



# RFID JOURNAL VIRTUALLY LIVE!

SEPTEMBER 30 - OCTOBER 1, 2020

# STMicroelectronics's Upgrades ST25RU3993 Reader Performance: Boosting Reader Performance to 800+ Tags Per Second

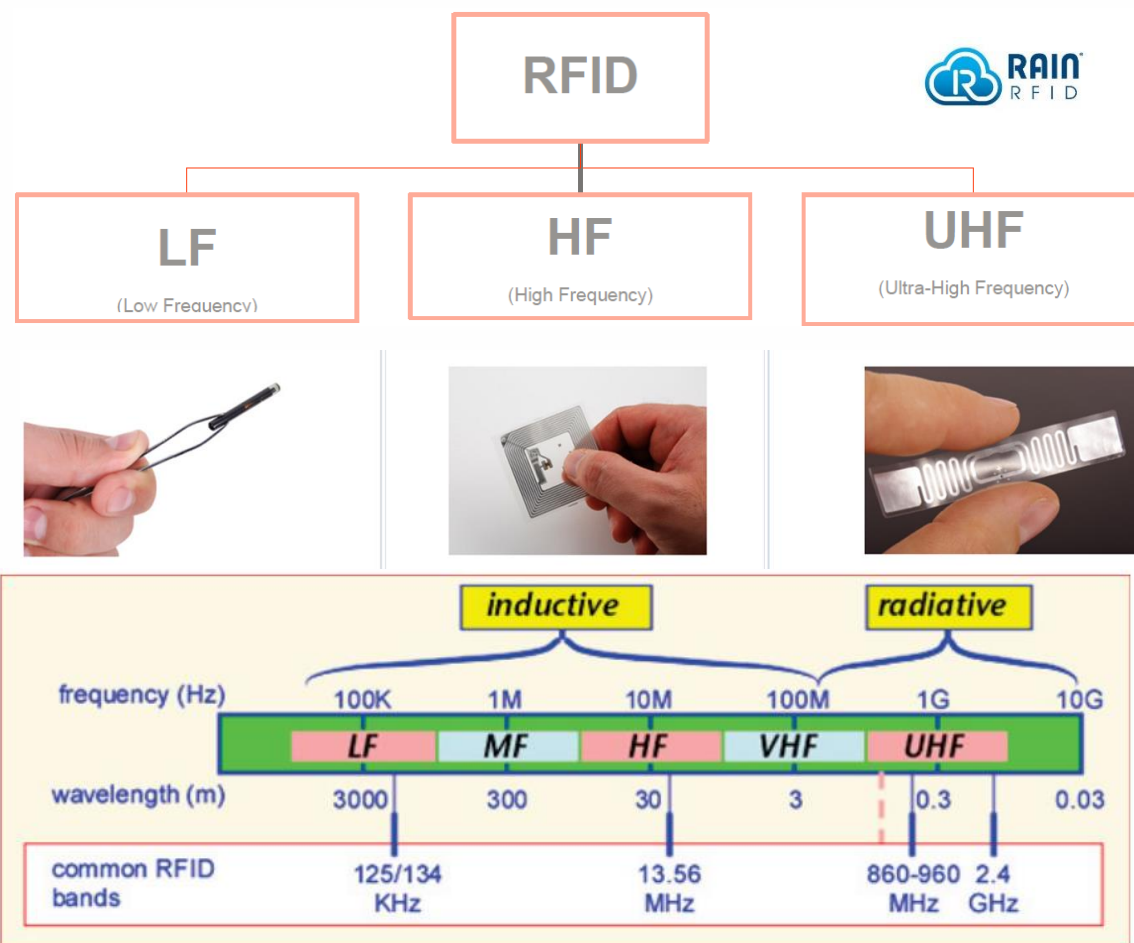
Jim Barlow

RFID/NFC Business Development and Technical Marketing

Sep 30, 2020



# RFID Technology – Introduction



FREQUENCY	RANGE	APPLICATIONS
<b>Low-frequency</b> 125 - 148 KHz	up to 80mm	Pet and ranch animal identification; car keylocks; factory data collection
<b>High-frequency</b> 13.56 MHz	up to 1 metre	Library book identification; smart cards; NFC; transit tickets <b>ST Readers + Tags</b>
<b>Ultra-high frequency (UHF)</b> 433 MHz	up to 100 metres (with active tags)	Container identification with active tags
<b>Ultra-high frequency (UHF)</b> 860 - 930 MHz	up to 15 metres	Supply chain tracking: item identification; apparel; healthcare; <b>ST Readers Only</b>
<b>Microwave:</b> 2.45 - 5.8 GHz	up to 2 metres	Highway toll collection; vehicle fleet identification

