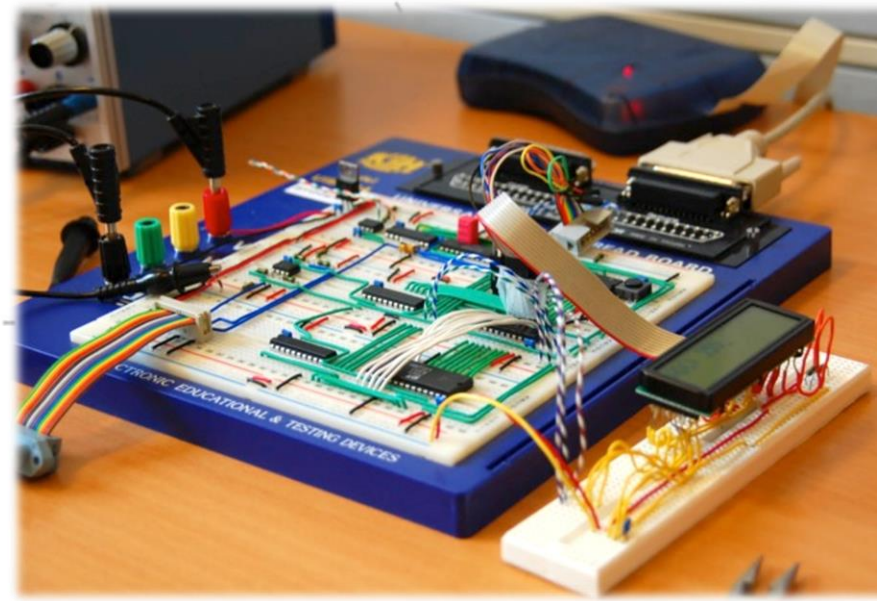
TTK4155

Industrial and Embedded Computer Systems Design



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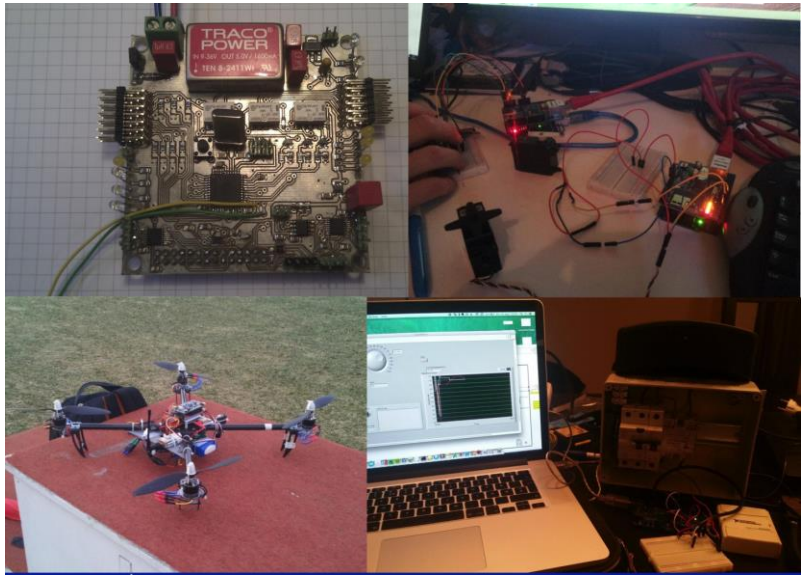
Lab lecture 1

- Introduction to the term project
- General and practical information
- Assignment 1 - Initial assembly of microcontroller and RS-232
- Git and VCS

