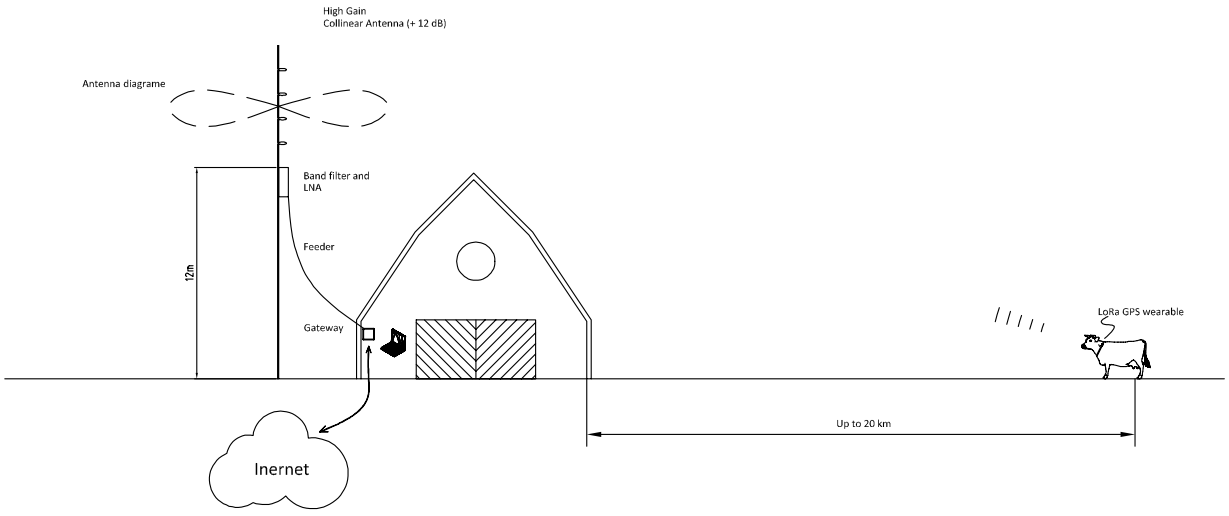
Preliminary design of wearable sensors and ad hock network for tracking and monitoring of domestic animals.

Terms of reference

The network should provide Internet connectivity of plurality of wearable sensors to via at least one gateway in robust, cost-effective way. The system should be independent from third party networks. Single point internet connectivity is required. The internet based server side software and user interface is not considered.

The overall cost of using the system per animal per year is the key design criterion. Any additional sensor or data that not add value for the customer should be avoided. The system should be operational even without internet connection.

- Technology used
  - RF link – Semtech™ LoRa SX1276/78
  - Microcontroller - ATmega 328 with Arduino bootloader
  - Basic sensors
    - GPS module
    - Body temperature sensor
    - Movement activity (accelerometer)
    - Anti-tamper switch
  - Auxiliary sensors and extensions
    - RFID reader -
    - Expansion/programming bus SPI/I2C
    - RFID thermometer - mlx90129
  - Gateway – single channel gateway SX1276/8 based



Cattle wearable tracker/monitor – Genial Arrangement

Design philosophy

The operation of the system is based on specific use of LoRa™ Long Range Spread Spectrum Communication. A one-way communication is used. The sensor nodes transmit data in 900 sec (15 min) frame length. A modification of Self Organized Time Division Multiple Access (SOTDMA) communication scheme is used. The time slots synchronization used GPS timing. Up to 1000 nodes is possible. The gateway works in receive-only mode. The receive-only mode allow high gain antenna without regulatory ERP requirements violation.

A single channel, low cost LoRa gateway will be used. The network has generally star type topology. More than one networks gateway is possible and duplication messages will be resolved by server side software. Encryption scheme is used for privacy protection and the nodes identification. Neighbor networks (i. g. neighbor farms) should use different channels to avoid crosstalk in a manner similar to cellular networks. The internet connection is not absolutely necessary for proper operation of the system. The gateway will be connected to local computer or smart mobile deice.

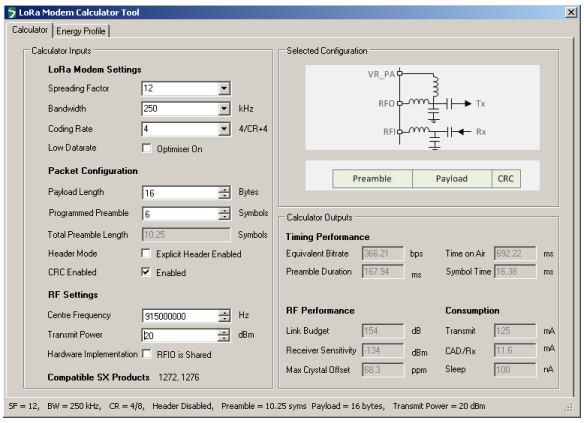
The power budget analysis shows that the limiting factor for battery life will be the GPS receiver consumption. The use of new generation ultra-low power GNSS modules may enhance battery life to one year without solar recharging.

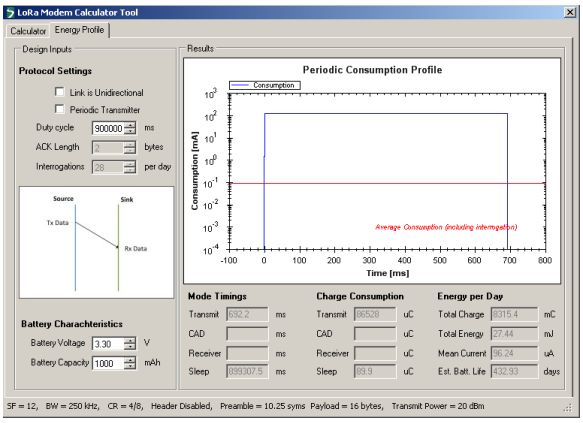
The data processing will follow early processing principle in contrast of general trend to collect large amount of raw information. For example embedded processor will recognize movement patterns associated with particular behavior instead to monitor continuously the animal's movement.

Radio link considerations

LoRa link range has been reported to exceed 20 kilometers at line of sight. In conditions that are more realistic it could be significantly lower. A 12 dB simple collinear antenna will potentially quadruple the range.

The short-range devices are low-power transmitters typically limited to 25–100 mW effective radiated power (ERP) or less and a high gain antenna may be used on receiver side only. The gateway use a high gain, revisiting-only antenna to achieve better coverage and to keep emitted RF power within regulatory limits.





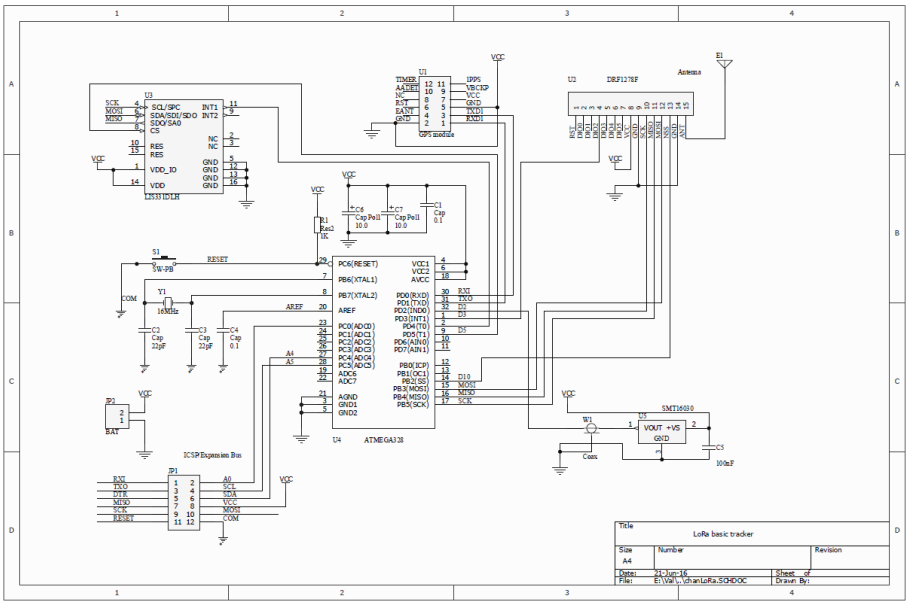
Link budget and Power consumption estimation.

Hardware

The basic tracker module is designed as simple as possible with option for functional upgrade by expansion bus. The basic module not includes RFID reader to keep the system and its operational maintenance as possible simple. The animal body temperature is measured by 3-wire sensor fixed in the animal ear by a standard ear clips tag with a little modification. The movement activity patterns will detected by embedded 3-axis accelerometer.

The expansion module may include high power VHF 13 MHz RFID transceiver (standard one have range <1 m), large log memory, pulse and breeding sensors etc.

All electronics is potted in polyurethane-compound. The collar attachment is aluminum plate and serve as antenna ground plane. The antenna is integrated in the collar. The firmware is updated over-the-air using high data rate FSK mode of SX1276/78. The same mode will be used for mass storage memory dumping.



Draft of basic tracker schematics. The power management circuitry is not shown.

Localization and Regulatory requirements

Spectrum allocations for sub-gigahertz diapason vary not only for UTU zones but also from country to country. The 915 MHz band is available for region 1. Long-range network with a single gateway is possible in flat rural areas of Americas – Pampas.

Cost estimation

The basic tracer module production cost based on components costs and PCB manufacturing and assembly costs (here in Sofia) is under $35 for battery operated (1 Y) and $ 50 for solar powered at 100. The base station - gateway antenna, mast and feeder may cost under $1000 using third party antenna pole and in-house electronics. The cost estimation not includes design, programming and management.

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