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ST25R3911B/12 product presentation

MMY division

ST25R3911B/12 use cases

Payment

EMVCo 2.6
Pairing

Consumer / gaming

Pairing
Power & data transfer

Industrial

Tracking & inventory
Data transfer & programming

Access control / Transport

Identification & authentication

Qi wireless charging protection

Card or phone identification
Authentication

ePasseport

VHBR data transfer
Authentication

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ST25R3911B/12 benefits

Outstanding analog performance

- No external amplifier required to achieve high field strength
- Excellent P2P interoperability
- Low power wakeup

Advanced Features

- Noise suppression receivers
- Automatic antenna tuning
- Active waveshaping

Fast time to market

- EMVCo, NFC Forum, and ISO compliant SW library
- Single SW library for all products
- Full integration into STM32 eco system

Proven solution

- Market proven solution in the consumer and automotive space
- Ensures best customer experience

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ST25R product lineup

	ST25R95	ST25R3911B	ST25R3912	ST25R3916	ST25R3917
Description	Entry-Level NFC Reader	High-Performance NFC Forum Reader	Mid-Range NFC Forum Reader	High-performance NFC Universal Device & EMVCo Reader	High-performance NFC & EMVCo Reader
Reader/Writer mode	ISO14443A/B ISO15693 Felica	ISO14443A/B ISO15693 FeliCa	ISO14443A/B ISO15693 FeliCa	ISO14443A/B ISO15693 FeliCa	ISO14443A/B ISO15693 FeliCa
Card emulation mode	Yes	-	-	Yes	-
AP2P mode	-	Initiator & Target	Initiator & Target	Initiator & Target	Initiator & Target
PP2P mode	-	Initiator	Initiator	Initiator & Target	Initiator
RF speed	424kbps	6.8Mbps (VHBR)	848kbps	848kbps	848kbps
Market	Consumer	Payment EMVCo 2.6, Industrial	Access control, Metering, Consumer	Payment EMVCo 3.0, Industrial, Consumer	Payment EMVCo 3.0, Industrial, Consumer
Advanced features	IWU	AAT, DPO, CIWU	DPO, IWU	AAT, DPO, NSR, DSA, AWS, CIWU, EMD	DPO, NSR, DSA, AWS, IWU, EMD
HW interface	SPI 2Mbps	SPI 6Mbps	SPI 6Mbps	I²C // SPI 10Mbps	I²C // SPI 10Mbps
SW interface	RFAL Unified Software Library for Frontends				
Power supply	2.7V - 5.5V	2.4V – 5.5V	2.4V – 5.5V	2.4V – 5.5V	2.4V – 5.5V
Output power	0.23W	1.4W	1.0W	1.6W	1.6W
Temperature range	-25°C to +85°C	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C
Package	32-pin QFN	WF 32-pin QFN / Wafer	WF 32-pin QFN / WLCSP-30	WF 32-pin QFN / WLCSP-36	WF 32-pin QFN

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VHBR: Very High Baud Rate
P2P: Peer to Peer mode
AAT: Automatic Antenna Tuning
AWS: Active Wave Shaping

EMD: Automatic EMD suppression
VHBR: Very High Baud Rate
DPO: Dynamic Power Output
CIWU: Capacitive & Inductive Wakeup

DSA: Drive Slope Adjustment
* Peak output power
NSR: Noise Suppression Receiver
IWU: Inductive Wakeup

ST25R3911B/12 product and features

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ST25R3911B
1.4W high power payment reader solution

ST25R3911B

Reader Writer	ISO14443 ISO15693 FeliCa	RAM BUFFER	SPI
AP2P Initiator & Target PP2P Initiator	NFC 6.8Mb/s	96-Byte	2.4/5.5V 6Mb/s
1.4W	VHBR: Very High Baud Rate DPO: Dynamic Power Output CIWU: Capacitive & Inductive Wake Up AAT: Automatic Antenna Tuning		


QFN32


Wafer

Use cases

- Ideal for **Payment** applications
- Access Control, Gaming, eGovernment passport

Key Features

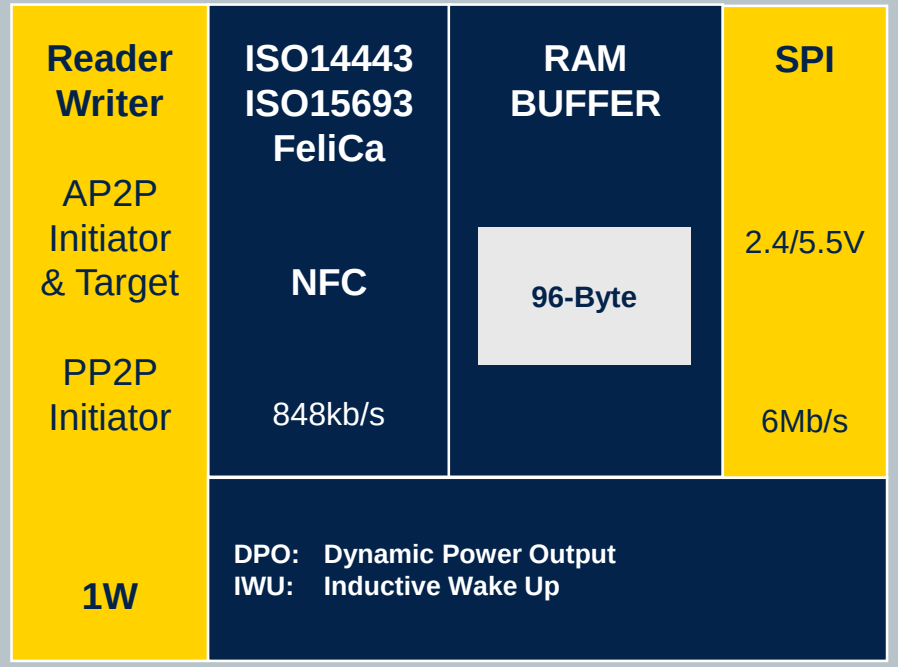
- All NFC modes supported (ISO14443, ISO15693, FeliCa) with P2P
- **1.4W** output power at 5V
- **EMVCo 2.6** & **PBOC** certification without external power amplifier
- Automatic Antenna Tuning
- **VHBR** support up to **6.8Mb/s**
- -40°C to **125°C** junction temperature range

Key Benefits

- Low power operation & Stand-by mode (capacitive wake-up)
- 2 antennas operation at the same time
- Enhanced fast transfer rate for Passport application

ST25R3912
smallest footprint, high power reader solution

ST25R3912




QFN32
Wetable flank


WLCSP

Use cases

- Ideal for EMVCo 2.6 legacy **Payment** and **small handheld mPOS**
- Access Control
- Gaming

Key Features

- All NFC modes supported (ISO14443, ISO15693, FeliCa) with P2P
- 1W output power at 5V
- **EMVCo** & **PBOC** certification without external power amplifier
- Small 3x2.8 **WLCSP** package
- -40°C to **125°C** junction temperature range

Key Benefits

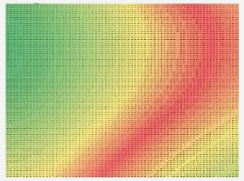
- Small Footprint on PCB, Low power operation & Stand-by mode
- 2 antennas operation at the same time

ST25R3911B/12 benefits

High RF Performance

- Larger operating volume/ smaller antenna
- Unrivaled RX sensitivity for challenging antenna designs simplifies electro-magnetic immunity and eases certification.

AAT: Automatic Antenna Tuning



- Easiest environmental/ lifetime compensation:
- Automatic adjustment of the tuning resonance and matching impedance driving adjustable capacitors

DPO: Dynamic Power Output

- Increase Efficiency and achieve min/max Limits
- The output power is adjusted automatically to reduce power and stay within certification limits.

CIWU: Capacitive & Inductive Wakeup

- Low power consumption in card detection mode
- Capacitive and Inductive wakeup allow for low power consumption while in card detection mode.

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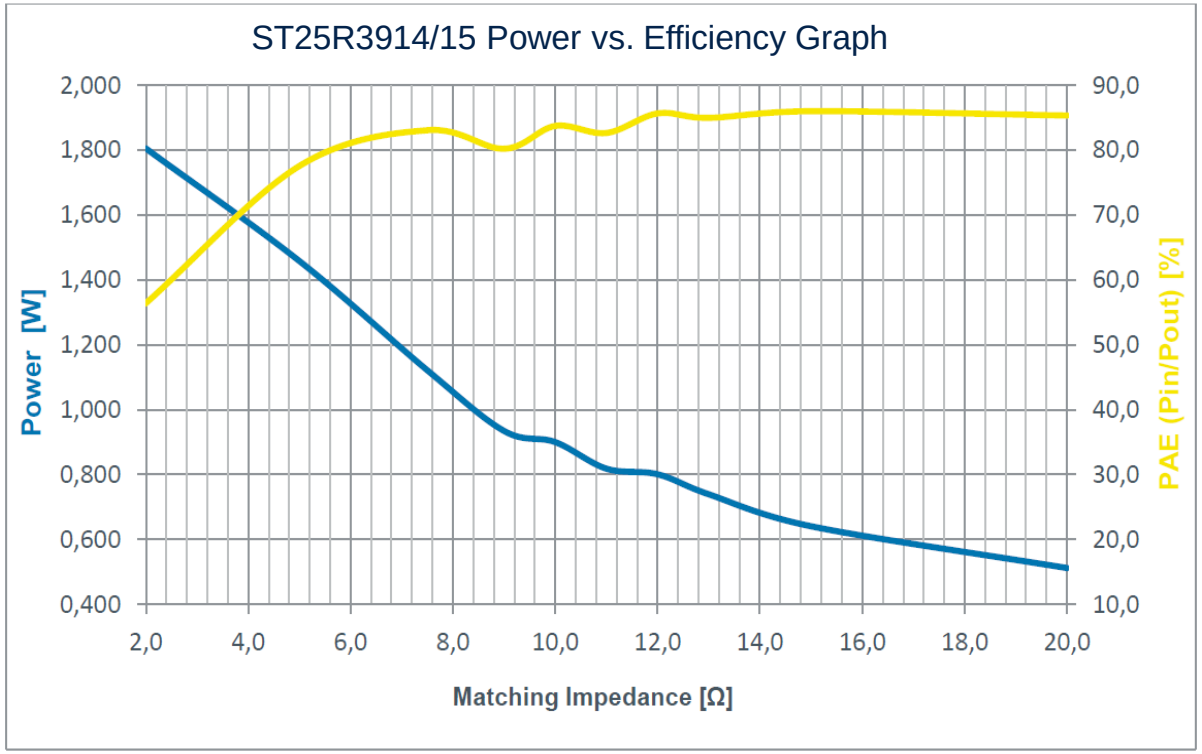
Highest output power & efficiency

