Delphi ESR Startup Guide

Version: 2.1
20 October 2015

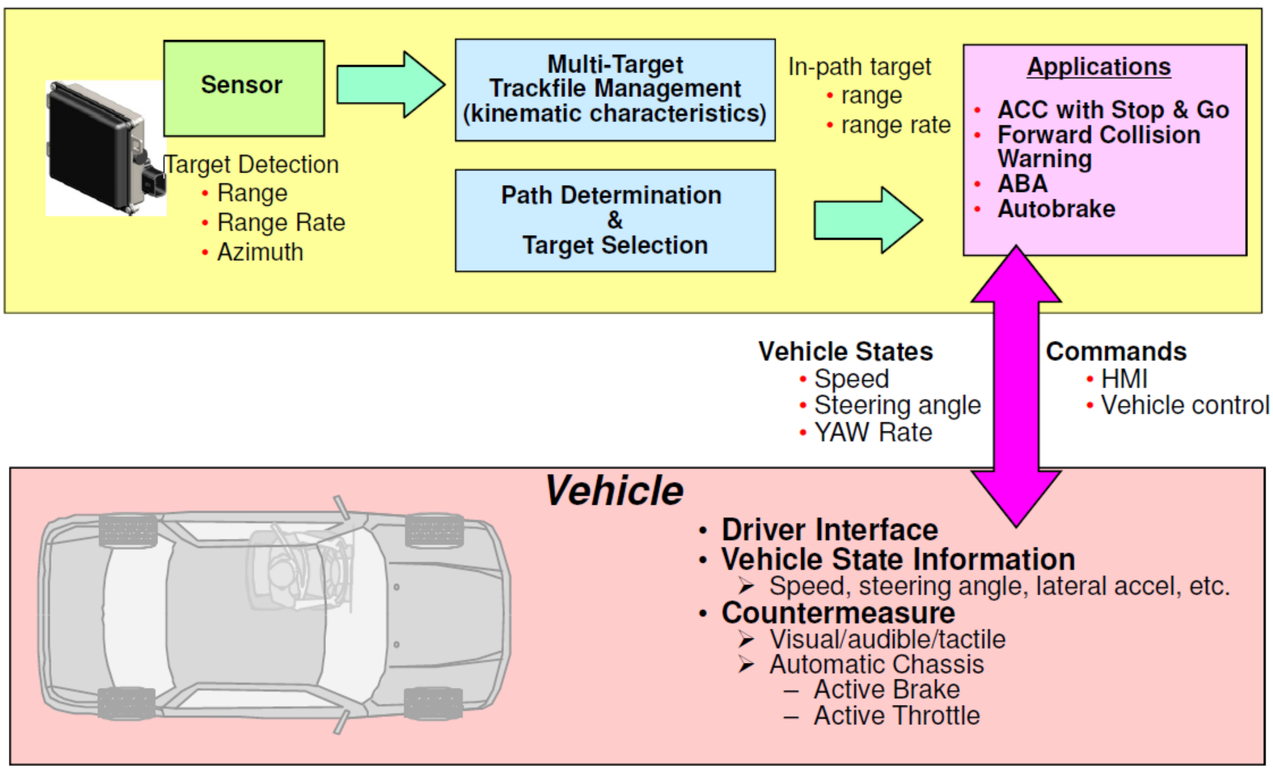
Table of Contents

1 Overview

Delphi's multimode ESR combines a wide field of view at mid-range with long-range coverage to provide two measurement modes simultaneously. While earlier forward looking radar systems used multiple beam radars with mechanical scanning or several fixed, overlapping beams to attain the view required for systems like adaptive cruise control, Delphi's multimode ESR provides wide coverage at mid-range and high-resolution long-range coverage using a single radar. Based on Simultaneous Transmit and Receive Pulse Doppler (STAR PD) Waveform technology, the ESR provides independent measurements of range and range-rate and superior detection of clustered stationary objects. Wide, mid-range coverage not only allows vehicles cutting in from adjacent lanes to be detected but also identifies vehicles and pedestrians across the width of the equipped vehicle. Long-range coverage provides accurate range and speed data with powerful object discrimination that can identify up to 64 targets in the vehicle's path.

