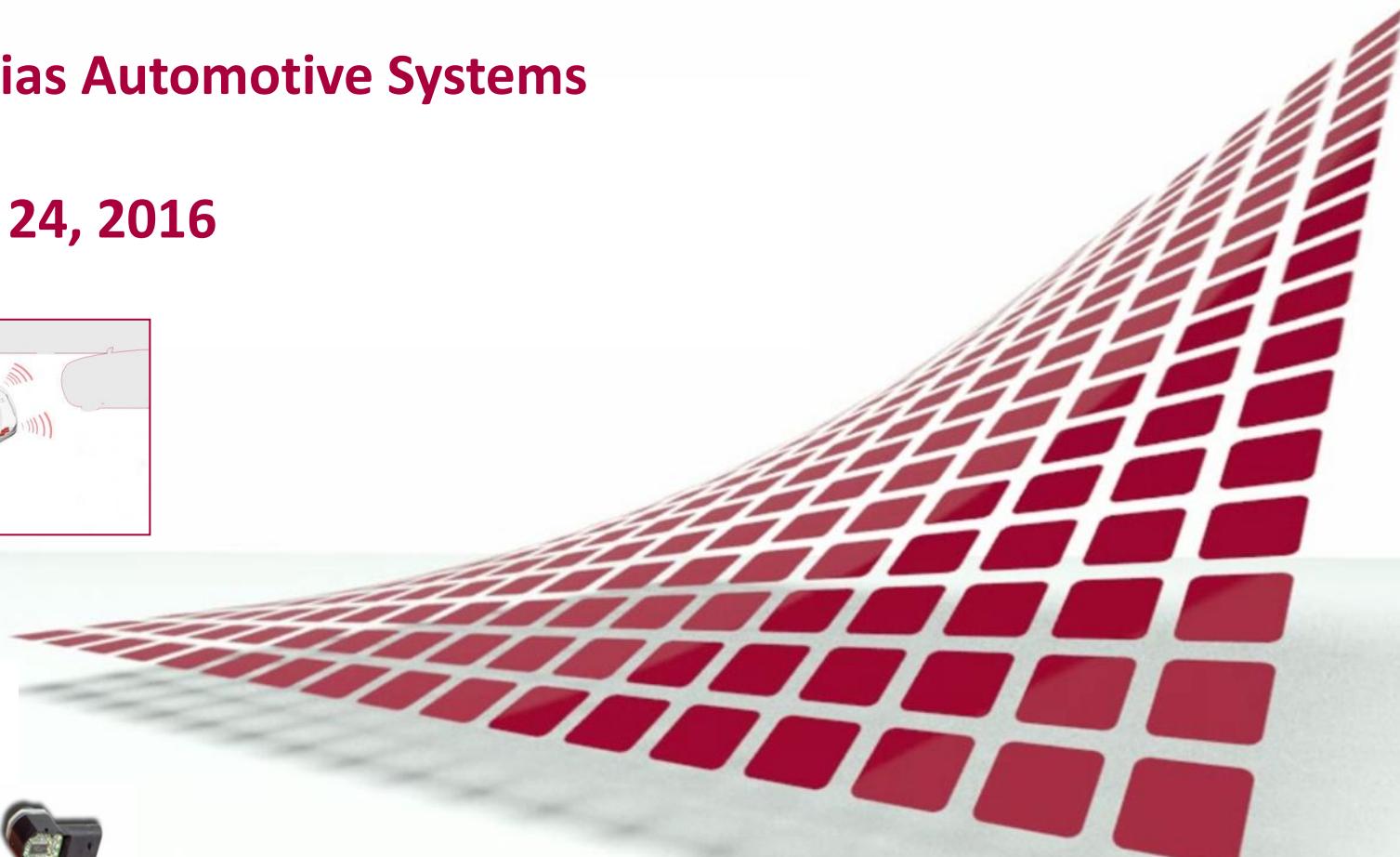


Elmos Ultrasonic Sensor Ics

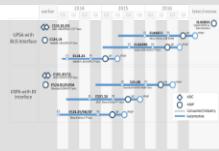
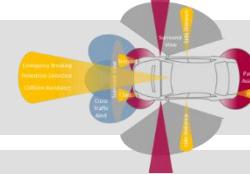
Visit to Dias Automotive Systems

February 24, 2016



Agenda

- Elmos Overview
- DIAS Overview
- Advanced Driver Assistance System (ADAS)
- Elmos Ultrasonic Sensor IC Portfolio and Roadmap
 - Elmos USPA ASSP IC Family
 - 524.08/09 2nd Gen I/O Type
 - 524.05/06 Direct I/O Type
 - 524.14/24 LIN μC Type
 - Future Roadmap
- Next generation of Ultrasonic Sensor ICs / PDC systems
 - DIAS Automotive Strategy
 - Elmos Innovations
- Joint measurement
- Discussion
- Line Tour
- Wrap Up, To Do

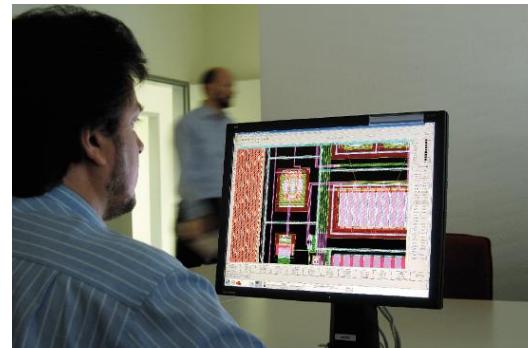
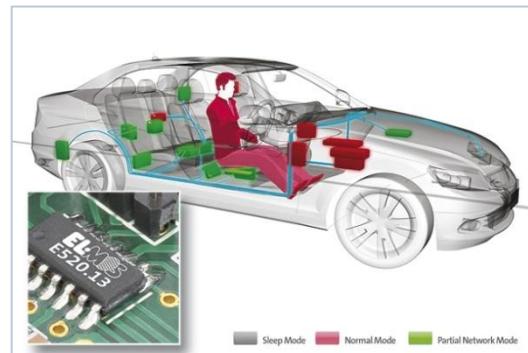




Company Overview

elmos

- Semiconductor IC Solutions
- Focus on automotive (85%)
- Automotive quality (< 0.5ppm)
- Design resources with 30+ years of experience
- Sensor ICs incl. own MEMS fab
- Supplies to automotive safety applications (ISO26262)
- Commitment to long term customer partnerships



Founded 1984

1.100 employees

219 Mio EUR revenues

Certified own waferfabs

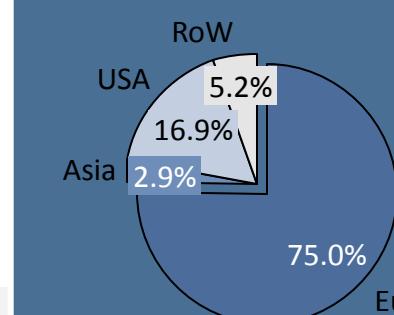
250+ Mio ICs per year

An increasingly global organization

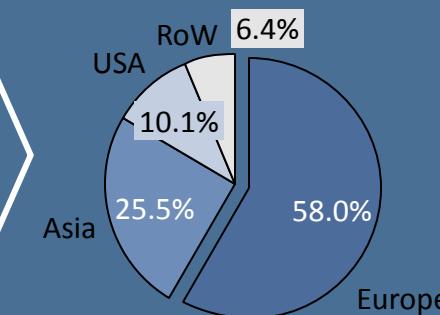
Elmos major locations



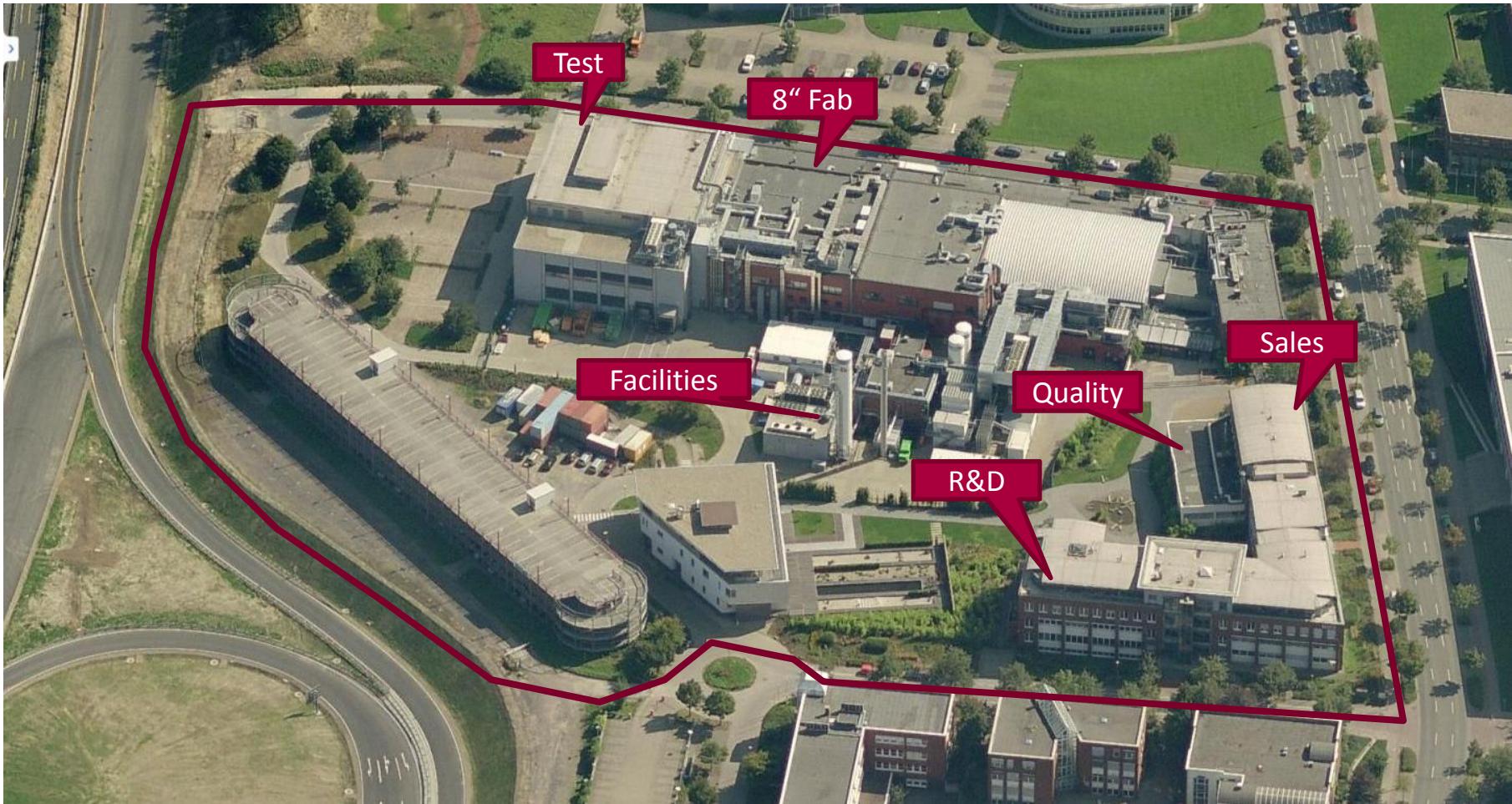
Regional sales 2006



2015



Elmos today



Technologie Park Dortmund today

Our expertise and reliability for your products

- 8“ wafer processing on 5,000 square meters
- Technology roadmap with line width down to $0.13\mu\text{m}$
- Long term product availability enabled by own production



Our knowledge ensures highest quality

- State of the art mixed-signal test systems including automated optical inspection
- Efficient multi-site handling systems



Own facilities and long term partners guarantee
cost effective global supply

elmos

Our fabs

elmos

2 waferfabs : Dortmund + Duisburg

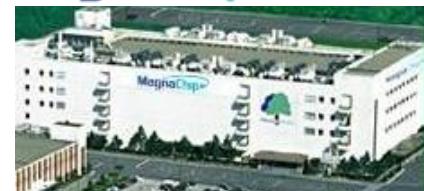


SILICON
MICROSTRUCTURES
INCORPORATED
Member of the ELMOS Group Milpitas



Foundries

MagnaChip

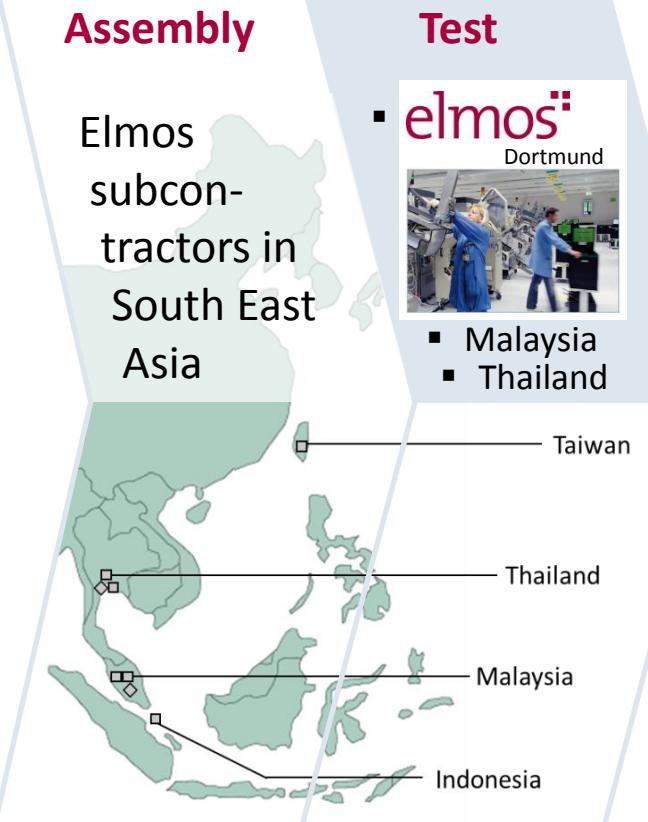


tsmc



Assembly

Elmos
subcon-
tractors in
South East
Asia



Test

elmos

Dortmund



- Malaysia
- Thailand

Elmos supplies to nearly all car OEMs



Selected Elmos automotive customers

Aisan	AISIN	ALPINE	Autoliv	HYUNDAI AUTRON	BEHR HELLA THERMO CONTROL	BorgWarner	BorgWarner BERU Systems	BOSCH
Continental	DELPHI	DELTEC	DENSO	ELDOR CORPORATION	SENSORIC	GENTEX CORPORATION	HELBAKO Kompetenz in Elektronik	HELLA
ISTEC	Johnson Controls	JOHNSON ELECTRIC	KAVOEO Pressure Sensors	KOSTAL	LEAR CORPORATION	lierda 利尔达科技集团	MAGNA	MAGNETI MARELLI
MARQUARDT	HYUNDAI MOBIS	MetaSystem ENERGY A Group Brand Legrand	NIPPON SEIKI	NAGANO KEIKI	KOLBENSCHMIDT PIERBURG	preh	RENESAS	SCHRADER ELECTRONICS A Tomkins Company
SEUFFER	STS silicon micro sensors	SMT & HYBRID	sumida	TAKATA	TURCK	Valeo	VTI TECHNOLOGIES	YAZAKI Vehicle power and data solutions

Car OEMs trust in Elmos technology

Audi	ALFA ROMEO	BMW	CHRYSLER	CITROËN	Mercedes-Benz	Fiat	Ford	GM	Hyundai
JAGUAR	KIA	LAND ROVER	MINI	MITSUBISHI	Nissan	OPEL	Peugeot	Porsche	Renault
SEAT	SKODA	TOYOTA	VW	VOLVO	BAIC MOTOR	Baojun	Brilliance	BYD	Chery
DFM	FAW	GEELY	Great Wall	Ha/ma	HANTAI AUTOMOBILE	JAC MOTORS	ROEWE 荣威	SOU EAST	QDROS

Elmos is driven by innovation – selected applications



Ultrasonic ICs



World market leader



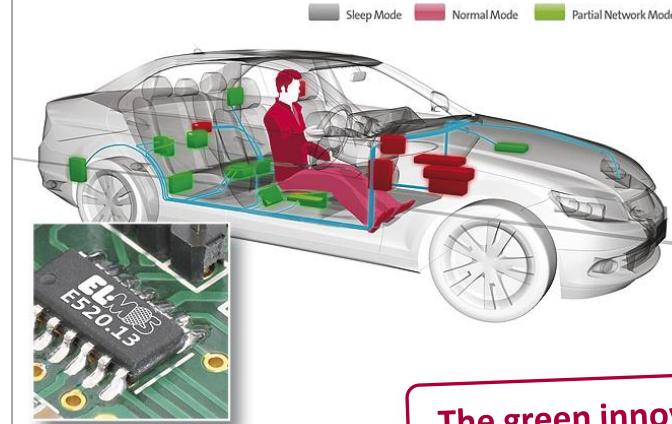
Advanced HMI ICs



Touchless 3D gesture control



Networking ICs (Partial CAN)



