Hardware Timers

Polling Hardware Timers

LECTURE 7

PEDRO SANTOS (SLIDES BY IOULIIA SKLIAROVA)

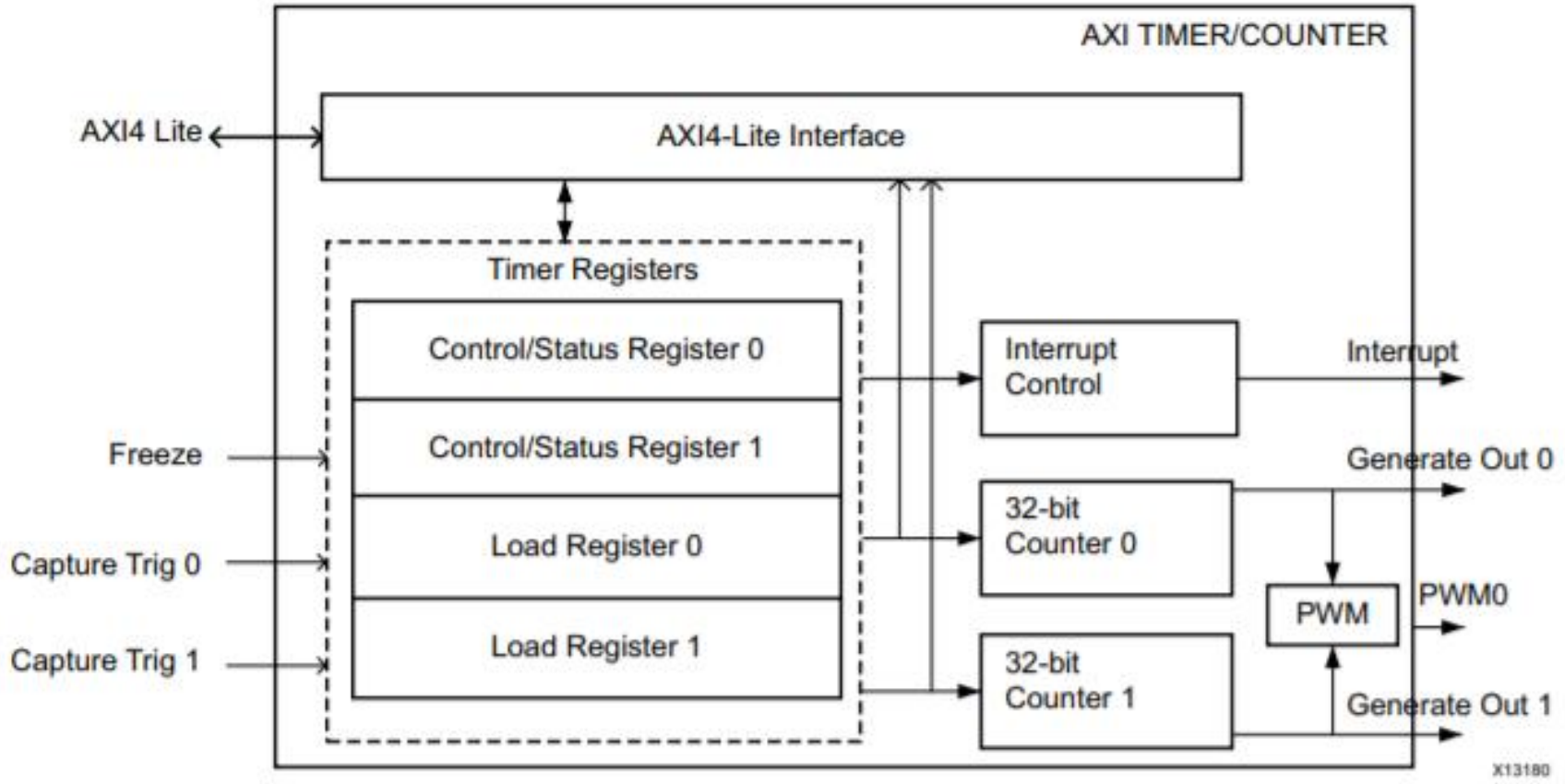
Hardware Timer IPs

- AXI Timer
  - AXI Timer/Counter is a 32/64-bit timer module that interfaces to the AXI4-Lite interface.
- Fixed Interval Timer (FIT)
  - The FIT core is a peripheral that generates a strobe (interrupt) signal at fixed intervals and is not attached to any bus.