# Wireless Technologies Compared

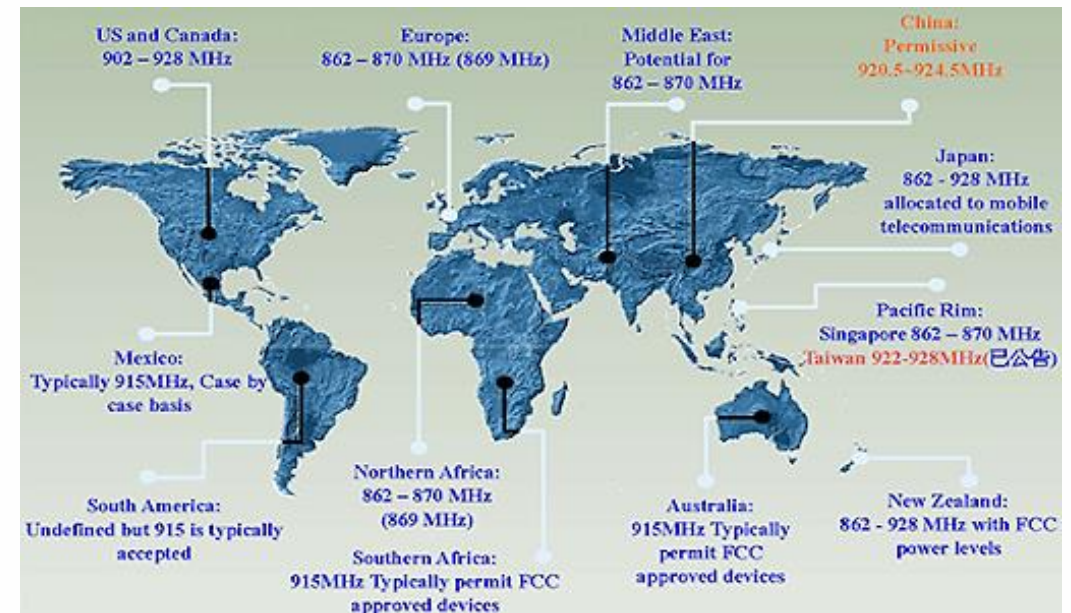
UHF is **cost-effective** solution for **high volume** applications



Feature	NFC	UHF	BTLE	Wifi	ZigBee
Base station cost (incl. reader)	\$\$	\$\$\$\$	\$\$\$	\$\$\$	\$\$\$
Receiver cost (tag)	\$\$	\$	\$\$\$	\$\$\$	\$\$\$
Passive receiver	Yes	Yes	No	No	No
Current consumption receiver	<0.1mA <i>passive</i>	<0.1mA <i>passive</i>	15mA	>100mA	15mA
Multipoint connection	No	Yes	No	Yes	Yes
User setup required	No	No	Yes	Yes	Yes
Typical number of receivers	1~5	>1000	~7	1~1000	32
Typical range	0.1m	1-15m	1-10m	1-100m	1-300m

# Rain RFID Technology – Readers

- All readers share basic functionality:
  - Read from tags
  - Write to tags
- Some may have additional features:
  - Tag localization
  - Multi-protocol support
  - Dense reader mode
  - Proprietary tag commands:
    - read a sensor
    - activate a switch or actuator
- Can be Portable or Fixed Install
- May be certified for a single country or may carry multiple radio certifications





# Rain RFID Portable, Desktop and Module Readers

- Can be Incorporated with barcode readers
- Often attached to a mobile computer or mobile phone
- Optimized for low power consumption to preserve battery power
- Can be dedicated devices
- Often designed around a reader module



# Rain RFID Fixed Readers

- One to many antennas.
- Typically require a strong power supply
- Connected to a network with
  - Ethernet cable – Often POE
  - Wireless communications capabilities.
- Some readers offer antenna steering
- Can be Located at a door, on a fork lift truck
- Optimized for long range and high data throughput



# Manufacturing

*process optimization with UHF*



## Tools & Inventory Management

Ensure availability of tools and planning certainty by automated tracking of tools and machinery as well as of the stock of inventory and goods.



## Process Optimization

Monitor manufacturing processes and supply routes to optimize machine usage or downtimes and to prevent traffic jams and bottlenecks within the factory.



## Condition Monitoring

Track and record environmental conditions of your products at production and in storage to ensure a correct handling.



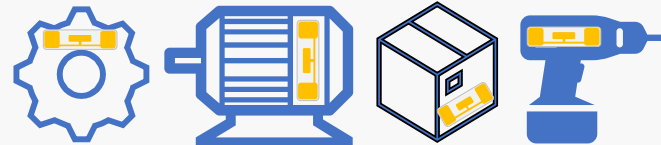
## Smart Sensing

Use battery- and wireless sensor tags to monitor various parameter and conditions of tools, goods or machinery with a simple and quick setup.

UHF reader  
with ST25RU



UHF tags  
third party



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# Logistics

*more control & enhanced operations with UHF*



## Automated Inventory Management

Use automated processes for check-in/check-out, priority setting (e.g. frozen food) and safety measures to improve storage speed, accuracy and quality.



## Process Optimization

UHF allows the handling of hundreds of tags per second over long distances and enables a significant increase in turnover rates.