Delphi's technologically advanced ESR uses proven solid state technology plus class-leading performance, packaging and durability to offer customers game-changing forward radar detection. The quality of data provided by Delphi's system enables powerful functionality including adaptive cruise control, forward collision warning, brake support and headway alert.

1.1 System I/0 and Interfaces



1.2 ESR Versions

1.2.1 Delphi ESR Firmware Version: 9.21.21 (formerly 9.21.00) - Standard

- Multi-mode, multi-application capability
- Simultaneous long- and mid-range functionality
- Solid-state Technology, no moving parts
- Extremely reliable Class-leading performance and durability
- Resistant to vibration and extremely robust
- Dual-mode classification enhances object reliability
- Simultaneous Transmit and Receive Pulse Doppler
- Compact packaging
- Complete radar module, including electronics, measures just 173.7 x 90.2 x 49.2 millimeters including mounting features
- Produced using processes proven in high-volume manufacture of engine control units

1.2.2 Delphi ESR Firmware Version: 9.21.15

With the same exact hardware/interface as the standard Delphi ESR the Delphi ESR V9.21.15 is a special DSP software which disables the Radar Tracker Grouping (grouping of detections into tracks), merging (combining of closely-spaced tracks into single track) and Filtering (range/range rate/angle filtering to smooth data).
This version tracks data that is output on the Private CAN bus that would come from individual detections providing lower level "raw" information than with the standard 9.21.00 ESR.

1.2.3 Delphi ESR 2.5

The Delphi ESR 2.5 has the special DSP software, which disables the Radar Tracker Grouping (grouping of detections into tracks), Merging (combining of closely-spaced tracks into single track) and Filtering (range/range rate/angle filtering to provide some smoothness in the data). The ESR 2.5 firmware version offers a much lower detection threshold and improved detection algorithm than previously offered with the past ESR. The interface specifications and mounting configuration are exactly the same as the current ESR radars helping to make the transition much easier.

- Multi-mode, multi-application capability
- Simultaneous long- and mid-range functionality
- Solid-state Technology, no moving parts
- Extremely reliable Class-leading performance and durability
- Vibration Resistant
- Dual-mode classification enhances object reliability
- Simultaneous Transmit and Receive Pulse Doppler
- Complete radar module, including electronics, measures just 178.3 x 91.3 x 40.8 millimeters including mounting features

1.2.4 Delphi ESR 2.5 24VDC with Integrated 3-Axis Accelerometer

- 24VDC for Commercial Applications
- Integrated 3-Axes Accelerometer
- Multi-mode, multi-application capability
- Simultaneous long- and mid-range functionality
- Solid-state Technology, no moving parts
- Extremely reliable Class-leading performance and durability
- Resistant to vibration and extremely robust
- Dual-mode classification enhances object reliability
- Simultaneous Transmit and Receive Pulse Doppler
- Compact packaging
- Complete radar module, including electronics, measures just 173.7 x 90.2 x 49.2 millimeters including mounting features
- Produced using processes proven in high-volume manufacture of engine control units
- Deleted range information

