CC2511 Week 1

Lecture 1

Welcome to Embedded Systems Design

In this subject you will:

1. Learn how to connect your software with the physical world.
2. Design and build electronics and software to control motors.
3. Build two printed circuit boards, one of which is your own design.

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Subject Outline

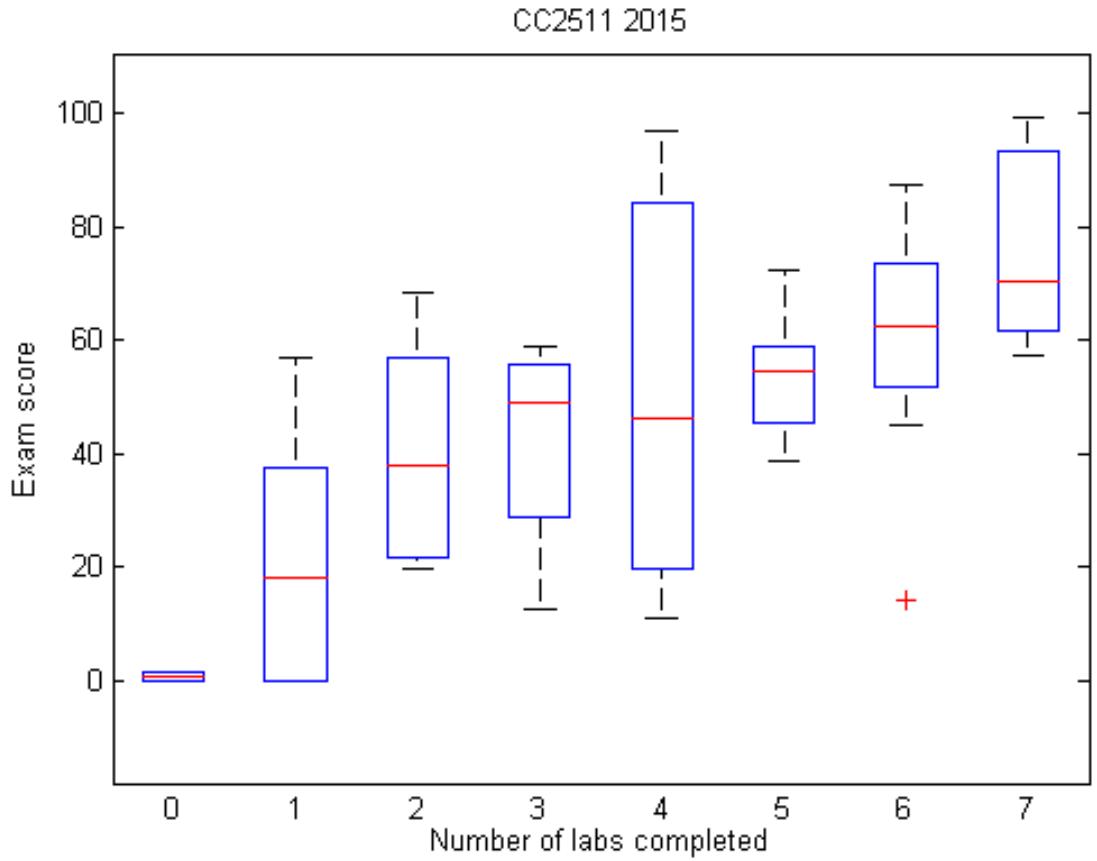
- Please read the Subject Outline (which can be found on LearnJCU)
  - This is our go-to for CC2511.

Workload

- 2 x lectures per week.
  - Later in the semester, this will transition to 1 lecture per week to give you more time to work on your design project.
- 1 x practical laboratory (3 hours).
- At the end of the scheduled session, your lecturer/tutor will assess your lab work as satisfactory or unsatisfactory.
  - The requirements for a “satisfactory” grade are detailed in each task sheet.
- You are expected to work on lab tasks, assignments, and general practise/study outside of the scheduled time.