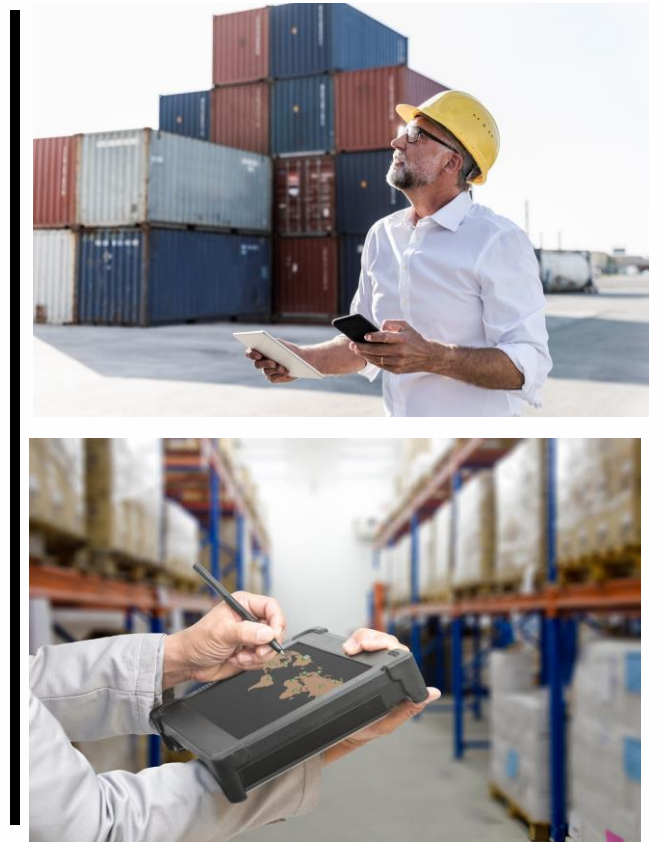
## Condition Monitoring

Track and record environmental conditions of your products during manufacturing and in storage to ensure a correct handling.



## Tamper Protection

Secure your sensitive products from tampering or altering with an UHF enabled protection and recognize a broken seal automatically at the next reader point.



UHF reader  
with ST25RU



UHF tags  
third party



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# Retail

*improved consumer experience & better security with UHF*



## Inventory Control & Security

Make sure you always have your items on stock and automatically synch your inventory with your online shop. Prevent losses or theft with minimum effort.



## Process Optimization

Improve the customer experience by providing UHF enabled fast check-out and minimum waiting times at the register by automated items scanning.



## Customer Interaction Tracking

Track your customer's interactions with items and gain vital information for improving product placement and other marketing activities.

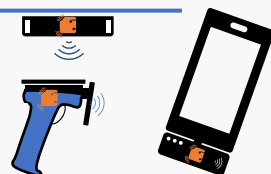


## Authentication

Allow immediate authentication of brands of products and goods.



UHF reader  
with ST25RU



UHF tags  
third party



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# Healthcare

*improved patient care & inventory oversight with UHF*



## Inventory Management

Manage the check-out and replenishment of medication. Automate processes and ensure stock of critical inventory.



## Safer Patient Care & Tracking

Avoid incompatible cross medication with UHF enabled safeguards. Track the movement and location of patients with special needs to ensure their safety.



## Access Control

Secure critical premises like storage or emergency rooms while ensuring automatic and remote opening of doors for patient beds or medical equipment.

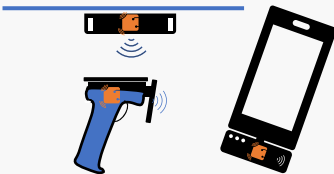


## Asset Management

Manage storage, maintenance, utilization tracking and access to assets.