2 Radar Performance Specifications

Parameter	ESR Long-Range Requirement	ESR Mid-Range Requirement
Minimum Range	< 1m (> 10dB target) < 1m (> 0dB target)	< 1m (> 10dB target) < 1m (> 0dB target)
Maximum Range	> 175m (> 10dB target) > 100m (> 0dB target)	> 60m (> 10dB target) > 50m (> 0dB target)
Range Accuracy	< +/-0.5m noise component with +/- 5% bias component	< +/-0.25m noise component with +/- 5% bias component
Range Discrimination for two targets at same angle & range rate	< 2.5m	< 1.25m
Minimum Range Rate	< -100m/s	
Maximum Range Rate	> +40m/s	
Range Rate Accuracy	< +/- 0.12m/s	
Range Rate Discrimination for two targets at same range & angle	< 0.5 m/s	
Acceleration	Acceleration to be generated as an output of the Tracker	
Minimum Lateral Relative Velocity	< -20 m/s	
Maximum Lateral Relative Velocity	> +20m/s	
Lateral Relative Velocity Accuracy	Lateral velocity is derived in the tracker based on change in measured angle vs. time. Accuracy in m/sec is a function of range.	
Azimuth Field of View	> 20deg	> 90deg
Azimuth Angle Centroid Accuracy	< +/- 0.3deg (corner reflector targets) < +/- 0.5deg (other targets)	< +/- 1.0deg
Azimuth Angle Resolution of two targets at same range & range rate	< 3.5 deg	< 12 deg
Vertical Field of View	4.2deg – 4.75deg	
Minimum Amplitude	< -10dB	
Maximum Amplitude	> 40dB	
Minimum Update Interval	>= 20Hz	
Minimum Target Tracking	64 fused targets total	
Response Time	Track confirmation within 150ms for an object entering detection zone Track drop within 250ms after an object leaves detection zone In-path classification of previously detected target that enters path of host vehicle within 100ms	
Movement Classification	Moving (including the sub-classifications of Oncoming and Crossing) Stationary and never moving Stationary and previously moving	
Bridge Classification	The probability of rejecting overhead bridges (by correct classification as a bridge) shall be 95% at 80m range increasing to 100% at 45m range. Minimum bridge height assumed to be 3.65m	
Blockage Detection	Blockage shall be detected if the maximum detection range of the sensor is less than 45m. Blockage detection time shall be < 20s for severe to complete blockage	
Splash Target Rejection	Rejects detections from heavy water spray directly behind or in adjacent lanes to confirmed target	
Target Grouping	Combines multiple detections from the same object into a single object track	
Lane Change Detection	Detects lead/host vehicle lane change from a lane once the lead/host vehicle completely exits that lane	
Automatic Azimuth Alignment	Automatically adjust azimuth alignment to keep ESR alignment within +/-0.3deg of vehicle centerline	
EMC False Target Rejection	The specified EMC environment shall not generate false targets.	

2.1 ESR 2.5 24V Voltage Specs

Maximum Operational Voltage (Umax.op)	32.0 ± 0.2V (as measured at the module with no ground offset)
Nominal Operational Voltage (Unom.op)	28.0 ± 0.2V (as measured at the module with no ground offset)
Minimum Operational Voltage (Umin.op)	22.0 ± 0.2V (as measured at the module with no ground offset)
Low (Communication Only) Voltage (Umin.comm)	16.0 ± 0.2V (as measured at the module with no ground offset)

2.2 Number of Radars per CAN channel

The ESR radars are limited to **one** radar per CAN channel. You cannot connect multiple ESR radars. The reason this is the radars would have the same hex IDs for sensor status and tracking information. There would be a conflict by putting multiple ESR radars on the same CAN channel. Please contact your AutonomouStuff representative for more information on using multiple Radars on one vehicle.

2.3 Vehicle CAN meassages the radar must have

- Vehicle Velocity
- Vehicle Yaw Rate

2.4 IP Addresses

ESR 2.5 12 Volt – Can be found on DV software.

ESR 2.5 24 Volt – Multiple IP address are available by special request from the factory.