On the importance of the weekly labs

- Lab participation correlates strongly with exam score.
- You learn embedded systems by doing it.



Requirements for this subject

- **If using the JCU computers: Portable USB drive** for storing lab and assignment work.
  - JCU computers delete your home directory some time after you log out.
- Freescale FRDM development board (loaned free of charge to all enrolled students)
- Use of the electrical workshop
  - Circuit board fabrication, construction, testing.
  - Standard components (resistors, capacitors, transistors)
  - Advice!

GitHub account

- GitHub is online hosting that will be used for your laboratory and assignment work.
- **You must sign up for a free account at github.com.**
- **Join the CC2511 organisation using the URL provided on LearnJCU.**
- You will receive a free private repository for your class work during the semester.
- Teaching staff have access to the repositories, allowing us to review your code and help you.

BYO Laptop?

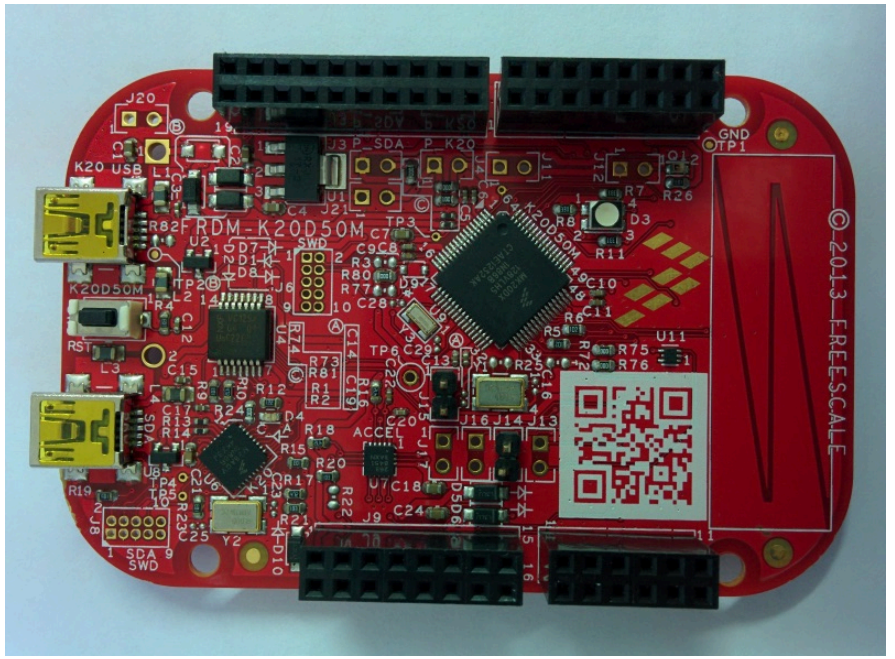
- You’re welcome to use your own laptop in labs if you prefer.
- A Windows operating system is required.
- See LearnJCU for links to the software to install.

