

BLE in Automotive – A Paradigm Shift

Emmanuel Sambuis

Vice President MCU and Connectivity
BL MICR

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SECURE CONNECTIONS
FOR A SMARTER WORLD

Agenda

- System Outlook
- Automotive BLE Portfolio
- Ranging and Localization
- BLE TPMS System
- Parts Numbers and Contacts



01. System Outlook



Bluetooth in Automotive | A Paradigm Shift

- **Smart Mobile Devices as the Digital Key**

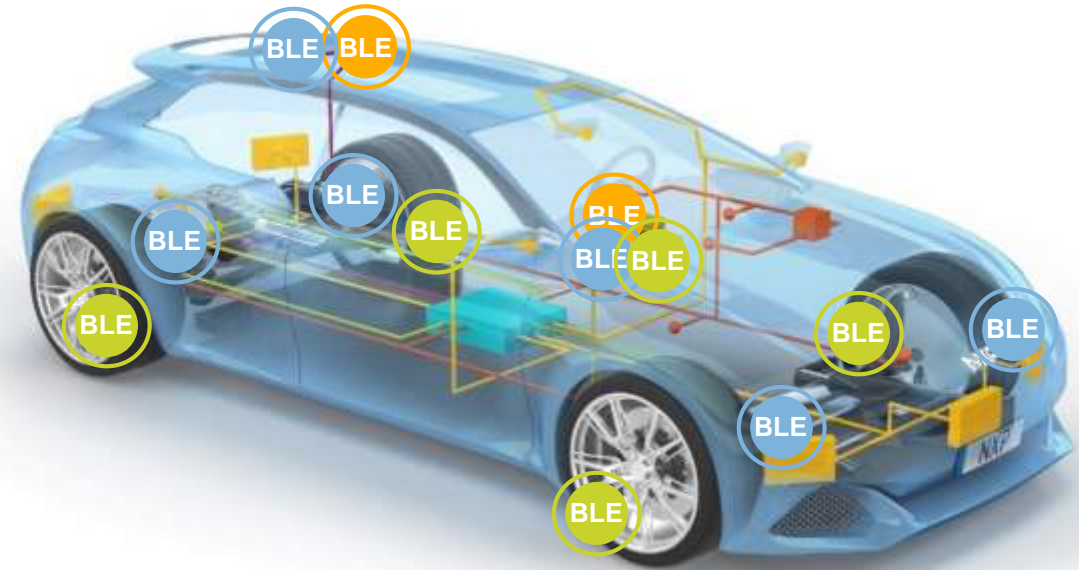
- Secured information is sent to the vehicle to lock/unlock or start the engine start.
- Sometimes combined with NFC and UWB for full security and convenience
- Enable Fleet management, Car Sharing and Car Rentals

- **Secure Key Fobs**

- BLE is integrated in the Key Fob for RKE (Remote Key Entry) to communicate directly with the car replacing Sub-1GHz communication
- BLE can be used for location use case
 - Passive Entry Passive Start (PEPS)
 - Welcome light and vehicle customization settings

- **Vehicle Condition & Status Monitoring**

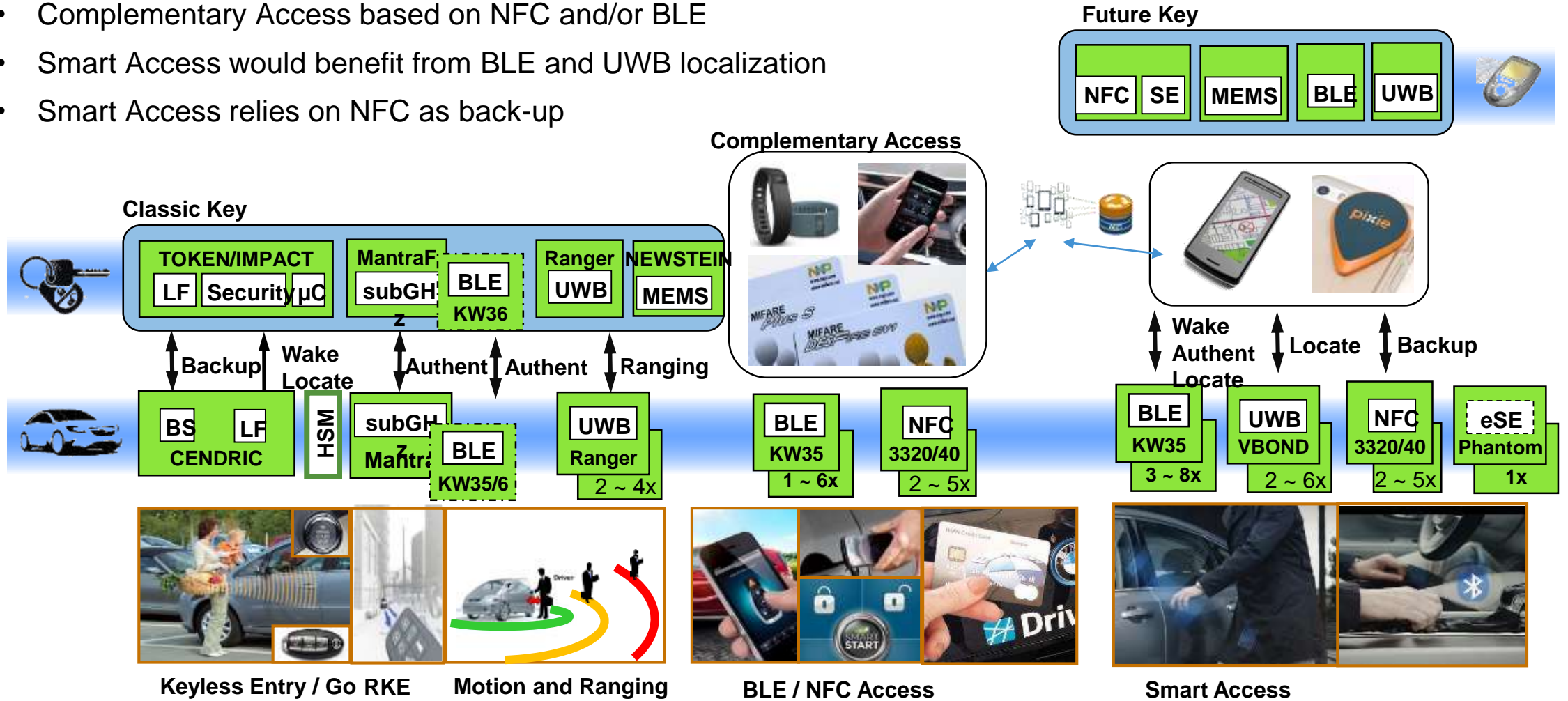
- Leverage BLE in the car for monitoring & updating vehicle status to Driver Information System & smart phone



