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October 12, 2012, 10:00am-10:50am. This is a closed book exam. You have 50 minutes, so please allocate your time accordingly. ***Please read the entire quiz before starting***.

```
#define GPIO_PORTG_DATA_R   (*((volatile unsigned long *)0x400263FC))
// all 8 bits of Port G
#define GPIO_PORTG_DIR_R    (*((volatile unsigned long *)0x40062400))
// direction register for Port G
#define GPIO_PORTG_AFSEL_R  (*((volatile unsigned long *)0x40026420))
// alternate function for Port G (0 for normal I/O, 1 for alternate I/O)
#define GPIO_PORTG_DEN_R    (*((volatile unsigned long *)0x4002651C))
// data enable register for Port G
#define GPIO_PORTG0         (*((volatile unsigned long *)0x40026004))
// GPIO_PORTG0 is just bit 0
#define GPIO_PORTG1         (*((volatile unsigned long *)0x40026010))
// GPIO_PORTG1 is just bit 1
#define SYSCTL_RCGC2_R      (*((volatile unsigned long *)0x400FE108))
// set bit 6 to turn on Port G clock
#define NVIC_ST_CURRENT_R   (*((volatile unsigned long *)0xE000E018))
// 24-bit down counter running at the bus clock
#define NVIC_SYS_PRI3_R     (*((volatile unsigned long *)0xE000ED20))
#define NVIC_ST_CTRL_R      (*((volatile unsigned long *)0xE000E010))
#define NVIC_ST_RELOAD_R    (*((volatile unsigned long *)0xE000E014))
#define NVIC_ST_CURRENT_R   (*((volatile unsigned long *)0xE000E018))
```

2N2222		TIP120	
	V_{ce} = 0.3V		V_{ce} = 0.8V
	V_{be} = 0.6V		V_{be} = 1.5V
	h_{fe} = 100		h_{fe} = 2000
	I_{ce} =500mA max		I_{ce} =5A max

LM3Sxxx parameters

I_{OL} = 2,4 or 8mA, I_{OH} = 2,4 or 8mA, I_{IL} = 2µA, I_{IH} = 2µA,
V_{OL} = 0.4V, V_{OH} = 2.4V, V_{IL} = 1.3V, V_{IH} = 2.0 V

For SysTick the CLK_SRC is 1, the INTEN is the arm bit, and the ENABLE is the enable bit. Bits 31-29 of PRI3 set the priority of SysTick. (RELOAD+1)*20ns is period.

Address	31-24	23-17	16	15-3	2	1	0	Name
$E000E010	0	0	COUNT	0	CLK_SRC	INTEN	ENABLE	NVIC_ST_CTRL_R
$E000E014	0	24-bit RELOAD value						NVIC_ST_RELOAD_R
$E000E018	0	24-bit CURRENT value of SysTick counter						NVIC_ST_CURRENT_R

Address	31-29	28-24	23-21	20-8	7-5	4-0	Name
$E000ED20	TICK	0	PENDSV	0	DEBUG	0	NVIC_SYS_PRI3_R

Table 5.3. SysTick registers.

(5) Question 1. What is the value of LR during the execution of an ISR?

(9) Question 2. You are asked to debug a FIFO queue module.
Part a) What does it mean to stabilize it?

Part b) What does it mean to profile it?

Part c) Why don't we use print statements to debug the FIFO?

(10) Question 3. This is the FIFO from the book. **Fifo_Put** enters one 8-bit word into the queue. Initialization occurs once before interrupts are enabled, but Put and Get can be called from multiple software locations at asynchronous times.

```
#define FIFOSIZE 10    // can be any size
#define FIFOSUCCESS 1
#define FIFOFAIL    0

typedef char DataType;
DataType volatile *PutPt; // put next
DataType volatile *GetPt; // get next
DataType static Fifo[FIFOSIZE];

// initialize FIFO
void Fifo_Init(void){
  PutPt = GetPt = &Fifo[0]; // Empty
}
```

```
// add element to FIFO
int Fifo_Put(DataType data){
  DataType volatile *nextPutPt;
  nextPutPt = PutPt+1;
  if(nextPutPt == &Fifo[FIFOSIZE]){
    nextPutPt = &Fifo[0];  // wrap
  }
  if(nextPutPt == GetPt){
    return(FIFOFAIL);
  }
  else{
    *(PutPt) = data;
    PutPt = nextPutPt;
    return(FIFOSUCCESS);
  }
}
```

Part a) Is this function reentrant? Yes or No.

Part b) If it is reentrant, prove it. If it is not reentrant, modify it so it is reentrant.

(5) Question 4. We need to store values from -10 to +10 cm, but need to represent fractions of a cm. Choose the best binary fixed-point format using we are using 8-bit precision. What resolution should we use? DO NOT USE DECIMAL FIXED POINT.

(6) Question 5. Show the C code to create a signed 16-bit global variable that has a scope such that it is only accessible to software within the same file.

(5) Question 6. Give an equation that relates current through to the voltage across an ideal capacitor, with capacitance C.

(20) Question 7. You are given two tasks: the subroutine **Task1()** should be executed every 1 ms. The subroutine **Task2()** should be executed every 2 ms. Minimize the jitter on executing **Task2()**. This means **Task2()** is never delayed by the running of **Task1**. Assume the PPL is active, making the bus clock 20 ns (50 MHz). You may assume there are other interrupts, but these tasks are most important.
Part a) Show the ritual to initialize this system. You will use SysTick interrupts.

Part b) Show the SysTick interrupt service routine. No backward jumps are allowed.

(20) Question 8. Draw a Moore FSM graph to solve the following problem. Your FSM graph must have less than 10 states and there should be NO wait parameter for this machine. There are two positive-logic switches as inputs, and there is one positive-logic output to an LED. You may assume the switches do not bounce. The switches may be touched one before the other, or touched at the same time. A touch is defined as the switch state going from not pressed to pressed. I.e., touching and holding down the switch counts as just one touch. The LED is initially off, and you may assume the both switches are initially off. Turn on and leave on forever the LED whenever there are two touches (either one switch touched twice, or each switch touched once). For each state give: the state name, the output, and four next states. The FSM controller sequence is output, input, change to next state. Just draw the FSM graph, no software is required. Full credit will be given to the machine with the fewest states that solves the problem. You may not include a time delay for each state.

(20) Question 9. Interface a 12V DC motor to the microcontroller. A digital output on PG0 controls the motor. If PG0 is high, power is applied to the motor (around 12V). If PG0 is low, no current is allowed to the motor. The maximum motor current is 1A. Decide whether to use the 2N2222 or the TIP120. You may use +3.3V, +5V, +12V, and/or +24V power. Show your work.

Power Sources

+24V ———
+12V ———
+5V ———
+3.3V ———

Computer

PG0

Motor