Nov 30, 2015

Distance measurement using Elmos Ultrasonic Sensor ICs

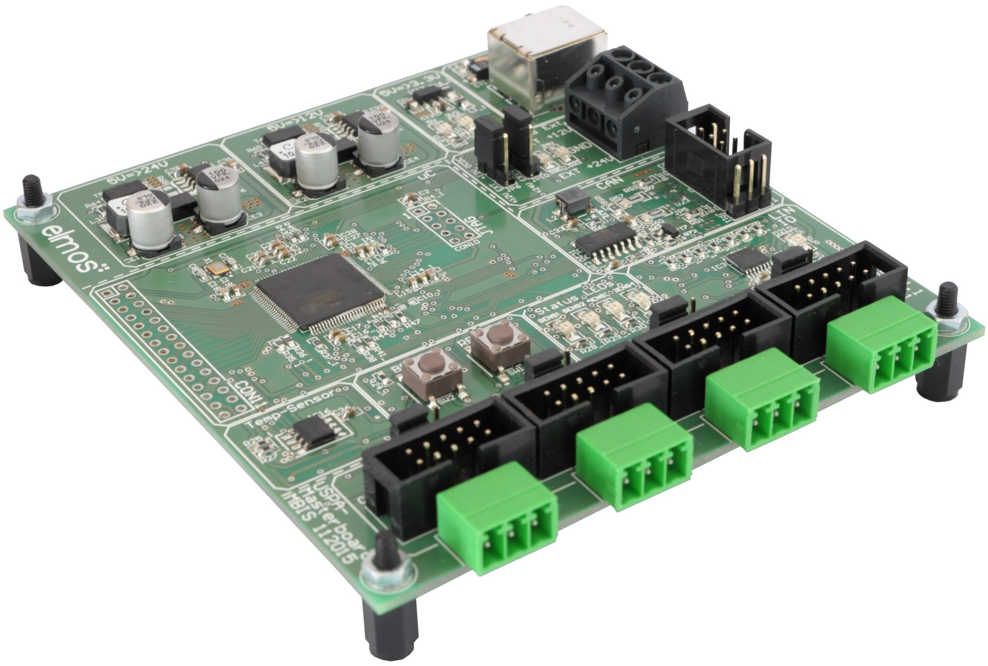


Figure 1: Ultrasonic Park Assist – Demonstrator Master Board

Elmos "Ultrasonic Park Assist" Demonstrator

With this USPA Master Board Elmos offers a complete "**U**ltra**s**onic **P**ark **A**ssist" Demonstrator, which allows you to check out the performance of the Elmos ultrasonic devices in detail. A complete system (1 Master Board and up to 4 Sensor Boards) offers the following options:

- Visualization of envelope and threshold curves
- Echo detection and distance measurement
- Easy configuration and adjustment of all IC parameters
- Non-volatile memory programming
- Multi-Sensor-Mode (One sensor sends out the ultrasonic burst and all sensors receive the signal)

1 What you get

- Elmos Ultrasonic Sensor Master Board
- USB cable to connect the Board with a PC
- CD with software package
- Documentation

2 What you need in addition

- At least one of the Ultrasonic Sensor Boards listened below
- Up to 4 Sensor Boards can be connect to this Master Board
- A mixture of different Sensor Boards is possible, but not recommended.

2.1 Optional available Boards

	Document	Order Code	Description
[1]	25AN0150E.xx	K5240X-0001	“Ultrasonic Park Assist” Demonstrator (Master Board)
[2]	25AN0151E.xx	K52402-0002	E524.02 – Ultrasonic Sensor Board
[3]	25AN0152E.xx	K52403-0002	E524.03 – Ultrasonic Sensor Board
[4]	25AN0153E.xx	K52405-0002	E524.05 – Ultrasonic Sensor Board
[5]	25AN0154E.xx	K52406-0002	E524.06 – Ultrasonic Sensor Board
[6]	25AN0155E.xx	K52408-0001	E524.08 – Ultrasonic Sensor Board
[7]	25AN0156E.xx	K52409-0001	E524.09 – Ultrasonic Sensor Board

2.2 Data Sheets

	Document	Description
[1]	25DS0068E.xx	E524.02 / E524.03 – Data Sheet
[2]	25DS0112E.xx	E524.05 / E524.06 – Data Sheet
[3]	25DS0138E.xx	E524.08 / E524.09 – Data Sheet

3 Set up the "Ultrasonic Park Assist" Demonstrator

The demonstrator contains function blocks / components which are also used in a standard parking application ECU. They are located in the lower section of the board, separated by the dashed line.

- 1x Elmos 521.50 Quad LIN transceiver (interface to the sensors)
- 1x Elmos 520.13 HS-CAN transceiver with partial networking (interface to the vehicle network)
- 1x microcontroller
- 1x temperature sensor

In addition there are further blocks for auxiliary supply generation and communication to a PC.

- 2x Elmos 910.26 Step-up converter for 12V and 24V supply
- 1x USB port for communication
- several LEDs for voltage status and connected sensors

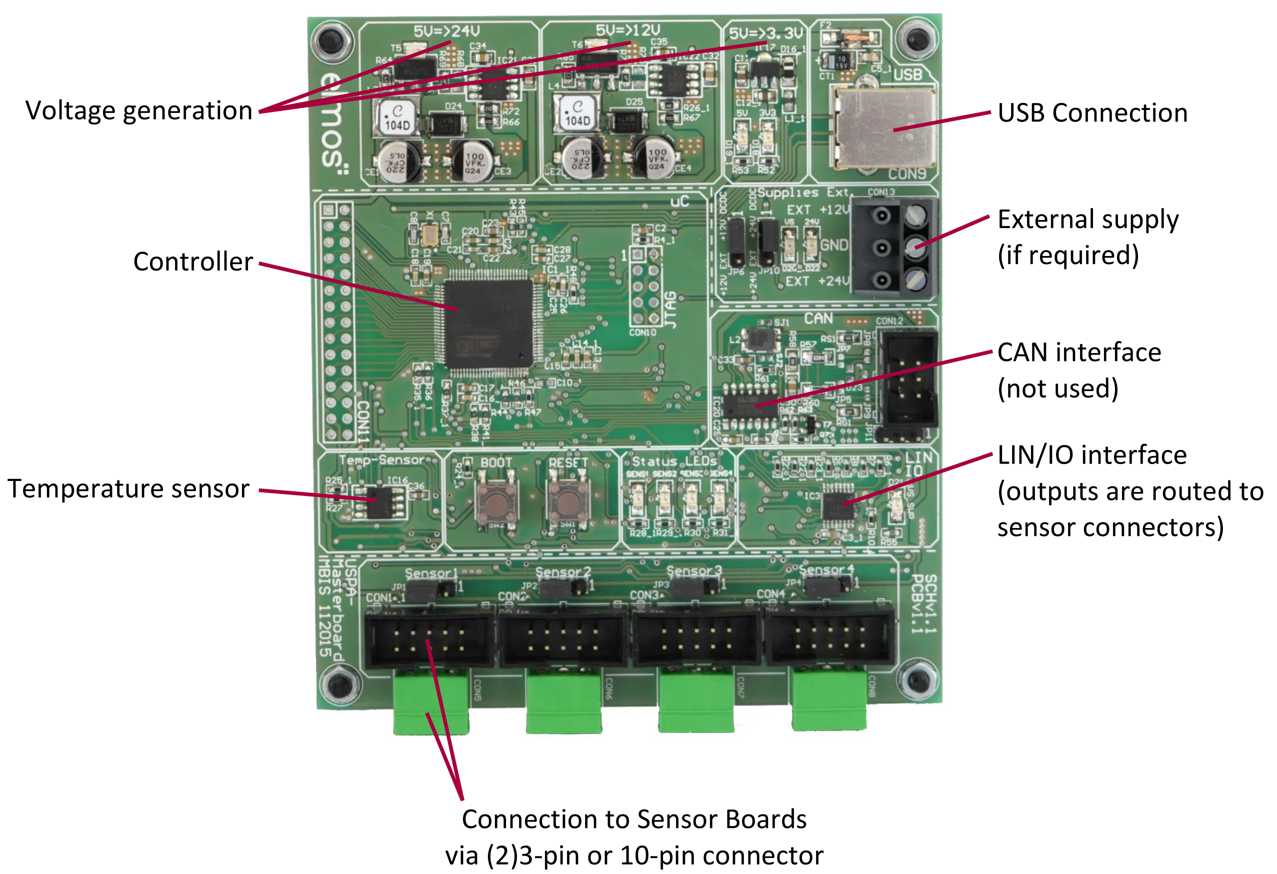


Figure 2: Master Board

3.1 Board Connections

3.1.1 USB connector

This port shall be connected to a USB interface of the PC which runs the "Ultrasonic Park Assist" Demonstrator application. This connector is used for communication and for the voltage supply of the master board and all connected sensors.

3.1.2 External supply voltage connector

The supply voltages VS and 24V are generated by two DCDC converters from the USB supply. In case, variable voltages or higher currents are needed, external supplies can be connected via terminals. Please refer to the top side marking of the PCB for the correct polarity. If external voltages are applied, the jumpers have to be set accordingly. The maximum voltages should not exceed more than 30V.

3.1.3 Ultrasonic sensor boards connector

The Ultrasonic Sensor Boards can be connected in two ways:

- via the 10-wire ribbon cable by using the 10-pin connector
  (for the visualization of envelope and threshold curves)
- via a 2- or 3-wire cable by using the 3-pin connector
  (for application mode)

3.1.4 CAN transceiver connector

This board is equipped with a CAN transceiver IC, but it is not used by the current software.

3.1.5 Quad LIN transceiver connector

This board is equipped with a Quad LIN transceiver IC, which is used as an interface to the sensor. The outputs of this IC are routed to the 3-pin and 10-pin connectors.

3.1.6 Indicators for supplies and communication

There are several LEDs on the board to display the current status.

- 5V supply — from the USB port
- 3.3V supply — used by the microcontroller
- VS (12V) supply — used by the interface ICs and all connected sensors
- 24V supply — used for non-volatile memory programming
- LED1 - LED4 — active sensors are connected to ports 1 - 4

3.2 Start of application

1. Connect 1 to 4 Sensor Boards to the Master Board
2. Connect USB cable from Master Board to the PC

   During the first start-up, the USB driver has to be installed (see chapter 3.2.1)
3. Execute the application “UltrasonicParkAssistDemo.exe”
4. After application start the following window appears

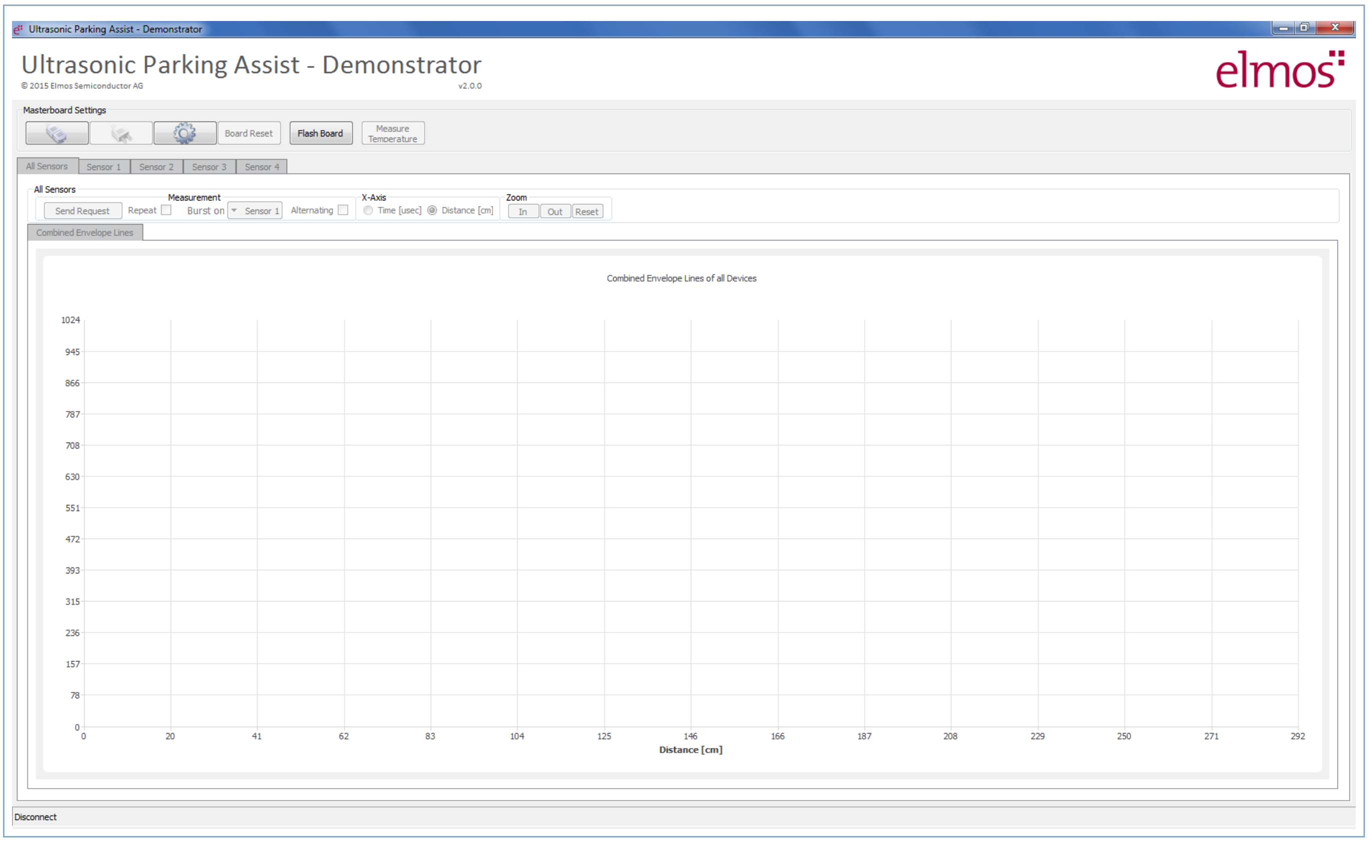


Figure 3: Application after start up

At the top, the “Master Board Settings” contain all elements to set up the communication between the board and a PC, reset or update the board. Additionally, it allows to measure the ambient temperature via the onboard temperature sensor.

The wide window below is used for all ultrasonic measurements. It allows to configure the different Elmos Ultrasonic Sensor ICs and to display and analyze all information returned by the IC.

3.2.1 USB driver installation

The board uses the USB interface of the microcontroller. In order to access this interface, an USB device driver shall be used. Thus, the board is shipped with two files “atmel_devices_cdc.inf“ and “atmel_devices_cdc.cat”, located in the directory “cdc-uspamasterboard”.

1. Log on with administrator rights
2. Connect the USB cable from the Master Board to the PC
3. The assistant for driver installation starts
4. When asked to connect to the internet to search for new software select “no” and click “next”
5. The assistant asks for the driver “Atmel USB Driver”
6. Select the option to install from a given source (no automatic installation) and click “next”
7. Now select the path with the driver provided by Elmos (file “atmel_devices_cdc.inf”) and click “next”
8. Select “continue installation”

Bootloader USB driver

In case of flashing the microcontroller on the board, an additional driver for the bootloader is required. Set the microcontroller in Bootloader mode and a new device appears in the Windows Device Manager. The driver is located in the directory “dfu-prog-usb-1.2.2”. Please follow the instructions above.

3.3 Master Board Settings

Figure 4: Master Board settings after start-up

This tab offers the following functions:

1. Connect to master board
2. Disconnect from master board
3. Communication settings
4. Reset master board
5. Flash master board
6. Measure temperature
7. Information and version overview

3.3.1 Establish the USB communication

First, click on the "wheel" button to open the communication settings / port configuration. In the new window all available communication ports are listened in the drop-down list. Select the correct port with the driver description below (figure 5).

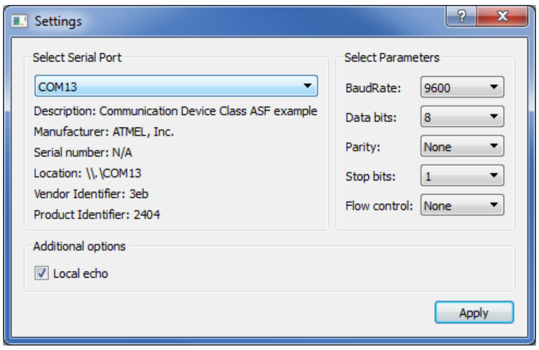


Figure 5: Select the communication port

Apply the settings and click on the "connect" button. Once the connection is established, the "connect" button will become inactive and other buttons will become active, as shown below. In addition, all connected sensors will be displayed in the tabs below (in this example 4 sensors with 524.06).