Enough power for great user experience

- No external Booster required
  - The ST25R3914/15 includes low impedance drivers capable of generating >1W of output power
  - EMVco certification for in car payment easily possible without external boosters
- Maximum transferred Power
  - Energy harvest for keyfob's
  - Ideal for small door handle antennas
- Ideal for Challenging Environment
  - The ST25R series is able to operate in metal encapsulation like doorlocks



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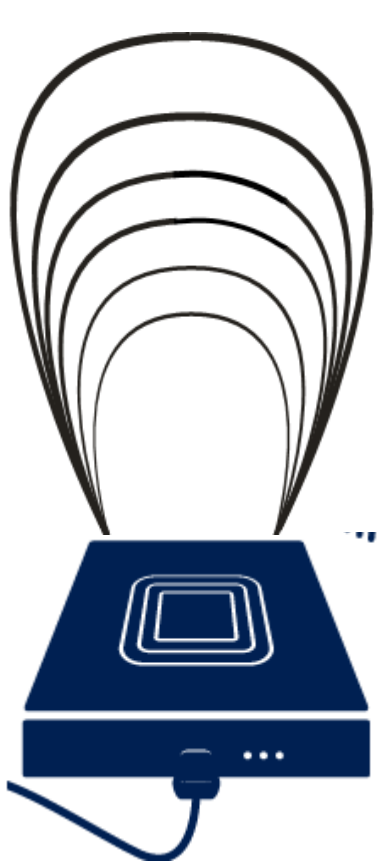
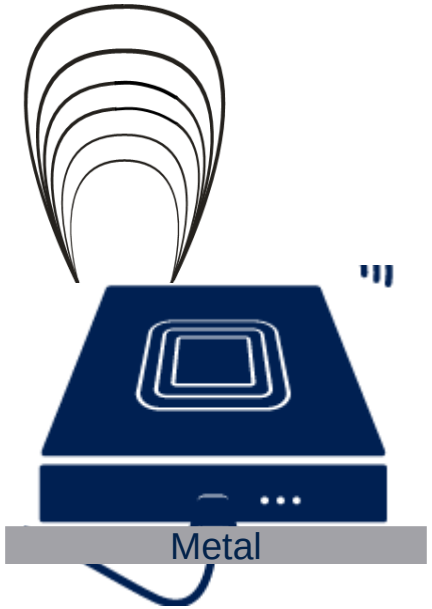
AAT: Match the antenna well and make sure it stays tuned

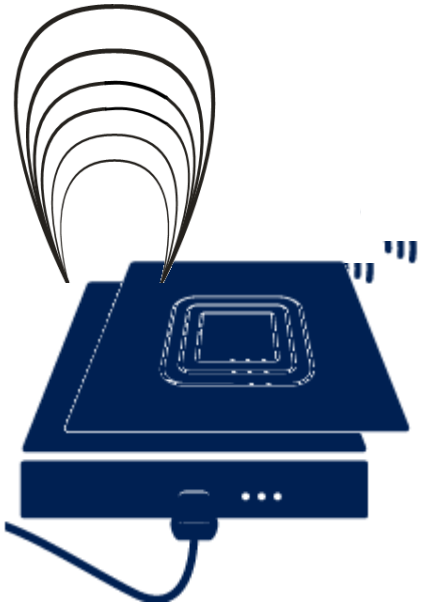
Placement, mounting and outside factors can detune and reduce performance – AAT will help



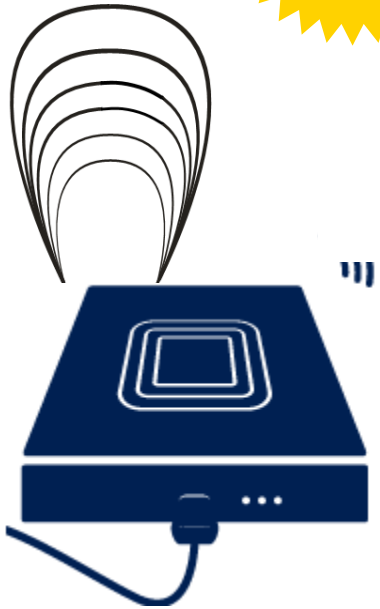
Metal objects



Placement



Mounting



Temperature

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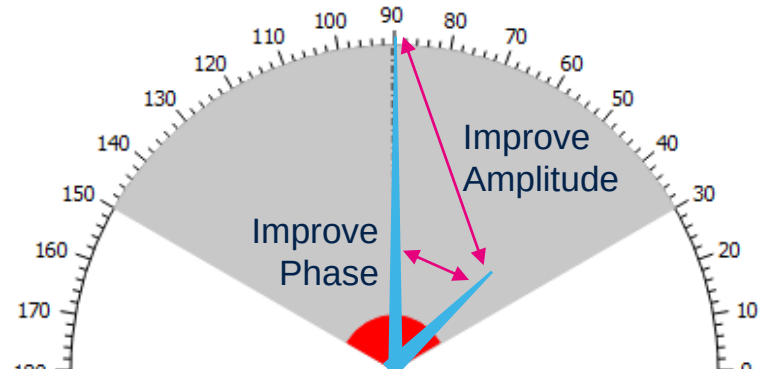
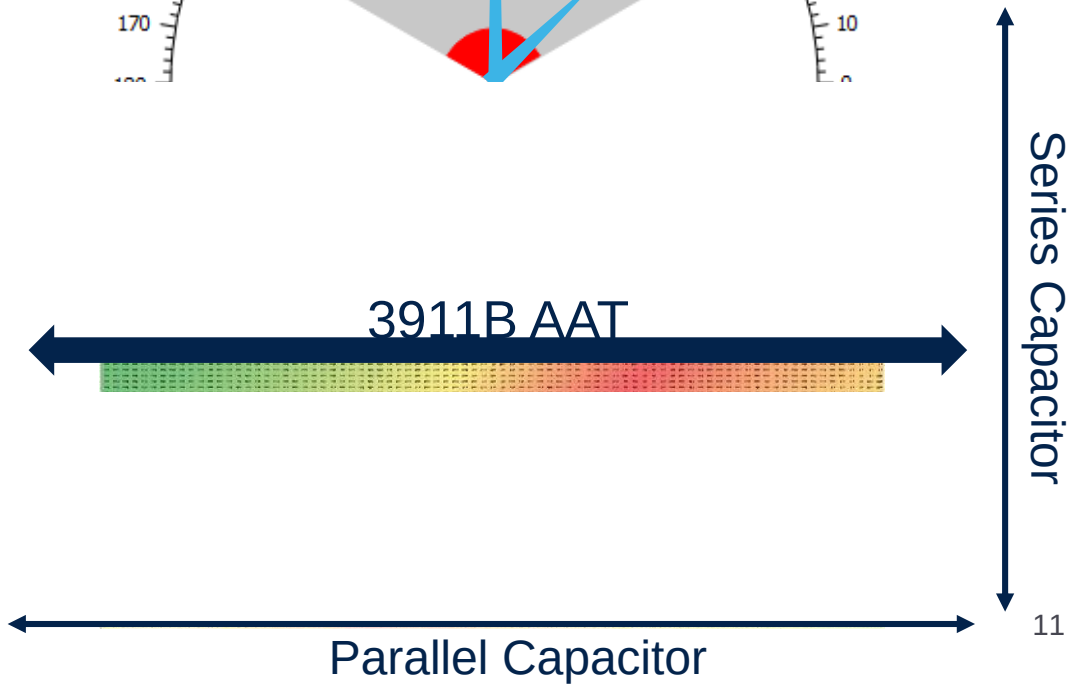
AAT: automatic antenna tuning be sure your antenna stays tuned

AAT will help to maximize performance in different situations

- Algorithm is based on antenna amplitude and phase measurement
- On ST25R3911B tuning is possible on the parallel path of the antenna
- Ideal for center console applications





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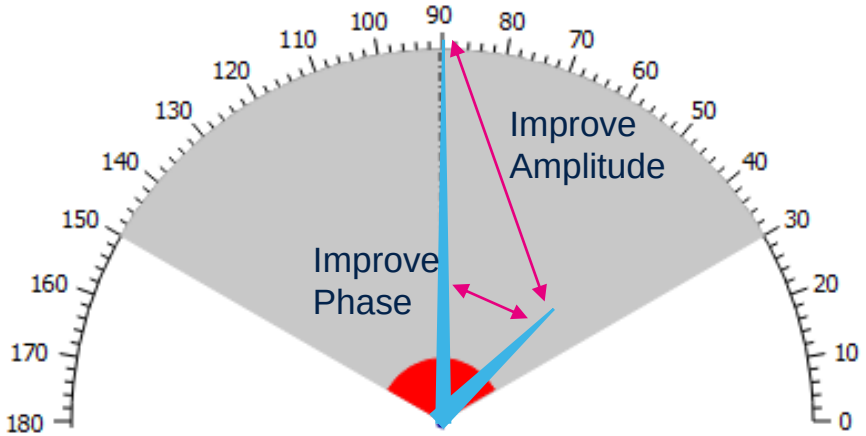
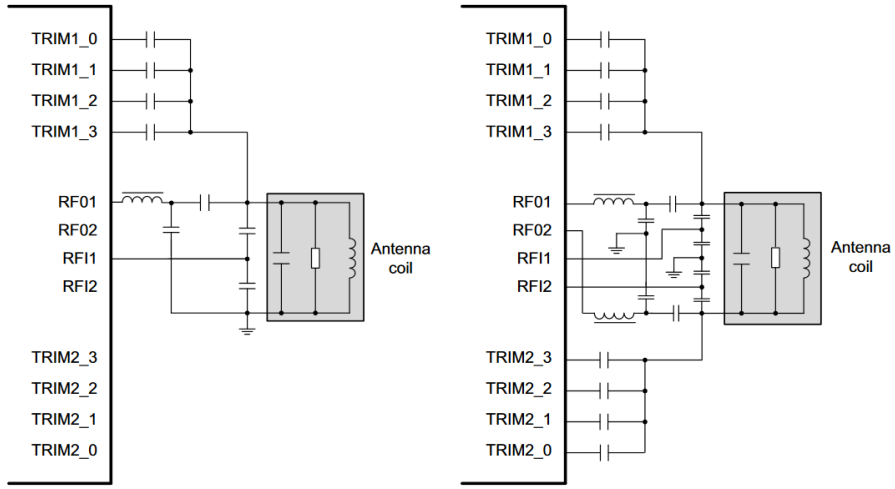
AAT: how to implement