System Outlook – From Classic Key to Smart Access

- Key Entry requires Relay Station Defense means
- Complementary Access based on NFC and/or BLE
- Smart Access would benefit from BLE and UWB localization
- Smart Access relies on NFC as back-up

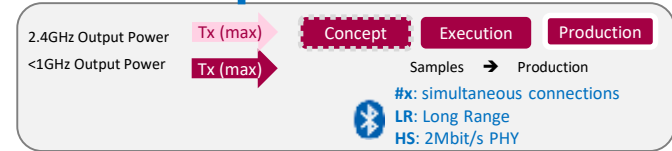
System Mkt



02. Automotive BLE Portfolio



Next-Gen Secure Connected MCU Roadmap



2.4GHz band

Consumer and Industrial

4.2, 2x, **KW21/31/41Z** +3.5dBm

48 MHz M0+, 512 kB Flash, 128 kB SRAM
48LQFN, 75WLCSP

5 w/ HS + LR, 12x, **K32W143Hx (HYPNOS)** +10dBm

96 MHz M33 (<35 uA/MHz), 1.5 MB Flash, 384 kB SRAM, USB FS,
ARM TrustZone, Security Crypto Accel., VFBGA, QFN

5, 8x, **K32W022/32/42S** +3.5dBm

96 MHz M4 (<70 uA/MHz) & M0+
1.25 MB Flash, 384 kB SRAM, Security Crypto,
176VFBGA, 191WLCSP

5 w/ HS + LR, 4x **K32W133Gx (APHRODITE)** +10dBm

64MHz M33, 256 kB Flash, 48 kB SRAM, 256 kB ROM
Security, 32QFN, Small CSP/BGA

Automotive Qualified

5, 8x **KW35/36A** +3.5dBm

48 MHz M0+, 512 kB Flash w/ ECC, 64 kB SRAM, EEPROM,
AES-128, CAN (KW36), LIN
40QFN/48LQFN, AEC-Q100 Grade 2

5, w/ LR+HS, 8x **KW37/38A** +5dBm

48 MHz M0+, 512 kB Flash w/ ECC, 64 kB SRAM, EEPROM,
AES-128, CAN (KW36), LIN
48LQFN, AEC-Q100 Grade 2

5.x w/ HS + LR, 8x **K32W133Gx (Fangio)** +7Bm

64MHz M33, 320 kB Flash with ECC,
48 kB SRAM, 256 kB ROM
Security, 32QFN/40QFN wettable flanks
CAN-FD and LIN, AEC-Q100 grade 2

2H17

2018

2019

2020



Kinetis KW35/36 MCU Family | Features

Core/Memory/System

- Arm® Cortex®-M0+ running up to 48 MHz
- KW35: 512kB (2x256kB, swappable) Program Flash with ECC; OR
- KW36: 256kB Program Flash + 256kB FlexNVM both with ECC;
- 64 kB SRAM
- KW36: 8 KB of user-segment defined byte write/erase EEPROM
 - Allocation of FlexNVM (minimum 32kB) to EEPROM emulation will determine effective endurance
- Four independently programmable DMA controller channels

Radio

- Support for BLE v5.0 and Generic FSK
- Rx Sensitivity, -95 dBm BLE ,
- -25 to +3.5 dBm programmable output power
- Increased coexistence performance; Radio I/O for Wi-Fi coexistence
- 6.8 mA Rx & 6.1mA Tx (0dBm) current target (DC-DC enabled)
- Integrated balun (~9% board area savings)
- Support for 8 concurrent connections

Communications/HMI/Timers

- 2xSPI, LP-UART with LIN, 2xI2C, CMT, GPIO with IRQ capability (KBI)
- KW36: CAN-FD and 2nd UART with LIN
- 3x FlexTimer (TPM) with PWM & quadrature decode support
- Low Power (LPTMR), Programmable Interrupt (PIT) and RTC timers

Analog

- 16-bit ADC with integrated temperature sensor and battery monitor
- 6-bit High-speed Analog Comparator

