ECE 2049 Lecture 8

Office Hours

- Today: 5-7PM EDT
  2-4PM
- Sunday 12-2PM
  2-4PM
  EDT

Administrivia

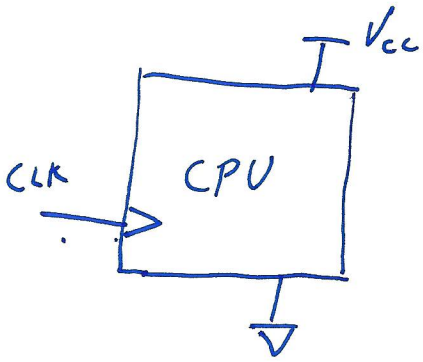
- Lab Today
- Lab 1: Due Tuesday (6/23)
  - Prelab: submit once you have started
- HW4: Online today, due Tues (6/23)
  - Short problem
  - Mid-term survey (Anonymous)
- Lab 2: Starts next week
  - If you have not done so already, review/order the extra parts listed on the Labs page. of the website.
- Exam 1: Hope to have back by Monday

Module 7. Intro to Clocks and Timers

Clocks

A microcontroller and its peripherals are just sequential logic circuits. Remember that sequential logic circuits need a *clock signal*. Before a CPU can operate, it must have power, a clock signal, and ground.

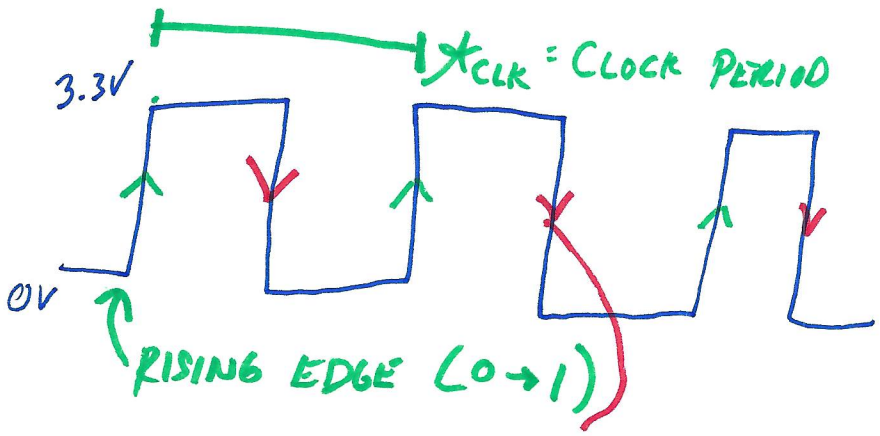
What does a clock signal look like?



- PROVIDES TIME REFERENCE

- DRIVES CODE EXECUTION

ALL CPU INSTRUCTIONS EXECUTE IN SOME NUMBER OF CLOCK CYCLES.



1 CLOCK PERIOD = 1 "TICK"

CLOCK FREQUENCY

$f_{CLK} = 1/T_{CLK}$

Clocks on the MSP430: The Unified Clock System (UCS)

Microprocessors usually allow you to configure the clocks used by the system. On the MSP430, this tasks is handled by the **Unified Clock System** (UCS), which is billed as "full featured and capable" (read: complex and confusing)!

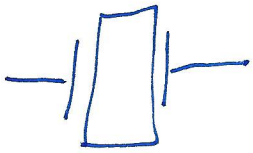
Like most microcontrollers, the MSP430 has a variety of configurable *clock sources* and clock *signals*:

SOURCES: CIRCUITS THAT PROVIDE TIME REFERENCE

SIGNALS: DRIVE PERIPHERALS + CPU CORE.

There are two types of clock sources:

- External sources:
  - OSCILLATOR CRYSTALS (XTAL) CONNECTED TO SPECIAL PINS



- Internal sources:
  - ON-CHIP CIRCUIT THAT MAKES AN OSCILLATOR (How? MicroII)

Why is all of this configurability important?

