

Project: Signal Generator for Digital Analyzer Demonstration

Claude BAUMANN (COMPUTARIUM)

Version 1.0

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Abstract

This lab report depicts a simple signal generator used for demonstrating a digital analyzer device. The idea is to send out the message COMPUTARIUM via UART to the analyzer at a sufficiently high repetition rate, in order to facilitate the analyzer manipulation. Additionally the generator should produce 7 square signals at different frequencies.

History:

- Version 1.0 December 5, 2022

I Schematics

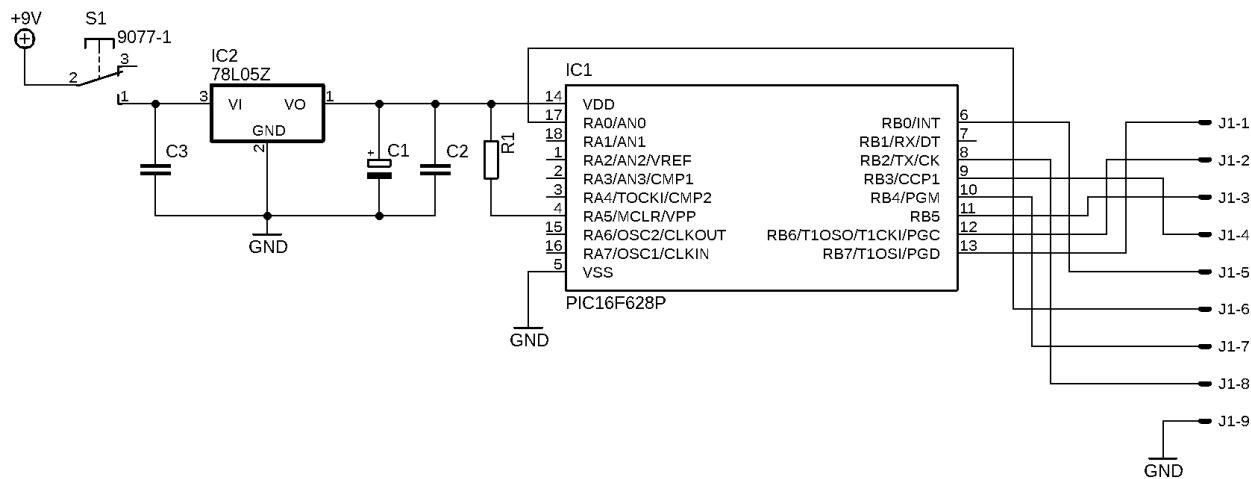


Figure 1: Design based on MICROCHIP PIC16F628.

II Output Pins

The device is programmed to produce the following signals:

1. Black: GND
2. White: UART TX (19200, 8, 1); send “COMPUTARIUM” every 8ms (message has duration: $d = 11 \cdot 10/19200 = 6\text{ms}$ (11 characters, 8 data bits +start and stop bit)
3. Grey: Interrupt based square wave (toggles every 8ms); interrupt starts the back-to-back UART TX sending. Signal frequency: 62.5Hz (Hard real-time)
4. Violet: Interrupt-based square wave: 122.07Hz (Hard real-time)

- Red, Orange, Yellow, Green, Blue: Each pin displays the bits <4..0> of a 5-bit software counter. Therefore, the frequency of any following pin must be divided by factor 2. Blue frequency: $\approx 100\text{Hz}$ (Weak real-time).

