TB028

Technique to Calculate Day of Week

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INTRODUCTION

Basically, there are two kinds of electronic systems that come with a built-in calendar. The first kind of system is used mainly to display a calendar for a user's convenience. Examples of these systems are digital watches, computers, VCRs and TVs with on-screen display features. The second kind of system is required to know whether a given date is a weekend or weekday. Examples of such a system are multi-rate meters (such as a phone bill meter) and electronic pricing systems, where the weekend rate and the weekday rate are different.

In order to build an electronic calendar into the system, the designer needs to write a piece of software that will be able to determine the day (Sunday, Monday, ….Saturday) of the week when a date is input into the system. This routine is the basic component of an electronics calendar.

This Technical Brief provides a technique to find the exact day for a given date input.

THEORY OF CALCULATION

The method used to calculate the day of week is a straight forward and simple one. This method makes use of 31 December 1989 as a reference point. The reason why this date was chosen as a reference point is because it was on the last day of the week (Sunday), and also on the last day of a year (this makes it easy to calculate the number of days since the next day/date will be first/first). One day after this date was Monday, and two days after this date was Tuesday, and so on.

The date given will be N days after the 31st December 1989, and if the number N is divided by the number of days in a week (7), the return will correspond to a specific day of the week. For this application, 0 corresponds to Sunday, 1 to Monday, and so on till 6 corresponds to Saturday. Therefore, when a date is given, the number of days from the date given after the 31 December can be calculated. Then the division of the number by 7 will give a remainder, which will correspond to the day of the week that the system required.

DESCRIPTION OF SOFTWARE

This application note provides two routines for the calculation of the day of the week. One is written in ANSI C and the other is written in assembly language using a PIC16C54 microcontroller.

In these routines, the number of days after 31 December 1989 is calculated and stored in a register called `AccValue`. There are a total of three steps involved in getting the number of days.

The first step is to find out the difference in years, and convert the difference into days. A 16-bit counter, `TempYear`, is used as a temporary counter and is initialized to the year 1990. The routine will keep comparing the contents of `TempYear` to the year (`CurrentYear` in the 'C' software) that is input in the software. If the `TempYear` value is less than the year value, `TempYear` will be increased by 1 until the contents of `TempYear` match the year given.

The `AccValue` will be increased by 1 (instead of 365, because 365MOD7 = 1) or by 2 (if `TempYear` is a leap year) for each comparison in which the `TempYear` value is less than the year value.

The second step involves calculating the number of days that have elapsed between the first day (inclusive) of that year and the first day of the month given. The number of days elapsed is calculated and pre-stored in a table. This value is retrieved with respect to the input month and added to the `AccValue`.

The way to calculate the pre-stored value is as follows; for January there is less than one month elapsed, therefore the value stored is 0. For February, the month passed is only 1 (January) and the value stored is 31MOD7, which is 3. For March, 2 months have passed, (January and February), so the value stored is (28+31)MOD7, which is 3.

