Discrete Logic Replacement

Frontend Controller

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OVERVIEW

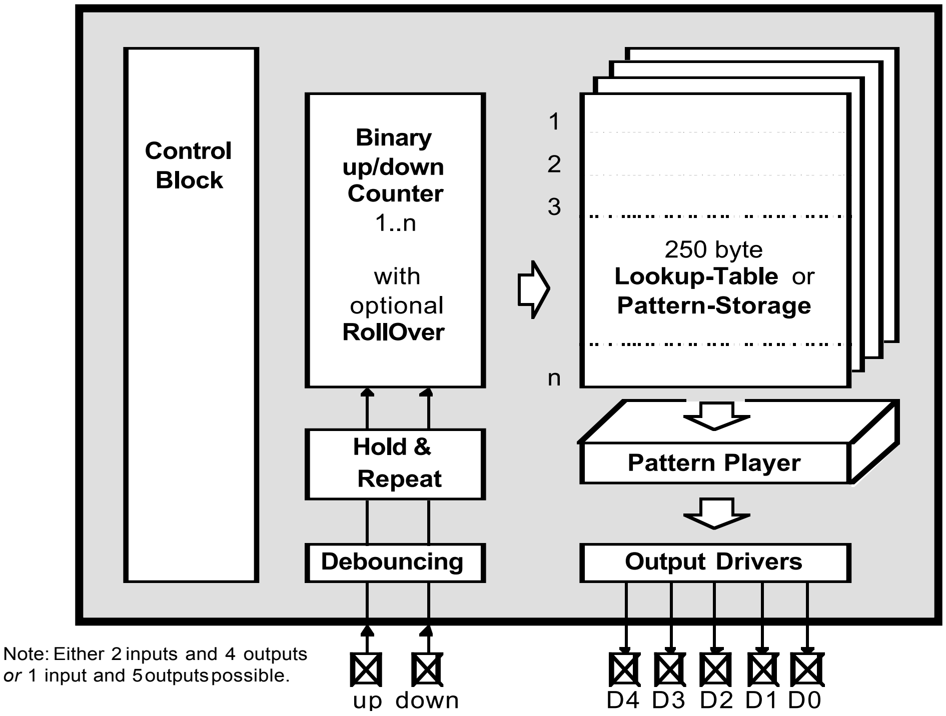
The *Frontend-Controller* replaces about half a dozen ICs one usually needs for human-machine-interaction and the lower control layers. A simple, but extremely powerful structure provides a variety of unexpected possibilities.

APPLICATION OPERATION

The *Frontend Controller* (Figure 1) provides two hold-and-repeat functional debounced button inputs, which drive a binary up/down counter. Using a lookup table, the counter value can be converted to decimal or gray code, for example. Alternatively, an individual pattern sequence may be released on the output for each counter stage, generating pulses or control signals for succeeding logic.

Let us go into detail first before demonstrating the power of this structure:

FIGURE 1: FRONTEND CONTROLLER



Note: Either 2 inputs and 4 outputs *or* 1 input and 5 outputs possible.

Note:	Please keep in mind how much discrete logic would be necessary for each feature offered by the *Frontend-Controller*!

Both button inputs are debounced as well as protected against noise. Upon pressing one of the buttons, the counter will change its state. Holding the button pressed for a certain time will initiate a repeat function, simulating a repeated button pressing (similar to the functionality of a PC keyboard).

The counters range is adjustable and not forced to multiples of two (e.g. 256), as the counters from the TTL series are. Upon reaching the counters maximum or minimum, it may either rollover or ignore any counting pulses in the corresponding direction. This way it is even possible to implement a modulo-5 counter (or frequency divider), for example.

Using a lookup-table, the counter value may be converted. Therefore it is possible to have the *Frontend-Controller* count binary, decimal or gray-code. The lookup-table may also contain bit patterns to drive succeeding components. This is even surpassed by the pattern player. It may release a whole sequence of patterns, individual for each counter stage, to generate pulses and control sequences for succeeding logic. Each sequence may be repeated upon reaching its end or it may be played just once.