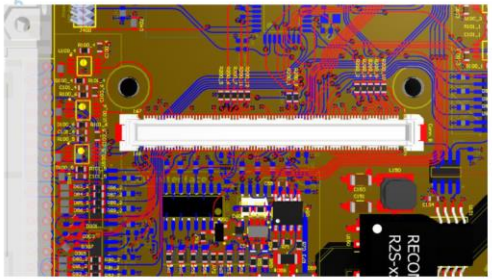
Reference Group

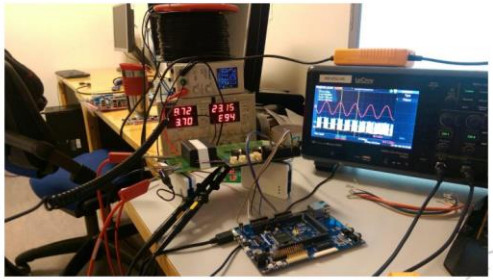
Any volunteers?? Preferably from different study programs….

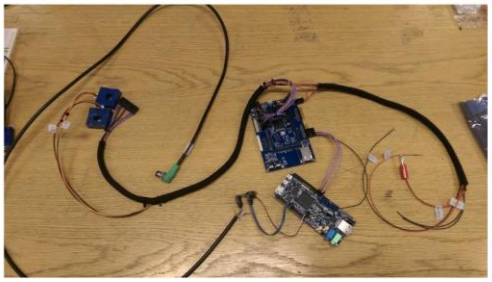
1) Kristoffer Landsnes (MITK)
2) …
3) …

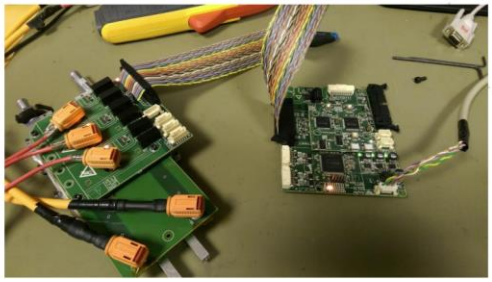


After this lab…









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The lab team

- Waseem Hassan
  - waseem.hassan@.ntnu.no or D135
  - Administrative tasks (groups, lab etc.), lab lectures
- Helge-André Langåker
  - Will act as proxy for Waseem when he is unavailable.
- Torstein Grindvik
- Torjus Kalfstad
- Johan Lofstad
- Didrik Rokhaug
- Jorgen Jackwitz
- SAs available 8 hours every lab day, minus a 1 hour break
  - Mon: 0800-1600; Wed:1000-1800; Fri: 1100-1900.
  - Use the lab whenever it is free. There are some free lab places.