3 Getting Started

Setup Conditions for ESR v9.21.00, v9.21.15, v9.21.21

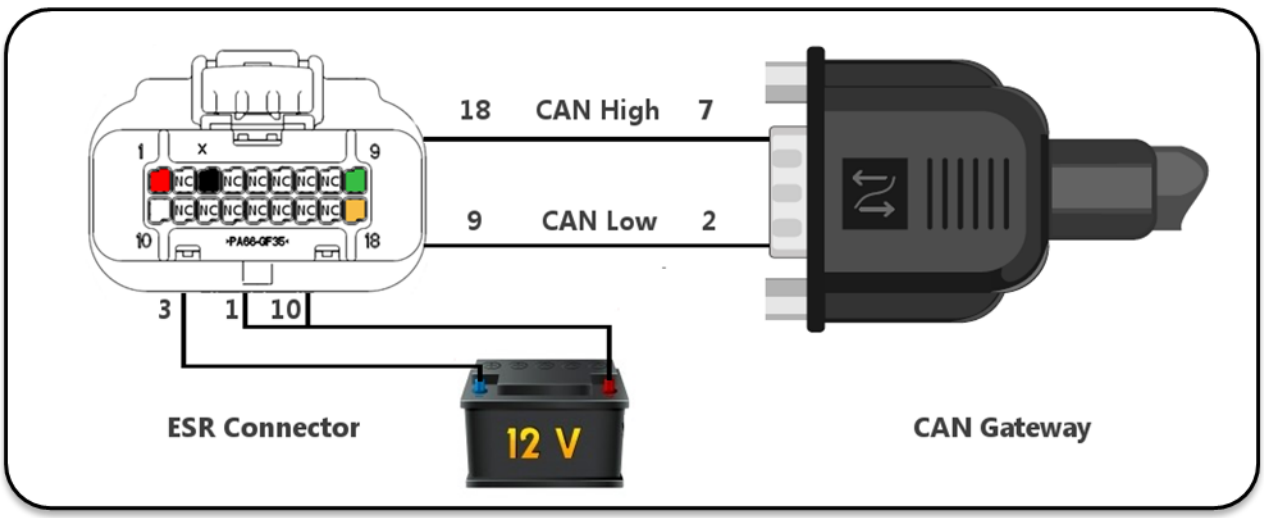
(24VDC ESR Setup Conditions found on page 22)
(ESR 2.5 found on page 13)

3.1 Setup Conditions (ESR)

3.1.1 Installation Wiring

1. Provide 12V to Pin 1 (Battery) and Pin 10 (Ignition). If using the AUT-CBL-ESR-2M or AUT-CBL-ESR-5M cable Pin 1 (Battery) is the red wire and Pin 10 (Ignition) is the white wire.
2. Connect Pin 3 (CAN Ground) the black wire on the AUT-CBL-ESR to ground.

Pin #	Delphi Pin Usage	AUT-CBL-ESR
1	Battery	Red
3	CAN Ground	Black
9	PCANL (Private CAN)	Green
10	Ignition	White
18	PCANH (Private CAN)	Orange



3.1.2 Kvaser Leaf Light v2

3. Install the driver before attaching your Kvaser hardware to the PC
4. Run the driver installation CD included with your Kvaser product and follow the on-screen instructions.
5. Plug in your Kvaser hardware. Part # (KVS-LL-V2-00685-0)
6. The Found New Hardware Wizard will detect and complete driver installation.
7. Confirm hardware installation by opening the Control Panel applet "Kvaser Hardware" and checking that your hardware is listed in the device tab. On the Device tab, select a channel of your device to check the hardware's firmware version to determine if an update is available.