- There are two possibilities to implement AAT on ST25R3911B
  - HW based with the chip internal algorithm
  - SW based, optimized for maximum amplitude

- While the HW based algorithm is fixed the SW based algorithm can be altered to certain needs if required

- In general tuning the Antenna is done in the following steps:
  - Measure the antenna
    - D3 Measure Amplitude
  - Adjust the antenna
    - Antenna Calibration register 21h-23h
    - This registers will disconnect the capacitors connected to the TRIMx pins and therefore change the impedance of the antenna





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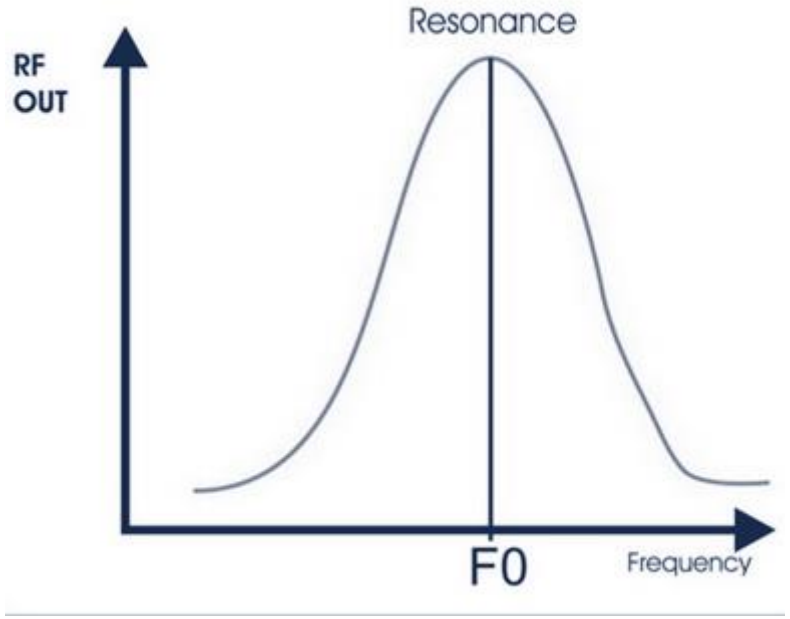
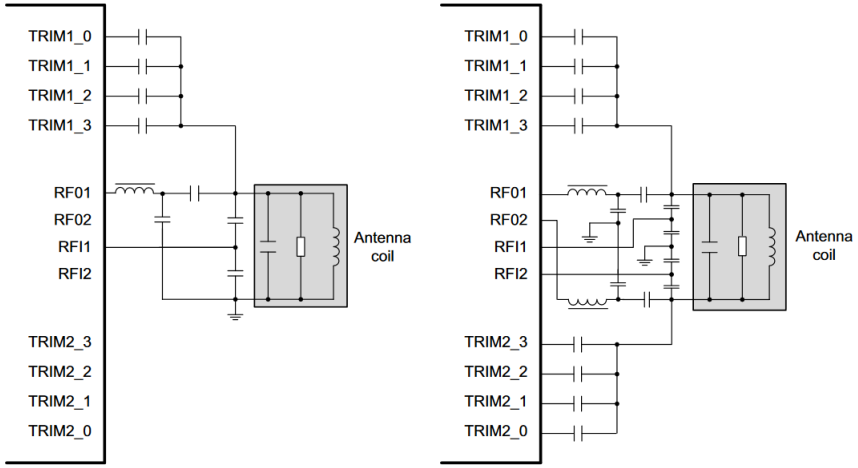
AAT: when to implement

- AAT can be used at any given timeframe by using the calibrate antenna D8 command.
- In terms of usability there are certain aspects where AAT has the highest benefits: Tuning of the
  - module after production
  - system during startup/shutdown
  - antenna in continous mode

- At what times can AAT be used looking at the standard:
  - As part of the polling loop
  - Before communication/transaction





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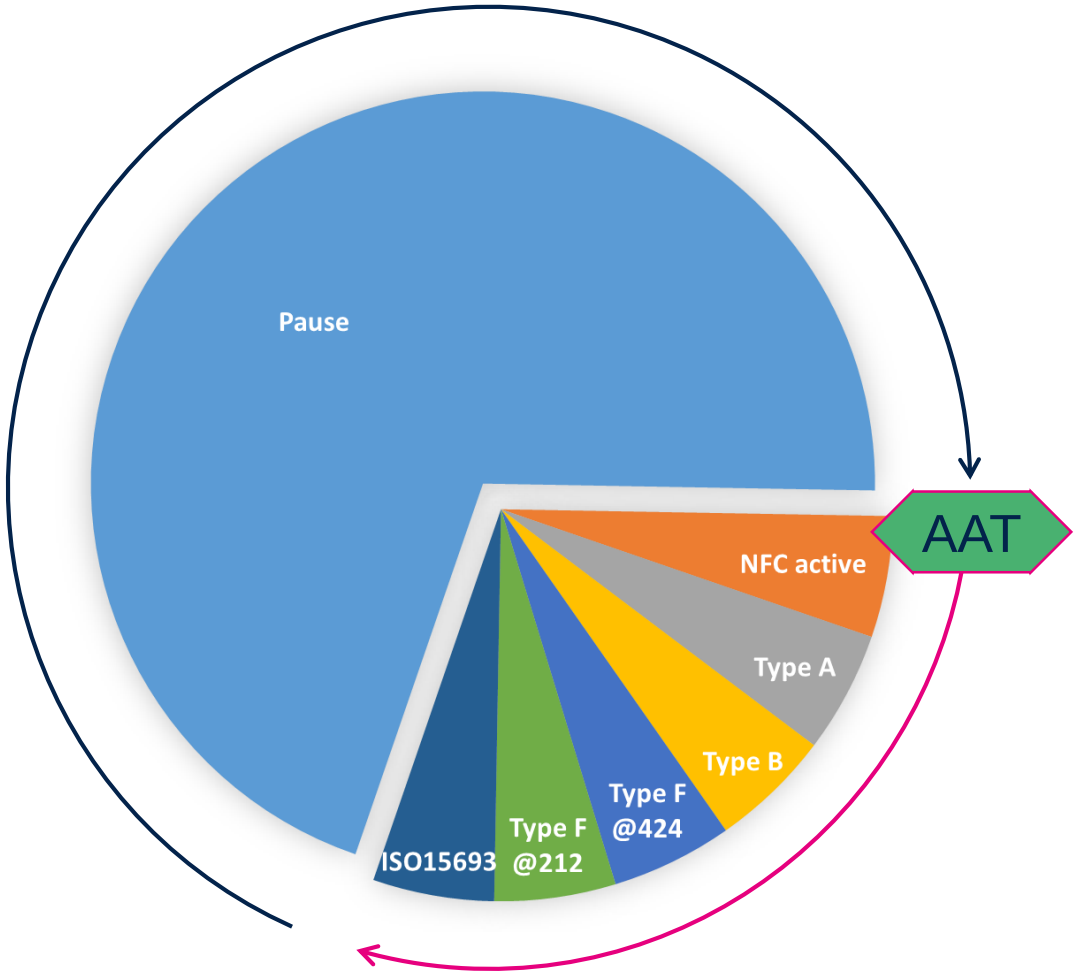
AAT: during polling loop

- AAT after a H-field switch on as part of the polling loop:
  - Listen before talk
  - Switch on unmodulated alternating H-field until settled
  - Execute AAT
  - Emit unmodulated H-field
  - Poll for cards in the operating volume, e.g. REQA,…
- It is allowed to do AAT after the alternating H-field is switched on and settled.
  There are no further restrictions.



