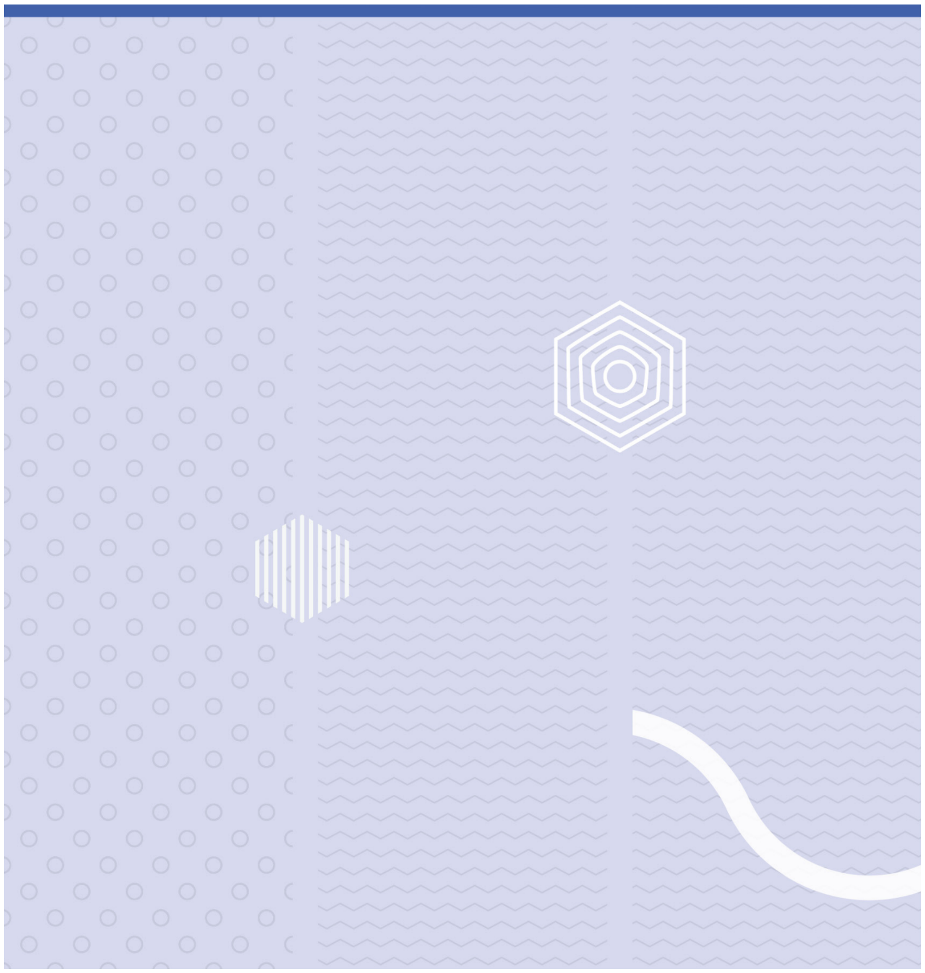
test

Hello



Title

Kent Odde, Stian Onarheim, Tarald Vestbøstad

October 20, 2020

Contents

1 Maybe useful text

Thursday 20. August 2020, the group gathered and had a meeting with Steven Bos. We discussed our project idea and the potential use of the Microsoft HoloLens 2. It was in the group's best interest to put our resources into the microcontroller rather than the goggles, dismissing any development with the HoloLens.

On September 10. the group met to plan the project. After deciding on the initial design, we drew a sketch and wrote a short description. This was sent to our professor, along with a list of required parts as well as the associated budget. The initial design can be seen in section XX.

On the 16th of September, we ordered three Arduino Nano 33 BLE Sense w/headers from Arduino.cc. This came to 1080NOK. In addition to this the professor provided us with a car for the project. It is called Turnigy Trooper [5], and was originally a radio controlled car. However everything but the battery and servo motors for thrust and steering, have been stripped away.