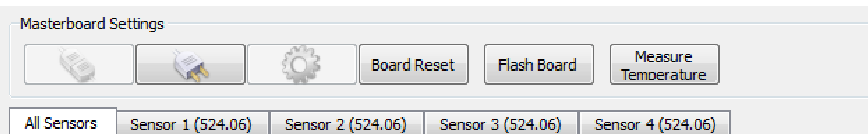


Figure 6: Master Board settings after established USB connection

3.3.2 Manual selection of a connected device

If the sensors are only connected via 2- or 3-wires, there is no automatic device detection. In this case, the connected device can be selected manually. All supported devices are listed in the drop-down list.

Please ensure, that the selection matches with the connected device.

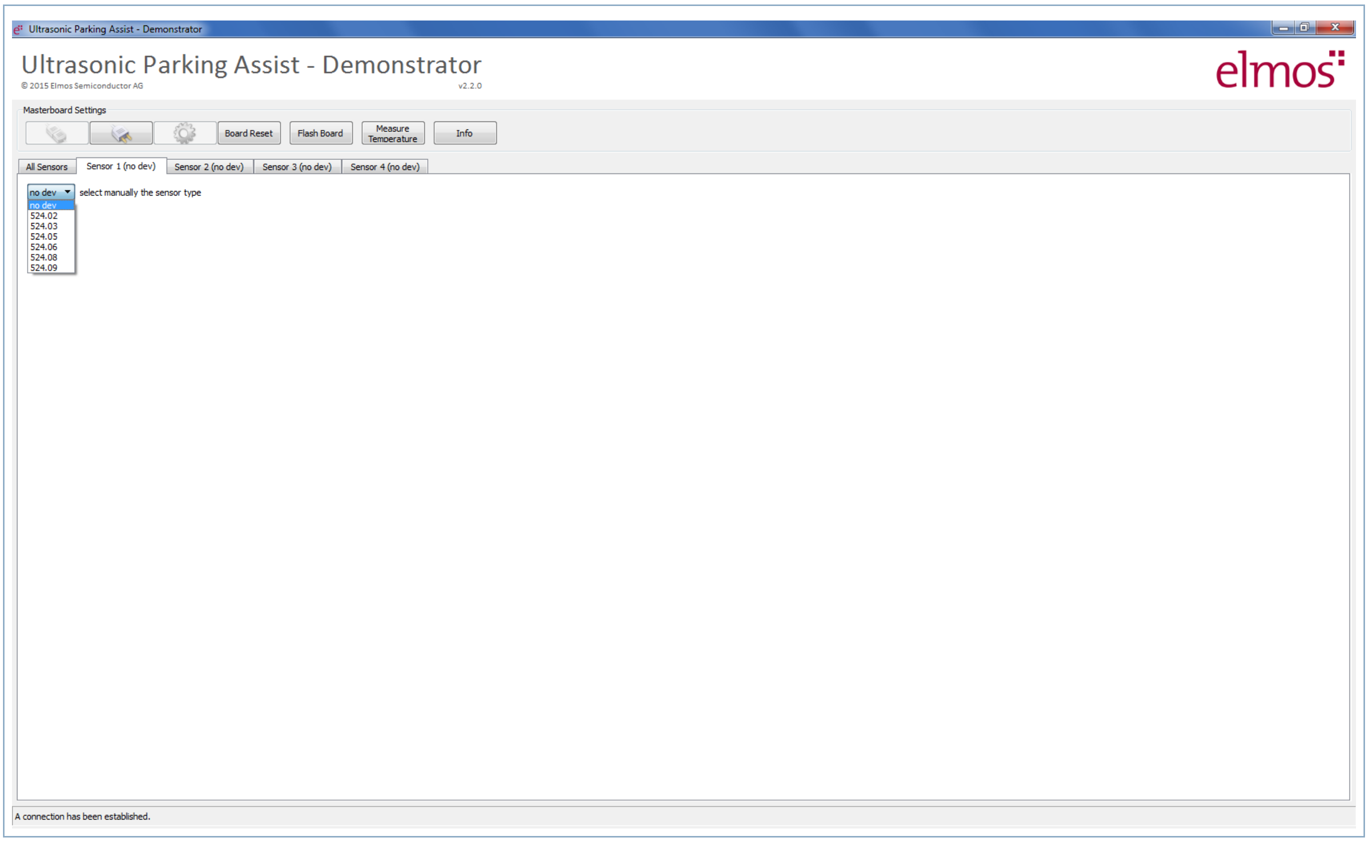


Figure 7: Manual selection of a connected device

3.3.3 Flash (update) of master board

The PC software allows to flash the master board, e.g. in case of newer software.

Therefore the master board has to be switched to the "bootloader mode". This bootloader will be activated when the "boot" button on the board is pressed at reset. Please make sure, that the bootloader driver (chapter 3.2.1) is installed.

After confirmation, a flash tool will be opened and the software will be updated. After a successfully programming as shown in figure 8, please restart the board and the application software.

Important: The tool starts only, if the software is located in a directory without any special characters or spaces.

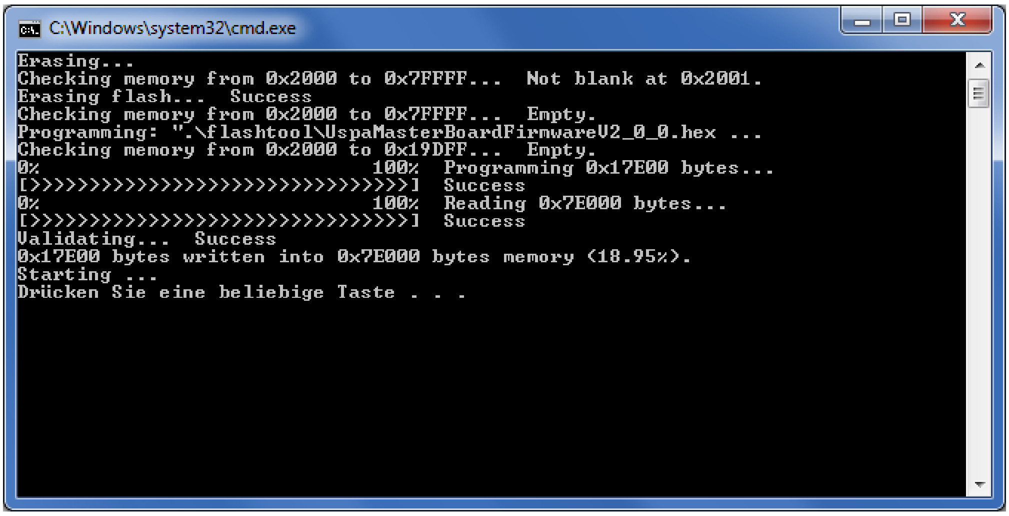


Figure 8: Flash (update) of master board

3.3.4 Measurement of ambient temperature

The master board has a temperature sensor to measure the ambient temperature. This temperature information is used to calculate the velocity of ultrasound which is further used for the distance measurement (see also chapter 4.1.1. After start-up the temperature measurement is done automatically.

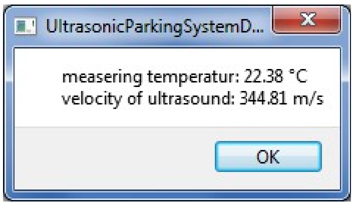


Figure 9: Measurement of ambient temperature

4 Measurements

The software and the master board supports two measurement modes

- single sensor mode (tabs “Sensor 1”, “Sensor 2”, “Sensor 3” and “Sensor 4”)
- multi sensor mode (tab “All Sensors”)

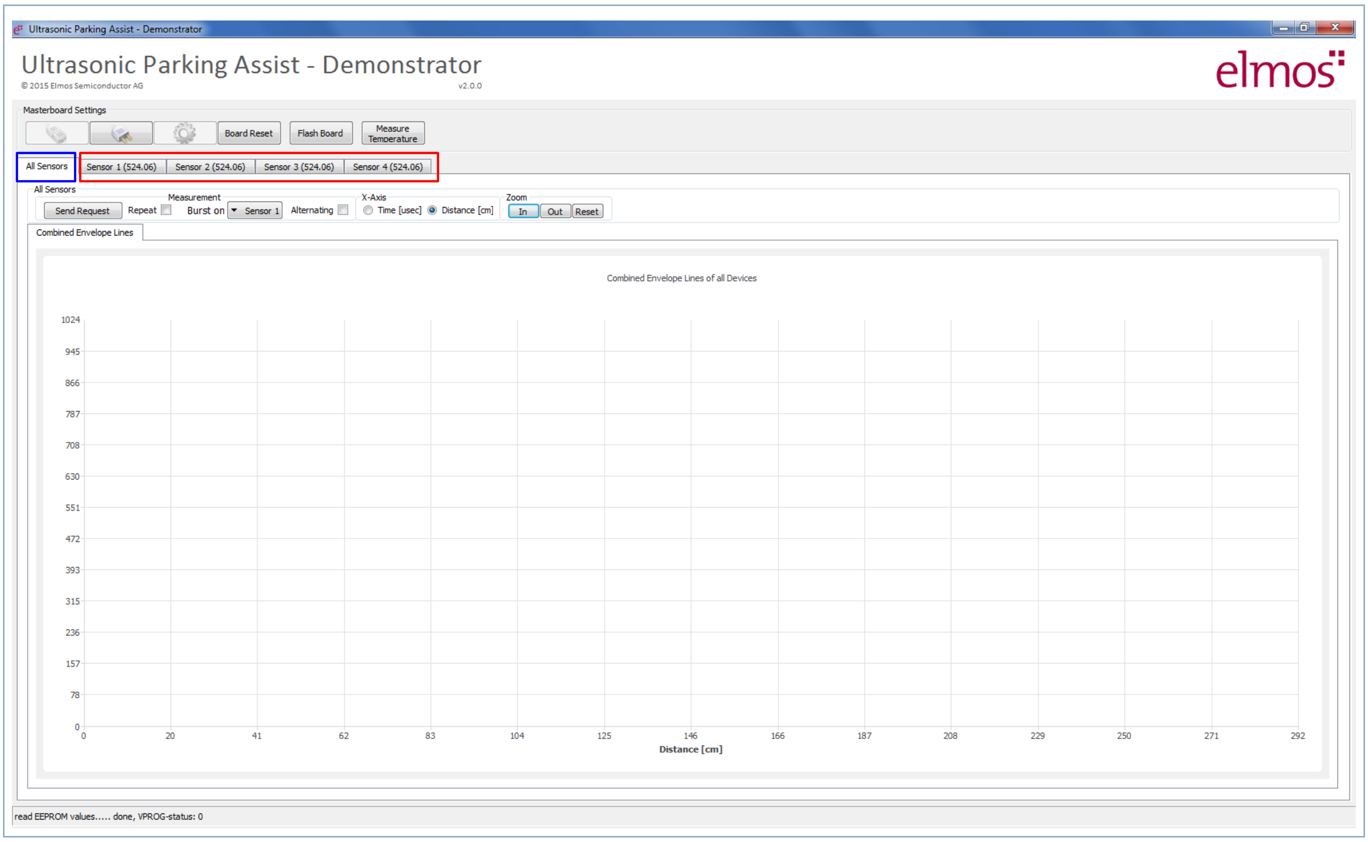


Figure 10: Single and Multi sensor modes

In single sensor mode, all IC parameters can be configured, all signals (envelope, threshold, IO line) can be visualized and additional status information can be read out.

In multi sensor mode, only the envelope signals of all connected sensors are visualized. One sensor sends out the ultrasonic burst and all sensors receive the incoming signal.

4.1 Single sensor mode

The measurement window in single sensor mode is divided into 4 blocks

1. Measurement configuration
2. Signal chart (displays envelope, threshold and IO line signals)
3. IC configuration
4. Message field (additional measurement and status information)

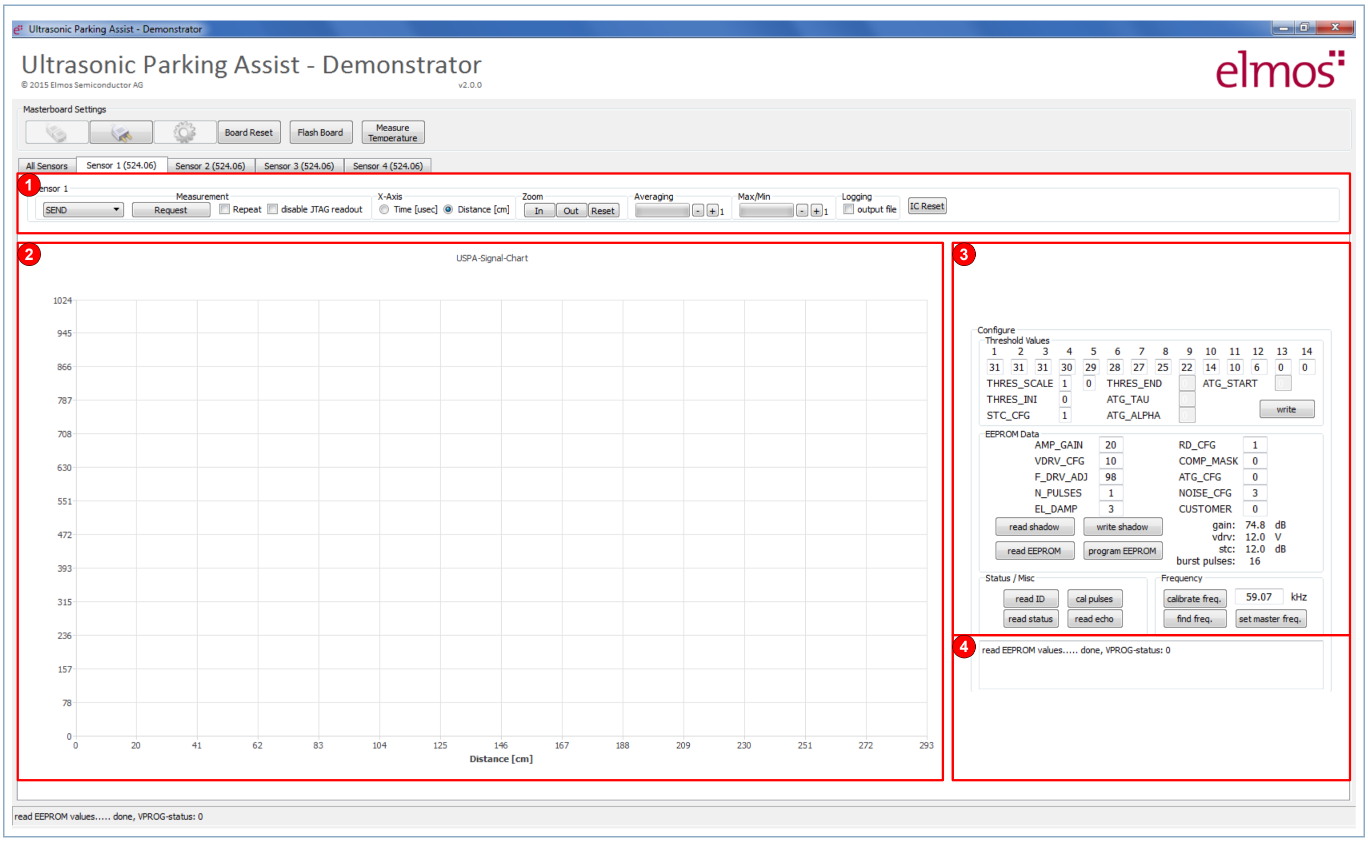


Figure 11: Measurement window in single sensor mode

4.1.1 Measurement configuration in single sensor mode

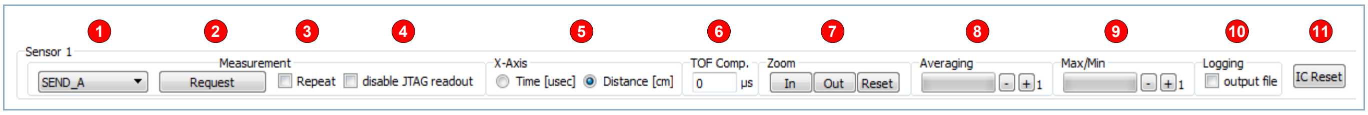


Figure 12: Measurement configuration in single sensor mode

Measurement

1. Selects the measurement type. This may be a standard “Send” or “Receive” request or further advanced measurements. Depending on the IC, different commands are supported. Please refer to the IC data sheets.
2. The “Request” button performs the selected measurement type.
3. If “Repeat” is selected, the selected measurement will be repeated continuously with the next “Request”. The continuous mode can be stopped by pressing “Repeat” again.
4. If “disable JTAG readout” selected, this disables the data sampling via JTAG interface from the sensor and only the signal of the IO line will be displayed.