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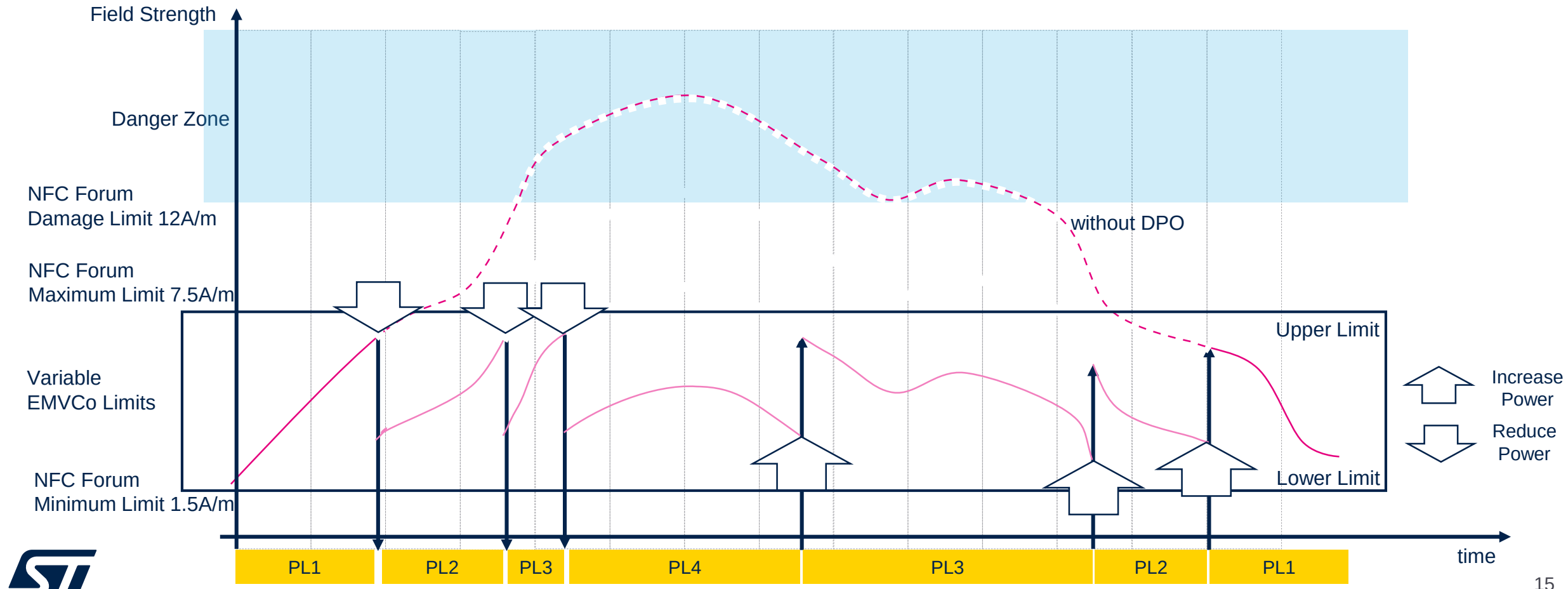
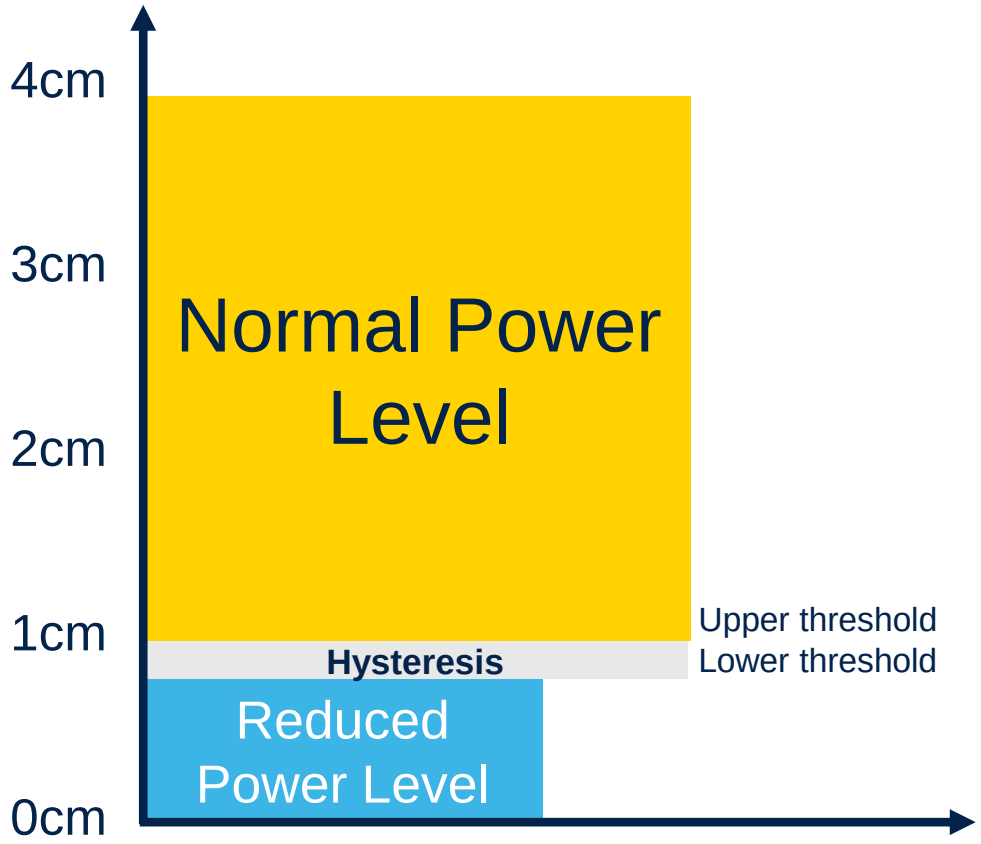
DPO: dynamic power output tweaks the power to your needs

DPO will keep power levels within requirements & limits



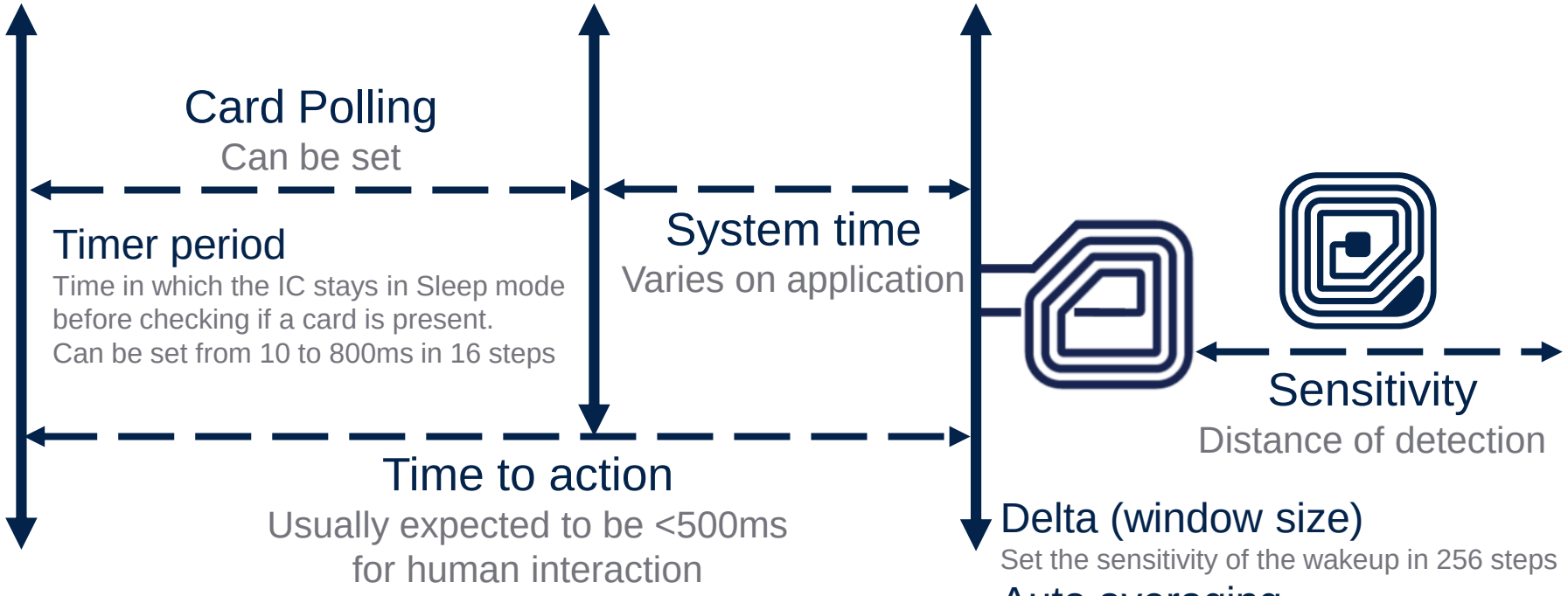
DPO: dynamic power output tweaks the power to your needs

- DPO Working Principle
  - The ST25R family is able to measure the antenna amplitude via Register 0x20 with the direct command “Measure amplitude”.
  - The antenna amplitude can be used to define certain levels/distances in which the power output defined in Register 0x27 can be changed via the driver resistance.
  - Thresholds can be set to decrease or to increase power output.



CIWU: Reduce power consumption while offering good detection range

Consider reaction time/sensitivity of the system



Automatic reference measurement

Measure the environmental influence to the capacitive sensor or the antenna
Used to calibrate the wakeup system at system start or at any required time

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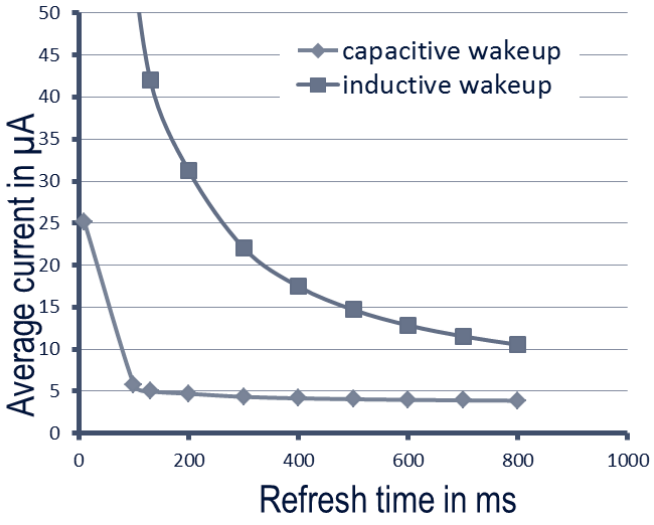
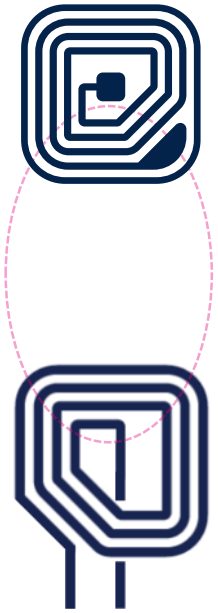
CIWU: Low power wakeup keeps the power consumption low

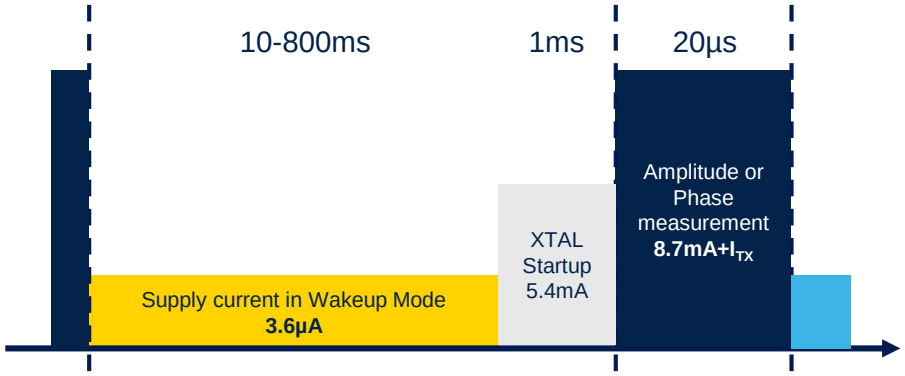
Low Power Wakeup will maximize your application lifetime





Inductive antenna

Inductive



Fully programmable wakeup scheme.
All relevant parameters like cycle time & sensitivity can be programmed and do not need MCU interaction.

