Homework Set 2 for Module 2

Due at the Beginning of Class (12:30 pm) on Wednesday, October 17

Name: _____ Class No: __ __ __ __ - __ Lab Div: ____

Signature: _____ Score: _____ / 100

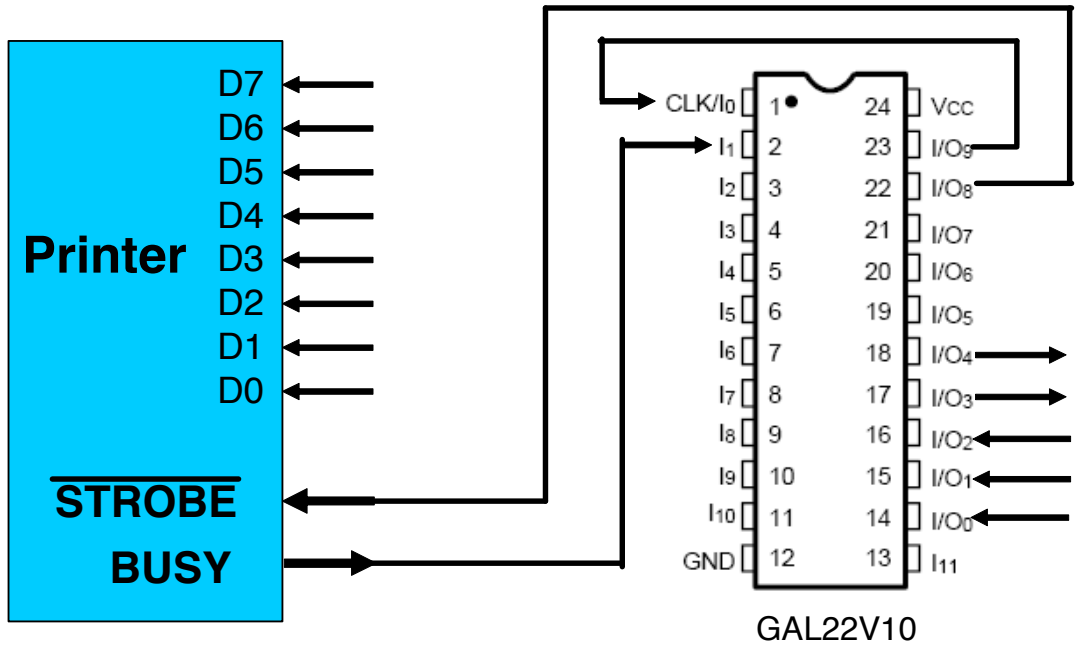
1. [20 points] An interrupt-driven printer interface is desired, but implemented with a GAL22V10 PLD instead of discrete logic. Your job is to: (a) complete the ABEL code for the PLD that implements the interface circuit, and (b) complete the circuit connections between the microcontroller, PLD, and printer. The following declarations and initialization routine are provided:

```
; Port declaration
PTT         equ   $0240       ; Port T I/O
DDRT        equ   $0242       ; Port T DDR
PTAD        equ   $0270       ; Port AD I/O
DDRAD       equ   $0272       ; Port AD DDR

; Mask declarations
imask       equ   $01         ; printer interrupt enable mask
cmask       equ   $02         ; device flag clear mask
smask       equ   $04         ; STROBE mask

; Buffer declarations
psize       equ   100t        ; buffer size
pbuf        rmb   psize       ; printer buffer
pin         rmb   1           ; printer IN ptr
pout        rmb   1           ; printer OUT ptr

; Initialization routine
pinit       clr   pin          ; reset buffer to EMPTY condition
            clr   pout

            movb  #$FF,DDRT    ; initialize DDRs
            movb  #$07,DDRAD

            clr   PTT          ; clear all output port pins
            clr   PTAD

            bset  PTAD,cmask   ; clear printer device flag
            bclr  PTAD,cmask

            bset  PTAD,smask   ; provide initial STROBE with
            bclr  PTAD,smask   ; ASCII null character

            cli                ; enable IRQ interrupts
            rts
```

Part (a). [12 points] ABEL file (targeted for a GAL22V10):