The servo motors are controlled by a pulse-width modulated signal. This means in essence that we send discrete signals, where the signal will rise at a fixed frequency. The length of time the signal is high before going low will determine the behaviour of the servo motors. Luckily for us there is a standard regarding the behaviour generated by a specific pulse width.

We will need to write a library which will abstract this away in the code. Where the interface for steering will take an angle, and the motor interface will hopefully be able to take a velocity in m/s, where negative numbers will mean going backwards.

After Steven showed us a proof of concept that it will be quite doable to base our library for the Arduino Nano on the existing toolchain for NRF52840, we started developing on the 17th of September. However there quickly emerged a problem, as Gnat arm-elf initally only supports ZFP-runtime libraries for this card. This meant that it would only support barebone functionality, and we would never be able to make use of the Ada realtime library, or even multi-threading the software. Luckily, there exists support for full ravenscar run-time libraries for the card. We followed the official guide at the bb-runtime repo [3], to generate and build them ourselves.

```
./build_rts.py --rts-src-descriptor ~/opt/GNAT/2020-arm-elf/arm-eabi/lib/
    gnat/rts-sources.json --output=temp nrf52840
```

```
gprbuild -P ~/opt/GNAT/2020-arm-elf/lib/gnat/arm-eabi/lib/gnat/ravenscar-
    full-nrf52840/ravenscar-build.gpr
```

On the 18th of September we improved our library build, by letting the project_wizard script in Ada drivers library generate the gpr-files for our board automatically. All we had to do was to provide some basic information about the microcontroller, and the script did the rest. We also started adapting the pin mappings from the nRF52832 to the nRF52840.

Provided that our efforts lead to a useful library, we will create a pull request into the Ada drivers library, so that others may benefit from our work.

```
./Ada_Drivers_Library/scripts/project_wizard.py
```

October 5.

We received the Segger J-Link debugger from our professor. In order to get this to work, we installed the firmware from segger.com. However we also had to install a pack for pyocd in order to find the debugger:

```
pyocd pack --install stm32l476VG
```

As all development within the group is done on Linux, we also had to add udev rules, so that we were able to access the usb ports without being root. These rule-sets were found on pyocds git repository.

We also had to give the respective user access to the serial port by running the command:

```
usermod -a -G dialout MY\_USER\_NAME
```

Legge til utilization test og grafikk.

October 12.

We are able to flash and debug by manually holding cables to the debug connections on the Arduino. We used the diagram on the segger website [4] to find out which JLink pins to "connect" to the Arduino points.

AnalogWrite seems like the perfect choice to generate a pulse for both servo and sensor. In the Ada Drivers Library [1] there is a very good example for controlling a servo. It changes the analog signal period with **Set_Analog_Period_Us** to generate a steady pulse.

However we were never able to make it work on the arduino. Seems to be a problem with incompatibility between the drivers and the Arduino or the nRF52840 chip.
We suspect it is tied to interrupts since the stacktrace from the debugger kept stopping on a new line each time.

Progress is slow because of the manual labour required for each flash and debugging session.

October 19.

We recieved the clamps from Richard and Steven was able to put it together with the Arduino and a breadboard. We are finally able to easily flash and debug.

We were able to create a steady pulse using digital I/O and tasks with a fixed priority. With a proper priority we were able to use three tasks for three separate servos and one task for three sensors.

We encountered some problems using a 9V battery power source, as the Ardino requires at least 5V and the peripherals need 5V.

2 Ravenscar

The full ravenscar run-time library offers what is called the Ravenscar profile. This is a subset of the Ada language, where the features and available libraries are limited. The reason for this is to ensure robust software on realtime and safety critical systems.

The specifications of the ravenscar profile are the following: https://www.ada-switzerland.ch/rm/RM-D-13.html

There are a couple of limitations here that will affect the way we initially planned our software.

The maximum number of entries in tasks are set to 0. This means that we won't be able do have dynamic tasking, and all tasks will rather have to be defined at compile-time.