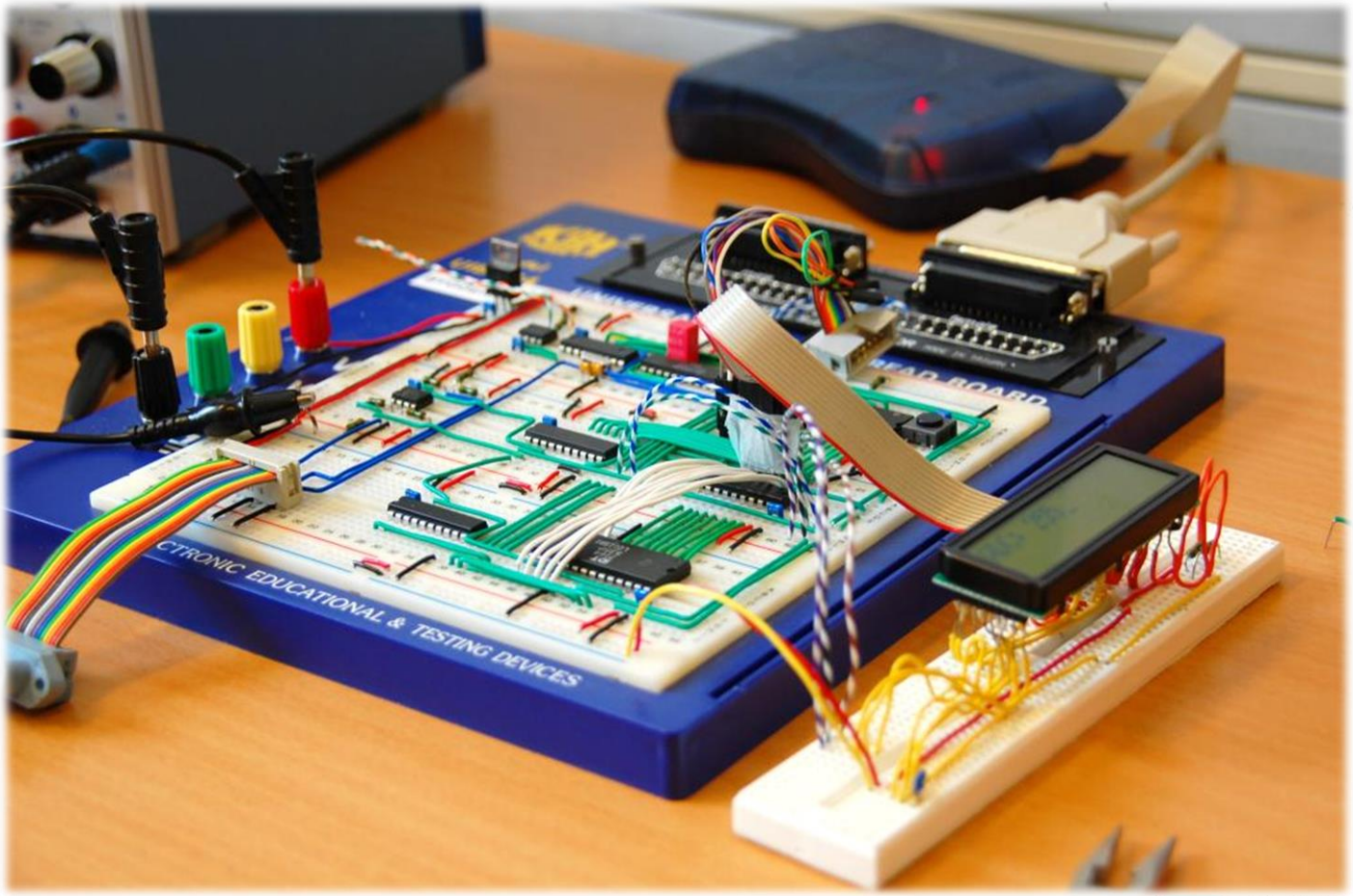
Lab Project

- A mechatronic project with the goal of building a computer controlled ping-pong game. Practical and fun!