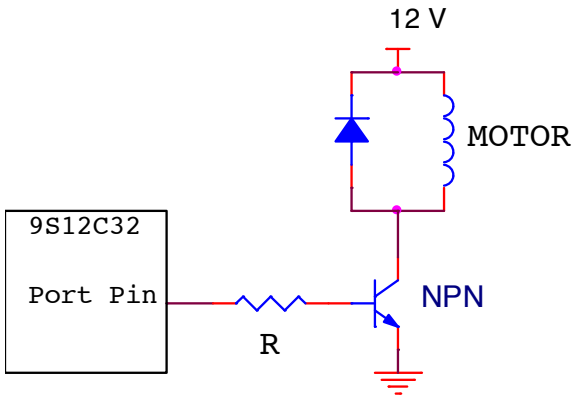
```
MODULE PrtInt
TITLE 'Printer Interrupt PLD'
CLOCK pin 1;
BUSY pin 2;
BUSYBAR pin 23 istype 'com';
STROBEBAR pin 22 istype 'com';
DEVFLAG pin 18 istype 'reg_D';
!IRQ pin 17 istype 'com';
FLAGCLR pin 16;
STROBE pin 15;
PIE pin 14;
EQUATIONS

BUSYBAR = _____________________________;

STROBEBAR = _____________________________;

DEVFLAG.CLK = _____________________________;

DEVFLAG.D = _____________________________;

DEVFLAG.AR = _____________________________;

IRQ = _____________________________;

END
```

Part (b). [8 points] Schematic (label all input/output signals):



2. [10 points] Calculate a suitable value for R, given that the motor coil requires 5 A of current to operate, that the NPN switching transistor has a $V_{BEsat} = 0.6$ V and an $h_{FE} = 600$, and that the 9S12C32 port pin is programmed to operate in "full drive" mode (i.e., pin can source up to 10 mA at $V_{OH} = 4.2$ V or sink up to 10 mA at $V_{OL} = 0.8$ V). Determine the EIA 5% (E24) resistor value that should be used (show calculations).

Reference: http://www.daycounter.com/Calculators/Standard-Resistor-Value-Calculator.phtml



Calculation of R value:

Choice of EIA 5% (E24) resistor value:

3. [10 points] Determine the ***interrupt rate*** and ***error range*** (associated with running *slow* vs. running *fast*) for a one-second time base if `RTICTL` is initialized to **`$5A,`** as well as the value of `RTICNT` that should be used for each case. Calculate the "wall clock" error (in minutes) that accumulates for each case after 24 hours of operation. Then answer the following questions: (a) Does either case (slow *vs*. fast) represent the *minimum error attainable* for a one-second RTI-based timer? (b) Does either case represent the *maximum error attainable* for a one-second RTI-based timer?

"slow" interrupt rate: _____ ms "slow" RTICNT: _____ "slow" error after 24 hrs: _____ min

"fast" interrupt rate: _____ ms "fast" RTICNT: _____ "fast" error after 24 hrs: _____ min

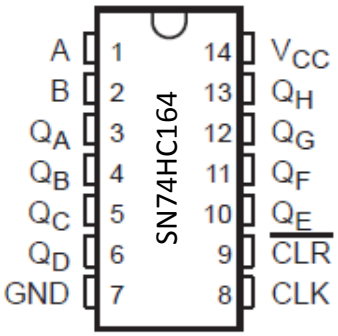
Does either case represent the *minimum error attainable* for a one-second RTI-based timer?

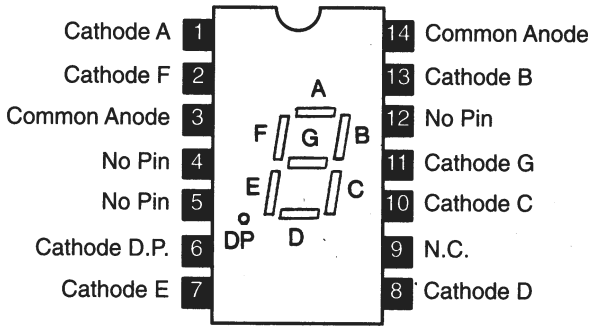
Does either case represent the *maximum error attainable* for a one-second RTI-based timer?