Inductive wakeup

Sleep/Wakeup-Mode (10-800ms)

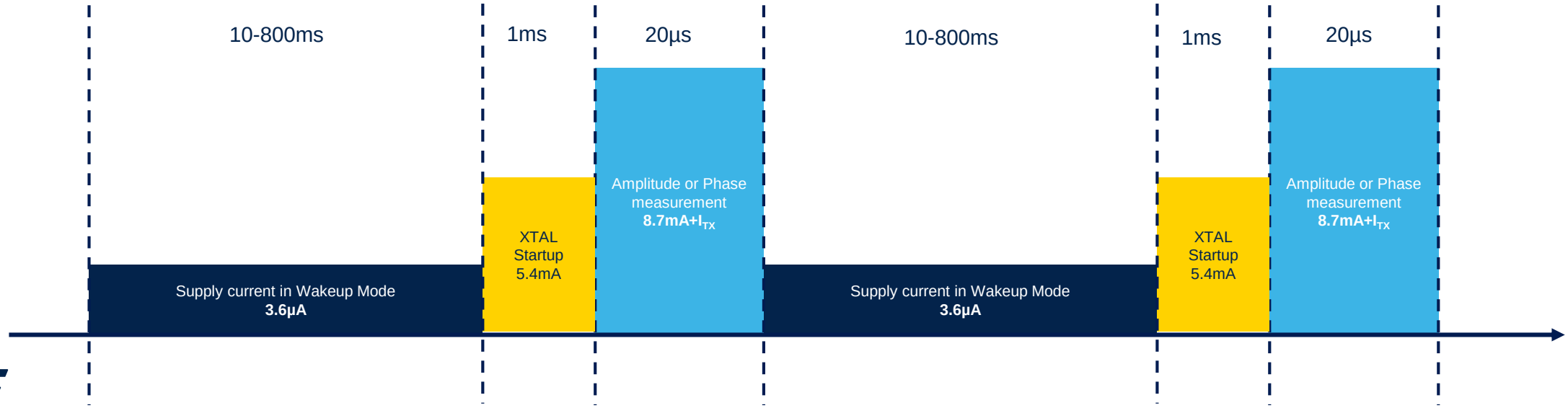
- IC will remain in low power wakeup mode before checking for a card ~3.6mAh

XTAL startup (1ms)

- Time for starting the external oscillator. ~5.4mAh

Actual measurement (20µs)

- The inductive wakeup is dedicated to detect approaching cards only ~8.7mAh + ITX



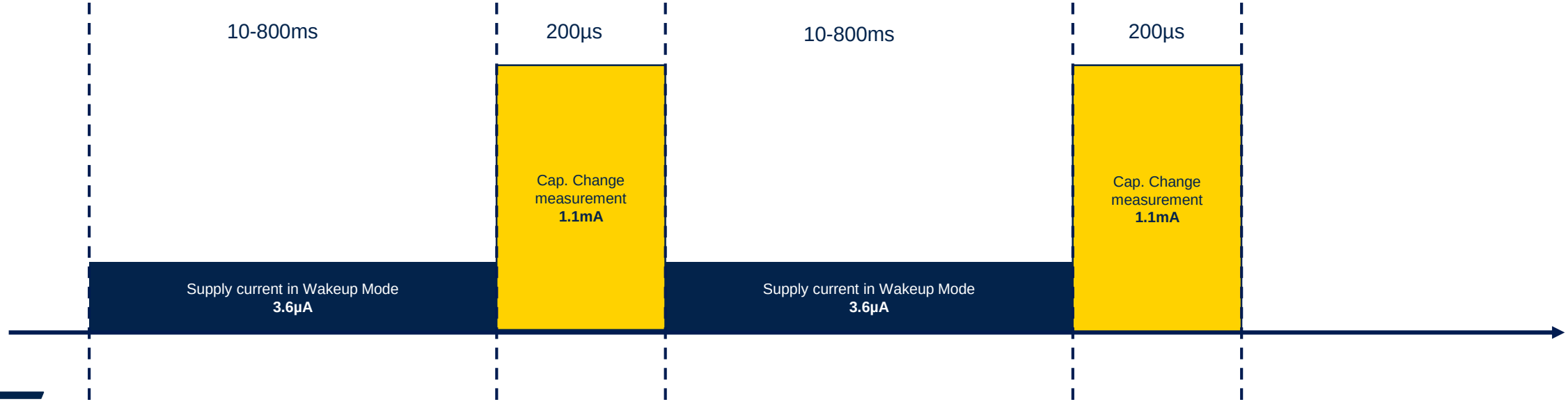
Capacitive wakeup

Sleep/Wakeup-Mode (10-800ms)

- IC will remain in low power wakeup mode before checking for a capacitive change. ~3.6µA

Actual measurement (200µs)

- The capacitive wakeup will be triggered by any capacitive change, e.g. the approach of a hand. 1.1mA



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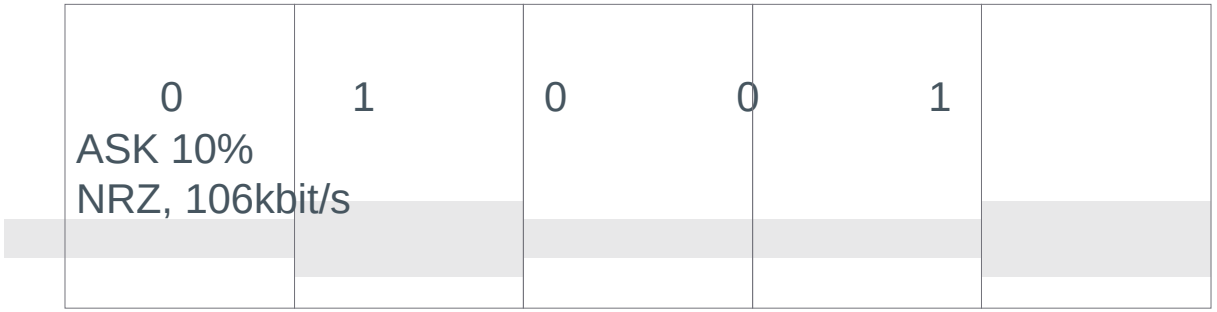
Automatic modulation depth adjustment

- for ISO14443B and ISO15693
  - ISO14443B: ASK 10% modulation index
  - ISO15693: 10-30%, 100% modulation index
- Automatic modulation depth adjustment keeps the modulation index within standard limits even under varying load conditions
- Cheaper components with higher tolerances can be used



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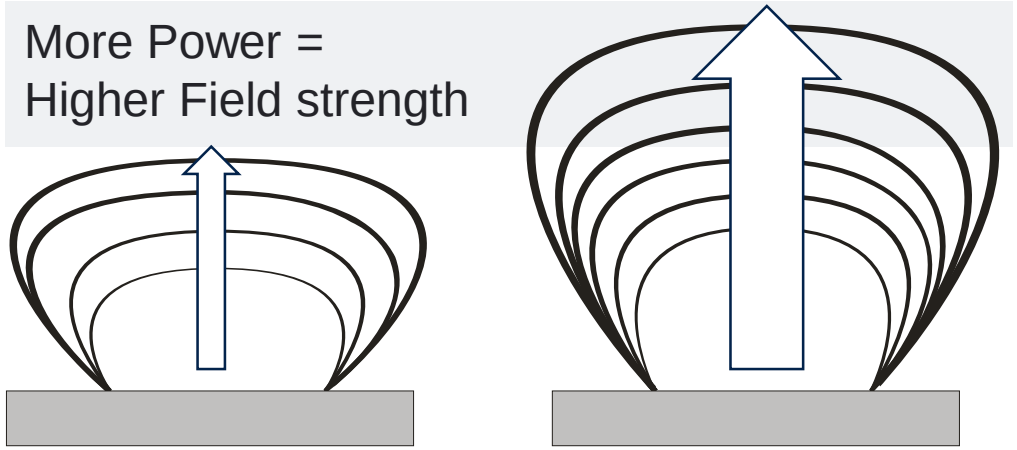
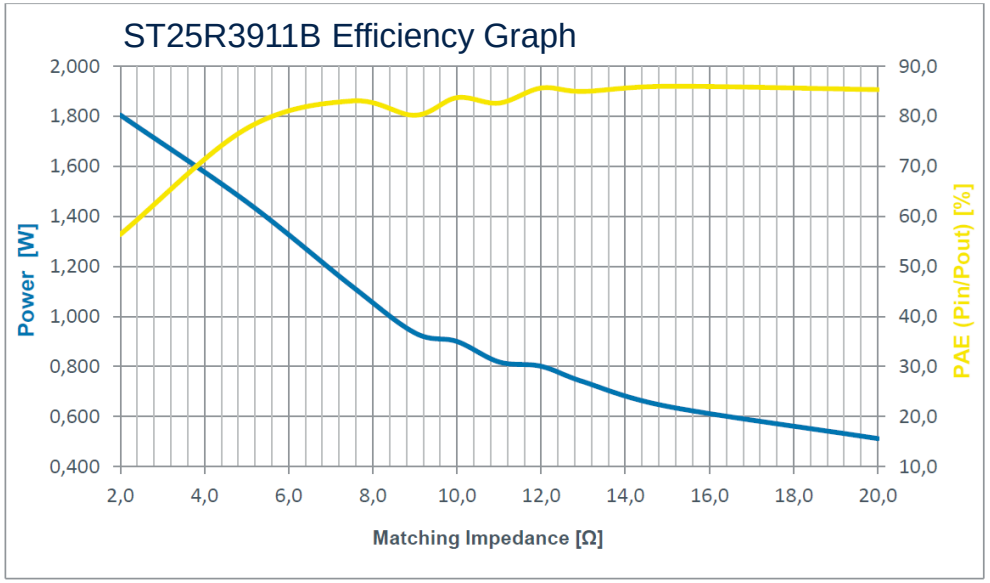
Highest output power & efficiency