X-Axis

5. The x-axis of the measurement chart can display either a time or a distance information. Typically ultrasonic sensors measure only a time information and the distance is calculated in the master control unit. Thus, in this software the distance is calculated based on the temperature information (see also chapter 3.3.4).

TOF compensation

6. By using the TOF compensation the delay of the internal processing can be compensated, so that the measured distance matches with the real distance of the obstacle.

Zoom

7. The zoom function may be very helpful to analyze small signals or a particular time period. It is possible to zoom in and zoom out the measurement chart. A reset will set the dimensions to default values. Additionally the mouse can be used to zoom. Press mouse button in the chart and draw the favored area.

Averaging

8. By using this function, the average of the last measurements is displayed in the chart. The number of measurements can be adjusted with -/+. The total maximum is 25. Default is 1 (no averaging). The echo detection on the IO will be disabled when using the averaging function.

Max / Min

9. By using this function, the minimum and maximum values of the last measurements are displayed in the chart, which is done by the additional grey plot. The number of measurements can be adjusted with -/+. The total maximum is 25. Default is 1.

Logging

10. The logging function writes all configuration data and all signals (envelope, threshold, IO line) to a file at every measurement request. If selecting the checkbox, a file name can be chosen. If the checkbox is deselected again, the logging stops. Be careful, when using the logging function together with continuous measurements, because the file size may get very large in short time.

IC-Reset

11. This resets the IC.

4.1.2 IC Configuration

The exact IC configuration depends on the connected device. For more detailed information, please refer to the IC data sheets.

Configuration of 524.02 / 524.03

The following figure shows the configuration, if either a 524.02 or a 524.03 is connected.

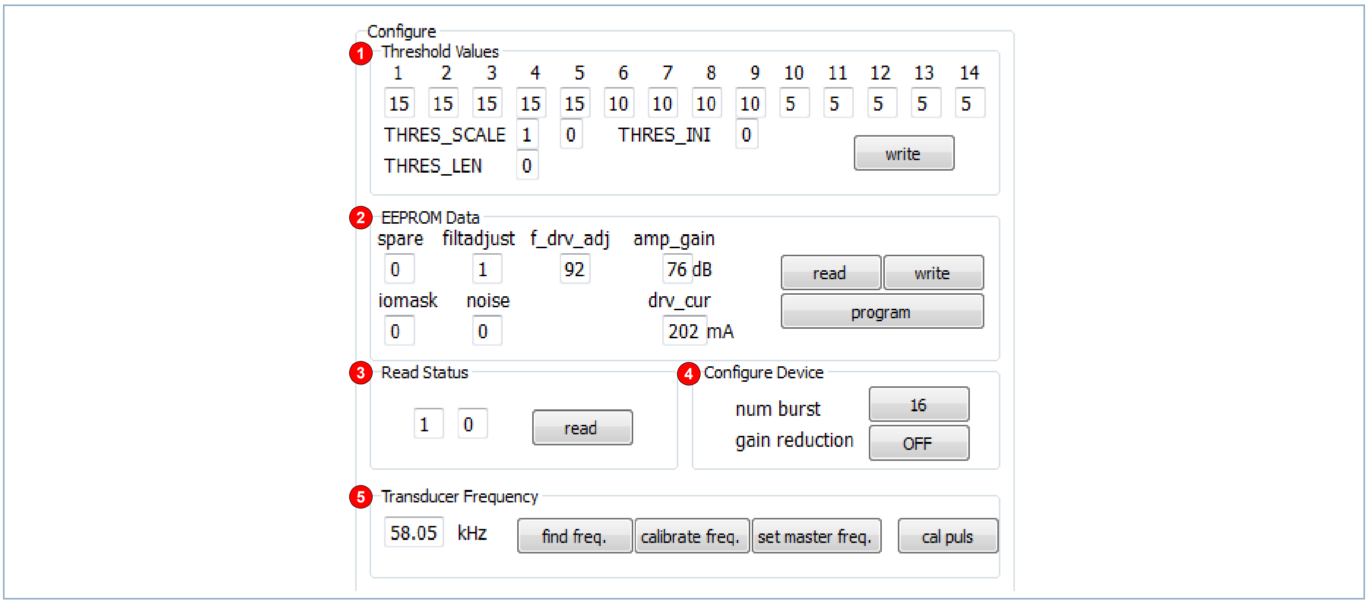


Figure 13: IC Configuration of 524.02 / 524.03

1. Threshold values:
   - configuration values for static threshold curve
   - write: write values to volatile registers

2. EEPROM data:
   - configuration values for amplifier, driver current, driver frequency, masking, noise and filter
   - write: write values to volatile sensor shadow registers
   - read: copy EEPROM cells to volatile sensor shadow registers and read out
   - program EEPROM: copy actual volatile sensor shadow register to EEPROM cells
     Note: a new setting for F_DRV_ADJ is active after programming the EEPROM

3. Read Status:
   - read: read the sensor status

4. Configure the device:
   - num burst: select 8 or 16 burst pulses
   - gain reduction: no gain reduction (off) / 6dB gain reduction (on)

5. Transducer Frequency:
   - calibrate: for an easy calibration of the sensor driver frequency the new frequency can be entered in [kHz] in the text field and the software searches for the best F_DRV_ADJ setting, finally the best settings is programmed into the EEPROM
   - find: the software starts a search algorithm to find out at which IO line master frequency the sensor is able to communicate. This is helpful if the sensor driver frequency (and therefore the IO protocol frequency) is unknown.
   - set master: set the IO protocol frequency of the master board
   - cal puls: measure the calibration pulses on IO and calculate the sensor driver frequency

   Remark: Be careful when adjusting the F_DRV_ADJ register or using the calibrate function. If the frequency has to be changed, please always use small steps and check the frequency after programming. If the frequency is out of range, further communication between the master board and the sensor board is not possible.

Configuration of 524.05 / 524.06

The following figure shows the configuration, if either a 524.05 or a 524.06 is connected.

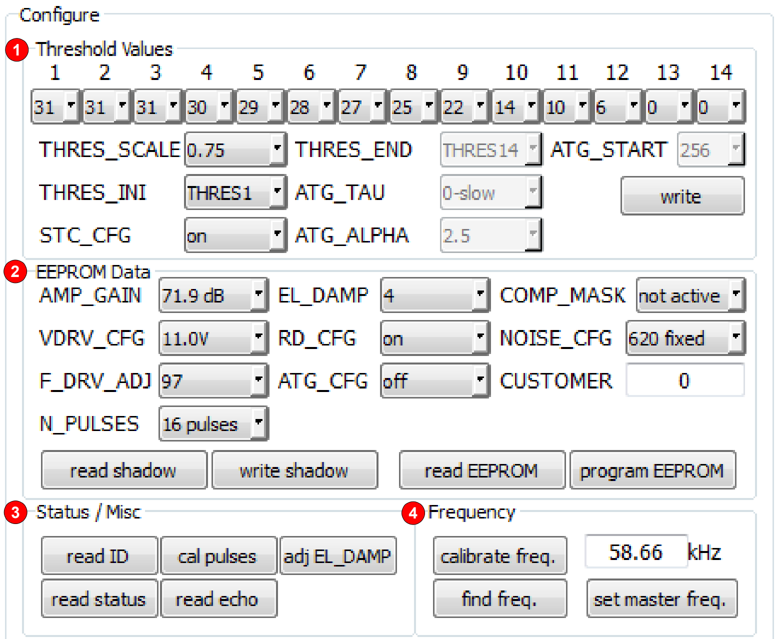


Figure 14: IC Configuration of 524.05 / 524.06

1. Threshold values:
   - configuration values for static threshold curve, automatic threshold and STC
   - write: write values to volatile registers

2. EEPROM data:
   - configuration values for amplifier, driver voltage, driver frequency, number of burst pulses, electronic damping, damping resistor, masking, automatic threshold and noise
   - read shadow: read out volatile sensor shadow registers
   - write shadow: write values to volatile sensor shadow registers
   - read EEPROM: copy EEPROM cells to volatile sensor shadow registers and read out
   - program EEPROM: copy actual volatile sensor shadow register to EEPROM cells
     Note: a new setting for F_DRV_ADJ is active after programming the EEPROM

3. Status / Misc:
   - read ID: read sensor identification
   - cal pulses: measure the calibration pulse width on IO and calculate the sensor driver frequency
   - read status: read sensor status and display the values in the message field
   - read echo: read out the height of the first detected echo during last measurement
   - adj_EL_DAMP: select automatically the optimum EL_DAMP setting to shorten the ringing time. During calibration of EL_DAMP no close obstacle should be in front of the transducer.

4. Frequency:
   - calibrate: for an easy calibration of the sensor driver frequency the new frequency can be entered in [kHz] in the text field and the software searches for the best F_DRV_ADJ setting, finally the best settings is programmed into the EEPROM
   - find: the software starts a search algorithm to find out at which IO line master frequency the sensor is able to communicate. This is helpful if the sensor driver frequency (and therefore the IO protocol frequency) is unknown.
   - set master: set the IO protocol frequency of the master board

Remark: Be careful when adjusting the F_DRV_ADJ register or using the calibrate function. If the frequency has to be changed, please always use small steps and check the frequency after programming. If the frequency is out of range, further communication between the master board and the sensor board is not possible.

Configuration of 524.08 / 524.09

The following figure shows the configuration, if either a 524.08 or a 524.09 is connected.

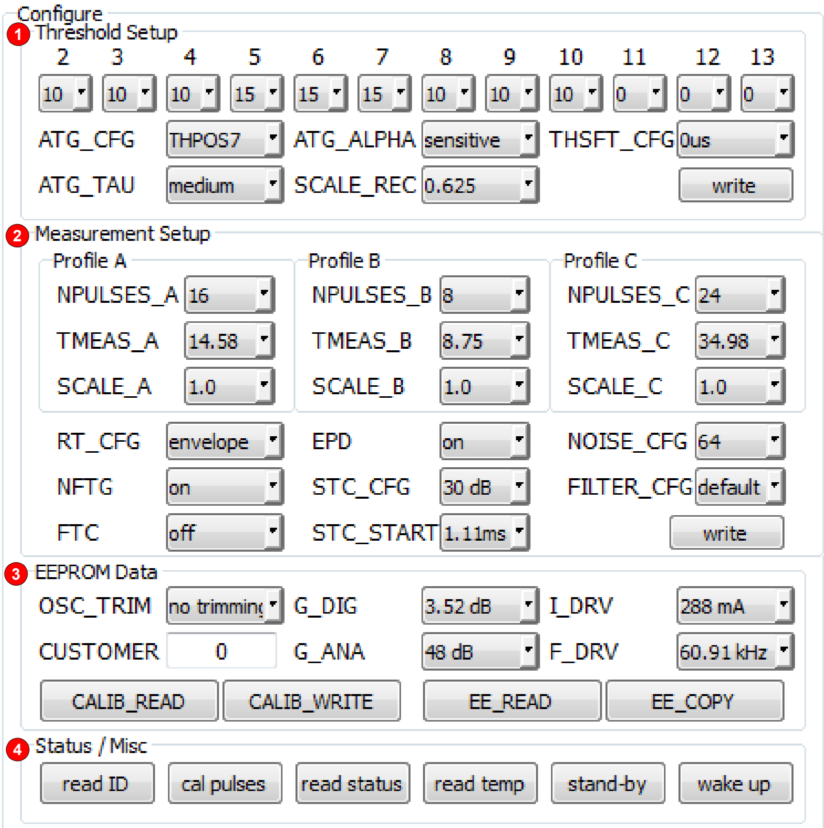


Figure 15: IC Configuration of 524.08 / 524.09

1. Threshold setup:
   - configuration values for static threshold curve and automatic threshold curve
   - write: write the data to volatile sensor registers

2. Measurement setup:
   - configuration values for measurement profiles A, B and C (burst length, measurement length, scaling)
   - additional configuration values to configure the signal processing and measurement behavior
   - write: write the data to volatile sensor registers

3. EEPROM data:
    - configuration values for amplifier, driver voltage, driver frequency, number of burst pulses, electronic damping, damping resistor, masking, automatic threshold and noise
    - calib_read: read out volatile sensor (calibration) register
    - calib_write: write values to volatile sensor (calibration) register
    - EE_read: copy EEPROM cells to volatile sensor (calibration) register and read out
    - EE_copy: copy actual volatile sensor (calibration) register to EEPROM cells

    Remark: Be careful when adjusting the OSC_TRIM register. If the oscillator frequency has to be changed, please always use small steps and check the frequency after programming. If the frequency is out of range, further communication between the master board and the sensor board is not possible.

4. Status / Misc:
    - read ID: read sensor identification
    - cal pulses: measure the calibration pulse width on IO and calculate the sensor driver frequency
    - read status: read sensor status and display the values in the message field
    - read temp: read the internal temperature sensor
    - stand-by: activate the stand-by mode
    - wake-up: deactivate the stand-by mode and go to normal operation mode

4.2 TOF compensation

The software supports a TOF (time-of-flight) compensation. Due to the internal signal processing the output of the echo detection is delayed and the measured distance (time) by the Ultrasonic Sensor IC does not fit to real distance of the obstacle. This delay depends on:

- chosen bandwidth
- number of burst pulses
- debouncing
- echo-width or echo-peak detection
- ...

By using the TOF compensation the delay of the internal processing can be compensated. All the graphs (envelope, threshold, IO line) are shifted by the adjusted time value. Practical Measurements are useful to estimate the best compensation value. For 16 burst pulses in combination with the echo-peak detection a compensation of 360µs is a good starting value.

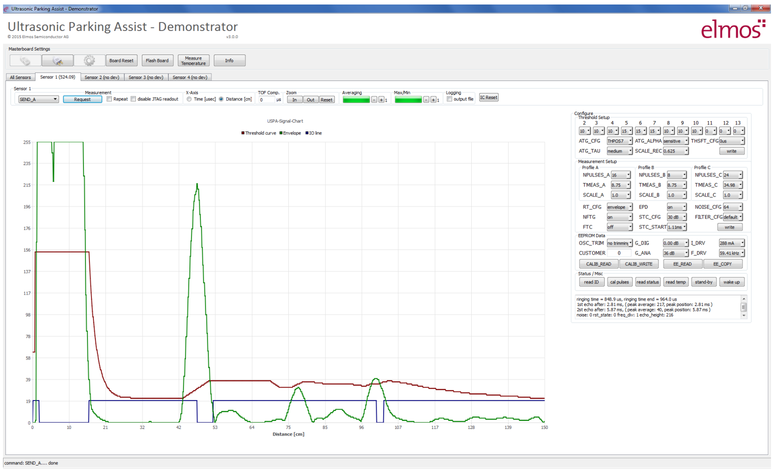


Figure 16: Measurement without TOF compensation

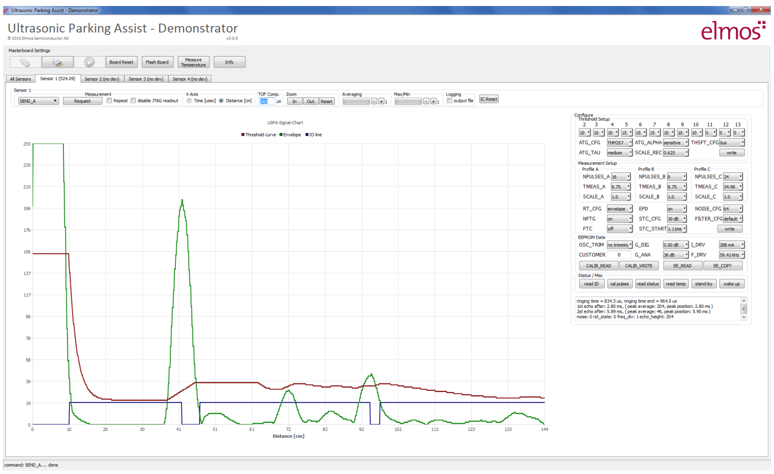


Figure 17: Measurement with TOF compensation

4.3 Measurement examples in single sensor mode

4.3.1 Example “Send” request with 524.02

The following screenshot shows the result of a send request with two obstacles in 100cm and 200cm.

