MEF UNIVERSITY
Your Freedom in Learning

EE 306 Microprocessors Spring 2018 – 2019
Final Exam – 15.05.2019

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Grades

1. Interrupt example: Ticking bomb

When a key is pressed, a bob is activated. If one writes the correct password and presses enter key in 3 minutes, the bomb is deactivated. After the bomb is activated, remaining time is shown on the seven-segment display. The system receives interrupts from 3 devices: KEYS, PRIV_TIMER and HPS_TIMER which are serviced by KEY_ISR, PRIV_ISR and HPS_ISR, respectively. When an interrupt occurs, the processors goes into IRQ mode and the following SERVICE_IRQ subroutine is executed. Complete the code and draw flowchart for this code piece.

```
SERVICE_IRQ:
/* save the first 8 general purpose registers and the link
register. */
     PUSH       {R0-R7, LR}

     /* Read the ICCIAR from the CPU interface */
     ___        R4, =MPCORE_GIC_CPUIF
     ___        R5, [R4, #ICCIAR]        // read the interrupt ID

PRIV_TIMER_CHECK:
     ___        __, #MPCORE_PRIV_TIMER_IRQ // check for priv.
timer interrupt
     /* If the interrupt source is private timer, go to the
private timer interrupt service routine then exit from IRQ mode.
Else, go check if the HPS timer requested an interrupt */

     _____________________________
     _____________________________
     _____________________________

HPS_TIMER_CHECK:
     /* check for HPS timer interrupt */
     ___        __, #HPS_TIMER0_IRQ
     /* If the interrupt source is HPS timer, go to its
interrupt service routine then exit from IRQ mode. Else, go
check if the KEY requested an interrupt */

     _____________________________
     _____________________________
     _____________________________
```

KEYS_CHECK:
/* check for KEYS interrupt. If the interrupt source is KEYS, go to its interrupt service routine then exit from IRQ mode. Else, the interrupt is not recognized, stop there */

_____

_____

_____

EXIT_IRQ:
/* Write to the End of Interrupt Register (ICCEOIR), bring the saved general purpose registers back and go back to the main routine. */

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2. Configure Timer: Ticking bomb

Configure the private timer to hold 3 minutes. The timer should be disabled until the bomb is activated. It should be configured to request interrupt and stop counting after reaching zero. Show how you calculate the load value and the control word. Write comments for your code.

Hints to survive the traps in this question:

a. 2^{32}=4.294.967.294

b. `MOV Rd, #imm16` `imm16` is an immediate value in the range 0-65535. `imm16` can be 16 bit.

2.4.1 ARM A9 MPCore Timers

Figure 3 shows the registers in the programmer's interface for each A9 core private timer. These registers have the base address 0xFFFEC600, as shown in the figure, and can be read or written using word accesses. To use the timer, it is necessary to first write an initial count value into the *Load* register. The timer can then be started by setting the enable bit *E* in the *Control* register to 1, and it can be stopped by setting *E* back to 0. Once enabled the timer decrements its count value until reaching 0. When it reaches 0, the timer sets the *F* bit in the *Interrupt status* register. The *F* bit can be checked by software using polled-I/O to determine when the timer period has expired. The *F* bit can be reset to 0 by writing a 1 into it. Also, if bit *I* in the *Control* register is set to 1, then a processor interrupt can be generated when the timer reaches 0. Using interrupts with the timer is discussed in Section 3.

When it reaches 0, the timer will stop if the auto bit (*A*) in the control register is set to 0. But if bit *A* is set to 1, then the timer will automatically reload the value in the *Load* register and continue decrementing. The current value of the timer is available to software in the *Counter* register shown in Figure 3. The timer uses a clock frequency of 200 MHz. The *Prescaler* field in the *Control* register can be used to slow down the counting rate, as follows. The timer decrements each *Prescaler* +1 clock cycle. Therefore, if *Prescaler* = 0, then the timer decrements every clock cycle, if *Prescaler* = 1, the timer decrements every second clock cycle, and so on.

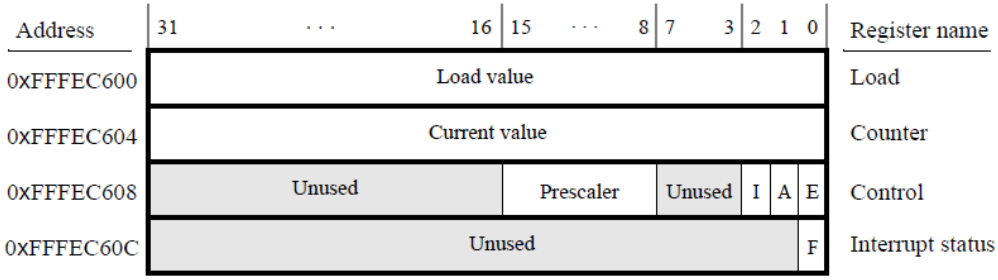

Figure 3. ARM A9 private timer port.

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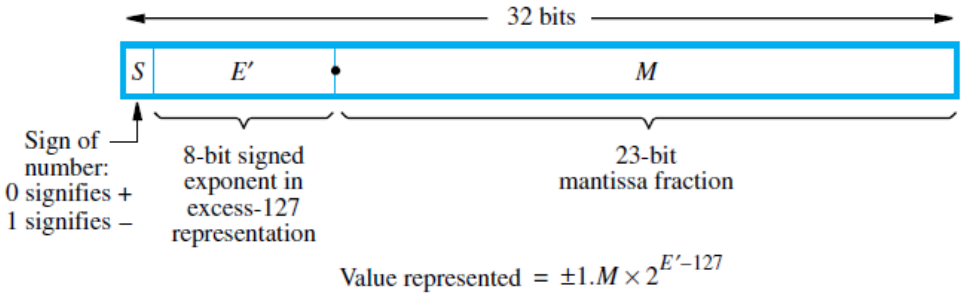
3. Floating point

You are asked to find the square root of a floating point number, approximately. The number is given in the excess-127 representation. Propose a method without using floating point co-processor. Plot the flowchart. Input is A with SA, E'A, and MA which are the sign, excess-127 exponent, and mantissa fraction, respectively. Square root of A is B with SB, E'B, and MB.

Hint 1: $\sqrt{(x)} = x^{½}$

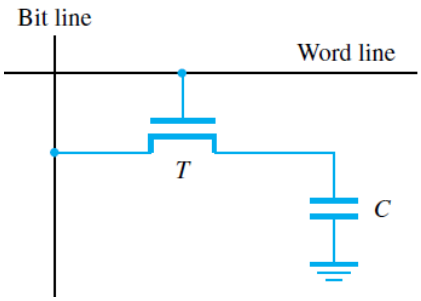
Hint 2: $\sqrt{(negative\_numbers)}$ → exception



4. Fill in the blanks. Avoid abbreviations.

Note that there were 20 blanks (36 points) in the real exam. Examples are given below.

A. A single transistor RAM cell is given in the figure. Information is stored in the form of a charge on a capacitor. This charge can be maintained for only tens of milliseconds. In order not to lose data, _____ is required. Therefore, this type of RAM is called _____.



B. Figure shows a 512K × 8 static memory chip. How many of these chips are required to organize a 2M × 32 memory module?

_____

Which logic block is required to generate chip-select signals of the memory chips?

_____