Security

- AES Accelerator and True Random Number Generator
- Advanced flash security

Integrated DC/DC Converter

- Normal: 1.71V to 3.6V
- Buck : 2.1V to 4.25V

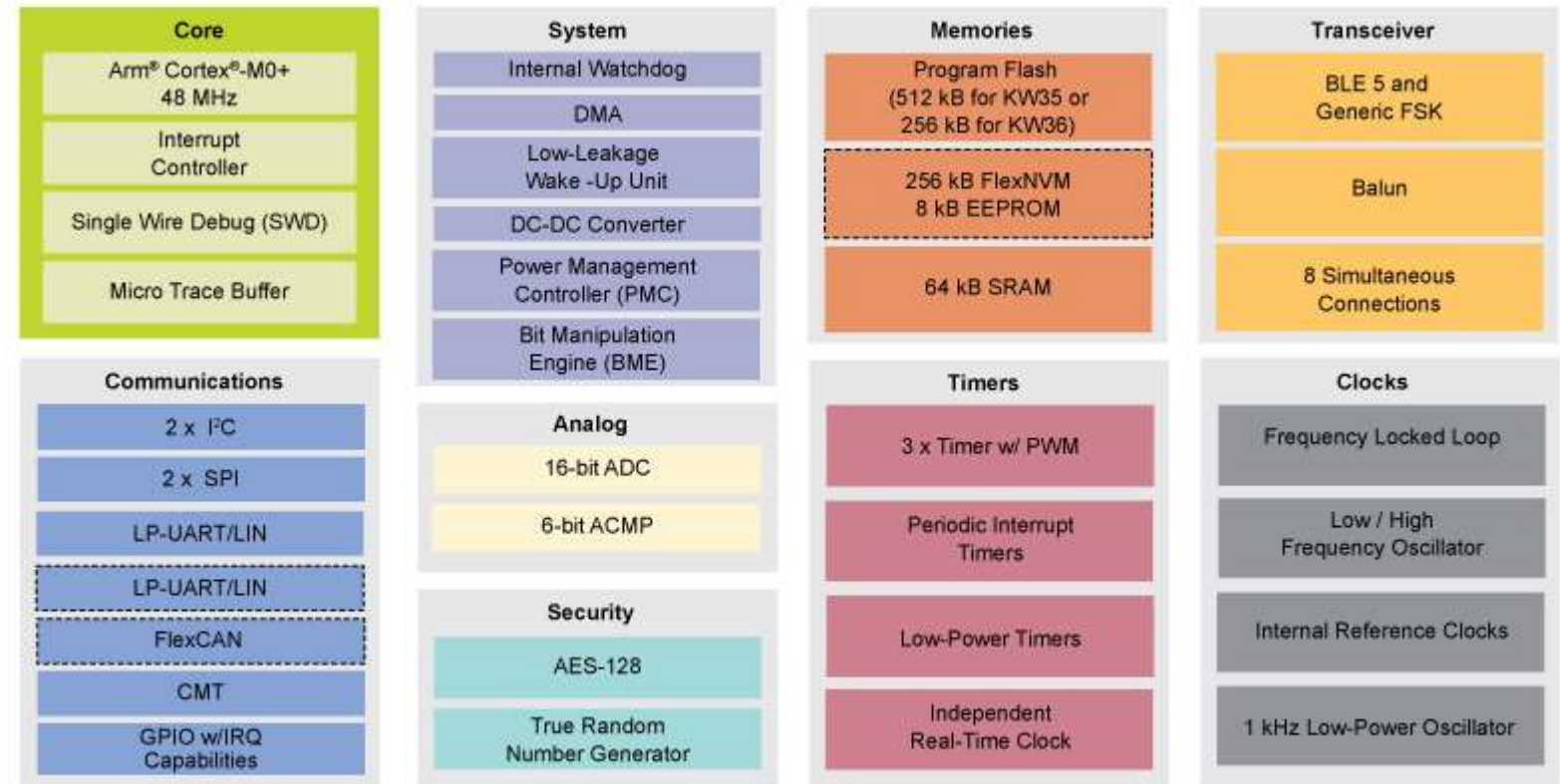
Unique Identifiers


- 80-bit device ID programmed at factory
- 40-bit unique number can be used for Bluetooth Low Energy

AEC Q100 Grade 2 (KW35/KW36A version only)

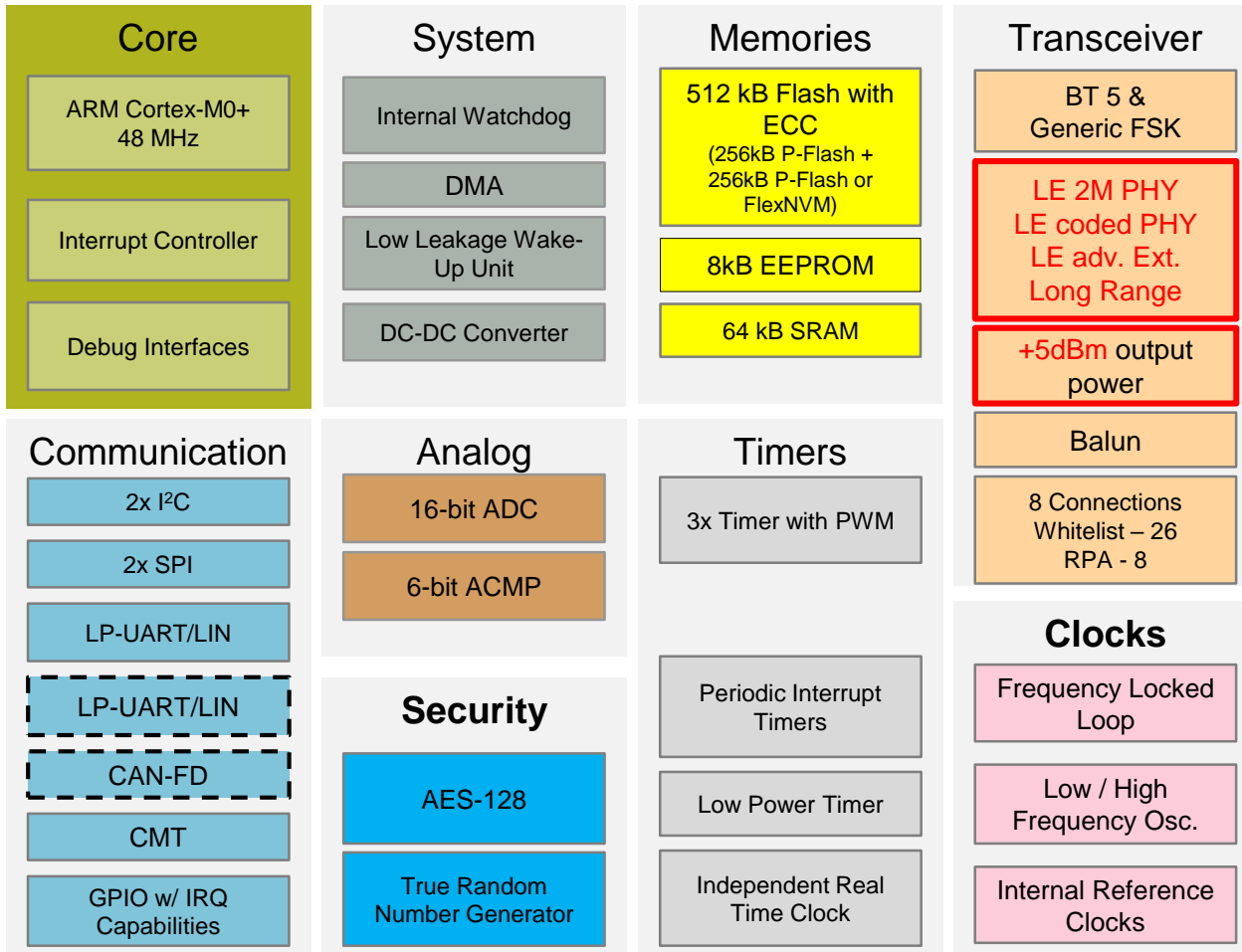
Operating Range (Ambient): -40°C to +105°C

