NEUROON OPEN : Inteliclinic Fully Nonconfidental Product Documentation

NEUROON

OPEN

DOCUMENTATION

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in case of technical questions: l.majewski@inteliclinic.com

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Hello!

We are glad you are here! Please enjoy the Neuroon Open.

In case of any technical help or suggestions we will put our best effort to help you.

For more information please visit our community webpage.

Have a nice day,

Inteliclinic team.

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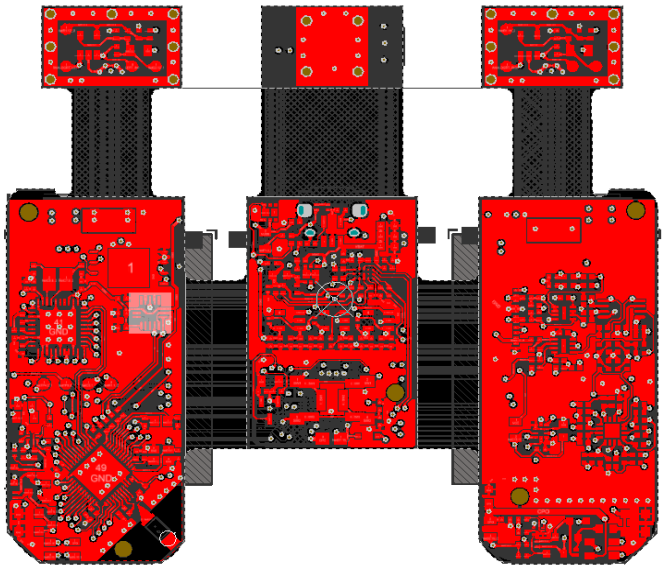
Movement Sensor (LIS3DH)

Functionality description:



LIS3DH is MEMS (Micro Electro Mechanical Sensor) ultra-low-power high-performance 3-axis "nano" accelerometer. In NEUROON it is used to detect motion, its duration and intensivity, what is used for wake-up tracking. Remember that head movement usually implies strong muscule signals which may influence the EEG measurement (muscle signals may be even 1000 times stronger than EEG) and sometimes its good to know that disturbances may be a result of movement.

Movement sensor play key role in power management. Using its readings it is possible to put microprocessor to sllep mode and wake it up in most proper time.

For further application it is possible to use it to measure the position of the forehead, however it may be necessary to apply calibration algorithm.

Producent note aviable here:
http://www.st.com/content/ccc/resource/technical/document/datasheet/3c/ae/50/85/d6/b1/46/fe/CD00274221.pdf/files/CD00274221.pdf/jcr:content/translations/en.CD00274221.pdf

Features:

- 16-bit data output
  - 12-bit in hi-resolution,
  - 10-bit in Normal resolution,
  - 8-bit in Low-powe mode
- I2C interface
- free-fall interrupt generator
- motion detection interrupt generator
- output data rate from 1 Hz to 5.3 kHz
- integrated 32-level FIFO buffer

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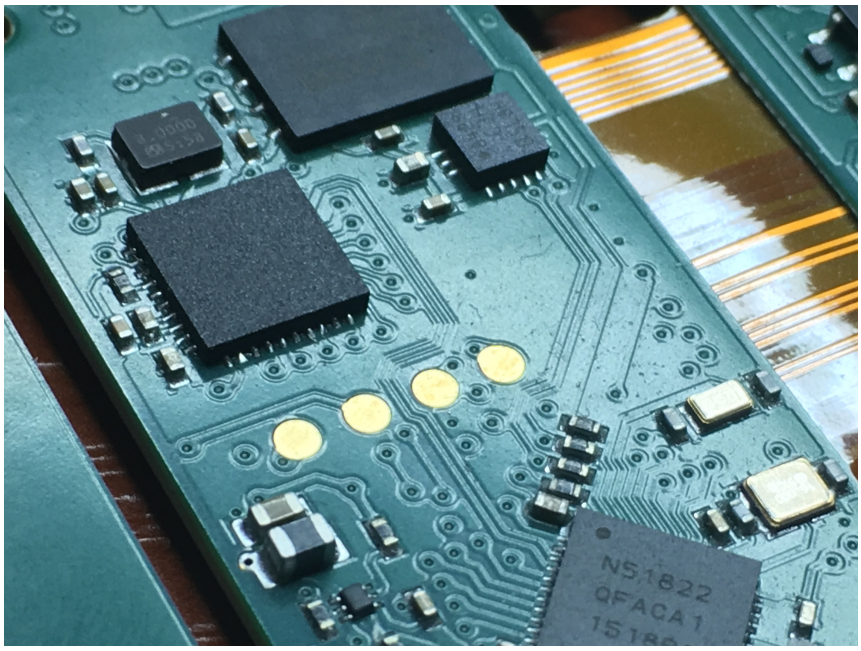
Module placement:

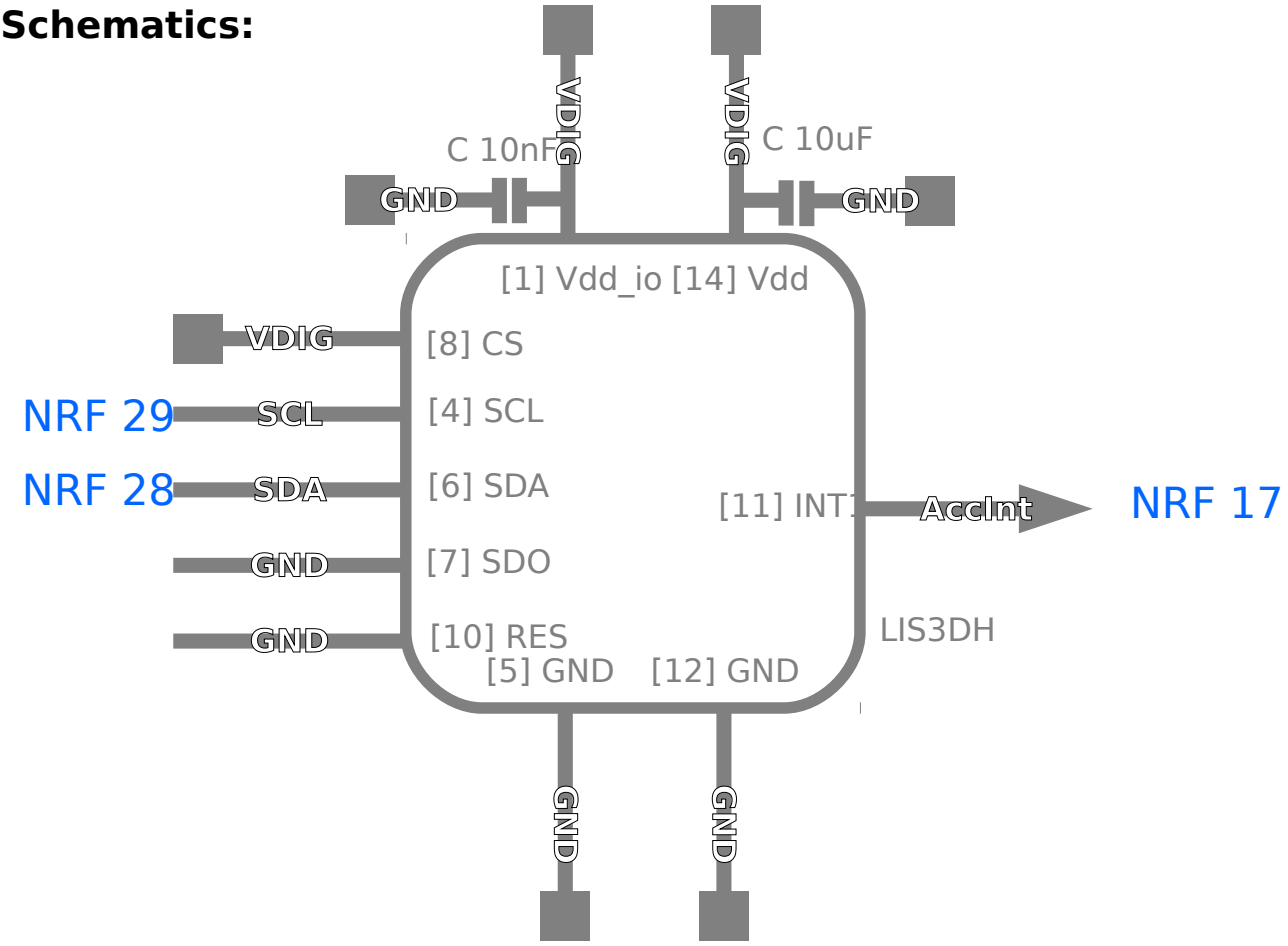


LIS3DH module is placed just below Flash memory on the same board as Nordic N51822 SoC.

Hardware connection

function	pin name	LIS3DH	N51822
I2C	CS	8	VDIG
	SDO	7	GND
	SDA	6	28
	SCL	4	29
interrupt	INT1	11	17

Schematics:



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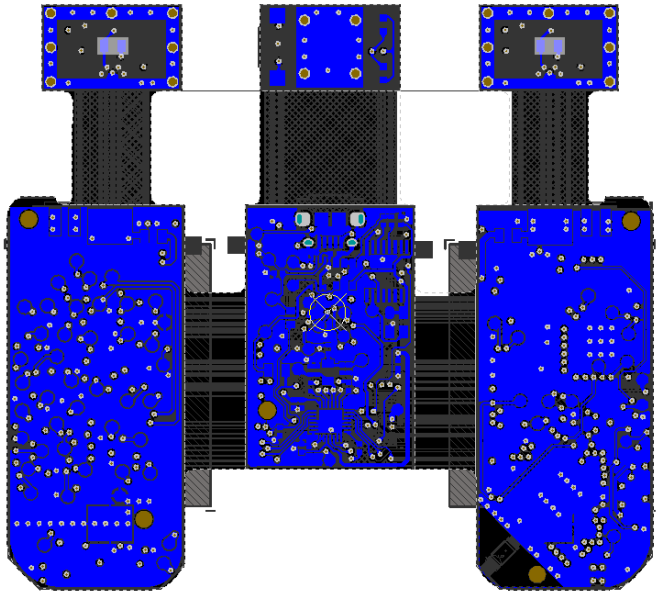
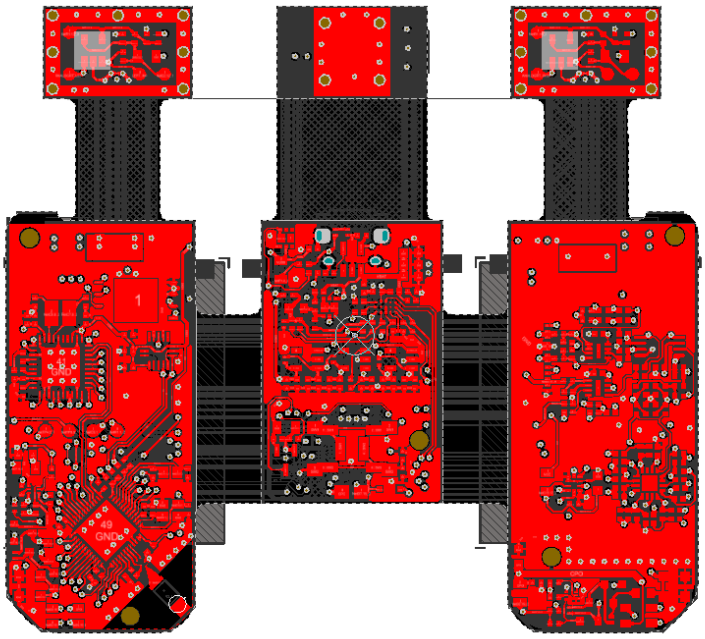
Temperature Sensors





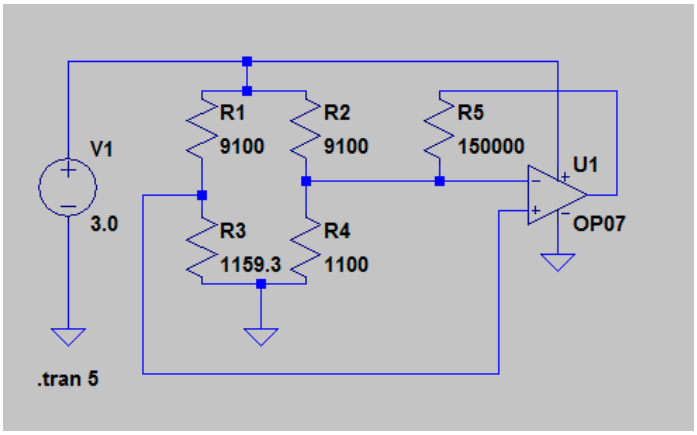
Neuroon has two independent themperature sensors. Each of them works as independent uncompensated Wheatsone bridge with platinium thermistor PT1000.

PT1000 is placed on bottom layer on separate PCB.

PT1000 is very precise and linear thermistor.

Temperature sensors are connencted to ADC in NRF SoC

Temperature sensor can be easily simulated in LTSpice like program:



As you may see, in our bridge we used two resistances: 9.1kΩ and 1.1kΩ. It simply means that measurement bridge is in equilibrium when left and right branch has the same resistance. Equilibrium means that the voltage difference between measurement points placed in each branch is equal almost zero. PT1000 has 1.1kΩ resistance in 26 Celsius degrees, what means that our bridge starts to measure temperature when is higher than 26 Celsius degrees.

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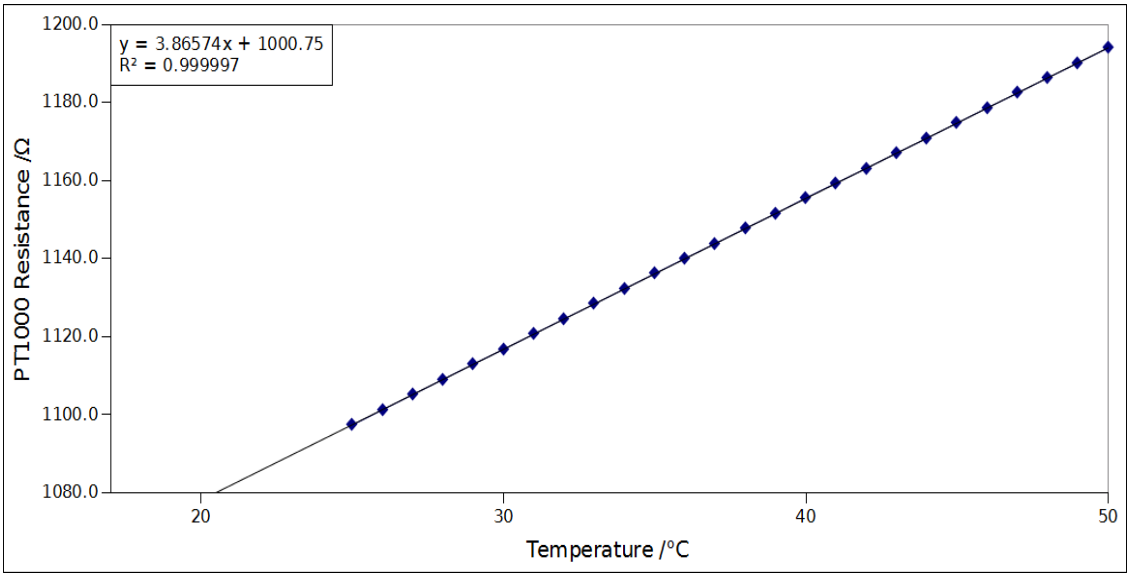
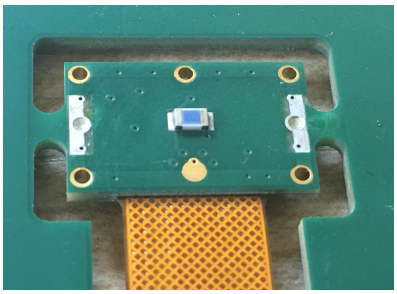
Finally the voltage signal (from range 0V up to 3V) enters **10bit Analog to Digital Converter in N51822 SoC.** That simply means that ADC reference has 2 to power 10 (210=1024) voltage levels.Possible references are 1V, 2V, 3V.

Reference voltage	1V	2V	3V
Quantisation levels	1023 (starting from 0)		
Single quant size	1V/1023=**0.0009775V**	**0.0019550 V**	**0.002932 V**

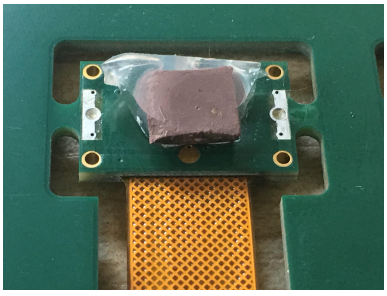
Small voltage quants make our thermometer really vulnerable to very small changes in temperature. The highest sensitivity is reached for 1V and 2V reference. Neuroon Open simply changes ADC reference to higher (or lower) depending on reading.



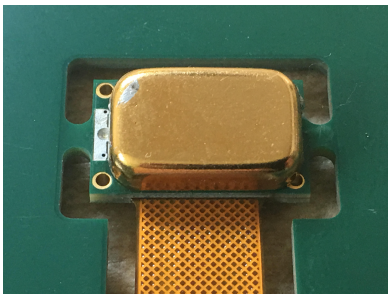
Temperature sensor heat transfer design:



[1]Bare PT1000



[2]Thermal grease



[3]Gold covered electrode

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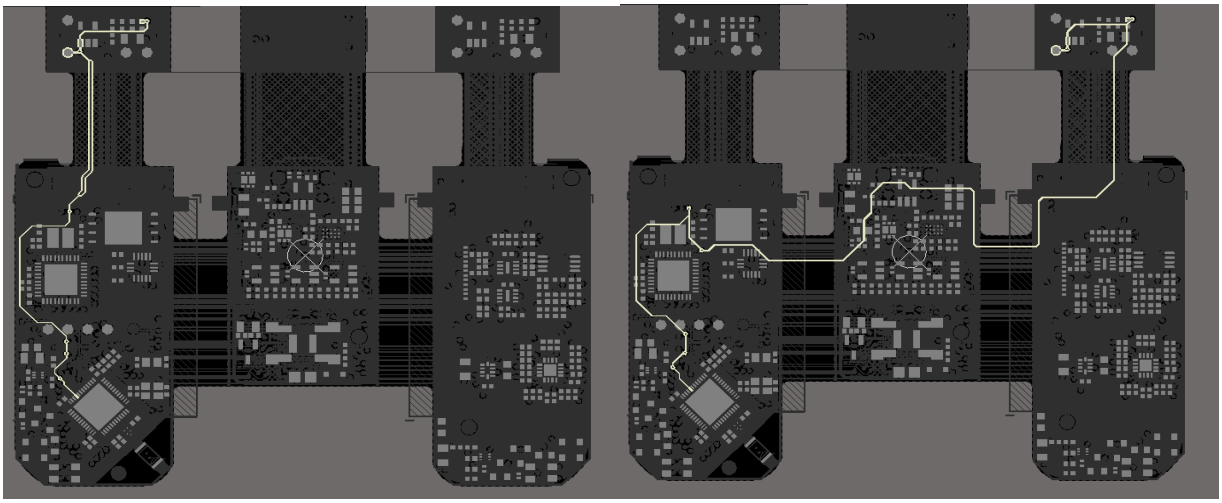
To avoid allergic skin reactions electrode is covered with thin gold layer. Electrodes are used for both: electrical signal measurements and temperature sensing. To measure the temperature accurately the distance between temperature sensor and electrode isfilled with thermal grease.

Functionality description:

Humans are homeotherms, that means they regulate precisely their inner body’s temperature. The day-night cycle is regulated by suprachiasmatic nucleus (SCN) located in the same region of the hypothalamus, where “cold” and “hot” reception is integrated, creates a balanced output, like a thermostat. It's no coincidence. Every cell of the mammalian body uses internal circadian oscillators to govern their circadian pattern of gene expression, which is crucial to metabolic activity control. These cellular oscillators are controlled by core body temperature.

Because the temperature might vary due to different reasons, like fever or poor environmental conditions, it is crucial to gather other clinical data before making any assumptions concerning one’s health. Changes in core body temperature might be connected to the disturbed circadian rhythm, as observed in high fever, autoimmune diseases. Unfavorable conditions like hot and moist environment might disturb your sleep.

Hardware connections **Amplifier to ADC** displayed below.



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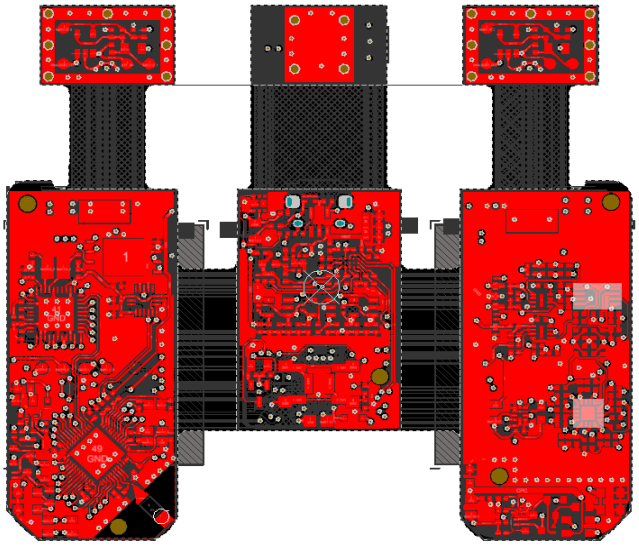
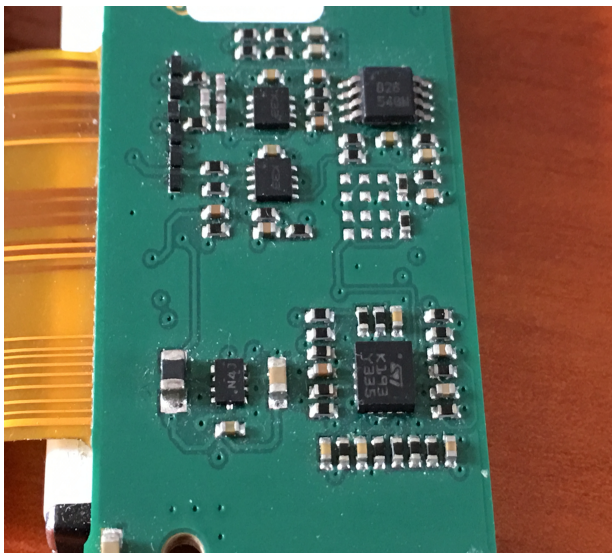
Biologigal signal amplifier



Biological amplifier circuit plays crutial role. It is responsible for taking measurements of EEG (Electroencefalography) and EMG (Electromyography), due to that fact it need to perform proper signal conditioning. Since the EEG signals are relatively weak (in comparison to muscle signals or noice signals) proper filtration is necessary. Amplification is realised by active, 4-th order low-pass filter. Analogue circuit is placed on separated PCB. Biological amplifier is realised using



Features:

- virtual ground feature
- impedance control circuit (may be used for electrode-skin contact detection and skin hydration sensing)
- EEG adjusted amplifier
- EMG adjusted amplifier
- Notch filter (cancels strong EM components that comes from electrical network)
- active 4-th order lo-pass filter

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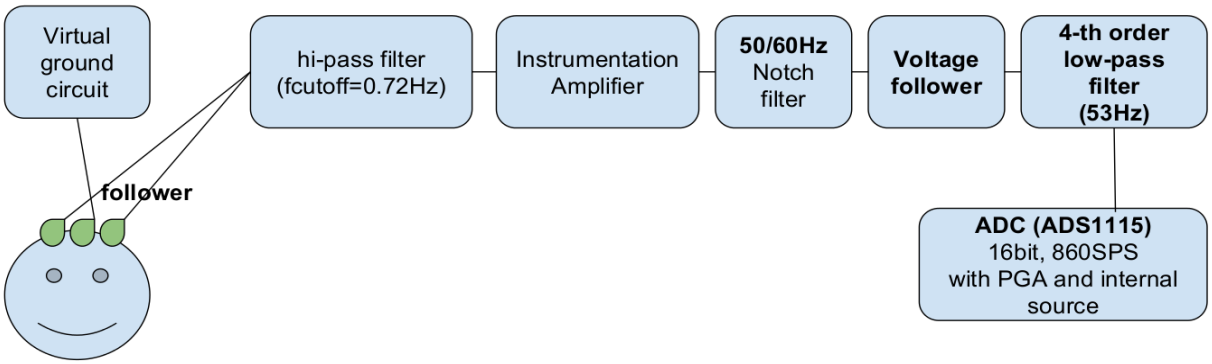
- hi pass filter (f=0.72Hz) removes slow electric signals that
- 16bit ADC (ADS1115) 860SPS with internal reference

Schematic diagram



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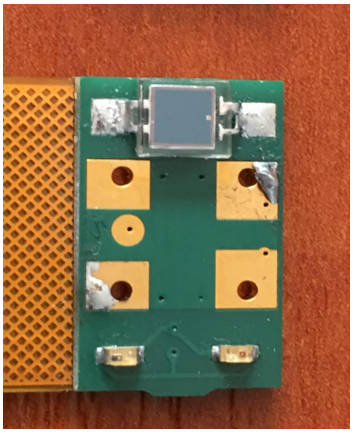
Pulse oximeter module

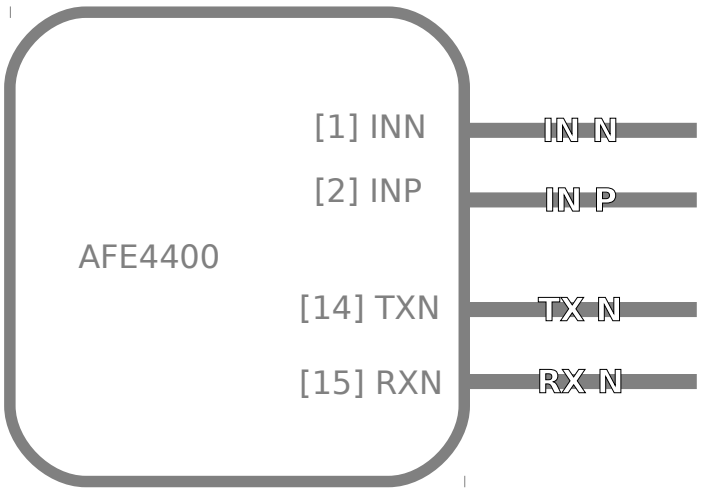
Pulse oximeter is realised on separated PCB. It is composed of two LEDs: red and infrared and photodiode. Puls oximeter sensor is connected to AFE4400 input. AFE4400 is an analog front end for heartrate monitors and low cost pulde oximeters



Features:

- pulse measurement
- monitoribng of oxygen in blod (ususally 92% or less is considered ad low level, more than 95% as normal)
- may be used for apnea detection
- integrated LED driver (H-bridge)
- low power
- 13 noice-free bits
- uses SPI Interface

AFE 4400



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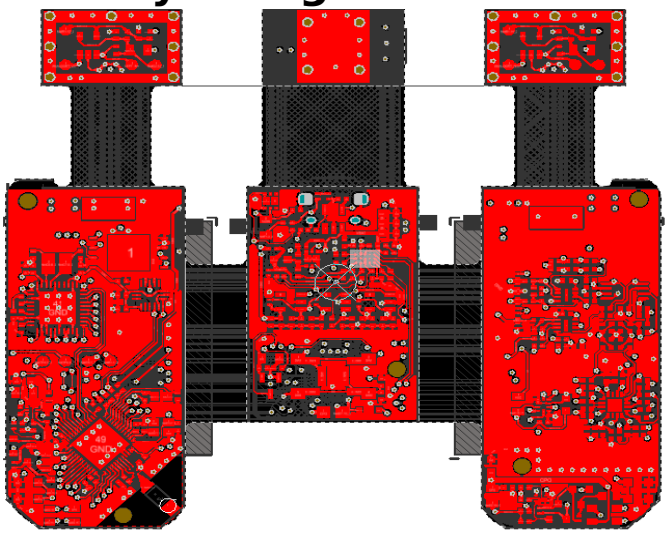
Power management and battery charger

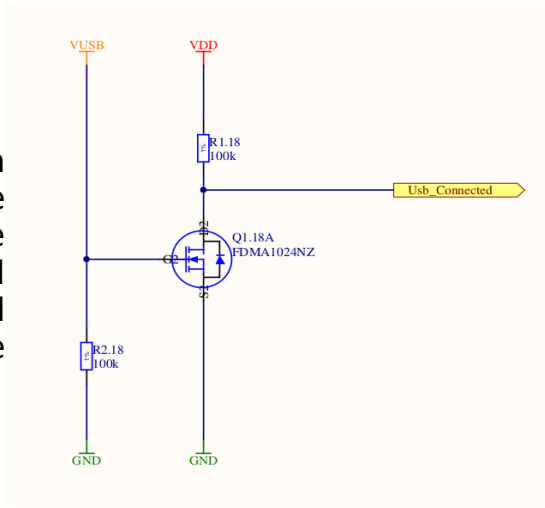


Power management is realised using following modules:

- BQ27742 used for battery protection
- two STLQ015M30R used for power distribution
- STC4054GR as battery charger
- STLQ015M30R as LDO
- fuses and thermistors

For user safety batteries are packed into special metal covers. Each battery pack has overheat thermistor attached directly to the cover.

Using USB_CONNECTED pin of NRF you may decide if the device should operate when the USB is attached. We recommend to use USB only for charging and disable normal operation while charging.



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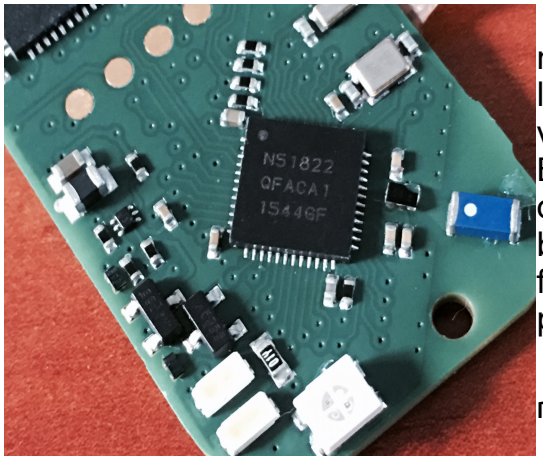
System-on-chip NRF



NRF 51822 is system-on-chip that performs many functionalities. It control all pherypheria, like: battery manager, FLASH memory, LED and vibrator driver, but also realises BlueTooth Low Energy (thats why blue antenna is connected so closely to it). The nRF51822 is built around a 32-bit ARM® Cortex™ M0 CPU with 256kB/128kB flash + 32kB/16kB RAM for improved application performance.

NRF is responisble for saving data on FLASH memory placed just below.

Features:

- 32-bit ARM® Cortex™ M0 CPU with 256kB/128kB flash + 32kB/16kB RAM
- responsible for BLE (Bluetooth Low Energy) communication
- responsible for LEDs and vibrator management
- communicte with external ADC
- its internal ADC is connected with temperature analog front end
- responsible for collecting data from movement sensor

NRF	function
SPI	
23	MOSI
22	MISO
6	SCKL
I2C	
29	SCL
28	SDA
UART	
19	Rx
20	Tx

NRF communication interfaces pinout

NRF	function
AFE	
2	CS
10	PDN
30	Reset
0	ADC_RDY

AFE Diag	
9	DIAG_END
8	LED_ALM
7	PD_ALM
21	CLKOUT

NRF AFE pinout

NRF	function
Temperature	
4	AnalogR
5	AnalogL
Electrode test	
3	Test E1
1	Test E2
14	Test Gen

NRF peripheria pinout

NRF	function
Flash	
13	Flash CS
18	FlashHold
PowerDistrib	
15	AnalogON
16	DigitalON
other	
25	LEDS ON
24	DIRECT ON
11	USB CONNECTED
17	ACC INT
12	POWER BUTTON