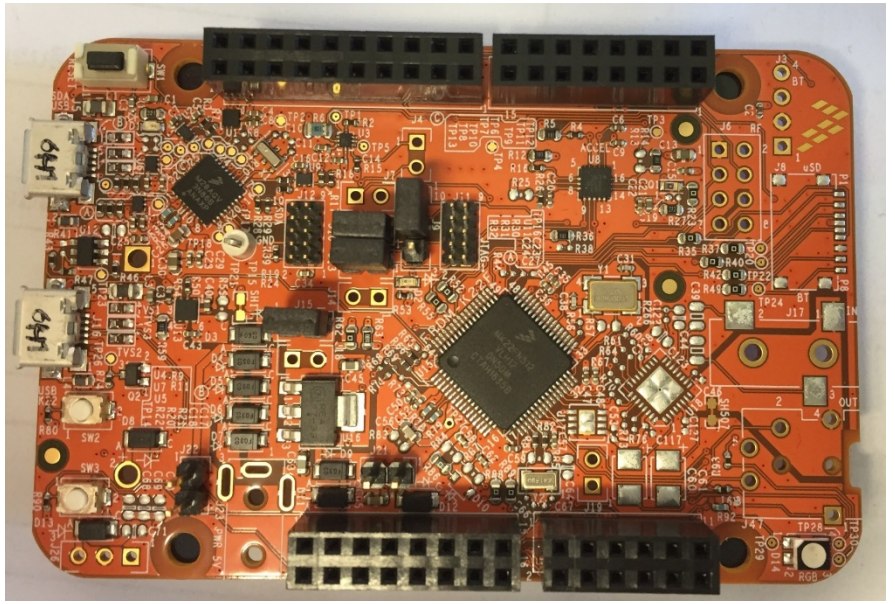
Laptops in class

- If you have a laptop you are encouraged to bring it to lectures **if you use it constructively**.
- Make sure you have the software installed (the instructions are on LearnJCU).

Dev boards

- You will sign out a development board in the first lab
- **Bring it to all subsequent labs!**
- You are expected to use it for programming outside of scheduled classes.
  - Set up your home computer with the necessary software (see LearnJCU), or
  - Use the labs (Townsville: 14-209; Cairns: E1-022). Swipe your student card for after-hours access.





Return of equipment

- We are loaning you a development board for the duration of the subject. It is yours to use at university and at home.
- You'll be required to sign a loan agreement.
- You must return the equipment at the end of the subject or else the university will hold you liable for the cost of replacing it.
- If the equipment is not returned you will get a result withheld (RW) grade.

Workplace Health and Safety

- **Closed-in shoes are mandatory in all lab or workshop environments.**