Another thing we planned was to specify which tasks would run on the respective cores of the CPU. This however, is not supported within the ravenscar profile, and we will need to do all the scheduling as if we only had a single-core processor.

3 Various problems we've encountered along the way

By the time you're reading this, some of these issues might have been fixed. Down below are some problems we have encountered during our development phase from 17.02.2020 - ??. Most of these issues have occured using Linux, it is stated otherwise.

- Flashing to the Arduino board without a debugging probe might be impossible.
- After installing software for the Segger J-Link debugger from their official webpage, a new .rules file for the debugger appears in */etc/udev/rules.d* containing the necessary information for the debugger to be found by *pyocd list*. This has only been successful with one of our computers. A workaround is to run pyocd with sudo privileges.
- Including unused libraries in the Ada source-code makes the arduino crash under run-time.

- When trying to flash to the board without having the cables soldered, errors in the list below have appeared as a consequence of unstable hands.
  - Unexpected error.
  - Unable to start CPU core.
  - chip has no power?.
  - Det var vel en til?
  - Unspecified Error.
- Including Arduino_Nano_33_Ble_Sense.Time makes the microcontroller crash in real time. –ref til Debug lstlisting i appendix–
- Only Digital I/O works. Possibly because Analog relies on interrupt/-timers which seem broken in our drivers or runtime.
- Generating a pulse accepted by the servos and ultrasonic sensor is more challenging than setting pins to low/high and using a delay.
- Using a copied bb-runtime library will not work correctly on other computers under debugging. They must be generated on every new computer.

3.1 Pin layout

11.10.2020
The nRF52840 has two ports, P0 has 32 pins while P1 has 16 pins.
We found the P1 base address for the nRF52840 seen on page 23 in the datasheet [8]. Without it we were only able to use the pins with P0 seen on figure 5.3. After adding the base address to the Ada code and the option to chose between 0 and 47 pin number we were able to make all the pins function.