The green innovation

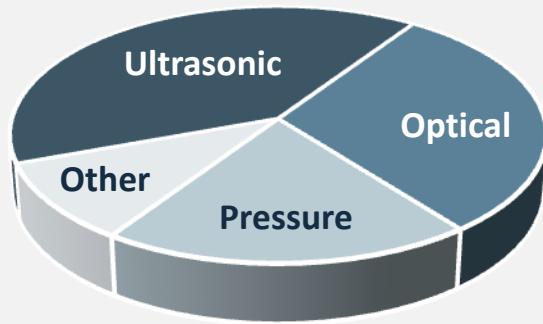


Tire pressure sensor cells



World market leader
and smallest IC in class

BL1 – Sensors



Ultrasonic park assistance



Worldwide
#1

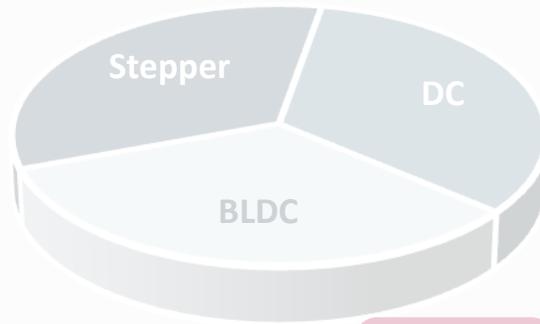
3D gesture control



Tire pressure monitoring



BL2 – Motor Control

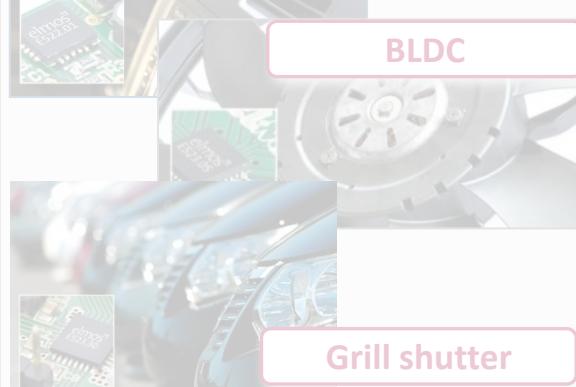


Climate flap control



Worldwide
#1

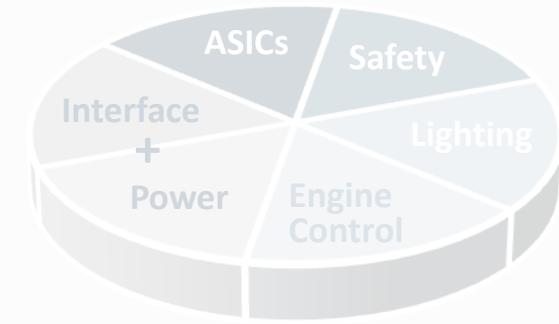
BLDC



Grill shutter



BL3 – Embedded Systems



Ambient LED light driver

Worldwide
#1



Smart home automation



Airbag



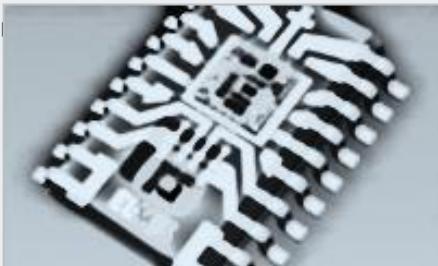
Front and rear light

Sensor Portfolio

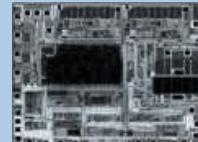
- Park Distance Control ASIC's
- Digital USPA
- Smart USPA
- Industrial US IC's



- Inductive Sensors
- Capacitive Sensors



- SSP's for Pressure, Strain, Force



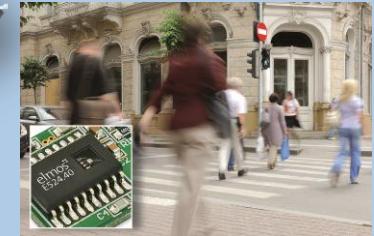
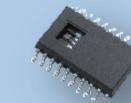
Ultrasonic

Optical

Other

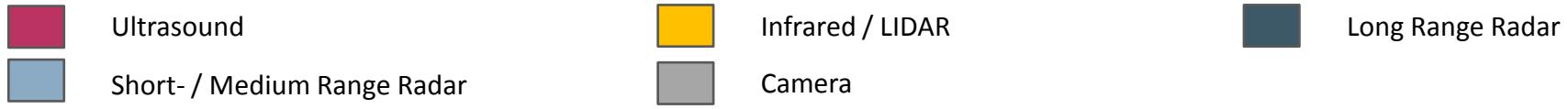
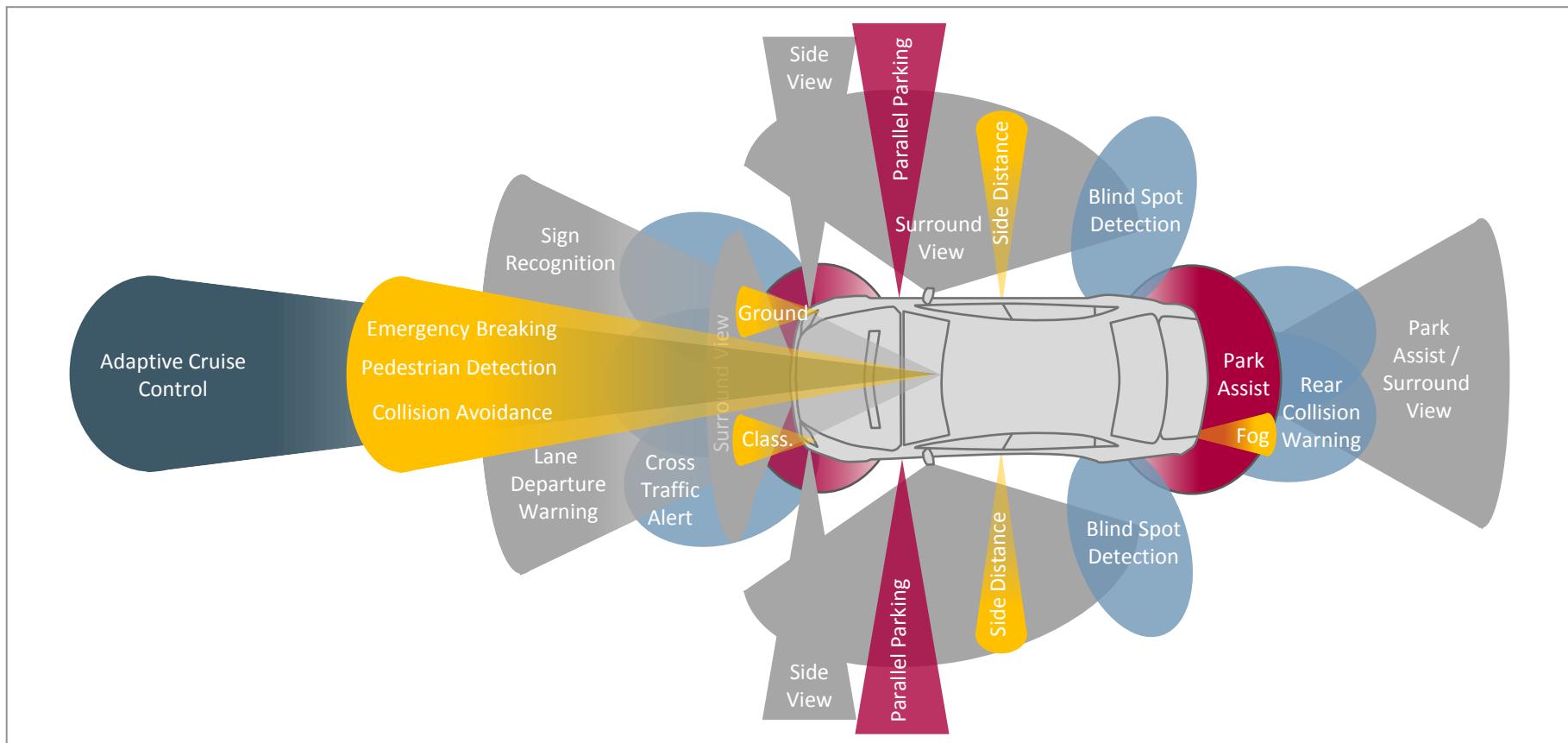
Pressure

- Proximity Sensors
- Gesture Recognition
- IR Distance
- Rain/Light Sensors
- Sun Angle Sensors
- Smoke/Dust Sensors
- Passive IR Sensors
- IR Temp Sensors



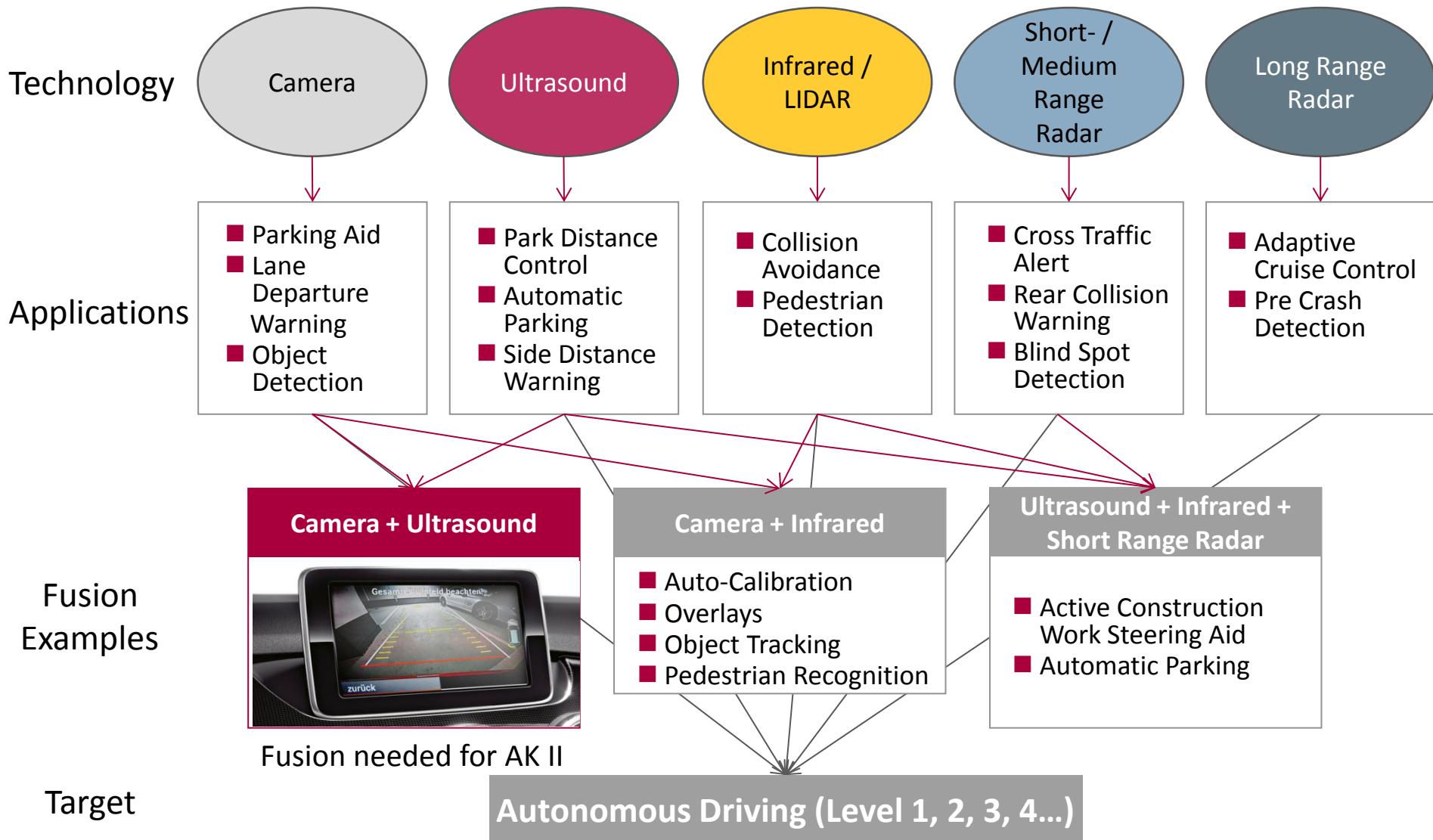
Advanced Driver Assistant Systems (ADAS) Application & Technology Overview