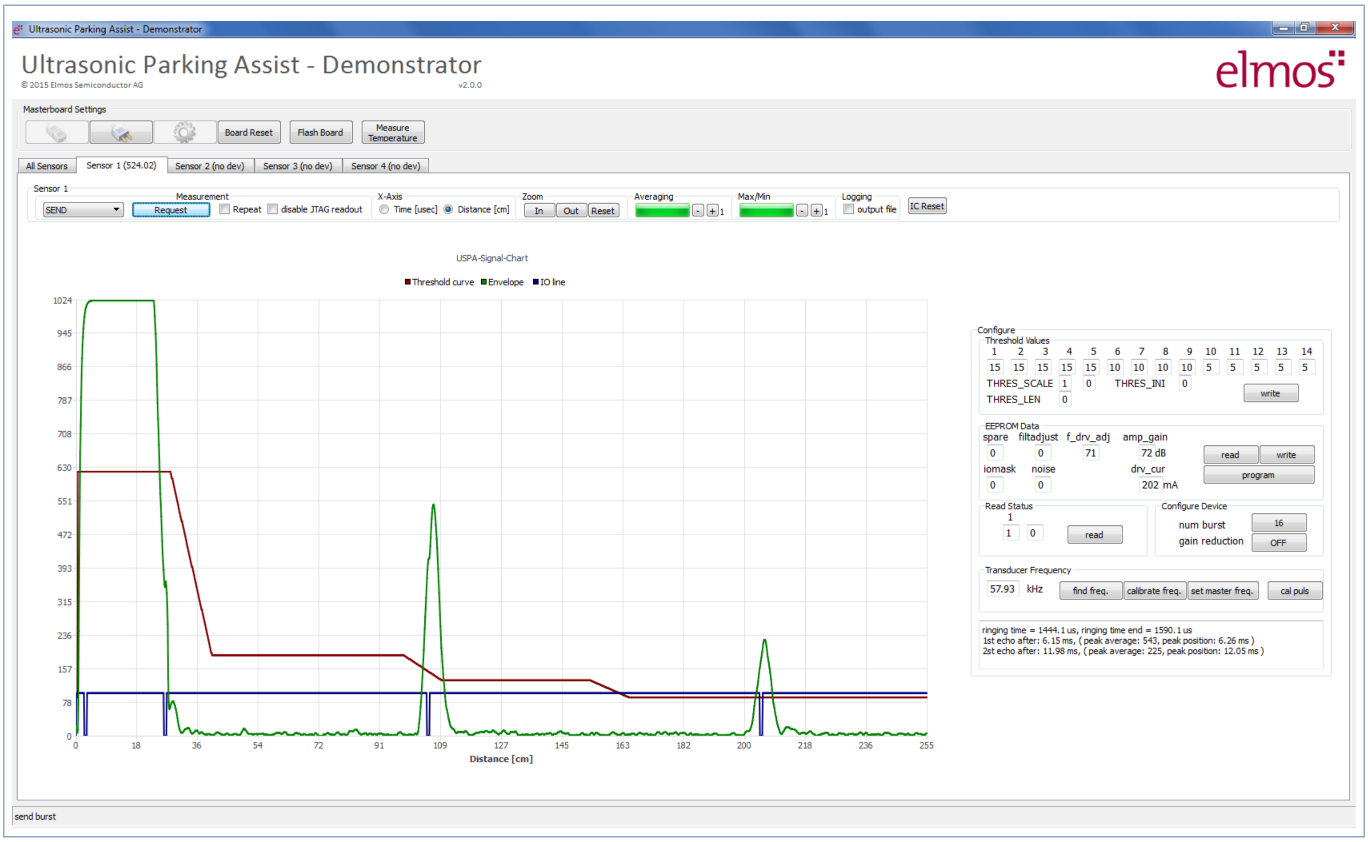


Figure 18: Example “Send” request with 524.02

Information in the message field:

ringing time	ringing time, time from 1st falling edge to the 2nd falling edge on IO line in [µs]
ringing time end	time from measurement start to the 2nd falling edge on IO line in [µs]
1st echo after	1st detected echo time from measurement start to the 3rd falling edge on IO line
2nd echo after	2nd detected echo time from measurement start to the 4th falling edge on IO line
peak-average	height of detected echo in LSB (only available with JTAG readout)
peak-position	measured time when the detected echo has its maximum (only available with JTAG readout)

4.3.2 Example "Send" request with 524.03

The following screenshot shows the result of a send request with two obstacles in 100cm and 200cm.

Figure 19: Example "Send" request with 524.03

Information in the message field:

ringing time	ringing time, width of first low phase on IO line in [µs]
ringing time end	time from measurement start to the 1st rising edge on IO line in [µs]
1st echo after	1st detected echo time from measurement start to the 2nd falling edge on IO line
2nd echo after	2nd detected echo time from measurement start to the 3rd falling edge on IO line
peak-average	height of detected echo in LSB (only available with JTAG readout)
peak-position	measured time when the detected echo has its maximum (only available with JTAG readout)

4.3.3 Example “Send” request with 524.05

The following screenshot shows the result of a send request with two obstacles in 50cm and 100cm.

Figure 20: Example “Send” request with 524.05

For information in the message field, see chapter 4.3.1

4.3.4 Example "Send" request with 524.06

The following screenshot shows the result of a send request with two obstacles in 50cm and 100cm.

Figure 21: Example "Send" request with 524.06

For information in the message field, see chapter 4.3.2

In the last row shows additional information which is transmitted after each measurement cycle (noise, reset, frequency deviation, echo height of the first echo)

4.3.5 Example “Send” request with 524.08

The following screenshot shows the result of a send request with two obstacles in 150cm and 400cm.

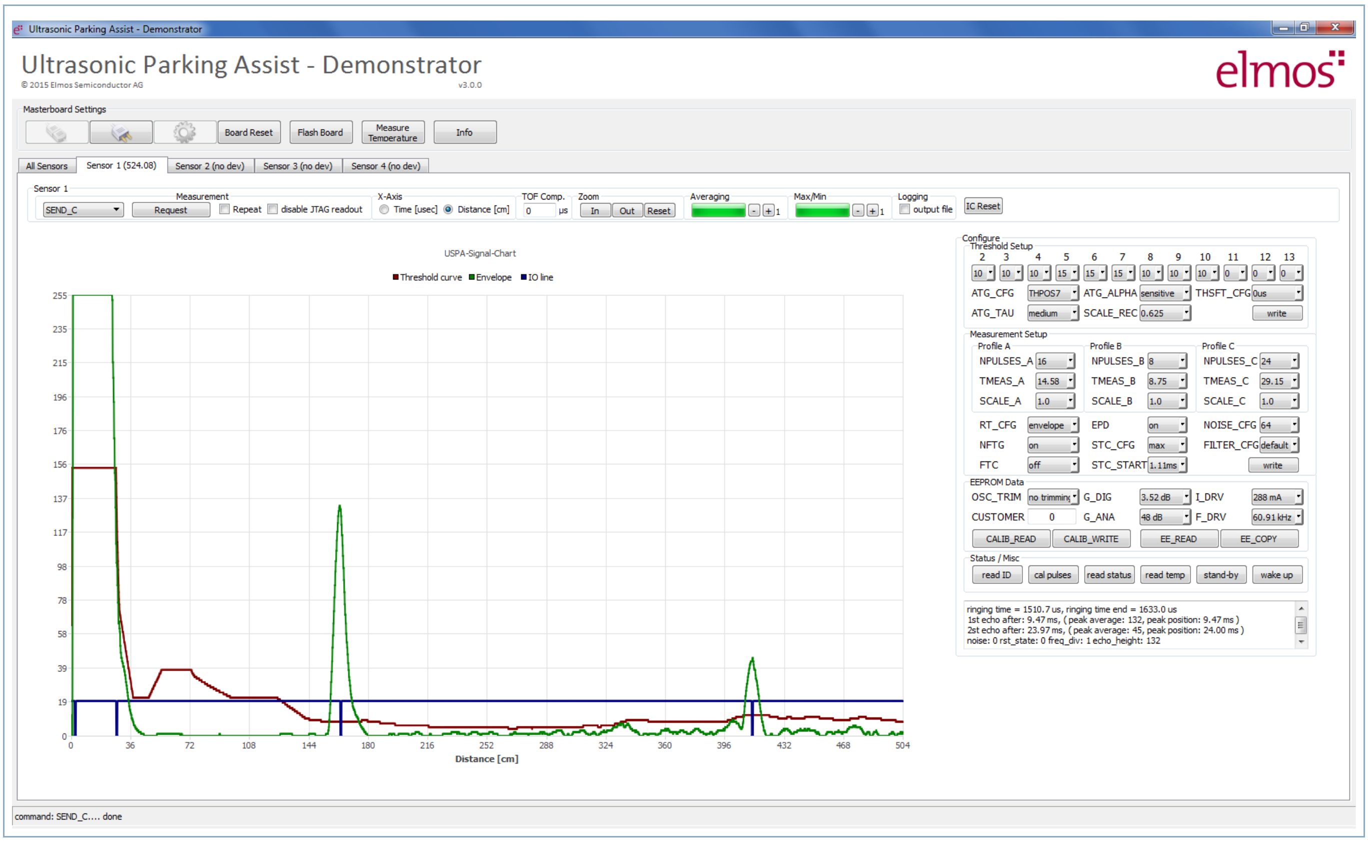


Figure 22: Example “Send” request with 524.08

For information in the message field, see chapter 4.3.1

In the last row shows additional information which is transmitted after each measurement cycle (noise, reset, frequency deviation, echo height of the first echo)

4.3.6 Example “Send” request with 524.09

The following screenshot shows the result of a send request with two obstacles in 150cm and 400cm.

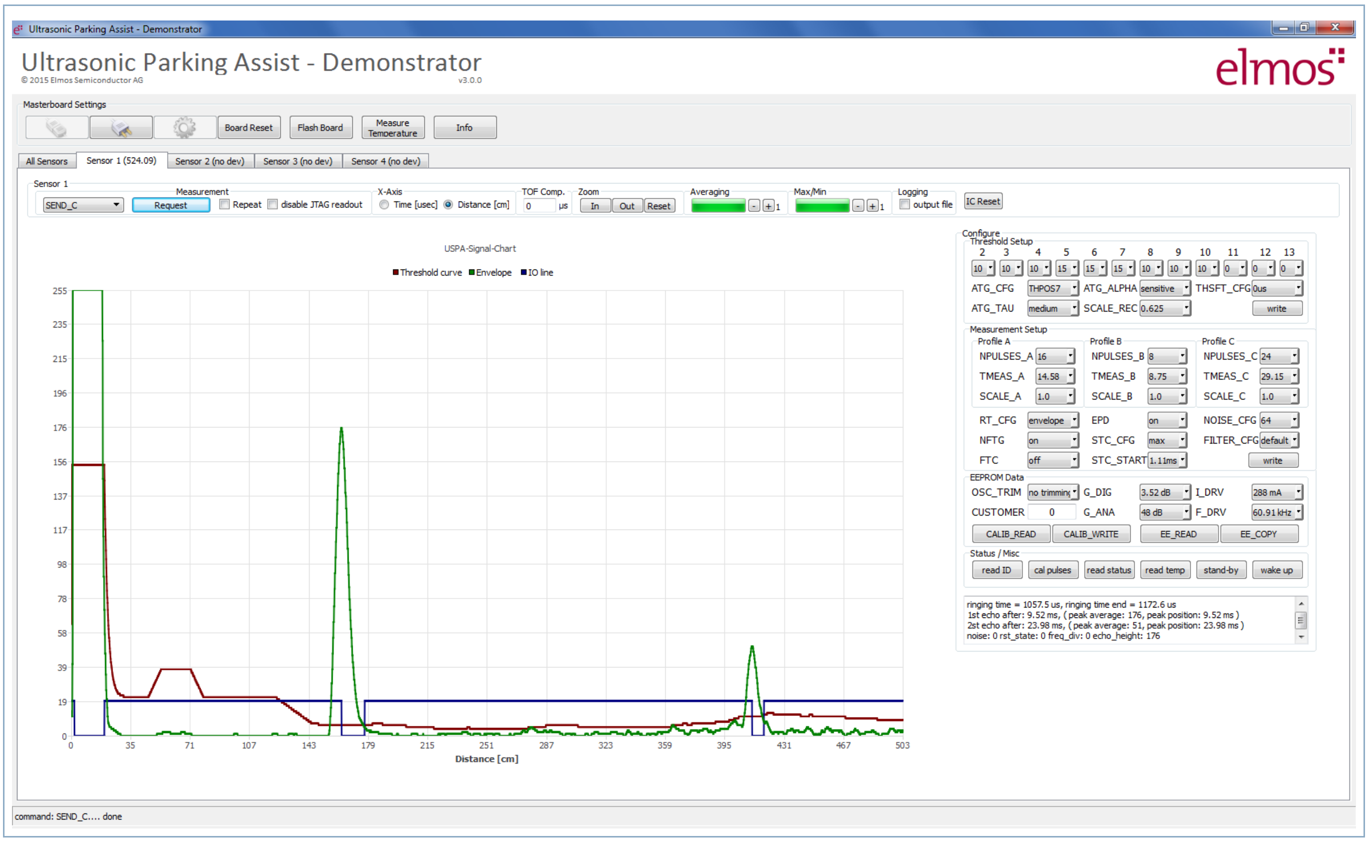


Figure 23: Example “Send” request with 524.09

For information in the message field, see chapter 4.3.2

The last row shows additional information which is transmitted after each measurement cycle.
(noise, reset state, frequency deviation, echo height of the first echo)

4.3.7 Example "Send" request without using the JTAG interface

The following screenshot shows the result of a send request with two obstacles in 50cm and 100cm. The JTAG readout is disabled.

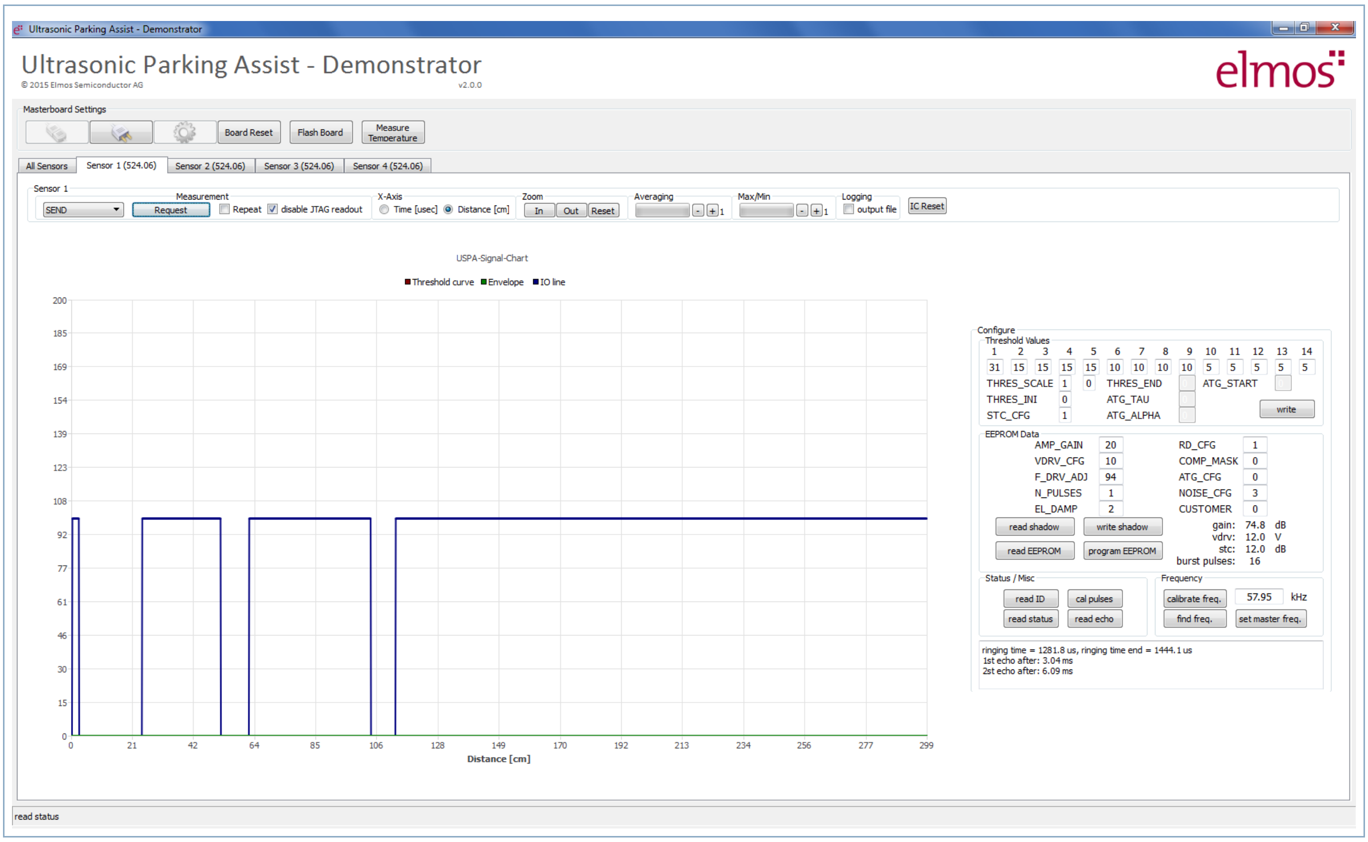


Figure 24: Example "Send" request without using the JTAG interface

Only the behavior on the IO line is shown and the information in the message field is reduced.