Mass Production NOW



 Kinetis KW36 wireless MCU only

Kinetis KW37/38 MCU Family | Features



Changes from KW35/36

Samples Available Q2 2019
Qualified devices Q4 2019

New IP vs KW35/36A

- **BLE PHY** (Digital IP, same as Aphrodite)
- **BLE Link Layer** (Digital IP, same as Aphrodite)

Modified IPs vs KW35/36A

- Increase **output power** to +5dBm(Analog IP, option already available in KW35/36A that need to be qualified)

New package

- 7x7 wettable flanks QFN48
- Has driven a new QFN48 package for KW35/36A

Kinetis Fangio MCU Family | Features in Discussion

Core/Memory/System

- Cortex-M33 running up to 64MHz
- 320kB (2x160kB, swappable) Program Flash with ECC;
- 48 kB SRAM
- 8 independently programmable DMA controller channels

Radio

- Support for BLE v5.x and Generic FSK
- Rx Sensitivity, -97 dBm @1Mbs BLE
- Rx Sensitivity -106dBm BLE 125kBps LR mode
- +7dBm programmable output power
- 3mA Rx & 3mA Tx (0dBm) current target (DC-DC enabled)
- 8mA Tx @ +7dBm current target (DC-DC enabled)
- Deep Sleep mode < 300nA
- Support for 8 concurrent connections

Communications/HMI/Timers

- 2xSPI, 2x LP-UART with LIN, 2xI2C, CMT, GPIO with IRQ capability (KBI)
- CAN-FD
- 2x6channels TPM with PWM & quadrature decode support
- Low Power (LPTMR), Programmable Interrupt (PIT) and RTC timers

Analog

- 16-bit ADC with integrated temperature sensor and battery monitor
- 8-bit High-speed Analog Comparator

Security

- Crypto acceleration Unit supporting
- AES-128/192/256
- ECB, CBC,CFB, OFB,CTR ,CBC-MAC
- RSA- 1024/2048/3072/4096 ,ECC INST P –256/384, ECDSA/DSA
- SHA – 1/2/256
- Advanced flash security