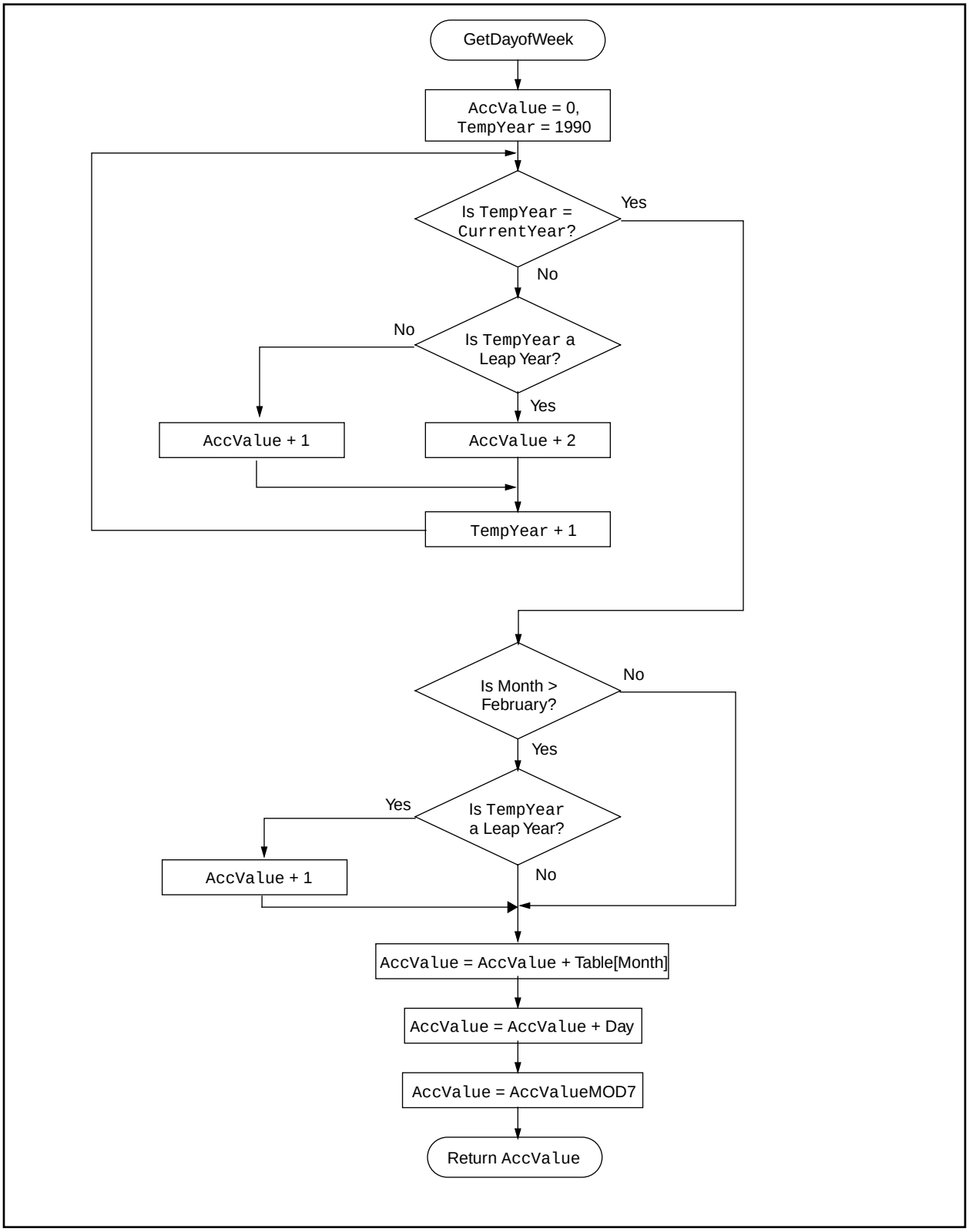
The third step involves adding the day given to the `AccValue`. The `AccValue` is then divided by 7, and the remainder gives the result corresponding to the day of week.

Figure 1 is a flowchart of the software routine.

The software here will only work if the input given ranges from 1 January 1990 to 31 December 2099.

The software does not check for the use of errorneous dates such as 29 February 1998, or 32 March 1999.