Of course, all timings and frequencies are adjustable.

EXAMPLE APPLICATIONS

Binary Modulo-7 Counter with Hold-and-Repeat

Set the counter to seven stages, enable rollover feature and store binary values 0… 6 into the lookup-table. A discrete solution would need button debouncing, two timers for hold and repeat, a counter, logic to detect counter stage 7 and reset counter: at least five integrated circuits.

Eight Stage PWM Generator with LED Display

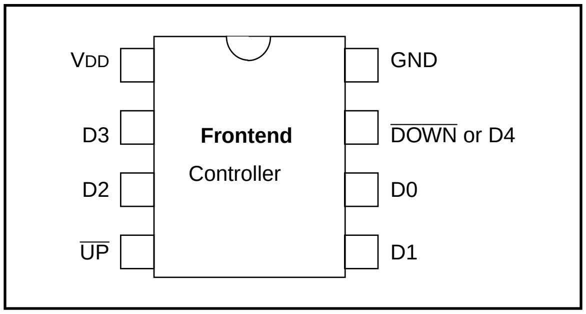
Set the counter to eight stages, optionally activate rollover feature and write eight sequences (each one eight patterns long) for the pattern player. Bit 0…2 of each sequence holds the binary value of the sequence number (which corresponds to the counter value). Connect a 7-segment LED driver to these outputs. Bit 3 will provide the PWM output: For sequence #n, it will be high in n patterns, and low in the remaining (8-n) patterns. Enable the loop feature for all eight sequences.

Six Stage Counter with (RS232) Serial Output

Set the counter to six stages and write six sequences. Bit 0.2 always contains the binary equivalent of the stage number, bit 3 is used to release the serial bit stream (therefore, the sequence length has to be about 10). Disable loop feature.

You see, the *Frontend-Controller*s structure is simple but extremely powerful!

GRAPHICAL HARDWARE REPRESENTATION



MICROCHIP TOOLS USED

Picstart Plus V1.3

ASSEMBLER/COMPILER VERSION

MPASM V1.5

APPENDIX A: SOURCE CODE

Notes on the software: A routine called `Interrupt` is permanently called from the main program. The routine will check the TMR0 for an overflow (which will happen regularly) and execute a kind of software interrupt routine then. This will debounce the inputs (to make the main program get rid of that), and it will handle the pattern player to make it run independent from the main program.