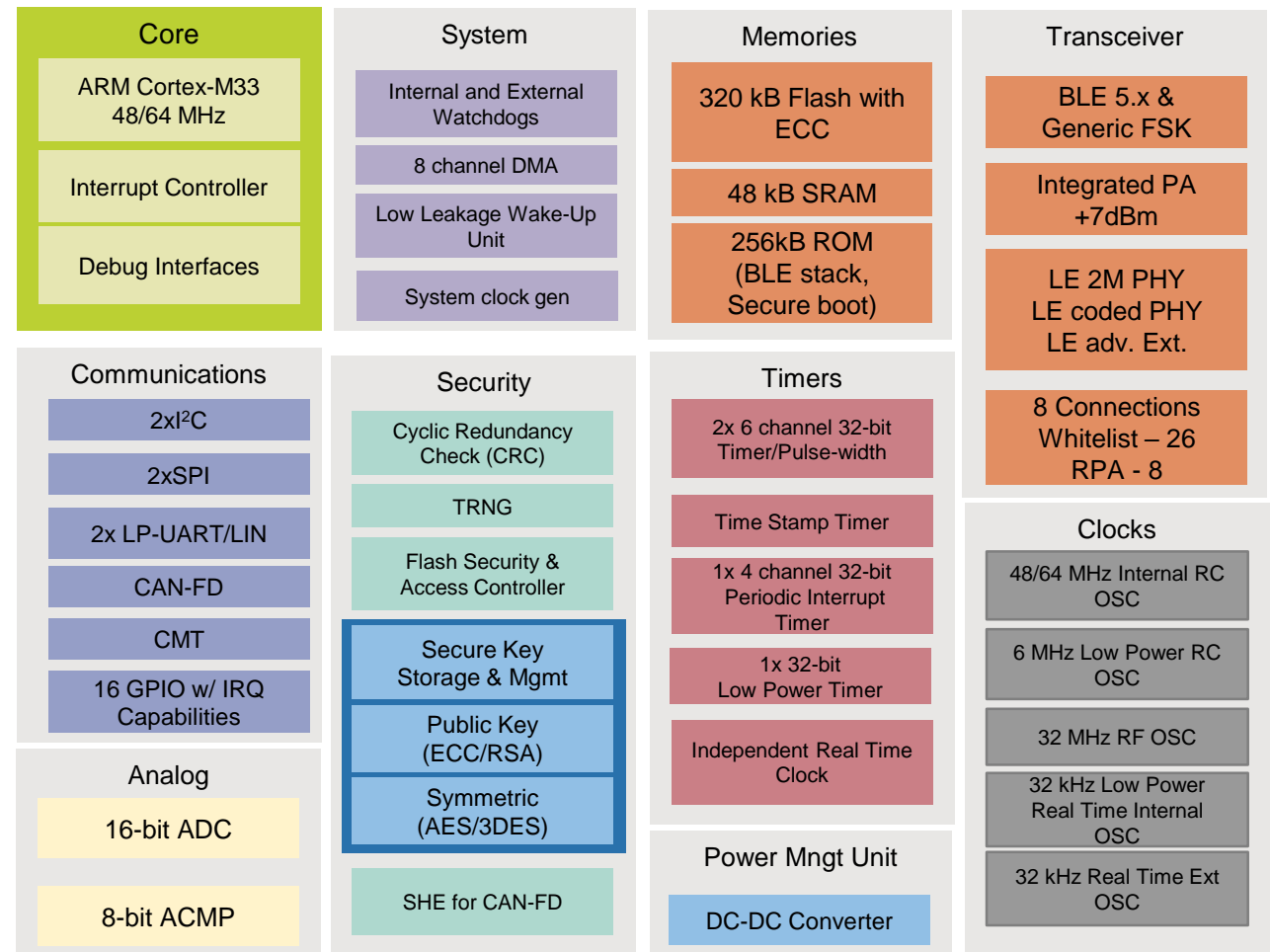
Integrated DC/DC Converter

- Normal: 1.95V to 3.6V
- Buck : 2V to 3.6V

Package

- 5x5 wettable Flank QFN
- 6x6 wettable Flank QFN

AEC Q100 Grade 2 Operating Range (Ambient): -40°C to +105°C



Summary of Bluetooth Low Energy 5 Features



Version of Standard	Features	Description	Category	KW35A	KW37A	Fangio
5.0	Errata	Core spec Errata of 4.2	Mandatory	☑	☑	☑
	LE 2M PHY	Higher data rate	Optional	x	☑	☑
	LE coded PHY	Longer range, reduced data rate support of 125/500kbps. Only available on LE 1M PHY	Optional	x	☑	☑
	LE advertising extensions	Enable longer advertising packet, more advertising channels, and more advertising type	Optional	x	☑	☑
	High Duty Cycle Non-connectable Advertising	Reduced the minimum advertising interval for non-connectable advertising, enable high duty cycle beacon	Optional	x	☑	☑
	LE Channel Selection Algorithm #2	Enable channel selection in sub-event	Optional	x	☑	☑

Kinetis KW35/36 MCU Family | Enablement

Software and Tools

- Common SDK framework (SDK 2.0) as Kinetis and LPC microcontrollers
- Common toolkit across Kinetis and LPC microcontrollers
- Support MCUXpresso and IAR
- Common NXP Bluetooth Low Energy host stack as KW31Z serials
- Shared iOS/Android App - Kinetis BLE toolbox



Hardware

- FRDM-KW36 Freedom Development Board
 - Includes MKW36Z512VHT4
 - Can be configured as Host or Shield for connection to Host Processor
 - Supports all DC-DC configurations
 - PCB inverted F-type antenna
 - Minimum number of matching components
 - FCC Part15 & EN300 328 compliant
 - Serial Flash for OTA firmware upgrades
 - On board NXP FXOS8700CQ digital sensor, 3D Accelerometer ($\pm 2g/\pm 4g/\pm 8g$) + 3D Magnetometer
 - CAN/LIN connectivity
 - OpenSDA and JTAG debug
 - Full MCUXpresso support
- USB-KW41Z: USB dongle for sniffer operations for Kinetis wireless MCUs with 2.4 GHz BLE, and generic FSK



KW35/36 is Now Available in Volume Production!

<https://www.nxp.com/products/wireless/bluetooth-low-energy-ble:BLUETOOTH-LOW-ENERGY-BLE>

	Target Completion date
BLE 5.0 Certification	DONE
CAB qualified (PPAP)	DONE
Software : Production Release	DONE
R-Gate : Product Release Mass Market Introduction	DONE