- You will be asked to leave the room if you do not have closed-in shoes.
- In the electrical workshop, wear safety glasses when soldering or cutting components.
- Follow directions when working in the electrical workshop.
- If you've never soldered before, **ask for help!** There are no stupid questions.

Lab induction

- Lab inductions will occur during the first lab sessions.
- Lab inductions must be completed before attending any labs. If you miss the induction see a technician (John Renehan / Ben Lyons) to get it sorted.

Assumed knowledge

- Essential: prior programming experience
  - EG1002, CP1404, or equivalent.
- Highly beneficial: Fundamentals of electric circuits
  - Ohm's law, Kirchhoff's circuit laws.
  - Function of resistors, capacitors, inductors.
  - Familiarity with circuit diagrams and ability to recognise function.
- **Please email me if you feel you might need to catch up on these topics.**

Any questions about administrative issues?

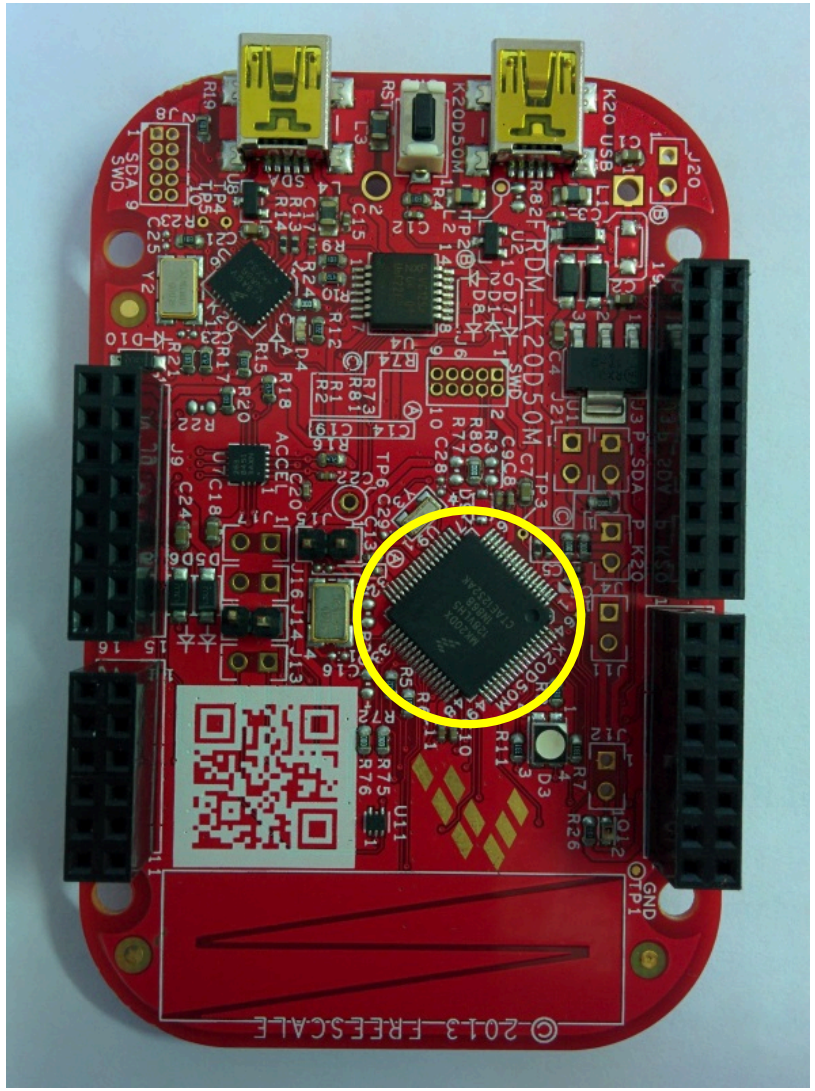
- Timetable clashes?
- Questions about workload?