III PICLab program

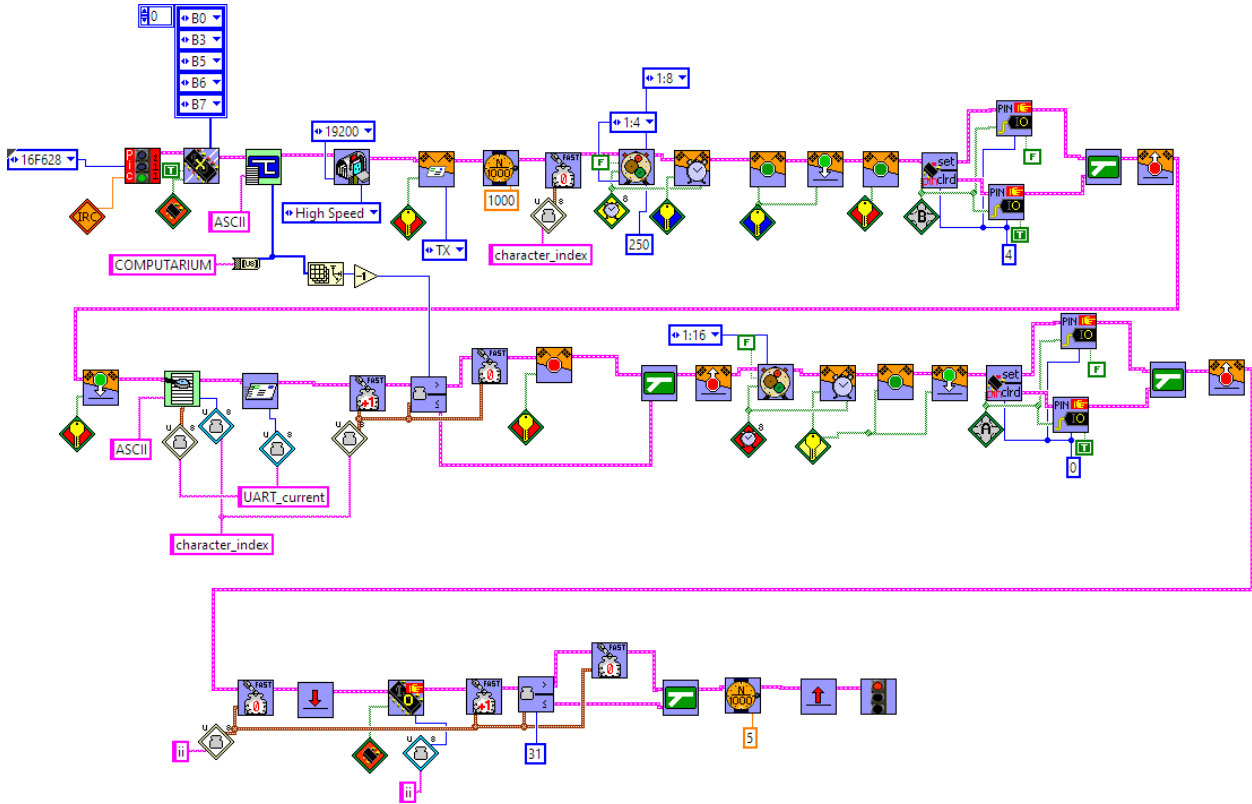


Figure 2: PICLab program

```

=====
;
;           Assembler code for send_computarium_UART5.vi created with PICLab
;
=====

LIST    p=16F628

#include "P16F628.INC" ; Include header file

__CONFIG (_BODEN_OFF&_CP_OFF&_PWRTE_ON&_WDT_OFF&_LVP_OFF&_MCLRE_ON&_INTRC_OSC_NOCLKOUT)

;*****Variable definitions*****

TEMPPORT8 EQU 0X20
TEMPX8 EQU 0X21
TEMPY8 EQU 0X22
RESULT8 EQU 0X23
TEMPX16 EQU 0X24
TEMPX16_H EQU 0X25
TEMPY16 EQU 0X26

```

```

TEMPY16_H EQU 0X27
RESULT16 EQU 0X28
RESULT16_H EQU 0X29
IDX16 EQU 0X2A
IDX16_H EQU 0X2B
TEMPY EQU 0X2C
OP_SIGN8 EQU 0X2D
ISR_TEMPPORT8 EQU 0X2E
ISR_TEMPX8 EQU 0X2F
ISR_TEMPY8 EQU 0X30
ISR_RESULT8 EQU 0X31
ISR_TEMPX16 EQU 0X32
ISR_TEMPX16_H EQU 0X33
ISR_TEMPY16 EQU 0X34
ISR_TEMPY16_H EQU 0X35
ISR_RESULT16 EQU 0X36
ISR_RESULT16_H EQU 0X37
ISR_IDX16 EQU 0X38
ISR_IDX16_H EQU 0X39
ISR_TEMPY EQU 0X3A
ISR_OP_SIGN8 EQU 0X3B
ISR_STATUS EQU 0X3C
ISR_W EQU 0X3D
ISR_FSR EQU 0X3E
UART_CURRENT EQU 0X3F
CHARACTER_INDEX EQU 0X40
II EQU 0X41
LOOKUP_TEMP EQU 0X42

```

*****Makro definitions and definitions of used operations*****

```

BANK0    MACRO
          BCF STATUS,RP0
          BCF STATUS,RP1
          ENDM
BANK1    MACRO
          BSF STATUS,RP0
          BCF STATUS,RP1
          ENDM
BANK2    MACRO
          BCF STATUS,RP0
          BSF STATUS,RP1
          ENDM

          GOTO START
          ORG 0X4
          GOTO LABEL_ISR

GRU8U8
  MOVF    TEMPX8,W
  SUBWF  TEMPY8
  BTFSS  STATUS,C
  RETLW  0
  RETLW  1

ISR_GRU8U8
  MOVF    ISR_TEMPX8,W
  SUBWF  ISR_TEMPY8
  BTFSS  STATUS,C