3.1.3 Kvaser CanKing

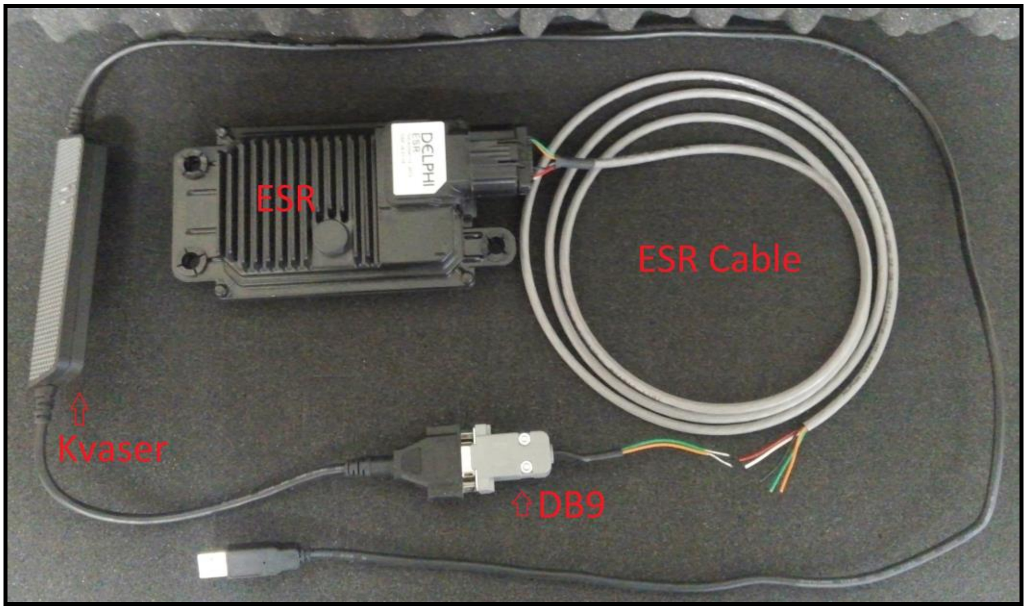
1. Run the CanKing installation CD included with your Kvaser product and follow the on-screen instructions.

3.1.4 Delphi DataView (DV)

1. Unzip the latest version of DataView (DV_esr). (Located in the Customer Folder on the USB supplied with the ESR)
2. Launch DV from sub-directory ESRTools/bin/DV_esr.exe

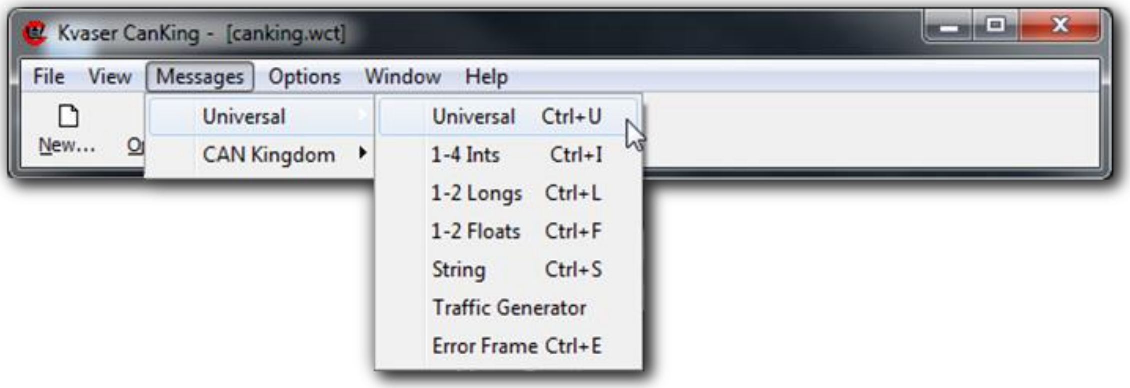
3.1.5 Connecting ESR to Computer for DataView

1. Connect ESR Cable (AUT-CBL-ESR) to ESR
2. Connect the green wire (CAN Low) to pin 2 of a DB9 connector.
3. Connect the orange wire (CAN High) to pin 7 of a DB9 connector.
4. Wire a 120 Ohm resister across CAN Low (pin 2) to CAN High (pin 7)
5. Supply 12v to the red and white wires of the ESR Cable (AUT-CBL-ESR).
6. Connect the black wire to GND.
7. Plug the DB9 connector into the Kvaser LeafLight v2.
8. Plug the Kvaser LeafLight v2 into the USB of a Windows 7 or older Computer.