4 Maybe useful pictures

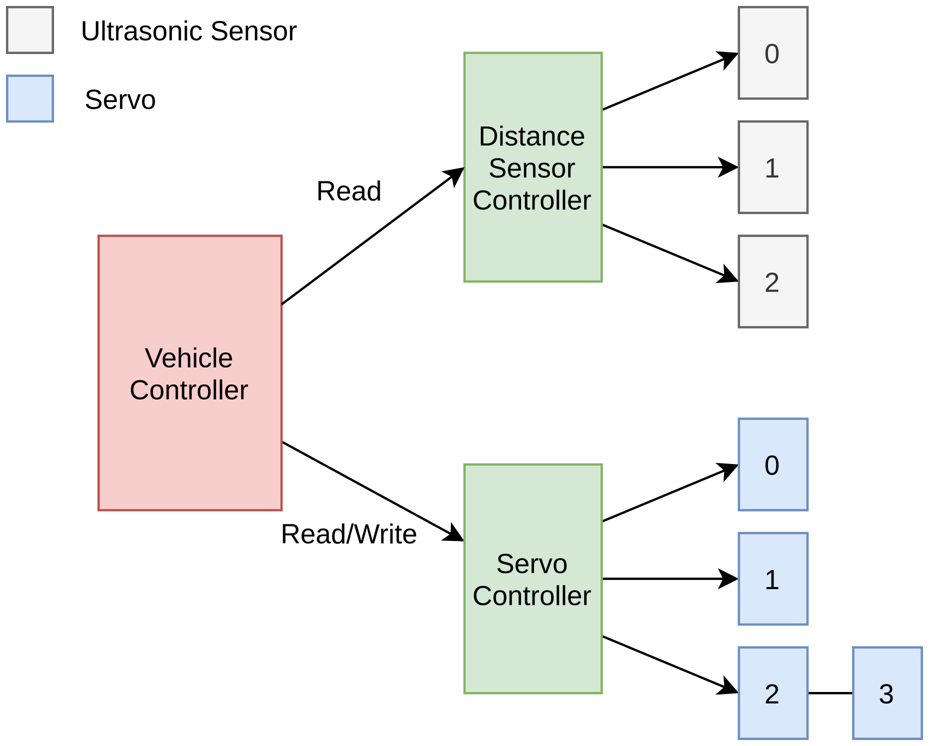


Figure 1: Block diagram of our system architecture

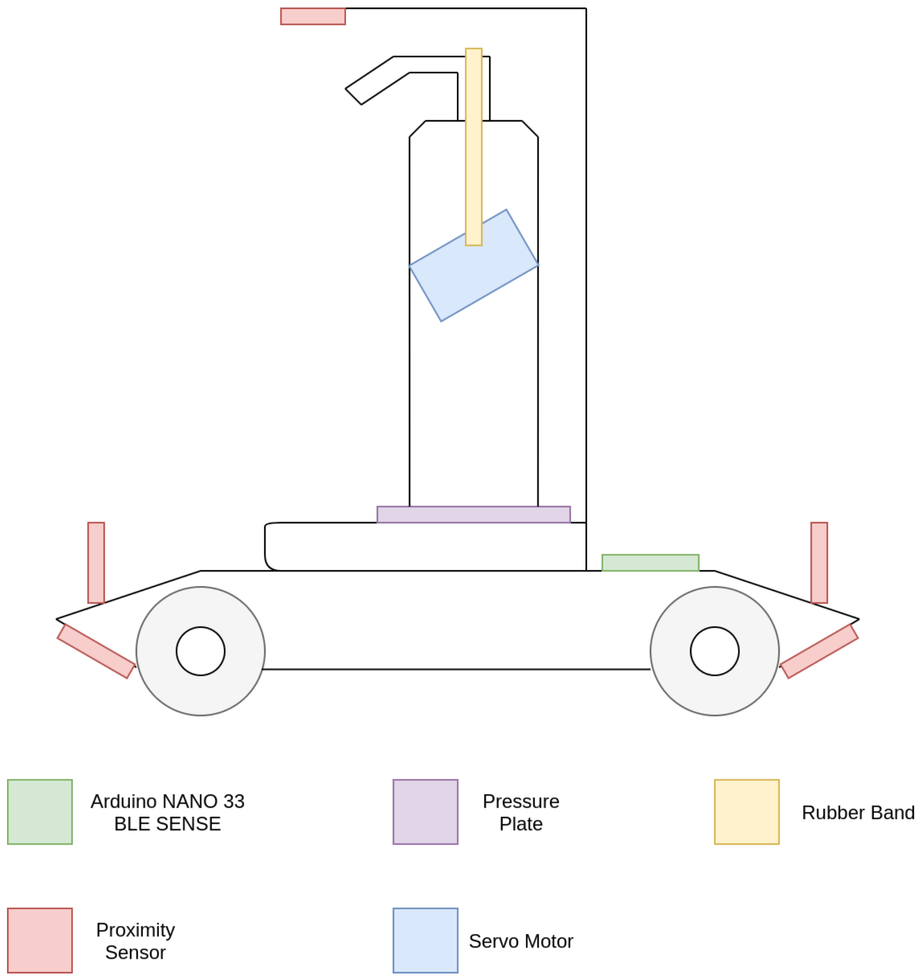


Figure 2: Prototype drawing of our vehicle

References

[1] Ada_Drivers_Library, github.com. https://github.com/AdaCore/Ada_Drivers_Library. Accessed: October-20.

[2] Arduino Nano 33 BLE Sense, arduino.cc. https://store.arduino.cc/arduino-nano-33-ble-sense-with-headers. Accessed: October-20.

[3] bb-runtimes, github.com. https://github.com/AdaCore/bb-runtimes. Accessed: October-20.

[4] JLink Arduino Nano setup, segger.com. https://wiki.segger.com/Arduino_Nano_33_IOT. Accessed: October-20.

[5] turnigy trooper, hobbyking.com. https://hobbyking.com/en_us/turnigy-trooper-sct-4x4-1-10-brushless-short-course-truck-arr.html?___store=en_u. Accessed: October-20.