Furthermore, the software listing contains some sample applications.

```
;****************************************************************************
;* DE$IGNING FOR DOLLAR$ entry:  FRONTEND-CONTROLLER                        *
;*                    by Marc Hoffknecht & Gabi Borgards                          *
;****************************************************************************

                     processor 12c508
                     radix dec
                     include “p12c508.inc”

#define              __12C508
                     __config _WDT_OFF & _IntRC_OSC & _MCLRE_OFF & _CP_OFF

                     CBLOCK 0x0C           ; start of RAM
                     ENDC

                     GOTO Main

;****************************************************************************
;* macros & standard definitions                                            *
;****************************************************************************

#define zero         STATUS, 2
#define carry        STATUS, 0

#define              SZ     BTFSS zero     ; (s)kip if (z)ero
#define              SNZ    BTFSC zero     ; (s)kip if (n)ot (z)ero
#define              RET    RETLW 0        ; (ret)urn

MOVLF                MACRO literal, file   ; (mov)e (l)iteral to (f)ile
                      MOVLW literal
                      MOVWF file
                     ENDM

#define TRUE-1
#define FALSE0

STrue                MACRO                 ; (s)kip if (true)
                      IORLW 0
                      BTFSC zero
                     ENDM
SFalse               MACRO
                      IORLW 0
                      BTFSS zero
                     ENDM

;****************************************************************************

#define              TMR0overrun    256    ; TMR0 will overrun every 256 us
#define              us   1/TMR0overrun
```

```
#define              ms    1000/TMR0overrun

EOS                  EQU 128               ; marks (e)nd (o)f (s)equence
RS                   EQU 128+64            ; marks (r)epeat (s)equence

                                           ; reorder bits from pattern
                                           ; definition to suit pinout:
Pattern    MACRO x                         ; 0->1, 1->2, 2->4, 3->5, 4->0
                      RETLW (((x)&3)<<1)|(((x)&12)<<2)|(((x)&16)>>4)|(((x)&192))
                     ENDM
Value                MACRO x
                      RETLW (((x)&3)<<1)|(((x)&12)<<2)|(((x)&16)>>4)|(EOS)
                     ENDM

;*****************************************************************************
;* configuration                                                             *
;*****************************************************************************

;                                              ;   range:  purpose:
;                                              ;
OutputWidth          EQU 5                            ;   4-5one input only if set to 5
DebounceTime         EQU  50*ms  ; .25-65ms        duration of input bouncing
RepeatDelay          EQU 500*ms  ;    -16 s        delay till automatic button repeat
RepeatTime           EQU 500*ms  ;    -16 s        speed of automatic button repeat
Pattern.Delay        EQU  50*ms  ; .25-65ms        speed of playing patterns
PullUps              EQU TRUE    ;                 activate internal pullups on inputs
RollOver             EQU TRUE    ;                 counter rollover feature

; sample application: five stage PWM generator
; bit 2..0 output stage number ( 0 ,  1 ,  2 ,  3 ,   4 ),
; bit 3 outputs a PWM signal of  0%, 25%, 50%, 75%, 100%

Pattern.LengthEQU 4

                     Pattern           0+0        ; use the ‘pattern’ macro to define
                     Pattern           0+0        ; sequences of patterns ...
                     Pattern           0+0        ; and mark each sequence’s end with either
                     Pattern           0+0+RS     ;  RS = repeat sequence or
                                                  ; EOS = end of sequence
                     Pattern           1+8
                     Pattern           1+0
                     Pattern           1+0
                     Pattern           1+0+RS

                     Pattern           2+8
                     Pattern           2+8
                     Pattern           2+0
                     Pattern           2+0+RS

                     Pattern           3+8
                     Pattern           3+8
                     Pattern           3+8
                     Pattern           3+0+RS

                     Pattern           4+8
                     Pattern           4+8
                     Pattern           4+8
                     Pattern           4+8+RS


; 2nd sample application: five stage decimal counter
;
; OutputWidth        EQU 5                 ;
; Pattern.LengthEQU 1; no sequence of patterns
;
;                           D4...D0
;                    Value b'00001'        ; use the 'value' macro to define
;                    Value b'00010'        ; patterns only ( no sequence )
;                    Value b'00100'        ; ( in fact 'value' defines a one pattern
;                    Value b'01000'        ;   long sequence and automatically marks
;                    Value b'10000'        ;   the EOS ).


Pattern.Max          EQU (($-1)/Pattern.Length)-1 ; calculate number of sequences

;****************************************************************************

CountUp              GOTO CountUp_         ; since CALL can only access the
