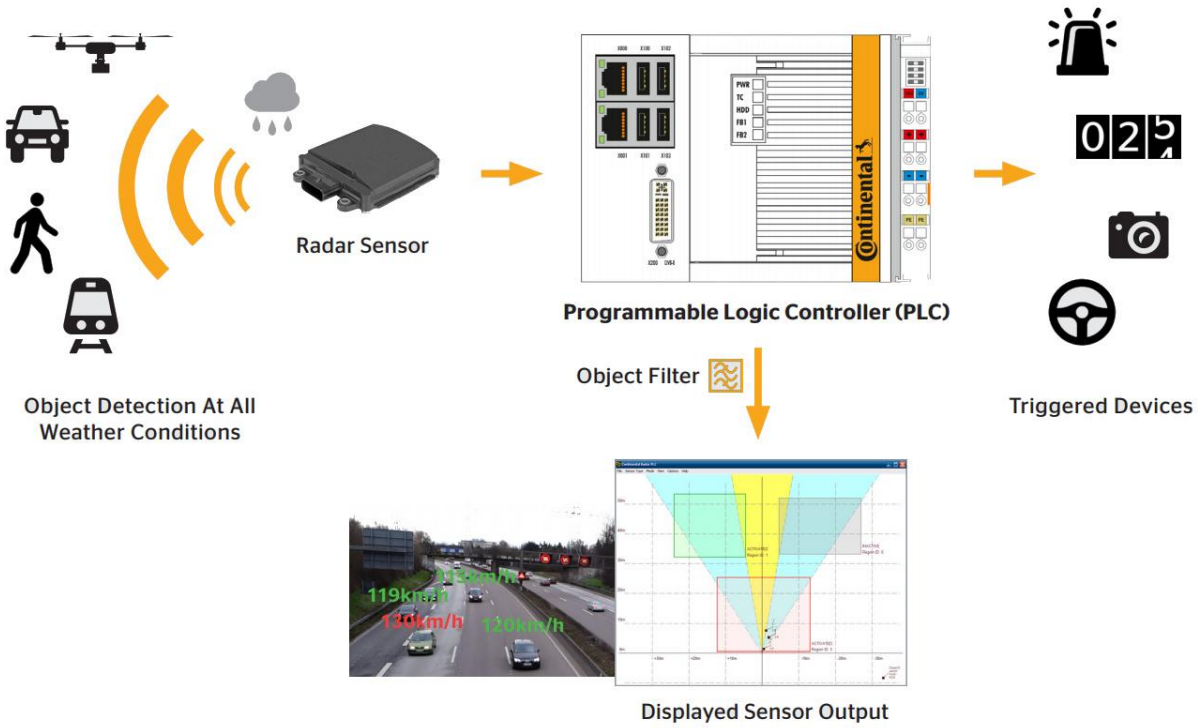
Radar PLC



Manual
Version 4.01 en

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CHANGE HISTORY

Version	*Date*	*Change Description*	*Author*
0.01	05.02.15	Initial Version	H.C. Enders
0.02	26.02.15	Update Filter	Thomas Kruppi
1.00	23.03.15	Release for fist system delivery	H.C. Enders
1.01	29.05.15	Some small updates	H.C. Enders
2.00	24.07.15	Update to SW Version 2.0	H.C. Enders
2.01	03.08.15	Updates after internal Review	H.C. Enders
3.00	03.12.15	Update Collision Detection	H.C. Enders
3.01	08.03.16	Update Collision Detection	Thomas Kruppi
3.02	09.03.16	Reference correction	Thomas Kruppi
4.00	25.10.16	Support of ARS 408	H.C. Enders
4.01	25.01.17	Marker Configuration Menu	H.C. Enders

Table 1: Change History

Please read this manual carefully before installing the system and carry out the installation procedures correctly.

This manual provides guidelines for installation, but it does not guarantee the quality of the installation work. Please complete all work in a responsible and professional manner. Electrical work should be performed by a qualified electrician.

Inhalt

1 Introduction

1.1 Scope of this documentation

This documentation is written for trained electricians. Knowledge of national standards is required. The following document should be read before installing and operating the Radar PLC. If the following issues are disregarded, the equipment may get damaged and the safe function is not ensured.

1.2 Liability Conditions

The responsible staff must ensure that all laws, standards, regulations and guidelines are fulfilled. All information is given in good faith; it does not represent a guarantee with respect to characteristics and does not exempt the user from testing the suitability of products and from ascertaining that the industrial property rights of third parties are not violated.

No liability whatsoever will be accepted for damage – regardless of its nature and its legal basis – arising from advice given in this publication. This does not apply in the event that we or our legal representatives or management are found guilty of having acted with intent or gross negligence.

No liability is borne for damage due to ordinary negligence. This exclusion of liability applies also to the personal liability of our legal representatives and employees and other persons employed in performing our obligations. All components are shipped in a condition to be able to fulfill the requirements in operation according to their scope.

The Radar PLC must not be used in order to reduce safety systems, especially personal safety. The System should only be operated by personnel who are familiar with all states that can occur! Software knowledge is mandatory. The products are improved continuously. This may lead to differences in the description.

We reserve the right to make technical modifications or to amend the delivery specifications.

Please contact your supplier if it should become necessary to check the technical functions or to repair the device.

1.3 Operating Personnel

Every user of the CONTINENTAL® Radar PLC has to read this handbook and must be acquainted with all the functions of the system.

Also every user has to read the documentation of the used continental Radar sensor.

1.4 Technical data

Parameter	Value
Processor	Intel® Atom™ E3845, 1.91 GHz, 4 cores (TC3: 50)
Flash memory	8 GB CFast card
Internal main memory	4 GB DDR3 RAM
Persistent memory	integrated 1-second UPS (1 MB on Compact Flash card)
Interfaces	2 x RJ45, 10/100/1000 Mbit/s, DVI-I, 4 x USB 2.0, 1 x CANopen,2x4..20mA Analoge,8x Relay
Diagnostics LED	1 x power, 1 x TC status, 1 x flash access, 2 x bus status
Clock	internal battery-backed clock for time and date (battery exchangeable)
Operating system	Microsoft Windows Embedded Standard 7 P
Control software	Continental Radar PLC Software
Power supply	24 V DC (-15 %/+20 %)
Dielectric strength	500 V (supply/internal electronics)
Max. power	24 W
USP	Integrated 1s UPS (Up to 20s power with standard configuration)
Dimensions (W x H x D)	185 mm x 100 mm x 92 mm
Weight	approx. 1,5 Kg
Operating/storage temperature	-25…+60 °C/-40…+85 °C
Relative humidity	95 %, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27
EMC immunity/emission	conforms to EN 61000-6-2/EN 61000-6-4
Protection class	IP 20
Approvals	CE
Mount	Cap rail

Table 2: Technical data Continental Radar PLC

1.5 Product identification

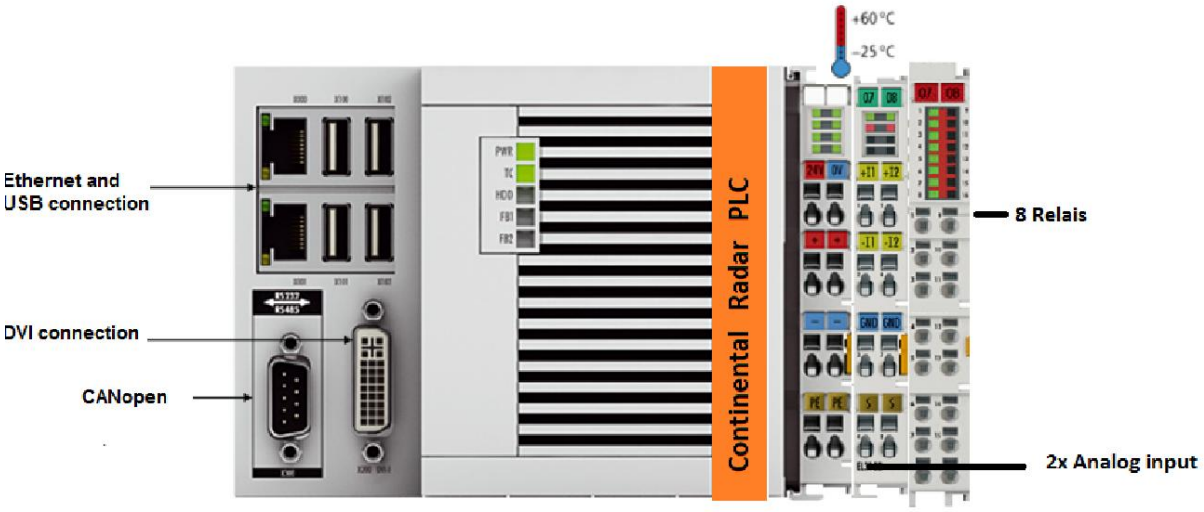


Figure 1: Radar PLC Hardware

The Radar PLC is designed to display the output of either one Continental SRR208 or ARS308 Radar Sensor on a monitor. If collision detection is supported by the sensor, it is possible to use this device to trigger up to 8 different Solid state relays.

The Radar PLC can be mounted on a cub rail.

2 Electrical Connection

2.1 Connection to Power

To bring the system into operation 24V DC has to be connected to the power input terminals.

Figure 2: Power input terminals

2.2 Connection to CAN

The CAN interface allows the communication between a Notebook or PC and the device via a separate converter CAN to USB. The CAN bus must have a terminal resistance of respectively 120 Ω between CAN H and CAN L at the first and last subscriber to avoid reflections. The standard cable harness from Continental includes this resistor.

The CAN BUS of the Radar Sensor has to be connected to the CANopen connector plug.

Figure 3: CANopen connector plug

2.3 Connection to relative Speed and yaw rate signal

When the radar is integrated in a vehicle, the radar sensor needs the vehicle speed. This can be done by an input current (4...20mA) from outside.

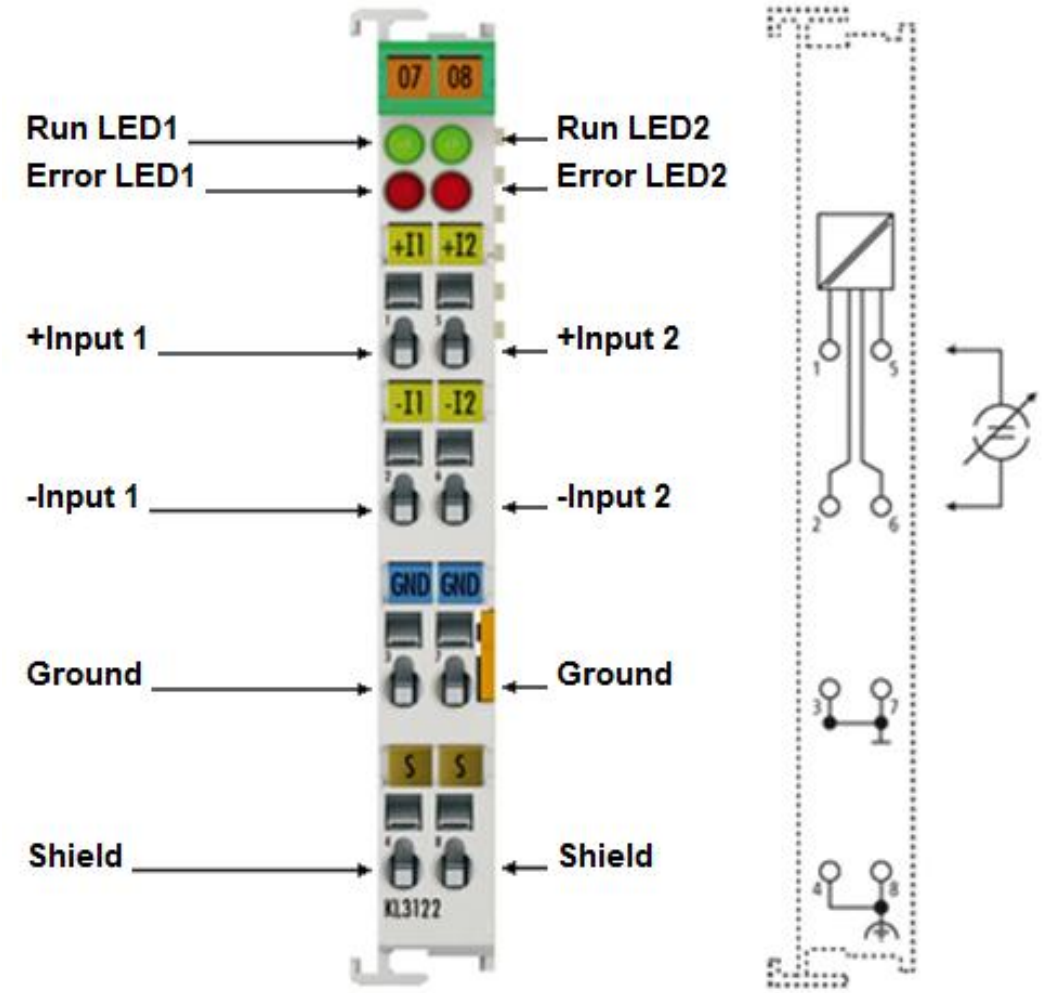


Figure 4: Analog input terminal

The speed signal has to be connected to terminal 1 and 2.

The run LEDs give an indication of the data exchange with the Bus Coupler. The error LEDs indicate an overload condition, also it shows a cable break (0mA).
Also it is possible to connect a yaw-rate to terminal 5 and 6.

Parameter	Value
Technology	differential input
Signal current	4…20 mA
Internal resistance	50 Ω typ. shunt, load: 60 Ω + diode voltage
Common-mode voltage UCM	35 V max.

Table 3: Technical data analog input terminal

2.4 Connection to Output Relays

The Radar PLCs is able to support up to 8 solid state relays, when a collision is detected[1]. With these Relays costumer specific functions can be triggered.

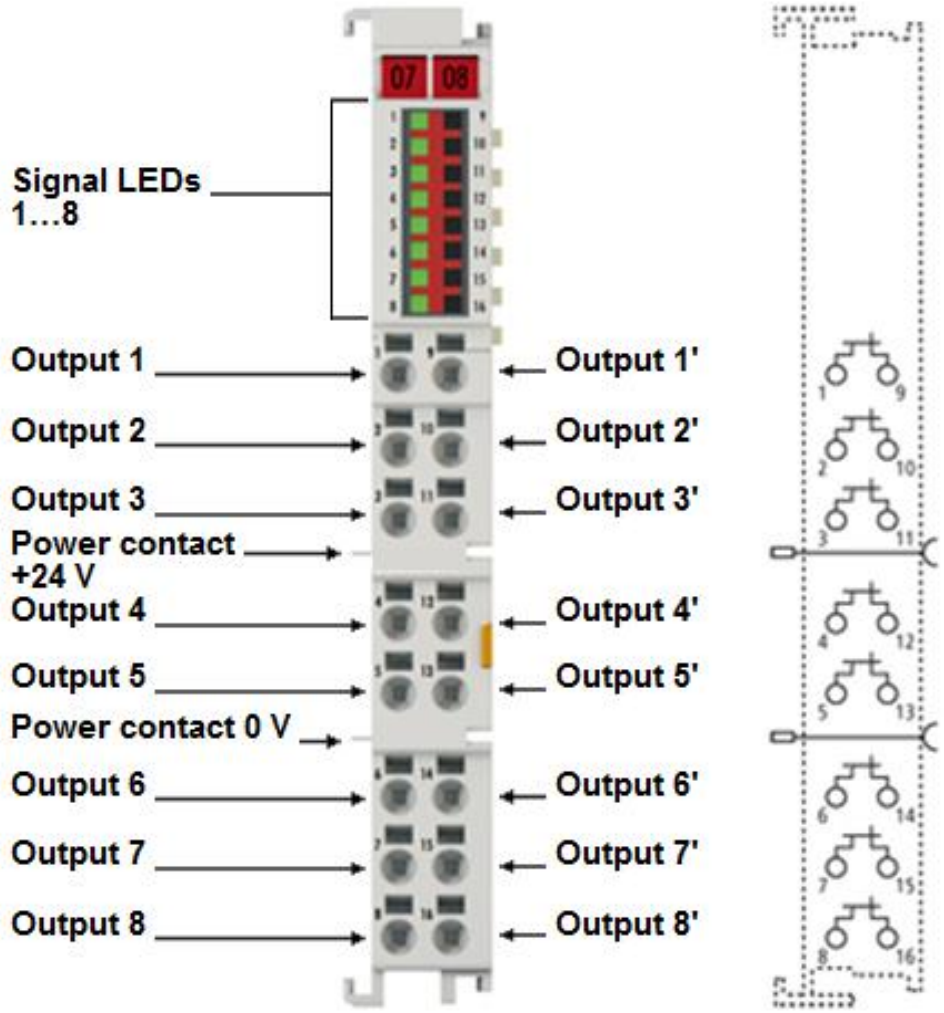


Figure 5: Relays output terminal

The digital Terminal provides eight switches that can be used like a relay contact for AC/DC voltages. The electronic switch is realized through high-performance MOSFET transistors with a low switch-on resistance. The switch itself is not short-circuit-proofed, but due to its high pulse current capability it can cope with currents until an external fuse triggers a switch-off. Wear resistance increases the availability of the application. Resistive and light inductive loads can be switched up to a rated voltage of 30 V AC/DC, completely resistive loads also up to a rated voltage of 48 V DC. High peak voltages and electromagnetic interference pulses are prevented.

[1] Only possible, if the radar sensor supports collision detection. (SRR 208-2C or ARS308C)

Parameter	Value
Rated load voltage	0…30 V AC/DC (only ohmic load: 0…48 V DC)
Short circuit current	not short-circuit-proof, see peak current
Output current	2 A (∑ 10 A @ 55° C)
Breakdown voltage	80 V
Peak current	5 A (100 ms), < 50 A (10 ms)
Conductor connection	solid wire conductors: direct plug-in technique; stranded wire conductors and ferrules: spring actuation by screwdriver
Rated cross-section	solid wire: 0.08…1.5 mm²; stranded wire: 0.25…1.5 mm²; ferrule: 0.14…0.75 mm²

Table 4: Technical data output relays

3 Software

The Radar PLC software starts automatically when powering up the embedded PC. It takes about 2 minutes.