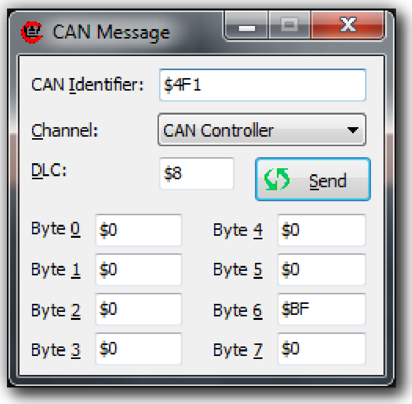


3.1.6 Establish ESR Communications

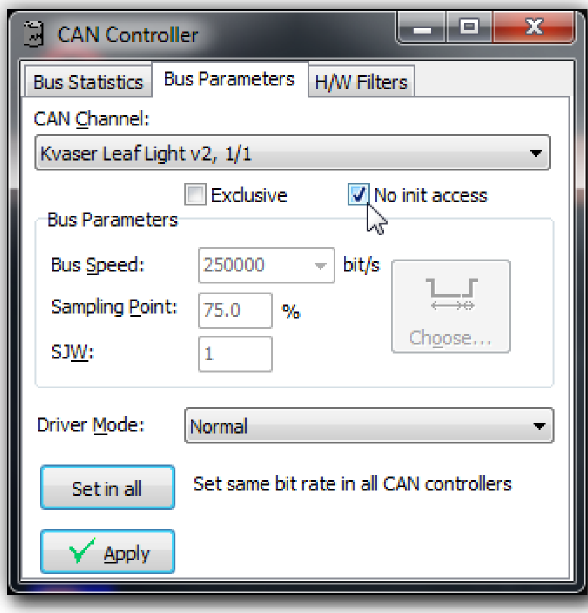
1. Start Kvaser CanKing.
2. Press Ok, I know what I'm doing
3. Create a new project using a template. Press OK
4. Select CAN Kingdom Basic template and press OK
5. OK the Tip of the Day.
6. Within the Kvaser CanKing main window, select Messages, Universal, Universal. Alternatively Ctrl+U



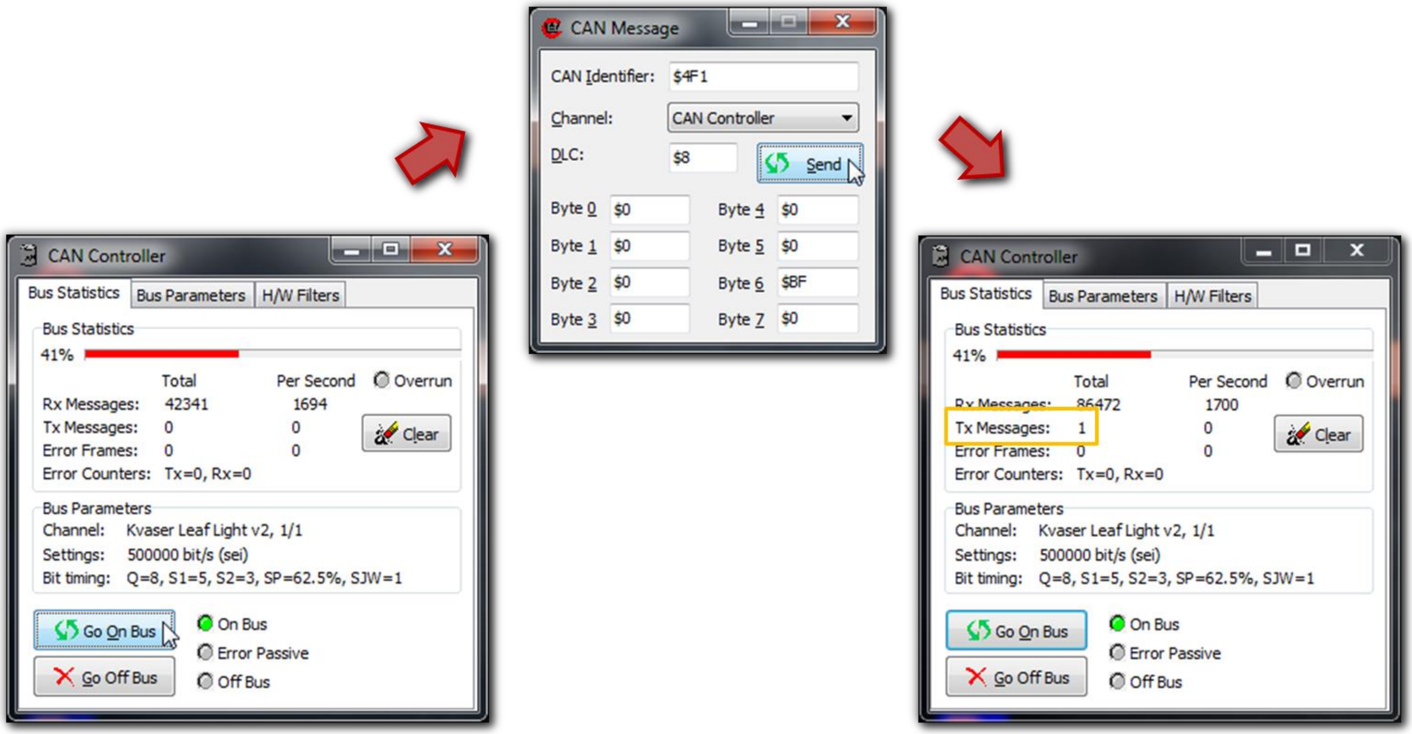
7. Prepare the RADIATE message in the CAN Message window as shown below. No need to press Send at this moment.
   - CAN ID: 4F1
   - DLC: 8
   - Byte 6: BF