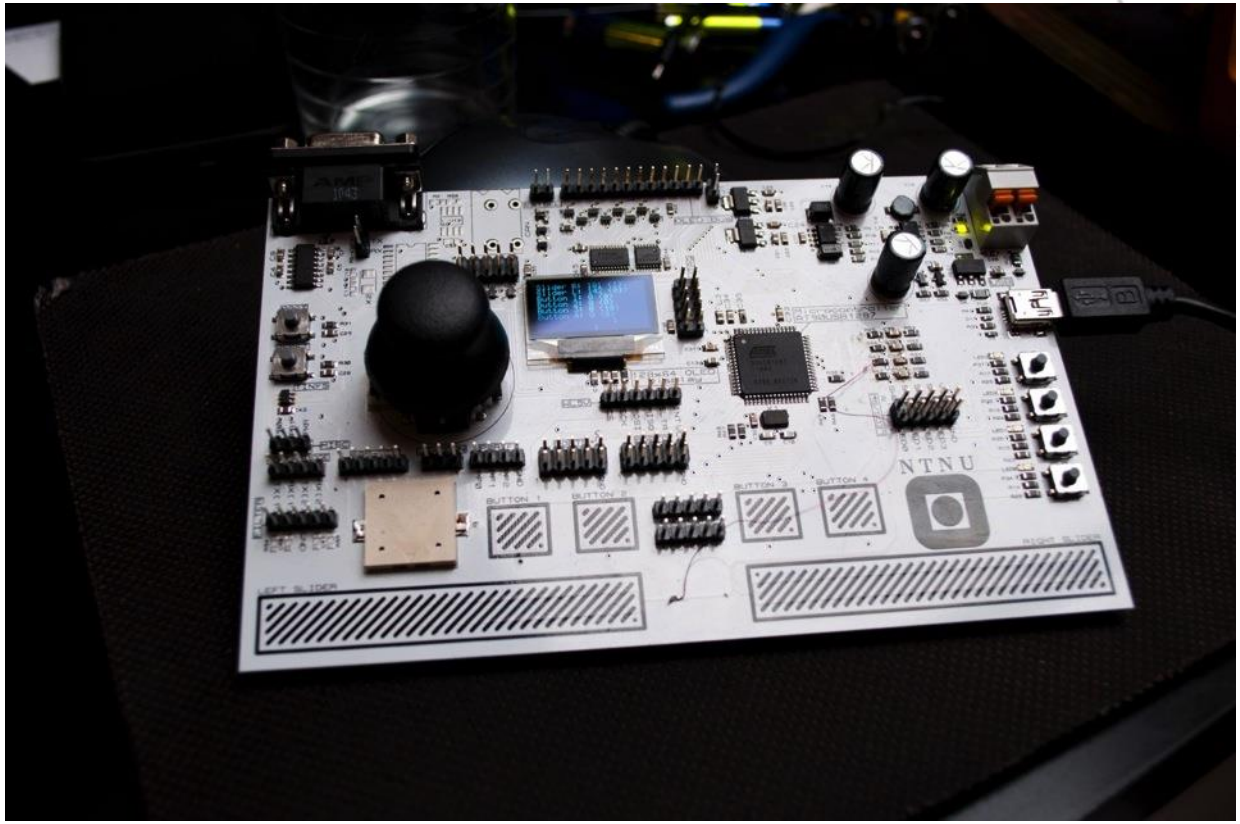
- Tasks
  - Build two microcontroller based (embedded) nodes.
  - For one of the nodes, assemble discrete components on breadboard. ICs, resistors, capacitors etc.
  - For both of the nodes, develop software device drivers in C.

- Project counts 50% of the final grade.