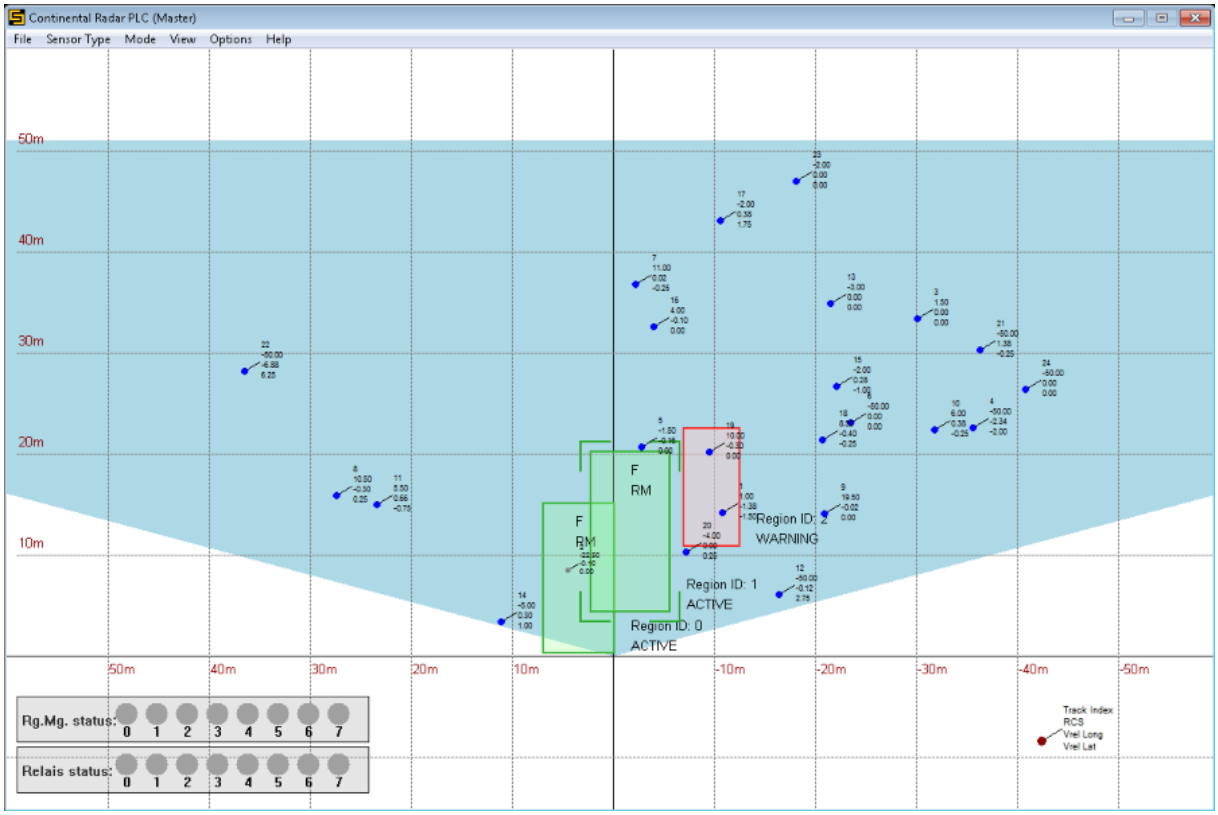


Figure 6: Radar PLC Software

3.1 Overview

The software consists of two parts:

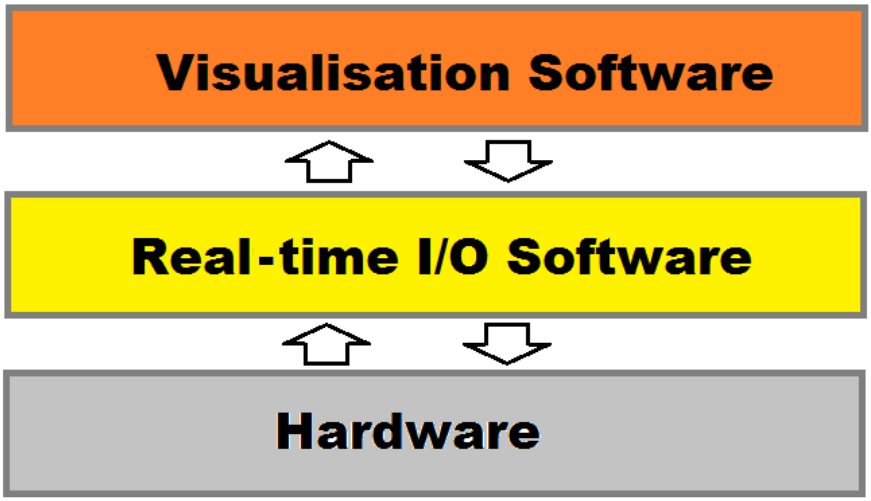


Figure 7: Two parts of the Radar PLC Software

3.1.1 Real-time I/O software

This software part is responsible for the communication between the In- and Output-channels and the Visualization software. It is operating between the hardware and the Windows operating system. This allows the software to work around the Windows system instantly providing exceedingly fast access times for hardware communication.

3.1.2 Visualization Software

This software represents the Graphical User Interface (GUI) for the Radar Sensor signals. The GUI operates on the Windows System and communicates with the real-time I/O software. It displays objects the Radar detected and allows the user to configure the Radar Sensor.

4 Graphical User Interface

The handling of the SRR- and ARS-Sensor is different. So the user has to configure the software according to the connected sensor.

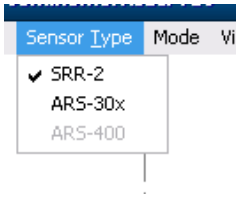


Figure 8: Configuration of Sensor type

The Continental Radar PLC menus and appearance is adjusted on startup according to the Sensor (SRR20X, ARS30X) referenced in the *"program.ini"* file in the Continental Radar PLC folder. By editing the *"program.ini"* the default startup sensor can be configured. To do so, edit the *"defaultSensor"* parameter in *"C:\Continental Radar-PLC\program.ini"*. Valid values for that parameter are *"ARS30x"* and *"SRR20X"*.

4.1 The Coordinate System

The entities detected by the radar sensor are displayed in a Cartesian coordinate system assuming the radar sensor is positioned in the origin. By default the axis maxima are limited by 60m in longitudinal direction and +/-60m in lateral direction (for the SRR 20X sensor). Negative longitudinal values are not possible.

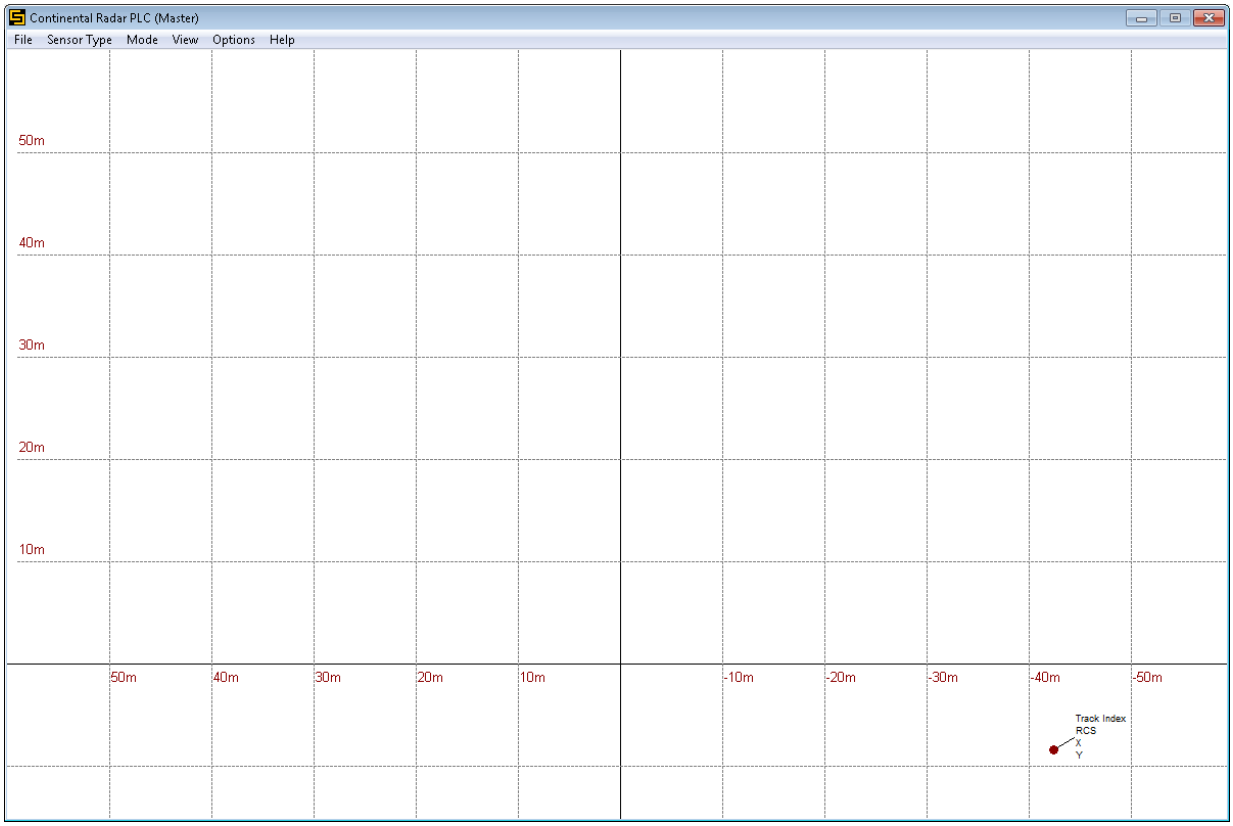


Figure 9: Cartesian Coordinate System used to display detected entities

The **reference lines** of the coordinate system grid have a fixed distance of 10m making it very easy to read and classify detected entities.

A **legend** of currently displayed information is visible in the lower right corner of the coordinate system. This is the currently displayed set of information shown next to each detected entity (See chapter 4.3(SRR20X) and 4.4(ARS30X) for sensor specific information). The current display and the coordinate system can be configured via the View Menu (Figure 10).

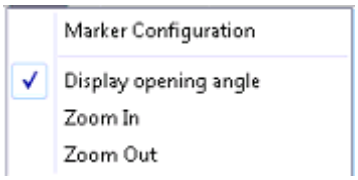


Figure 10: View Settings for display and coordinate system configuration

In the **View Menu** it is possible to switch the currently displayed set of entity information between *Positioning* and *Velocity* information. Furthermore it is possible to display the *Opening Angle (Field of view)* of the currently used radar sensor. This option is activated by default. Figure 11 shows the plain coordinate system (a), the opening angle for the SRR20X (b), and the opening angle for the ARS30X sensor (c).

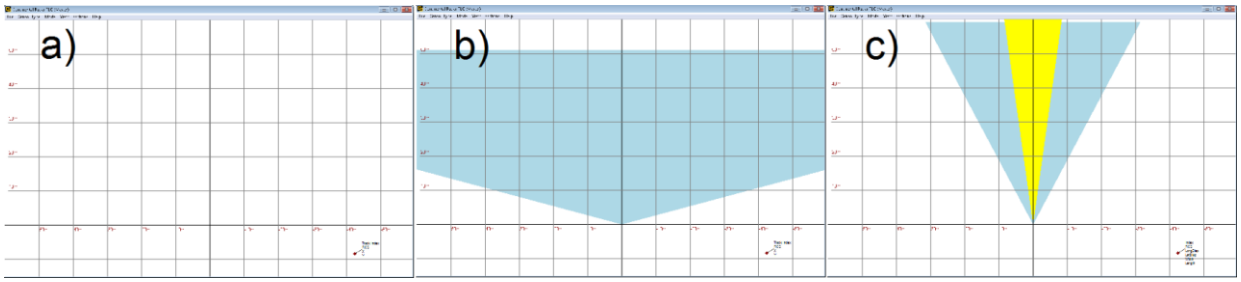


Figure 11: Different appearances of the coordinate system

It is also possible to scale the coordinate system. To do so either simply scroll the mouse wheel up to zoom-in and down to zoom-out or select the **Zoom In/Zoom Out** option from the **View Menu** (Figure 10). By default the zoom is performed symmetrically meaning the longitudinal and lateral axis are zoomed by the same factor (Figure 13-a). This can be adjusted by right-clicking into the Main Screen and opening the **Zoom-Options**.

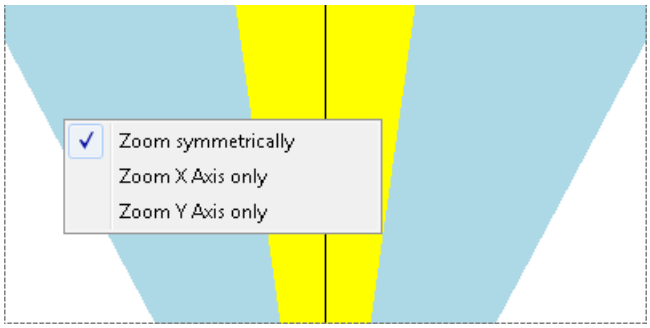


Figure 12: Zoom Options for symmetrical, longitudinal only or lateral only zoom.

When selecting the "**X Axis only**" option only the lateral axis is scaled upon zooming. The longitudinal axis stays at its current value (Figure 13-b). Respectively when selecting the "**Y Axis only**" option from the zoom menu, only the longitudinal axis is scaled and the lateral axis remains at its current value (Figure 13-c).

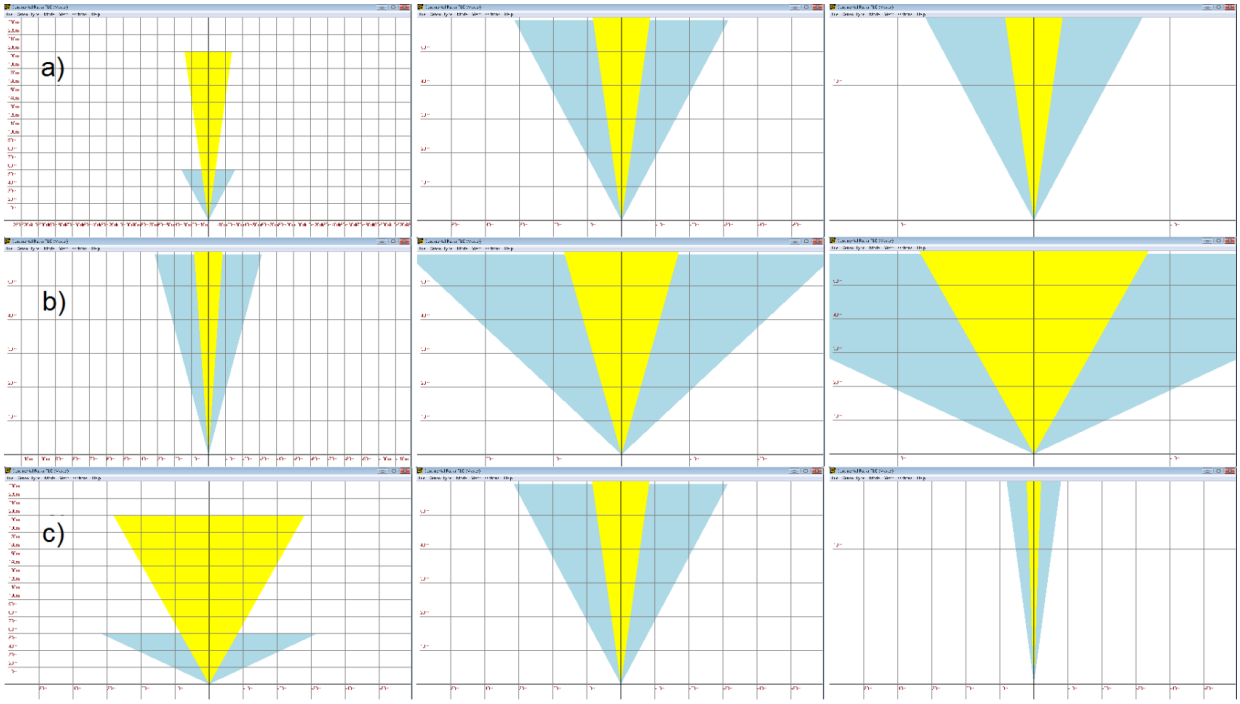


Figure 13: Exemplary zoom modes and stages

4.2 Markers

Each entities detected by the radar can carry additional information.

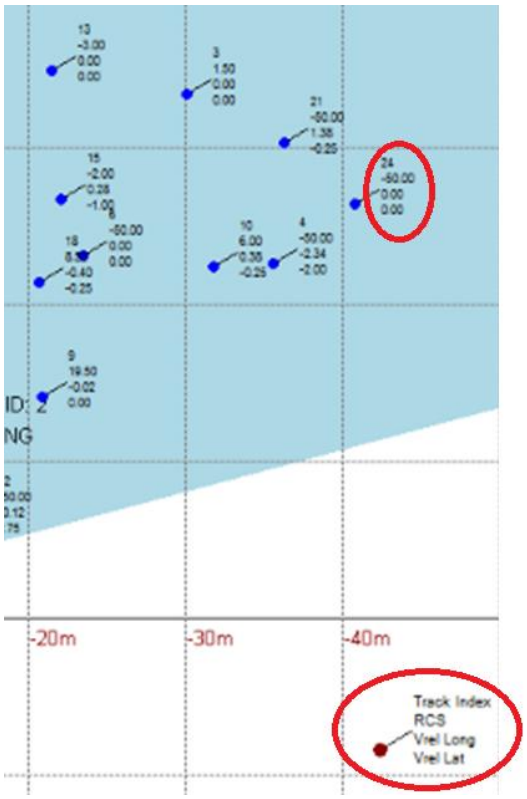


Figure 14 Additional Information

Depending on the Sensor and the operation mode different additional information is available. Up to 6 configurable different values can be displayed at once. The menu can be found under View / Marker Configuration.