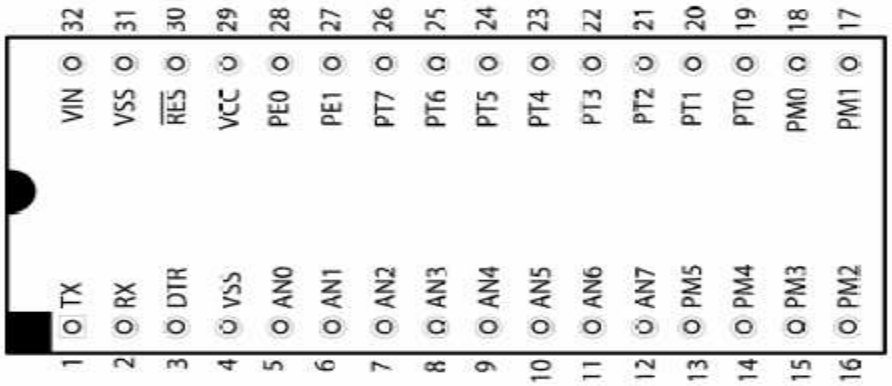
4. [20 points] Show how a 7-segment common anode LED display could be interfaced to your microcontroller module using a 74HC164 8-bit shift register. Calculate the value of current limiting resistor needed for each segment based on the D.C. characteristics of the 74HC164 (see data sheet posted on homework page) – assume the forward voltage of each LED segment is **2.1** V at a (maximum) forward current of 20 mA, and that "maximum brightness" of the display is desired. Determine the EIA 10% (E12) resistor value that should be used and complete the circuit, below.

   NOTE: A "0" in a shift register bit will turn the corresponding segment "on" (i.e., current must be sunk by a 74HC164 output pin to turn on the corresponding LED segment). Assume data is shifted out "DP" first, followed by segment g, segment f, etc.

Calculation of R value: Choice of EIA 10% (E12) resistor value:







5. [20 points] Write an initialization routine that configures the microcontroller port pins used by the interface you designed for Problem 4. Then, write a device driver `out7` that takes the 7-segment display code passed in the A register (ordered **DP-g-f-e-d-c-b-a** from *msb* to *lsb*) and "clocks" it into the 74HC164 shift register. Identify any timing constraints imposed on your interface based on the 74HC164's A.C. characteristics. Finally, determine the total number of cycles required to execute your `out7` routine.

Initialization routine:

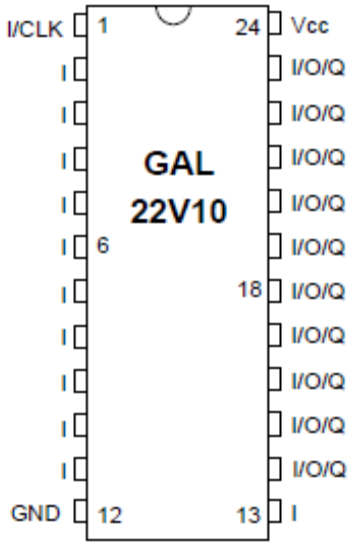
Device driver:

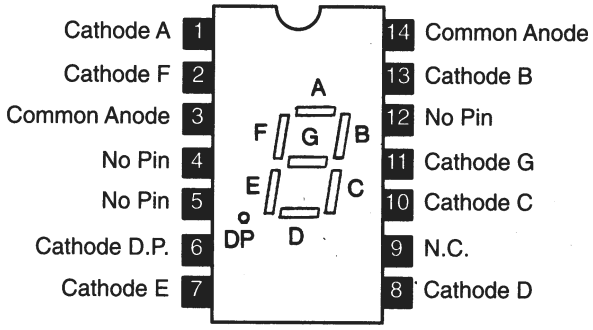
Timing constraints and total cycle count:

6. [20 points] Repeat Problem 4 using a GAL22V10 (programmed as shown) in place of the 74HC164. Calculate the value of current limiting resistor needed for each LED segment based on the D.C. characteristics of the GAL22V10 (see data sheet posted on homework page) – assume the forward voltage of each LED segment is **2.1** V at a (maximum) forward current of 20 mA, and that "maximum brightness" of the display is desired. Determine the EIA 10% (E12) resistor value that should be used and complete the circuit, below. *Note which of the two designs* (74HC164 vs. GAL22V10) *yields the "brightest" display*.

NOTE: A "1" in a shift register bit will turn the corresponding segment "on" (i.e., current must be sunk by a GAL22V10 output pin to turn on the corresponsing LED segment). Assume data is shifted out "DP" first, followed by segment g, segment f, etc.

Calculation of R value: Choice of EIA 10% (E12) resistor value:






```
MODULE shiftreg
TITLE '8-bit Shift Register'
DECLARATIONS
clock pin 1;
serial_in pin 2;
!q0..!q7 pin 14..21 istype 'reg';

EQUATIONS
[q1..q7] := [q0..q6];
q0 := serial_in;
[q0..q7].clk = clock;
END
```