- No external Booster required for POS
  - The ST25R3911B includes low impedance drivers capable of generating >1.4W of output power
  - EMVCo certification easily possible without external boosters
- Maximum transferred Power
  - “Slave” devices like interface tags are able to harvest far more energy for battery less devices
  - Ideal for sophisticated NextGen Gaming platforms
- Ideal for Challenging Environment
  - The ST25R series is able to operate in metal encapsulations like doorlocks





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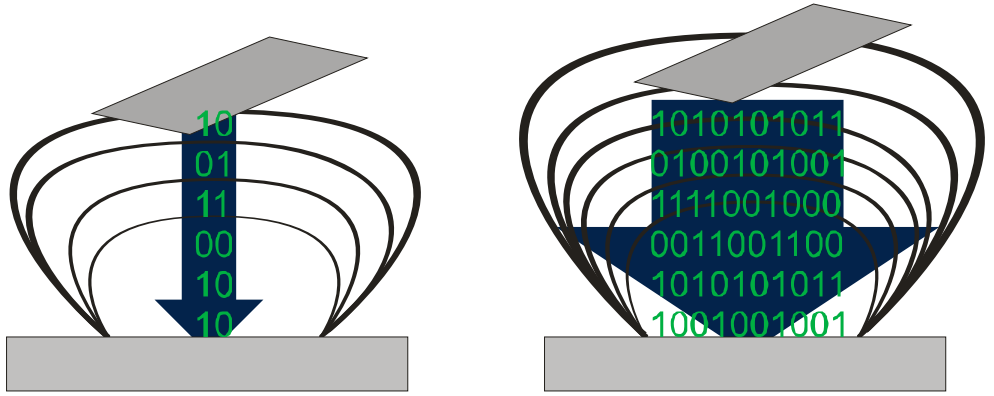
VHBR

- Very High Baud Rate (VHBR) technology allows the exchange of large amounts of data between a contactless smart card and a reader. Faster data rates create potential for new applications of NFC
- ST25R3911B supports VHBR communication without additional external components

- Ideal for eGovernment & Passport
  - The ST25R3911B increases the maximum bitrate from 848kBit to 6.8Mbit
  - 8x less transfer time reduces waiting time at boarder control and allows to increase data on eGovernment/ Healthcare cards (e.g. high-resolution images)

- 8x Faster data transfer



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Antenna option

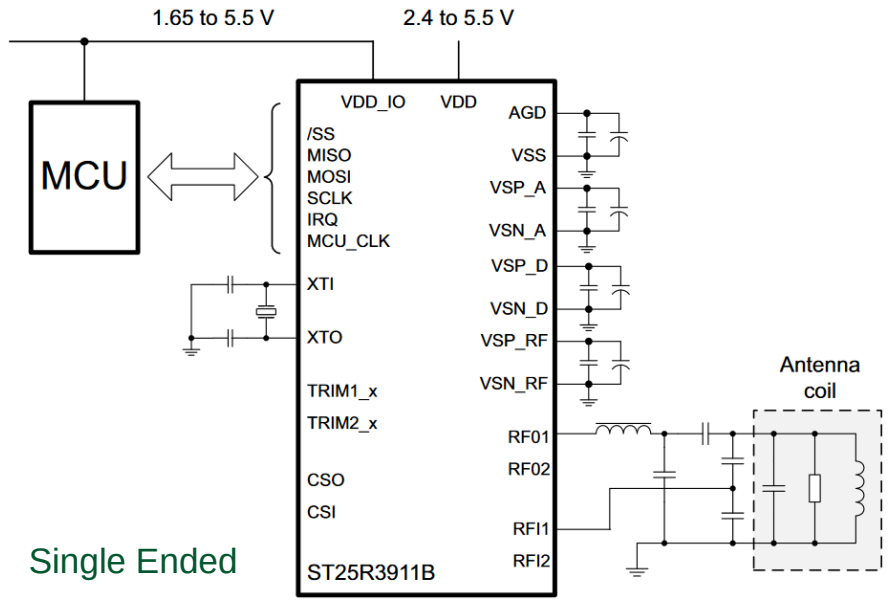
The ST25R series allows to drive two single ended antennas or one differential antenna. Address 00h is used for configuration.

For single ended antennas bit 7 must be 1. Bit 6 then allows to switch between the antenna ports.

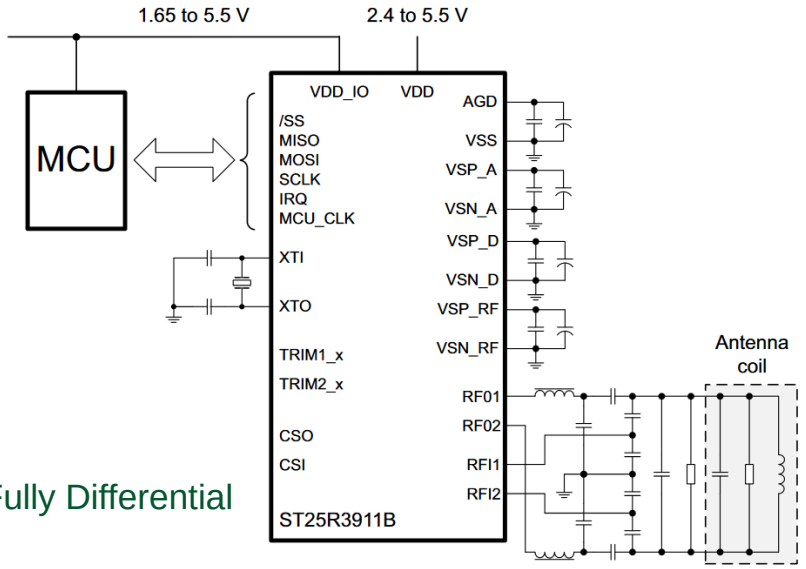
- Driving two independent antennas
- Less field strength than a differential antenna

On fully differential antennas bit 7 must be 0. bit 6 is a “don’t care”.

- Achieve the maximum field strength possible
- Less sensitive to noise, eg GND bounce



Single Ended



Fully Differential

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Functional Overview

ST25

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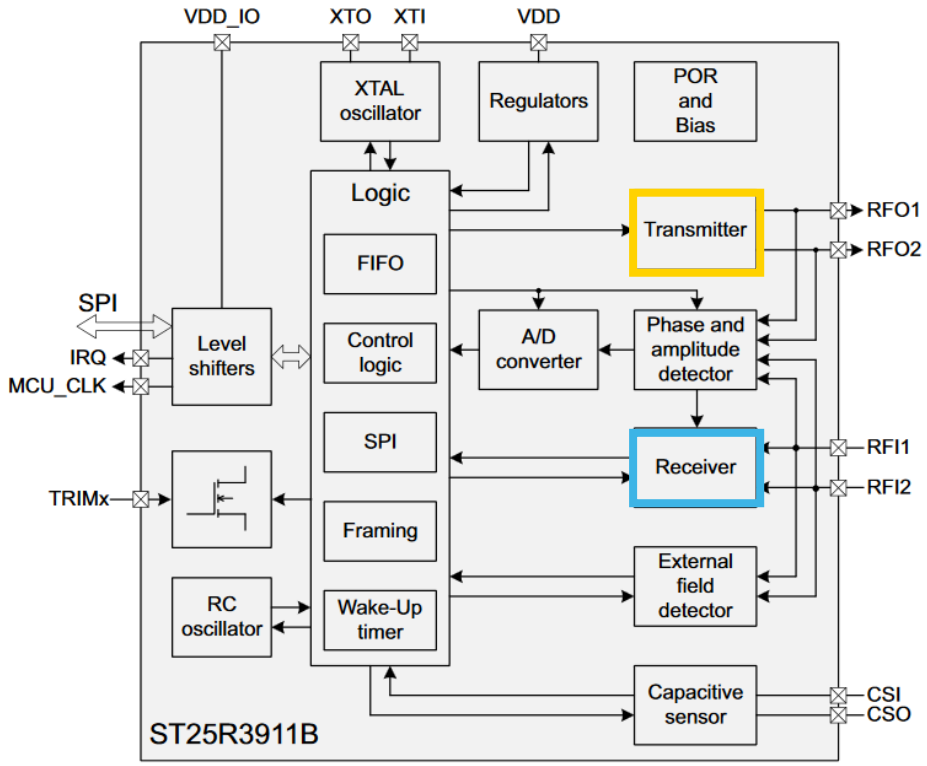
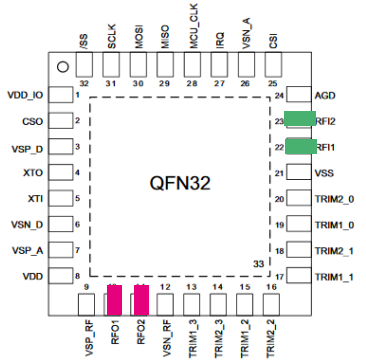
Functional overview (1/4)

- Transmitter
  - The transmitter incorporates drivers that drive external antenna through pins RFO1 and RFO2. Single sided and differential driving is possible. The transmitter block additionally contains a sub-block that modulates transmitted signal (OOK or configurable AM modulation).
  - The ST25R3911B transmitter is intended to directly drive antennas (without 50Ω cable, usually antenna is on the same PCB). Operation with 50Ω cable is also possible, but in that case some of the advanced features are not available.
- Receiver
  - The receiver detects transponder modulation superimposed on the 13.56 MHz carrier signal. The receiver contains two receive chains (one for AM and another for PM demodulation) composed of a peak detector followed by two gain and filtering stages and a final digitizer stage.
  - The filter characteristics are adjusted to optimize performance for each mode and bit rate (with sub-carrier frequencies up to 6.8MHz.
  - The receiver chain inputs are the RFI1 and RFI2 pins. The receiver chain incorporates several features that enable reliable operation in challenging phase and noise conditions.