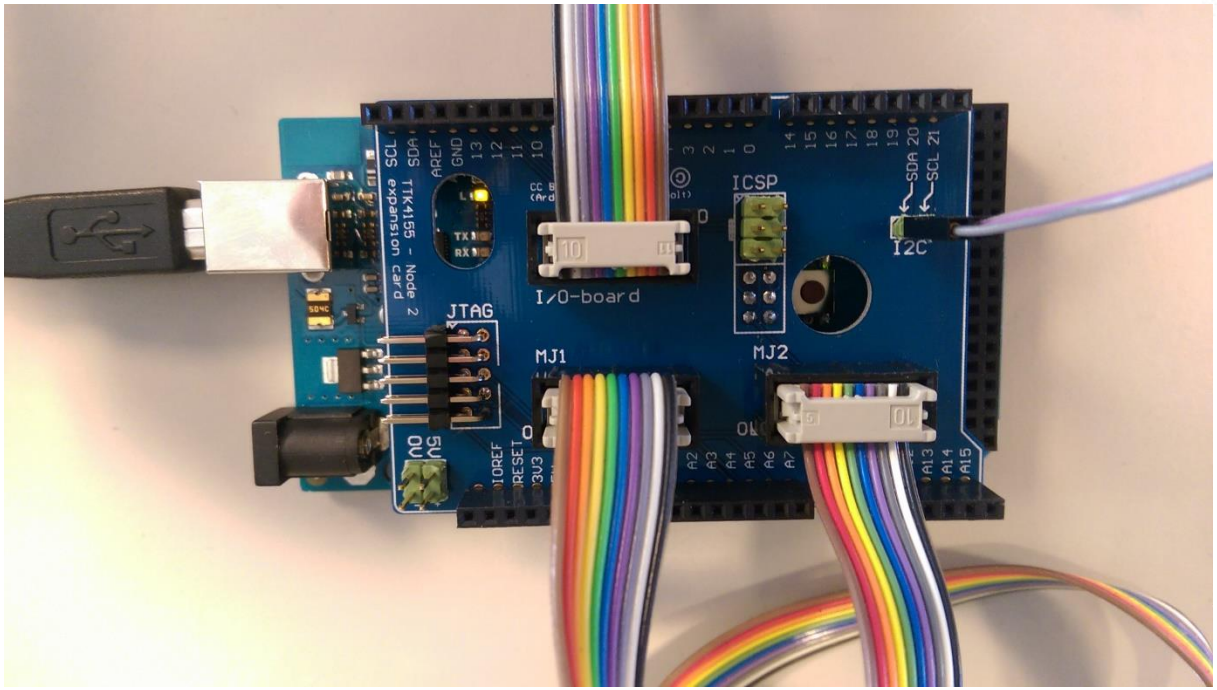
Node 1

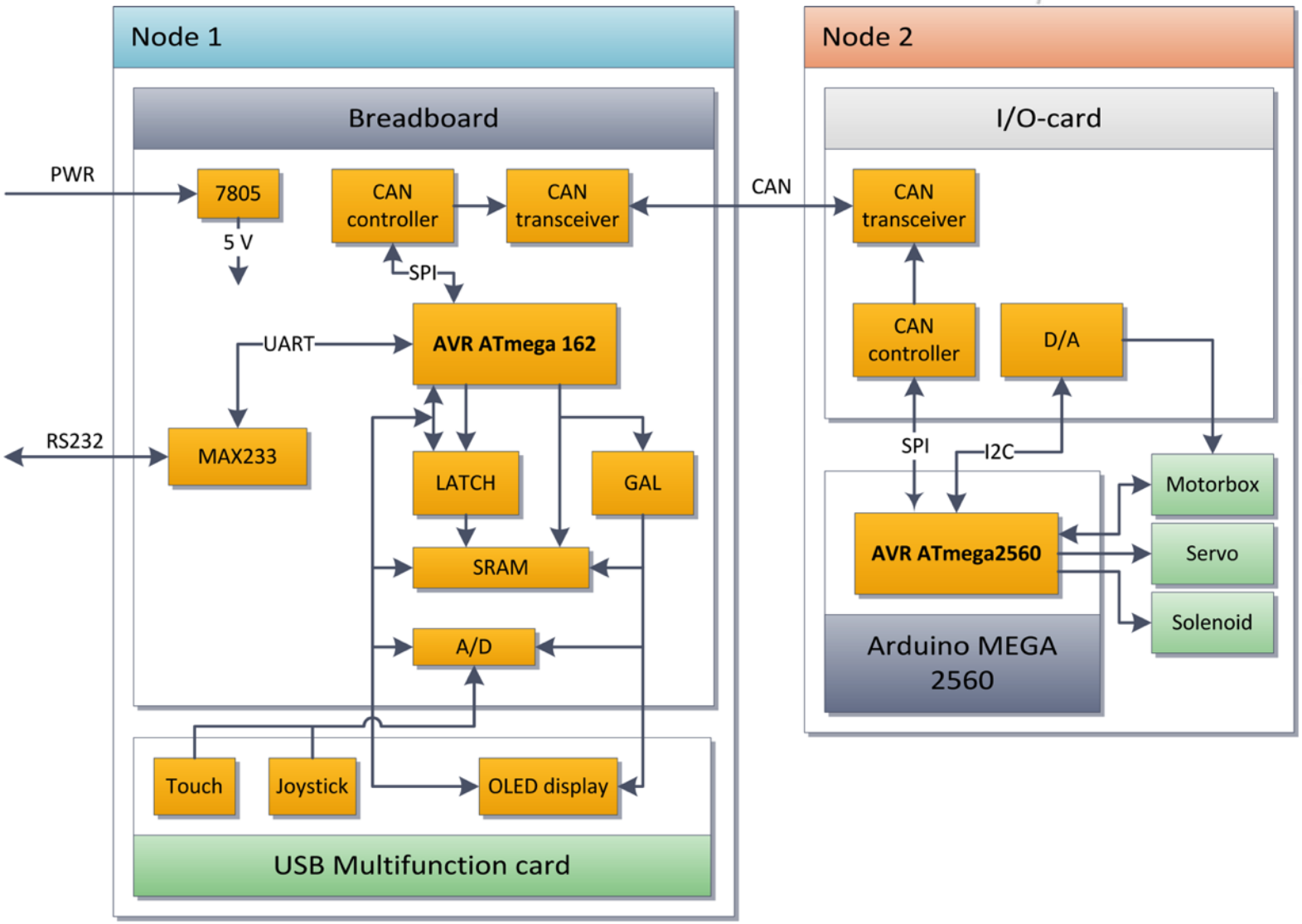


The «USB Multifunction Board»



Node 2
The Arduino Mega 2560




Node 1
Breadboard
PWR
7805
5 V
CAN controller
CAN transceiver
SPI
UART
AVR ATmega 162
RS232
MAX233
LATCH
GAL
SRAM
A/D
Touch
Joystick
OLED display
USB Multifunction card
CAN
Node 2
I/O-card
CAN transceiver
CAN controller
D/A
SPI
I2C
Motorbox
AVR ATmega2560
Servo
Solenoid
Arduino MEGA 2560

Lab Groups

- Group of THREE students with some groups having two students.
- We have published groups on Blackboard please see your lab day and group members.
- If you were alone or a new member has been added to your group, please break ice. It helps a lot!

Lab, Kit and Components

- Lab located in the EL-building, second floor, room G203 and G204 (up the stairs near “Infohjørnet” helpdesk) “Sanntidssalen”
  - Not a student of Cybernetics? Test your card and send me an e-mail with your full name and card number (below the return address, not the one starting with “NTNU”) ASAP if you don’t have access.
  - Reserved Mondays, Wednesdays and Fridays.

- Components: handed out in the component store
  - Åsmund Stavdahl
  - Cybernetics Building D, room D-040
  - Go there at the beginning of your first lab day.
  - Deposit fee of 200 NOK, bring exact amount.
  - Must be returned in good condition to get access to the exam

Additional Components

- Not all components in the kit e.g. cables, headers, connectors etc.
- Additional components are available in Real Time lab at the SA desk.
- If you need more specific components, ask SAs they might help you with arranging component from the store etc.

Remember to buy a padlock

- There are lockable cabinets outside the lab where you can put your equipment between lab sessions. Use the locker corresponding to your group number.

- Don't lock in common lab equipment e.g. game boards

Lab Assignments

- Eight assignments in total.
  - Each assignment is described in lab manual (exercise in the manual).
  - Assignments are followed by a lab lecture => x8 lab lectures. Schedule on Blackboard
  - Lab lectures briefly explain the assignment and give tips for the assignment.
- Assignments must be approved by an SA.
  - Try to get approved in the assignment week.
  - Helps you at the end e.g. if your project fails…

Lab Manual

- Please send me an email if you notice any error or missing information.
  - It describes each assignment and also gives tips for debugging/common errors.
- Might be updated during the course.
- Read thoroughly before each assignment and also exam.

Saving your work

- Do not save locally, always make a remote copy/on a secure device.
- We recommend to use a version control system (VCS) e.g. Git
- This project => ideal learning scenario for Git. Helge will introduce Git. SAs will provide assistance with Git during the lab.