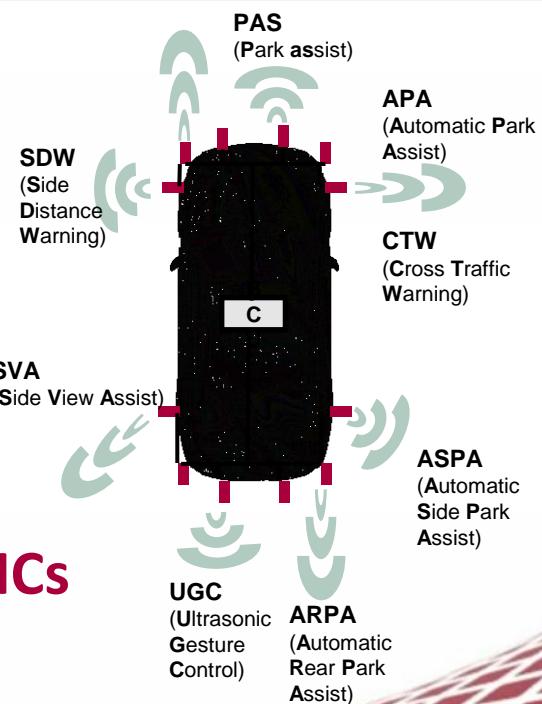
elmos



Sensor Fusion features additional and more sophisticated ADAS

elmos



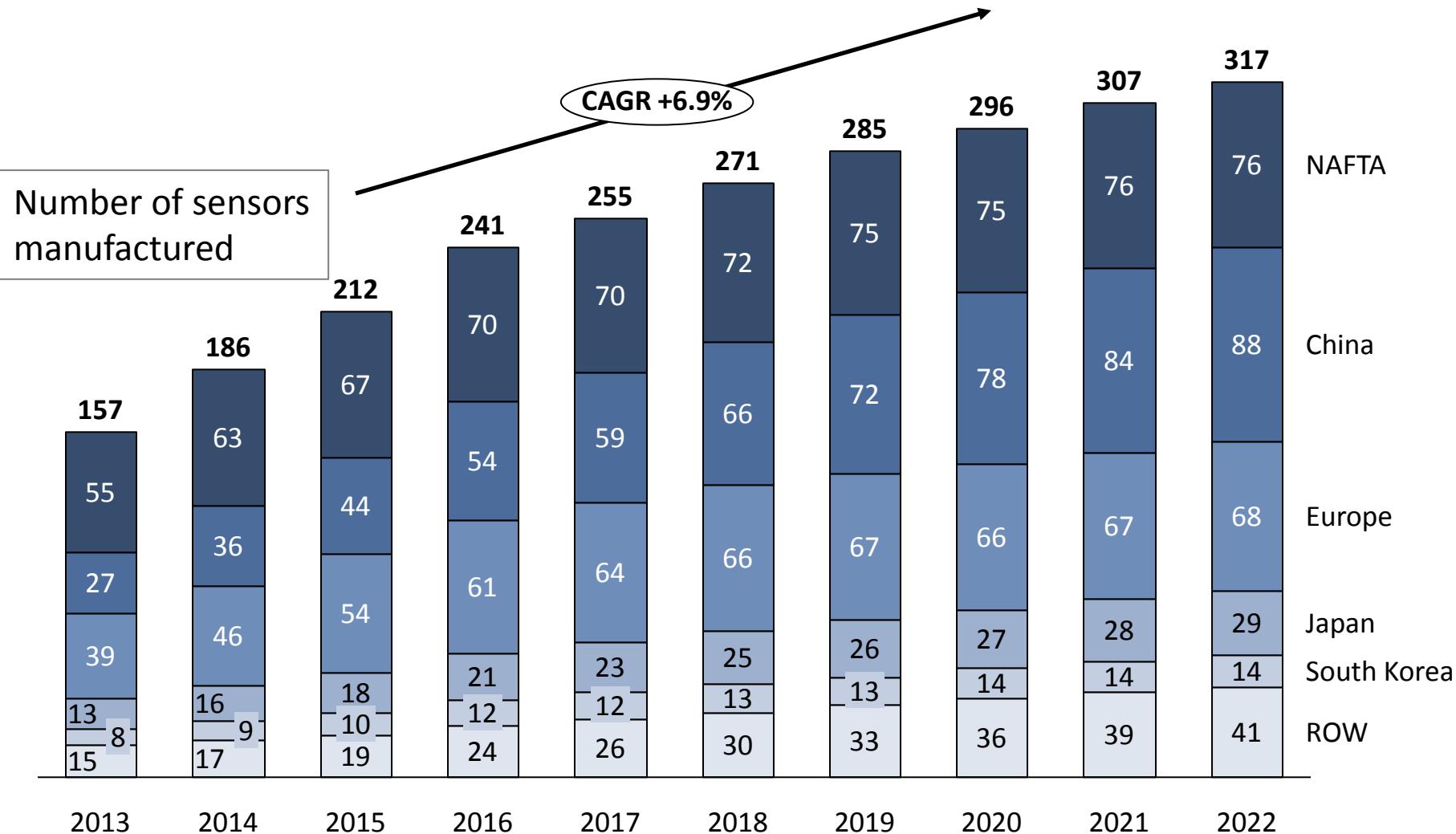


Elmos Smart USPA ICs



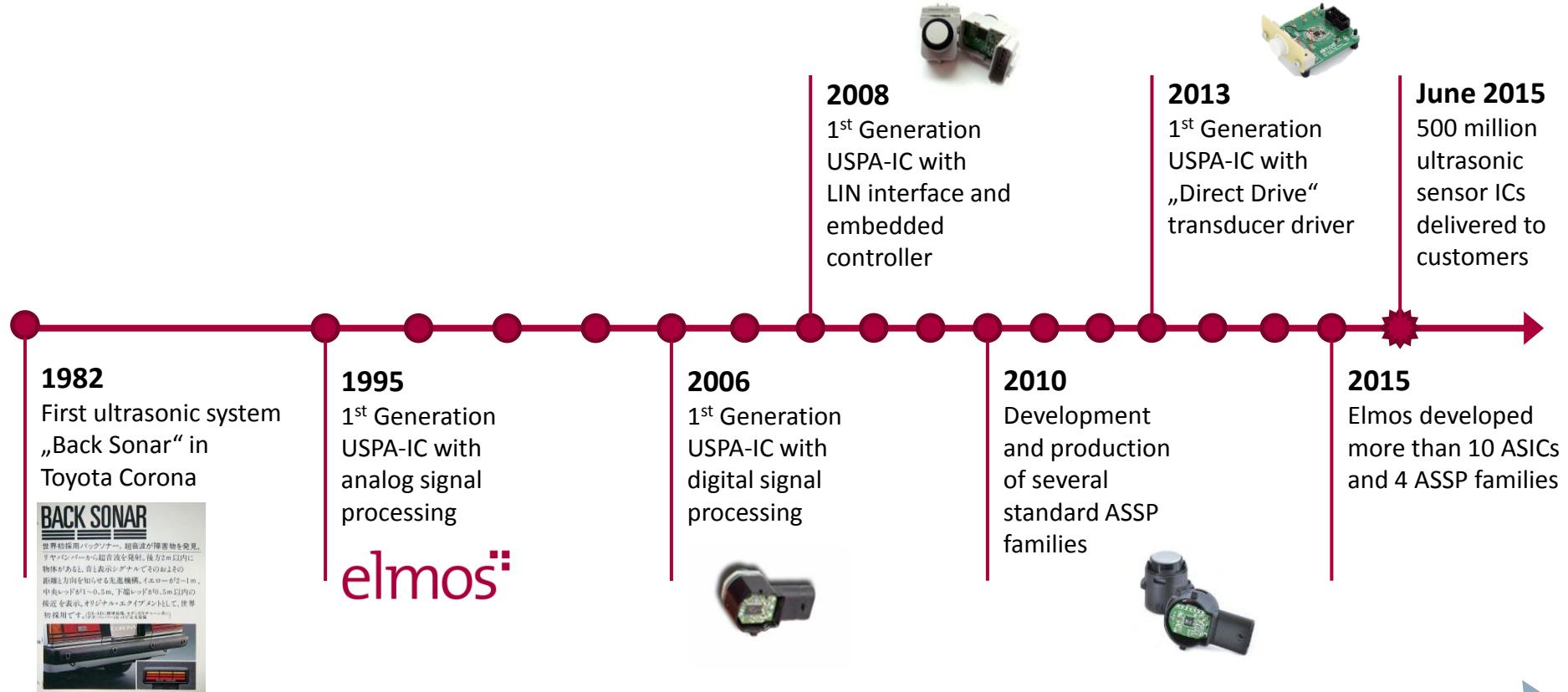
Total ultrasonic sensor demand based on OEM vehicle assembly location

elmos



Elmos History in Ultrasonic Applications

elmos

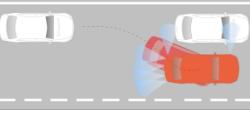
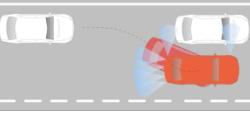
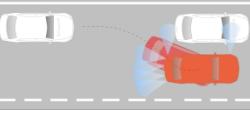


Applications

- Park Assist

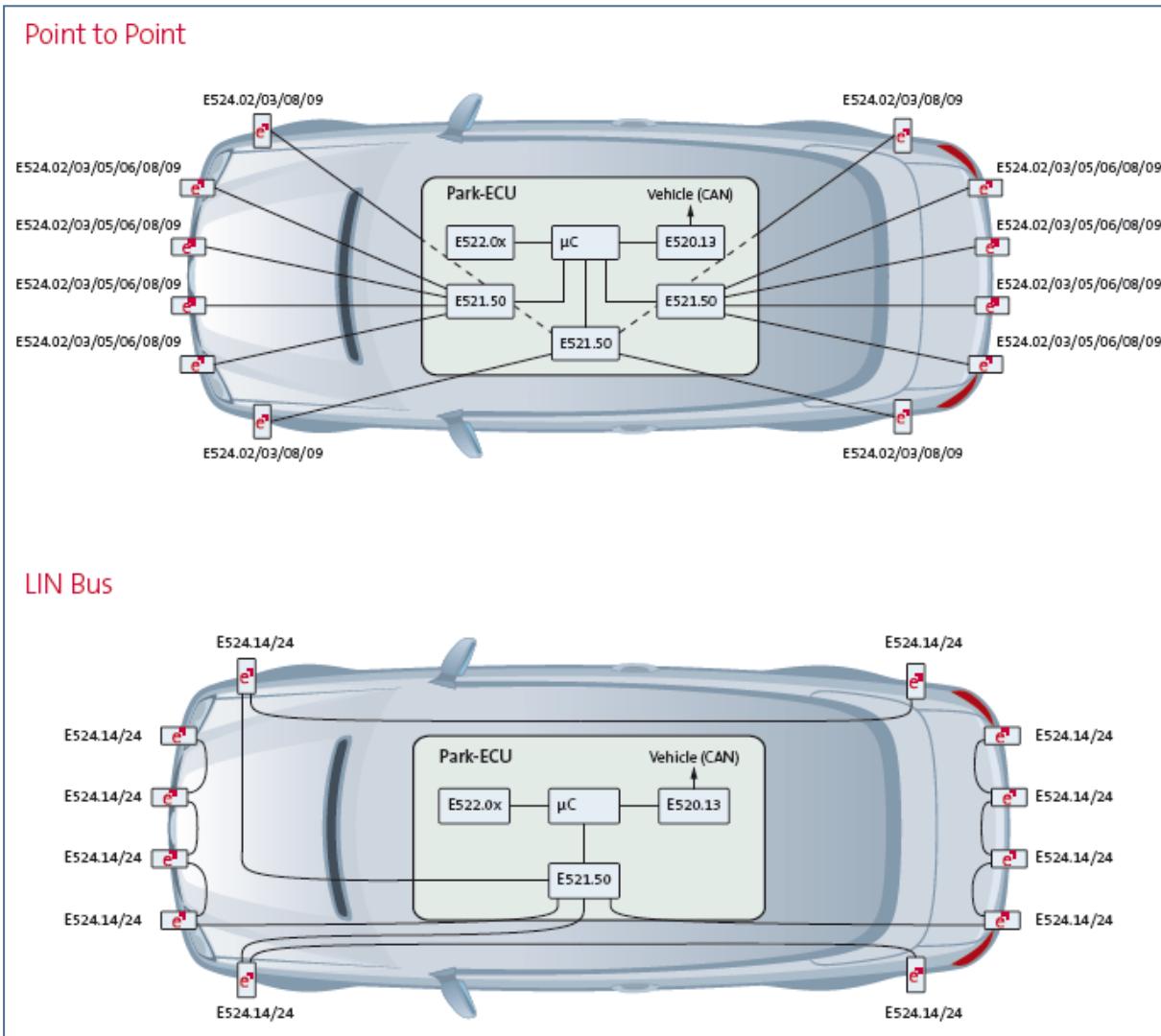
- Automatic Parking (Side)
- Park Assist
- Automatic Parking (Side and Rear)
- Park Assist
- Gesture Control
- Emergency Break
- Side View Assist
- Automatic Parking (Side and Rear)
- Park Assist

Elmos' Competitive Advantages

Advantage	Application	Elmos Advantage
Shorter →←	<ul style="list-style-type: none"> ■ Park Assist ■ Ultra Short Distance Detection 	<ul style="list-style-type: none"> ■ Distance Measurement from 10-12cm onwards ■ Near Field Detection under investigation
Longer ←→	<ul style="list-style-type: none"> ■ Automatic Parking ■ Side Distance Warning ■ Low Speed Emergency Break 	<ul style="list-style-type: none"> ■ Features for noise reduction ■ Distance Measurement up to 6.0m (pole) ■ Distance Measurement up to 8.0m (wall)
Faster →→→	<ul style="list-style-type: none"> ■ LIN Bus System with high data rate communication ■ Faster Pt-to-Pt Interfaces 	<ul style="list-style-type: none"> ■ Advanced, flexible IO communication ■ LIN Interface with SNPd (auto-addressing) ■ Quad LIN IC 521.50 (ECU side) ■ Faster Interfaces (e.g. PSI5)
More accuracy ↔↔→	<ul style="list-style-type: none"> ■ Park Assist ■ Automatic Parking 	<ul style="list-style-type: none"> ■ Diagnosis information (Dirt, Mud, Ice, Water,...) ■ Temperature sensing ■ Precise echo peak detection (EPD)
Less Cost →\$←	<ul style="list-style-type: none"> ■ Park Assist 	<ul style="list-style-type: none"> ■ Direct Drive without transformer

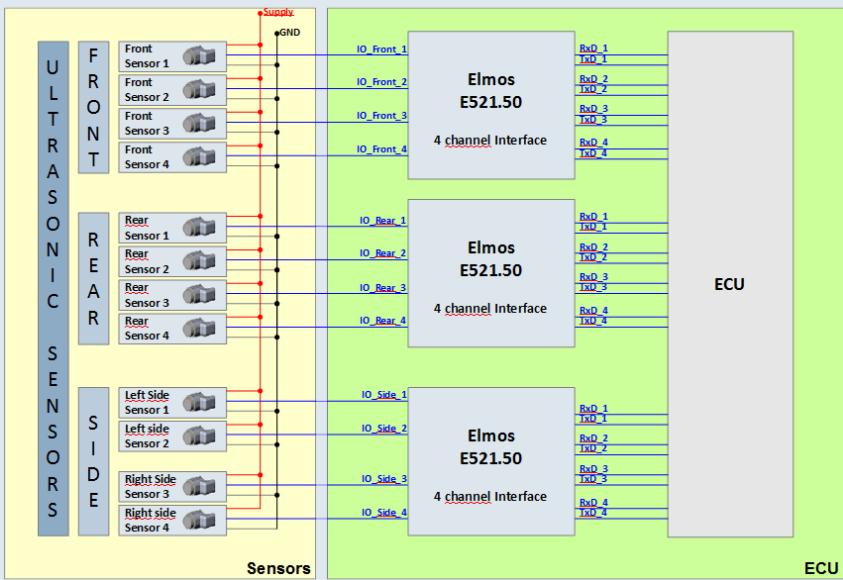
Ultrasonic Parking Assist Applications

elmos



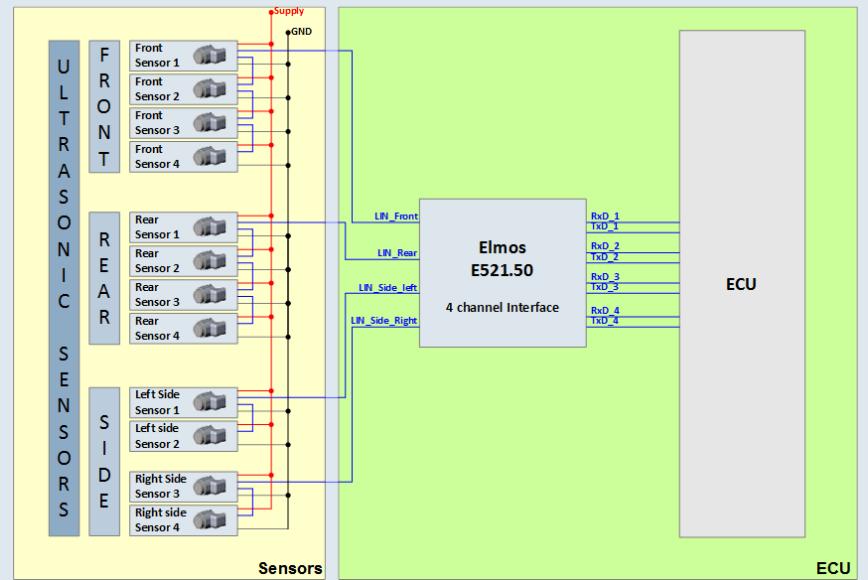
Point-to-Point vs. (LIN)Bus Communication

Point-to-Point



- very flexible solution
- direct, simultaneous control of each sensor due to dedicated communication lines
- standard 3 pin connector at sensor (German working group)
- high number of RxD and TxD communication lines (24 lines with 12 sensors) between the interface IC and the controller
- Lower communication bandwidth

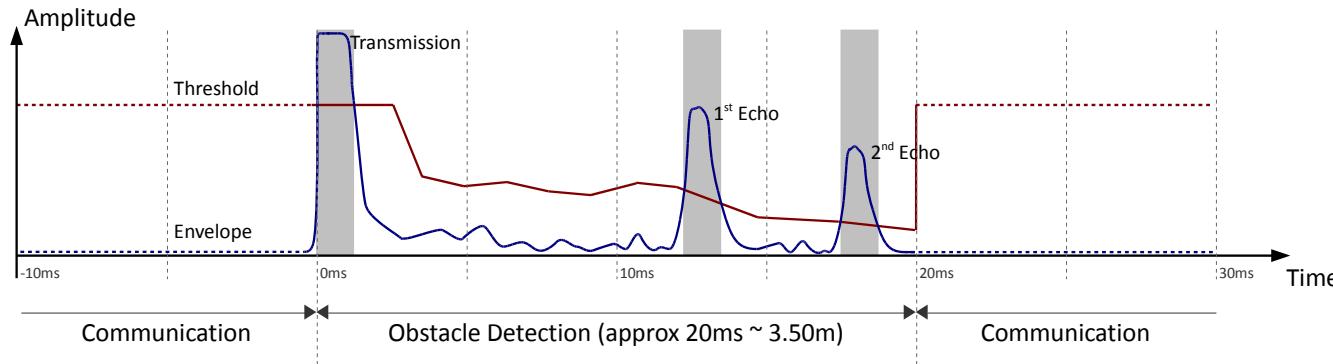
LIN-Bus



- reduced wiring harness
- standardized LIN network
- standardized sensor protocols
- higher communication bandwidth
- changed wiring harness and connector at ECU
- longer measurement/communication cycles