4.3.8 Example “Averaging” function

The following screenshot shows the result of a send request by using the averaging function. In this example the E524.09 is used and two obstacles are placed in distances of 150cm and 300cm.

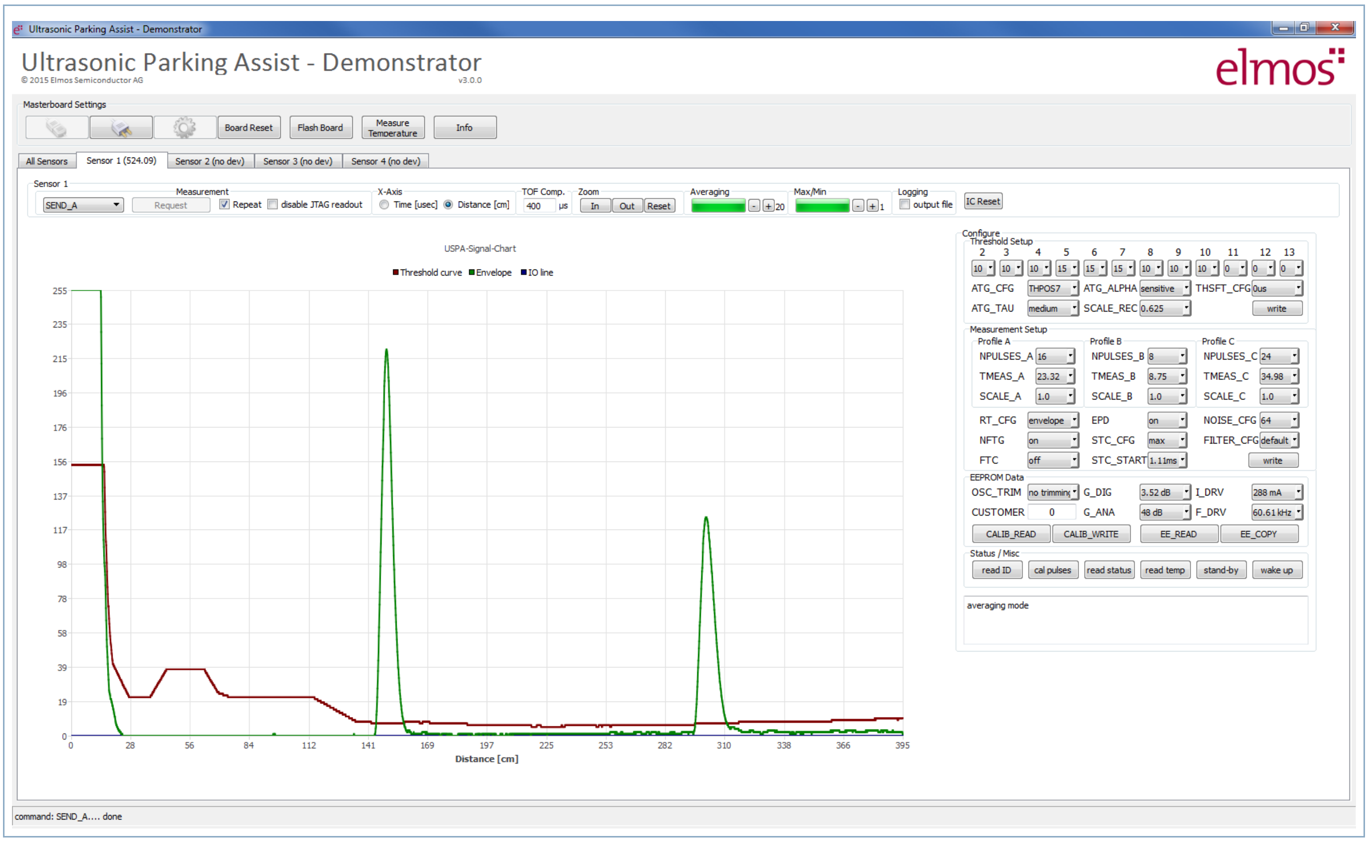


Figure 25: Example “Averaging” function

This function may be helpful during evaluation, e.g. to measure the echo height over several measurements.

Remark: The echo detection on the IO will be disabled when using the averaging function.

4.3.9 Example “Max/Min” function

The following screenshot shows the result of a send request by using the max/min function. In this example the E524.09 is used and two obstacles are placed in distances of 150cm and 300cm.

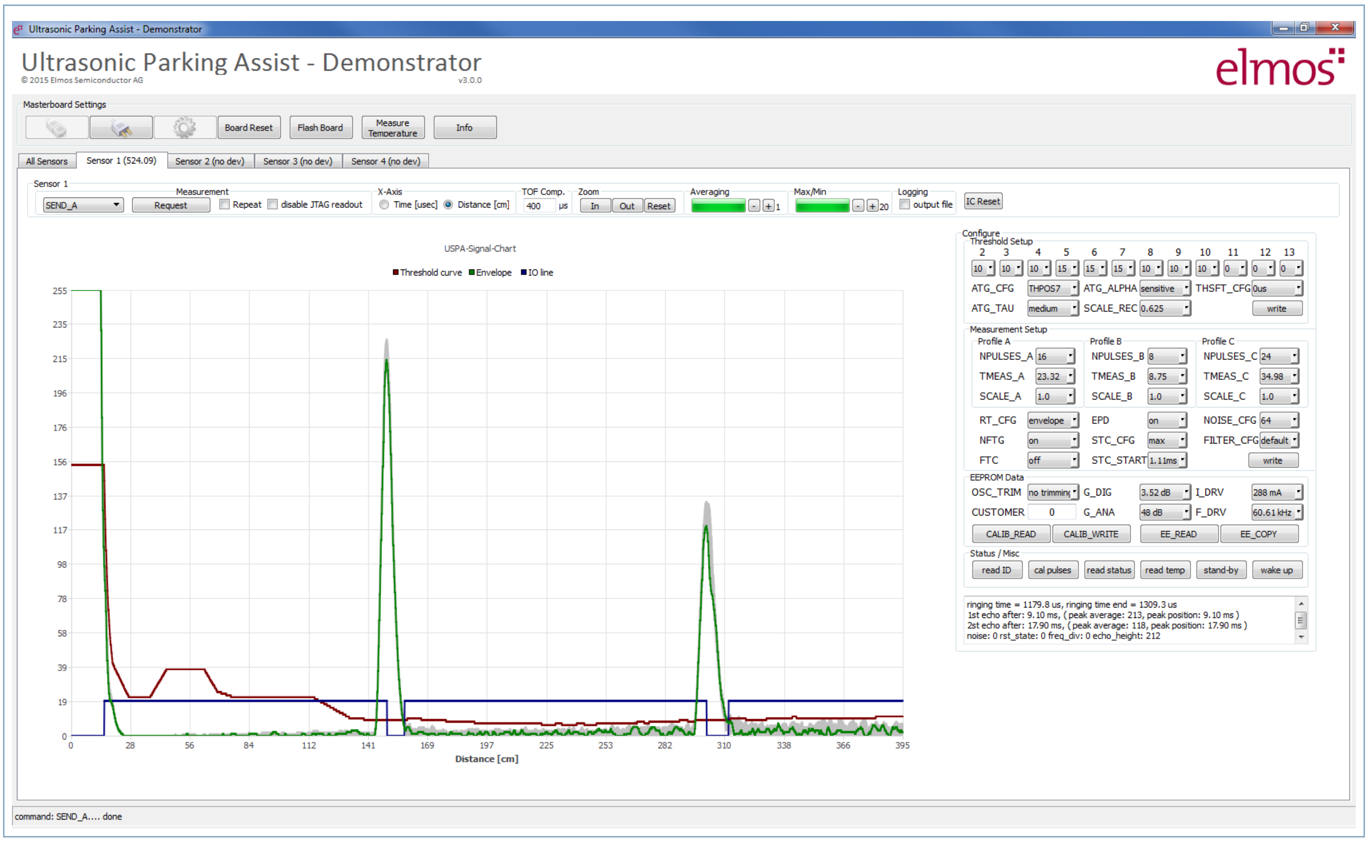


Figure 26: Example “Max/Min” function

This function is helpful during evaluation to observe the signal variability over several measurements. The minimum and maximum values are defined by the grey area.

Averaging function and max/min function can be used together.

4.3.10 Example “Receive” request

The following screenshot shows the result of a receive request.

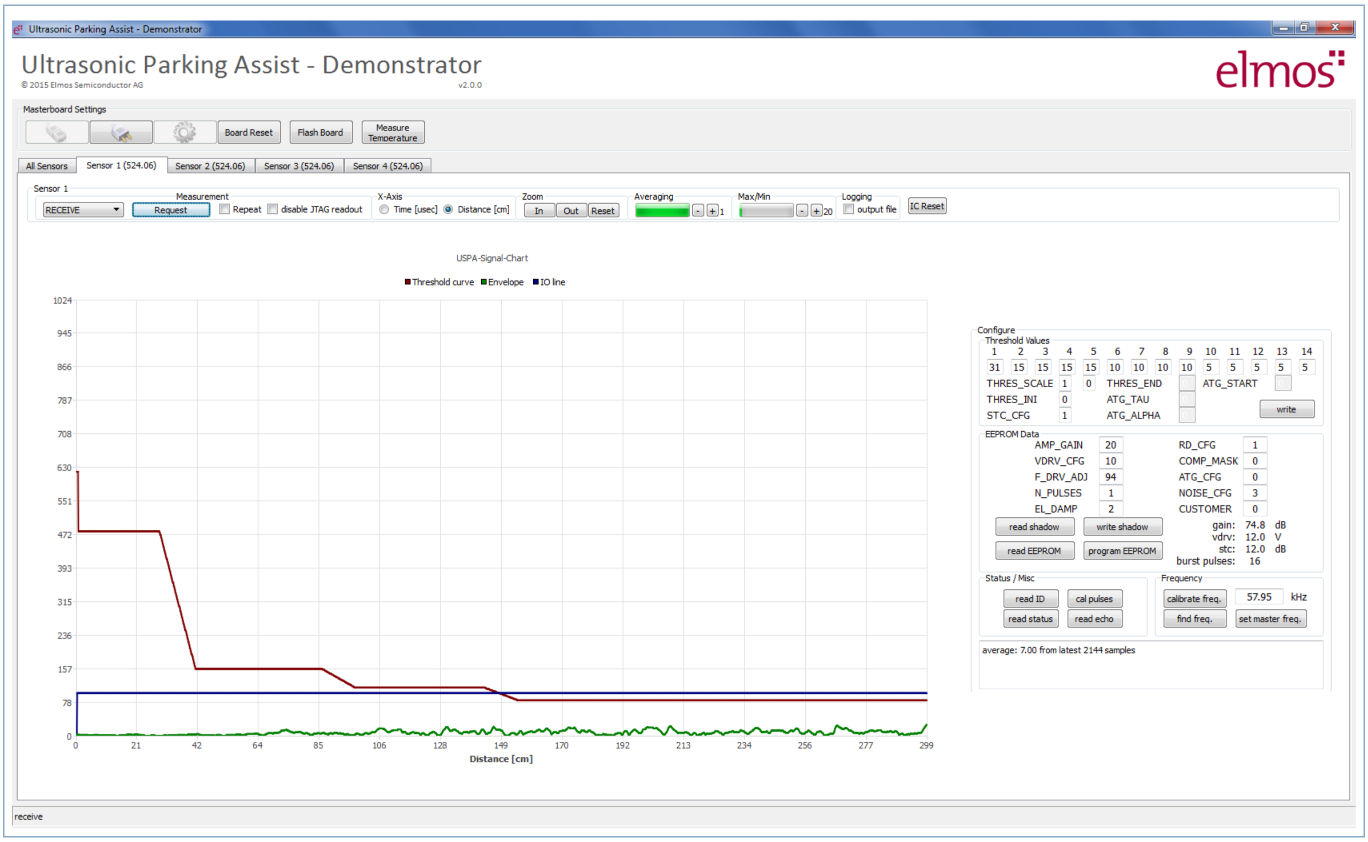


Figure 27: Example “Receive” request

Information in the message field:

average	the average noise value is calculated and the result is given in the message field

Remark: If echoes are detected during the “Receive” request, the same echo information as during “Send” request is shown in the message field.

4.3.11 Example “Read Status”

The information from additional commands like “read status”, “read ID”, “read Echo” and “cal pulses” are always shown in the message field. Depending on the IC, different commands and answers are possible. Please refer to the IC data sheets.

The following figure and information was taken after a “read status” command by using the 524.06.

Figure 28: Example “Read Status”

Information in the message field:

freq. deviation	deviation between ringing and driver frequency, the given number in percent is valid, if valid=1
vdrv	the driver voltage was at its configured value during the latest burst phase, if vdrv=1
threshold received	if a threshold with a correct checksum has been received a '1' is displayed
noise detected	if the envelope signal was above the threshold during the low phase at IO of the latest send request command the noise detection gives a '1' as result.

4.3.12 Example "Send" request with active automatic threshold

The following screenshot shows the result of a send request with activate automatic threshold

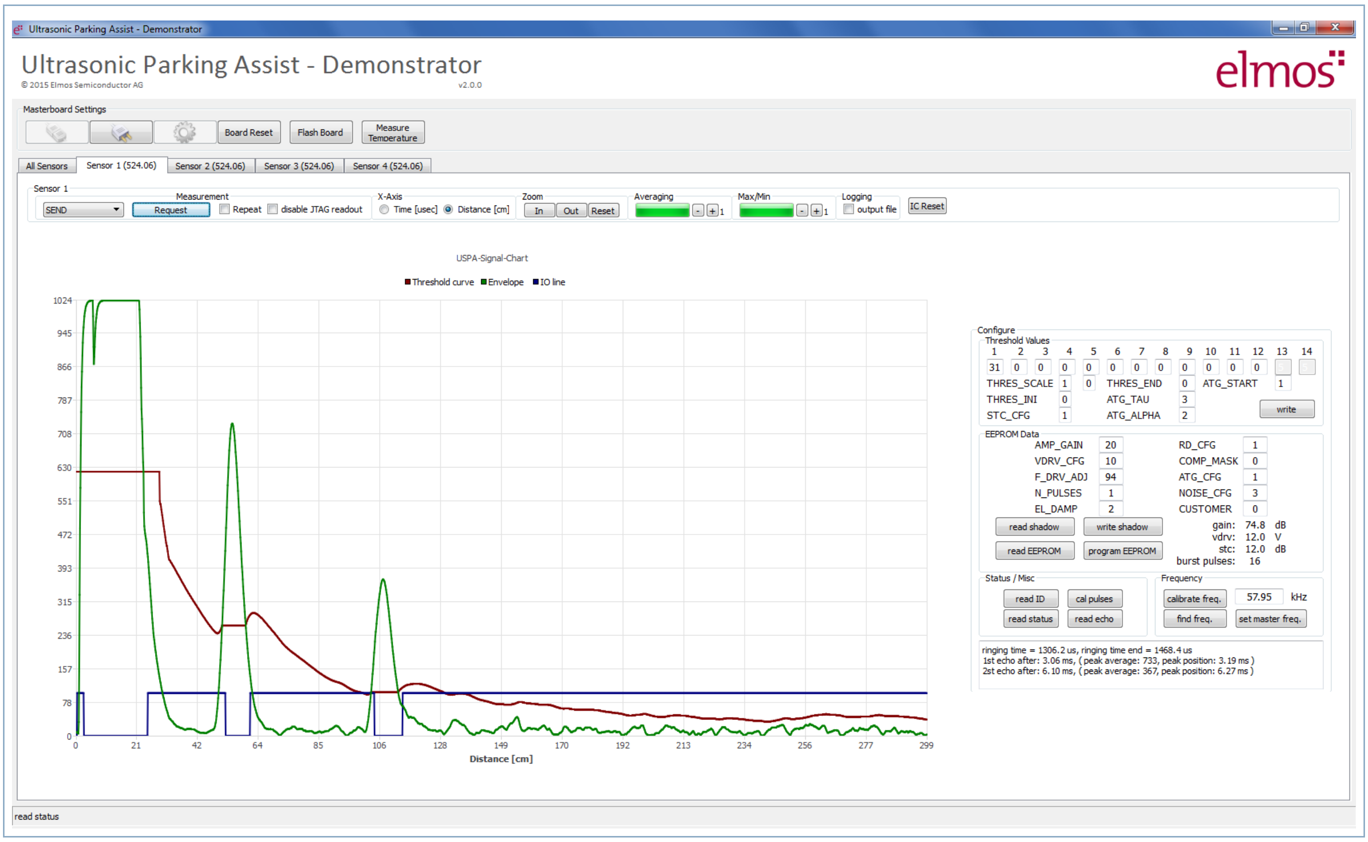


Figure 29: Example "Send" request with active automatic threshold

In comparison to the static threshold (figure 21), now the threshold is generated automatically by the IC. The behavior of this threshold curve is adjustable by ATG_TAU, ATG_ALPHA and ATG_START.