AXI Timer - Operation

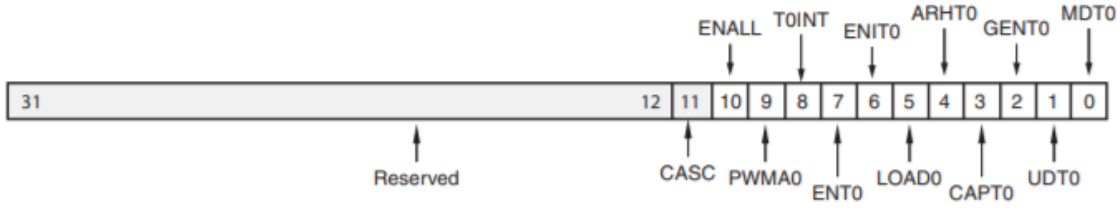
- Two programmable interval timers with interrupt, event generation, and event capture capabilities.
- Each timer module has an associated **load** register that is used to hold either the initial value for the counter for event generation or a capture value, depending on the mode of the timer.
- In the Generate mode, the value in the **load** register is loaded into the counter. The counter, when enabled, begins to count up or down, depending on the selection of the Up/Down Count Timer (UDT) bit in the Timer Control Status Register (TCSR).
- On transition of the carry-out of the counter, the counter stops or automatically reloads the generate value from the load register and, after reaching the timeout value, continues counting as selected by the Auto Reload/Hold (ARHT) bit in the TCSR.
- The Timer Interrupt Status (TINT) bit is set in TCSR and, if enabled, the external *GenerateOut* signal is driven to 1 for one clock cycle.
- If enabled, the interrupt signal for the timer is driven to 1 when reaching the timeout value. Clear the interrupt by writing a 1 to the Timer Interrupt register. Use this mode for generating repetitive interrupts or external signals with a specified interval.

AXI Timer's Block Diagram



AXI Timer Control/Status Register

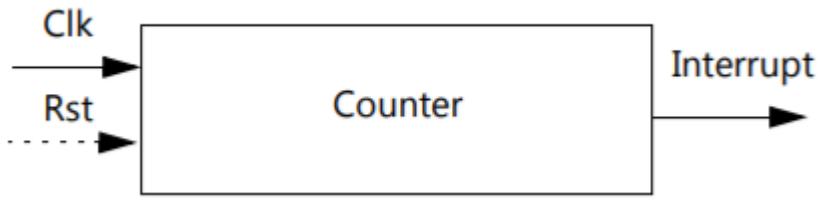
- T0INT - Timer 0 Interrupt Indicates that the condition for an interrupt on this timer has occurred.
  - Read:
    - 0 = No interrupt has occurred
    - 1 = Interrupt has occurred
  - Write:
    - 0 = No change in state of T0INT
    - 1 = Clear T0INT (clear to 0)



- ENT0 - Enable Timer 0
  - 0 = Disable timer (counter halts)
  - 1 = Enable timer (counter runs)
- LOAD0 - Load Timer 0
  - 0 = No load
  - 1 = Loads timer with value in TLR0
- ARHT0 - Auto Reload/Hold Timer 0 (when the timer is in Generate mode, this bit determines whether the counter reloads the generate value and continues running or holds at the termination value).
  - 0 = Hold counter
  - 1 = Reload generate value
- UDT0 – Up/Down Count Timer 0
  - 0 = Timer functions as up counter
  - 1 = Timer functions as down counter

Fixed Interval Timer (FIT)

- The FIT core is a peripheral that generates a strobe (interrupt) signal at fixed intervals and is not attached to any bus.
- The FIT core generates an interrupt every C_NO_CLOCKS.
- The interrupt signal is held high for one clock cycle.
- The core begins operation immediately after device configuration if the reset is not connected.