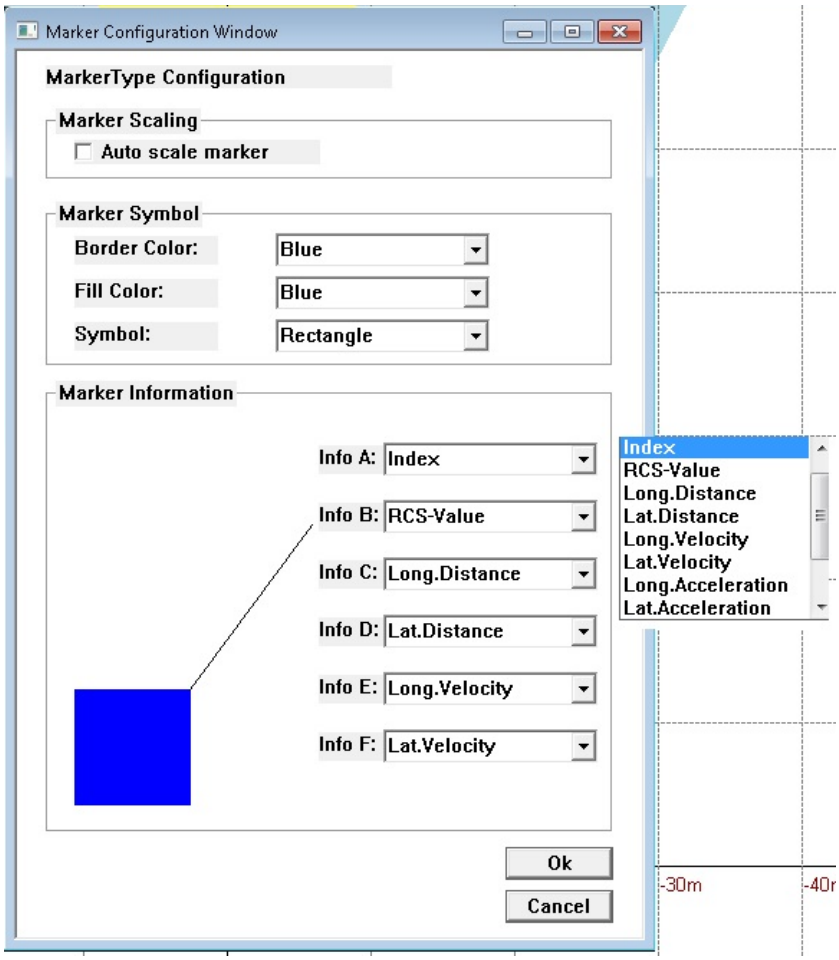


Figure 15 Marker Configuration

On the ARS408 in object mode the following values are selectable:

-Index

-RCS Value

-Longitional Distance

-Lateral Distance

-Longitional Velocity

-Lateral Velocity

-Longitional Acceleration

-Lateral Acceleration

-Object class

For the markers of all Sensor types and operation modes color and Symbol can be changed.

Also on the ARS408 a auto scale of the marker size is available. The scaling is done by the detected object width and length for rectangle and by RCS by Circle.

4.3 Short Range Radar (SRR 208) Sensor

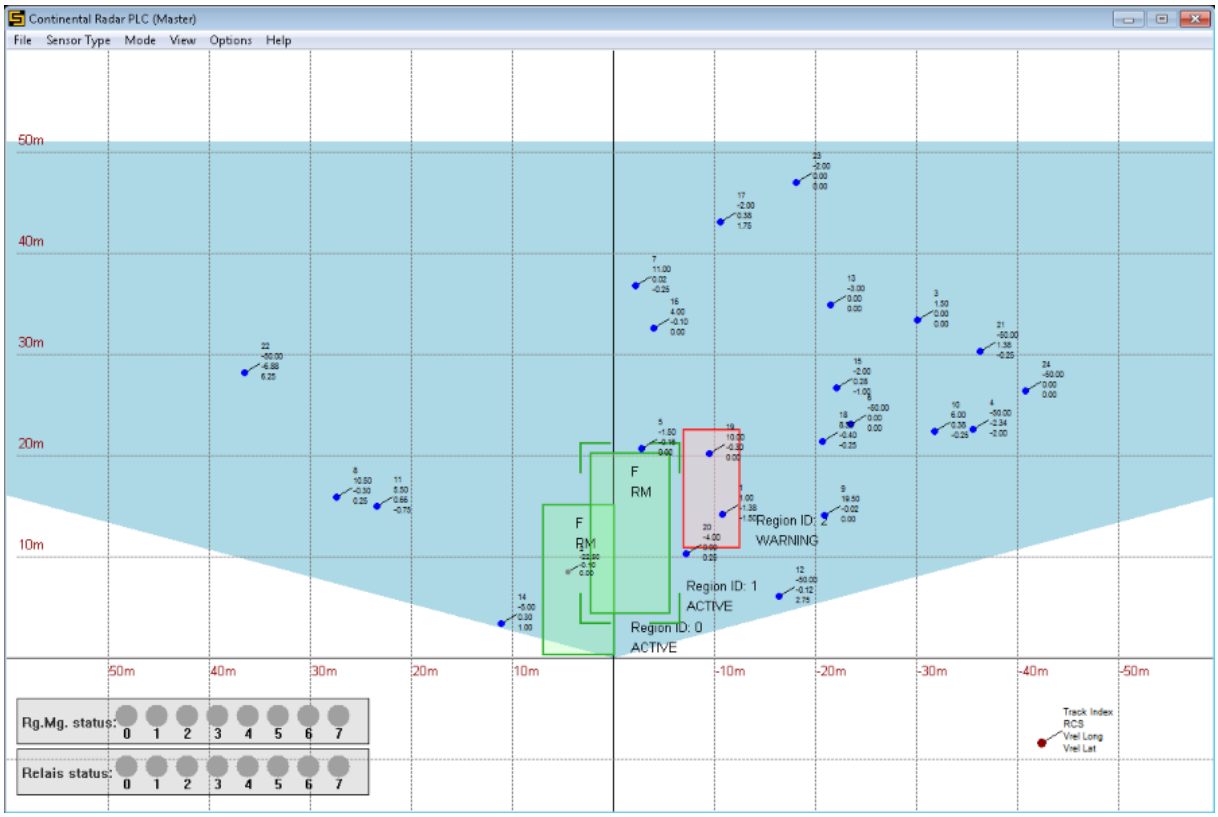


Figure 16: SRR Main Screen

The main screen shows the SRRs field of view, marked by the light blue area. The white regions mark everything outside the sensors field of view. By the sensor detected entities are displayed within the field of view of the sensor. Markers also provide additional measurement data about detected entities (Radar Cross Section (RCS), speed..) A legend is shown in the lower right corner of the Main Screen.

The sensor supports two operation modes. It can deliver Tracks or Cluster[2] data.

4.3.1 Cluster

The Cluster mode can be activated by selecting Cluster from the Mode Menu.

[2] See the SRR208 manual for description

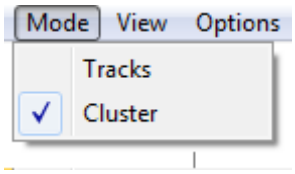


Figure 17: Mode selection for Cluster

Clusters represent reflected signals with similar position and movement. The software is able to display up to 128 Cluster at once. Each Cluster provides a set of information.

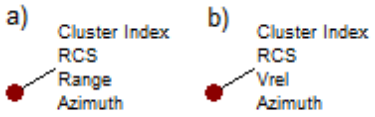


Figure 18: SRR Cluster Markings

Parameter	Description
Index	Current index of the cluster in the cluster list
RCS	Radar Cross Section[dB*m^2]
Range	Radial distance of the cluster[m]
Azimuth	Cluster angle[°]
Vrel	Relative velocity of the cluster[m/s]

Table 5: Cluster parameter overview

4.3.2 Tracks

The Track mode can be activated by selecting Tracks from the Mode Menu.

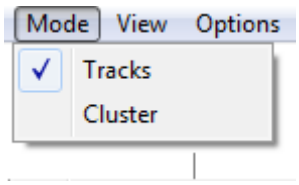


Figure 19: Mode selection for Tracks

Tracks in contrast to Cluster have a history. They represent Cluster tracked over time. The software is able to display up to 25 Tracks at once. Each Track provides a set of information.

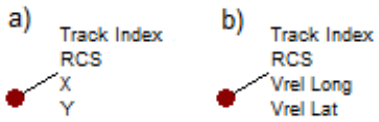


Figure 20: SRR Track Markings

Parameter	Description
Index	Current index of the track in the track list
RCS	Radar Cross Section[dB*m^2]
X	Longitudinal position of the track[m]
Y	Lateral position of the track[m]
Vrel Long	Relative longitudinal velocity[m/s]
Vrel Lat	Relative lateral velocity[m/s]

Table 6: Track parameter overview

4.3.3 Sensor Configuration Window

Basic Sensor properties can be adjusted in the "**Sensor Configuration**" window. To open it, select Options/ Sensor Configuration.

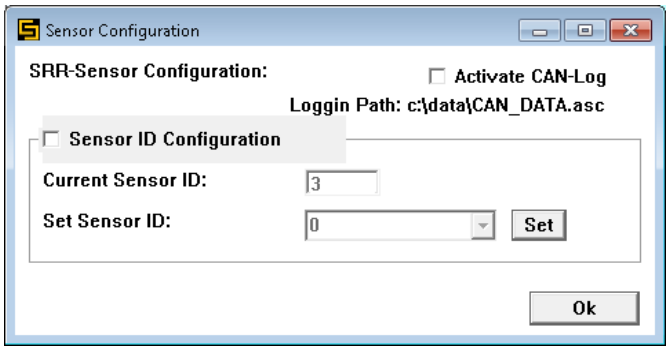


Figure 21: The Sensor Configuration Window

4.3.3.1 CAN-Bus Log

In the "**Sensor Configuration**" window you can activate a CAN-Log which will record every CAN-Message sent by the sensor.

The logging file *"CAN_DATA.asc"* is stored at the location shown at *"Logging Path"*. This is the **default Logfile location**. If you want to adjust the Logging Path, you can do so by changing the *"logPath"* parameter in the *"program.ini"* file in the program folder *"C:\Continental Radar-PLC\program.ini"*.

Note: When changing the default Logfile location, it is **mandatory** to enter a **valid path-string** e.g. *c:\data\CAN_DATA.asc* without any apostrophes or quotation marks. In general it might be helpful to create backup copies of all **.ini* files before changing parameter values.

4.3.3.2 Sensor ID Configuration

The **Sensor ID Configuration** allows selecting a sensor ID for the connected sensor. The Sensor ID also determines the address space of CAN communication messages according to (base message ID | (0x10 * sensor ID)).

The **Current Sensor ID** option shows the currently used Sensor ID. The **Set Sensor ID** option allows changing the Sensor ID. Therefore a value between 0 and 7 can be selected from the drop-down menu. Confirming the new value by pressing the **Set-Button** will write the new configuration to the Radar-Sensor.

4.3.4 Filter application relevant Cluster or Tracks

To see only application relevant Cluster or Tracks it is possible to set filter values. This allows the software to reject entities that violate the set of rules established by the filter values thus displaying only relevant Cluster or Tracks.

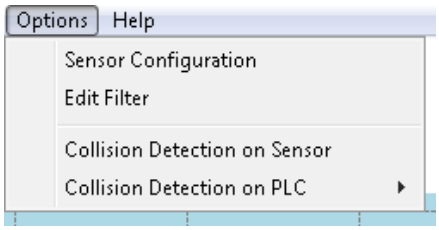


Figure 22: Enable Filter

The filter can be adjusted and activated in the Filter Settings, available through the *Options/Edit Filter Menu*. Since Tracks and Cluster data come with different sets of parameters the Filter Menu automatically adjusts to the respective display mode. Figure 23 and Figure 24 display the Filter Settings for Cluster and Tracks.

Customized filter values can be written to an **Ini-File** for later use by pressing the "**Save to Ini"** Button. Depending on whether Cluster or Tracks are selected, the filter values will be written to the *"C:\Continental Radar-PLC\SRR20X.ini"* File at the Key *"filter_tracks"* for Track-Mode or *"filter_cluster"* when the display mode is set to Cluster. Formerly saved customized filter values can be loaded from the Ini by pressing the "**Load from Ini"** Button.

Important:

- The filtering is only active, when “Activate Filter” is selected and Apply is pressed
- The Ini-Filter values will be loaded automatically after program startup and when switching the Sensor-Type or Send Mode. This includes the filter activation.

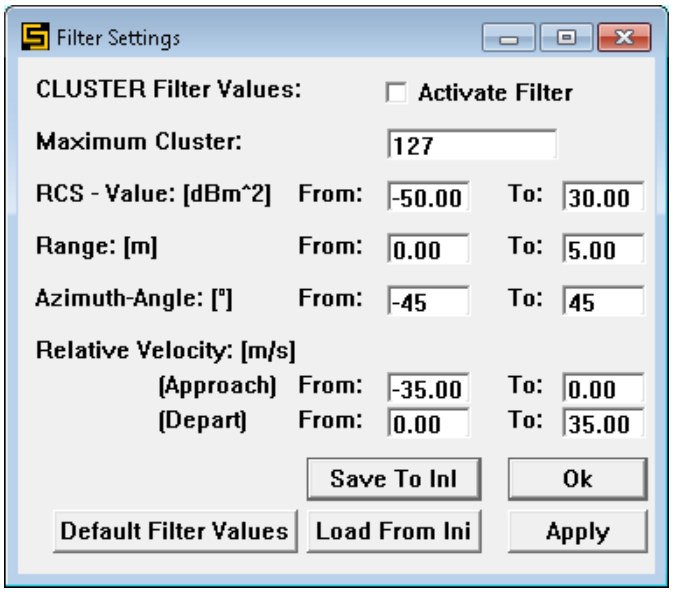


Figure 23: Cluster Filter Settings

Parameter	Description
Activate Filter	Flag the filter to be activated on confirmation
Maximum Cluster Index	Maximum Cluster Index to be displayed
RCS-Value	Radar Cross Section range to be displayed
Range	Distance range in which Cluster should be displayed
Azimuth-Angle	Angle range in which Cluster should be displayed
Relative Velocity	Relative Velocity range for Cluster that should be displayed

Table 7: Cluster Filter value description

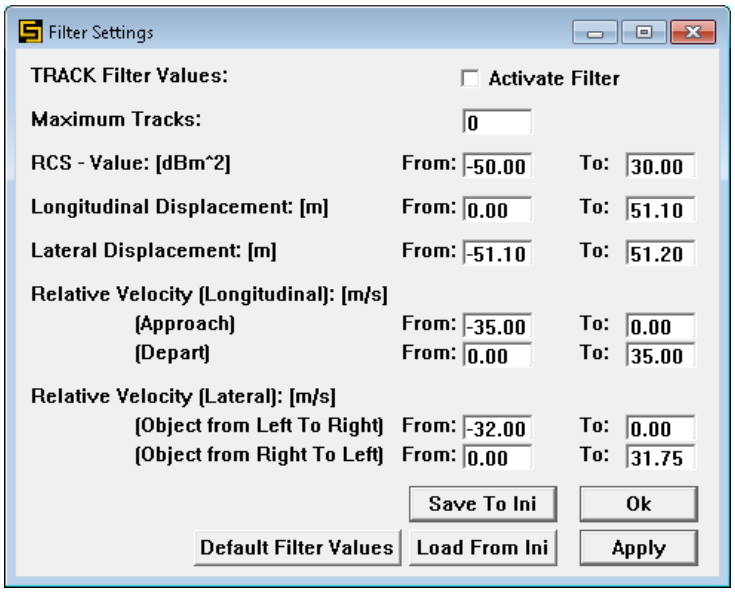


Figure 24: Track Filter Settings

Parameter	Description
Activate Filter	Flag the filter to be activated on confirmation
Maximum Track Index	Maximum Track Index to be displayed
RCS-Value	Radar Cross Section range to be displayed
Longitudinal Displacement	Displacement range in longitudinal direction in which Tracks should be displayed
Lateral Displacement	Displacement range in lateral direction in which Tracks should be displayed
Relative Velocity (Longitudinal)	Relative velocity range in longitudinal direction for Tracks that should be displayed
Relative Velocity (Lateral)	Relative velocity range in lateral direction for Tracks that should be displayed

Table 8: Track Filter value description

4.3.5 Collision Detection on sensor

Collision Detections is only supported with a SRR 208 with sensor internal collision detection software (optional).

The Collision Detection recognition is done directly on the sensor itself and the visualization software only reflects the current collision states monitored by the Radar. So the filter function is not supported. At present the Collision Detection for the sensor versions mentioned above is only available for Tracks. See *Software Collision Detection on* PLC for collision detection with filter ability for Tracks and Cluster (Chapter 4.5).

The collision detection Configuration is accessible through the Options/Collision Detection Menu.

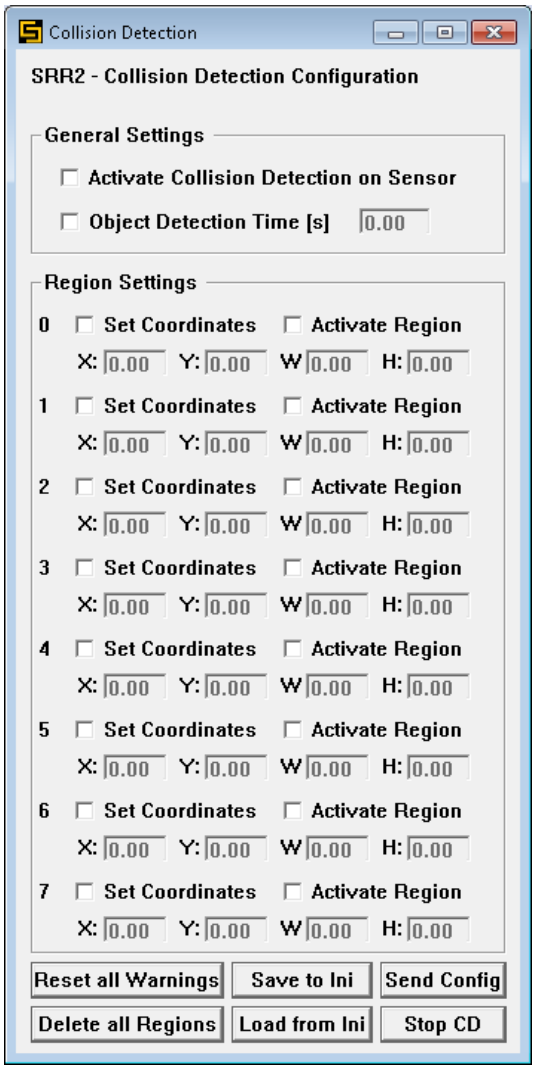


Figure 25: SRR Collision Detection Configuration

Parameter	Description
General Settings	
Activate Collision Detection	Region independent. De-/activate collision detection function
Set Object Detection Time	Minimum time an objects needs to be detected before warning is triggered
Region Settings	
0…7	Number of the region
Set Coordinates	Activates selected region for drawing
Activate Region	Activates selected region for collision detection
X	X value of the upper left corner of the warning region
Y	Y value of the upper left corner of the warning region
W	Width of the warning region
H	Height of the warning region

Table 9: SRR Collision Detection Settings

In Collision Detection Mode the user is able to define and activate up to 8 Warning Regions for which he will receive collision detection information.