<http://www.nxp.com/Wireless/KinetisKW35>

Bluetooth Listings

<https://launchstudio.bluetooth.com/Listings/Search>

Advanced Search ▾

NXP Semiconductors



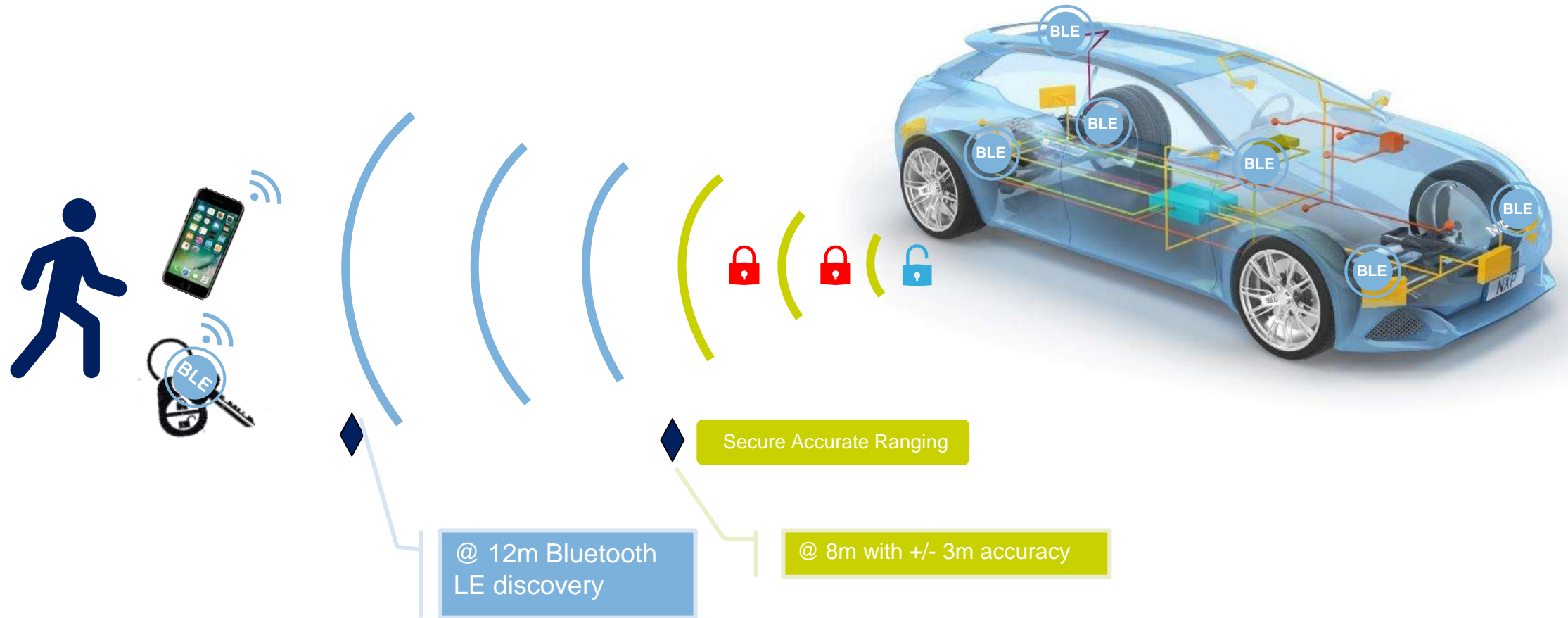
Reset

Declaration ID	QDID(s)	Company	Products	Specification Name	Listing Date
D038956	110727 - Component (Tested)	NXP Semiconductors	Kinetis KW35A/KW36A and KW35Z/KW36Z BLE 5.0 Host, Kinetis BLE 5.0 Host	5.0	2018-04-11
D038955	108102 - Component (Tested)	NXP Semiconductors	Kinetis KW35A/KW36A and KW35Z/KW36Z BLE 5.0 Controller, Kinetis BLE 5.0 Controller	5.0	2018-04-11