Update MicroBlaze Platform

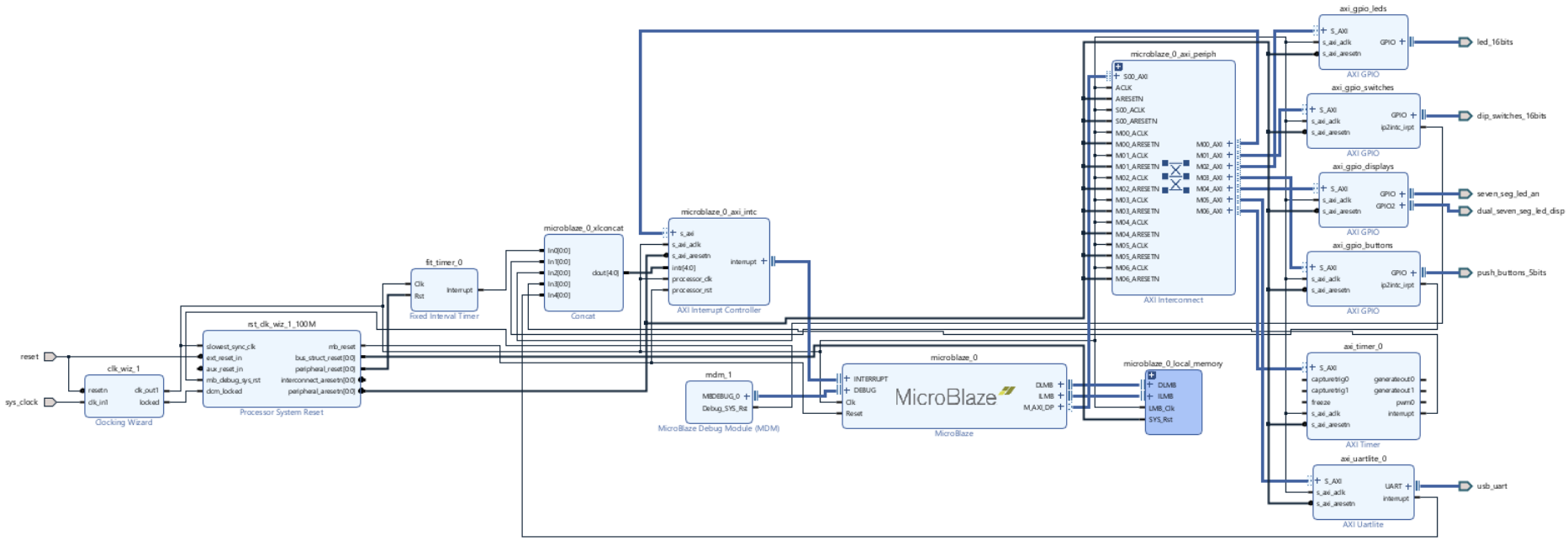
To make use of timers and interruptions, the design of the MicroBlaze platform developed in Lab.5 needs to be updated.

Instructions:

1. Open project from Lab.5; save it as Lab.6
2. Follow instructions in

   Guião para atualizar plataforma MicroBlaze com Interrupts

Block Design (BD)