- Let’s begin!

What is a microcontroller?

A microcontroller is a small computer intended for uses such as:

- Monitoring
- Control
- Data logging
- Portable electronics



Example applications

Examples:

- Building management (e.g. heating, ventilation, air-conditioning)
- Household appliances (e.g. washing machines, microwaves)
- Radio systems (e.g. restaurant pagers, remote controlled toys)
- Robotics
- Consumer electronics (e.g. portable music players)
- Vehicles (e.g. engine control unit, ABS, electronic stability control)

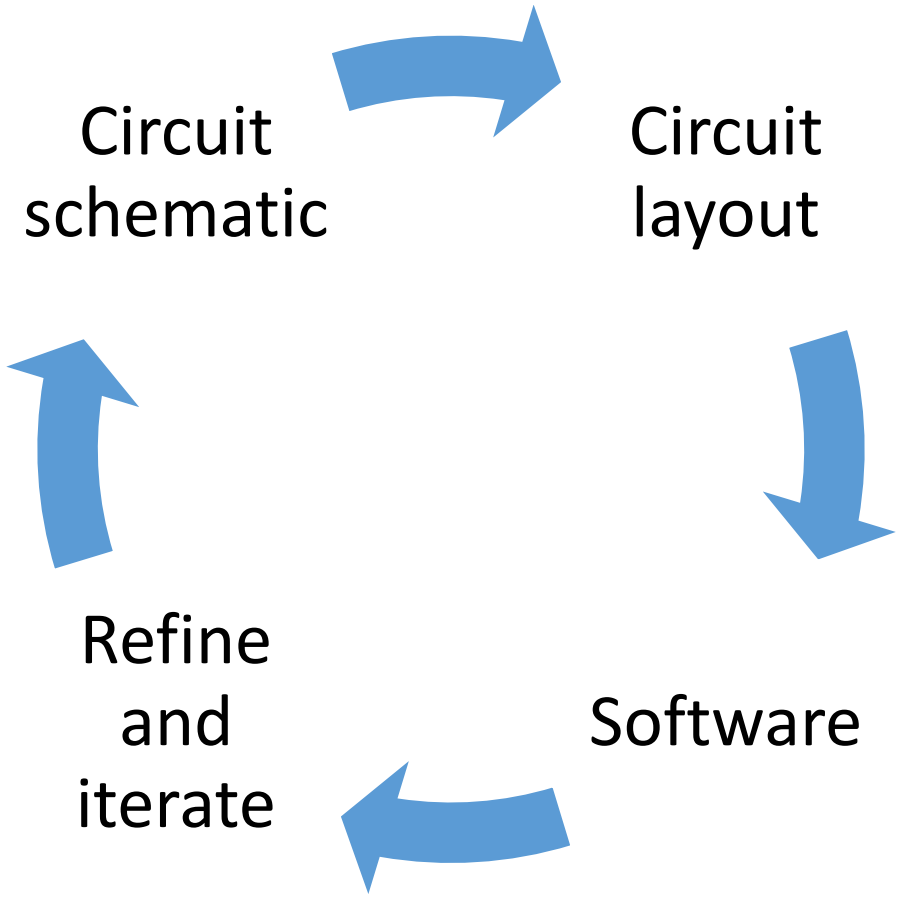
Terminology

- **Microprocessor:** a computer's central processing unit (CPU). Typically contains only the CPU and does not have memory or storage built-in.
- **Microcontroller:** a CPU with memory and other peripherals built-in.
- In this course we use microcontrollers.
- Sometimes people use these terms interchangeably but be aware that there is technically a difference.

Embedded Systems Design Process

- The microcontroller is “embedded” within a larger device or installation. The presence of the computer is not always immediately obvious.
- Hardware and software are developed together.
- We will focus on:
  - The microcontroller and the software it runs.
  - The circuit board that houses the microcontroller and connects it to peripherals.