```

```

RETLW 0
RETLW 1

;*****BEGIN OF MAIN PROGRAM*****

START

;INITIALIZE PORT A
BANK0
CLRF PORTA
MOVLW OX07
MOVWF CMCON
BANK1
MOVLW OX0
MOVWF TRISA

;INITIALIZE PORT B
BANK0
CLRF PORTB
BANK1
MOVLW OX0
MOVWF TRISB

;CONFIGURE VIRTUAL PORT
;CONFIGURE PORT OUTPUTS
MOVF TRISB,W
ANDLW OX16
MOVWF TRISB

;CONFIGURE UART
BSF TRISB,1
BSF TRISB,2
MOVLW OXC
MOVWF SPBRG
BSF TXSTA,BRGH
BCF TXSTA,SYNC
BANK0
BSF RCSTA,SPEN
BCF RCSTA,RX9
BSF RCSTA,CREN
BANK1
BCF TXSTA,TX9
BSF TXSTA,TXEN

;WAIT
BANK0
MOVLW OXE6
MOVWF TEMPYY
LABEL_1004
MOVLW OX7
MOVWF IDX16
LABEL_1005
MOVLW OXCD
MOVWF IDX16_H
LABEL_1006
DECFSZ IDX16_H,F
GOTO LABEL_1006
DECFSZ IDX16,F
GOTO LABEL_1005

```

```

DECFSZ TEMPYY,F
GOTO LABEL_1004
NOP
NOP
NOP
NOP
NOP
NOP
NOP
NOP

BANK0
CLRF CHARACTER_INDEX

;CONFIGURE TMR2
MOVLW  B'111101'
MOVWF  T2CON
MOVLW  OXFA
BANK1
MOVWF  PR2

;START MONITORING INTERRUPTS
BANK0
BCF  PIR1,TMR2IF
BANK1
BSF  PIE1,TMR2IE
BSF  INTCON,GIE
BSF  INTCON,PEIE

;CONFIGURE TMRO
MOVLW  B'11010000'
ANDWF  OPTION_REG
MOVLW  B'11'
IORWF  OPTION_REG

;START MONITORING INTERRUPTS
BANK0
BCF  INTCON,TOIF
BANK1
BSF  INTCON,TOIE
BSF  INTCON,GIE
BSF  INTCON,PEIE

BANK0
CLRF  II

LABEL_0

;SET VIRTUAL PORT VALUE WITH VARIABLE U8
BANK0
MOVF  II,W
MOVWF TEMPPORT8
CALL  OUT_GENERIC_PORT0

BANK0
INCF  II,F

;BEGIN OF IF-STRUCTURE
;COMPARE-OPERATION
;SET VARIABLE U8 WITH VARIABLE U8

```

```

MOVF   II,W
MOVWF  TEMPX8
;SET VARIABLE U8 WITH CONSTANT
MOVLW  0X1F
MOVWF  TEMPY8
CALL   GRU8U8
BANKO
MOVWF  RESULT8
BTFSC  RESULT8,0
GOTO   LABEL_1014

                BANKO
                CLRF  II

GOTO   LABEL_1015
LABEL_1014

LABEL_1015
;END OF IF-STRUCTURE

;WAIT
BANKO
MOVLW  0X7
MOVWF  TEMPYY
LABEL_1016
MOVLW  0XB9
MOVWF  IDX16
LABEL_1017
DECFSZ  IDX16,F
GOTO   LABEL_1017
DECFSZ  TEMPYY,F
GOTO   LABEL_1016
NOP
NOP

GOTO   LABEL_0

LABEL_1018

GOTO   LABEL_1018

;*****SUBROUTINES*****

OUT_GENERIC_PORTO
BANKO
CLRF  RESULT16
BCF   RESULT16,0
BTFSC  TEMPPORT8,0
BSF   RESULT16,0
BCF   RESULT16,3
BTFSC  TEMPPORT8,1
BSF   RESULT16,3
BCF   RESULT16,5
BTFSC  TEMPPORT8,2
BSF   RESULT16,5
BCF   RESULT16,6
BTFSC  TEMPPORT8,3
BSF   RESULT16,6
BCF   RESULT16,7