Evaluation

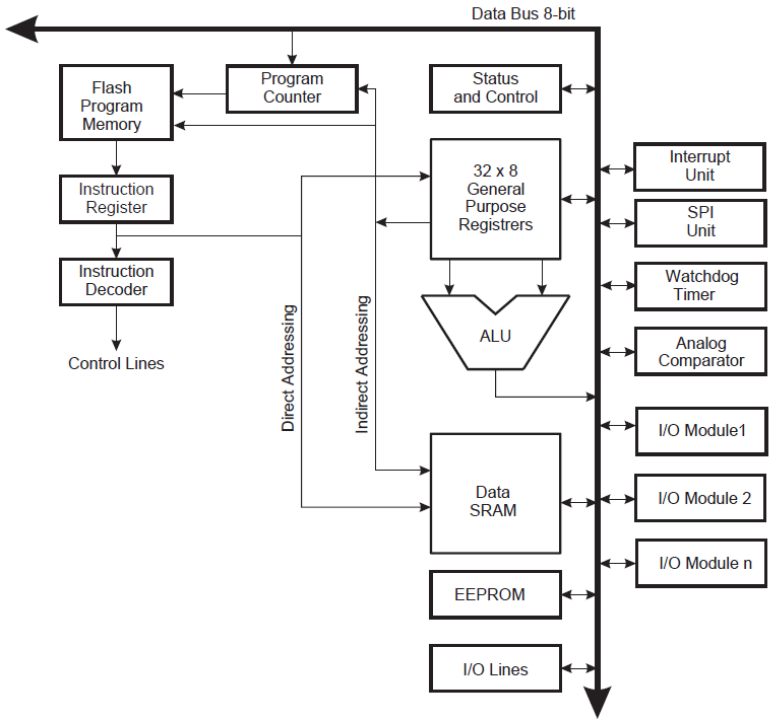
- All code submitted at the end of the project
- Only use your own code except in the cases where permission is given.
- System demonstration and presentation (15 min)
- No reports or written material required
- Completion and functionality (perfect score): 80%
  - Approved exercises does not guarantee full score
- Extra features and creativity: 20%

How to work with the project

- ✓ Read the assignment before the each lab
- ✓ Master C and electronics
- ✓ Be careful and thorough when implementing each part
- ✓ Organize your code in compact drivers with logical interfaces
- ✓ Keep a nice and tidy breadboard
- ✓ Test frequently
- ✓ Use the web, but do not copy other people's work
- ✓ Read through the assignment text and perform the debugging steps before asking for help
- ✓ Read the datasheets carefully
- ✓ Go on with the next assignment when ready
- ✓ Make documentation!