[6] Alan Burns and Andy Wellins. *Analysable Real-Time Systems, Programmed in Ada*. Createspace Independent Publishing Platform, 2009.

[7] Henning Gundersen. DSA3102 slides, canvas. https://usn.instructure.com/courses/22239/files. Accessed: October-20.

[8] Nordic Semiconductors. *nRF52840*, 2 2009. v1.1.

5 Maybe appendix

5.1 Stacktrace

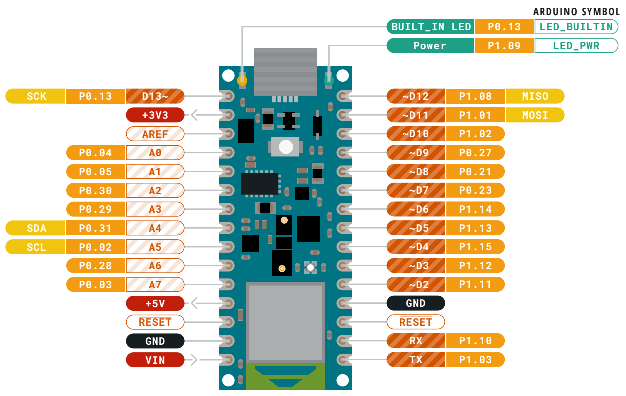
```
# -*- asm -*- #############################
# Automatically generated by SVD2Ada
# For the nRF52840 reference description for radio MCU with ARM 32-bit
    Cortex-M4 Microcontroller target
############################################

   .syntax unified
   .cpu cortex-m4
   .thumb

   .text
   .globl __vectors
   .p2align 8
__vectors:
   /* Cortex-M core interrupts */
   .word  0                  /* stack top address */
   .word  fault              /* 1 Reset. */
   .word  fault              /* 2 NMI. */
   .word  fault              /* 3 Hard fault. */
   .word  fault              /* 4 Mem manage. */
   .word  fault              /* 5 Bus fault. */
   .word  fault              /* 6 Usage fault. */
   .word  fault              /* 7 reserved. */
   .word  fault              /* 8 reserved. */
   .word  fault              /* 9 reserved. */
   .word  fault              /* 10 reserved. */
   .word  __gnat_sv_call_trap /* 11 SVCall. */
   .word  __gnat_bkpt_trap   /* 12 Breakpoint. */
   .word  fault              /* 13 reserved. */
   .word  __gnat_pend_sv_trap /* 14 PendSV. */
   .word  __gnat_sys_tick_trap /* 15 Systick. */
   /* MCU interrupts */
   .word __gnat_irq_trap     /* 16 POWER_CLOCK */
   .word __gnat_irq_trap     /* 17 RADIO */
   .word __gnat_irq_trap     /* 18 UARTE0_UART0 */
   .word __gnat_irq_trap     /* 19 SPIM0_SPIS0_TWIM0_TWIS0_SPI0_TWI0 */
   .word __gnat_irq_trap     /* 20 SPIM1_SPIS1_TWIM1_TWIS1_SPI1_TWI1 */
   .word __gnat_irq_trap     /* 21 NFCT */
   .word __gnat_irq_trap     /* 22 GPIOTE */
   .word __gnat_irq_trap     /* 23 SAADC */
   .word __gnat_irq_trap     /* 24 TIMER0 */
   .word __gnat_irq_trap     /* 25 TIMER1 */
   .word __gnat_irq_trap     /* 26 TIMER2 */
   .word __gnat_irq_trap     /* 27 RTC0 */
   .word __gnat_irq_trap     /* 28 TEMP */
   .word __gnat_irq_trap     /* 29 RNG */