4.3.13 Example “Receive” request with active automatic threshold

The following screenshot shows the result of a send request with activate automatic threshold.

Figure 30: Example “Receive” request with active automatic threshold

In comparison to the static threshold (figure 27), now the threshold is generated automatically by the IC. The behavior of this threshold curve is adjustable by ATG_TAU, ATG_ALPHA and ATG_START.

4.3.14 Example "Read Temperature"

The following figure and information was taken after a "read temp" command by using the 524.09.

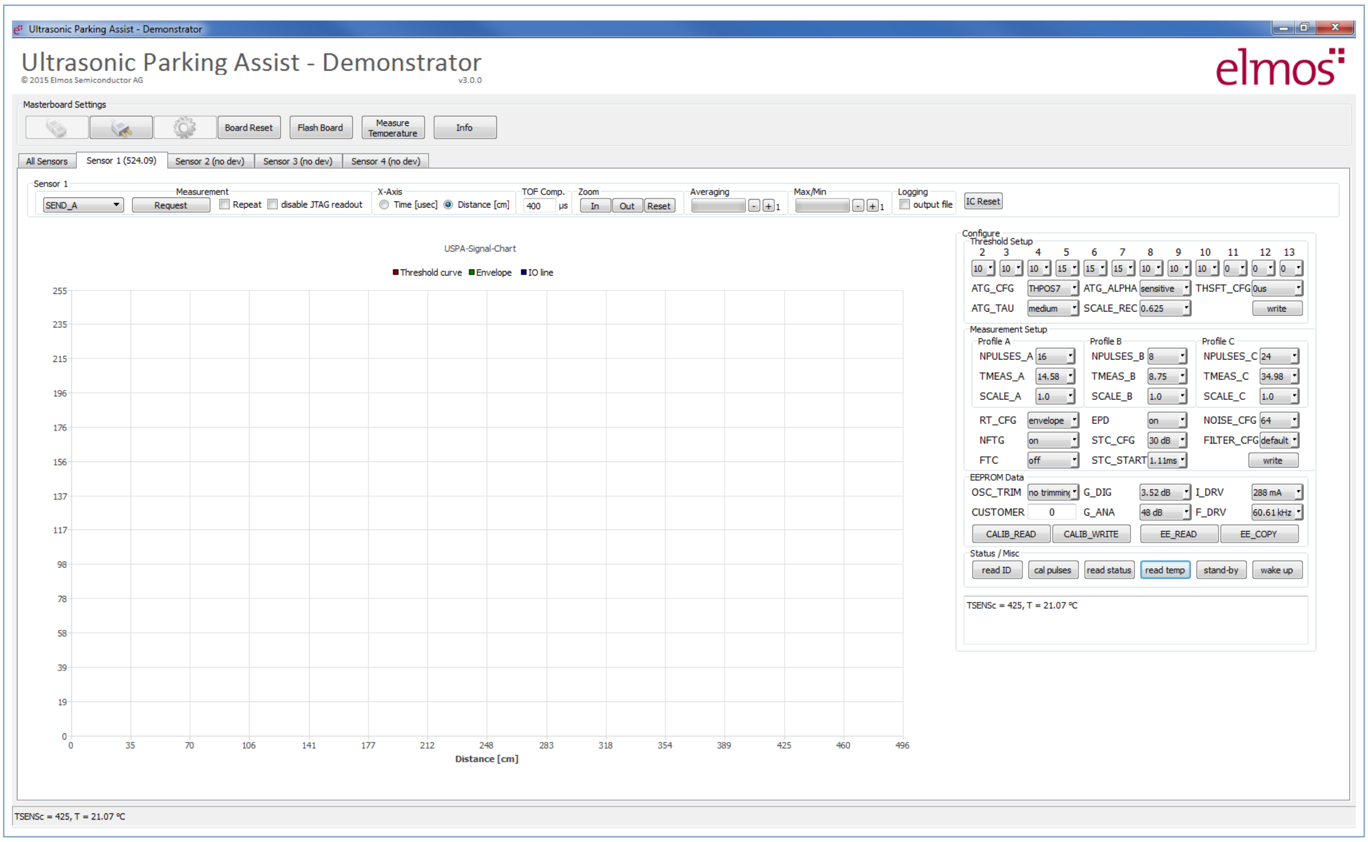


Figure 31: Example "Read temperature"

Information in the message field:

TSENSc	Temperature sensor code in LSB
T	Calculated temperature from the read value TSENSc $T(TSENS_C) = 25^{\circ}C + (TSENS_C - TSENS_{C\_RT}) \cdot TSENS_{SLOPE}$

4.3.15 Example "Send" request with analog envelope output via the IO line

In addition to the digital envelope readout via JTAG, the E524.09 supports also an analog output of the measured envelope signal. This is very helpful to analyze the behavior of an assembled sensor module, if the JTAG lines are not accessible. By using two special commands (one for "Send" request and one for "Receive" request), the envelope signal is shown on the IO line instead of the echo detection.

The following two screenshots show signal behavior of the burst and two obstacles in 150cm and 200cm. The upper one is measured with the software and the lower one is measured with a scope connected to the IO line.

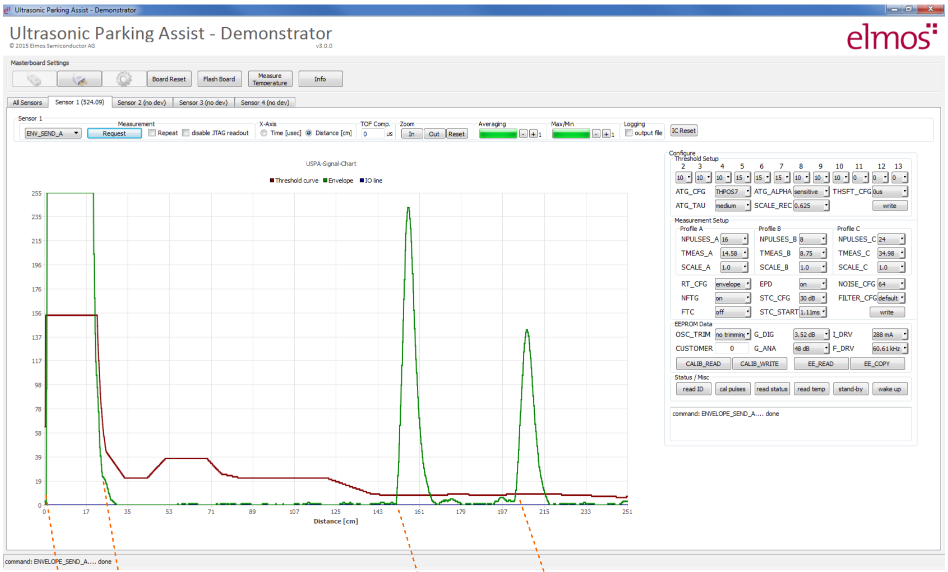


Figure 32: Example "Send" request with digital envelope output via JTAG

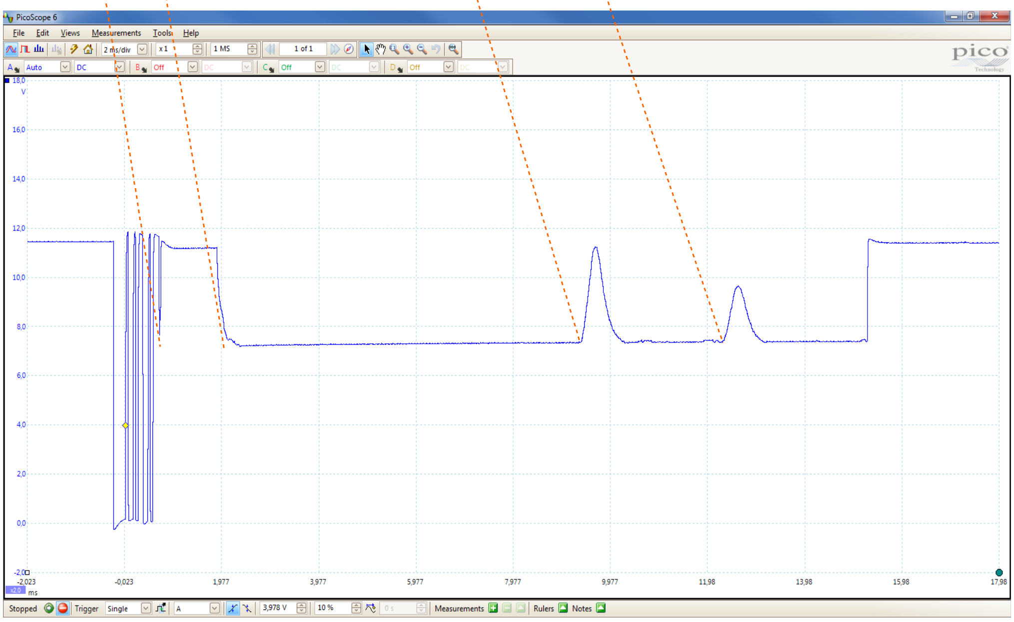
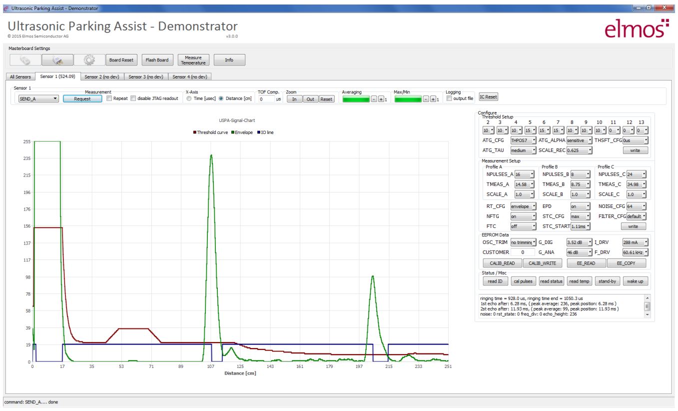


Figure 33: Example "Send" request with analog envelope output via IO line

4.3.16 Example "Using different measurement profiles"

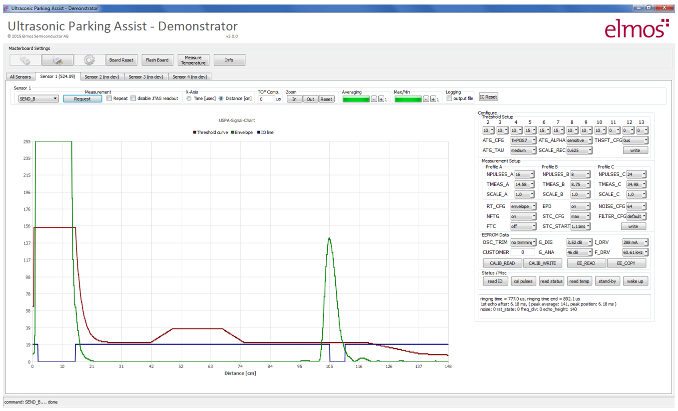
The 524.08 and 524.09 support different measurement profiles (defined by the number of burst pulses, measurement length and a scaling factor), which can be changed from one measurement cycle to the next one and makes the measurement behavior very flexible.

The following three screenshots use the profiles A, B and C. Obstacles are placed in 100cm, 200cm and 400cm



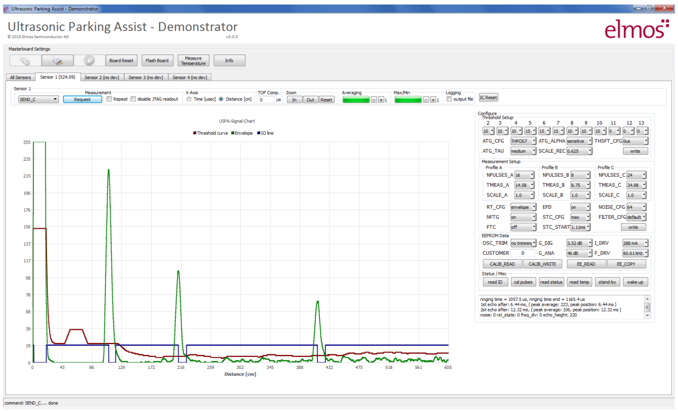
Send A: (normal measurement)

- Number of burst pulses: 16
- Measurement length: 14.58ms
- Scaling factor: 1.0



Send B: (short range measurement)

- Number of burst pulses: 8
- Measurement length: 8.75ms
- Scaling factor: 1.0



Send C: (long range measurement)

- Number of burst pulses: 24
- Measurement length: 34.90ms
- Scaling factor: 1.0

Figure 34: Example "Using different measurement profiles"

4.4 Multi sensor mode

The measurement window in multi sensor mode is divided into 2 blocks

1. Measurement configuration
2. Signal chart (displays envelope signals)

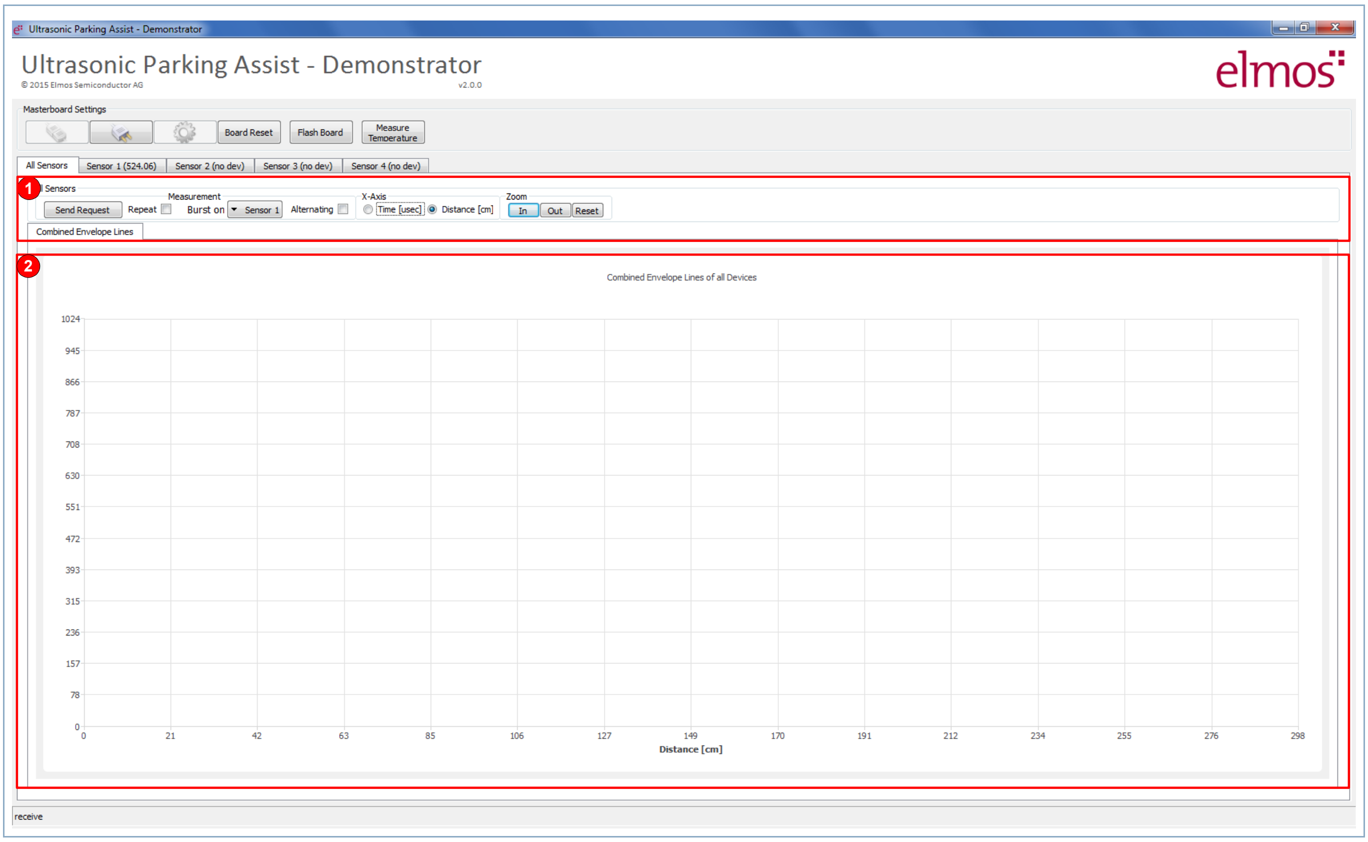


Figure 35: Measurement window in multi sensor mode

In the signal chart only the envelope signals of all connected sensors are visualized. One sensor sends out the ultrasonic burst and all sensors receive the incoming signal.

