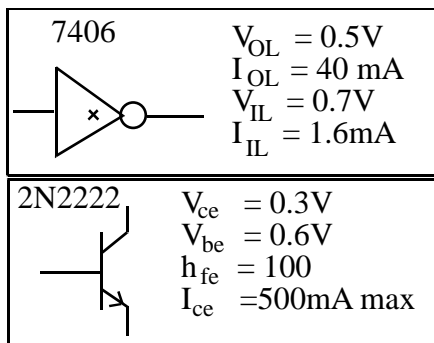


Jonathan W. Valvano First: \_\_\_\_\_ Last: \_\_\_\_\_  
 October 7, 2011, 2:00pm-2:50pm. This is a closed book exam. You have 50 minutes, so please allocate your time accordingly. **Please read the entire quiz before starting.**

```
#define GPIO_PORTG_DATA_R  (*((volatile unsigned long *)0x400263FC))
// all 8 bits of Port G
#define GPIO_PORTG_DIR_R  (*((volatile unsigned long *)0x40026400))
// 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
```



LM3Sxxx parameters

$$I_{OL} = 2,4 \text{ or } 8\text{mA}, \quad I_{OH} = 2,4 \text{ or } 8\text{mA}, \quad I_{IL} = 2\mu\text{A}, \quad I_{IH} = 2\mu\text{A},$$

$$V_{OL} = 0.4\text{V}, \quad V_{OH} = 2.4\text{V}, \quad V_{IL} = 1.3\text{V}, \quad V_{IH} = 2.0 \text{V}$$

Assuming the  $V_{CC}$  of the XBee is 3.3V,  $0.35 * V_{CC} = 1.155\text{V}$ ,  $0.7 * V_{CC} = 2.31\text{V}$ ,  $V_{CC} - 0.5\text{V} = 2.8 \text{V}$

Table 1-03. DC Characteristics (VCC = 2.8 - 3.4 VDC)

Symbol	Characteristic	Condition	Min	Typical	Max	Unit
$V_{IL}$	Input Low Voltage	All Digital Inputs	-	-	$0.35 * V_{CC}$	V
$V_{IH}$	Input High Voltage	All Digital Inputs	$0.7 * V_{CC}$	-	-	V
$V_{OL}$	Output Low Voltage	$I_{OL} = 2 \text{ mA}, V_{CC} \geq 2.7 \text{ V}$	-	-	0.5	V
$V_{OH}$	Output High Voltage	$I_{OH} = -2 \text{ mA}, V_{CC} \geq 2.7 \text{ V}$	$V_{CC} - 0.5$	-	-	V
$I_{IN}$	Input Leakage Current	$V_{IN} = V_{CC} \text{ or } GND$ , all inputs, per pin	-	0.025	1	$\mu\text{A}$
$I_{OZ}$	High Impedance Leakage Current	$V_{IN} = V_{CC} \text{ or } GND$ , all I/O High-Z, per pin	-	0.025	1	$\mu\text{A}$
TX	Transmit Current	$V_{CC} = 3.3 \text{ V}$	-	45 (XBee) 215 (PRO)	-	mA
RX	Receive Current	$V_{CC} = 3.3 \text{ V}$	-	50 (XBee) 55 (PRO)	-	mA
PWR-DWN	Power-down Current	SM parameter = 1	-	< 10	-	$\mu\text{A}$

**(15) Question 1.** Assume SysTick is running with a reload value of 0x00FFFFFF. Write a minimally intrusive debugging instrument that records the 24-bit SysTick timer (`NVIC_ST_CURRENT_R`) at the time the instrument is called. For the first 256 measurements, you simply record the time. After 256 recordings, you will discard the oldest when a new measurement is obtained. Your solution will store the measurements in any order. Show the variables, initialization, and the instrument.

**(20) Question 2.** In this question you must use **semaphores**. There is an ISR and a main program, which are shown below. The interrupt has priority equal to 4. The goal of the problem is force Fun0 and Fun1 to be executed alternately (i.e., Fun0, Fun1, Fun0, Fun1, Fun0, Fun1, Fun0, Fun1,...) with Fun0 going first. You should add code, but may not delete any existing code. You may not add additional calls to Fun0 or Fun1. You are not allowed to arm, disarm, enable, disable, or change the timer interrupt rate. I.e., you cannot access any timer or NVIC registers. You may not add any backward jumps, but are allowed if-then statements.

```
void Timer0A_Handler(void){
```

```
    Fun0();
```

```
    TIMER0_ICR_R = TIMER_ICR_TATOCINT; // acknowledge timer0A timeout
}
```

```
void main(void){
```

```
    while(1){
```

```
        Fun1();
```

```
    }
}
```

**(10) Question 3.** In Lab 10 we will be interfacing an XBee wireless module to the LM3S1968.

**Part a)** Can we connect the LM3S1968 input to an XBee output? If yes, give all inequalities with both symbolic and numerical values to prove it works. If no, give at least one inequality both symbolic and numerical values that is not satisfied.