UHF reader  
with ST25RU



UHF tags  
third party

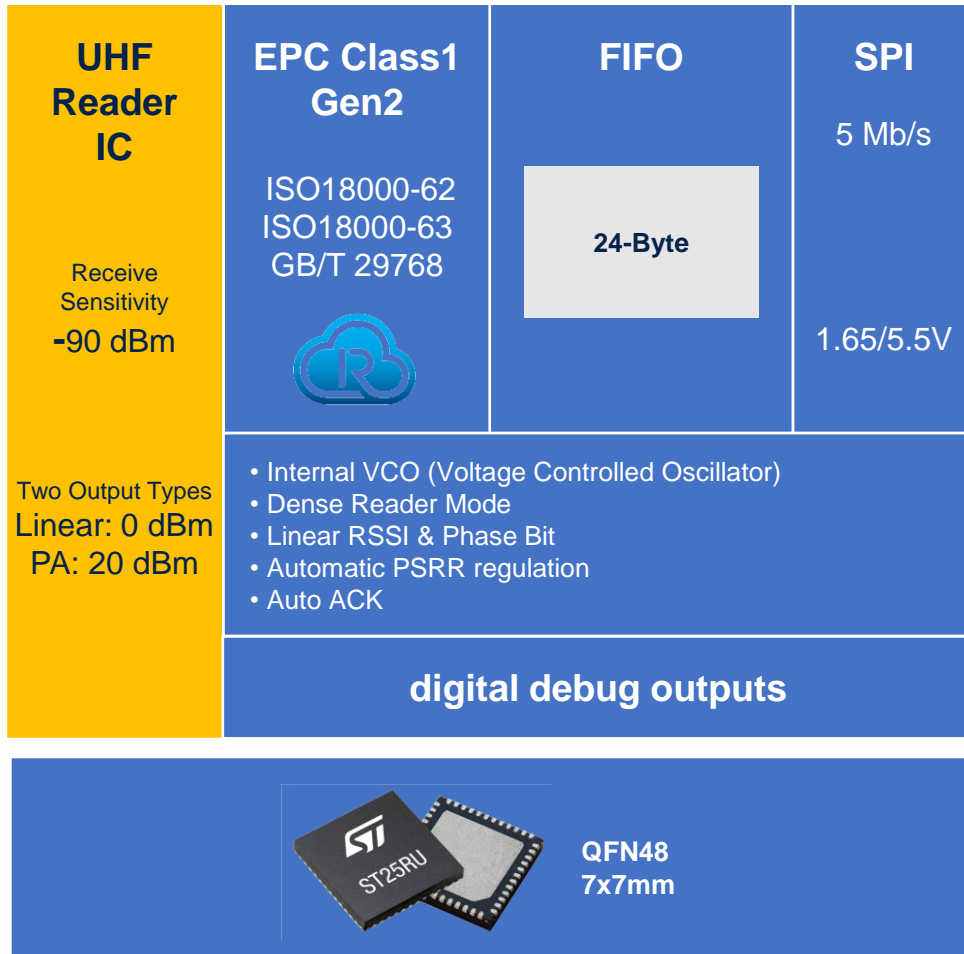


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# ST25RU3993 UHF RFID reader



## Key Features

- Tuneable frequency 840 to 960 MHz
- Support of **all regions** worldwide
- Output configurations
  - Adjustable linear output: 0 dBm for external amplification
  - Adjustable **internal power amplifier**: 20 dBm
- Single ended and differential RX input options
- Receive sensitivity of **-90dBm**
- Power consumption down to 65mA
- **Power Down Mode** with 3.3 µW
- **950 tags/s** single tag read speed @ 2 bytes EPC length, 640 kHz, FM0
- Temperature Range: -40 to 85°C

# Technical Data Overview



Description	RAIN UHF RFID reader
Protocols	EPC Class1 Gen2 , ISO18000-62 & -63 , ISO29143 GB/T 29768 transparent mode: custom protocols possible
Modulation Modes	Double Side Band (DSB) transmit modulation Phase Reversal Amplitude Shift Keying (PR-ASK) transmit modulation
Tuneable frequency	840 to 960 MHz
Power Supply	1.65 V –3.6 V
Power Consumption <i>normal</i>	210 mW
Power Consumption <i>standby / power-down</i>	9.9 mW / 3.3 µW
Communication Interface	Serial Peripheral Interface (SPI) 5Mb/s
Sensitivity (IC)	-90 dBm
Output Power <i>linear for external PA / internal PA</i>	0 dBm / 20 dBm
Output Power Adjustment	1 dB steps
Read Speed <i>single / unique</i>	950 tags/s , 440 tags/s
Operating temperature	-40 to +85°C
Package	48-pin QFN (7x7mm)
Advanced Features	Dense Reader Mode Internal Voltage Controlled Oscillator (VCO) Linear Received Signal Strength Indication (RSSI) & Phase Bit Automatic Power Supply Rejection Ratio (PSRR) regulation Auto Acknowledge (ACK) Transparent Mode



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# Additional Features of ST25RU3993

## received signal strength indication (RSSI)

measurement of power level of an incoming transponder signal or detection of external RF signal levels in the vicinity of the carrier frequency.

## internal VCO

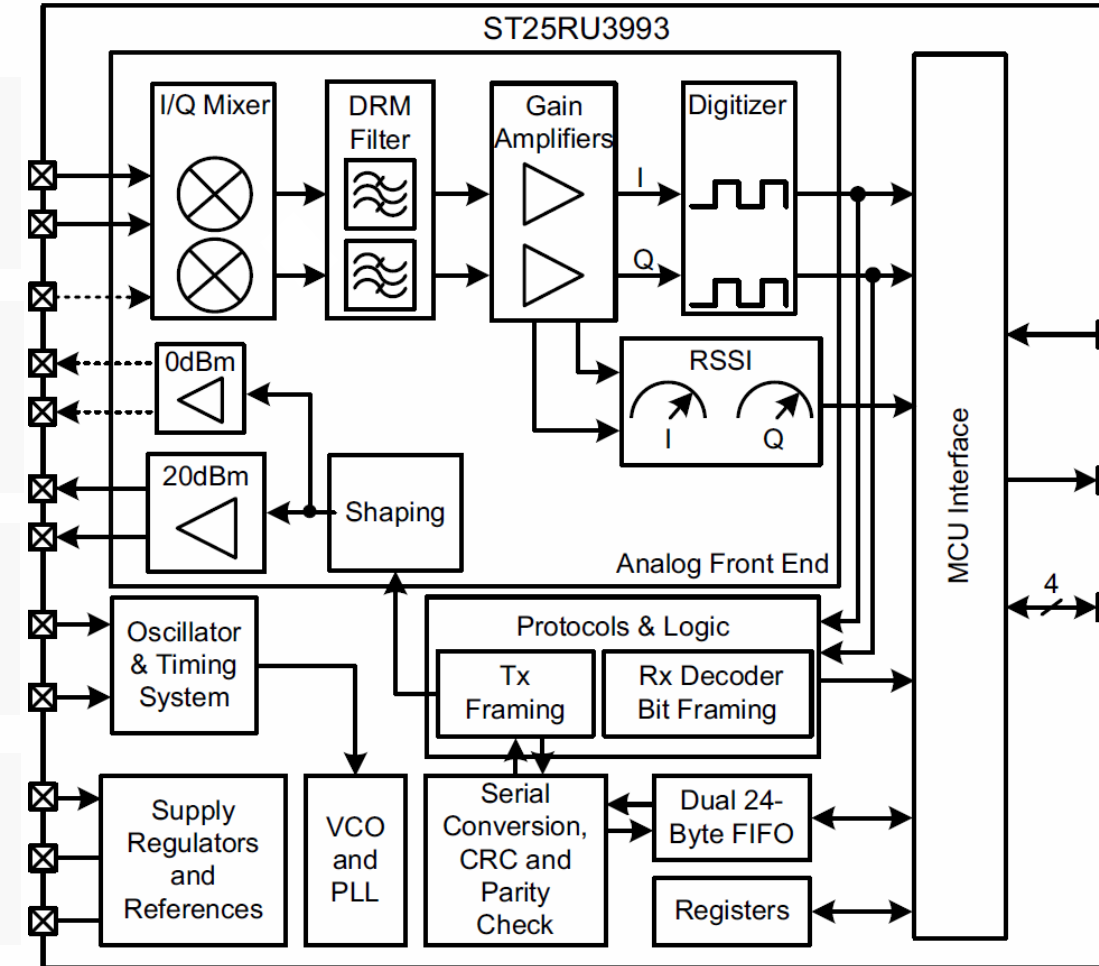
on-board generation of RF signal with integrated voltage-controlled oscillator (VCO). reduction of BOM costs and development efforts.