- PRECISE CONTROL OF CLOCK SPEEDS FOR APPLICATION

  ⇒ MAXIMIZE POWER EFFICIENCY

The MSP430F5529 has 5 possible clock sources:

XT1CLK — Low-frequency oscillator (LFXTAL)
32768Hz crystal (32.768 kHz)

XT2CLK — High frequency oscillator (HFXTAL)
4 MHz crystal

DCOCLK
↳ Digitally Controlled Oscillator

REFOCLK
VLOCLK
↳ Internal oscillators

These provide 3 clock signals to the CPU and peripherals:

ACLK - Auxiliary Clock: (XTICLK)
- Used for peripherals
- Usually 32768 Hz

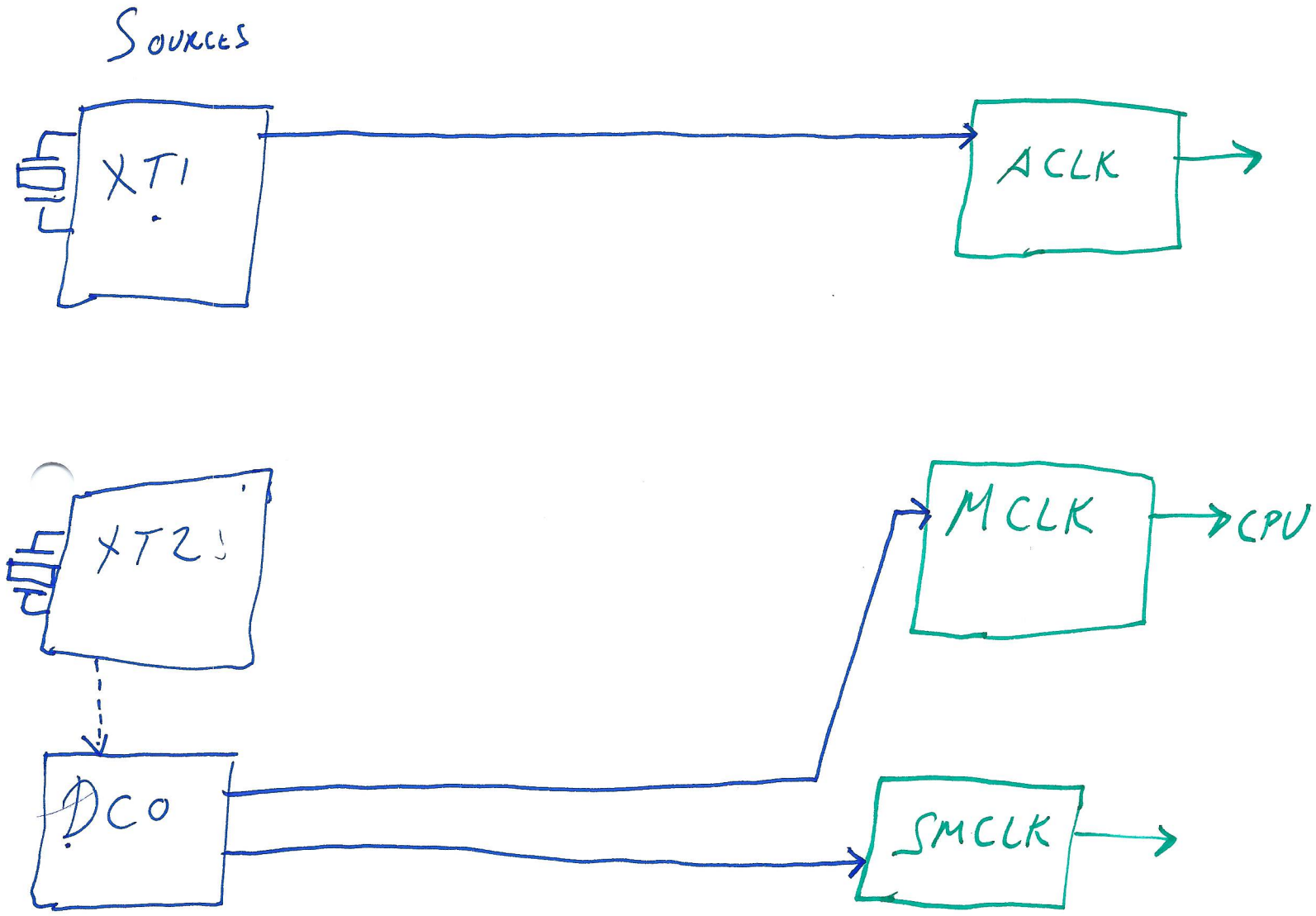
MCLK - Main or Master Clock:
- Used by CPU core (how fast code runs)
- MSP430: 20kHz – 20MHz