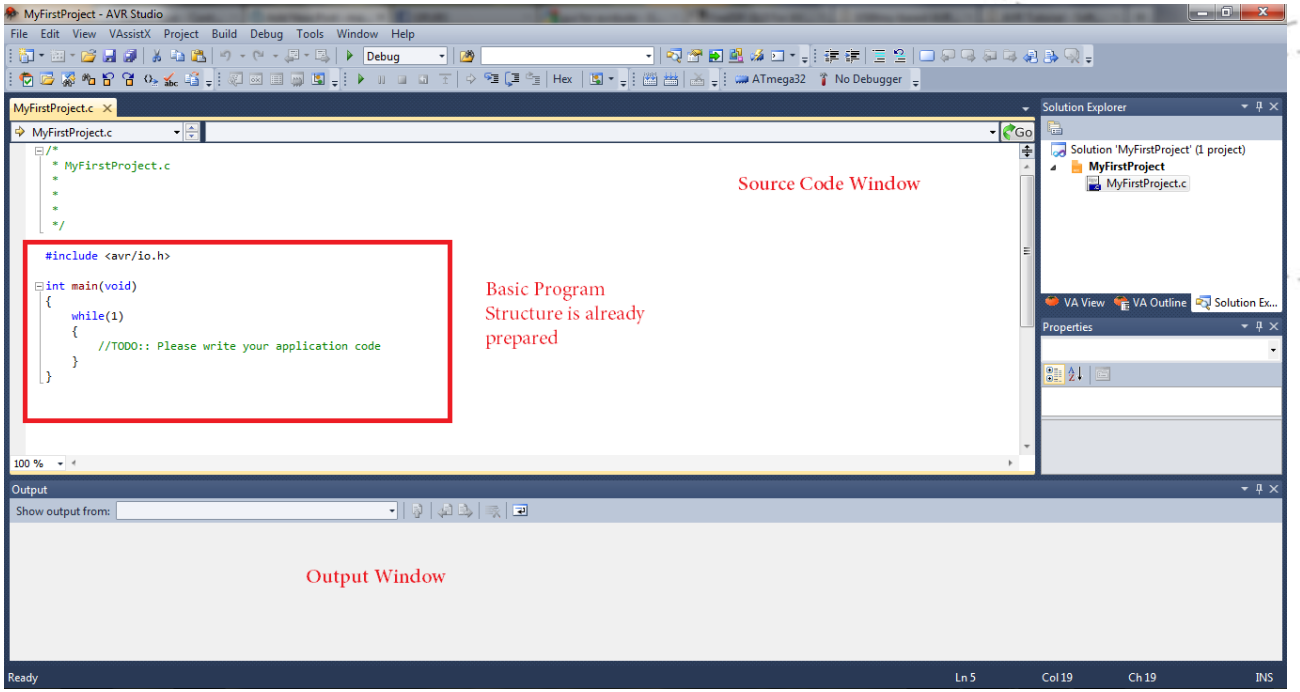
Microcontrollers

- A small computer on a single integrated circuit.
  - Processor core.
  - Memory.
  - Programmable input/output units.
    - Input/output pins we can control.
    - Communication interfaces.
    - ADCs.
    - DACs.
- Embedded applications.
- This project: Atmel AVR family.



Atmel Studio 6.2

- Write code
- Compile
- (Simulate)
- Program
- Debug



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Exercise 1: Initial assembly of µC

- The microcontroller needs
  - Power => Voltage regulator.
  - Clock signal => Crystal oscillator.
  - Programming interface => JTAG (Atmel ICE).
- Everything you need to do is described in the assignment text and referenced datasheets.
- This will get the «main unit» up and running.
- Other units will then be connected in later assignments.

UART & RS232

- Difference
  - UART => device used for asynchronous comm.
  - RS232 => standard, defines electrical aspects of comm. e.g. voltages, signaling, cables etc.
- RS232 standard interface, used quite often.
- Makes your embedded system to communicate with other devices e.g. a PC etc.
- Useful in debugging. Make wrapper for printf function and you can print your desired status messages using standard C function.

UART Software Buffer

- Not required or mandatory just an advance method.
- Read this tutorial and try to implement buffered UART. Again it is an extra in case you finish earlier and have time.

UART s/w buffer

Example: programming for AVR µCs in C

- I/O pins are organized as ports
- main()
- Bit manipulation
- Modularity
- Polling and interrupts

- Only the bit in position CS02 set
  `(1 << CS02)`
- Only the bits in position COM01, COM00 and CS02 set
  `(1 << COM01) | (1 << COM00) | (0 << WGM01) | (1 << CS02)`
- Set the bits CS02 and COM01 in TCCR0 register, clear the other bits
  `TCCR0 = (1 << CS02) | (1 << COM01);`
- Set the bits CS02 and COM01, leave the other bits unchanged
  `TCCR0 |= (1 << CS02) | (1 << COM01);`
- Clear the bit CS02, leave other bits unchanged
  `TCCR0 &= ~(1 << CS02);`

HW Debugging Tips

- Power off the circuit before debugging.
- Check power and ground connections and also loose connections first => use DMM.
- Oscilloscope is a powerful tool. Use for time varying signals.
- Double check programmer's connection. (Atmel ICE)
- Verify crossing of cables e.g. serial cable Tx and Rx.
- Read datasheets carefully and try to make the circuit as shown in the datasheets of IC(s).
- Tidy wiring helps in debugging.

  Do it from start.

Questions?

Auf wiedersehen...