**Part b)** Can we connect the LM3S1968 output to an XBee input? If yes, give all inequalities with both symbolic and numerical values to prove it works. If no, give at least one inequality both symbolic and numerical values that is not satisfied.

**(15) Question 4.** The following multithreaded system uses Port G as a debugging profile. PG0 goes high during ISR0 and PG1 goes high during ISR1. One interrupt has higher priority than the other. **Stuff0** and **Stuff1** are unrelated. Is there a critical section? If yes, explain how to remove his particular critical section. If no, justify your answer in 16 words or less.

```

void ISR0(void){
    GPIO_PORTG_DATA_R ^= 0x01;
    Stuff0();
}

void ISR1(void){
    GPIO_PORTG_DATA_R ^= 0x02;
    Stuff1();
}

```

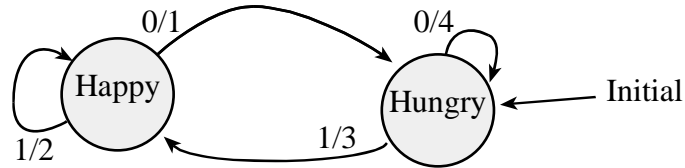
The assembly code for ISR0 is

```

ISR0    PUSH    {lr}
        LDR     r0,[pc,#180]    ; R0 points to Port G
        LDR     r0,[r0,#0x00]   ; R0 contains the value from Port G
        EOR     r0,r0,#0x01     ; toggle bit 0
        LDR     r1,[pc,#152]    ; R1 points to Port G
        STR     r0,[r1,#0x3FC]  ; write new value to Port G
        BL.W   Stuff0          ; call function
        POP     {pc}           ; return from interrupt

```

**(10) Question 5.** You can convert any Mealy FSM to a Moore FSM and convert any Moore FSM to a Mealy FSM. Typically, Moore machines have a simpler controller, while Mealy machines have fewer states. One minor difference is Mealy machines get the first output after the first input, while a Moore machine has a first output before it senses the first input. In this Mealy machine the state transition arrows are input/output. You may assume the initial state is Hungry and the initial input is 0. The execution order for this Mealy is input, output (depends on input and state), then next (depends on input and state).



Redraw this FSM graph in Moore format. The execution order for the Moore machine is output (depends on state), input, then next (depends on input and state). Just draw the Moore graph (no hardware or software required).

**(15) Question 6.** The objective is to implement a function to calculate the surface area of a cylinder using fixed-point calculations.  $r$  is radius of the cylinder, which can vary from 0 to 1 cm. The radius is stored as a fixed point number with resolution 0.001 cm. The software variable containing the integer part of the radius is  $n$ , which can vary from 0 to 1000. The height of the cylinder is 1 cm. The surface area is approximated by (I greatly simplified  $2\pi$ , so the math would be easier without a calculator)

$$s = 6.2 * (r^2 + r)$$

The surface area can range from 0 to 12.400 cm<sup>2</sup> ( $6.2*(1^2 + 1)$ ). The surface area is stored as a fixed point number with resolution 0.001 cm<sup>2</sup>. The software variable containing the integer part of the surface area is  $m$ , which can vary from 0 to 12400. **Write C code to implement** (no floating point allowed) the conversion from  $n$  to  $m$ . This table shows some typical results

$r$ (cm)	$n$	$s$ (cm <sup>2</sup> )	$m$
0.000	0	0.000	0
0.001	1	0.006	6
0.010	10	0.063	63
0.100	100	0.682	682
1.000	1000	12.400	12400

**unsigned long n,m;**

You are allowed to define additional variables. Hand execute your code with  $n=100$  to verify it calculates  $m= 681, 682$  or  $683$  using integer math.

**(15) Question 7.** A high-power LED requires 3.2 V at 100 mA to activate. Assume an ideal diode:  $I=0$  for  $V<3.2V$ ,  $I=100mA$  for  $V=3.2V$ , and  $I=infinite$  for  $V>3.2V$ . Interface this LED to the LM3S1968 port pin PG0, such that when the software outputs a one, the LED comes on, and when the software outputs a zero, the LED goes off. If more than one possibility exists, choose the cheapest method. Label all interface components and resistor values. Show the hardware interface (no software is required). You can specify resistor values using an equation, rather than calculating the exact number. You will choose whether to power it from the 3.3 or 5 V supply.