Point-to-Point vs. (LIN)Bus Communication

elmos



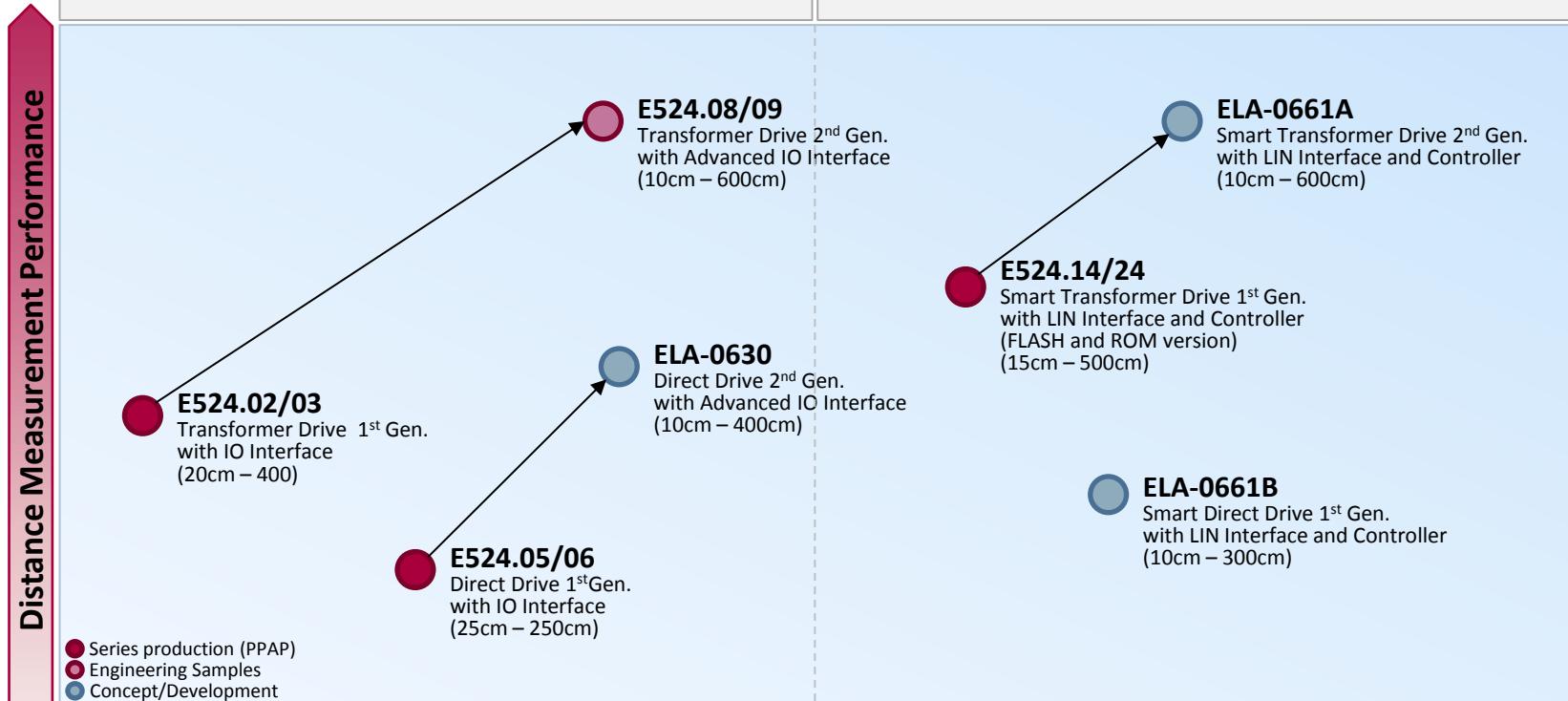
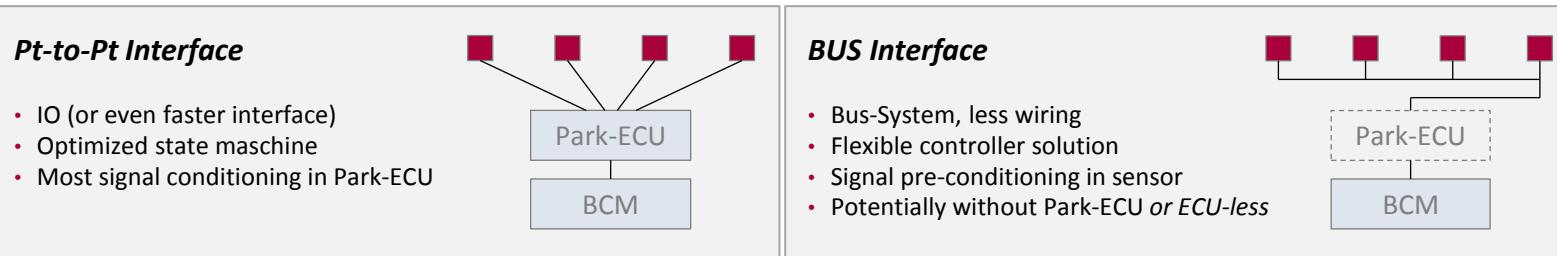
Point-to-Point

- Custom specific protocol, combination of low/high pulses
- Fast measurement (“real-time” echo recognition)
- Two times faster compared to LIN

LIN

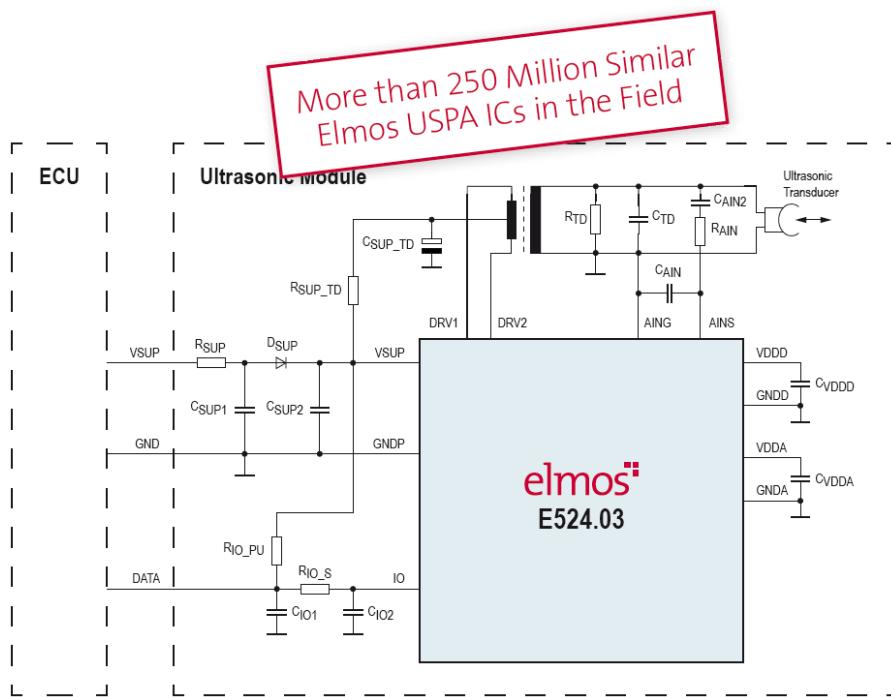
- Master is sending an echo order and defines sending and receiving sensor.
- Waiting till sending and receiving is finished.
- Master is requesting evaluated results from the sensors.
- Sensors are sending pre-processed data.

Performance of distance measurement is independent from the chosen interface



Elmos ... your partner for ultrasonic applications!

Typical Application



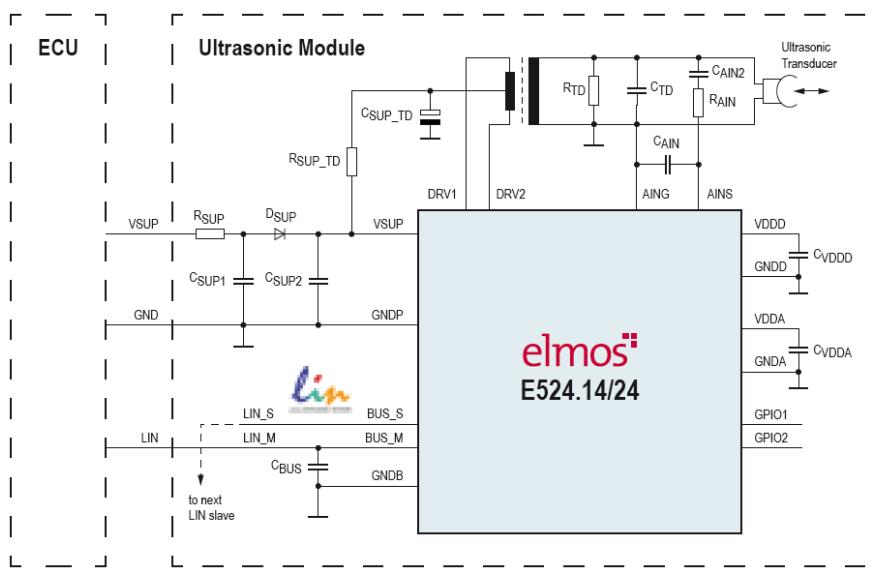
Key Feature & Benefits

- **Transformer-based transducer driver**
- Supply voltage between **7V** and **18V** (POR at 5.0V)
- Bi-directional interface in 2-wire & 3-wire variants
- Driver Power and Signal Gain Programmable
- **Digital Filtering and Signal Processing**
- 14 Programmable Threshold / Time Settings
- Adjustable calibration parameters **via EEPROM**
- Package: **QFN20L4**
- Temperature range between **-40°C** and **855°C**

Status

Mass Production

Typical Application



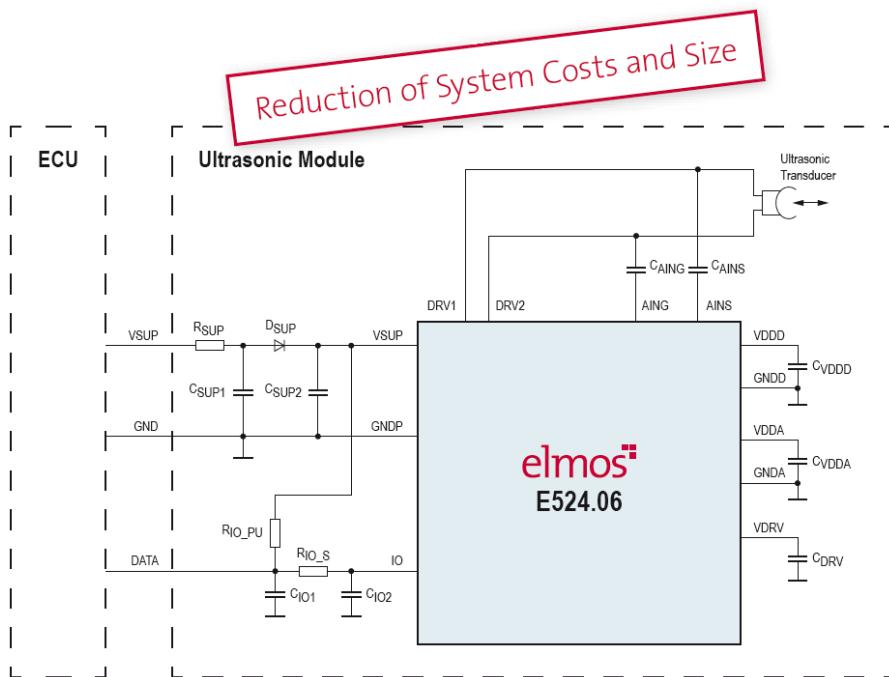
Key Feature & Benefits

- **Transformer-based transducer driver**
- Supply voltage between **8V** and **18V** (POR at 5.2V)
- **Digital Filtering and Signal Processing**
- **CPU** with 16MHz Clock
 - 8KByte Customer FLASH/ROM,
 - 512Byte RAM
 - 128Byte EEPROM
- **LIN Interface with auto-addressing capability**
- Fast Calibration Data Exchange via LIN
- **IC and Transducer diagnosis information**
- Package: **QFN20L5**
- Temperature range between **-40°C** and **105°C**
- **Integrated temperature sensor (E524.24)**
- Ready-to-use **standard software (E524.24)**

Status

Mass Production

Typical Application



Key Feature & Benefits

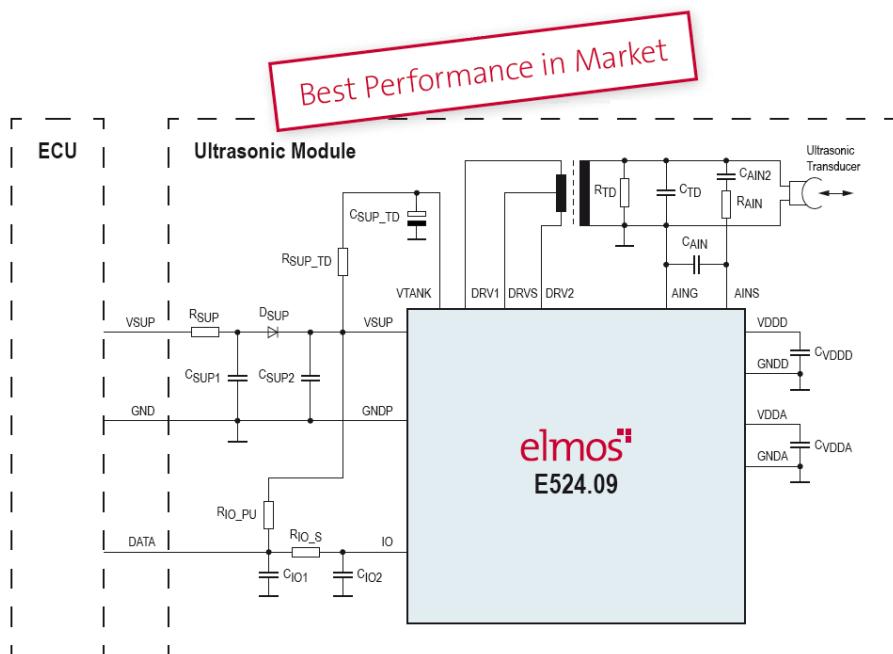
- Transformerless direct transducer driver
- Supply voltage between **7V** and **18V** (POR at 4.5V)
- Bi-directional interface in 2-wire & 3-wire variants
- **Optimized short & long range performance by:**
 - Electronic damping
 - STC (sensitivity time control)
 - **Automatic Threshold Generation (ATG)**
- **IC and Transducer diagnosis information**
- Adjustable calibration parameters via **EEPROM**
- Customer readable Chip ID for **traceability**
- Package: **QFN20L4**
- Temperature range between **-40°C** and **105°C**
- **Reduction of system costs and size**