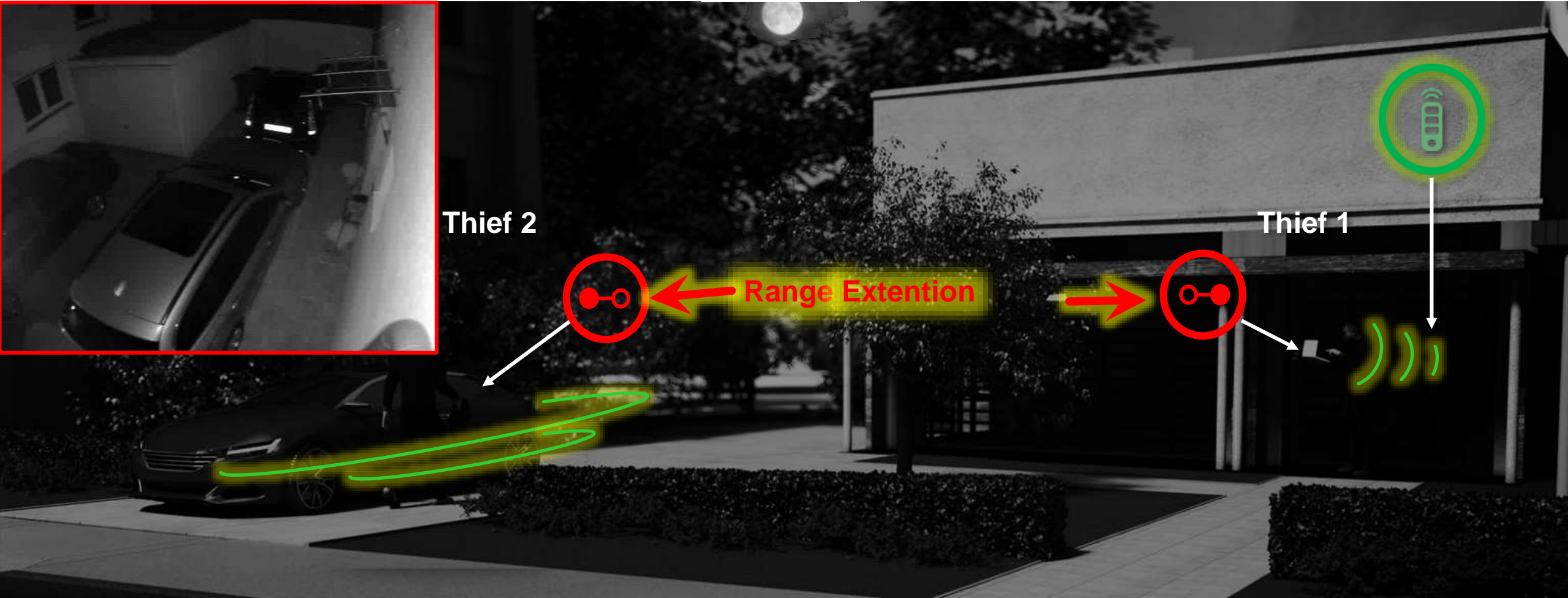
03. Ranging and Localization



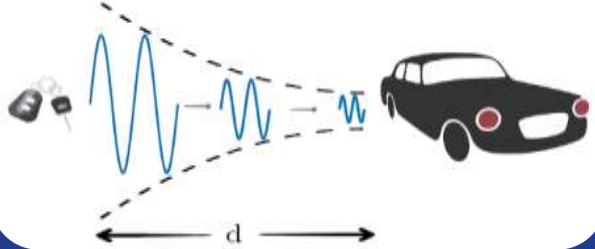
Ranging in Automotive



Relay Attack Threats Convenience – Driveway Attack

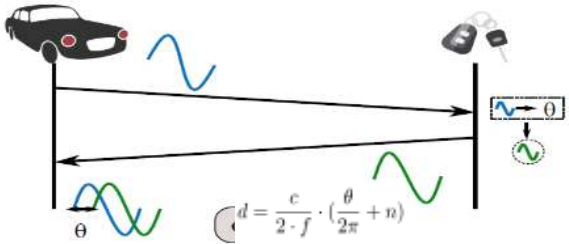


Wireless Ranging Techniques Examples



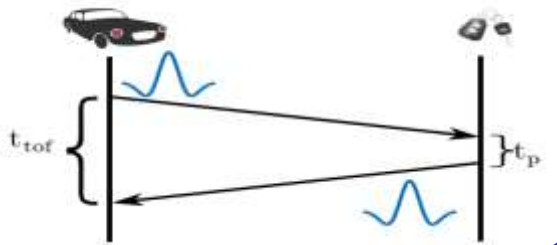
RSSI-based distance estimation

- Derived from free space path loss equation
- Acceptable accuracy within $\sim 1\text{m}$ range, progressively worse beyond
- Example: Bluetooth-based proximity (i.e. beacons)



Phase-based distance estimation

- Derived from phase difference between a received continuous wave signal and a local reference signal
- Good accuracy in environments with little multipath
- Example: Bluetooth Location Based Systems



Time-of-Flight distance estimation

- Round-trip Time-of-Flight: Distance is $(t_{tof} - t_f)/2 \cdot \text{speed of light}$
- Merging Angle-of-Arrival and Time-of-Flight provides 2D position
- Good accuracy in dense multi-path, provided decent signal bandwidth is applied

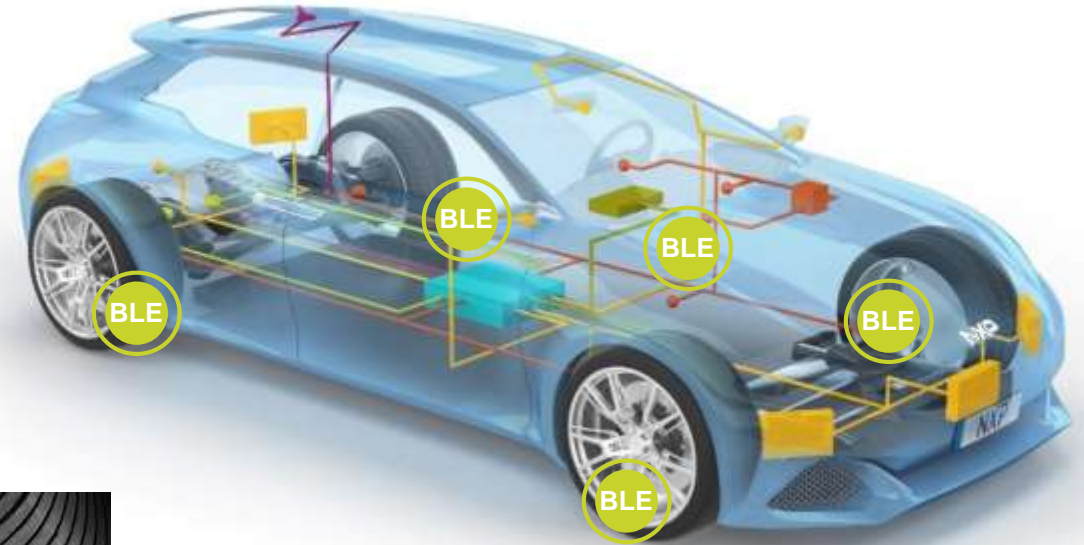
KW35/36 Localization Hardware Capabilities

- High accuracy I/Q capture for AoA and Phase based ToF
- High performance PLL with RMS phase error
- Advanced acquisition techniques like DMA trigger based on Access Address
- Fast setting AGC
- Antenna switching
- Accurate Time Stamp for ToF calculation
- RSSI absolute accuracy is ± 1 dB for Distance Estimation (with 1 point calibration at room temperature)
- Sensitivity better than -95dBm

04. BLE TPMS System



KW35/36 MCU Family | Typical Application-TPMS



TPMS 2.4GHz Communication

2-chip solution: FXTH87E + KW36A

170-29580

BLE Software implementation

STEP 1 one-way communication: Advertising frames are sent from the tire to the smartphone to give all sensor information (pressure, voltage...).

STEP 2 bidirectional communication: the user can decide to establish a **Connection** between a specific tire and the smartphone.

Use case: if a warning is triggered for one of the tires (pressure low, battery low...), then bidirectional communication allows the user (driver, tire shop...) to send specific commands to this tire in order to establish a diagnostic.