```

```

BTFSCL TEMP8,4
BSF      RESULT16,7
MOVLW 0X16
ANDWF PORTB,W
IORWF RESULT16,W
MOVWF PORTB
RETURN

;*****LOOKUP-TABLES*****

ORG 0X1ED
LABEL_LOOKUP_ASCII

;BEGIN OF IF-STRUCTURE
;COMPARE-OPERATION
;SET VARIABLE U8 WITH VARIABLE U8
BANK0
MOVF  LOOKUP_TEMP,W
MOVWF TEMP8
;SET VARIABLE U8 WITH CONSTANT
MOVLW 0XA
MOVWF TEMP8
CALL GRU8
BANK0
MOVWF RESULT8
BTFSCL RESULT8,0
GOTO LABEL_1002

                RETLW 0X0

GOTO LABEL_1003
LABEL_1002

LABEL_1003
;END OF IF-STRUCTURE

MOVLW 0X2
MOVWF PCLATH
BANK0
MOVF  LOOKUP_TEMP,W
ADDWF PCL
RETLW 0X43
RETLW 0X4F
RETLW 0X4D
RETLW 0X50
RETLW 0X55
RETLW 0X54
RETLW 0X41
RETLW 0X52
RETLW 0X49
RETLW 0X55
RETLW 0X4D

;*****INTERRUPT SERVICE ROUTINE*****

LABEL_ISR
MOVWF 0X7F
SWAPF STATUS,W
BANK0

```

```

MOVWF ISR_STATUS
MOVF 0X7F,W
MOVWF ISR_W
MOVF TEMPPORT8,W
MOVWF ISR_TEMPPORT8
MOVF FSR,W
MOVWF ISR_FSR
BANK1
BTFSS PIE1,TXIE
GOTO LABEL_1019
BANK0
BTFSS PIR1,TXIF
GOTO LABEL_1019
CALL LABEL_EVENT0
BANK0
BCF PIR1,TXIF
LABEL_1019
BANK1
BTFSS PIE1,TMR2IE
GOTO LABEL_1020
BANK0
BTFSS PIR1,TMR2IF
GOTO LABEL_1020
CALL LABEL_EVENT1
BANK0
BCF PIR1,TMR2IF
LABEL_1020
BANK1
BTFSS INTCON,TOIE
GOTO LABEL_1021
BANK0
BTFSS INTCON,TOIF
GOTO LABEL_1021
CALL LABEL_EVENT2
BANK0
BCF INTCON,TOIF
LABEL_1021
BANK0
MOVF ISR_FSR,W
MOVWF FSR
MOVF ISR_TEMPPORT8,W
MOVWF TEMPPORT8
MOVF ISR_W,W
MOVWF 0X7F
SWAPF ISR_STATUS,W
MOVWF STATUS
SWAPF 0X7F,F
SWAPF 0X7F,W
RETFIE

;*****EVENT-ROUTINES*****

LABEL_EVENT1

;START MONITORING INTERRUPTS
BANK0
BCF PIR1,TXIF
BANK1
BSF PIE1,TXIE

```



```

;BEGIN OF IF-STRUCTURE (DEPENDING ON BIT/PIN)
BANK0
BTFSS PORTB,4
GOTO LABEL_1007

                ;SET SINGLE OUPUT PIN
                BANK0
                BCF PORTB,4

GOTO LABEL_1008
LABEL_1007

                ;SET SINGLE OUPUT PIN
                BANK0
                BSF PORTB,4

LABEL_1008
;END OF IF-STRUCTURE

RETURN

LABEL_EVENT0

;CALL LOOKUP-TABLE
;SET VARIABLE U8 WITH VARIABLE U8
BANK0
MOVF CHARACTER_INDEX,W
MOVWF LOOKUP_TEMP
CALL LABEL_LOOKUP_ASCII
BANK0
MOVWF UART_CURRENT

;SEND MAIL
LABEL_1009
BTFSS PIR1,TXIF
GOTO LABEL_1009
;SET SFR WITH VARIABLE U8
BANK0
MOVF UART_CURRENT,W
MOVWF TXREG

INCF CHARACTER_INDEX,F

;BEGIN OF IF-STRUCTURE
;COMPARE-OPERATION
;SET VARIABLE U8 WITH VARIABLE U8
MOVF CHARACTER_INDEX,W
MOVWF ISR_TEMPX8
;SET VARIABLE U8 WITH CONSTANT
MOVLW OXA
MOVWF ISR_TEMPY8
CALL ISR_GRU8U8
BANK0
MOVWF ISR_RESULT8
BTFSC ISR_RESULT8,0
GOTO LABEL_1010

```

```

        BANK0
        CLRF CHARACTER_INDEX

        ;STOP MONITORING INTERRUPTS
        BANK1
        BCF PIE1, TXIE

        GOTO LABEL_1011
LABEL_1010

LABEL_1011
;END OF IF-STRUCTURE

        RETURN

LABEL_EVENT2

        ;BEGIN OF IF-STRUCTURE (DEPENDING ON BIT/PIN)
        BANK0
        BTFSS PORTA,0
        GOTO LABEL_1012

                ;SET SINGLE OUPUT PIN
                BANK0
                BCF PORTA,0

        GOTO LABEL_1013
LABEL_1012

                ;SET SINGLE OUPUT PIN
                BANK0
                BSF PORTA,0

LABEL_1013
;END OF IF-STRUCTURE

        RETURN

        ;$$

        END

```