8. In CAN Controller window under Bus Parameters check No init access



9. In CAN Controller Window under <u>Bus Statistics</u> press <u>Go On Bus</u>. You should begin receiving traffic.
10. <u>Send</u> RADIATE message.



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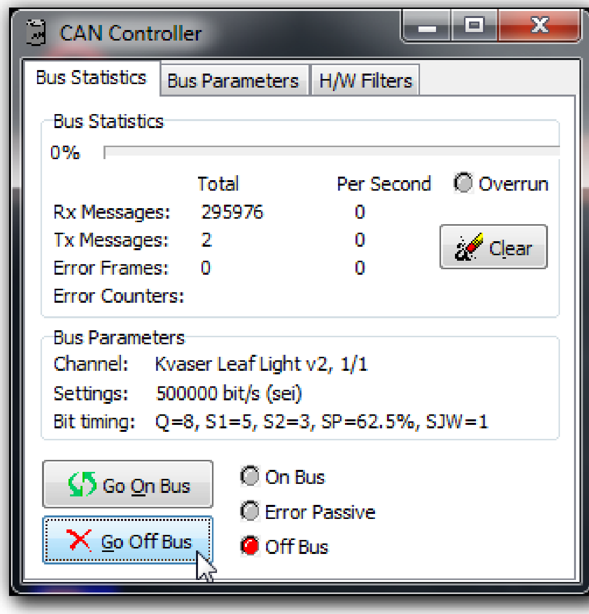
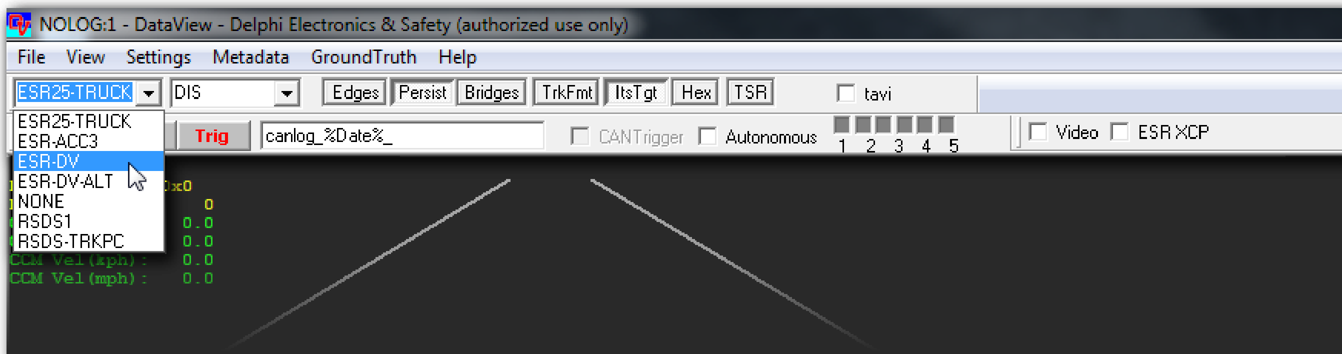
Users need send the RADIATE command only once per power cycle, not continuously. Radiate status may be confirmed by checking the ESR's current draw - it is < 200mA without radiating and over 500mA while radiating. There is an option to have the ESR auto-radiate on power up Please ask AutonomouStuff for details.