3-chip solution: KW36A + FXTH87E + FXLS8962

170-29508

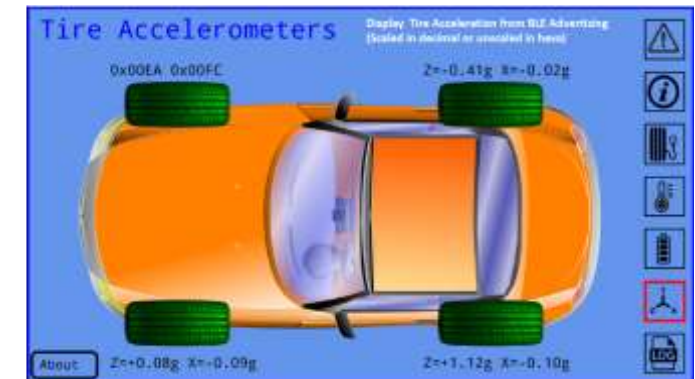
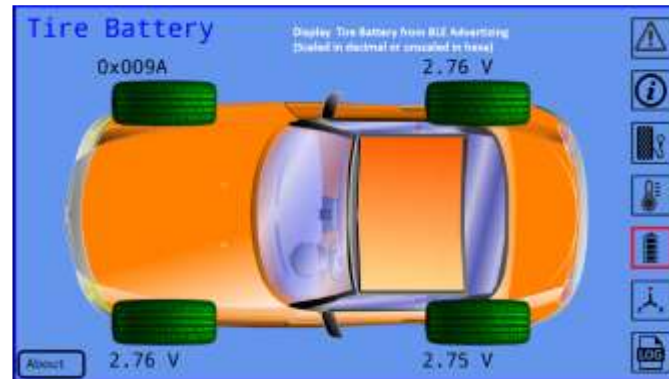
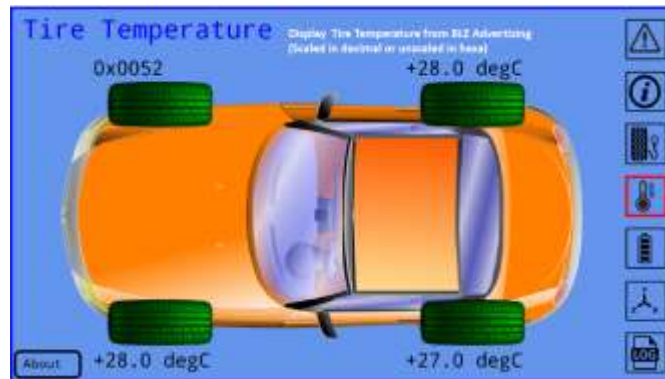
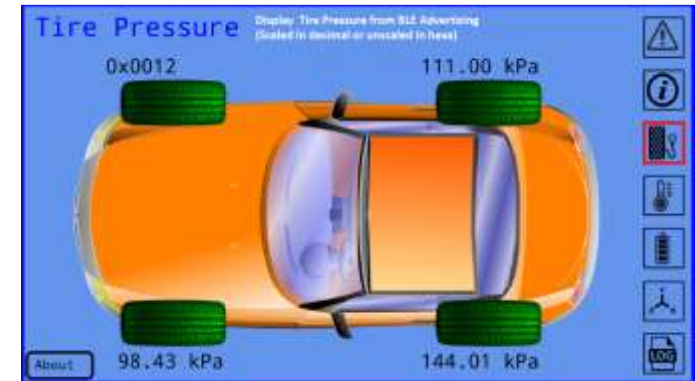
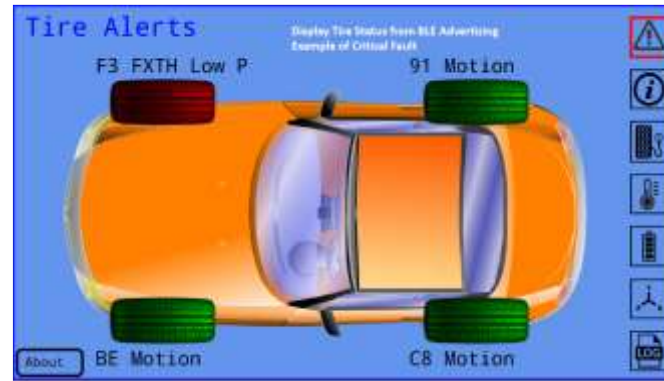
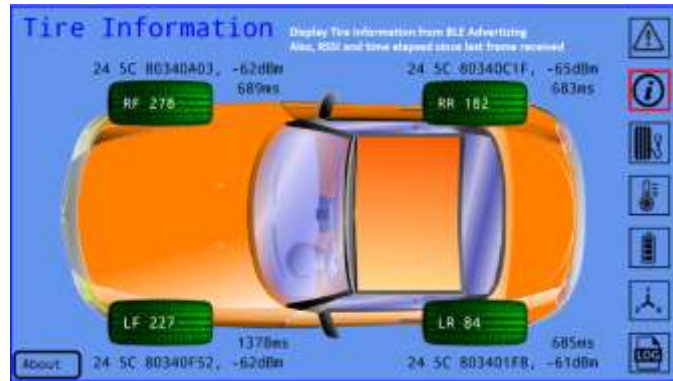
Now Available!

FXLS8962: accelerometer (package 2mmx2mm) that can be used as motion detection e.g. wake up FXTH when the car starts moving



BLE Demo – Advertising Mode

Information Provided by the Application



05. Part Numbers and Contacts



Kinetis KW35/36 MCU Family | Availability and Part Numbers

Part Number	Qualification	CAN FD	2nd UART with LIN	8kB EEPROM	Package
MKW36A512VFP4	Automotive	Y	Y	Y	6 x 6 40-pin Wettable QFN
MKW36Z512VFP4	Industrial	Y	Y	Y	
MKW35A512VFP4	Automotive	N	N	N	
MKW36A512VHT4	Automotive	Y	Y	Y	7X7 48-pin Laminate QFN
MKW36Z512VHT4	Industrial	Y	Y	Y	
MKW35Z512VHT4	Industrial	N	N	N	

Contacts for KW Devices

- Director Product Mktg (Austin, TX): Sujata Neidig Sujata.neidig@nxp.com
- KW35/36 Product Mktg (France): Pascal Bernard Pascal.bernard@nxp.com
- Application Manager (Austin, TX): Juan Mendoza Juan.mendoza@nxp.com
- KW35/36 Application (Mexico): Miguel Reyes JoseM.Reyes@nxp.com
- Localization algorithms (Mexico): Carlos Neri Carlos.neri@nxp.com

Contacts for TPMS Team

- Andreas Heldwein, Segment Mgr – Chandler, USA
andreas.heldwein@nxp.com
- Camille St. Jean, Applications Engr – Taipei, TW
camille.saint-jean@nxp.com
- Matt Muddiman, Systems Engr – Chandler, USA
matt.muddiman@nxp.com

KW35/36 MCU Family

The Industry's First Automotive-Qualified Bluetooth 5-Ready Wireless Microcontrollers (MCU) with integrated CAN-FD



Automotive and industrial qualified wireless MCUs; AEC Q100-Grade 2 temperature range qualification



Simplified integration of Bluetooth connectivity in cars, enabling automotive manufacturers to deliver added convenience for consumers



Complements NXP's automotive secure access portfolio



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