CountDown  GOTO CountDown_                 ; first 256 byte of memory, we need
                                           ; to place these jump vectors here.

;****************************************************************************
;* button debouncing                                                        *
;****************************************************************************

; This section handles the button input(s). The variable 'Buttons' holds the
; valid ( debounced ) state of the corresponding pin. When the button state
; is changing, a timer will start running down. If it reaches zero, the button
; was validly pressed, otherwise it had to be noise.

                     CBLOCK
                      Buttons              ; holds the valid button states
                      TimerUp
                      TimerDown
                     ENDC

#define              Button.Up             Buttons, 3
#define    Button.DownButtons, 0

                     ;

InitButtons          MACRO
                 MOVLF DebounceTime, TimerUp
                 MOVLF DebounceTime, TimerDown
                       MOVLF 255, Buttons  ; button inputs are active low
                     ENDM

                     ;

HandleButtons        MACRO

HandleUp    MOVF GPIO, W                   ; mark all pins that differ between
                      XORWF Buttons, W     ; 'GPIO' and 'Buttons' with a '1',
                      ANDLW b'001000'      ; and mask out button ( bit 3 ).
                      SNZ                  ; 'w' will be zero, if there are no
                       GOTO ReloadTimerUp  ; changes,
                      DECFSZ TimerUp       ; otherwise, a timer has to reach
                       GOTO HandleDown     ; zero first.
                      XORWF Buttons
ReloadTimerUp MOVLF DebounceTime, TimerUp

HandleDown
                     IF OutputWidth==4
             MOVF GPIO, W
                       XORWF Buttons, W
                       ANDLW b'000001'
                       SNZ
                        GOTO ReloadTimerDown
                       DECFSZ TimerDown
                        GOTO Buttons.done
                       XORWF Buttons
ReloadTimerDown   MOVLF DebounceTime, TimerDown
```

```
Buttons.done
                      ENDIF

                     ENDM

;****************************************************************************
;* pattern player                                                           *
;****************************************************************************

; This section provides routines for an interrupt driven pattern player.
; The 'SetPattern' macro is used to arrange everything for a new pattern
; sequence. Therefore, load 'w' with the memory location of the first pattern
; in the sequence. Bits 6 & 7 are used as a repeat-flag & end-of-pattern
; flag.

                     CBLOCK
                      Pattern.Timer
                      Pattern.Begin
                      Pattern.Pointer
                      Pattern.Current
                     ENDC

                     ;

ReadMemory           MOVWF PCL

SetPattern MACRO                            ; load pointer to next patt.
                      ;                     ; into 'w' and execute this
                      ;
                      MOVWF Pattern.Pointer ; save pointer
                      CALL ReadMemory       ; load word at w from memory
                      MOVWF Pattern.Current ; and save it
                      MOVWF GPIO
                      MOVLF Pattern.Delay, Pattern.Timer
                     ENDM

                     ;

HandlePatternPlayer MACRO
                          LOCAL done

                          DECFSZ Pattern.Timer
                           GOTO done

                          BTFSC Pattern.Current, 7; bit 7 marks end of sequence
                           GOTO EndOfSequence; jump, if we are at the end

                          INCF Pattern.Pointer, W; no, we are within the seq.
                          SetPattern
                          GOTO done

EndOfSequence     BTFSS Pattern.Current, 6; end of sequence reached
                           GOTO done        ;  exit, if no 'RepeatFlag'
                          MOVF Pattern.Begin, W
                          SetPattern
done
                         ENDM

;****************************************************************************
;* software-interrupt                                                       *
;****************************************************************************

; Execute 'CALL Interrupt' every now and then. It will check the TMR0 for
; an overflow. When an overflow is detected, a kind of 'software-interrupt'
; is executed. The oftener 'Interrupt' is called, the more accurate will the
; timing be ...
; The interrupt routine will provide a timer which is incremented about every
; 256 us. TRUE will be returned in ‘w’ when this timer hits zero.


                     CBLOCK
                      OldTMR0
                      TimerL
                      TimerH
                     ENDC

                     ;

Interrupt      MOVF OldTMR0, W             ; overflow occured if OldTMR0 > TMR0
                     SUBWF TMR0, W
                     BTFSC carry
                      GOTO Interrupt.done
                     ADDWF OldTMR0

                     ; ***********************************************************
                     ; software-interrupt: program enters here about every 256 us

                     HandleButtons
                     HandlePatternPlayer