The Collision Detection Configuration is separated into General Settings which affect the Collision Detection function as a whole and Region dependent settings which only affect the selected Warning Region. To bring the Collision Detection to work the user first needs to activate the Collision Detection Functionality on the sensor. Furthermore at least one Warning Region needs to be **defined** and **activated**. Only then the Sensor will monitor the defined region for collision detection violations.

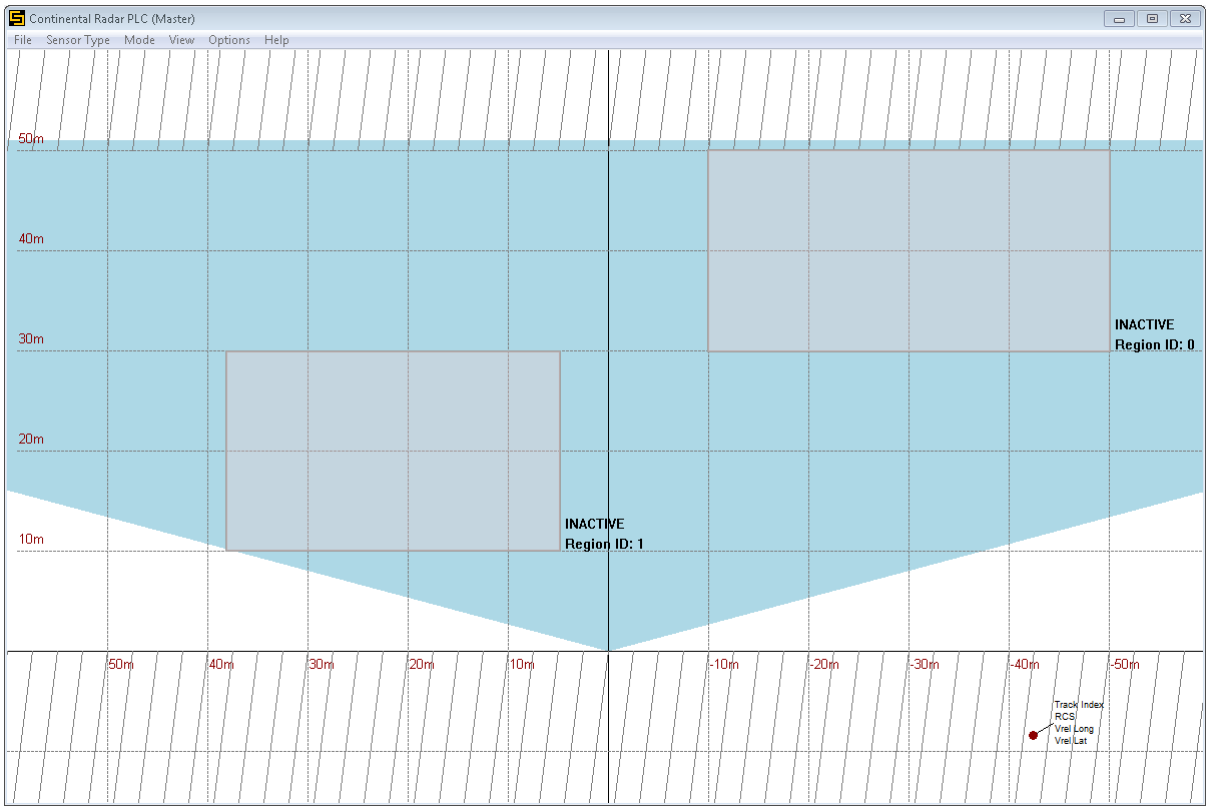


Figure 26: SRR defining warn regions

To define a Warning Region, the *Set Coordinates Flag* of the respective region needs to be set. This activates the selected region for drawing. By left-clicking into the Main Screen and dragging the mouse a rectangular, Warn Region can be created. While moving the mouse the regions *X*, *Y*, *W* and *H* Parameters in the Collision Configuration Window will be updated.

When selecting a Region for drawing, some crossed out areas can be seen. Those limit the Sensors detection scope and make sure only valid regions are defined. When trying to set invalid values to warning regions by starting or ending outside the detection scope the region will automatically use the maximum valid value for the respective invalid coordinate (

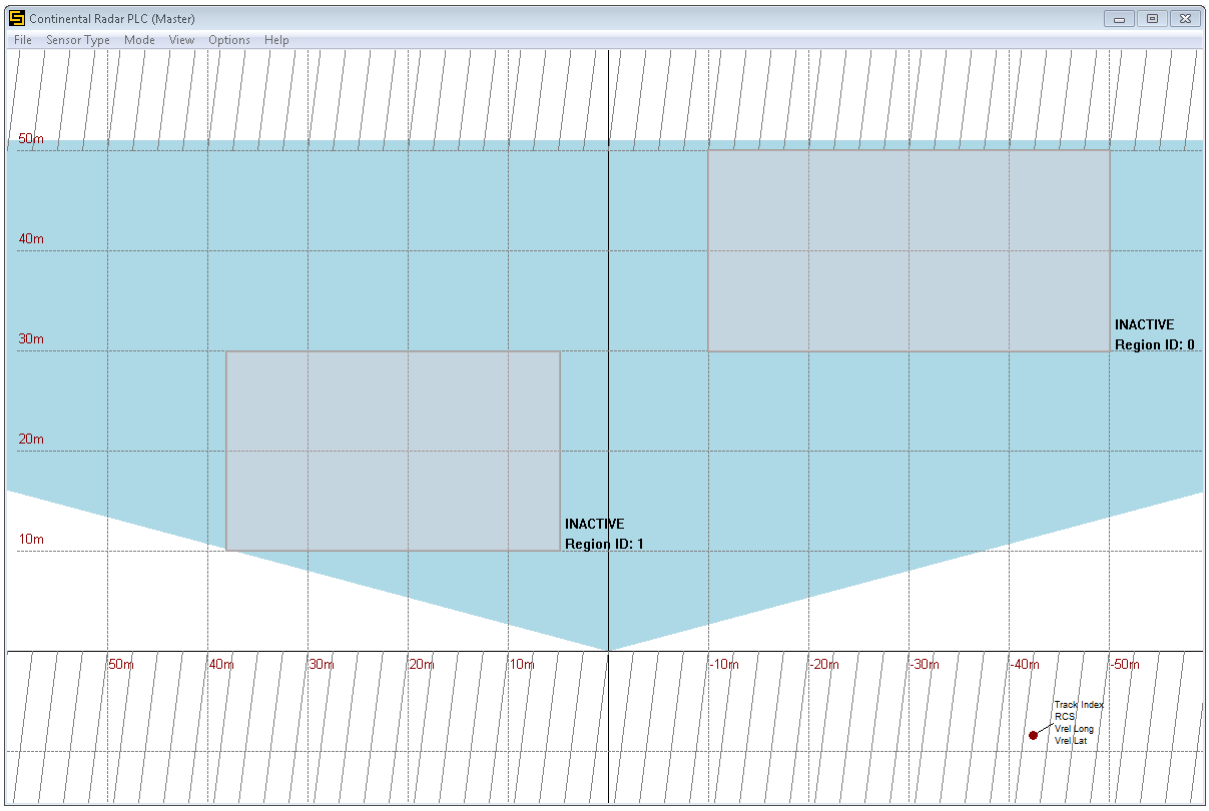


Figure 26).

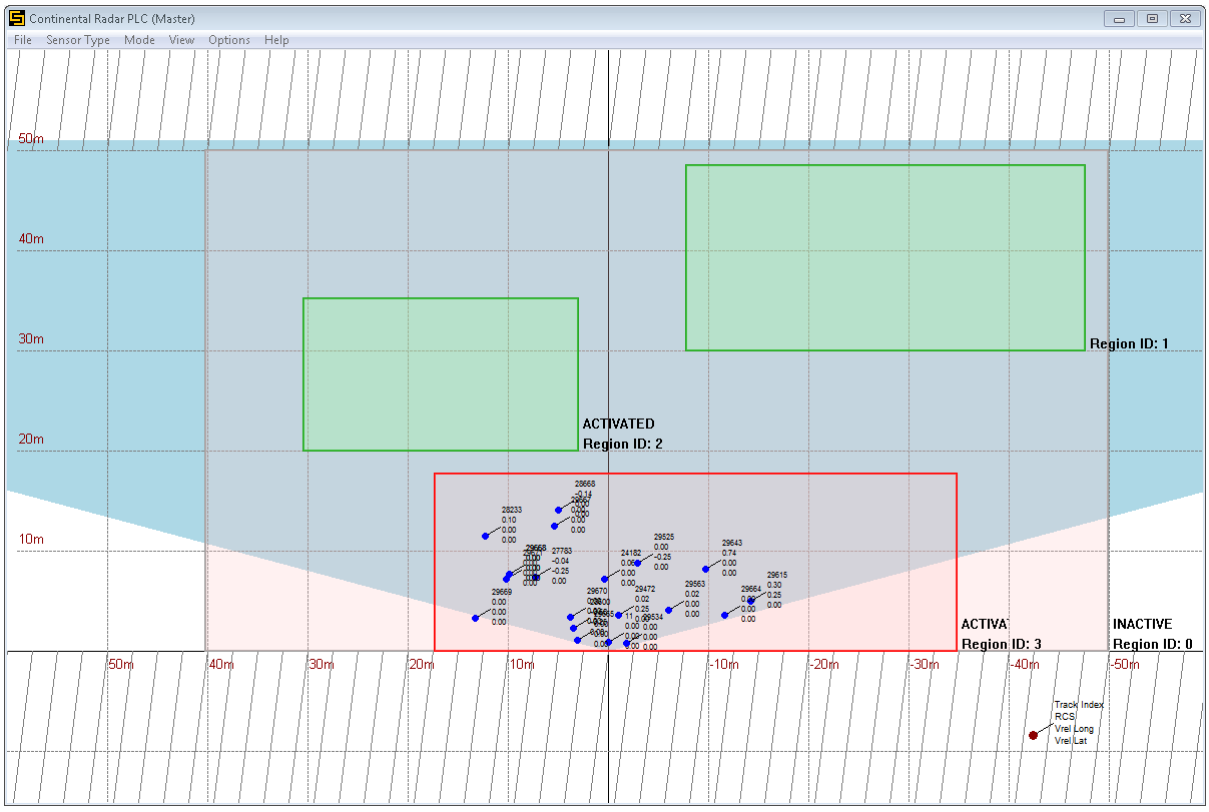


Figure 27: SRR Collision Detection Mode

To activate the region the "*Activate Region"* flag needs to be set. The *Send Config* Button will write the General Settings and the Region Settings of active Regions to the Radar Sensor.

The Regions current color also reflects the regions current state (grey = inactive, green = activated, red = warning).

A defined Region-Setup can be stored by pressing the "**Save to Ini"** Button. Hereby all region coordinates and their active state as well as the general Collision Detection settings are written to the *"C:\Continental Radar-PLC\SRR20X.ini"* at the key *"coll_det_regions"*. Respectively a saved Region-Setup can be loaded by pressing the "**Load from Ini"** Button.

By selecting the "**Reset all Warnings"** Button, all active Warning Regions on the Sensor will be reset to the *"No Warning* State*"* (green) until another violation of the region is detected. This can be immediately if no restrictions are set or after the Minimal Detection Time if it is selected and written to the sensor.The "**Delete all Regions"** Button deletes all Regions that are currently observed by the Radar Sensor. No Collision Detection Warnings will be sent after this, unless a new region is created.

By selecting the "**Stop C***(ollision)***D***(etection)"* Button the Collision Detection Functionality will be shut down. No more Collision Detection Warning Messages are sent until the Functionality gets reinitialized.

In Collision Detection Mode the Radar Sensor is unable to send regular Track Signals displayed in None Collision Detection Mode, however creating a warning region that covers the whole valid Main Screen will allow the sensor to detect all Tracks within his detection scope. But note that the displayed tracks are Warning Tracks, meaning Tracks that triggered a Collision Detection Warning, thus the region activation is mandatory.

4.4 ARS 308 Sensor (Long Range)

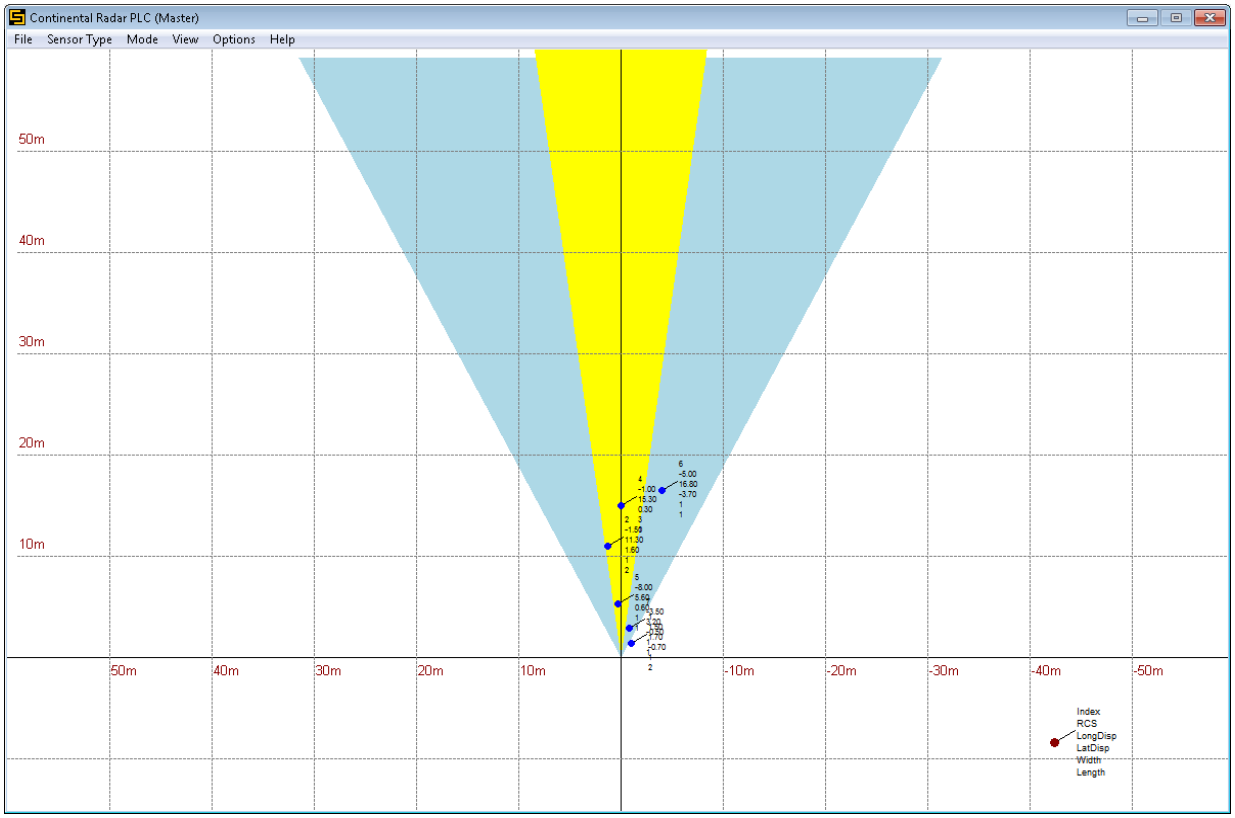


Figure 28: ARS308 Main Screen in Near-View

The *Main Screen* shows the ARS308s field of view. The Yellow and light blue areas indicate the sensors Near- and Long-Range detection areas. The white regions are outside the sensors detection scope. By the sensor detected entities are displayed within the field of view of the sensor. The markers also provide additional information about detected entities. Besides the entities location further information about its speed, dimensions, Radar Cross Section (RCS)… are displayed. A legend is shown as information in the lower right corner of the *Main Screen*. The sensor supports two modes. It can display the measured data either as Objects or Targets[3].

4.4.1 Targets

The Targets display can be activated by selecting Targets from the *Mode Menu*.

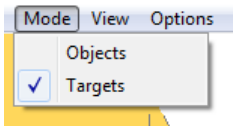


Figure 29: Mode Selection for Targets

Targets represent reflected signals with similar position and movement. The software is able to display up to 96 Targets at once. Each Target provides a set of configurable information.

Parameter	Description
NoOfTarget	Target number in the Target List
RCS	Radar Cross Section[dB*m^2]
Range	Target Range
Angle	Target Angle[°]
Vrel	Target relative velocity[m/s]

4.4.2 Objects

The Objects display can be activated by selecting Objects from the *Mode Menu*.

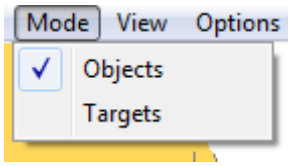


Figure 30: Configuration - Targets / Objects

Objects in contrast to Targets have a history. They represent Targets tracked over time. The software is able to display up to 40 Objects at once. Each Object provides a set of measured data.

[3] See the ARS308 manual for description

Parameter	Description
ObjectID	Unique Object ID
Length	Object Length[m]
Width	Object width[m]
RCS	Radar Cross Section[dB*m^2]
VrelLong	Relative longitudinal speed[m/s]
Vlat	Object lateral velocity[m/s]

Table 10: Object parameter overview

4.4.3 Sensor Configuration Window

Basic Sensor properties can be adjusted in the "**Sensor Configuration"** Window. To open it, select Options/ Sensor Configuration.

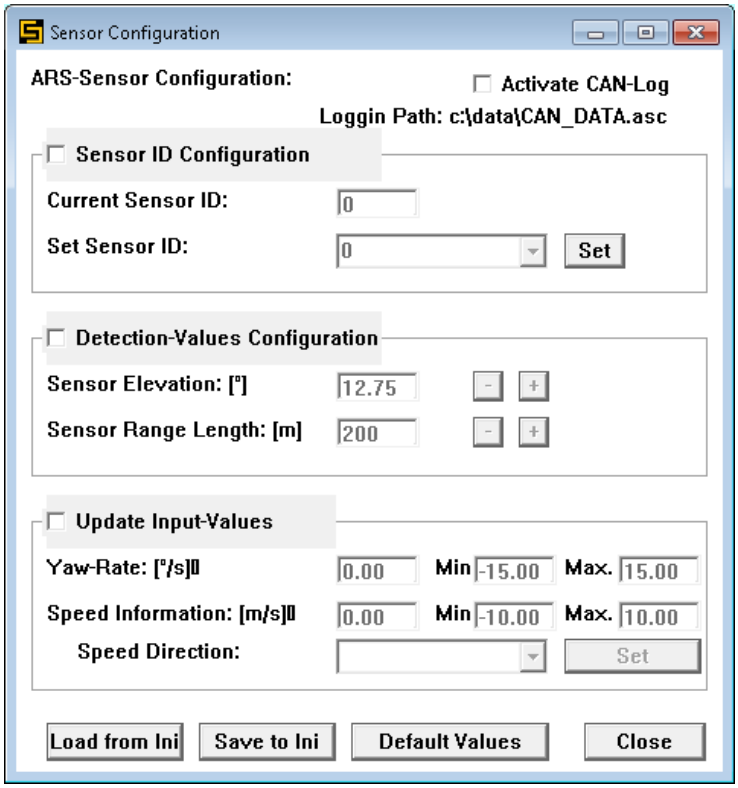


Figure 31: ARS 308 Sensor Configuration Window

4.4.3.1 CAN-Bus Log

In the "**Sensor Configuration**" window you can activate a CAN-Log which will record every CAN-Message sent by the sensor.