## full access to chip registers

optimized functionality and debugging capabilities with full access to all chip registers.

## ST open source approach

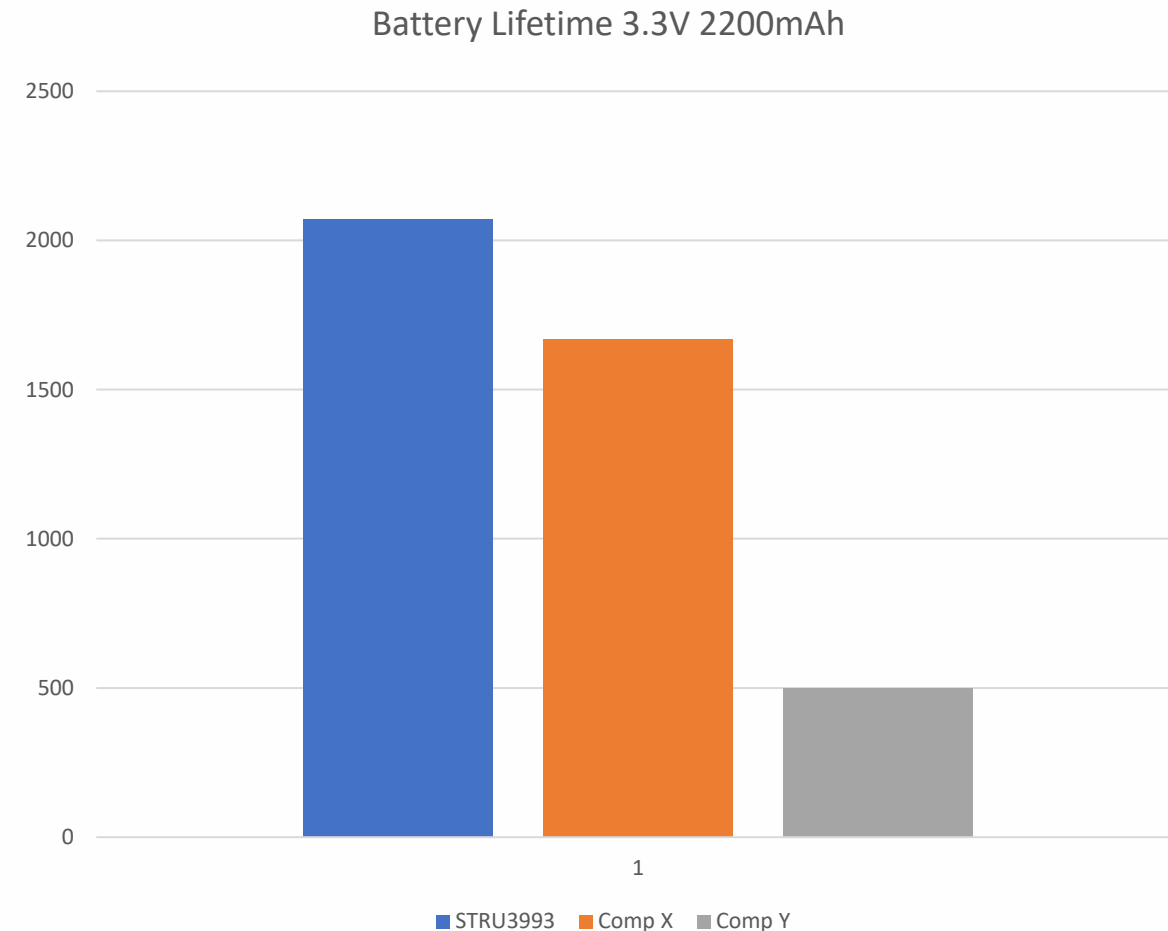
free access to source code, examples for various platforms like Linux, Raspberry Pi, Beaglebone) and libraries.