Status

Mass Production

Typical Application

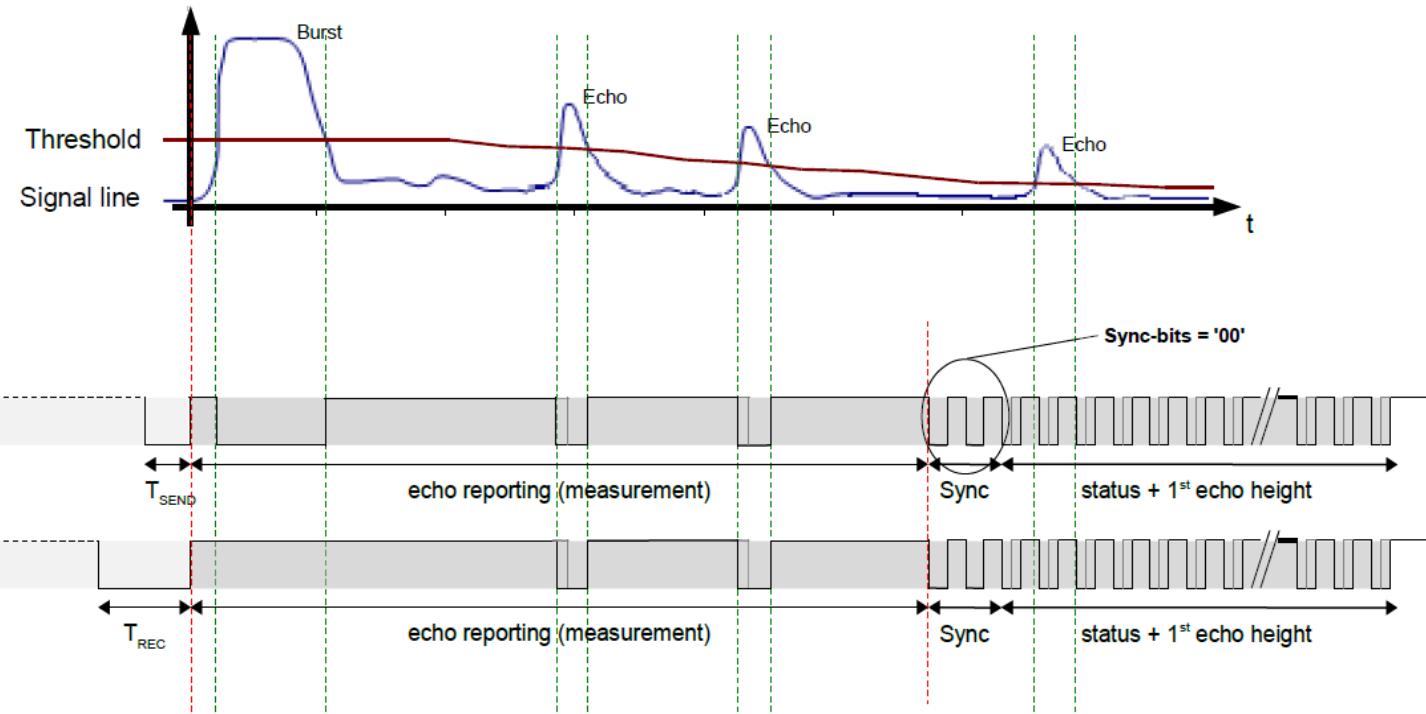


Key Feature & Benefits

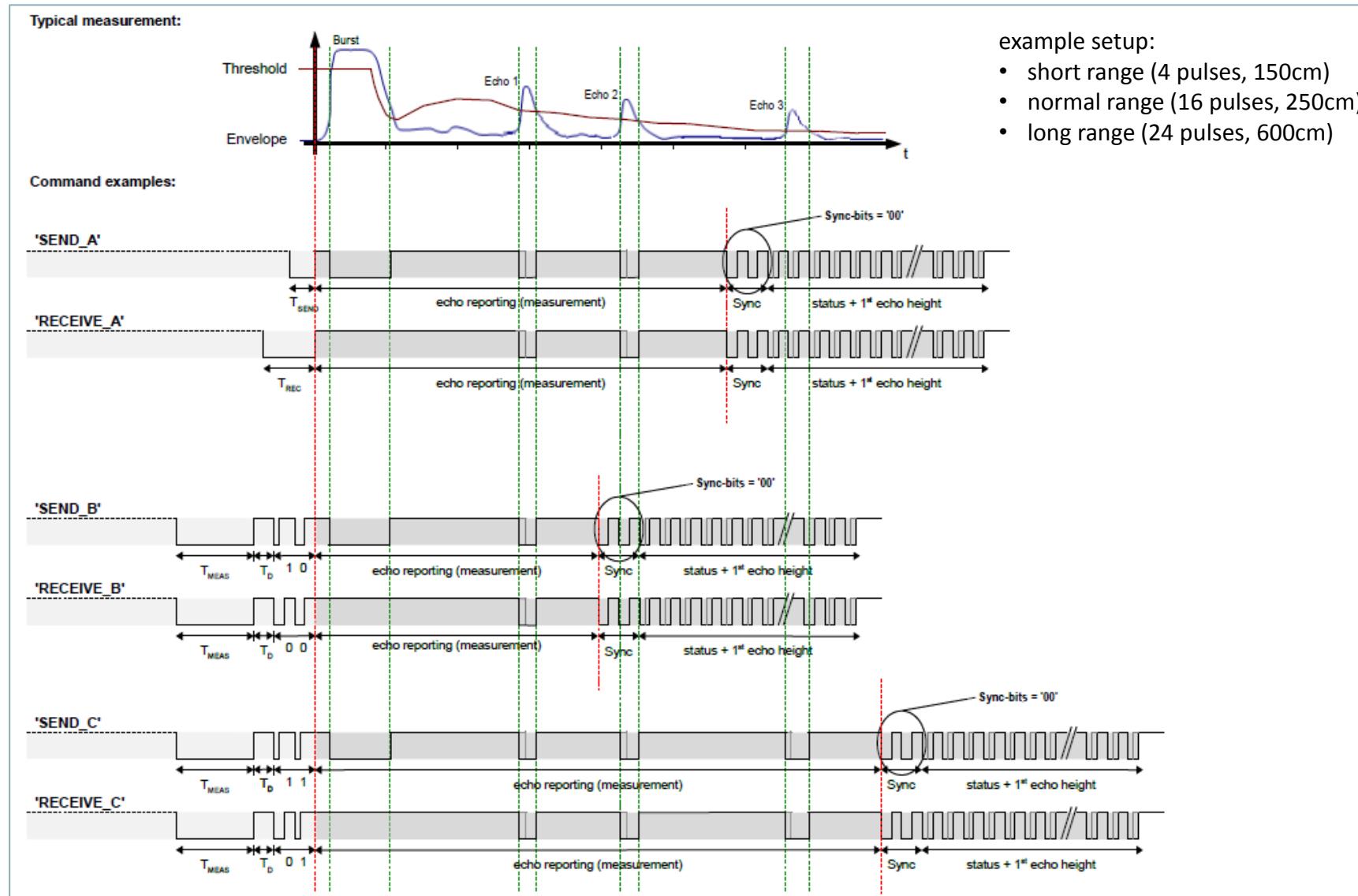
- **Transformer-based transducer driver**
- Supply voltage between **6V** and **18V** (POR at 4.5V)
- Bi-directional interface in 2-wire & 3-wire variants
- **Excellent short & long range performance** due to:
 - Wide signal gain range
 - Dynamic gain control
 - Automatic threshold generation
 - Near-field threshold generation
 - Fast time constant algorithm
 - Echo peak detection
- Flexible, **advanced IO protocol**
- **IC and Transducer diagnosis information**
- **Integrated temperature sensor**
- **Envelope readout via IO or testmode**
- Package: **QFN20L4**
- Temperature range between **-40°C** and **105°C**

Status

Engineering Samples available

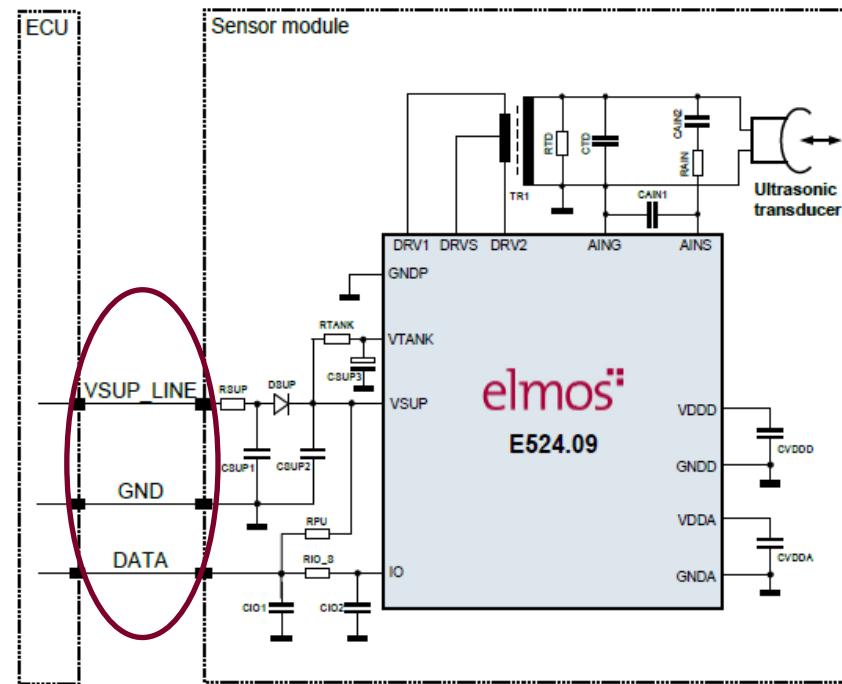
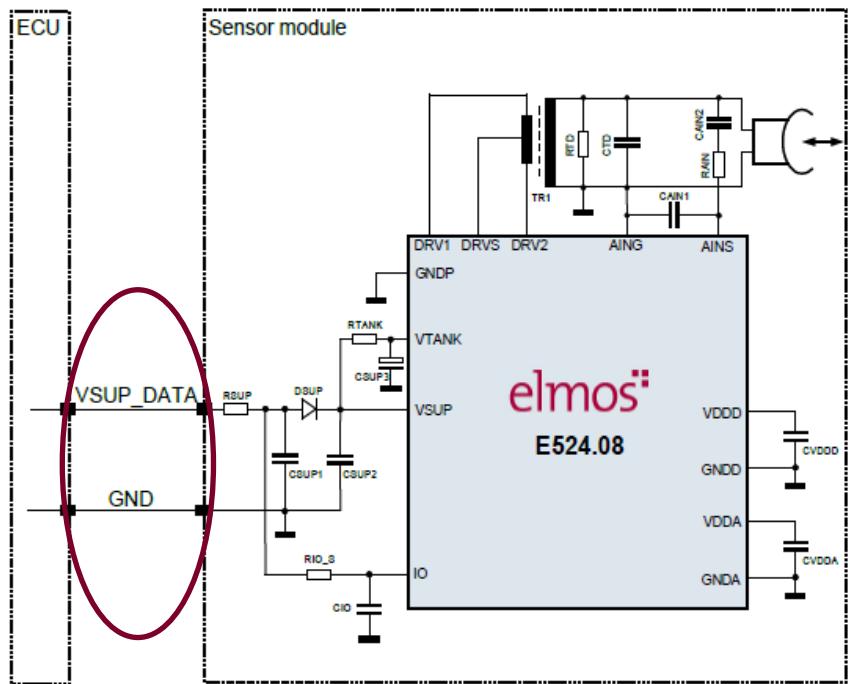


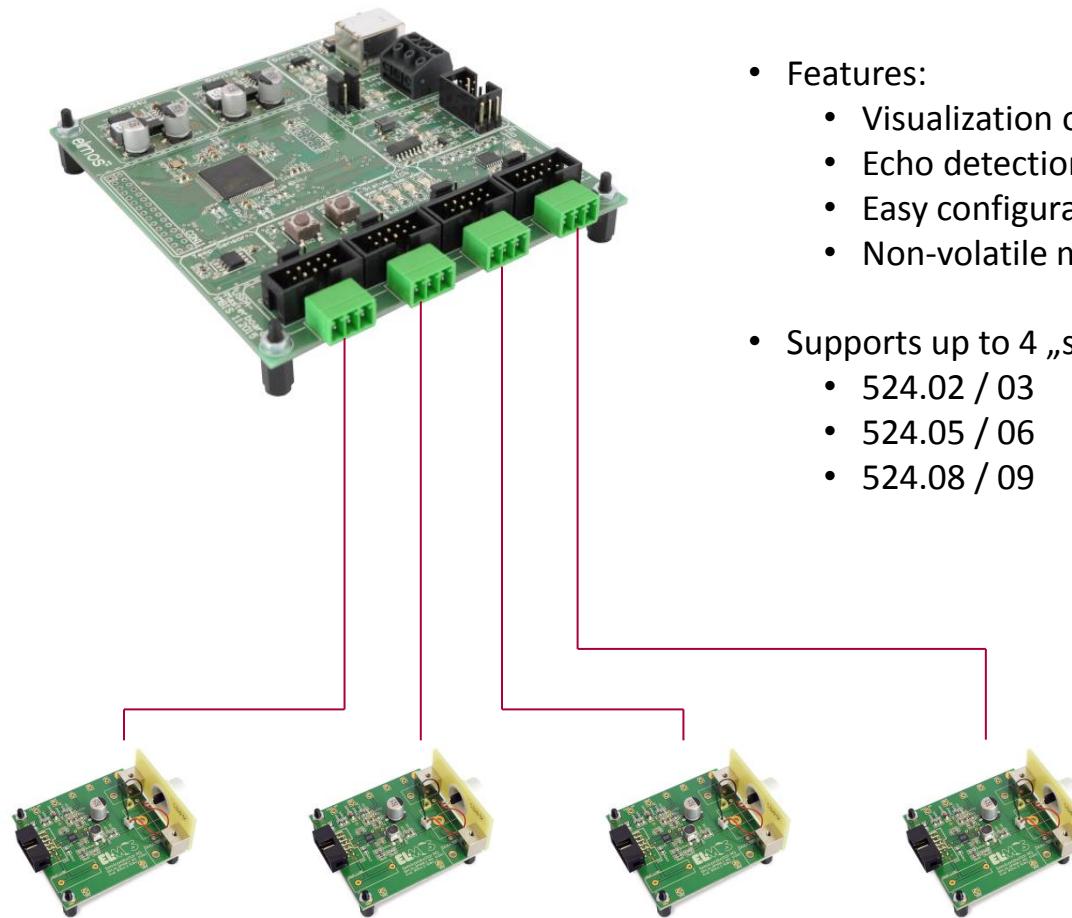
- + Additional status information after a completed measurement cycle
- + Reduced communication time due to less commands



E524.08/09 – 2nd Generation Standard USPA – 2-wire and 3-wire variants

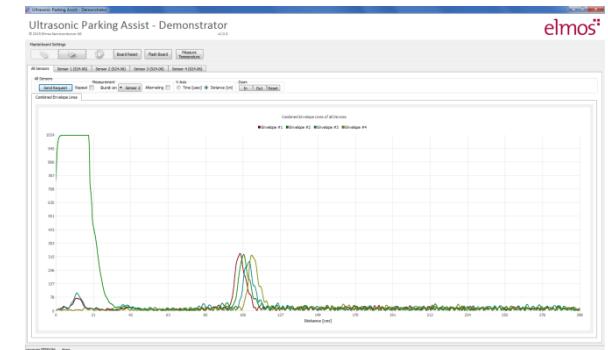
elmos



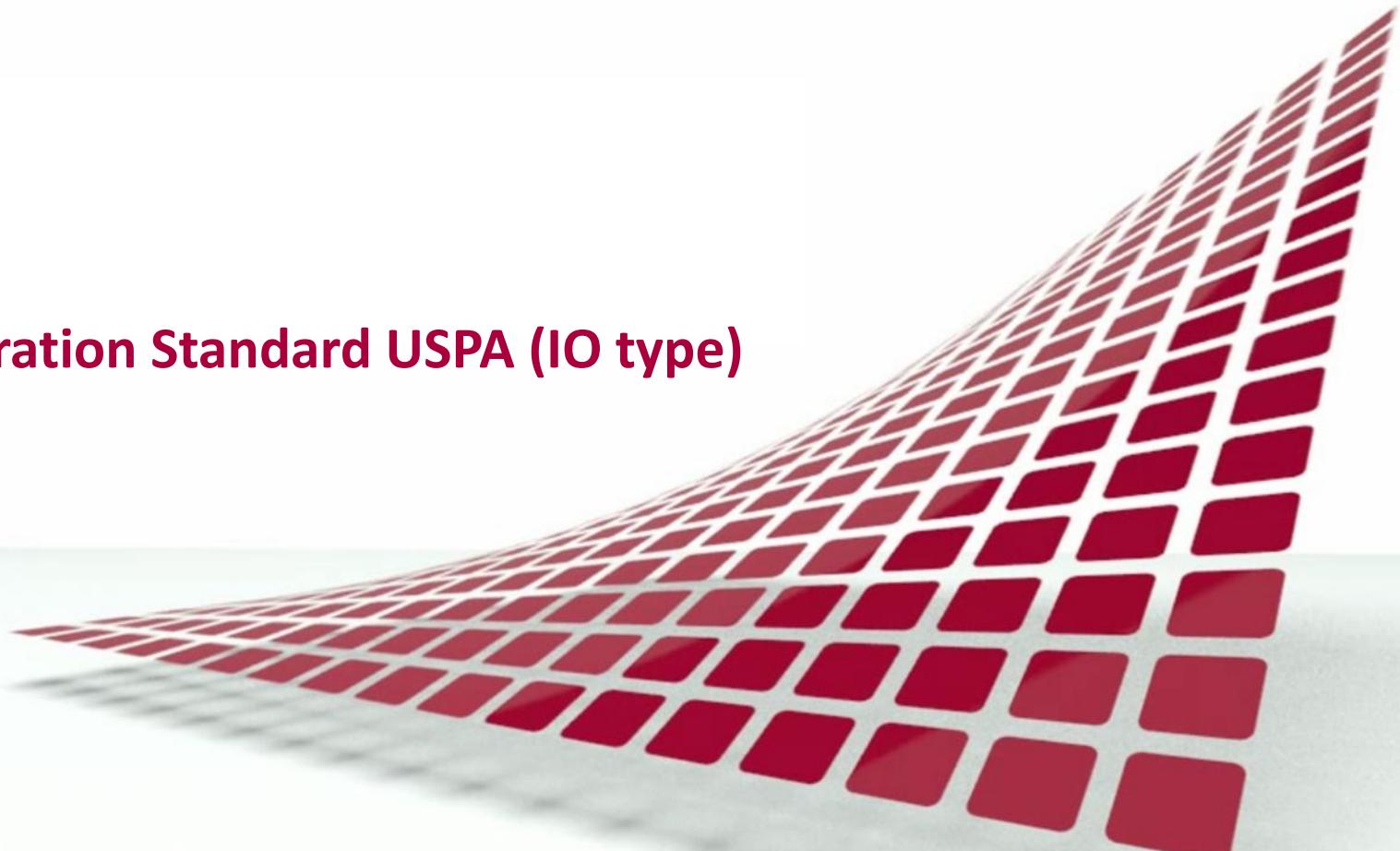


„USPA – Masterboard“

- Features:
 - Visualization of envelope and threshold curves
 - Echo detection and distance measurement
 - Easy configuration and adjustment of all IC parameters
 - Non-volatile memory programming
- Supports up to 4 „sensor boards“ of the following IC family:
 - 524.02 / 03
 - 524.05 / 06
 - 524.08 / 09

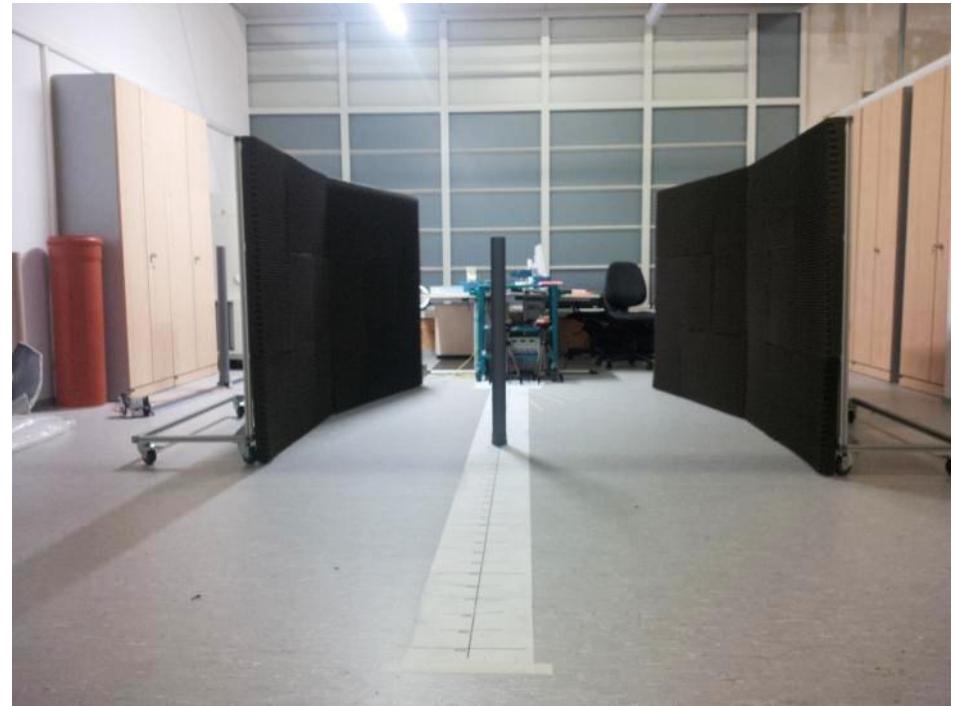


2nd Generation Standard USPA (IO type)