The logging file *"CAN_DATA.asc"* is stored at the location shown at *"Logging Path"*. This is the **default Logfile location**. If you want to adjust the Logging Path, you can do so by changing the *"logPath"* parameter in the *"program.ini"* file in the program folder *"C:\Continental Radar-PLC\program.ini"*.

Note: When changing the default Logfile location, it is **mandatory** to enter a **valid path-string** e.g. *c:\data\CAN_DATA.asc* without any apostrophes or quotation marks. In general it might be helpful to create backup copies of all **.ini* files before changing parameter values.

4.4.3.2 Sensor ID Configuration

The **Sensor ID Configuration** allows changing the ID between 0 and 7 for the connected sensor. The Sensor ID also determines the address space of CAN communication messages according to (base message ID | (0x10 * sensor ID)).

The **Current Sensor ID** option shows the currently used Sensor ID. The **Set Sensor ID** option allows changing the Sensor ID. Therefore a value between 0 and 7 can be selected

from the drop-down menu. Confirming the new value by pressing the **Set-Button** will write the new configuration to the Radar-Sensor.

4.4.3.3 Detection Value Configuration

The **Detection Value Configuration** allows adjusting the Radar sensors detection scope by changing the **plate elevation** and the **Range Length**. By adjusting the sensor's plate, the elevation angle of the radar beam is altered between **0°** *(inclined towards the sky)* and **32°** *(inclined towards the ground)*. By setting the range length parameter, the maximum distance at which objects will be detected can be adjusted between **50m** and **200m**. By adjusting both parameters the radar sensor can be calibrated to receive optimal reflections from an area of interest. With a shorter range, the measurement accuracy of the measured distances is getting better.

4.4.3.4 Update Input Values

These values are used, when the sensor is mounted on vehicle. It helps to separate moving objects from the environment.

By selecting **Update Input Values** the currently **vehicle speed** and **yaw rate** are displayed and continuously updated. Those signals are calculated from the externally set input current (4…20mA) on the EL3122 module (2.3, p.8).The default minimum and maximum values for speed and yaw rate are set to the sensors limits. Both values can be adjusted by entering new values in the *"Min."* and *"Max."* fields and activated by pressing the Set Button.

It is also possible to save **Detection Value Configuration** and the **set minimum and maximum values of the Input Values Configuration** to the *"ARS30x.ini"* file. Respectively a saved Detection Value Configuration and Input Value Configuration can be loaded by pressing the "**Load from Ini"** Button.

The "**Default Values"** Button resets the **Set Sensor ID** within the **Sensor ID Configuration** the whole **Detection Values Configuration** and the **minimum** and **maximum** values for speed and yaw rate within the **Input Values Configuration** to their individual default value given by the radar sensor.

4.4.4 Filter application relevant Targets or Objects

To display only application relevant Targets or Objects it is possible to set filter values.

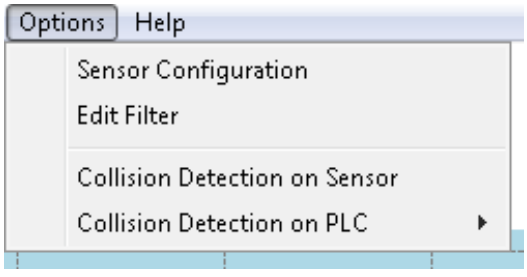


Figure 32: Enable Filter

The filter can be adjusted and activated in the *Filter Settings*, available through the *Options/Edit Filter Menu*. Since Objects and Targets data come with different sets of parameters the Filter Menu automatically adjusts to the respective display mode. Figure 33 and Figure 34 display the Filter Settings for Objects and Targets.

Customized filter values can be written to an **Ini-File** for later use by pressing the "**Save to Ini"** Button. Depending on whether Objects or Targets are selected, the filter values will be written to the *"C:\Continental Radar-PLC\ARS30x.ini"* File at the Key *"filter_objects"* for Object-Mode or *"filter_Targets"* when the display mode is set to Targets. Formerly saved customized filter values can be loaded from the Ini by pressing the "**Load from Ini"** Button.

Important:

- The filtering is only active, when "Activate Filter" is selected and Apply is pressed
- The Ini-Filter values will be loaded automatically after program startup and when switching the Sensor-Type or Send Mode. This includes the filter activation.

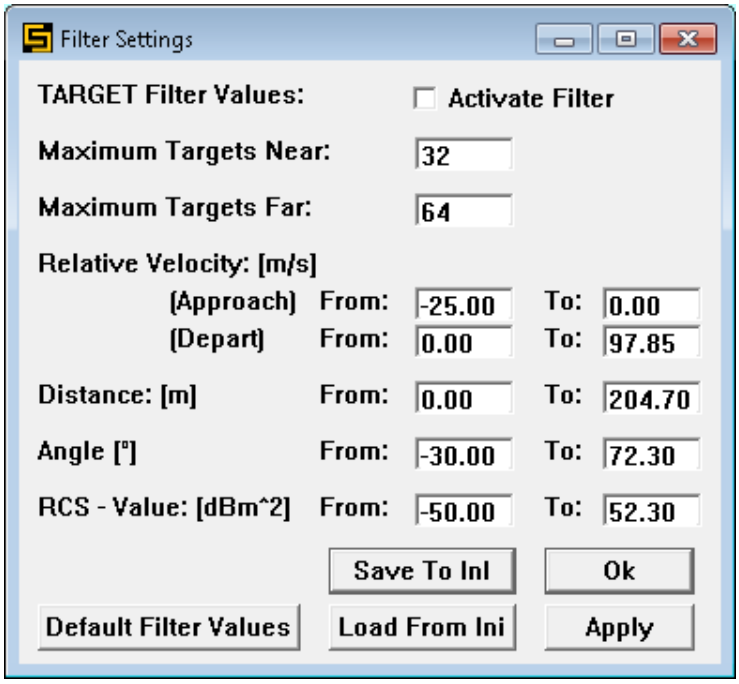


Figure 33: Target Filter Settings

Parameter	Description
Activate Filter	Flag the filter to be activated on confirmation
Maximum Target Index Near	Maximum Index of Targets in Near distance to be displayed
Maximum Target Index Far	Maximum Index of Targets in Far distance to be displayed
Relative Velocity	Relative velocity range for Targets that should be displayed
Distance	Distance range in which Targets should be displayed
Angle	Angle range in which Cluster should be displayed
RCS-Value	Radar Cross Section range to be displayed

Table 11: Target Filter value description

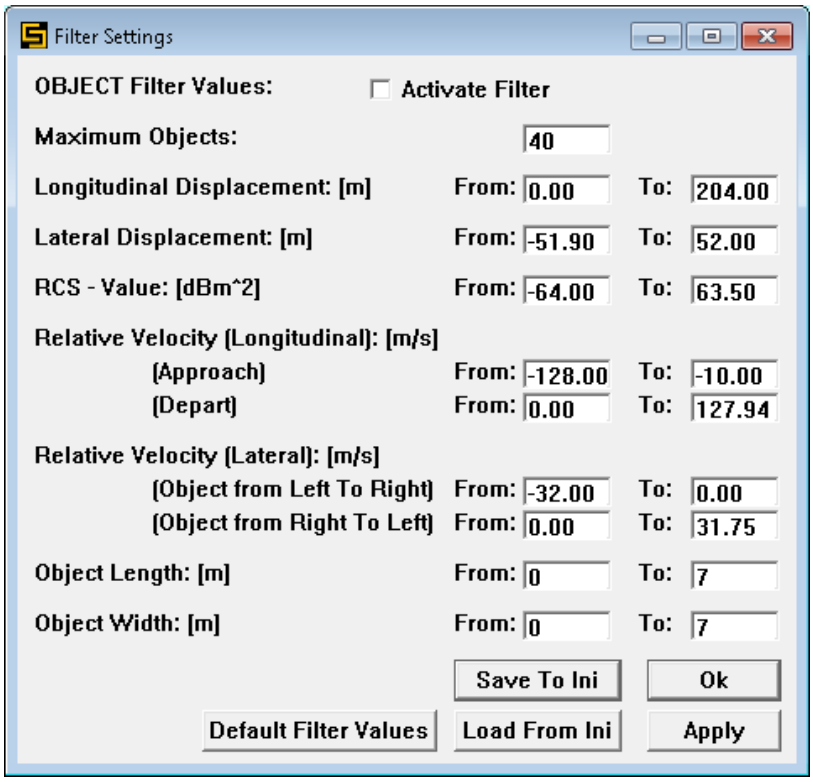


Figure 34: Object Filter Settings

Parameter	Description
Activate Filter	Flag the filter to be activated on confirmation
Maximum Object Index	Maximum Object Index to be displayed
Longitudinal Displacement	Displacement range in longitudinal direction in which Objects should be displayed
Lateral Displacement	Displacement range in lateral direction in which Objects should be displayed
RCS-Value	Radar Cross Section range to be displayed
Relative Velocity (Longitudinal)	Relative velocity range in longitudinal direction for Objects that should be displayed
Relative Velocity (Lateral)	Relative velocity range in lateral direction for Objects that should be displayed
Object Length	Length range for Objects that should be displayed
Object Width	Width range for Objects that should be displayed

Table 12: Object Filter Value description

In the Filter Settings the signals can be filtered by all relevant information. Only Targets/Objects within the activated filter range will be displayed on screen. For the filter to take effect it needs to be activated and applied. Upon start and when no customized filter values have been saved to the Ini file, the filter value range for each parameter reflects the sensors default value range. Edited filter values can easily be restored to the original sensor

default value range by resetting the filter values. Edited filter values can easily be restored to the original sensor default value range by pressing the “**Default Filter Values”** Button.

4.4.5 Collision Detection

If the ARS308 Radar Sensor supports internal collision detection, this function can be activated. This is done directly by the sensor itself and the visualization software only reflects the current collision states monitored by the Radar Sensor. So the filter function is not supported. Collision Detection is only available for Objects.

The collision detection Configuration is accessible through the Options/Collision Detection on Sensor Menu.

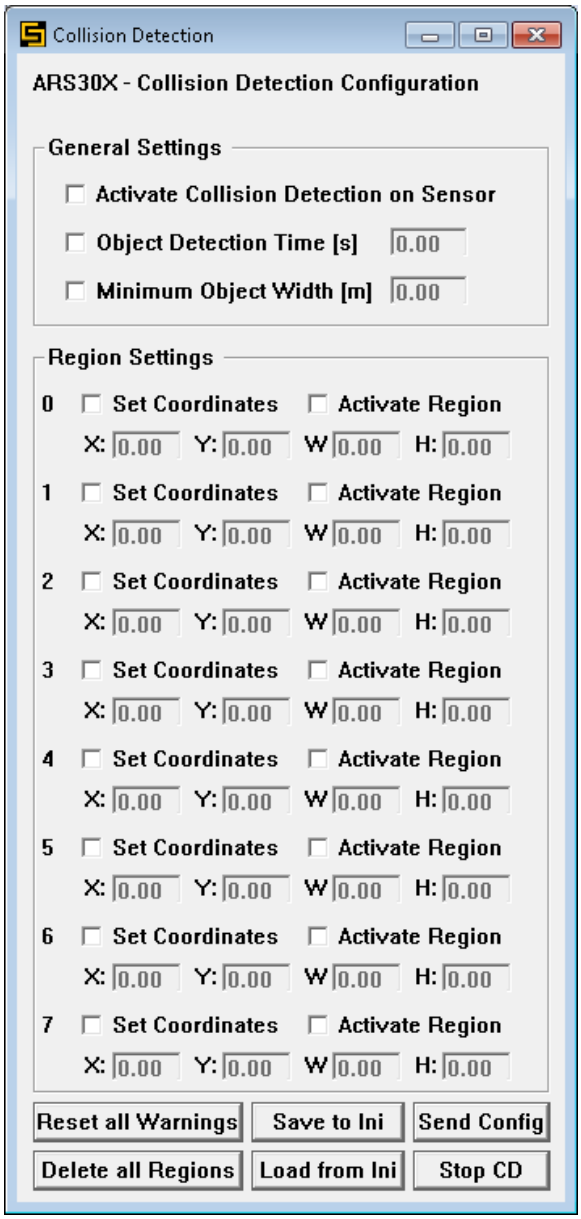


Figure 35: ARS308 Collision Detection Configuration

Parameter	Description
General Settings	
Activate Collision Detection	Region independent. De-/activate collision detection function
Set Object Detection Time	Minimum time an objects needs to be detected before warning is triggered
Minimum Object Width	Minimum Width an object needs to have in order to trigger a warning.
Region Settings	
0…7	Number of the region
Set Coordinates	Activates selected region for drawing
Activate Region	Activates selected region for collision detection
X	X value of the upper left corner of the warning region
Y	Y value of the upper left corner of the warning region
W	Width of the warning region
H	Height of the warning region

Table 13 ARS Collision Detection Settings

In Collision Detection mode the user is able to define and activate up to 8 warning regions for which he will receive collision detection information. Each warning region is connected to an output relay (See 2.4)

The Collision Detection Configuration is separated into General Settings which affect the Collision Detection function as a whole and Region dependent settings which only affect the selected Warning region. For starting the Collision Detection, the user first needs to activate the Collision Detection Functionality on the sensor. Furthermore at least one Warning Region needs to be **defined** and **activated**. Only then the Sensor will monitor the defined region for collision detection violations.

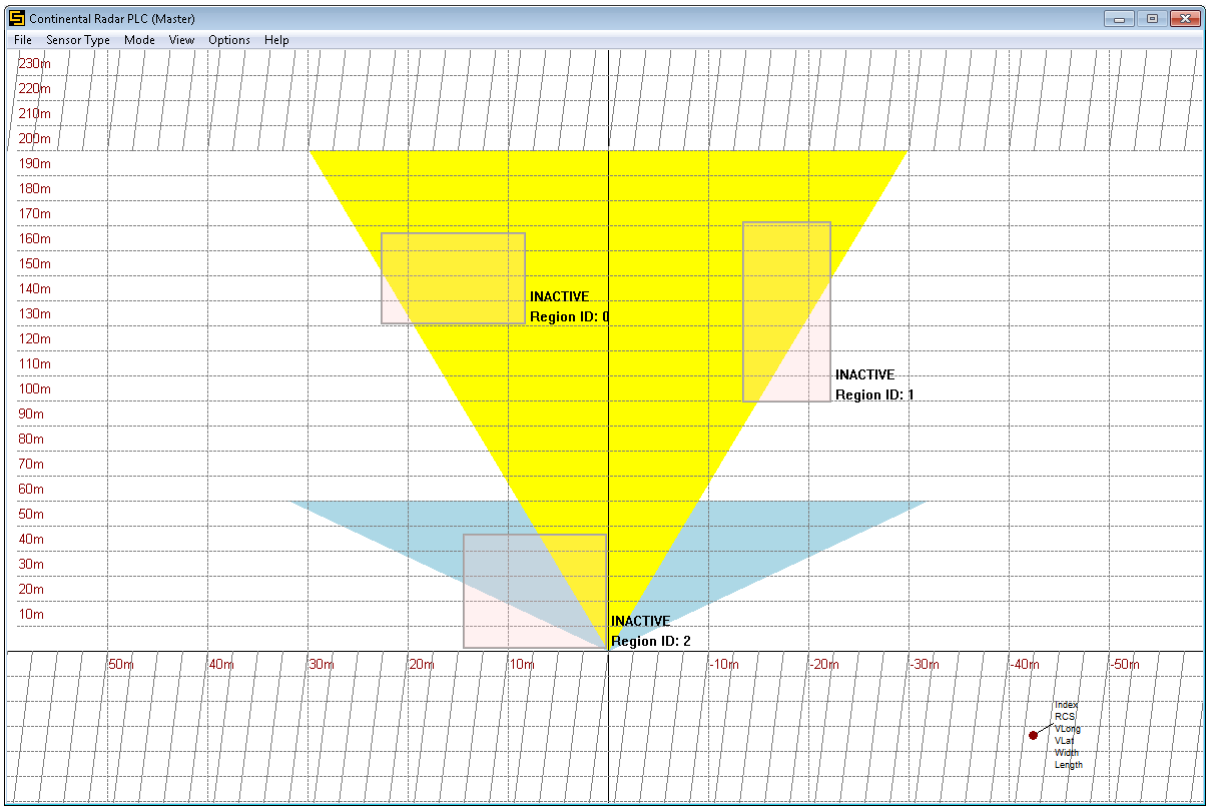


Figure 36: ARS 308 defining warn regions

To define a Warning Region the *Set Coordinates* Flag of the respective region needs to be set. This activates the selected region for drawing. By left-clicking into the *Main Screen* and dragging the mouse a rectangular Warn Region can be created. While moving the mouse the regions *X*, *Y*, *W* and *H* Parameters in the Collision Configuration Window will be updated.

When selecting a Region for drawing, a crossed out area can be seen. It limits the Sensors detection scope and makes sure only valid regions are defined. When trying to set invalid values to warning regions by starting or ending outside the detection scope the region will automatically use the maximum valid value for the respective invalid coordinate (Figure 36).