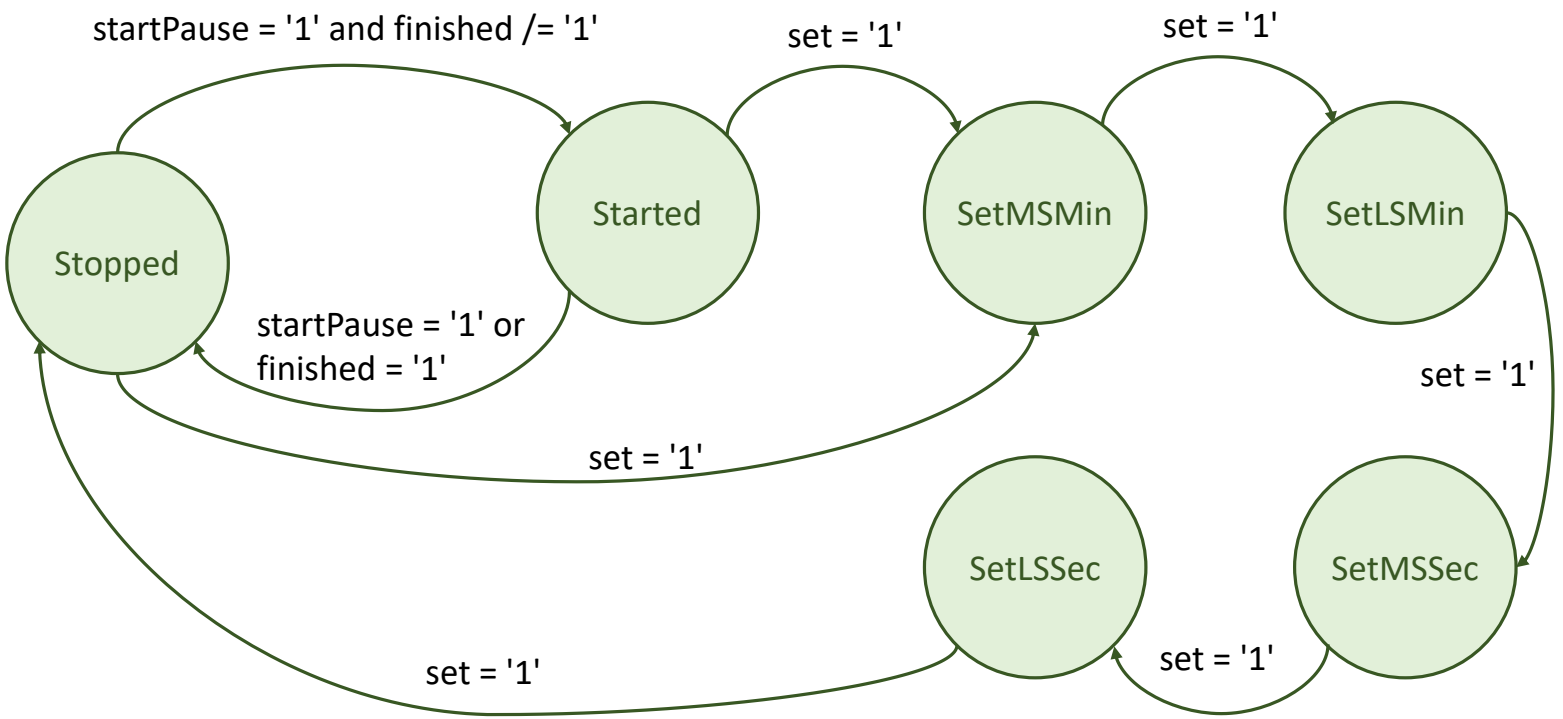
Polling

- **Polling** means repeatedly reading a timer register and testing the input data value.
  - simple to code
  - not very efficient because the polling happens even if the timer reading has not achieved the required value
- Low-level driver functions (or macros) that can be used to access the timer:
  - `XTmrCtr_SetControlStatusReg`
  - `XTmrCtr_GetControlStatusReg`
  - `XTmrCtr_SetLoadReg`
  - `XTmrCtr_GetTimerCounterReg`