SMCLK - Sub-main Clock: Default: 1.048576MHz
- Used for peripherals
- Usually 1.048576 MHz

The three clock signals are *software selectable*, meaning that the user can configure the clock sources and speeds for the CPU and peripherals **at runtime**.

Configuring the UCS: The Gist

In general, configuring the UCS boils down to connecting the various clock sources (XT1, XT2, DCO, etc.) to the 3 clock signals (ACLK, MCLK, SMCLK):



In addition, you also need to configure some parameters for the sources (like the DCO), and the signals (like clock dividers).

Configuration notes

Configuring XT1 and XT2

The low frequency and high frequency crystals XT1 and XT2 are connected via pins on the MSP430. On the MSP430F5529, these pins are multiplexed with P5.4-5 (for XT1) and P5.2-3 (for XT2).

If you want to use XT1 or XT2, you need to configure these pins for **function mode** (as opposed to digital I/O mode) by setting their corresponding bits in P5SEL to 1:

```
P5SEL |= (BIT5|BIT4|BIT3|BIT2);
```

FUNCTION MODE!

In our lab, this is already done for us in the template in the `configDisplay` function.

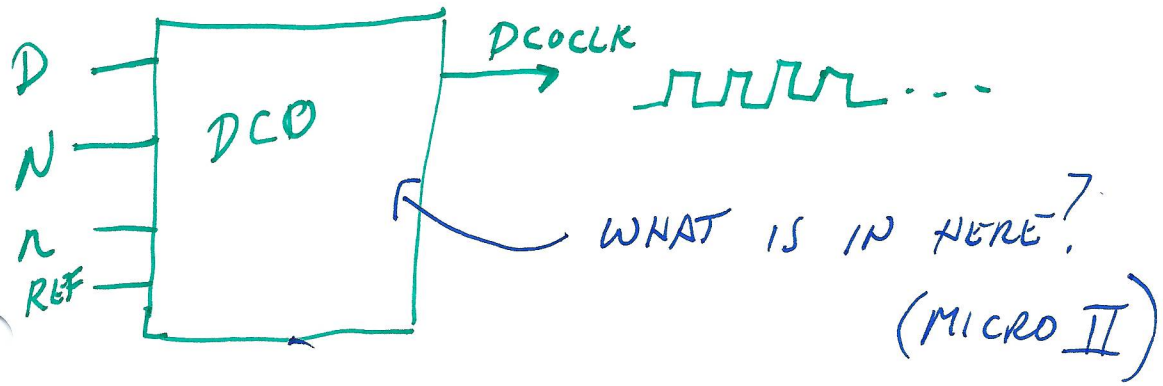
The DCO (Digitally-controlled oscillator)

The DCO is a *digitally-controlled oscillator*, which means that you can configure its frequency in software. The UCS module provides a frequency-locked loop (FLL) to stabilize the DCO. The frequency for the DCO is defined by the following formula:

$$f_{DCO} = D * (N + F)(f_{FLLREFCLK} \div n)$$

SOME CLOCK SOURCE
XT1
XT2, ...

DEFINED IN REGISTERS



Default clock configuration

After decoding the default register values, we know that **by default**, SMCLK = MCLK, and both use DCOCLK as their source. In addition, ACLK = XT1CLK (if enabled). From this, we can conclude that the default clock settings are as follows:

- ACLK (Auxiliary clock) = 32768 Hz
- MCLK (Master/CPU clock) = 1.048576 MHz (CPU)
- SMCLK (Sub-main clock) =

In our labs, we will keep it simple and use these default settings! These are important. Remember them!

IN LAB, WE WILL CONFIGURE PERIPHERALS TO USE THESE.