                     INCFSZ TimerL
                      RETLW FALSE
                     INCFSZ TimerH
                      RETLW FALSE
                     RETLW TRUE            ; return TRUE upon hitting zero

                     ; ***********************************************************

Interrupt.doneADDWF OldTMR0
                     RETLW FALSE

;****************************************************************************

LoadTimer  MACRO Value
                      MOVLW low(-Value)
                      MOVWF TimerL
                      MOVLW high(-Value)
                      MOVWF TimerH
                     ENDM

;****************************************************************************
;* multiply macro                                                           *
;****************************************************************************

; (MUL)tiply(L)iteral(W)    performs w * literal -> w

                     CBLOCK
                      mul
                     ENDC

MULLW                MACRO literal
                      VARIABLE i

                      MOVWF mul
                      CLRW
                      BCF carry

                      i=0
                      WHILE ( literal >= (1<<i) )
                       IF ( literal & (1<<i) )
                        ADDWF mul, W
                       ENDIF
                       RLF mul
                       i += 1
                      ENDW
                     ENDM

;****************************************************************************
;* main program                                                             *
;****************************************************************************

                     CBLOCK
                      Counter
                     ENDC

Main                 MOVWF OSCCAL

                     IF PullUps
                      MOVLW b’10011000’
                     ELSE
                      MOVLW b’11011000
                     ENDIF
                     OPTION                ; -> TMR0overrun every 256 us

                     MOVLW 1               ; initialize pattern player
                     MOVWF Pattern.Begin   ; set first pattern ( sequence )
                     SetPattern
                     CLRF Counter

                     IF OutputWidth==4
                      MOVLW b’001001’      ; two button inputs
                     ELSE
                      MOVLW b’001000’      ; only one button input
                     ENDIF
                     TRIS GPIO

                     InitButtons

;****************************************************************************

MainLoop   CALL Interrupt
                     BTFSS Button.Up       ; button inputs are active low
                      GOTO UpPressed
                     BTFSS Button.Down
                      GOTO DownPressed
                     GOTO MainLoop

                     ;

UpPressed  CALL CountUp                    ; Upon pressing button, count one
                     LoadTimer RepeatDelay ; stage up. When holding the button
UpLoop               BTFSC Button.Up       ; down, count one stage up again
                      GOTO MainLoop        ; after the ‘RepeatDelay’. And then
                     CALL Interrupt        ; again every ‘RepeatTime’.
                     STrue
                      GOTO UpLoop
                     CALL CountUp
                     LoadTimer RepeatTime
                     GOTO UpLoop

                     ;

DownPressedCALL CountDown
                     LoadTimer RepeatDelay
DownLoop   BTFSC Button.Down
                      GOTO MainLoop        ; exit if button is no more pressed
                     Call Interrupt
                     STrue                 ; ‘Interrupt’ returns ‘TRUE’ upon
```

```
                      GOTO DownLoop        ; hitting zero in the timer.
                     CALL CountDown
                     LoadTimer RepeatTime
                     GOTO DownLoop

                     ;

CountDown_ TSTF Counter                    ; check counter boundaries and count
                     SZ                    ; one stage down here.
                      GOTO Decrease
                     IF RollOver
                      MOVLF Pattern.Max, Counter
                      GOTO CalcPatternBegin
                     ELSE
                      RET
                     ENDIF

Decrease   DECF Counter
                     GOTO CalcPatternBegin

                     ;

CountUp_   MOVLW Pattern.Max; check counter boundaries and count
                     SUBWF Counter, W      ; one stage up here.
                     BTFSS carry
                      GOTO Increase
                     IF RollOver
                      CLRF Counter
                     ELSE
                      MOVLF Pattern.Max, Counter
                     ENDIF
                     GOTO CalcPatternBegin

Increase   INCF Counter
                     GOTO CalcPatternBegin

                     ;

CalcPatternBegin                           ; Calculate the beginning of the
                     MOVF Counter, W       ; pattern for the new ‘Counter’
                     MULLW Pattern.Length  ; value...
                     MOVWF Pattern.Begin
                     INCF Pattern.Begin    ; pattern start at memory loc. 1

                     MOVF Pattern.Begin, W ; prepare to play this pattern
                     SetPattern
                     RET

;****************************************************************************

                     END
```

NOTES: