Radiocrafts
Embedded Wireless Solutions

Welcome!
Webinar will start in a moment . . .

Radiocrafts

Wireless solution for hard-to-reach places
2019-06-20

Wireless solution for hard-to-reach places
Webinar, 2019-06-20

- Presenter: Peder Martin Evjen, Managing Director
- Organizer: Omar Khalil, Technical Support

House-keeping

- The seminar today is scheduled for 40 minutes with a 10-15 minutes Q&A afterwards.
- Post your questions in the chat window during the seminar, and we will answer as good as we can in the Q&A session.
- We will post a recorded version of the webinar on our website after the webinar, if you want to go back and see it again.

Wireless solution for hard-to-reach places

- Smart Metering
  Smart City
  Industrial IoT
  -all can make a challenge for wireless communication to hard-to-reach places
- Sensors, actuators and different type of devices may be located in
  -basements
  -deep inside buildings
  -in steel cabinets or behind concrete walls
  -in pits, in tunnels, under ground
- Today we will looking into radio technologies that helps us reach where the sun does not shine!

Main takeaways from this webinar

- Comparison of the radio coverage of 169, 433 and 868 MHz in real-life installations
- Examples of using 169 MHz under ground, and under ice!
- Wireless systems based on 169 MHz:
  Wireless M-Bus mode N
  Wize protocol

What determines the radio range

- Range is given by some key parameters
  - ERP (effective radiated power) of the transmitter
    - Output power
    - Antenna gain
  - Path loss
    - Distance
    - Frequency
    - Height of devices over terrain
    - Obstructions in the path (reflections, attenuation)
  - External interference
  - Gain in receiving antenna
  - Sensitivity of the receiver

Path loss and frequency

- Free space path loss

$$\text{Free Space Path Loss} = \left(\frac{4\pi df}{c}\right)^2$$

- Path loss for **2 km** at 868 MHz
  = 10km at 169 MHz
- At a specific distance 169 MHz has 14 dB less path loss than 868 MHz
- At lower frequencies the antenna is larger (longer wavelength) and therefore the effective antenna area is larger. More power is captured at the same distance, and the range gets longer!
- **Lower carrier frequency yields longer range due to antenna area**
- What about obstructions in case of hard-to-reach places?

Obstructions, diffraction, attenuation

- Higher frequencies tend to propagate in straight lines (light)
- Lower frequencies tend to diffract (“bend”) more around objects, due to the wave property of light/RF/photons
- Penetration depth into materials increase with wavelength, hence lower frequency penetrate deeper

- 2.45 GHz is the resonance frequency of water, converting radio energy into heat
- It was deemed not usable for satellite communication, hence allocated to “short range communication”

Wireless candidates for IoT

- Low Power Wide Area Network, LPWAN
  - LoRaWAN
  - Sigfox
  - NBIoT, “Narrowband” IoT
- LoRaWAN, Sigfox = 868 / 915 MHz
- NBIoT = typical 700 – 900 MHz (4G), 200 kHz BW
- WiFi, BT, BLE etc using 2.45 GHz and beyond give even shorter range
- Long range and penetration into buildings are not only about maximum link budget, but also about properties of the radio signal, especially the frequency
- They all operate in UHF range, but we know lower frequency (VHF) has better properties for hard-to-reach places

A better solution

- 169 MHz in the VHF frequency band
- Was used for pagers, now open to Smart city, metering, industrial IoT applications
- True narrowband, 12.5 kHz (high sensitivity)
- High Power, 500 mW (high ERP)
- ➔Gives a good link budget (range)
- The “low” RF frequency gives much better range and penetration into hard-to-reach places

Real-life evaluation of 169 / 433 / 868 MHz

- 4 pilot installations done by GRDF in France
- 4-5000 gas meters in each pilot
- Repeaters and gateways

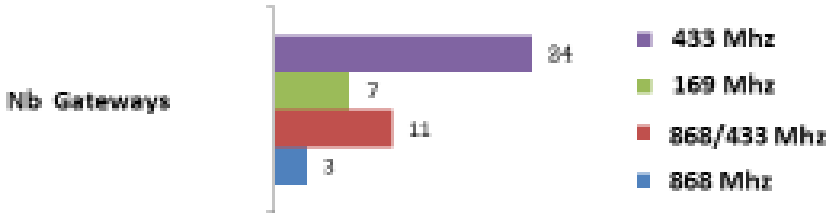
- Main performance criteria: Reading the meter daily

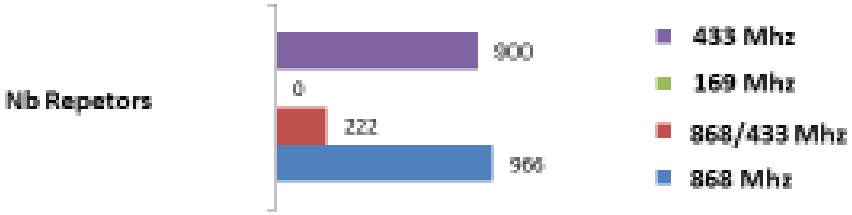
- Number of units failing during the test period
- Reasons for failures

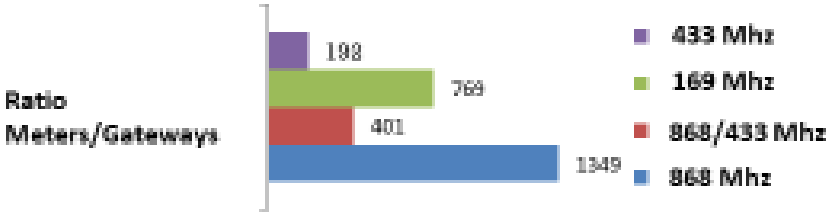
[Source GRDF]

Keys figures

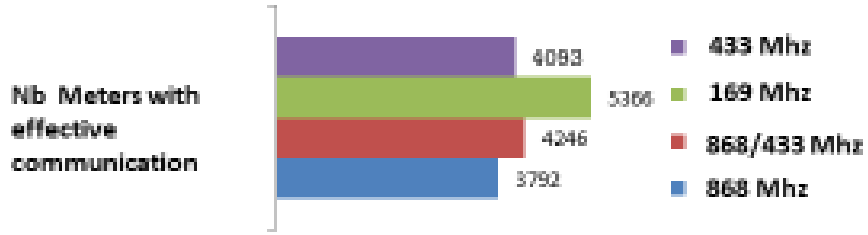
1 Equipements rolled-out

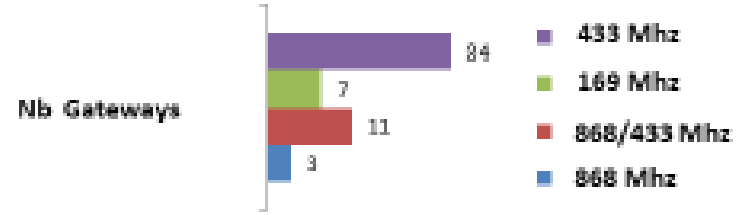


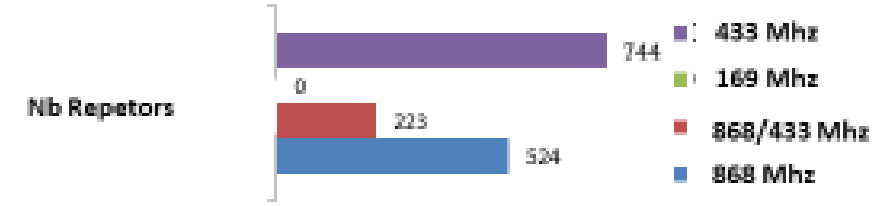


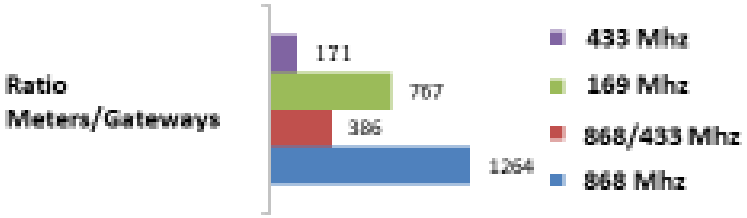


2 Equipements really operationnals after roll-out



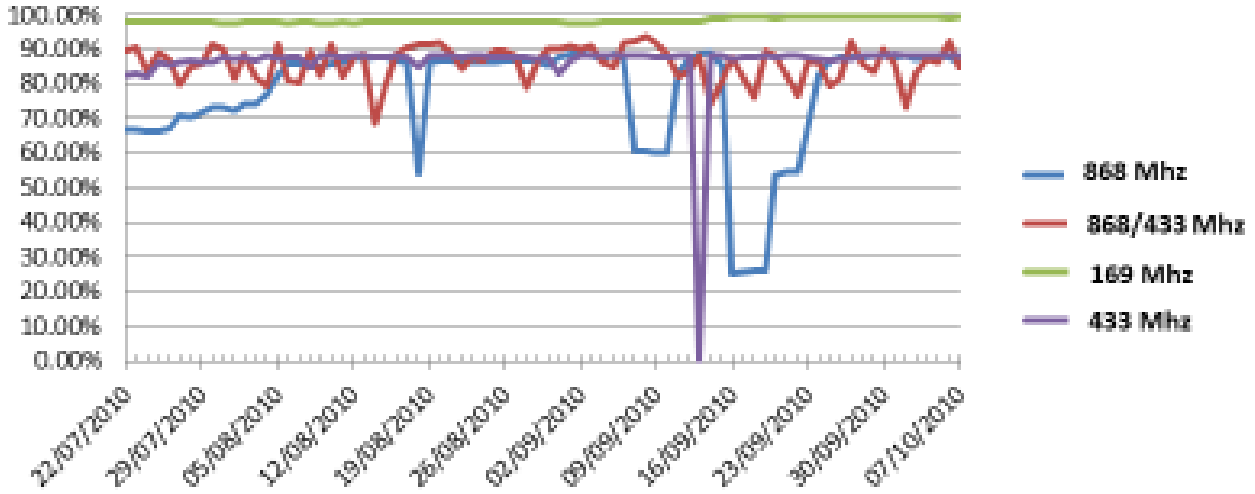






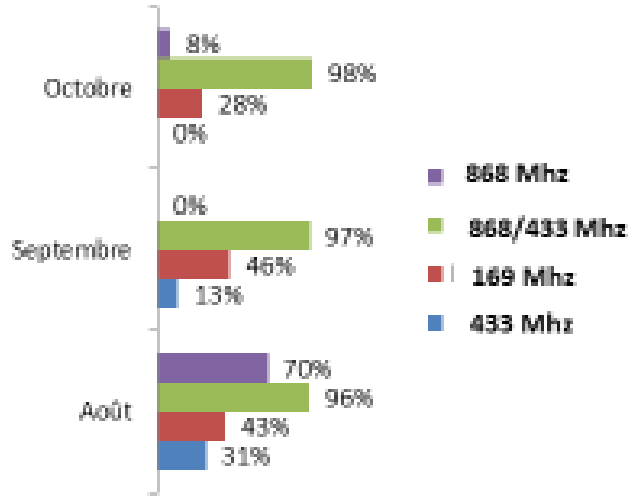
Premiers indicateurs sur le fonctionnement des solutions

3 Daily data read rate

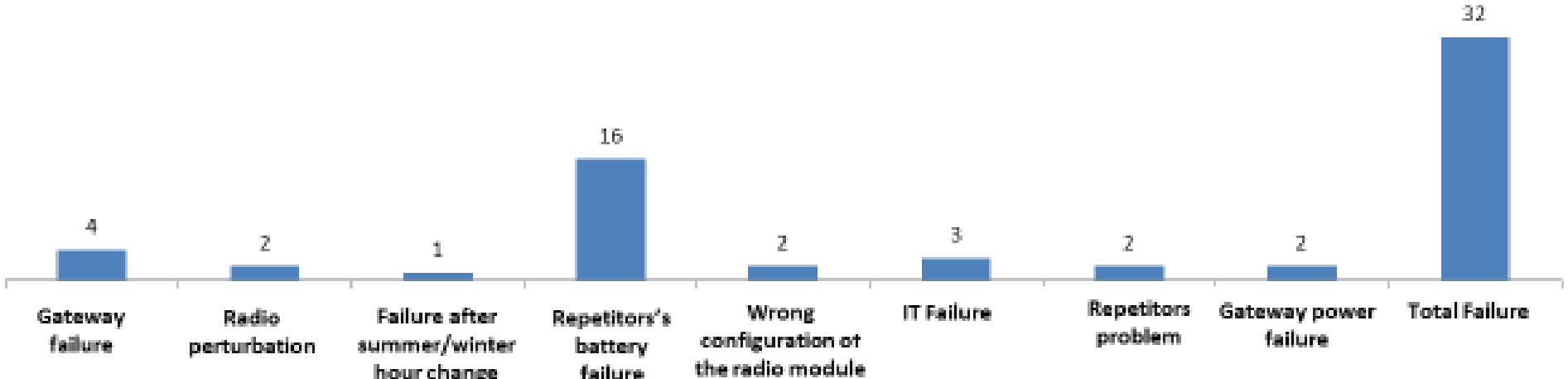


4 Stability

Ratio of meters read each days in a month



5 Majors failures detected during one years (number)



Main conclusion from pilot test

- 169 MHz gives best reliability
  - Range
  - Reaching hard-to-reach gas meters
- No repeaters, hence no failing repeaters
- High meter / gateway ratio

Building Penetration Loss (BPL)

- Comparative study of Building Penetration Loss (BPL)

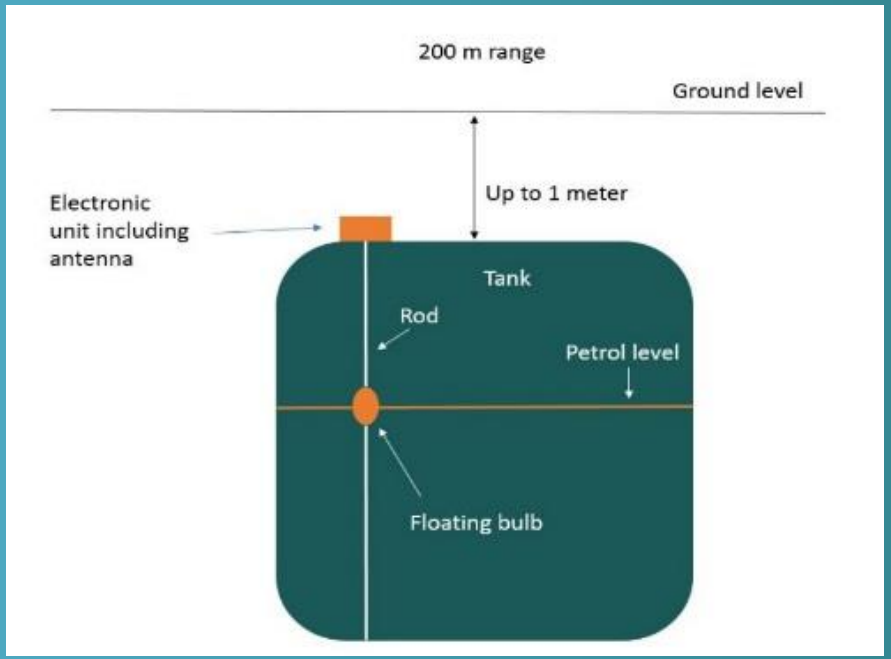
Frequency [MHz]	Avaialable Technology / Standard	Excess loss wrt 169 [dB]	<BPL> [dB]
169	wMBUS	0	7,5
500		9,5	11
800/900	LTE, RFID, GSM, GPRS, NB-IoT, LoRaWAN, Sigfox	14,5	12
2400	WiFi, ZigBee, 802.15.4	23	15
3500	WiMAX	26,3	17

Fuschini, F.; Barbiroli, M.; Corazza, G.E.; Degli-Esposti, V.; Falciasecca, G., "Analysis of Outdoor-to-Indoor Propagation at 169 MHz for Smart Metering Applications," Antennas and Propagation, IEEE Transactions on Antennas and Propagation, vol.63, no.4, pp.1811,1821, April 2015, doi: 10.1109/TAP.2015.2399507;

- **169 MHz will reach deep inside closed rooms (basements) and buried objects (pits)**

Example: Penetration in pit under ground

- Alisonic: Petrol tank sensor for petrol stations
- Sensor and antenna up to 1 meter under ground
- 200 meter range

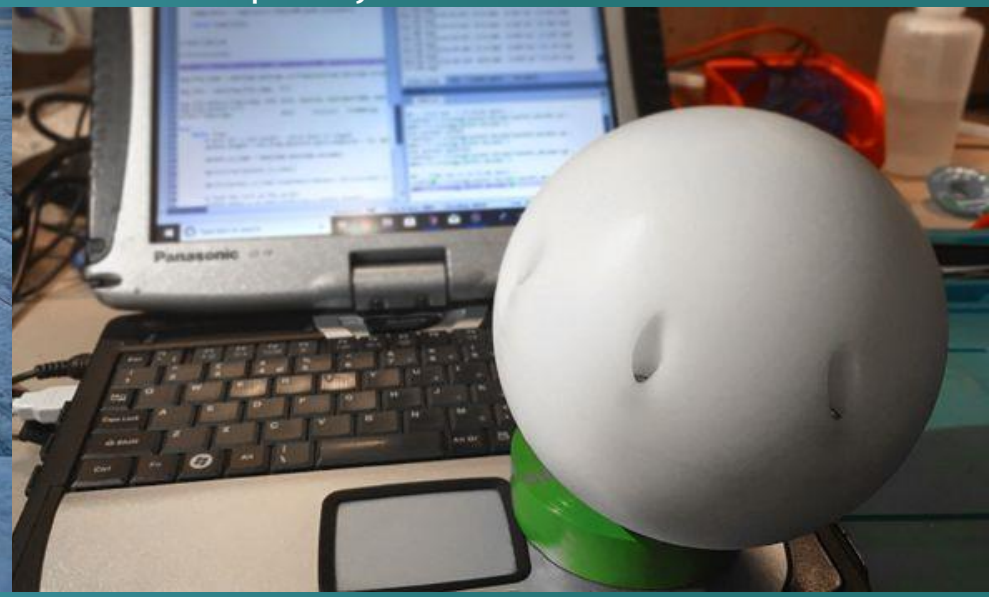


Example: “Cryoegg” to explore under Greenland Ice Sheet

https://www.bbc.com/news/science-environment-48638958

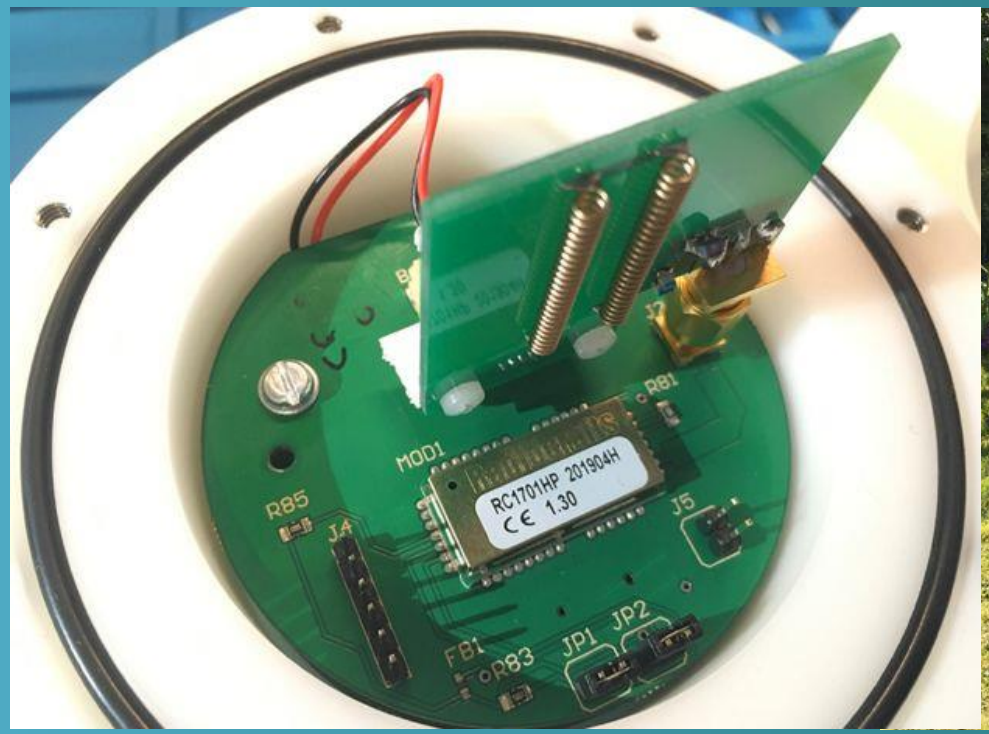
What exactly is a Cryoegg?

It's a 1.2kg, 120mm-diameter sphere. Inside are the electronics for three sensors, to measure water temperature, pressure and conductivity. The egg's compact volume also contains a radio to send its data through the ice, back to the surface. A battery should enable remote working for up to a year. The Cardiff-led team has been developing the concept for a number of years, and it incorporates some fascinating technology choices. The radio system is taken from smart meters that would normally be reporting consumers' gas and electricity usage. This radio's low-frequency transmissions should



Cryoegg

- RC1701HP working at 169 MHz
- 2.5 km-long ice core, how far can they reach?



169 MHz based wireless solutions

- Wireless M-Bus mode N
  - RC1701HP-MBUS4 / MPC1 / MSM
- Wize protocol, based on Wireless M-Bus
  - RC1701HP-WIZE
- RC232, Radiocrafts proprietary point-to-point protocol
  - RC1701HP-RC232
- Tinymesh, proprietary mesh protocol
  - RC1701HP-TM

Main features of Wize (wMB mode N)

- 169 MHz
  - low VHF frequency with good penetration
- Narrowband 12.5 kHz channels
  – small receiver bandwidth makes it more sensitive and selective, less susceptible to interference
- Low data rate (2.4, 4.8, 6.4 kbps)
  – low data rate means transmitting more energy per bit, which gives more range
- High power, 500 mW
  – longer ranger
- **Benefit: Long range, penetrates into buildings**

Relationship between Wize and Wireless M-Bus mode N

- Wize uses PHY of Wireless M-Bus mode N (169 MHz)
- Link layer
  - Introduced a “priority bit” in the C-field
  - Link Layer Address = device address
- Transport/Presentation layer (CI = 20h)
  - Encryption, AES-128-CTR
  - Authentication (on link layer and end-to-end), AES-128-CMAC
- Application layer (L6App)
  - Specific for water (00h) and gas (01h)
  - Generic application layers being defined now
- Two-way communication (only one request/response per cycle)
- Installation with “ping/pong” to select best base station
- Firmware download OTA using broadcast
- White Paper 18: Relationship Between the Wize Protocol and Wireless M-Bus

What the Wize protocol offers

- Robust communication and wide area coverage using VHF band
- Secure transfer of data in terms of privacy, data integrity and authentication
- A low power battery operated solution with lifetime > 15 years
- A proven solution based on the established Wireless M-Bus standard
- Firmware download over-the-air as an integral part of the protocol
- **Benefits: Large coverage, secure, low power and future proof**

Wireless M-Bus / Wize – Sigfox - LoRa

- wMB/Wize is an open standard, no license, no IP fee
  - Sigfox is proprietary, must use their network
  - LoRa is proprietary, only one chip vendor
- wMB/ Wize is narrowband, robust long range
  - Sigfox is also narrowband, but very low data rate / long transmissions
  - LoRa is Chirp modulation (spread spectrum), very low data rate, and less robust with respect to interferers
- wMB/ Wize is 169 MHz, better range and penetration
  - Sigfox is 868 MHz
  - LoRa is 868 MHz
- wMB/ Wize provide FW update OTA
  - Sigfox too low data rate / capacity for download
  - LoRa (at very long range) too low data rate

169 MHz challenges – extra effort with great rewards!

- 169 MHz is a relatively low RF frequency
  - Antennas are larger, more difficult to implement in small devices
- 169 MHz uses high power (TX 500 mW)
  - Needs a super-cap (~1 F) that can delivery high peak current
- 169 MHz has a low data rate (long transmissions ~100 ms)
  - Needs battery and super-cap that can deliver high energy
- Radiocrafts has implemented compact water meters
  - Antenna < 7cm, AA-cell + super-cap, >15 years

RC1701HP-WIZE

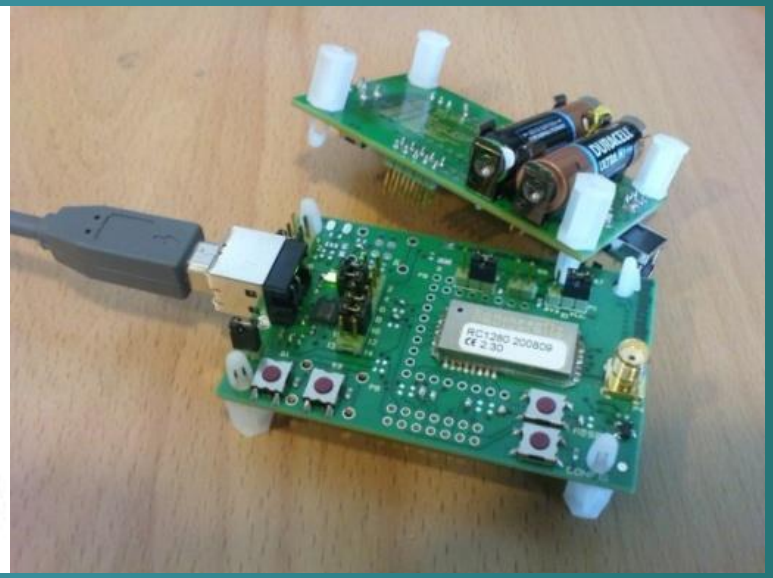
- Complete Wize Protocol modem application in a single external MCU
- UART interface for data and configuration
- Secure Encryption and Authentication
- Easy-to-use command interface
- Configurable:
  - Unique ID, encryption keys
  - Radio channel, Data rate
  - Output power (max 27 dBm)
- 12.7 x 25.4 x 3.7 mm (0.5 x 1.0 inch)
- Very low current, automatic sleep modes, battery lifetime >15 years
- Conforms with EU RED directive (DoC), designed for EX compliance
- Tape and reel delivery for volume production

Custom Wize module with water meter profile

- Customized application specific module
- Complete water meter profile implementation
- Ping/pong installation
- Encryption
- Authentication
- NFC interface for local communication
- Pulse or SPI interface to metrology controller
- Remote (RF) or local (NFC) parameter read/write
- Over-the-air FW download
- EPOCH2013 counter (timekeeping)

Wireless M-Bus / WIZE / RC232 / TM 169 MHz Development Kit

- Two Development Boards with the module of choice, onboard USB level shifter and USB connector, SMA antenna connector, I/O break-out
- Quarter-wave stub antennas with SMA connector
- USB cables
- The HP variants include additionally AC/DC Power Supplies



Radio regulations at 169 MHz

- 169 MHz band
- Paging systems, before cell phone and SMS
- EU decision 2013/752/EU
  - Metering devices
  - Assistive Listening Devices (ALD)
  - Non-specific Short Range Devices (SRDs)
- ERC REC CEPT 70-03 on 169 MHz
  - Not only EU, but Europe
  - Except Russia, Ukraine, Belarus)
- Water meter and gas meters utilizing the long range and properties of VHF frequency for radio coverage
- Many other industrial IoT applications can now take benefit of the same technology
- White Papers available from www.radiocrafts.com
- White Paper 10 Regulatory Requirements at 169MHz


Radiocrafts
Embedded Wireless Solutions
Fast to market.
Proven quality.

Thank you!

- Q & A