   .word __gnat_irq_trap     /* 30 ECB */
   .word __gnat_irq_trap     /* 31 CCM_AAR */
   .word __gnat_irq_trap     /* 32 WDT */
   .word __gnat_irq_trap     /* 33 RTC1 */
   .word __gnat_irq_trap     /* 34 QDEC */
   .word __gnat_irq_trap     /* 35 COMP_LPCOMP */
   .word __gnat_irq_trap     /* 36 SWI0_EGU0 */
   .word __gnat_irq_trap     /* 37 SWI1_EGU1 */
   .word __gnat_irq_trap     /* 38 SWI2_EGU2 */
   .word __gnat_irq_trap     /* 39 SWI3_EGU3 */
   .word __gnat_irq_trap     /* 40 SWI4_EGU4 */
   .word __gnat_irq_trap     /* 41 SWI5_EGU5 */
   .word __gnat_irq_trap     /* 42 TIMER3 */
   .word __gnat_irq_trap     /* 43 TIMER4 */
   .word __gnat_irq_trap     /* 44 PWM0 */
   .word __gnat_irq_trap     /* 45 PDM */
   .word __gnat_irq_trap     /* 46 IRQ 30. */
   .word __gnat_irq_trap     /* 47 IRQ 31. */
   .word __gnat_irq_trap     /* 48 MWU */
   .word __gnat_irq_trap     /* 49 PWM1 */
   .word __gnat_irq_trap     /* 50 PWM2 */
   .word __gnat_irq_trap     /* 51 SPIM2_SPIS2_SPI2 */
   .word __gnat_irq_trap     /* 52 RTC2 */
   .word __gnat_irq_trap     /* 53 I2S */
   .word __gnat_irq_trap     /* 54 FPU */
   .word __gnat_irq_trap     /* 55 USBD */
   .word __gnat_irq_trap     /* 56 UARTE1 */
   .word __gnat_irq_trap     /* 57 QSPI */
   .word __gnat_irq_trap     /* 58 CRYPTOCELL */
   .word __gnat_irq_trap     /* 59 IRQ 43. */
   .word __gnat_irq_trap     /* 60 IRQ 44. */
   .word __gnat_irq_trap     /* 61 PWM3 */
   .word __gnat_irq_trap     /* 62 IRQ 46. */
   .word __gnat_irq_trap     /* 63 SPIM3 */

   .text

   .thumb_func
.weak __gnat_irq_trap
.type __gnat_irq_trap, %function
__gnat_irq_trap:
0: b 0b
   .size __gnat_irq_trap, . - __gnat_irq_trap

   .thumb_func
.weak __gnat_sv_call_trap
.type __gnat_sv_call_trap, %function
__gnat_sv_call_trap:
0: b 0b
```

```
   .size __gnat_sv_call_trap, . - __gnat_sv_call_trap

   .thumb_func
.weak __gnat_pend_sv_trap
.type __gnat_pend_sv_trap, %function
__gnat_pend_sv_trap:
0: b 0b
   .size __gnat_pend_sv_trap, . - __gnat_pend_sv_trap

   .thumb_func
.weak __gnat_sys_tick_trap
.type __gnat_sys_tick_trap, %function
__gnat_sys_tick_trap:
0: b 0b
   .size __gnat_sys_tick_trap, . - __gnat_sys_tick_trap

   .thumb_func
fault:  b fault
```