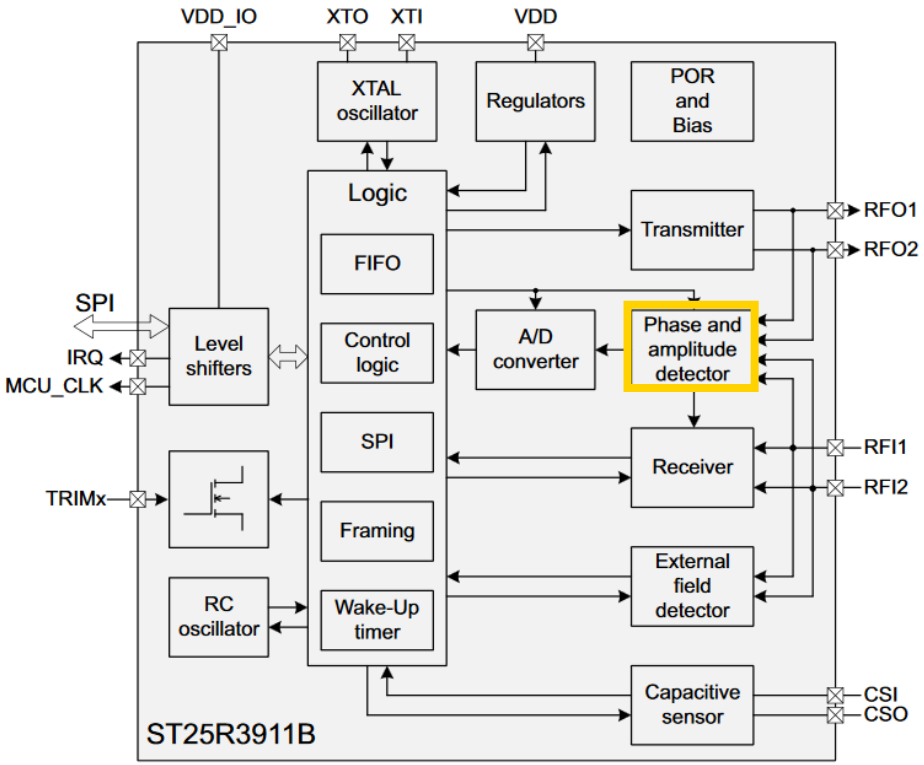


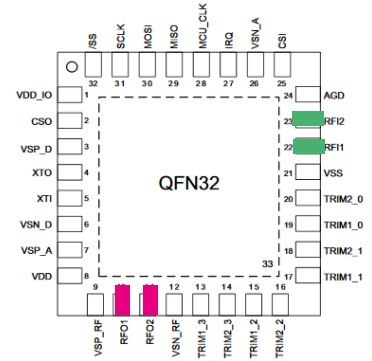


Functional overview (2/4)

- Phase and amplitude detector
  - The phase detector is observing the phase difference between the transmitter output signals (RFO1 and RFO2) and the receiver input signals (RFI1 and RFI2). The amplitude detector is observing the amplitude of the receiver input signals (RFI1 and RFI2) via self-mixing. The amplitude of the receiver input signals (RFI1 and RFI2) is directly proportional to the amplitude of the antenna LC tank signal.

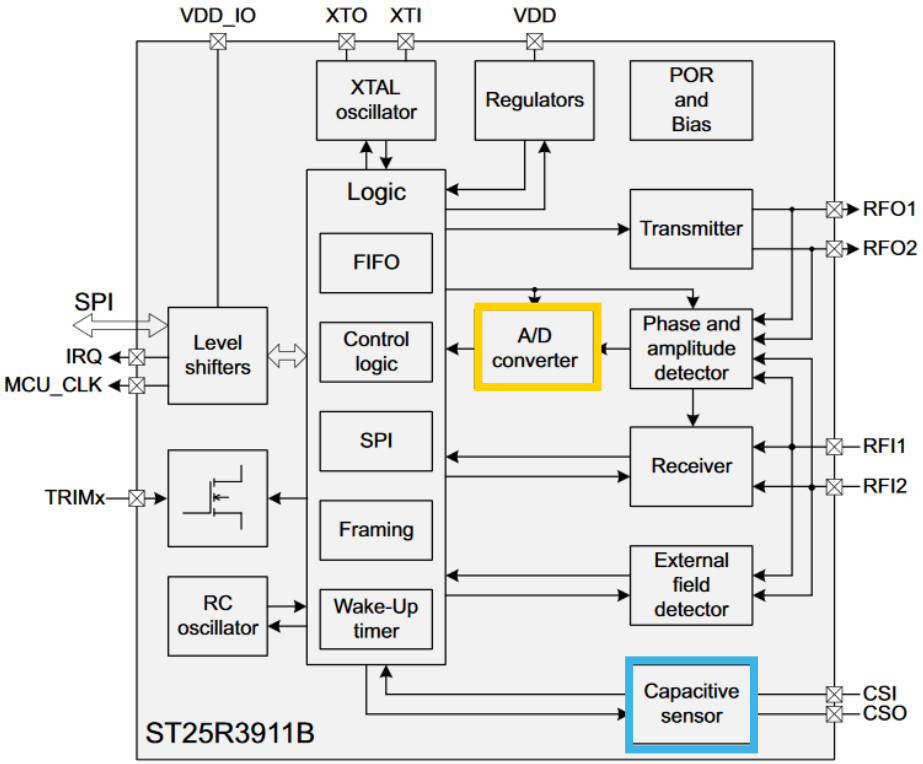
- The phase detector and the amplitude detector can be used for the following purposes:
  - Doing PM demodulation by observing RFI1 and RFI2 phase variation
  - Checking average phase difference between RFOx pins and RFIx pins and optimize antenna tuning
  - Measure amplitude of signal present on RFI1 and RFI2 pins is used to check and optimize antenna tuning.

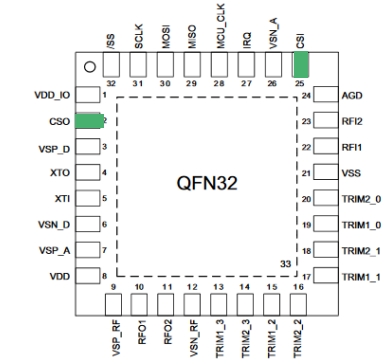




Functional overview (3/4)

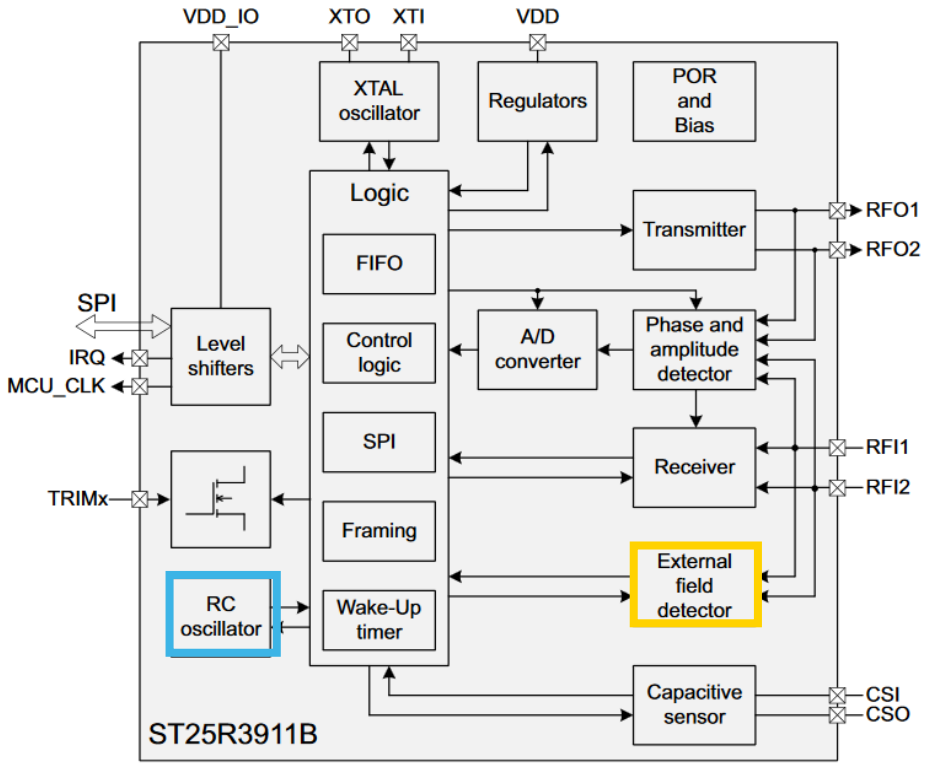
- A/D converter
  - The ST25R3911B contains a built in Analog to Digital (A/D) converter. Its input can be multiplexed from different sources and is used in several applications (measurement of RF amplitude and phase, calibration of modulation depth...). The result of the A/D conversion is stored in the A/D Converter Output Register and can be read via SPI.
- Capacitive Sensor
  - The capacitive sensor is used to implement low power detection of transponder presence, it measures the capacitance between two copper patches connected to the CSI and CSO pins. The capacitance changes with the presence of an object (card, hand). During calibration the reference capacitance (representing parasitic capacitance of the environment) is stored. In normal operation the capacitance is periodically measured and compared to the stored reference value, if the measured capacitance differs from the stored reference value by more than a register defined threshold, then an interrupt is sent to the external controller.

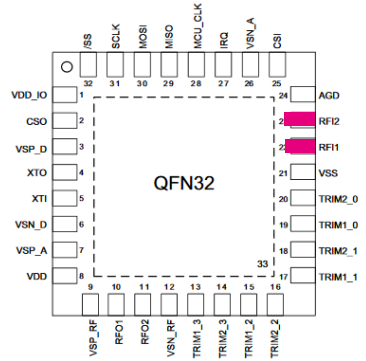




Functional overview (4/4)

- External field detector
  - The External field detector is a low power block used in NFC mode to detect the presence of an external RF field. It supports two different detection thresholds, Peer Detection Threshold and Collision Avoidance Threshold. The Peer Detection Threshold is used in the NFCIP-1 target mode to detect the presence of an initiator field, and is also used in active communication initiator mode to detect the activation of the target field. The Collision Avoidance Threshold is used to detect the presence of an RF field during the NFCIP-1 RF Collision Avoidance procedure.
- Quartz crystal oscillator
  - The quartz crystal oscillator can operate with 13.56 MHz and 27.12 MHz crystals. At start-up the trans conductance of the oscillator is increased to achieve a fast start-up. The start-up time varies with crystal type, temperature and other parameters, hence the oscillator amplitude is observed and an interrupt is sent when stable oscillator operation is reached.
  - The use of a 27.12 MHz crystal is mandatory for VHBR operation.