Design process

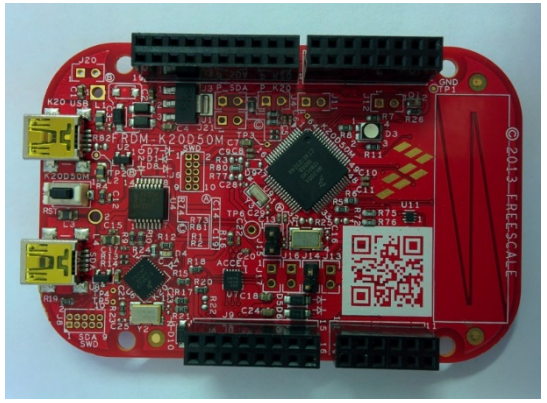


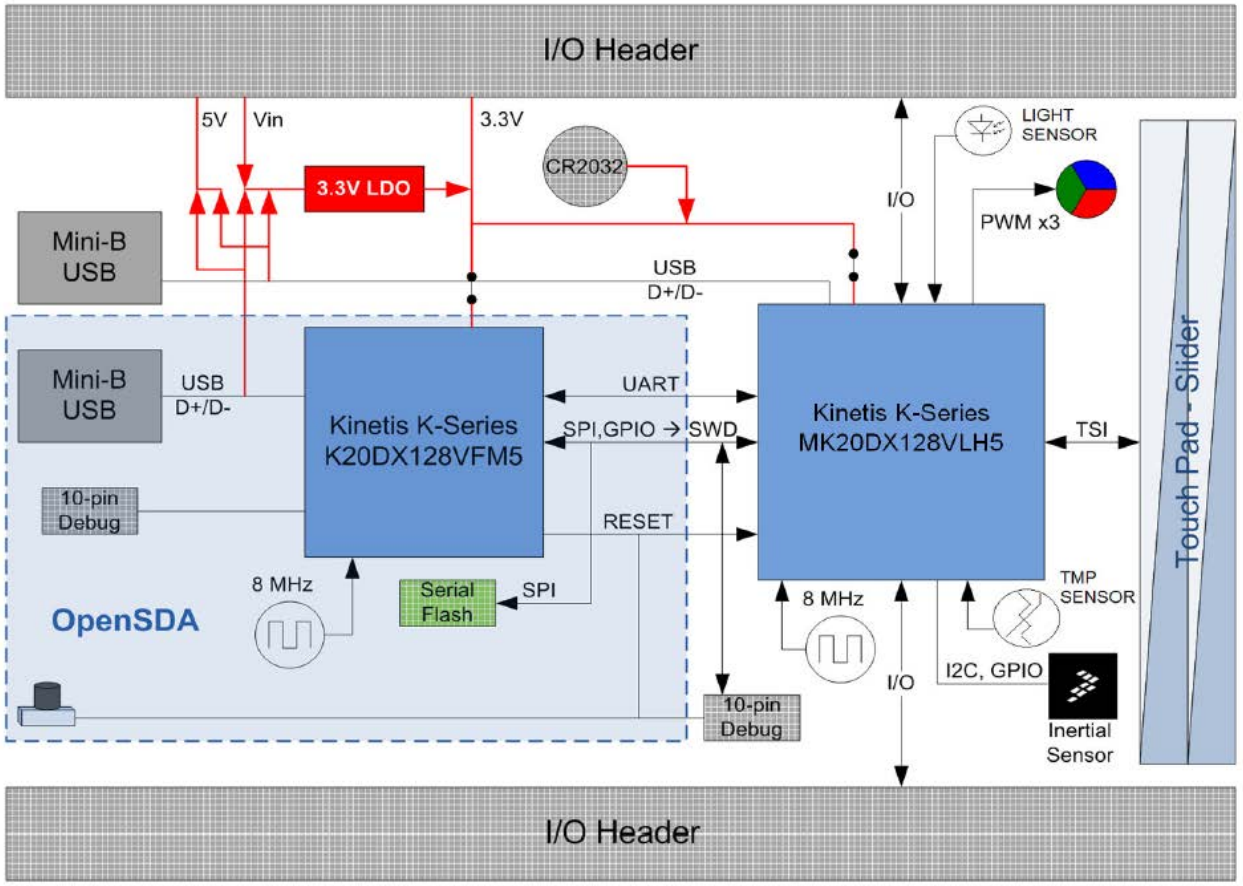
Embedded Software

- Embedded systems are generally programmed “in the factory.”
- The user is not expected to reprogram the machine.
  - Often, they are not able to reprogram it even if they wanted to.
- The application is carefully tuned for the task it is to perform.

The K20D50M board (Townsville)

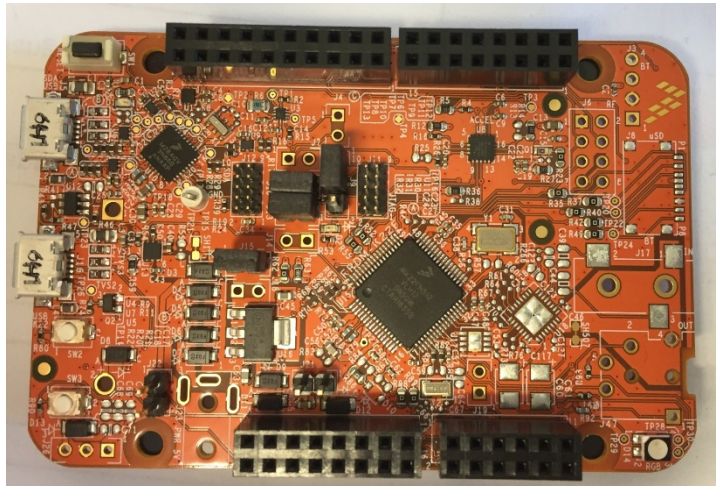
- “Kinetis K20” microprocessor
- Light sensor, temperature sensor, accelerometer, capacitive touch panel, red-green-blue (RGB) LED, USB interface.