Lab. 6

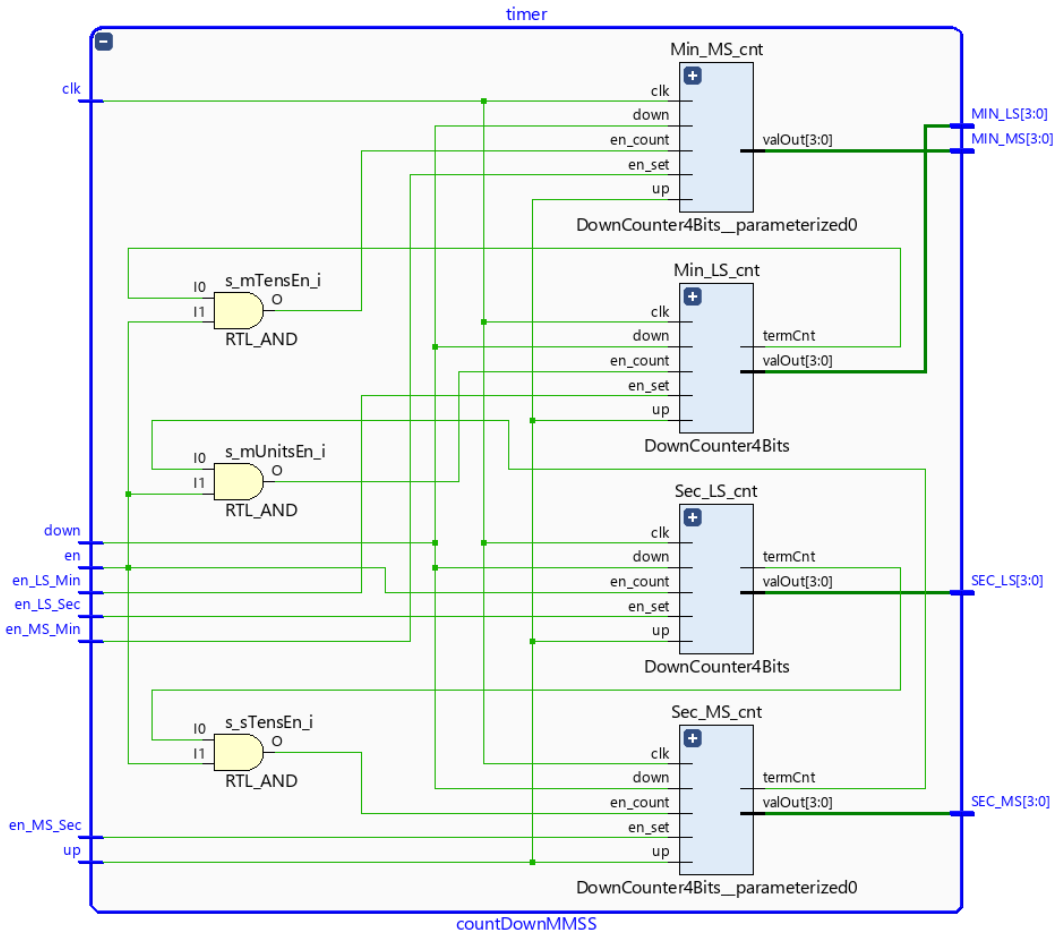
Countdown Timer Controlpath

set = btnR
startPause = btnC



Countdown Timer Datapath

Min_MS | Min_LS . Sec_MS | Sec_LS



Countdown Timer in Software

- What periodic operations have to be executed and at what frequencies?
- 1 Hz
  - to decrement the countdown timer
- 800 Hz
  - to refresh the 7-segment displays
- 2 Hz
  - to set the time
  - to blink the point separating minutes and seconds (with 1Hz frequency)
- 4 Hz
  - to make the digit being set to blink (with 2Hz frequency)
- 8 Hz
  - to read the buttons status

C Code for the Countdown Timer

```c
// State machine data type
typedef enum {Stopped, Started, SetLSSec, SetMSSec, SetLSMin, SetMSMin} TFSMState;

// Buttons GPIO masks
#define BUTTON_UP_MASK      0x01
#define BUTTON_DOWN_MASK    0x04
#define BUTTON_RIGHT_MASK   0x08
#define BUTTON_CENTER_MASK  0x10

// Data structure to store buttons status
typedef struct SButtonStatus
{
    bool upPressed;
    bool downPressed;
    bool setPressed;
    bool startPressed;

    bool setPrevious;
    bool startPrevious;
} TButtonStatus;

// Data structure to store countdown timer value
typedef struct STimerValue
{
    unsigned int minMSValue;
    unsigned int minLSValue;
    unsigned int secMSValue;
    unsigned int secLSValue;
} TTimerValue;
```

Final Remarks

At the end of this lecture you should be able to:

- write C programs that poll a hardware timer

To do:

- Lab. 6 part 1