# Competition benchmark on power consumption

- ST25RU3993 offers longer battery lifetime
- ST25RU3993 runs 2070min  
ST offers maximum battery lifetime
- Competitor X runs 1670min  
offers 80% battery lifetime vs ST
- Competitor Y runs 500min offers 25%  
battery lifetime vs. ST



# SW & FW Improvements



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# Improvements – UART Data Rate

- Increased UART speed to 3 Mb/s (vs. 115kb/s)
- This change was key for many subsequent improvements:
  - High tag read speeds - highest BLF (640 kHz) and shortest tag encoding (FM0)
  - Include tag read statistics in data packages



# Improvements – Anti-Collision – But why?

## Efficiently inventory tag populations that may change in size

- One reader vs. many tags → not all tags may communicate at once!!
- The reader needs to serialize its tag communication
  - The reader provides a number of slots → a “schedule”
  - Tags randomly select a slot
    - Some slots might remain vacant / not selected by any tag → empty slot
    - Some slots might be occupied by more than one tag → collision
- Fundamental problem:
  - Typically the number of present tags is unknown - How many slots to provide?
- → The quicker the reader adjusts the number available slots the faster multiple tags can be inventoried



# Anti-collision in Gen2V2

- An initiating QUERY command, declares the available number of slots to all participating tags
- The corresponding parameter in the QUERY command is called Q

$$\text{Number of slots} = 2^Q$$

- All tags randomly pick a slot within the range 0 and  $2^Q - 1$
- A tag with slot 0 is allowed to communicate with the reader
- All other tags wait for the next reader command
- Tags receiving a QUERYREP command decrement their slot number  $\rightarrow$  next slot
- Tags receiving a QUERYADJUST command choose new slots with the new range  $\rightarrow$  new Q

# New: Adaptive Anti-collision

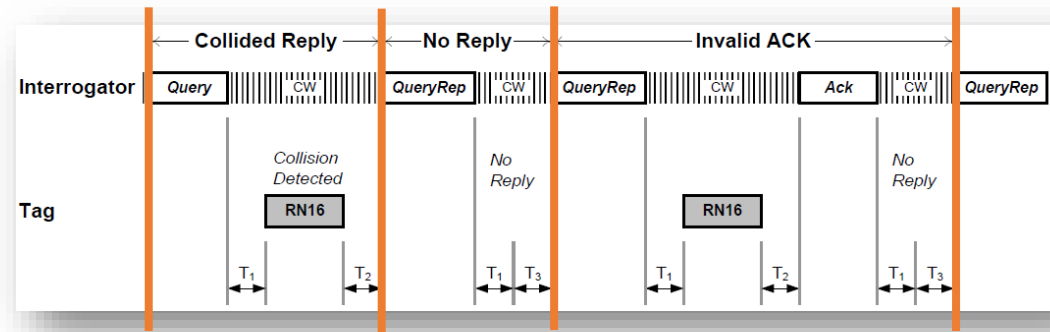
- Before the EVAL SW offered a static anti-collision only
  - Q had to be selected by the GUI user and did not change during the scanning
  - During a demo at which the tag population size is known in advance Q can be selected optimally – for highest throughput.
  - Drawback:
    - If tags  $\gg$  slots, then read performance appears weak
    - If tags  $\ll$  slots, then read speed is low
- Now a adaptive anti-collision is supported
  - User does not need to care for Q during a demo
  - Q is adjusted automatically
    - Reader starts from a default Q then counts the empty and collided slots
    - Too many collisions  $\rightarrow$  increase the number of slots (Q up)
    - Too many empty slots  $\rightarrow$  reduce the number of slots (Q down)

The number of tags	Optimum frame length (size, Q)
1-5	4 (2)
6-11	8 (3)
12-22	16 (4)
23-44	32 (5)
45-88	64 (6)
89-180	128 (7)
181-355	256 (8)
356-700	512 (9)
701-1420	1024 (10)
701-1420	2048 (11)



# Improvement – Anti-collision

- Many versions of anti-collision algorithms exist – see Gen2 protocol for a proposal
- ST chose an algorithm which recognizes the fact that an empty slot is faster to process than a collision



- Our algorithm tries to avoid collisions and favors empty slots
- Two different “weights”,  $C_1$  and  $C_2$  decide how fast to increase or to decrease  $Q$
- $C_1$  defines the how many empty slots cause  $Q$  to decrease
- $C_2$  defines the how many collision cause  $Q$  to increase

# Carrier Cancellation Tuning Speed

- Changes to the antenna environment happens relatively slow when compared to tag inventory speeds.
- Nonetheless we have increased the overall tuning speed by optimizing the code.
- Recap:
  - FAST: tunes for the minimum using the current CCC configuration
    1. Tunes until a minimum is reached
    2. Copy the new CCC configuration to neighboring frequencies.
  - SLOW: tunes for the minimum using multiple starting points
    1. Tune for each frequency using the FAST algo.
    2. Sort all the results and pick the best setting giving the lowest reflected power.