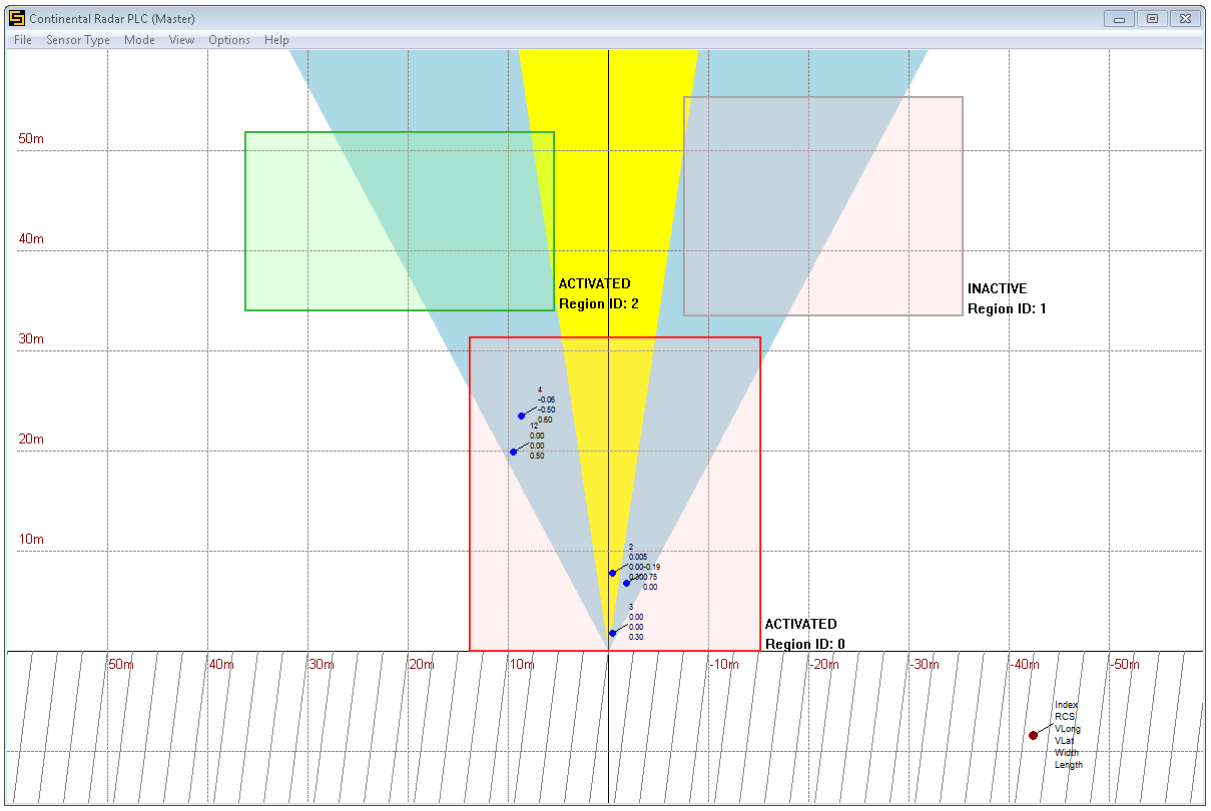


Figure 37: ARS-Collision Detection Mode

To activate the region the *Activate Region* flag needs to be set. The "**Send Config**" Button will write the General Settings and the Region Settings of the currently selected Region to the Radar Sensor.

The Regions current color also reflects the regions current state (grey = inactive, green = activated, red = warning).

A defined Region-Setup can be stored by pressing the "**Save to Ini"** Button. Hereby all region coordinates and their active state as well as the general collision settings are written to the *"C:\Continental Radar-PLC\ARS30x.ini"* at the key *"coll_det_regions"*. Respectively a saved Region-Setup can be loaded by pressing the "**Load from Ini"** Button.

By pressing the "**Reset all Warnings"** Button, all active warning regions on the Sensor will be reset to the *"No Warning State"* (green).

The "**Delete all Regions"** Button deletes all Regions that are currently observed by the Radar Sensor. **No Collision Detection Warnings** will be sent after this.

By selecting the **Stop C***(ollision)* **D***(etection)* **Button** the Collision Detection Functionality is shut down. **No more Collision Detection Warning Messages** are sent until the Functionality gets reinitialized.

In Collision Detection Mode the Radar Sensor is unable to send the regular Object Signals displayed in None Collision Detection Mode, however creating a Warning Region that covers the whole Main Screen will allow the sensor to detect all Objects within his detection scope. But note that the displayed Objects are Warning Objects, meaning Objects that triggered a Collision Detection Warning, thus the region activation is mandatory.

4.5 Software Collision Detection on PLC

The Collision Detection on PLC functionality is performed on the Radar PLC and is independent from the Radar Sensors Collision Detection. It works for all Sensor Models (SRR208, ARS308) as well as all output configurations (SRR208: Tracks, Cluster; ARS308: Objects, Targets).

Note: *It is not possible to activate Collision Detection on Sensor and on PLC at the same time!*

The Collision Detection on PLC offers a bandwidth of features and options that are not supplied by the Collision Detection on Sensor, thus granting a great level of flexibility for various custom applications. The Collision Detection on PLC is accessible through the Options/Collision Detection on PLC Menu.

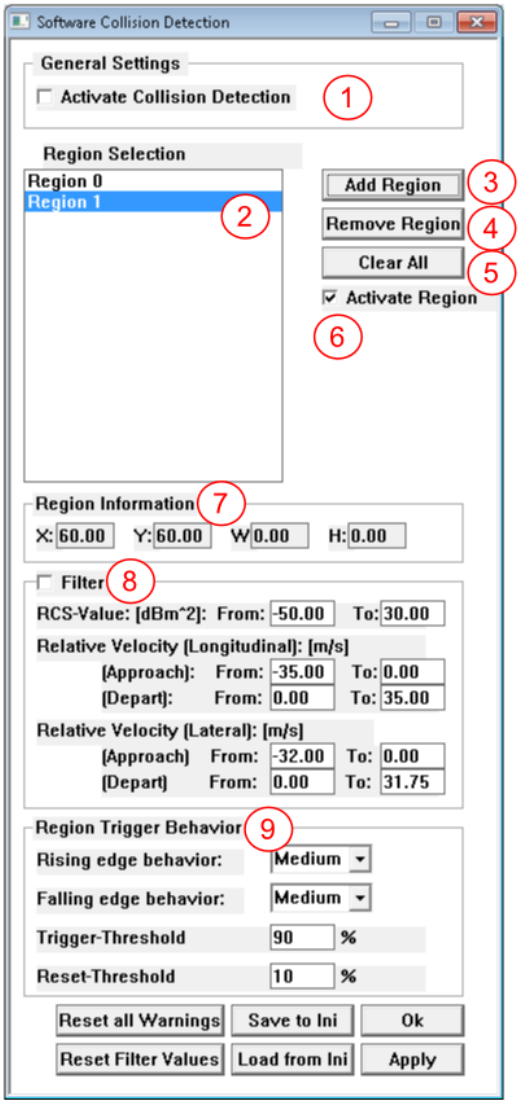


Figure 38: The Collision Detection on Sensor Window

In Collision Detection on PLC Mode the user is able to define and activate up to 24 Warning Regions, each of which will deliver collision detection information.

The feature itself can be activated by selecting the *Activate Collision Detection* Option (Figure 38-1). By default the feature is deactivated.

In order to perform Collision Detection at least one Region needs to be **created**, **defined** and **activated**. Only then the defined region will be monitored for collision detection violations.

4.5.1 Definition of Regions

To **create** a new region, press the "**Add Region"** Button (Figure 38-3). A new region will be added to the *Region Selection* at the next available index (0…23). To **define** the region, select it from the Region Selection and left-click into the Main Screen while dragging the mouse to define the regions X, Y, W and H parameters (Figure 38-7).

Regions can either be selected by directly left-clicking on the region itself, or by selecting the region from the Region Selection. Both ways the region will be surrounded with a selection frame. To adjust a regions position left-click the region while dragging the mouse. Note that changes made to a regions properties, e.g. *Filter Values* or *Trigger Behavior* need to be **applied** to take effect. Unapplied changes will be lost upon selecting a different region.

To **delete** a region, select the region and either press the "**Remove Region**" Button (Figure 38-4) or hit the "**delete**" Key on the keyboard.

In order to remove all regions press the "**Clear All**" Button (Figure 38-5).

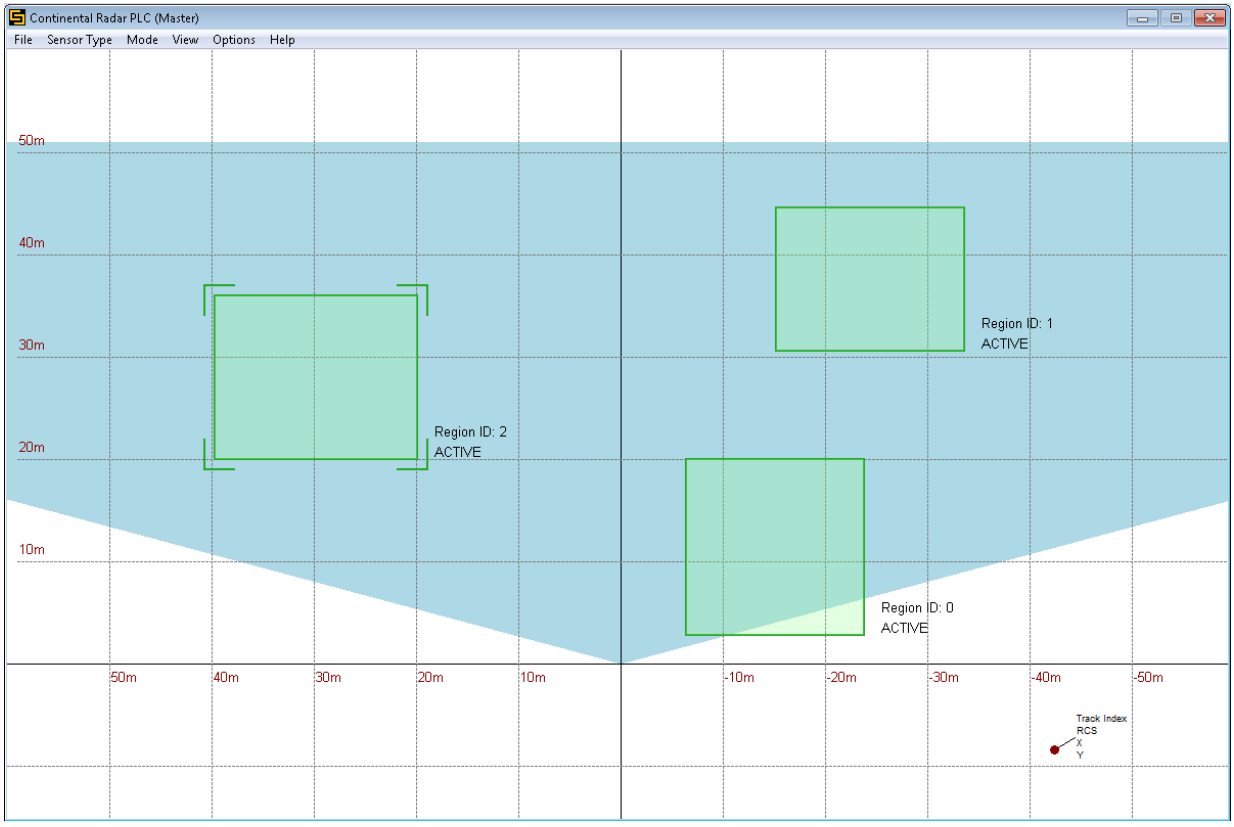


Figure 39: SRR Collision Detection on PLC defining warn regions

4.5.2 Region States

Depending on whether a collision warning is currently detected or not, warning regions feature different states represented by their color.

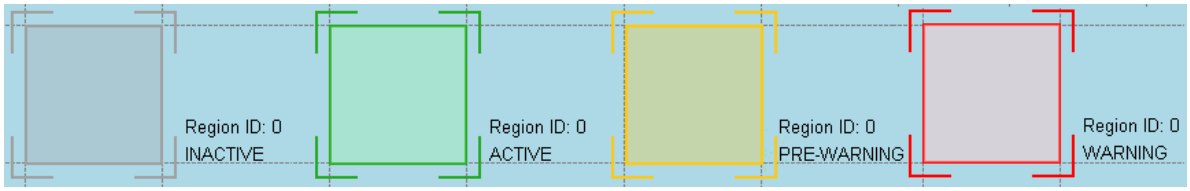


Figure 40: A regions different states

A deactivated region has the state **inactive** and will appear gray. It is visually displayed in the *Main Screen* but it is excluded from the collision detection function, hence it cannot raise a collision warning even though entities might be displayed in the area.

An **active** region is displayed green and will perform collision detection for all entities. It is able to raise a collision detection warning upon entity detection.

In order to prevent the regions state to rapidly flicker between warning and no warning in case a detected entity appears and disappears periodically the **pre-warning** state was implemented. It serves as a noise filter to validate a detected entity and ensure its being relevant rather than just background noise. This trigger-filter is performed by a moving average calculation and explained in section 4.5.4. A region in pre-warning state appears in a bright orange. If an entity or several entities are detected past the pre-warning state, a collision detection warning is being raised and the region changes to the warning state. This state stays active as long as entities are detected within the region. When no more entities are detected, the region will reset and its state changes back to active.

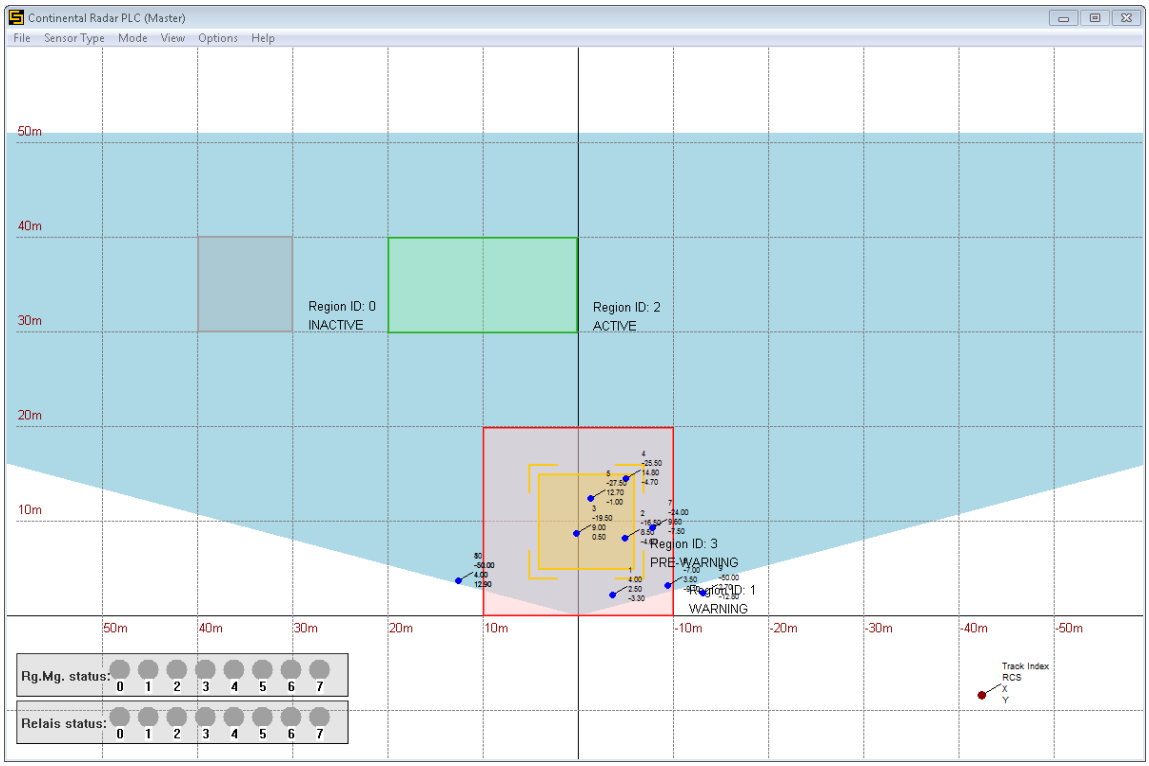


Figure 41: Different warning states during a collision detection measurement.

4.5.3 Region specific Filter

Just as the global filters (4.3.4) that operate on raw Track or Cluster data, each region offers a set of filters to refine the view on detected entities. This allows for regions to neglect certain Tracks or Cluster outside the scope of the application leaving only pre-selected entities to trigger warning messages.

The Filter can be activated by checking the "**Filter**" option (Figure 38-8) in the Collision Detection on PLC Window. A region with an activated filter is indicated by an "**F**" character in the upper right corner (Figure 44). Since Tracks and Cluster data come with different sets of parameters, the Filter Menu automatically adjusts to the respective display mode. Figure 42 and Figure 43 display the Filter Settings for Tracks and Cluster.

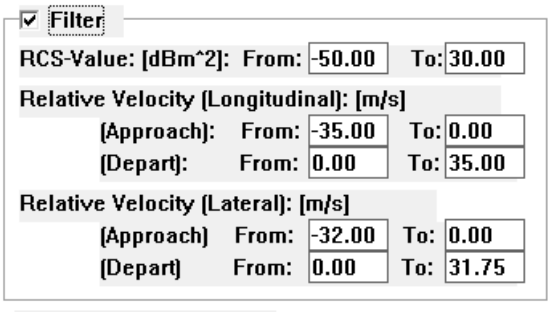


Figure 42: Region Filter for Tracks

Parameter	Description
Filter	Flag to activate or deactivate the region filter
RCS-Value	Radar Cross Section range to be displayed
Relative Velocity (Longitudinal)	Relative velocity range in longitudinal direction for Tracks to be displayed
Relative Velocity (Lateral)	Relative velocity range in lateral direction for Tracks to displayed

Table 14: Region Filter value description for Tracks

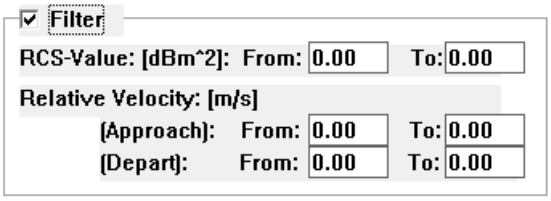


Figure 43: Region Filter for Cluster

Parameter	Description
Filter	Flag to activate or deactivate the region filter
RCS-Value	Radar Cross Section range to be displayed
Relative Velocity	Relative Velocity range for Cluster to be displayed

Table 15: Region Filter value description for Cluster

The default filter value range for each parameter reflects the sensors default value range. Edited filter values can easily be restored to the original sensor default value range by pressing the “**Default Filter Values**” Button.