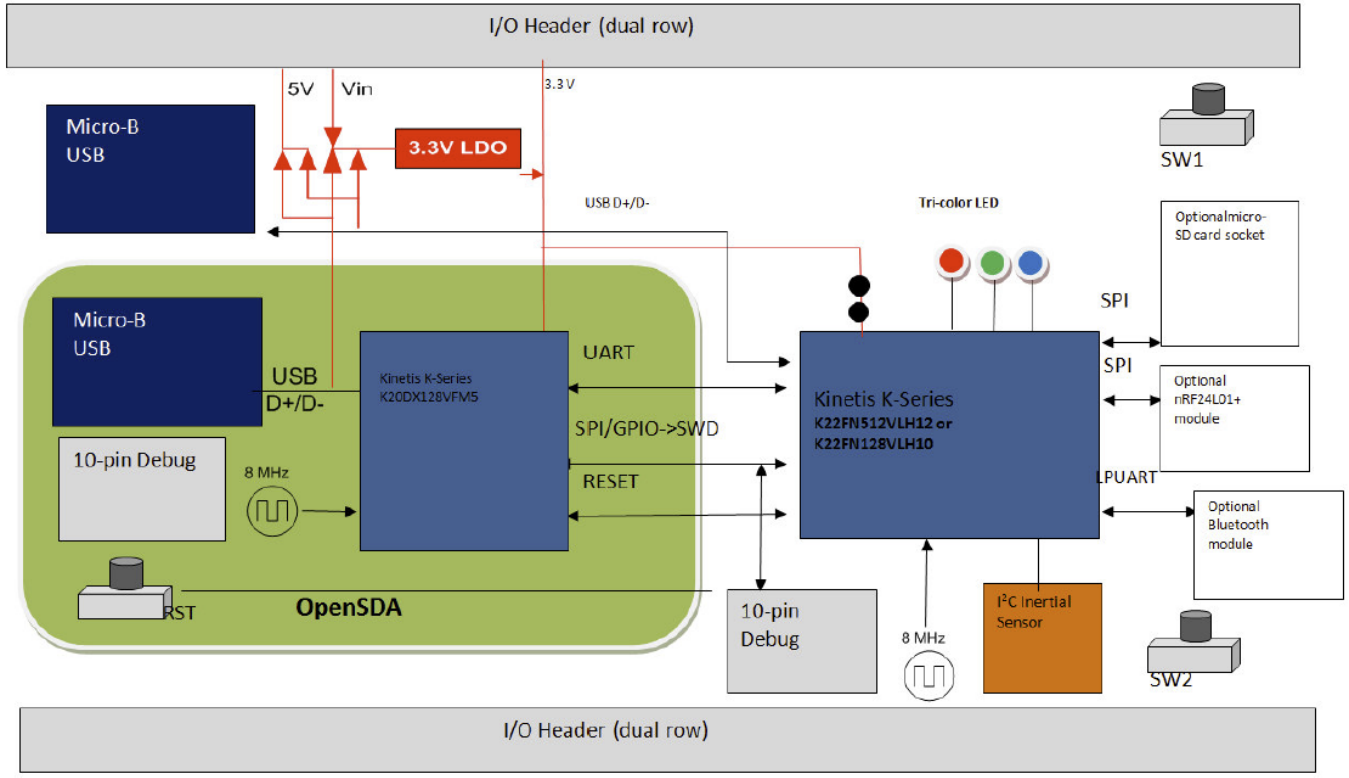




The K22F board (Cairns)

- “Kinetis K22” microprocessor
- Light sensor, accelerometer + magnetometer, two switches, red-green-blue (RGB) LED, USB interface, footprint for Micro SD card.





Accessing documentation

- The microprocessor manufacturer (NXP) publishes the documentation on their website.
- http://nxp.com/FRDM-K22F
- http://nxp.com/FRDM-K20D50M
- Also available on LearnJCU.