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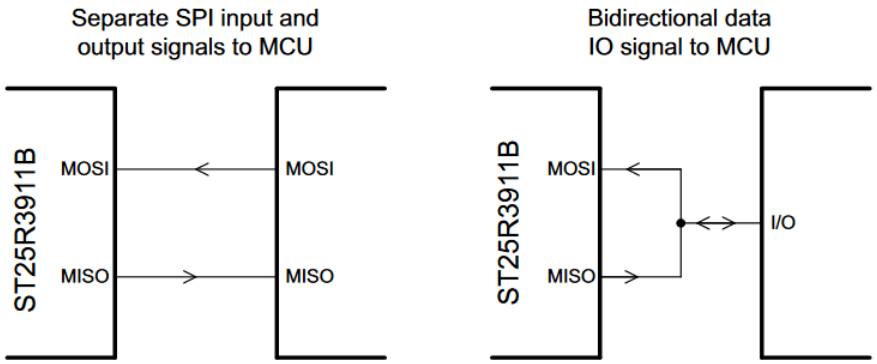
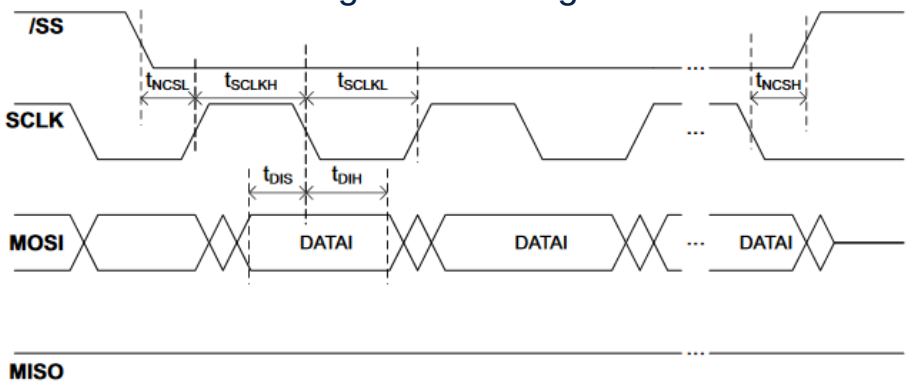
Communication with external MCU

- The ST25R3911B is a slave device and the external microcontroller initiates all communication
- Communication is performed by a 4-wire Serial Peripheral Interface (SPI)
  - The ST25R3911B sends an interrupt request (pin IRQ) to the microcontroller, which can use clock signal available on pin MCU_CLK when the oscillator is running



SPI general timing

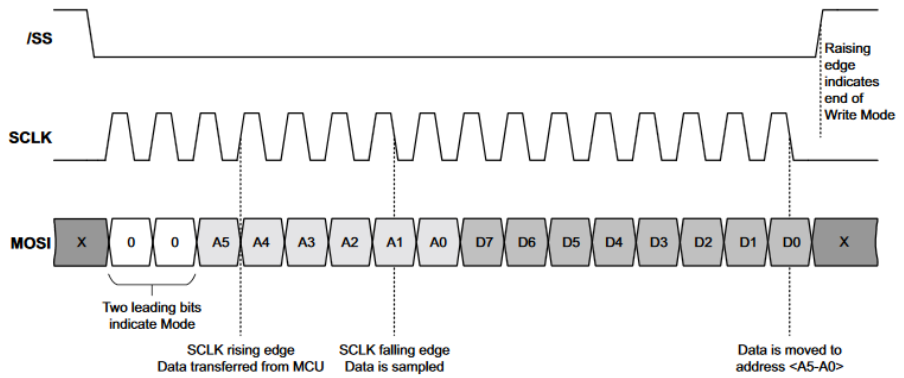


Symbol	Parameter	Min	Typ	Max	Unit	Comments
General timing (V_{DD} = V_{DD_IO} = V_{SP_D} = 3.3 V, 25 °C)						
T_{SCLK}	SCLK period	167	-	-	ns	T_{SCLK}=T_{SCLKL}+T_{SCLKH}, use of shorter SCLK period may lead to incorrect FIFO operation.
T_{SCLKL}	SCLK low	70	-	1		-
T_{SCLKH}	SCLK high	70	-	-		-
T_{SSH}	SPI reset (/SS high)	100	-	-		-
T_{NCSL}	/SS falling to SCLK rising	25	-	-		First SCLK pulse
T_{NCSH}	SCLK falling to /SS rising	300	-	-		Last SCLK pulse
T_{DIS}	Data in set-up time	10	-	-		-
T_{DIH}	Data in hold time	10	-	-		-
Read timing (V_{DD} = V_{DD_IO} = V_{SP_D} = 3.3 V, 25 °C, C_{LOAD} ≤ 50 pF)						
T_{DOD}	Data out delay	-	20	-	ns	-
T_{DOHZ}	Data out to high impedance delay	-	20	-		-

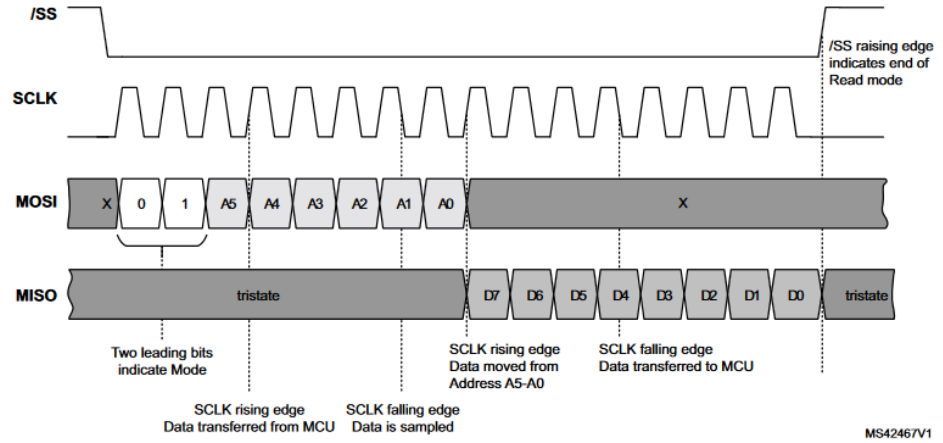
Communication with external MCU

- Writing data to addressable registers (Write mode)
  - After the SPI operation mode bits, the address of register to be written is provided.
  - Then one or more data bytes are transferred from the SPI, always from the MSB to the LSB. The data byte is written in register on falling edge of its last clock.
- Reading data from addressable registers (Read mode)
  - After the SPI operation mode bits the address of register to be read has to be provided from the MSB to the LSB.
  - Then one or more data bytes are transferred to MISO output, always from the MSB to the LSB. As in case of the write mode also the read mode supports auto-incrementing address.
  - MOSI is sampled at the falling edge of SCLK (like shown in the following diagrams), data to be read from the ST25R3911B internal register is driven to MISO pin on rising edge of SCLK and is sampled by the master at the falling edge of SCLK.

Writing a single byte



Reading a single byte



Evaluation boards & ecosystem

ST25

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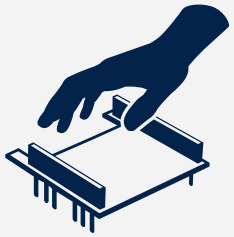
ST25R rich eco-system



- Dicovery kits based on STM32 MCU
- STM32 Nucleo boards ecosystem
- STM32Cube software ecosystem

- Antenna e-design tool
- Schematic, BOM
- Gerber files

- PC software tool ST25
- MCU drivers firmware

- Documentation
- e2e community
- Webinar / MOOC
- Training

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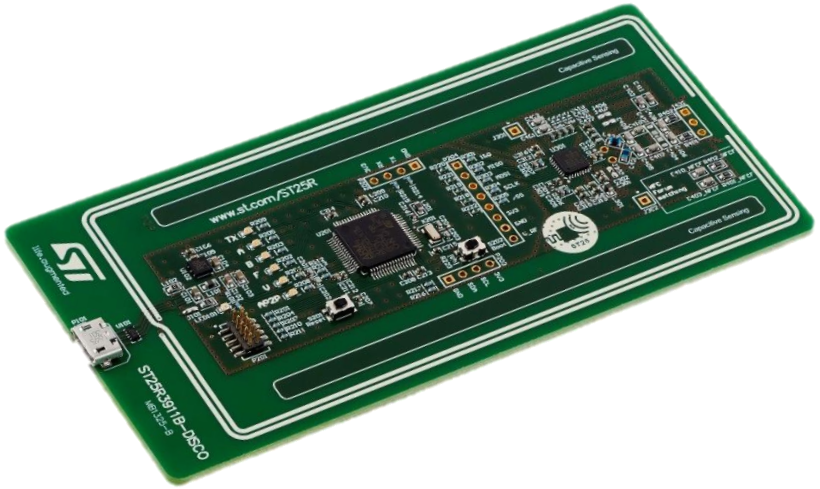
Evaluation boards



ST25R3911B-DISCO

X-NUCLEO-NFC05A1

ST25R3911B-EMVCO

ST25R3911B discovery kit

- **ST25R3911B** HF reader / NFC initiator IC
- 105x52mm 2 turns antenna and associated VHBR tuning circuit
- STM32L476RET6 32-bit MCU
- Micro-USB connector
- Additional UART / I²C Host interfaces, as well as NFC SPI and JTAG/SWD points

ST25R3911B Nucleo shield

- **ST25R3911B** HF reader / NFC initiator IC
- 47x34mm 4 turns antenna
- Compatible with STM32 Nucleo boards
- Equipped with Arduino™ UNO R3 connector

ST25R3911B EMVCO kit

- **ST25R3911B** HF reader / NFC initiator IC
- 65x74mm 2 turns antenna etched on PCB
- STM32L476 32-bit MCU
- Micro-USB connector
- Comprehensive Device Test Environment (DTE) for EMVCo Level 1 FW control
- S-Touch controller

ST25R3911B discovery kit and Nucleo shield are also valid for ST25R3912

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Solutions for NFC / RFID Tags & Readers

ST25

ST25 SIMPLY MORE CONNECTED

Thank you

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