Please note: The tab “combined envelope lines” will only be available, if equal devices are connected to the board.

4.4.1 Measurement configuration in multi sensor mode

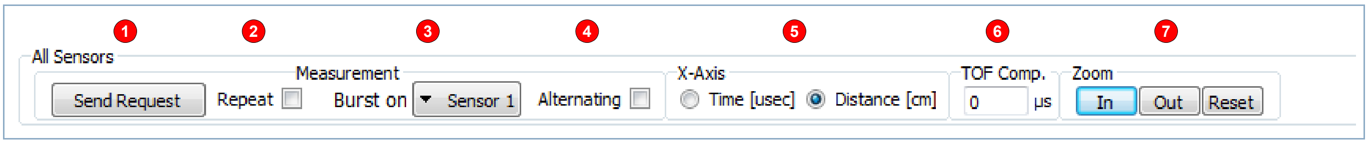


Figure 36: Measurement configuration in multi sensor mode

Measurement

1. The “Request” button performs a measurement. The selected sensor sends out the ultrasonic burst and all connected device will receive the incoming signal.
2. If “Repeat” is selected, the selected measurement will be repeated continuously with the next “Request”. The continuous mode can be stopped by pressing “Repeat” again.
3. Select the sensor, which should send out the burst
4. If “Alternating” is selected, the burst sequence is “sensor1”, “sensor2”, “sensor3” and “sensor4”.

X-Axis

5. The x-axis of the measurement chart can display either a time or a distance information. Typically ultra-sonic sensors measure only a time information and the distance is calculated in the master control unit. Thus, in this software the distance is calculated based on the temperature information (see also chapter 3.3.4).

TOF compensation

6. By using the TOF compensation the delay of the internal processing can be compensated, so that the measured distance matches with the real distance of the obstacle.

Zoom

7. The zoom function may be very helpful to analyze small signals or a particular time period. It is possible to zoom in and zoom out the measurement chart. A reset will set the dimensions to default values. Additionally the mouse can be used to zoom. Press mouse button in the chart and draw the favored area.

4.5 Measurement examples in multi sensor mode

4.5.1 Example measurement with an obstacle straight in front of the sensors

The following screenshot shows the result of one measurement. The obstacle is placed straight in front of 4 connected sensors. The second sensor (green curve) sends out the ultrasonic burst, while all others are just listening.

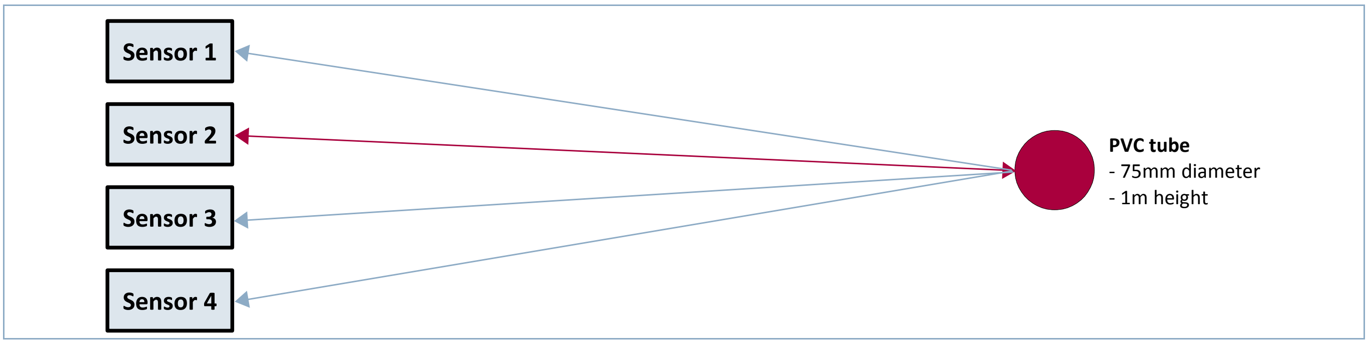


Figure 37: Setup with an obstacle straight in front of the sensors

Due to the fact that the obstacle is straight in front of the sensors, the measured distance of all devices is nearly the same.

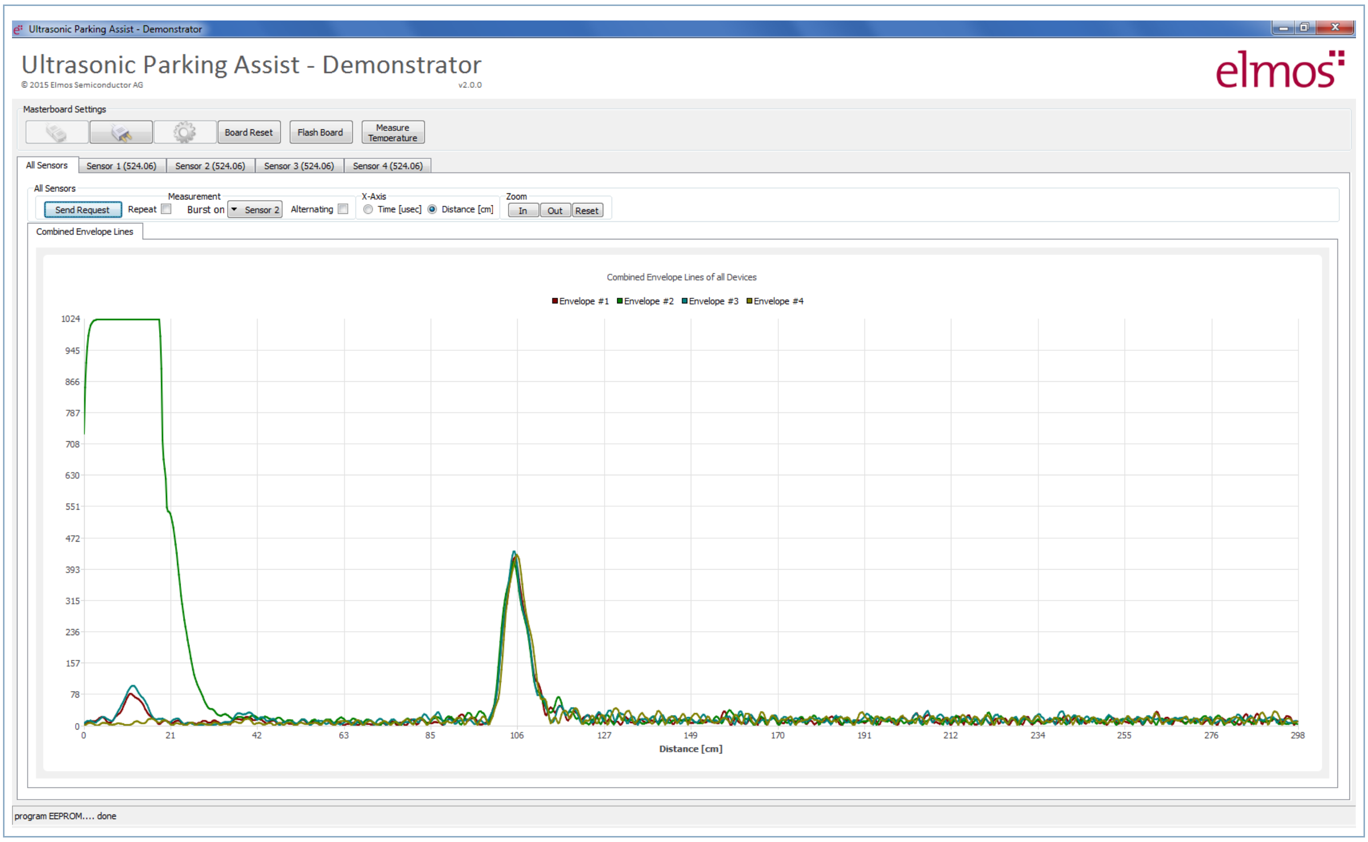


Figure 38: Example measurement with an obstacle straight in front of the sensors

4.5.2 Example measurement with an obstacle beside the sensors

The following screenshot shows the result of one measurement. The obstacle is placed beside the 4 connected sensors. The second sensor (green curve) sends out the ultrasonic burst, while all others are just listening.

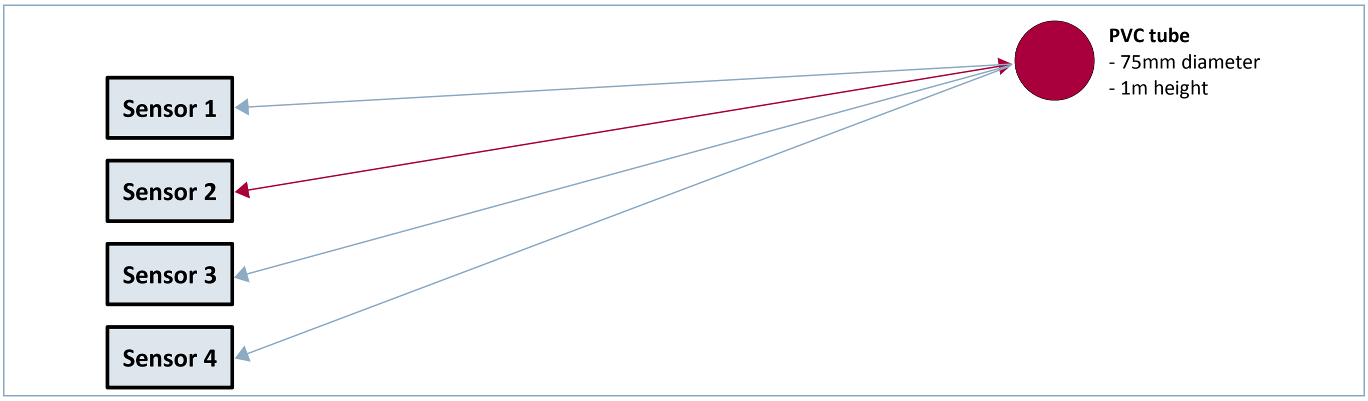


Figure 39: Setup with an obstacle beside the sensors

Due to the fact that the obstacle is beside the sensors (close the sensor 1), sensor 1 measures the shortest distance while sensor 4 measures the longest distance. This information can be used for more advanced triangulation algorithms.

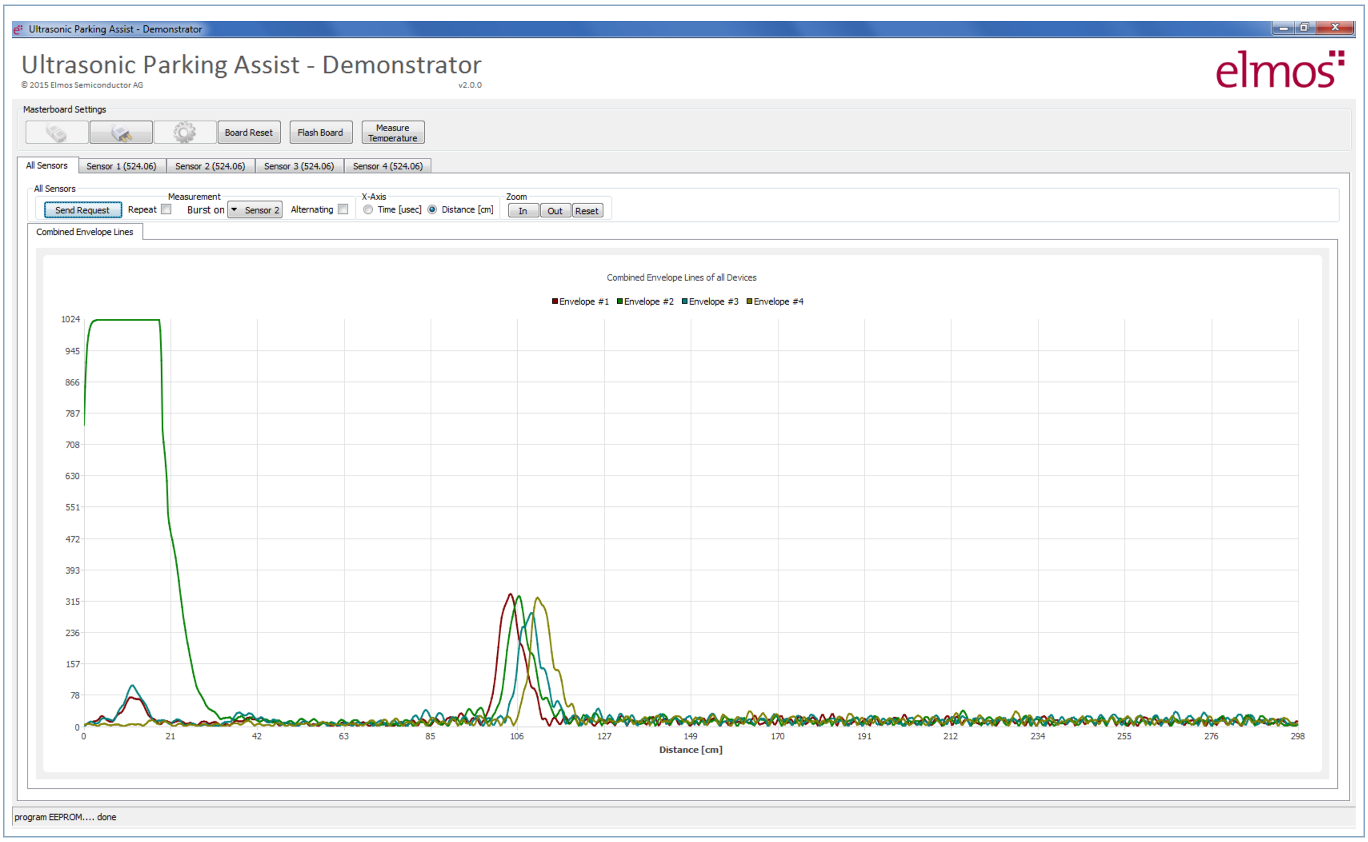


Figure 40: Example measurement with an obstacle beside the sensors

4.5.3 Example measurement with an obstacle close to the sensors

The following screenshot shows the result of one measurement. The obstacle is placed very close between sensors 1 and 2. The second sensor (green curve) sends out the ultrasonic burst, while all others are just listening.