Measurement Performance

- Elmos
 - IC 524.09
 - Sensor Board (25AN0156E.00, schematic v1.3)
 - Master Board (25AN0156E.01, software v3.0)
- Transducer
 - Murata MA58MF-7N
- Obstacle
 - PVC tube (1m height, 75mm diameter)
- 20°C room temperature



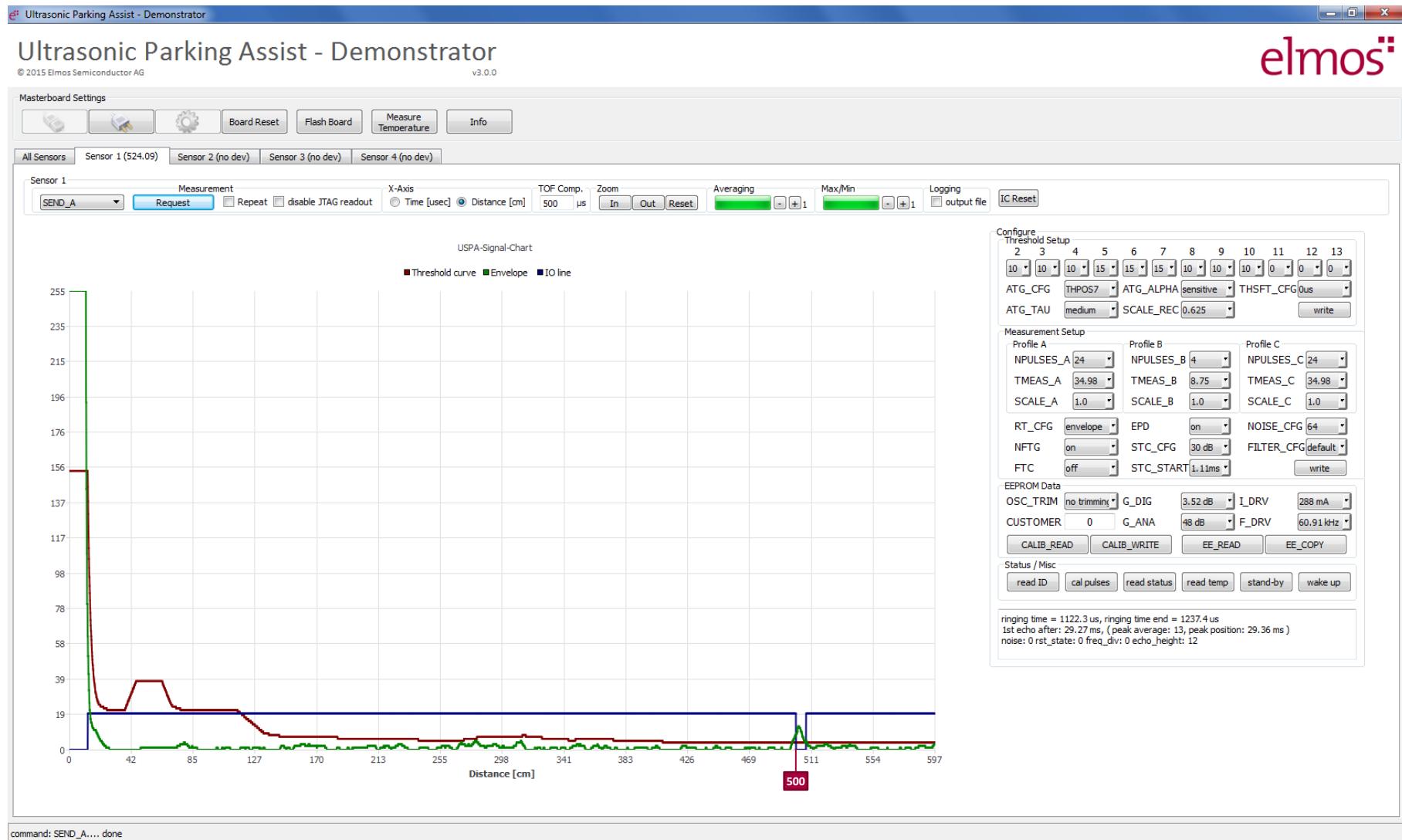
Long Range Performance (ISO Pole in 400cm with 24 burst pulses)

elmos



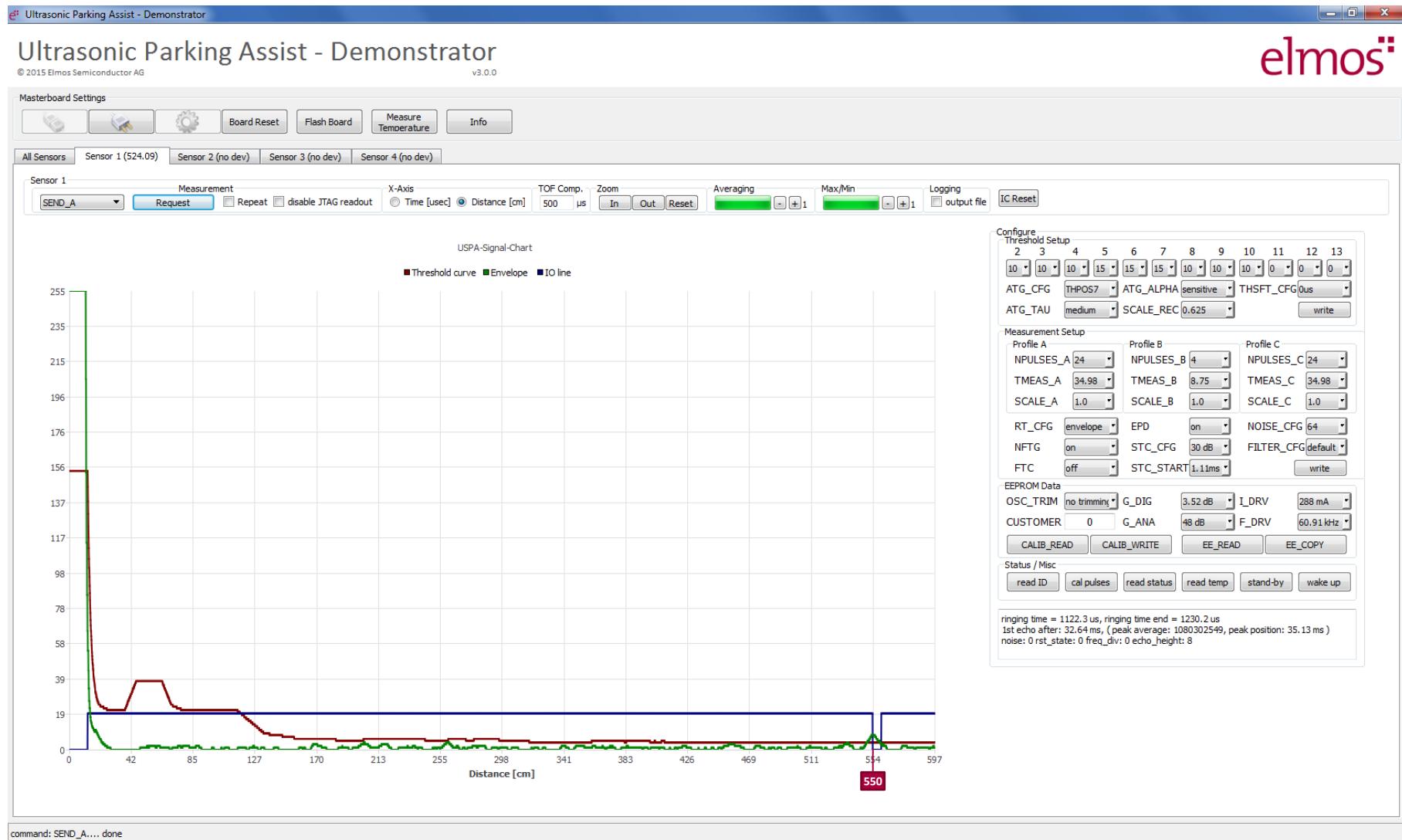
Long Range Performance (ISO Pole in 500cm with 24 burst pulses)

elmos



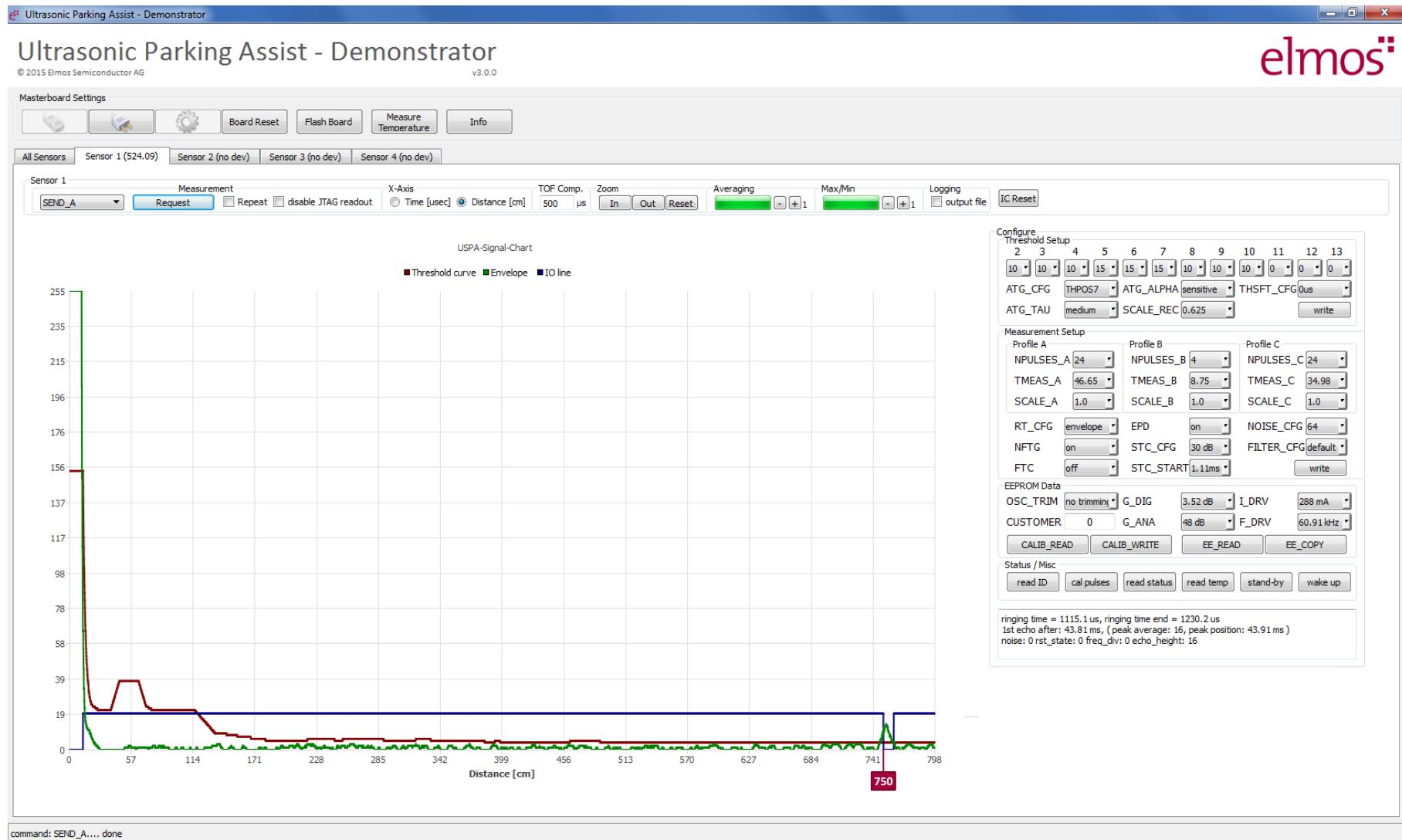
Long Range Performance (ISO Pole in 550cm with 24 burst pulses)

elmos



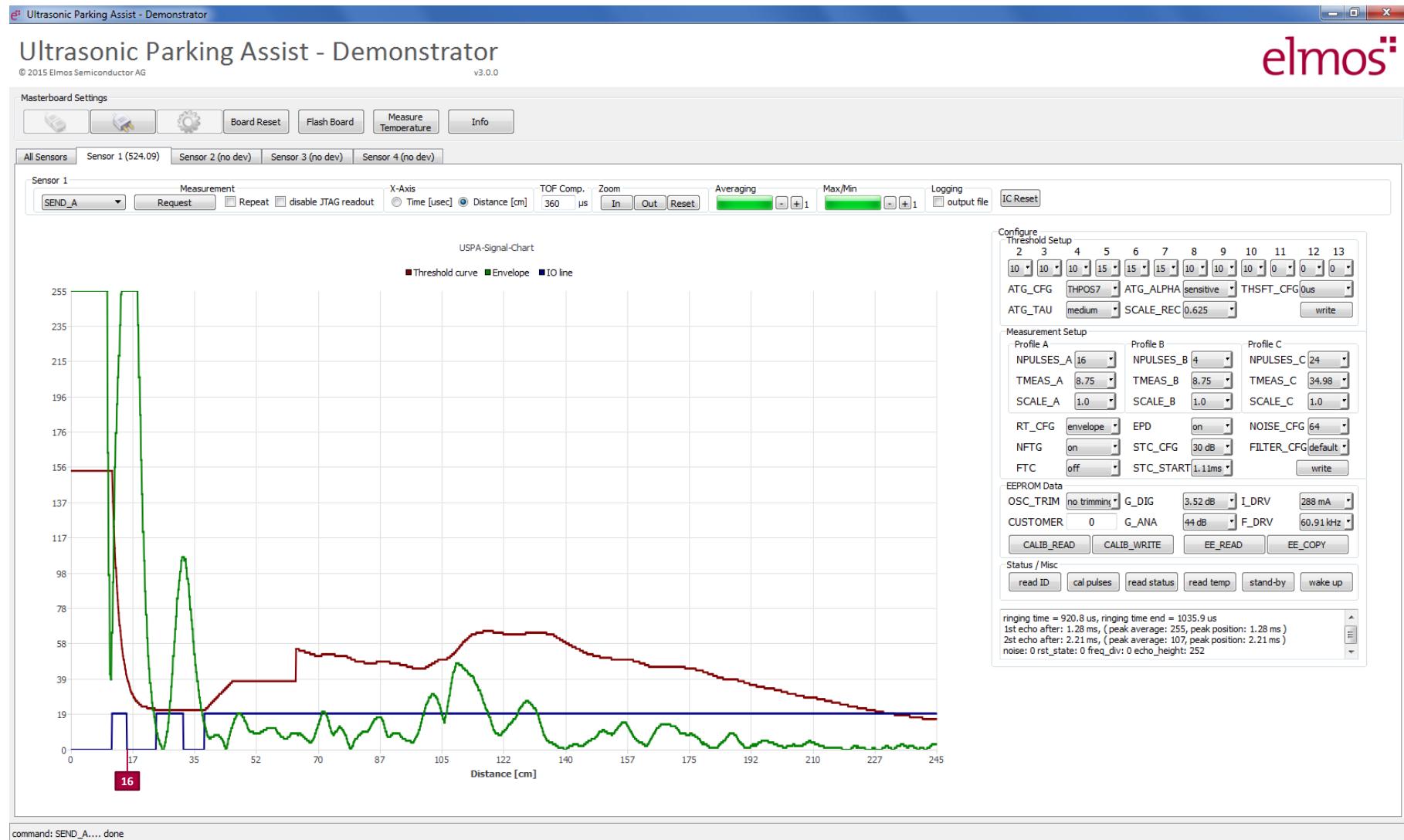
Long Range Performance (Wall in 750cm with 24 burst pulses)

