC_SC->EXTINT |= 1; //Clear Interrupt
        for (int j=0; j<1000000; j++); // to avoid effect of bouncing
}

int main(void) {

      LPC_PINCON->PINSEL4     |=    (1<<20); // using pin p2.10
      NVIC_EnableIRQ(EINT0_IRQn);

      init();

    while(1) {
    }
    return 0 ;
}
```