## Improvement:

- FAST old: ~100 measurements = **~800 msec** → FAST new: ~100 measurements = **~40 msec**
- SLOW old: ~3000 measurements = **~20 sec** → SLOW new : ~3000 measurements = **~970 msec**
- Tuning is currently handled by the GUI → processing moved to the FW

# New Tuning Algorithms

- MEDIUM: tunes for the minimum using multiple starting points
  1. Test reflected power value for all starting points
  2. Use the starting point with the lowest reflected power and fine-tune until the minimum is reached
- FAST & SLOW:
  1. Tune 1<sup>st</sup> frequency with the SLOW algo. to find DTC settings for lowest refl. power
  2. Use the resulting DTC setting of the previously tuned frequency as the starting point for next frequency



# Evaluation boards & Enablement

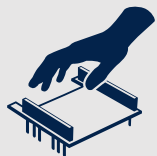


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# Debugging & development support

## Hardware



**Evaluation Boards**  
*ST25RU3993-EVAL*  
*ST25RU3993-HPEV*

**Antenna kits**

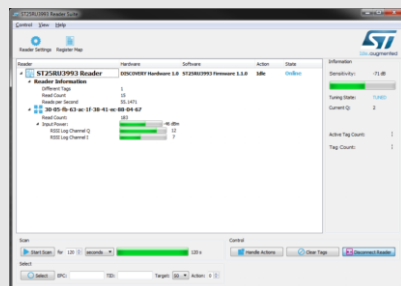


## Software Tools



### GUI

*Register access*  
*Mode selection*  
*Parameter read-out*  
*Tag access*  
*Evaluation*

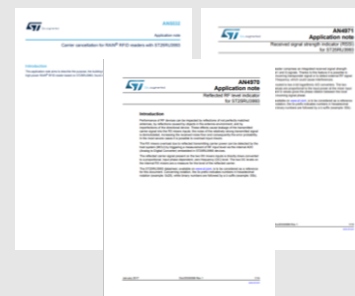


## Documentation



### Documentation

*Datasheets*  
*Application Notes*  
*Open Source Libraries*  
*Examples (Linux, RPi,...)*



## Support



**e2e community**

**Trainings**



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# New ST25RU3993-HPEV kit

## ST25RU3993-HPEV High Power Evaluation Board

- Based on the ST25RU3993 high performance **RAIN (UHF) RFID reader IC** and an STM32L476 MCU
- Included accessories
  - Near field antenna for communications <10 cm
  - 1 x ETSI far field antenna
  - 1 x FCC far field antenna
  - SMB / SMA antenna cable
  - USB Cable, 2 x UHF RFID tags
- Features
  - External PA: 30.5 dBm max TX power
  - Internal PA: 18 dBm max TX power
  - Differential RX input
  - Max. sensitivity: -80 dBm
  - Frequency: 840 MHz – 960 MHz
  - Two antenna connectors: SMB (F)



*ETSI far field antenna*



*FCC far field antenna*



*Near field antenna*

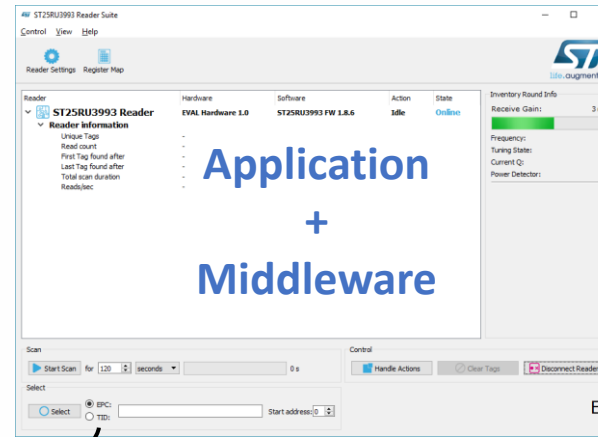
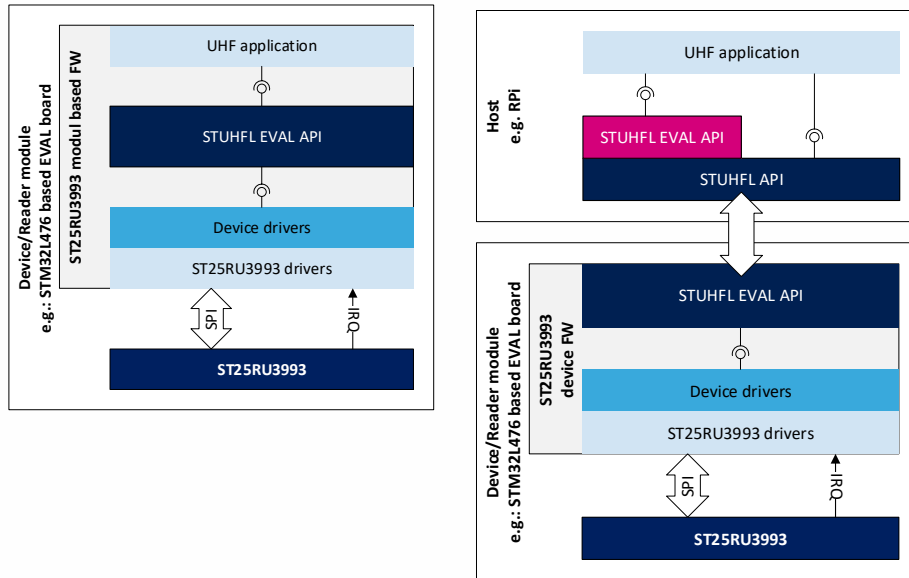