elmos



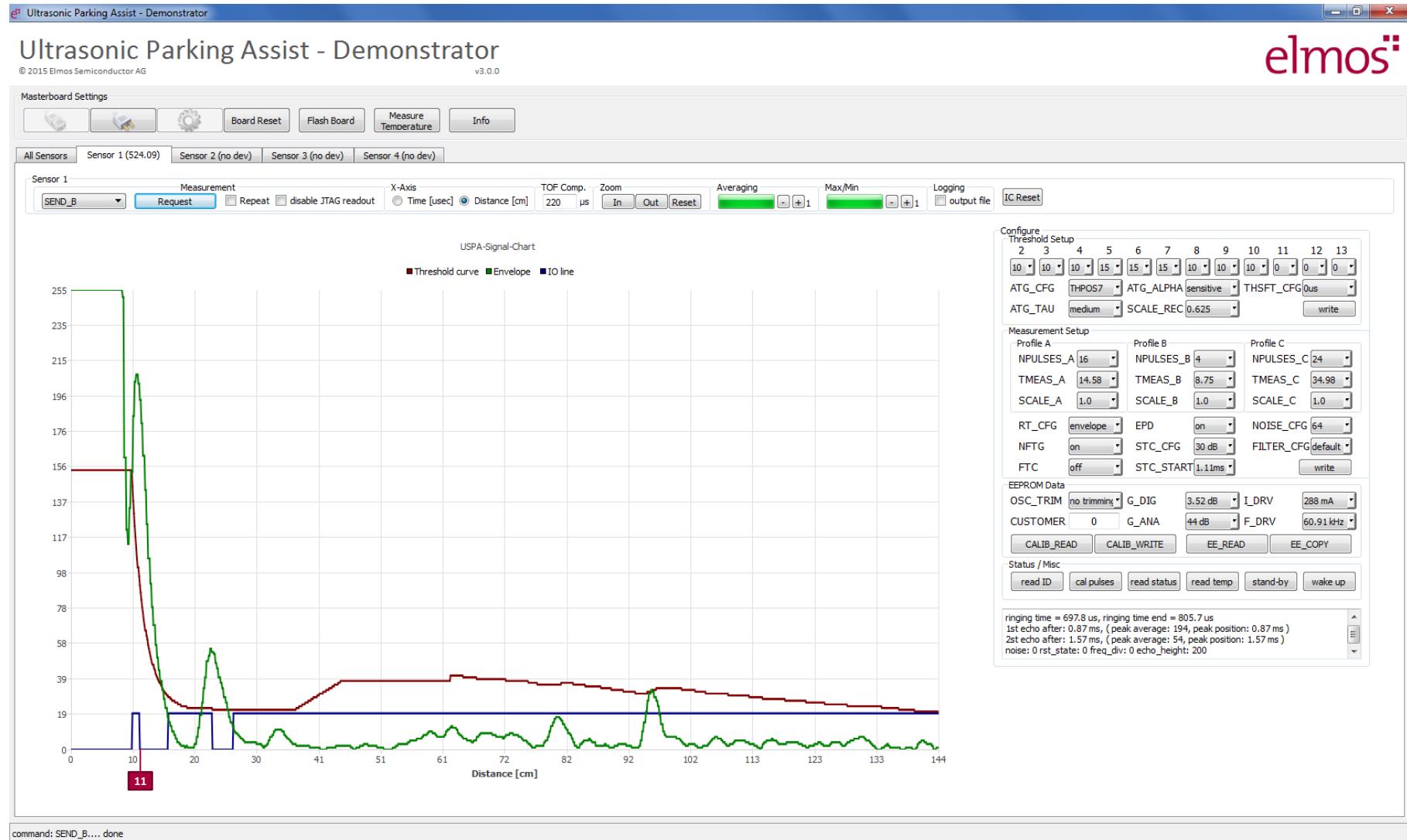
Short Range Performance (ISO Pole in 16cm with 16 burst pulses)

elmos



Short Range Performance (ISO Pole in 11cm with 4 burst pulses)

elmos



New Functions and Features of 524.08/524.09 (compared to 524.02/03 or 524.05/06)

- STC (Sensitivity Time Control)
- EPD (Echo Peak Detection)
- NFTG (Near Field Threshold Generation)
- ATG (Automatic Threshold Generation)
- Ringing Time Measurement
- FTC (Fast Time Constant)
- Measurement Profiles
- Protocols
- Have you seen any irregular behavior of the IC?
- Is there anything (function, feature, behavior...), which should be improved?
- Have you performed system ESD measurements? What are the results?
- Have you performed system EMC measurements? What are the results?

Questionnaire



DOCX-Datei

Planned optimizations

- **Increase analog gain**

- Current: 36-50dB
 - Planned: 42-56dB

- **Increase accuracy of temperature sensor**

- Current: +/- 10 °C
 - Planned: +/- 6°C (@ 25°C)

- **Improve protocols**

- Current: Only „Write“ command for Threshold Setup and Measurement Setup
 - Planned: „Write“ and „Read“ commands for Threshold Setup and Measurement Setup

- **Change of default threshold**

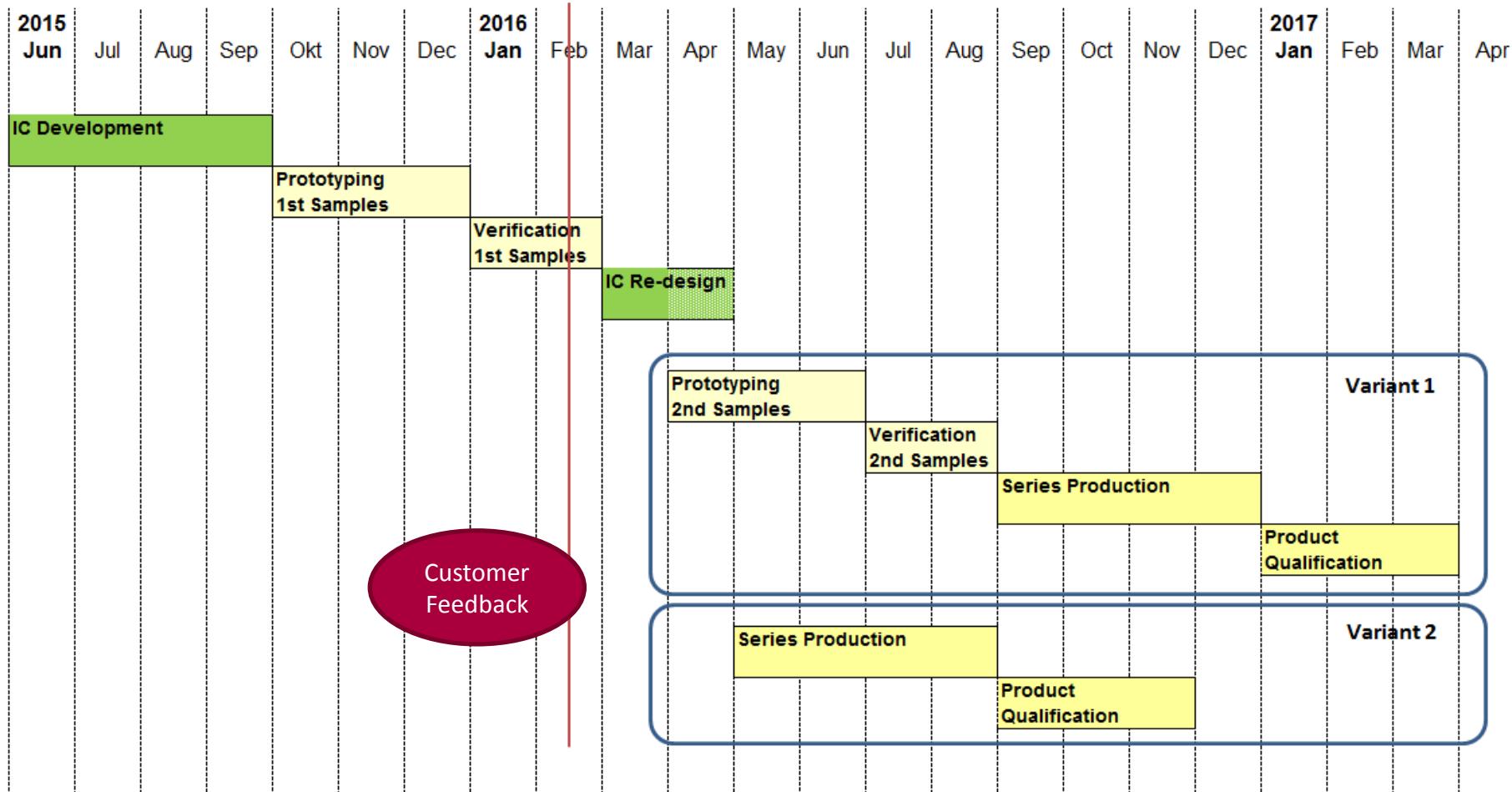
- Current: 10,10,10,15,15,15,10,10,10,0,0,0
 - Planned: **15,15,15,15,15,15,10,10,10,0,0,0**

- **Parameter optimization of Automatic Threshold**

- ATG_TAU, ATG_ALPHA?

- **Additional demands?**

Current Elmos Time Schedule (524.08/09)



Elmos Innovations and continuous Improvements



Innovations / Improvements

Power supply



Feature / Function	524.02/03 (IO 1st Gen)	524.14/24 (LIN 1st Gen)	524.05/06 (IO DD 1st Gen)	524.08/09 (IO 2nd Gen)
Maximum supply voltage	30V (40V t<500ms)	30V (40V t<500ms)	36V (40V t<500ms)	36V (40V t<500ms)
Operating supply voltage	7V - 18V	8V - 18V	7V - 18V	6V - 18V
Supply reset threshold	5.0V	5.2V	4.5V	4.5V
Maximum supply current	12mA	15mA	7mA	7mA
Standby mode	no	no	no	yes
Supply current in standby mode	-	-	-	< 1mA

Feature	524-02/03	524-14/24	524-05/06	524-08/09
Max current consumption (mA)	100	100	100	100
Operating voltage (V)	12	12	12	12
Supply voltage (V)	12	12	12	12
Max. number of sensors supported	16	16	16	16
Standby mode	Yes	Yes	Yes	Yes
Supports ADAS	No	No	No	Yes

- Driven by:**
- German OEM working group specification requires a standby mode
 - In a fully equipment car (12-16 sensors) and ADAS functionality, single sensors can be set to sleep mode

- Benefits:**
- + Reduced current consumption

Innovations / Improvements

Transducer Driver and Amplifier/Signal Path



Feature / Function	524.02/03 (IO 1st Gen)	524.14/24 (LIN 1st Gen)	524.05/06 (IO DD 1st Gen)	524.08/09 (IO 2nd Gen)
Transducer driver frequency	40kHz - 58kHz	30kHz - 80kHz	38kHz - 72kHz	30kHz - 83kHz
Transducer driver frequency, number of steps	64	128	128	256
Transducer driver current	108mA - 310mA	188mA - 518mA	8V - 14.5V	168mA - 354mA
Under-/Overvoltage detection during burst	no	(yes)	no	yes
Transformer switch off during measurement	no	no	(yes)	yes
Amplifier gain	67dB - 82dB	56.5dB - 88dB	60dB - 95dB	36dB - 98dB
Amplifier gain, number of steps	16	64	32	128
Amplifier noise	7nV / sqrt(Hz)	7nV / sqrt(Hz)	7nV / sqrt(Hz)	3.8nV / sqrt(Hz)
Sensitivity Time Control / Dynamic Gain Control	no	yes (software)	yes (12dB)	yes (45dB)

Innovations / Improvements

Transducer Driver and Amplifier/Signal Path

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Fea

Tran

Tran

Tran

Und

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Amp

Amp

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524_02/02

524_11/24

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n)

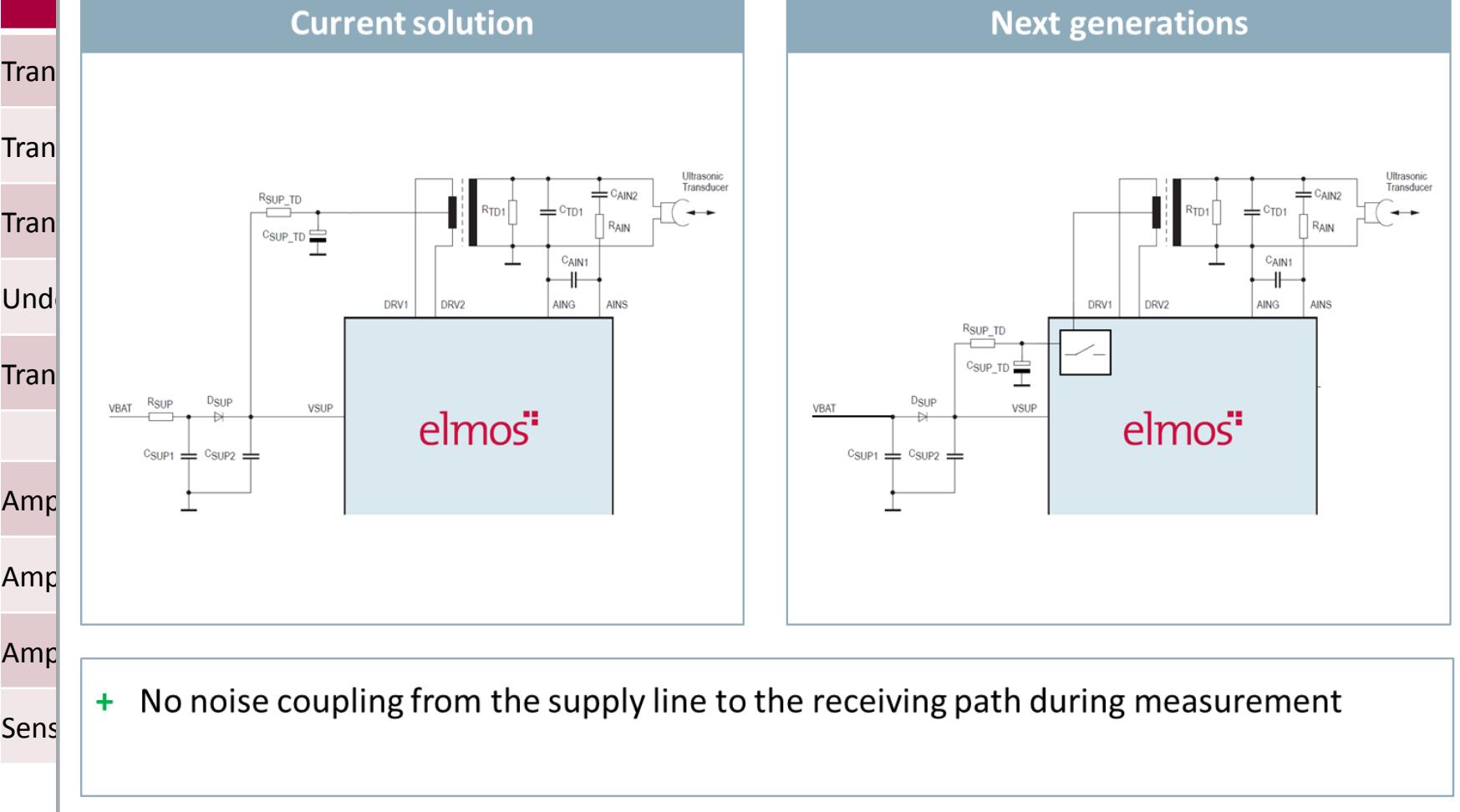
(Hz

lmA

IB

IB

(Hz)



Innovations / Improvements

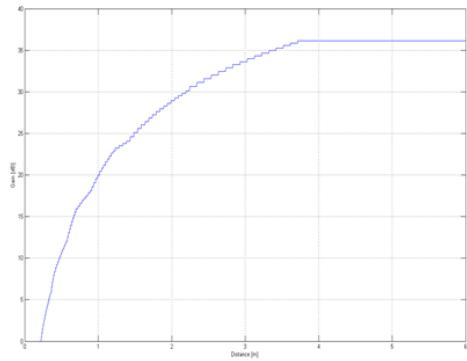
Transducer Driver and Amplifier/Signal Path

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Features

Advantages:

- Shorter ringing time
- Reduction of ground echoes at short range
- No overdrive at short range
- Increased amplitude at long range
- More constant echo amplitude over distance range



- + Short-Range improved by additional 3-5 cm
- + Good detection of any small gap between ringdown signal and echo signal

524-02/02

524-11/24

524-05/06

524-08/09

n)

(Hz

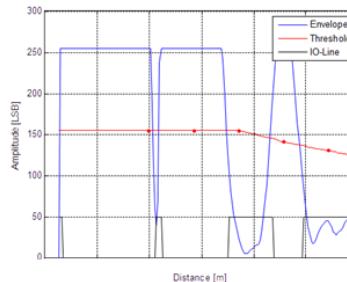
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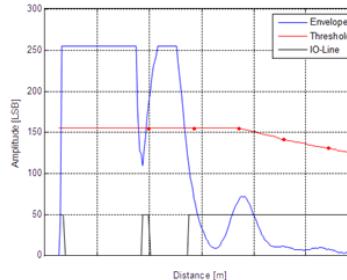
(Hz

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Current signal path



Next generations



Innovations / Improvements

Measurement Cycle

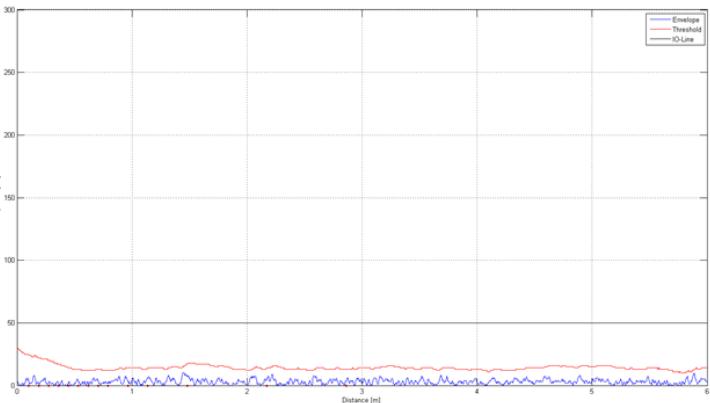


Feature / Function	524.02/03 (IO 1st Gen)	524.14/24 (LIN 1st Gen)	524.05/06 (IO DD 1st Gen)	524.08/09 (IO 2nd Gen)
Variable measurement profiles	no	(yes)	no	yes (3 profiles)
Variable measurement length	2 settings (short / long)	yes (software)	1 setting	8 settings (1.5m - 8m)
Variable burst length	2 settings (8 / 16)	yes (1 - 64)	10 / 16 + 4, 8, 12, 24	8 settings (4 - 32)
Static threshold	yes (5bit)	yes (software)	yes (5bit)	yes (5bit)
Automatic threshold	no	no	yes	yes
Near-Field threshold	no	no	no	yes
Differentiation algorithm (FTC)	no	no	no	yes
Echo width detection	yes	yes	yes	yes
Echo peak detection	no	(yes) (if not saturated)	no	yes
Echo height measurement	no	yes	yes	yes