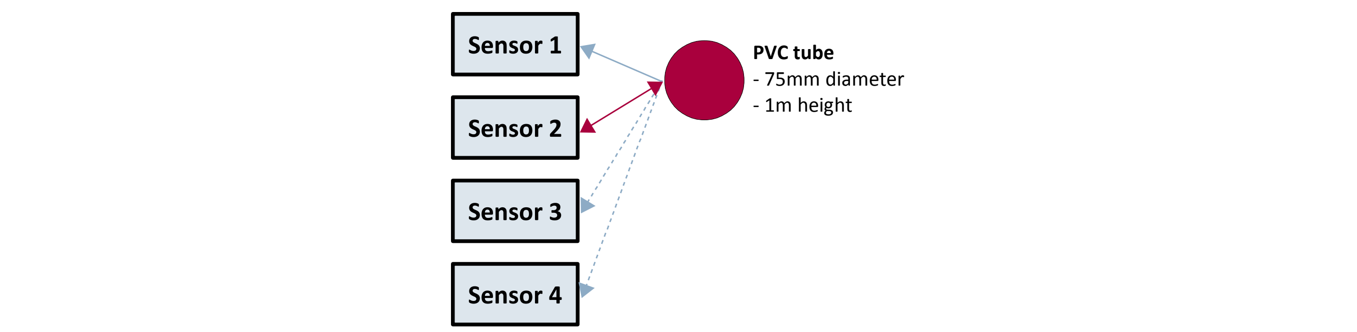


Figure 41: Setup with an obstacle close to the sensors

Due to the short distance between the sensors and the obstacle, the sending sensor (green curve) cannot measure the distance, because the sensor is still in ringing (decay) phase.

But the signal can be measured by sensor 1 (red curve) which allows a close distance measurement.

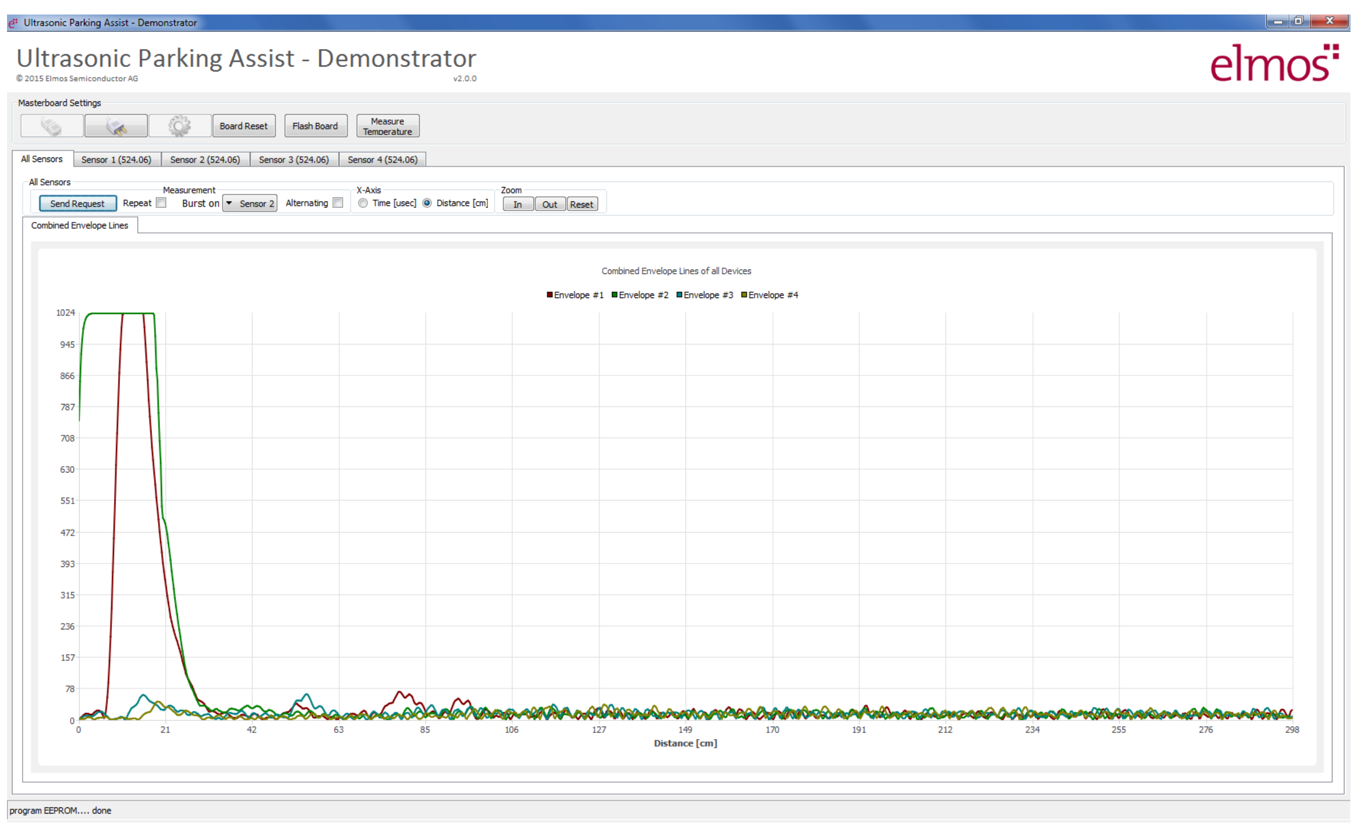


Figure 42: Example measurement with an obstacle close to the sensors

5 Layout

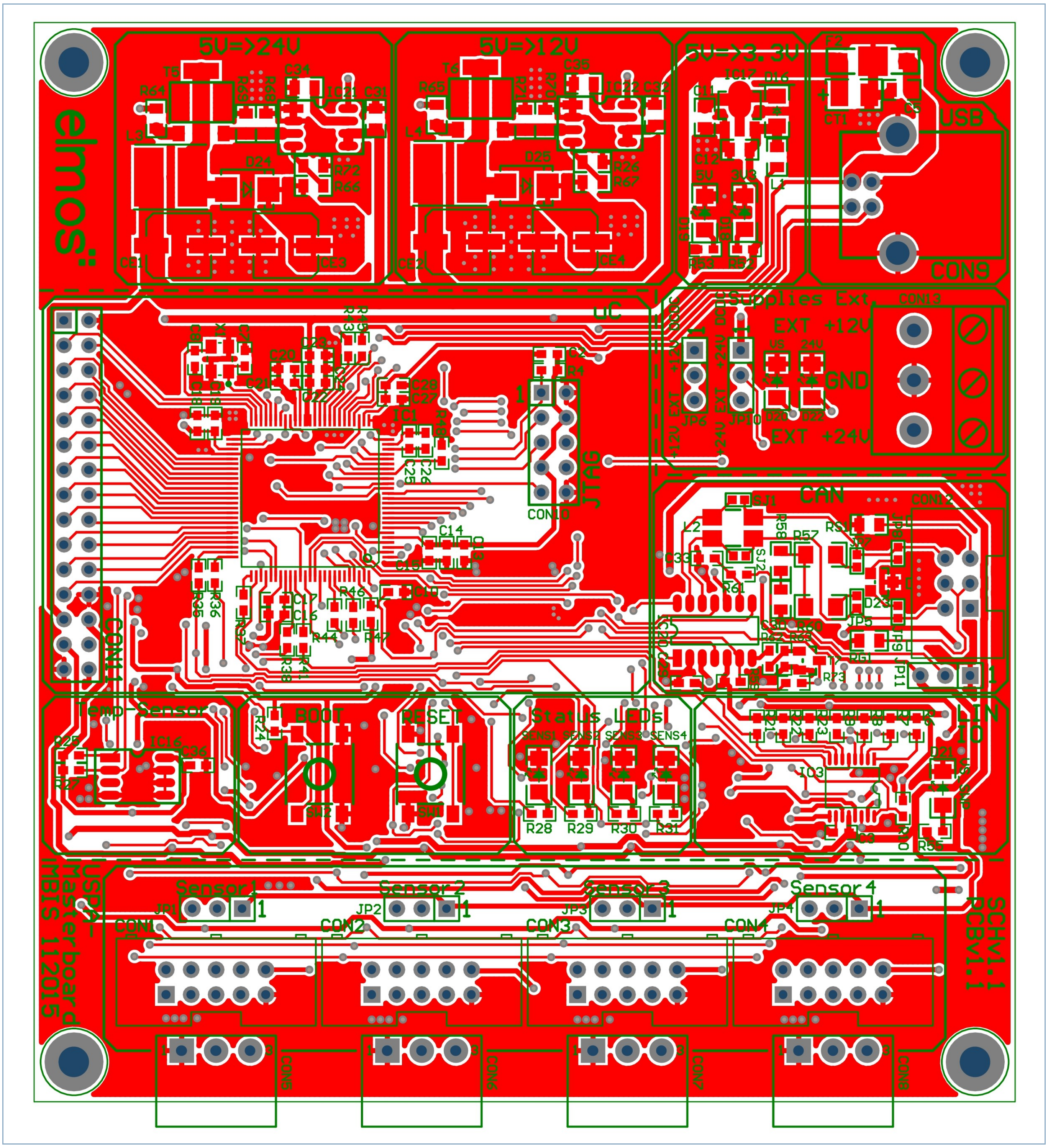


Figure 43: Top-Layer of Master Board

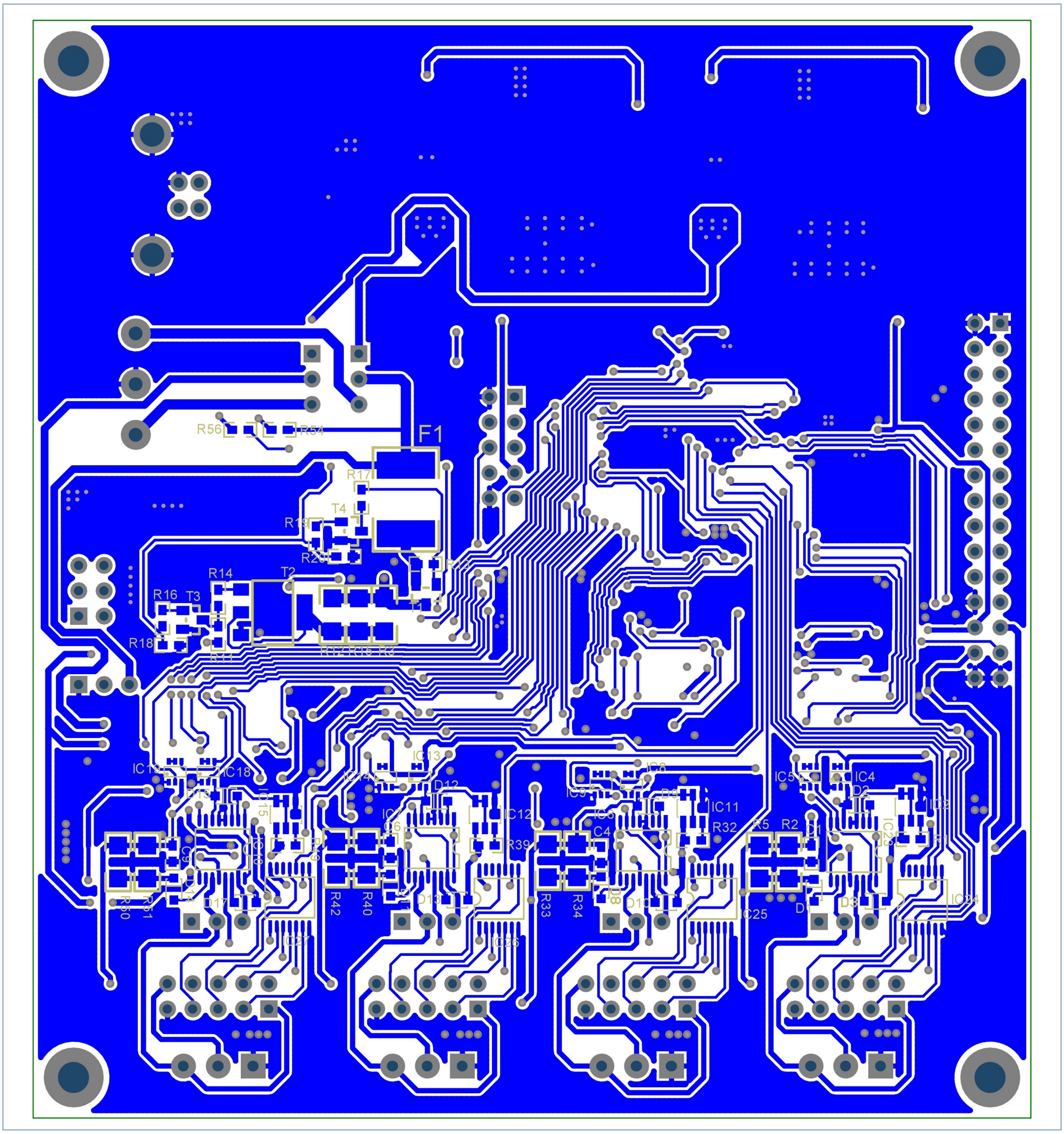


Figure 44: Bottom-Layer of Master Board

6 Schematic

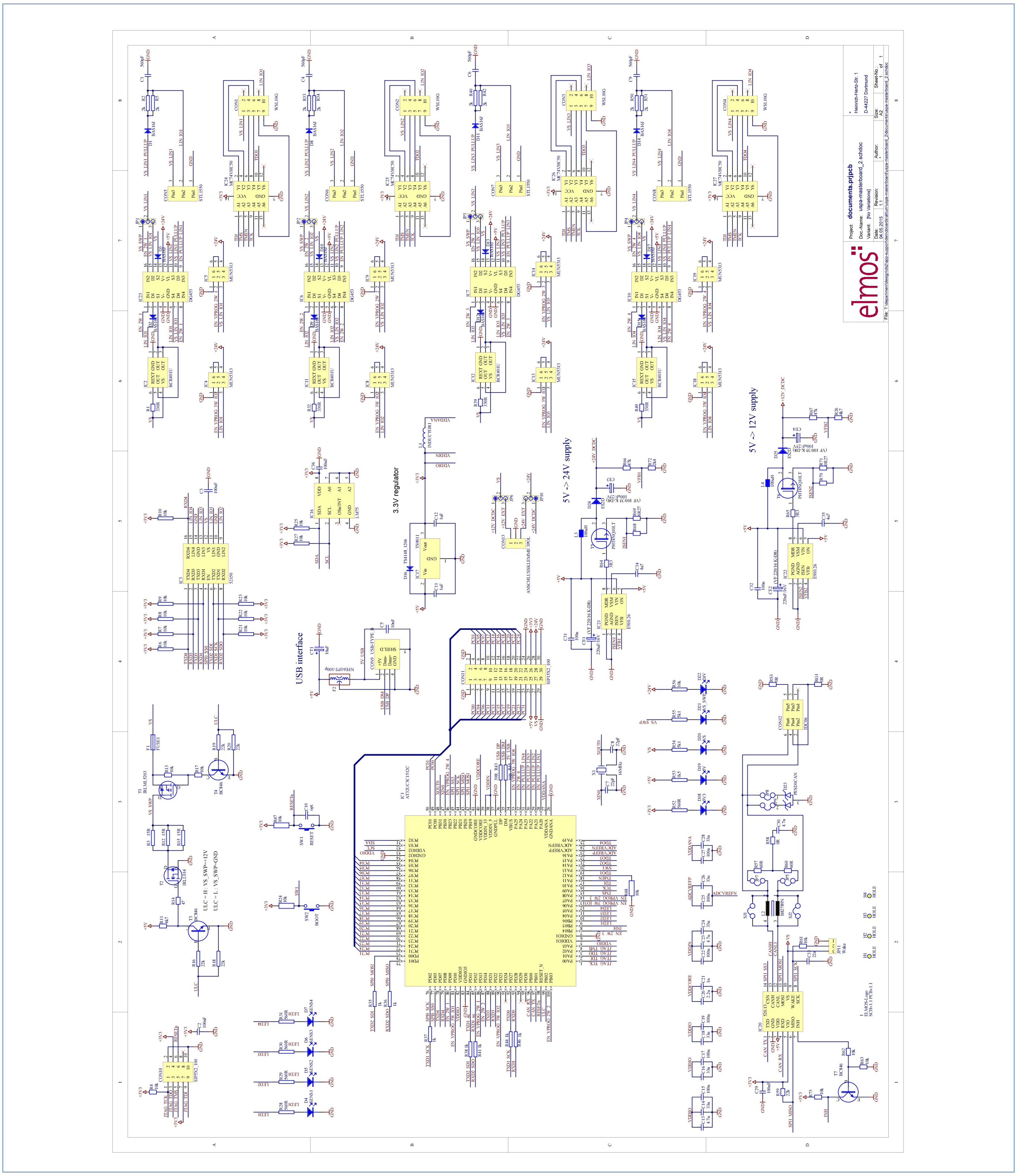


Figure 45: Schematic of Master Board

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