A region’s set of filter values is reduced compared to the global filter since a regions position, width and height replace filter such as longitudinal or lateral displacement. The filter settings allow filtering all relevant information and only Cluster or Tracks within the range will pass. In contrast to the global filter, the region specific filter won’t remove filtered entities from the entity list but exclude them from the Collision Detection function. Excluded – or filtered – entities appear as small gray rectangles (Figure 44).

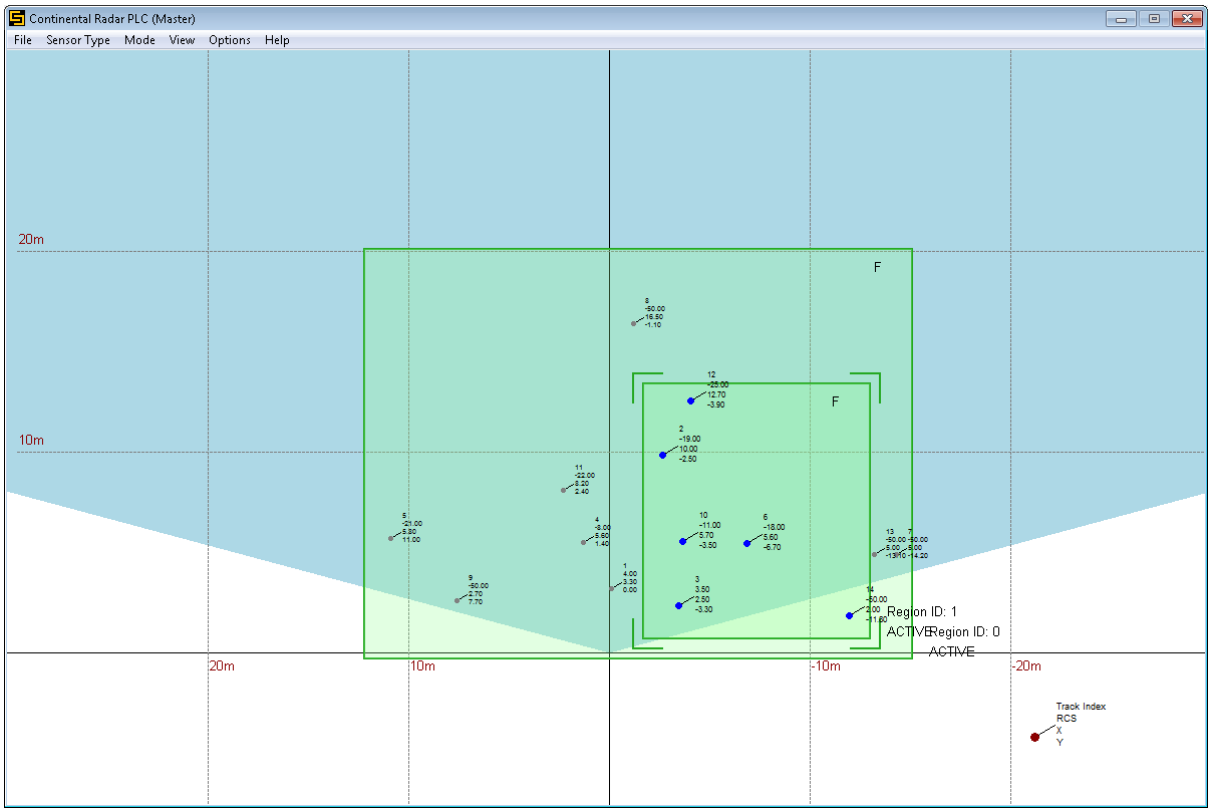
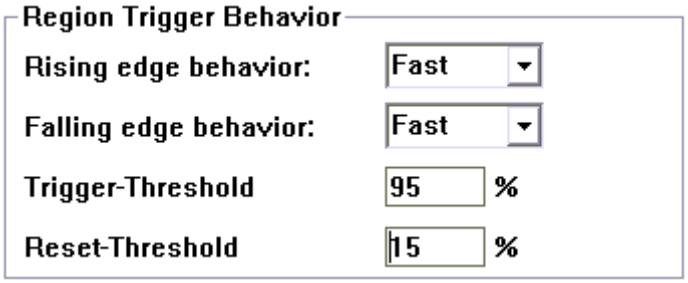


Figure 44: Active region filtering

4.5.4 Region trigger Behavior

Depending on environmental surroundings the radar sensor detects a lot of background noise due to multiple reflections on obstacles and surfaces. These reflections are usually not permanent and lead to flickering Tracks or Cluster that are visible only for a very short period of time before disappearing. With the pre-warning state between the active- and warning-state we introduced an intermediate state that serves as noise filter to prevent exactly those occasionally occurring entities to cause collision detection violations and thus constantly setting/resetting possibly connected relays. The noise filter is a moving average based on the entity detection within a region every radar processing cycle.

The region trigger behavior (Figure 38-9) determines the way a region changes from the pre-warning to the warning state granting the possibility to adjust the noise filters parameters. These parameters affect the rising- and falling-edge of the moving average which are the steepness of the curve and the trigger-thresholds. With the thresholds shall define a hysteresis.



Parameter	Description
Rising edge behavior	Steepness of the rising edge of the moving average curve (Fast, Medium,Slow)
Falling edge behavior	Steepness of the falling edge of the moving average curve (Fast, Medium,Slow)
Trigger-threshold	Trigger level in [%] at which the region will change from pre-warning to warning – Use this value for finetuning
Reset-threshold	Reset level in [%] at which the region will reset from warning to active – Use this value for finetuning

Table 16: Region trigger behavior configuration parameters

4.5.5 Region Manager

The Region Manager is used to manage warning regions created for the Collision Detection on PLC and can be found in *the Options\Region Manager Menu*.

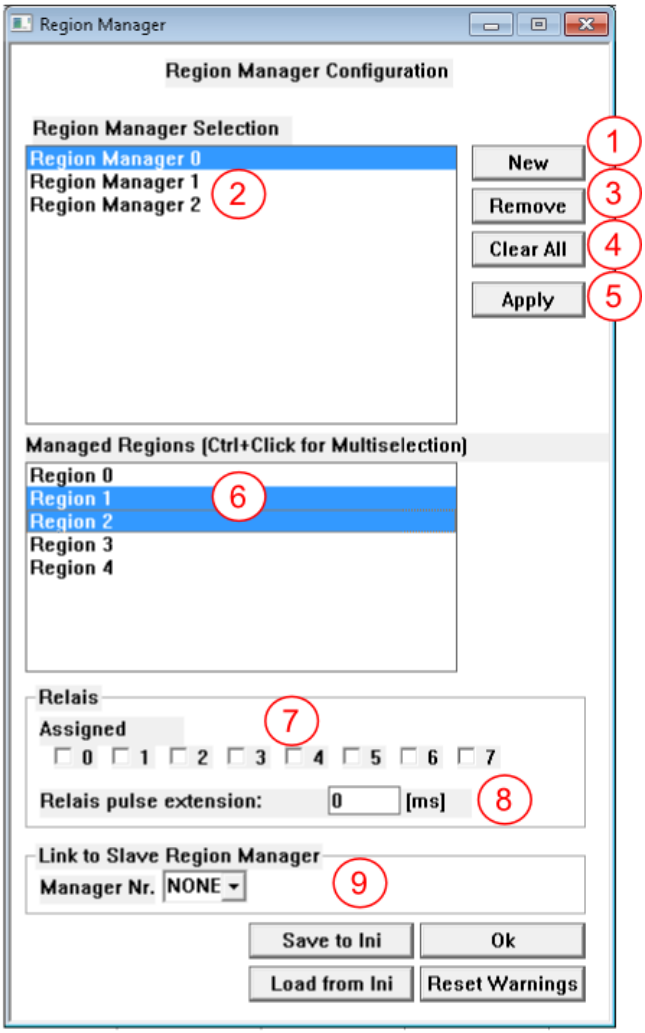


Figure 45: The Region Manager Window

With a Region Manager it is possible to link different Warning Regions together, directly connecting them with the internal warning state of the Region Manager itself. The Region Manager will trigger as soon as a Warning is raised by any one of its managed regions and will hold its warning state until none of his managed regions raises warnings anymore, hence linking them together. This way it is possible to observe irregular shaped areas or only several single spots for Collision Detection violations.

Furthermore it is possible to assign up to *8 Solid State output Relays* to the Region Manager that are set by the Manager once one of the monitored regions triggers a warning.

The Relays can be used to switch electronic devices (Warning lamps, signal horns…)

4.5.5.1 Creating a Region Manager

To **create** a new Region Manager, press the "**New**" Button (Figure 45-1). A new Region Manager will be added to the Region Manager Selection (Figure 45-2) at the next available index (0…8). Note that changes made to Region Manager Properties e.g. *Managed Regions*, *Link to Slave Region Manager* or *Relays* need to be applied to take effect (Figure 45-5). Unapplied changes will be lost upon selecting a different Region Manager. To delete a Region Manager, select the Manager from the Region Manager Selection and press the "**Remove**" Button (Figure 45-3).

In order to remove all Region Manager, press the "**Clear All**" Button (Figure 45-4).

4.5.5.2 Assigning Regions

It is possible to assign up to 24 regions to a Region Manager. After creating a new Region Manager the available regions will be displayed in the Managed Regions Section of the Region Manager Window (Figure 45-6). Regions created after opening the Region Manager Window require reopening the window in order to update the Managed Region List.

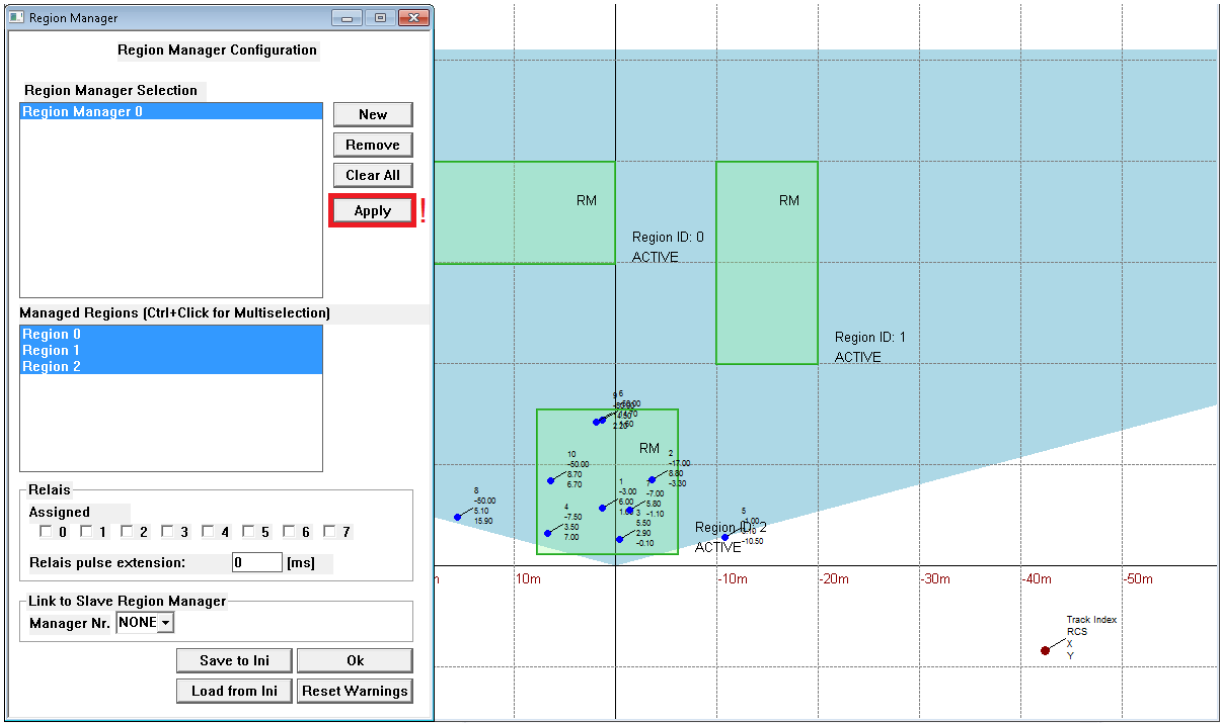


Figure 46: Assigning regions to a Region Manager

To assign a region, select the Region Manager from the Region Manager Selection and left-click on the Region you want to assign. For multi selection press the Ctrl-Key and left-click on the regions you want to assign. All regions assigned to any Region Manager are indicated an "**RM**" String in the upper right corner (Figure 46).

4.5.5.3 Region Manager Status and Relays assignment

It is possible to assign up to 8 Solid State Relays to a Region Manager, that is triggered if any one of the Managers regions raises a collision detection warning (red). To assign one or more Relays to a Region Manager simply select the checkbox of the respective Relay in the Region Manager Window (Figure 45-7). With activated Collision Detection Function the

current state of the Region Manager and Relays is displayed in the lower left Corner of the Main Screen (Figure 47).

Example:

In this example we create a Region Manager and assign 3 Regions to be managed. Furthermore we assign the Relays 0…3 to be triggered by the Manager upon entity detection. In Figure 47-1 you can see that neither the Region Manager nor the assigned relays are triggered as long as no Warning Messages are sent by any one of the managed regions. As soon as one of the managed regions raises a warning message, the Region Manager switches its state and triggers the assigned relays. This state will be active as long as a warning is active in any one of the assigned regions.

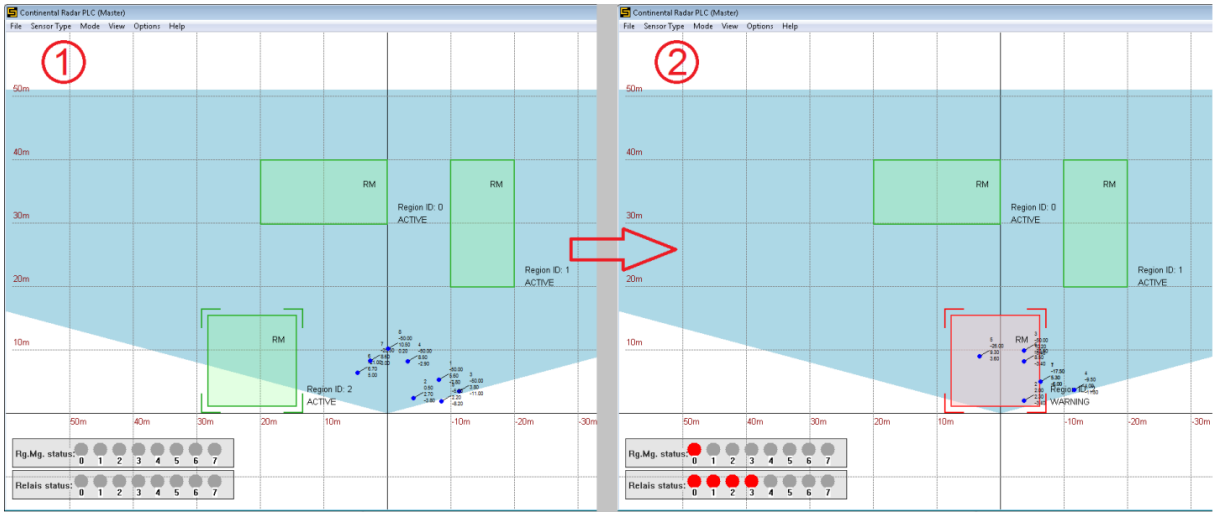


Figure 47: Interaction of Regions, Region Manager and Relays.

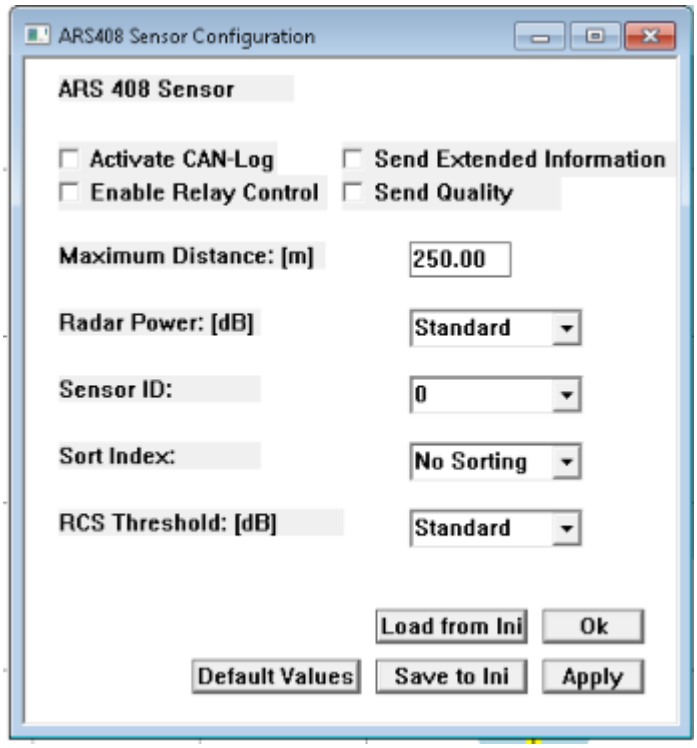
When no warnings are detected anymore the region will reset to the active state but the Region Manager and the assigned relays will stay triggered until the Relay Pulse Extension is expired. The Pulse Extension prolongs the reset and is adjustable by entering a time period in milliseconds [ms] (Figure 45-8).

4.6 ARS 408 Sensor (Long Range)

The ARS 408 Sensor is the successor of the ARS308 Sensor. This sensor is from the communication and features equal to the ARS 308. This chapter describes the additional features and differences of the ARS 408 Sensor in the PLC software.

4.6.1 Sensor Configuration

Basic Sensor properties can be adjusted in the "**Sensor Configuration"** Window. To open it, select Options/ Sensor Configuration.



4.6.1.1 CAN-Bus Log

In the "**Sensor Configuration**" window you can activate a CAN-Log which will record every CAN-Message sent by the sensor.

The logging file *"CAN_DATA.asc"* is stored at the location shown at *"Logging Path"*. This is the **default Logfile location**. If you want to adjust the Logging Path, you can do so by changing the *"logPath"* parameter in the *"program.ini"* file in the program folder *"C:\Continental Radar-PLC\program.ini"*.

Note: When changing the default Logfile location, it is **mandatory** to enter a **valid path-string** e.g. *c:\data\CAN_DATA.asc* without any apostrophes or quotation marks. In general it might be helpful to create backup copies of all **.ini* files before changing parameter values.

4.6.1.2 Send Extended Information

This Entry can activate “Extended Object Data”(See ARS 408 manual), which is transmitted from the ARS 408 on the CAN Bus. It delivers the Length and Width of the detected objects. Users that are interested in theses parameters should activate this function.