Innovations / Improvements

Measurement Cycle

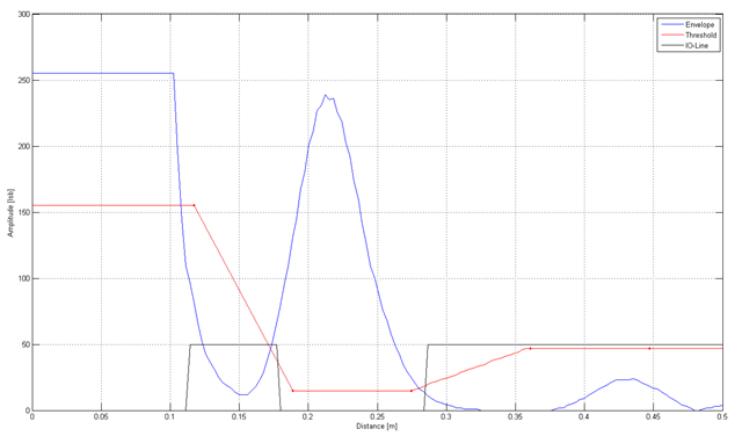
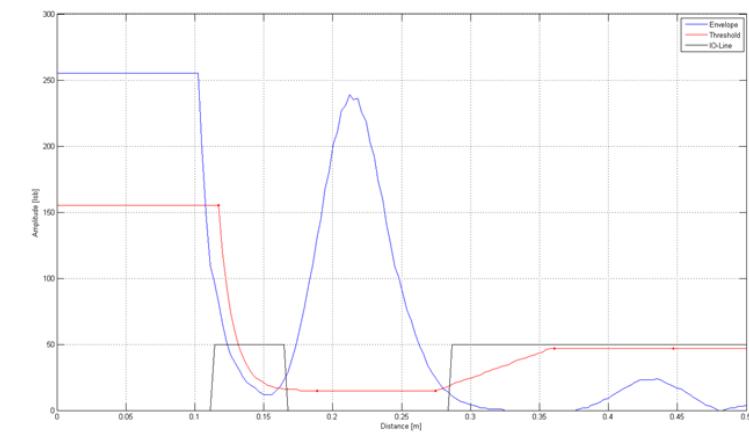
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Feature	524.02/02	524.11/24	524.05/06	524.08/09	Design
Variability	Current solution	Next generations			
Variability	<ul style="list-style-type: none">Linear, adjustable threshold curve	<ul style="list-style-type: none">Automatic threshold generation			
Variability					
Stability					
Autonomy					
Near-field					
Differences					
Echo cancellation	<ul style="list-style-type: none">+ Calculated threshold line is close to the current noise level+ No safety margin for worst case transducers / systems needed+ Higher robustness against acoustic disturbance (pneumatic brake, rain,...)				
Echo cancellation					
Echo cancellation					

Innovations / Improvements

Measurement Cycle

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Feature	524-02/03	524-11/24	524-05/06	524-08/09
Variation	• Linear interpolation or steps			
Variation				
Variation				
Static				
Automatic				
Near-field				
Difference				
Echos	<ul style="list-style-type: none">• Improves short distance detection• Also catches small echos close to the sensor			
Echos				
Echos				

Feature

Variation

Variation

Variation

Static

Automatic

Near

Differen-

Echo

Echo

Echo

F24-02/03

F24-11/24

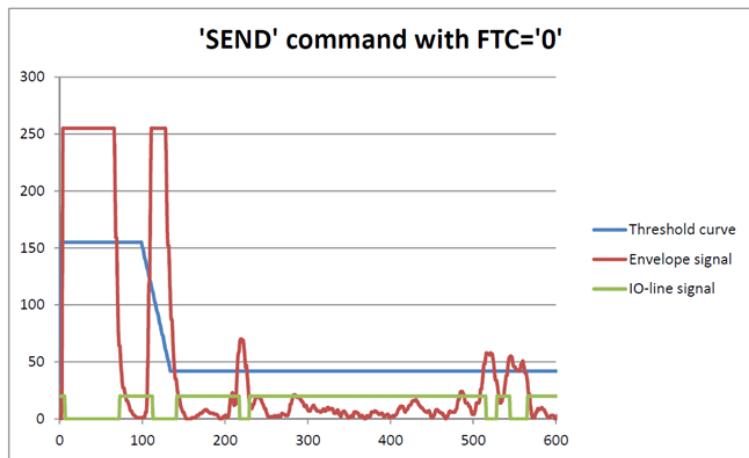
F24-05/06

F24-08/09

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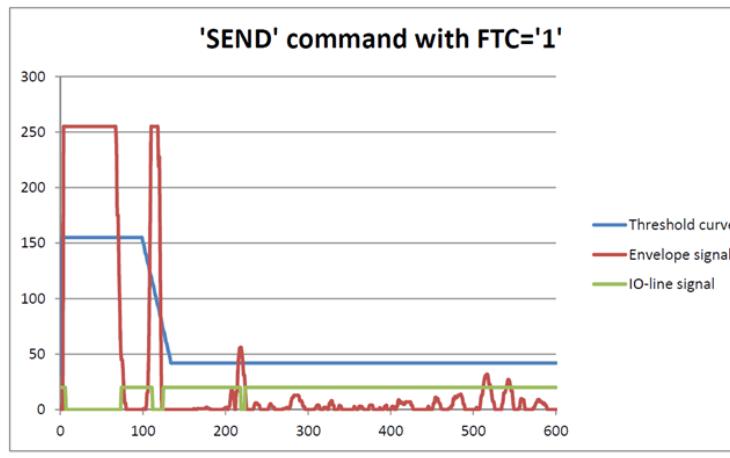
Current solution

- Normal envelope processing



Next generations

- Envelope processing with FTC algorithm



- The Fast Time Constant (FTC) method uses a differentiation algorithm
 - + The noise floor is reduced
 - + The envelope output is robuster against external disturbance

Innovations / Improvements Measurement Cycle

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Feature

Variation

Variation

Variation

Static

Auto

Near

Differ

Echo

Echo

Echo

524-02/03

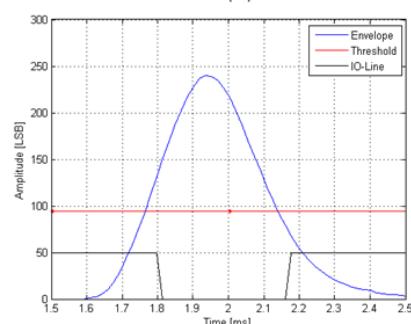
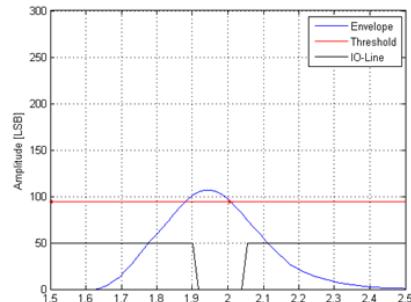
524-11/24

524-05/06

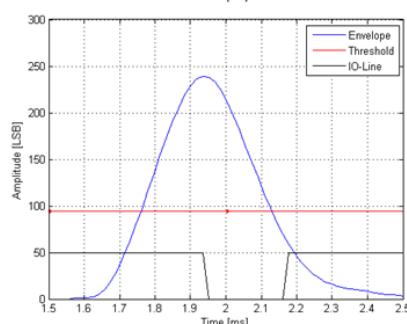
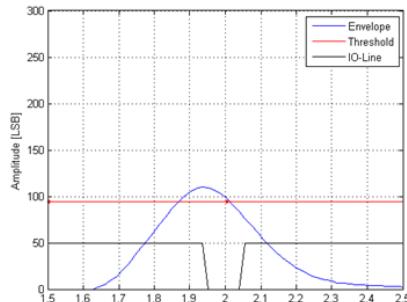
524-08/09

(n)

Current solution



Next generations

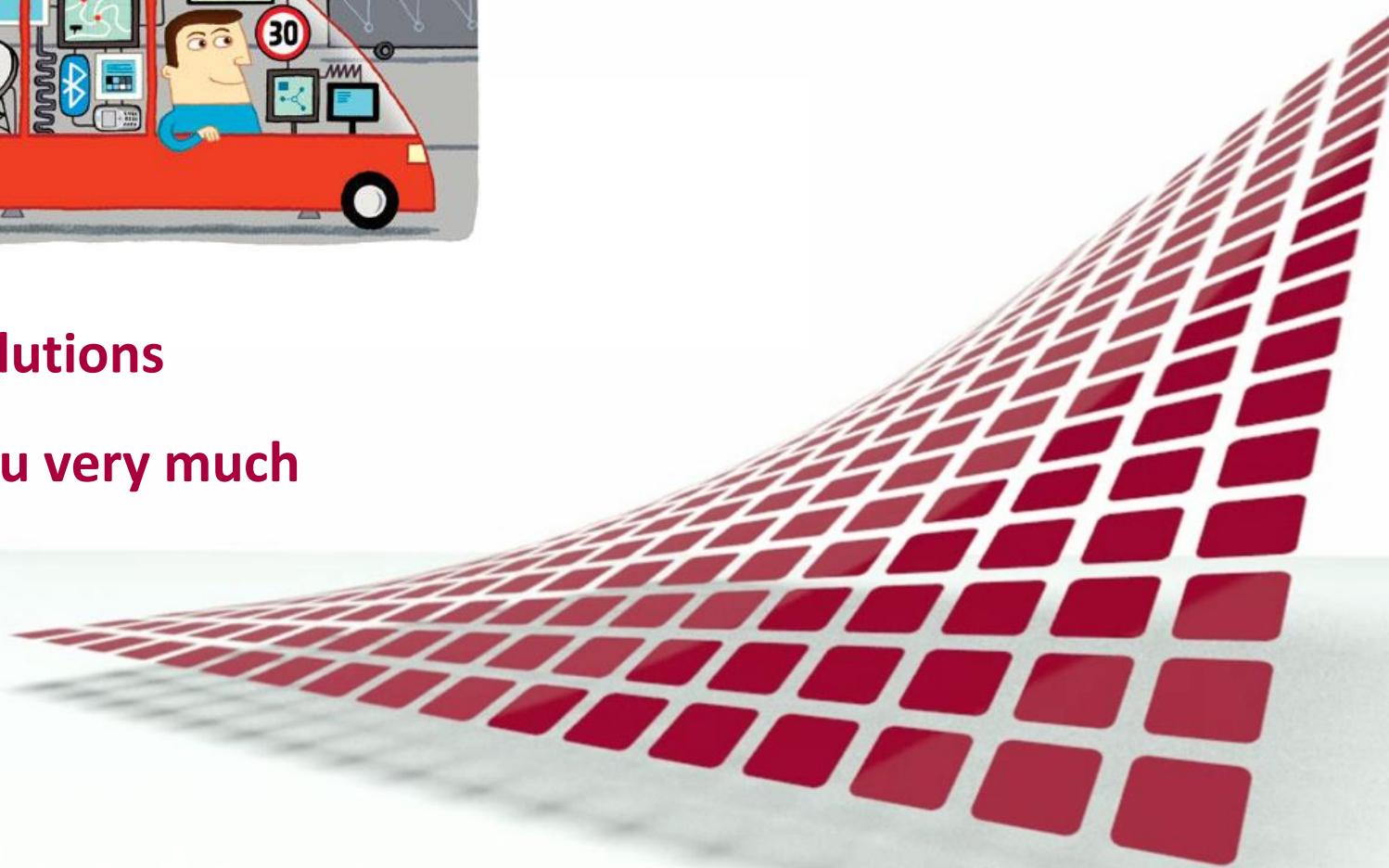


- + The detected position of an obstacle nearly stays constant
- + Allows a more precise distance measurement



Elmos Solutions

Thank you very much



Elmos Semiconductor AG

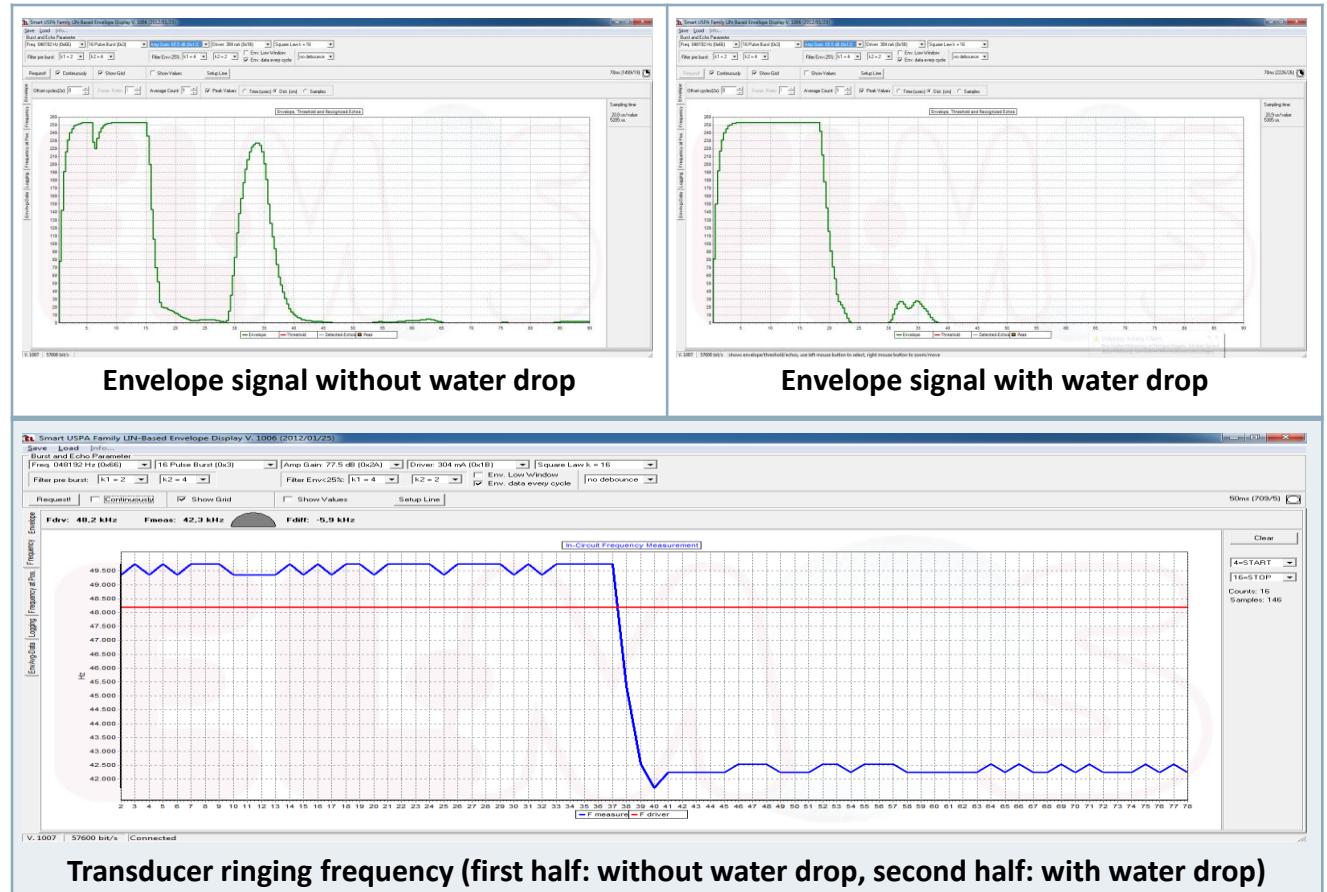
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Blocking analysis of water, ice, mud, ...



Frequency shift of transducer can be used to recognize water droplets, dirt or blockade due to icing.

ELMOS introduces this feature with the E524.14/24.



Self Diagnosis for various sensor blockages

Innovations / Improvements

Diagnosis



Feature / Function	524.02/03 (IO 1st Gen)	524.14/24 (LIN 1st Gen)	524.05/06 (IO DD 1st Gen)	524.08/09 (IO 2nd Gen)
Ringing time measurement	yes (done in ecu)	yes	yes (done in ecu)	yes (done in ECU)
Ringing frequency measurement	no	yes	yes	yes
Envelope read out via JTAG	yes	yes	yes	yes
Envelope read out via LIN/IO	no	yes (digital)	no	yes (analog)
Internal temperature sensor	no	yes (only 524.24)	no	yes
Under-/Overvoltage protection	no	(yes)	no	yes
Package	QFN20L4	QFN20L5	QFN20L4	QFN20L4
Status	AECQ Qualified Mass Production	AECQ Qualified Mass Production	AECQ Qualified Mass Production	Engineering Samples available since Q4/15