FIGURE 1: APPLICATION FLOWCHART



APPENDIX A: PIC16C54 ASSEMBLY CODE

```
      ListP=16C54
;
;*********************************************************
;
PCL          equ     02h
STATUS       equ     03h
;
#define      Z       STATUS,2
#define      C       STATUS,0
;
YearHi       equ     10h            ;Store the Upper byte of Year
YearLw       equ     11h            ;Store the Lower byte of year
Month        equ     12h            ;Store the Month(1 for January, 2 for February and so on)
Day          equ     13h            ;Store the Day
AccValue     equ     14h
TempA        equ     15h
TempB        equ     16h
TempYearHi   equ     15h
TempYearLw   equ     16h
Lbyte        equ     17h
Hbyte        equ     18h
Ltemp        equ     19h
Htemp        equ     1Ah
Temp         equ     1Bh
;
      org 0x00
;*********************************************************
; Test program for GetDayofWeek
; The End Result willbe  stored in AccValue
;*********************************************************
;
main         movlw   19h            ;Set Date as 21 September 1998
             movwf   TempA
             movlw   98h
             movwf   TempB
             movlw   9
             movwf   Month
             movlw   D'21'
             movwf   Day
;
             call    BCDtoBin       ;Convert the 4-digit BCD Year to 16bit int value
;
             movfw   Lbyte
             movwf   YearLw
;
             movfw   Hbyte
             movwf   YearHi
;
             call    GetDayofWeek   ;Calculate Day
;
Loop  gotoLoop
;
;*********************************************************
; Accumulated Value for Month
; This routine return the remainder value when
; number of days summed up and divided by 7
;*********************************************************
;
GetMonthValueaddwfPCL,1
             nop
             retlw   0              ;January
             retlw   3              ;February, %(31/7) = 3
             retlw   3              ;March, Remaider for (3+28)/7
             retlw   6              ;April, (3+31)/7
             retlw   1              ;May, (6+30)/7
```

```
                retlw   4               ;June, (1+31)/7
                retlw   6               ;July,%(4+30)/7= 6
                retlw   2               ;August, %(6+31/7) = 2
                retlw   5               ;September, %(2+31)/7=4
                retlw   0               ;October, %(5+30)/7=6
                retlw   3               ;November, (0+31)/7=3
                retlw   5               ;December, (3+30)/7=5
;
;*********************************************************
;               Routine : GetDayofWeek
;*********************************************************
;
GetDayofWeekclrfAccValue
                call    CheckValidInput
                btfss   Z               ;Is input Valid ?
                retlw   08
;
                movlw   0C6h            ;Set the Temp counter to 1990(Decimal)
                movwf   TempYearLw
                movlw   07
                movwf   TempYearHi
;
GetDay_0        call    CompYear        ;Check is Year > Temp counter
                btfsc   Z
                goto    GetDay_1        ;Year = Temp
;
;Year is > Temp Year
;
                incf    AccValue,1
                call    IsLeapYear      ;Check is TempYear = Leap Year
                btfsc   Z               ;Is Leap Year ?
                incf    AccValue,1      ;Yes !
;
                call    IncTemp
                goto    GetDay_0
;
GetDay_1        movlw.3
                subwf   Month,W         ;Check is Month > February ?
                btfss   C
                goto    GetDay_2        ;No !
;
                call    IsLeapYear      ;Check for Leap year
                btfss   Z
                goto    GetDay_2        ;Not Leap Year!
                incf    AccValue,1
;
GetDay_2        movf    Month,w
                call    GetMonthValue
                addwf   AccValue,1      ;Sum the AccValue with Month Value
                movf    Day,w   ;
                addwf   AccValue,1      ;Sum the AccValue with Day Value
                call    Modula_7        ;AccValue%7
                retlw   0
;
;*********************************************************
;               Routine: Check Valid Input for 1990-2099
;               (equivalent to 07C6h - 0833h)
;               If Input Valid, return Valid = 1
;               Else Valid = 0
;*********************************************************
;
CheckValidInput movlw   07h
                subwf   YearHi,w
                btfss   C
                goto    NotValid        ;YearHi is < 07h
;
```

```
            btfss   Z
            goto    CheckValid_0   ;YearHi not equal to 07h
;
;YearHi is = 07h Check For Year low
;
            movlw   0C6h
            subwf   YearLw,w
            btfss   C
            goto    NotValid       ;YearLw is <90
;
ValidYear   bsf     Z
            retlw   0              ;Year is valid
;
;YearHi is greater 07h, check for YearHi=08h
;
CheckValid_0 movlw  08h
            subwf   YearHi,w
            btfss   Z
            goto    NotValid       ;YearHi is > 20
;
;YearHi is 20, check for YearLw < or = 33
;
            movlw   34h
            subwf   YearLw,w
            btfss   C              ;is YearLw end with Hex value ?
            goto    ValidYear      ;Not a valid value
;
NotValid    bcf     Z
            retlw   0
;
;*********************************************************
;           Routine: Modula_7
;           Register: ACC
;           Output: Remaider of Acc/7
;*********************************************************
;
Modula_7    movlw   .7
            subwf   AccValue,w
            btfss   C
            goto    Modula_70
;
;Contents of Acc > 7
;
            movlw   .7
            subwf   AccValue,1
            goto    Modula_7
;
Modula_70   movf    AccValue,w
            movwf   Temp
            retlw   0
;
;*********************************************************
;           Routine : CompYear
;           ReturnZ=1 if Year > TempYear
;           Else return 0
;*********************************************************
;
CompYear    movf    YearHi,w
            subwf   TempYearHi,w
            btfss   Z
            retlw   0              ;YearHi > TempYearHi
;
            movfw   YearLw
            subwf   TempYearLw,w
            retlw   0
;
```

```
;*********************************************************
;               Routine: IsLeapYear
;               Return Z=1 if TempYear is Leap year
;               Else Return 0
;*********************************************************
;
IsLeapYear      btfsc   TempYearLw,0
                goto    NotLeapYear
;
                btfsc   TempYearLw,1
                goto    NotLeapYear
;
                bsf     Z
                retlw   0
;
NotLeapYear     bcf     Z
                retlw   0
;
;*********************************************************
;               Routine: IncTemp
;               Increment The Temporary Counter
;*********************************************************
;
IncTemp         incfsz  TempYearLw,1
                retlw   0
;
                incf    TempYearHi,1
                retlw   0
;
;*********************************************************
;               Routine : BCDtoBin
;               This routine convert 4-Digit BCD value(D3D2D1D0)
;               into 16Bit Binary code
;               input : 2 digit High Byte is stored in TempA
;                     2 digit Low byte is store in TempB
;               Output: Hbyte:Lbyte
;               For more on the BCD to Bin conversion please refer
;               to AN544
;*********************************************************
;
BCDtoBin        clrf    Htemp
                clrf    Ltemp
                clrf    Lbyte
                clrf    Hbyte
;
                swapf   TempA,w         ;D3*10
                call    Mpy10
;
                movfw   TempA           ;[(D3*10)+D2]*10
                call    Mpy10
;
                swapf   TempB,w         ;{[(D3*10)+D2]*10+D1}*10
                call    Mpy10
;
                movfw   TempB           ;
                andlw   0x0f
;
                addwf   Lbyte,1         ;{[(D3*10)+D2]*10+D1}*10+D4
                btfsc   C
                incfH   byte,1
                retlw   0
;
```

```
;*********************************************************
;            Routine : Mpy10
;            This routine multiply the value store in W register by 10
;            Theory : Let say the input is N,
;            1st,  Store the product of 2*N into Temporary register
;            2nd,  Multiply the value N by 8, (8*N) and store in Hbyte and Lbyte
;            3nd,  Sum up the value obtained in 1st and 2nd steps
;            The whole process is equivalent to 2*N+8*N = N(2+8) = 10*N
;*********************************************************
;
Mpy10        andlw   0x0f
             addwf   Lbyte,1        ;2*N and store the product in temp
             btfsc   C
             incf    Hbyte,1
;
             bcf     C
             rlf     Lbyte,w
             movwf   Ltemp
             rlf     Hbyte,W
             movwf   Htemp
;
             bcf     C              ;8*N
             rlf     Lbyte,1
             rlf     Hbyte,1
;
             bcf     C
             rlf     Lbyte,1
             rlf     Hbyte,1
;
             bcf     C
             rlf     Lbyte,1
             rlf     Hbyte,1
;
             movfw   Ltemp          ;8*N+2*N =10*N
             addwf   Lbyte,1
             movfw   Htemp
             addwf   Hbyte,1
             retlw   0
;
;*********************************************************
;
     END
```