- HW
  - EVAL board
  - ST-LinkV2

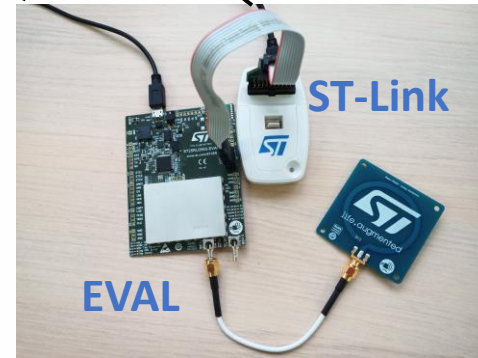
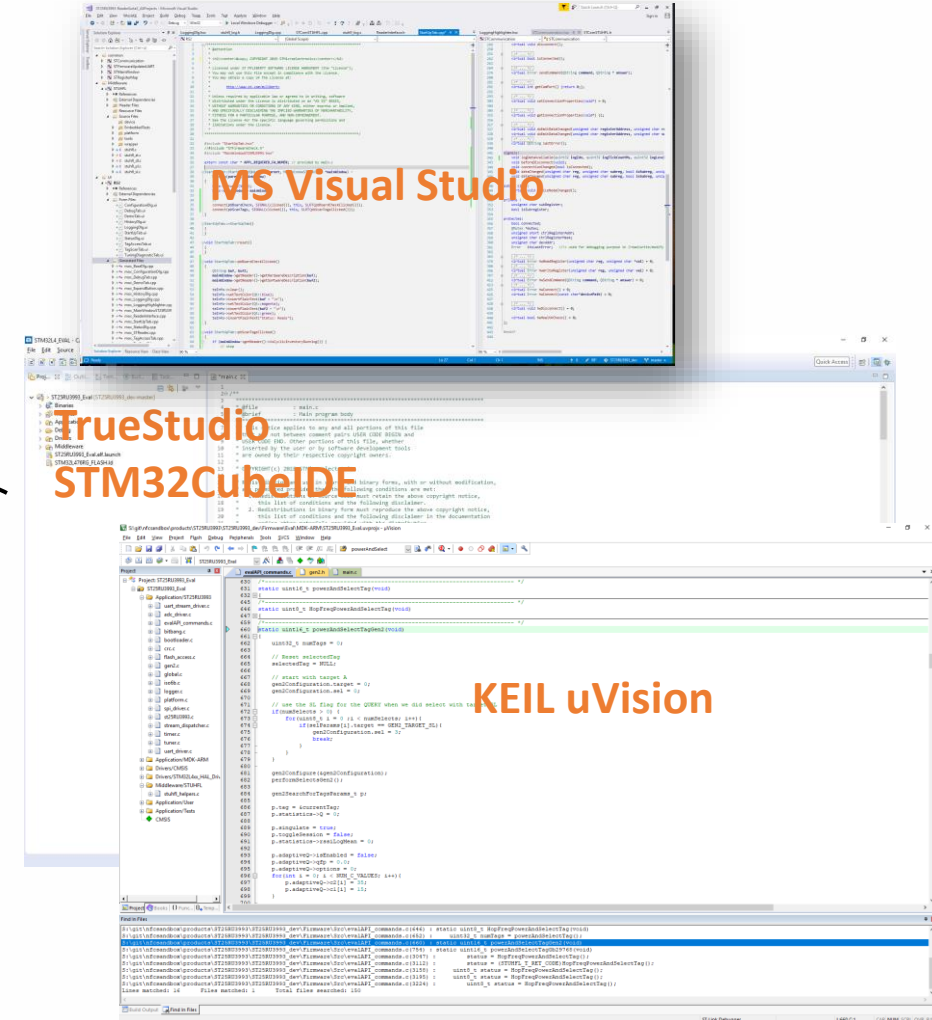
# Full Enablement of HW and SW

- Middleware & Application
  - STSW-ST25RU-SDK
  - Visual Studio 2017
- Firmware
  - KEIL or Atollic TrueStudio

Common Code for Host & Embedded



Application  
+  
Middleware



EVAL

ST-Link

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# Performance Enhancement Summary Video

Link Provided for Easy Reference:



[ST25RU3993 Performance Improvements](#)

The screenshot shows the STMicroelectronics website interface. At the top, there's a navigation bar with the ST logo and 'life.augmented' tagline. Below it, a dark blue navigation bar contains links for Products, Applications, Solutions, Tools & Software, and About ST. A search bar is present with the text 'st25ru3993' and a magnifying glass icon. To the right of the search bar are links for 'My bookmarks' and 'Search History'. Below the search bar, there's a summary of search results: 'Products (1)', 'Tools & Software (3)', 'Resources (24)', and 'Videos (1)'. The 'Videos (1)' section is expanded, showing a single video result: 'ST25RU3993-EVAL Read Performance Demo'. The video thumbnail includes text: 'We will show you how the ST25RU3993-EVAL reaches', 'Read speed above 760 kbytes/s', 'Distance range up to 4.3m', and 'Detection of 200 tags in 665ms'. Below the thumbnail, the video title 'ST25RU3993-EVAL Read performance demonstration' is displayed, along with a 'Watch time 02:00' indicator.

# THANK YOU



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