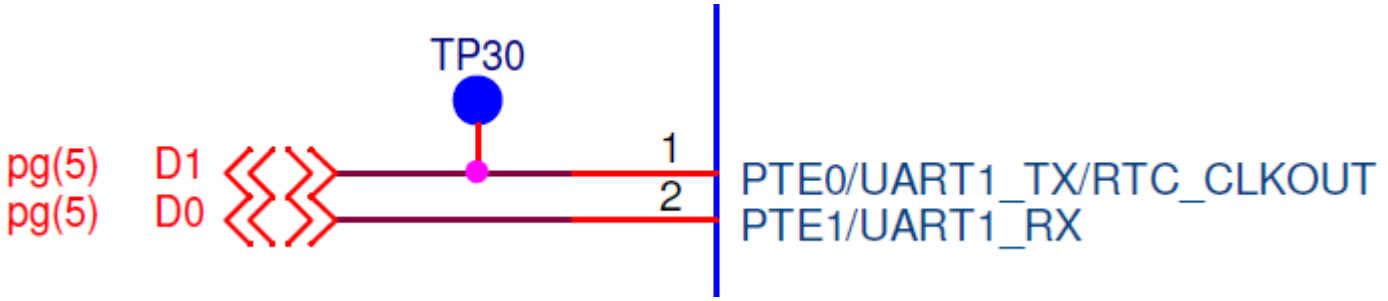
How to read a schematic

- If you have a laptop, open LearnJCU → Reference Materials → FRDM Schematic.

- Otherwise, look at the printed copy.

Reading a schematic

- Electrical connections are shown with lines
- Signals with the same name are electrically connected. Below, “D1” and “D0” are signal names.
- pg(5) means that this signal also appears on page 5.
- “PTE0/UART1_TX/RTC_CLKOUT” is a pin name on the microprocessor.
- “TP” is a test point where the signal is brought to the surface of the board for electrical testing.



Practice reading the FRDM schematic (K20D50M board)

Questions:

1. Which microprocessor pin is connected to the temperature sensor?
2. Explain how the temperature sensor can be isolated if that pin is needed for another purpose.
3. There are two USB ports. USB supplies 5 volts DC. If both are connected, two power supplies exist. What happens?

   (Hint: Consider if the *same* USB power supply is used, and contrast this to what would happen if *different* USB power supplies are used. What assumptions are you making?)

Practice reading the FRDM schematic (K22F board)

Questions:

1. Which microprocessor pin is connected to the visible light sensor?
2. If you wanted to find the datasheet for the light sensor, what part number would you search for?
3. Which microprocessor pin is connected to the green LED? If this pin can be set to either of 3.3V or 0V, which will turn on the LED?
4. There are two USB ports. USB supplies 5 volts DC. If both are connected, two power supplies exist. What happens?

   (Hint: Consider if two USB ports on the *same computer* are used vs. if *different computers* supply the USB power. What assumptions are you making?)

The datasheet

- The datasheet provides electrical, mechanical and thermal ratings and specifications.

Freescale Semiconductor
Data Sheet: Technical Data

Document Number: K20P64M50SF0
Rev. 4 5/2012

Energy Efficient Solutions
optimized for low power

K20 Sub-Family

Supports the following:
MK20DN32VLH5, MK20DX32VLH5,
MK20DN64VLH5, MK20DX64VLH5,
MK20DN128VLH5, MK20DX128VLH5,
MK20DN32VMP5, MK20DX32VMP5,
MK20DN64VMP5, MK20DX64VMP5,
MK20DN128VMP5, MK20DX128VMP5

K20P64M50SF0

Reading the datasheet

Questions:

1. What is the range of supply voltages for which the microprocessor will operate?
2. What is the maximum current that can be supplied from a digital output pin?
3. What is the range of voltages that can be read by the analog-to-digital converter?

The reference manual

- The reference manual describes how to use the features of the microprocessor.
- For each feature:
  - Functional description and block diagram
  - Pin usage
  - How to configure the relevant registers

Summary: documentation

- **Schematic:** Shows all the components on the dev board and how these are connected.
- **Datasheet:** Gives the electrical, thermal and mechanical specifications.
  - For simpler parts, also defines the operational parameters and how to use that component.
- **Reference manual**: Defines the software interface to each component inside the microprocessor.

Summary: workload

- 2 lectures per week
- 1 lab per week
- Sign out the dev boards
- Bring to EVERY lab:
  - A USB drive or your own laptop
  - The FRDM board

What to do next

- Use the GitHub link on LearnJCU to activate your free private repository for CC2511 work.
- Sign up for a lab class.