APPENDIX B: C IMPLEMENTATION

```
#include<P17C756.H>

#defineOK 1
#defineError8

charGetDayofWeek();
charCheckValidInput(unsigned int);
charIsLeapYear(int);

rom     constunsigned charTable[13]={0,0,3,3,6,1,4,6,2,5,0,3,5};

unsigned intCurrentYear;
unsigned charMonth,Day;

/*********************************************************
* Test Program for the routine GetDayofWeek()
*********************************************************/
voidmain(){

  charTemp;

  CurrentYear = 1998;/*Date : 21 September 1998*/
  Month    = 9;
  Day         = 21;

  Temp = GetDayofWeek();/*Result stored in Temp*/
  do{
  }while(1);
}

/*****************************************************************
* GetDayofWeek
* This routine calculate the Day(Sunday, Monday,...Saturday) of
* week  when a Date(year, Month, Day) is given.
* Input :  Year, Month and Day which in this routine is used
* as global variable.
* Output Variable :  0 to 6(which correspond to Sunday to Saturdaday
* respectively) if the input is acceptable, else a value 8 is return
*****************************************************************/
charGetDayofWeek(){

  unsigned intTempYear;
  unsigned charAccValue, Temp;

  if(CheckValidInput(CurrentYear)!=OK)/* Return Error if input not Valid*/
      return Error;

  TempYear = 1990;/*Comparation start with year 1990*/
  AccValue = 0;/*Init AccValue to 0*/


/* If TempYear is a leap year AccValue +2, else AccValue+1 */

  while(TempYear != CurrentYear){
      AccValue++;
      if(IsLeapYear(TempYear))
          AccValue++;
      TempYear++;
  }

  if(Month > 2){
      if(IsLeapYear(TempYear)==1)
              AccValue++;
  }
```

```
  AccValue += Table[Month];
  AccValue += Day;

  AccValue= AccValue%7;

  return(AccValue);
}

/*************************************************************************
* CheckValidInput
* Return a '1' if the input is within the required range. Else
* return a '0'.
*
* Input Variable : 16Bit Unsigned Int
* Output Varible  : '1' if input ranges between 1990 & 2099 inclusively
*************************************************************************/
charCheckValidInput(unsigned int  Input){

  if(Input>=1990 && Input<=2099 )
      returnOK;
  else
      return  !OK;

}

/*************************************************************************
* IsLeapYear
* Return a '1' if the input is a leap year. Else return a '0'
*
* Input Variable : 16Bit Unsigned Int
* Output Varible  : '1' if is a leap year, else '0'.
*************************************************************************/
charIsLeapYear(int Year){

  Year=Year&0x0003;
  if(Year==0)
      return 1;
  else
      return0;
}
/*************************************************************************/
```

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