4.6.1.3 Enable Relay Control

The ARS 408 internal Collision detection supports one Wilke CAN Modul box with 4 Channels. If this option is activated, the first 4 collision detection Regions are triggering the Relais 1-4 on the Wilke Modul. If the ARS 408 internal Collision detection and the Wilke CAN outputs are activated, an autonomous Collision Detection without Radar PLC can be done.

The Module has to be terminated on the CAN BUS on both Ends with a 120 Ohm resistor.

Figure 48 CAN-Bus I/O Module: 4 digital Outputs (Article Code DV-CANFRAS4-01)

To use this module it has to be configured to 500kBit/s. The module address has to be configured to 0x8 (Upper switch:0, bottom switch:1).

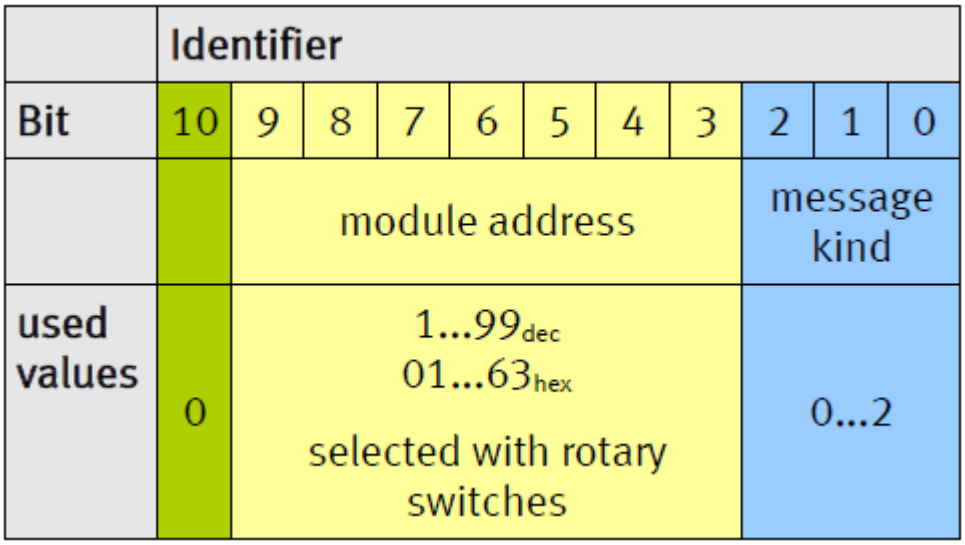


Figure 49 Wilke CAN Module configuration

4.6.1.4 Send Quality

If this feature is activated, quality information shall be sent for Clusters or Objects (See ARS 408 Documentation).These information and only be found in the ARS 408 CAN Bus messages. They are not displayed by the Radar PLC

4.6.1.5 Maximum Distance

Configuaration of the Maximum distance of far scan (near scan maximum distance is set proportionally). The parameter can be set from 196m to 260m (See ARS 408 Documentation).

4.6.1.6 Radar Power

Radar output power. This menu allows to change the Radar Output Power(See ARS 408 Documentation).

4.6.1.7 Sensor ID Configuration

The **Sensor ID Configuration** allows changing the ID between 0 and 7 for the connected sensor. The Sensor ID also determines the address space of CAN communication messages according to (base message ID | (0x10 * sensor ID)).

The **Current Sensor ID** option shows the currently used Sensor ID. The **Set Sensor ID** option allows changing the Sensor ID. Therefore a value between 0 and 7 can be selected

from the drop-down menu. Confirming the new value by pressing the **Set-Button** will write the new configuration to the Radar-Sensor.

4.6.1.8 Sort Index

Allows do define the sorting order of the Object. If range is selected, the sensor delivers the nearest objects first. If RCS is selected, the sensor sends out the object with the strongest Radar echo at first.

4.6.1.9 RCS Threshold

This Entry activates the sensors high sensitive mode. It can help to detect small objects.

4.6.2 Filter Configuration

The ARS 408 Sensor is able to filter out application relevant Objects/Clusters. The relevant Objects can be used together with the sensor internal collision detection.

4.6.2.1 Object filter

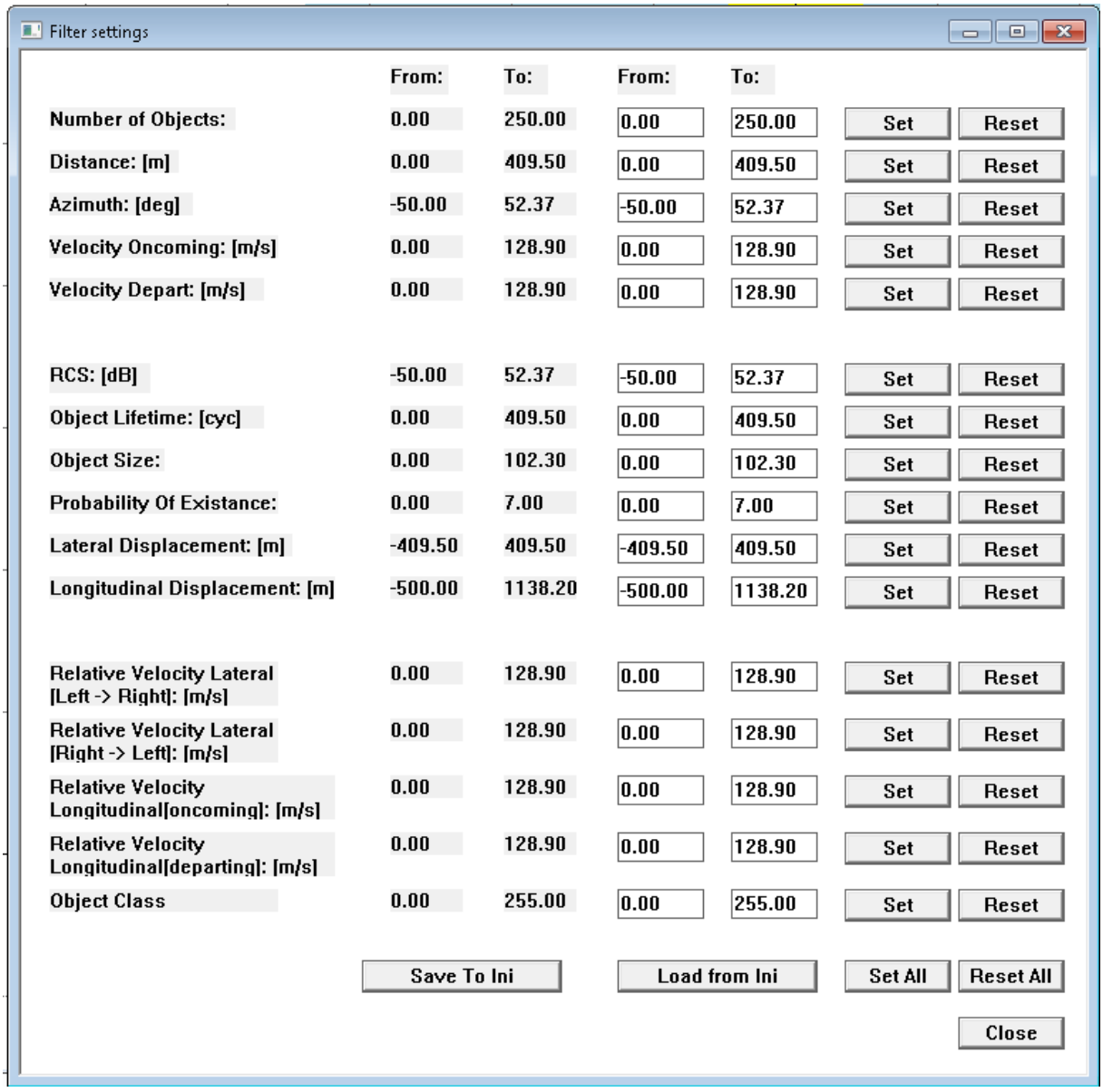


Figure 50 Object filter configuration

The following option can be used to filter out application relevant clusters. A combination of several of these filters can be activated also.

4.6.2.1.1 Number of Objects

This filter can be used that the sensor only delivers a defined maximum amount of Objects. For example:

When the Maximum Value is set to 2 and the sensors sorting order is configured to distance the nearest 2 Objects are filtered out.

4.6.2.1.2 Distance

An Object detection operation range can be defined.

4.6.2.1.1 Azimuth

A view range between to angles can be defined

4.6.2.1.2 Radial Velocity

With this filter, objects within a speed range can be filtered out

For example:

If only moving objects should be filtered out, the following configuration will do the job:

Velocity Oncoming: 0.3m/s to 128.9m/s

Velocity Departing: 0.3m/s to 128.9m/s

4.6.2.1.3 RCS

With this filter is possible to see only strong Object or from Objects with weak radar refection.

4.6.2.1.4 Object Lifetime

When an Object is captured by the sensor internal tacking, the Lifetime is measured. With this filter it is possible separate new (or sporadic) from solid Objects.

4.6.2.1.5 Object Size

Filter for the object size in m^2

4.6.2.1.6 Probability of Existence

This sensor internal tracking algorithm is capable of estimating the **probabilities** of Object **existence** while tracking them. This estimation is given in a range from 0 to 7, where 7 hast the highest probability of existence

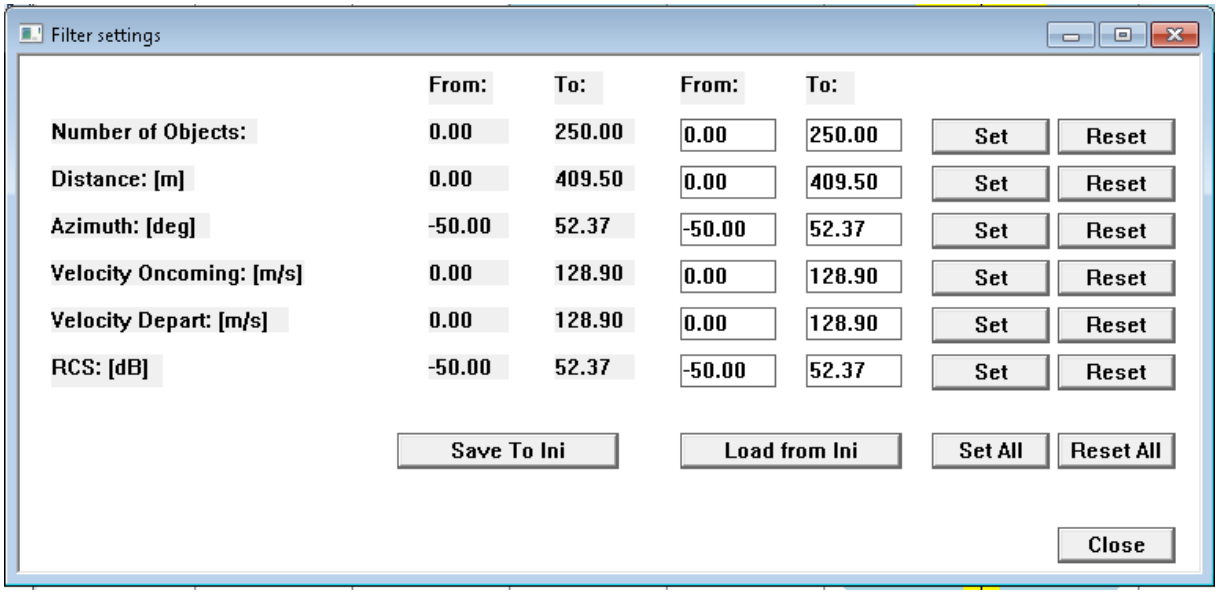
4.6.2.1.1 Lateral/Longitudinal displacement

This filters can be set, when a certain supervision area shall be defined.

4.6.2.1.1 Relative Velocity

With this filter, objects within a speed range in for different directions can be filtered out

4.6.2.2 Cluster Filter



4.6.2.2.1 Number of Cluster

This filter can be used that the sensor only delivers a defined maximum amount of Clusters

4.6.2.2.2 Radial Distance

A Target detection operation range can be defined.

4.6.2.2.3 Azimuth

A view range between to angles can be defined

4.6.2.2.4 Radial Velocity

With this filter, objects within a speed range can be filtered out

For example:

If only moving objects should be filtered out, the following configuration will do the job:

Velocity Oncoming: 0.3m/s to 128.9m/s

Velocity Departing: 0.3m/s to 128.9m/s

4.6.2.2.5 RCS

With this filter is possible to see only strong Object or from Objects with weak radar refection.

5 Support of a second Radar Sensor

It is possible to connect a second Radar Sensor to the PLC. That allows to compare different radar sensors for one application or expands the

The second sensor has to be connected to the right hand side CAN interface on the Radar PLC. That has to be done before booting up the radar PLC. Two sensors can work together in collision detection. In this scenario the Continental Radar PLC software runs in two instances, one in MASTER and one in SUB-UNIT configuration.

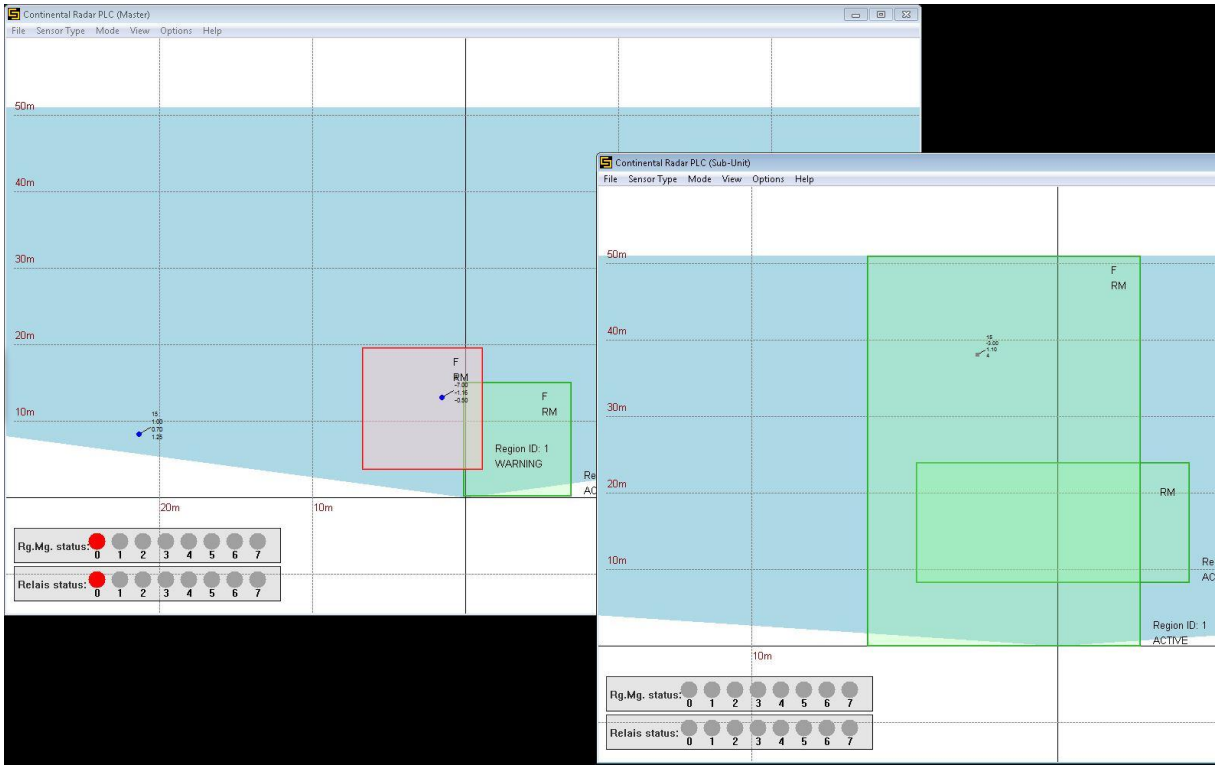


Figure 51: Exemplary setup of a master-sub-unit system. Each Radar-PLC visualization covers one of the connected sensors.

By using the “Link to Sub-Unit Region Manager” Option in the Region Manager Window it is possible to create a logical AND connection between a Sub-Unit and Master-Unit Region Manager. This adds the Sub-Unit Region Manager state as a condition to the Master-Units Region Manager trigger behavior. Only when the Sub-Units Region Manager signals a Warning, the Master Region Manager is able to trigger the connected relays.

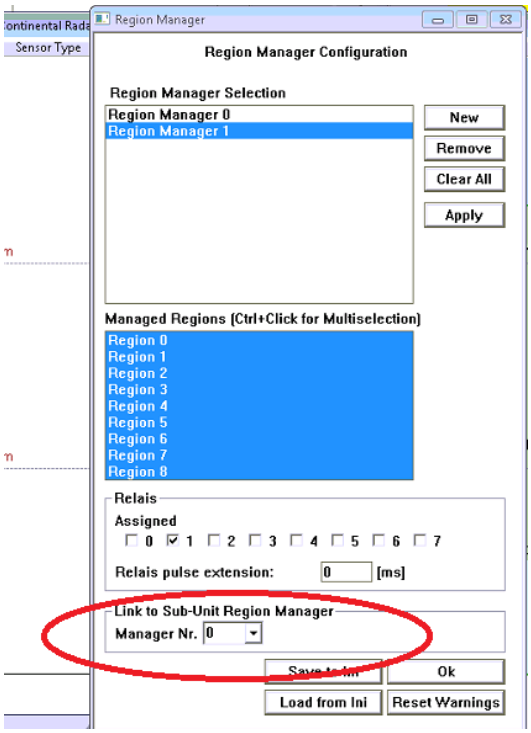


Figure 52 Add sub-unit manager to master region manager

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6 Tools

6.1 Remote Desktop

When the Radar PLC is connected over an Ethernet cable to another computer it is possible to access the Radar PLC over Remote Desktop. The Remote Desktop connection needs the Ethernet Port, which is configured with a fix IP Address – X001.

IP – Address:
169.254.167.240

Password:
Arcus

7 Appendix

7.1 Power Supply AC/DC

For the Power supply with 100-240 VC AC it is possible to use the PULS ML 30.106 power supply. It delivers 24V DC for the Radar PLC and 12V or 24V for the Radar Sensor. For further information about the Sensor voltage and power consumption please see the respective sensor data sheet.

Figure 53: PULS ML 30.106 power supply

7.2 Power Supply DC/DC

RS 50W Single Output 12V DC/DC voltage converter – Output 24V DC

Figure 54: 12/24V DC/DC voltage converter

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