5.2 Arduino Nano 33 BLE sense PIN layout

ARDUINO

ARDUINO
NANO 33 BLE SENSE
STORE.ARDUINO.CC/NANO-33-BLE-SENSE



- ■ Ground
- 🟥 Power
- 🟩 LED
- ■ Internal Pin
- ■ SWD Pin
- ▨ Digital Pin
- ▨ Analog Pin
- □ Other Pin
- 🟧 Microcontroller's Port
- 🟨 Default

⚠ **MAXIMUM** ouput current per pin is 15mA

⚠ **MAXIMUM** input current per pin is 5mA

⚠ **MAXIMUM** external current is 25mA for the sum of all GPIO currents and the current being drawn from VDD

VIN 5-21 V input to the board.

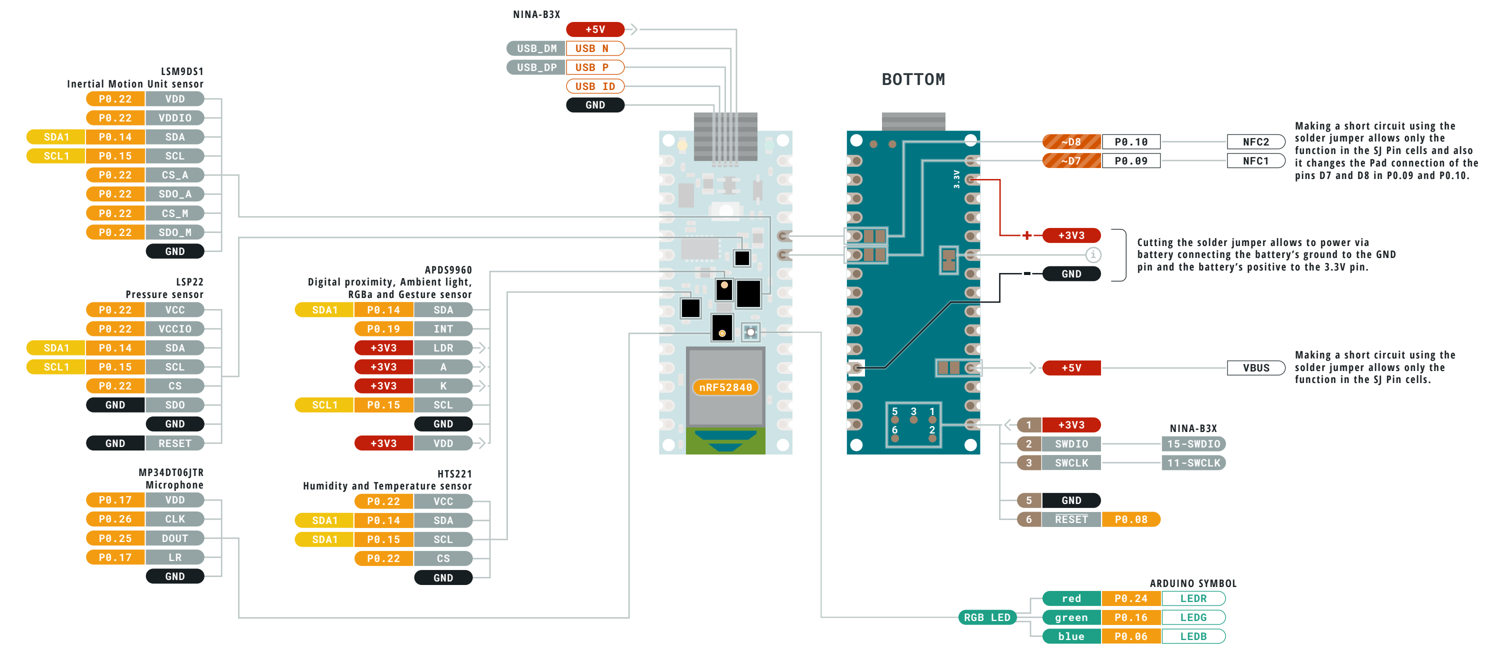
ARDUINO.CC

Last update: 16/09/2020

5.3 Arduino Nano 33 BLE sense PIN layout

ARDUINO

ARDUINO
NANO 33 BLE SENSE
STORE.ARDUINO.CC/NANO-33-BLE-SENSE



■ Ground	▨ Digital Pin	☐ SJ Pin Making a short circuit using the solder jumper allows only the function in the SJ Pin cells.
🟥 Power	▨ Analog Pin	
🟩 LED	☐ Other Pin	
■ Internal Pin	🟧 Microcontroller's Port	
🟫 SWD Pin	🟨 Default	

⚠ **MAXIMUM** ouput current per pin is 15mA

⚠ **MAXIMUM** input current per pin is 5mA

⚠ **MAXIMUM** external current is 25mA for the sum of all GPIO currents and the current being drawn from VDD

VIN 5-21 V input to the board.

ARDUINO.CC

Last update: 16/09/2020