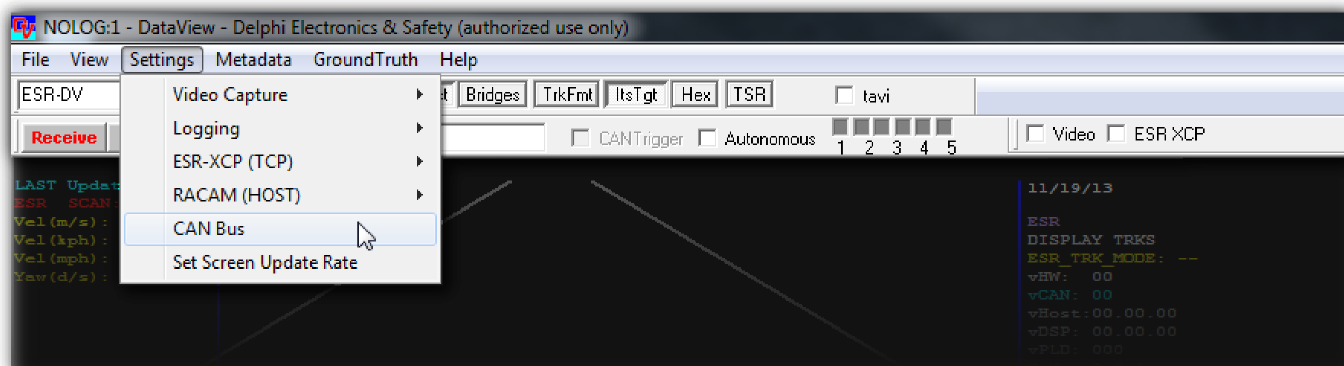
11. Press Go Off Buss to ensure DV tool functions properly.



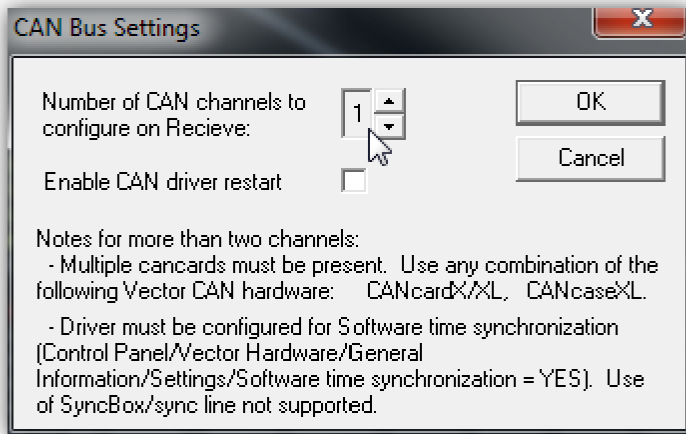
12. Start DV_esr from sub-directory ESRTools/bin/DV_esr.exe
13. Press ESR-DV from drop down list.



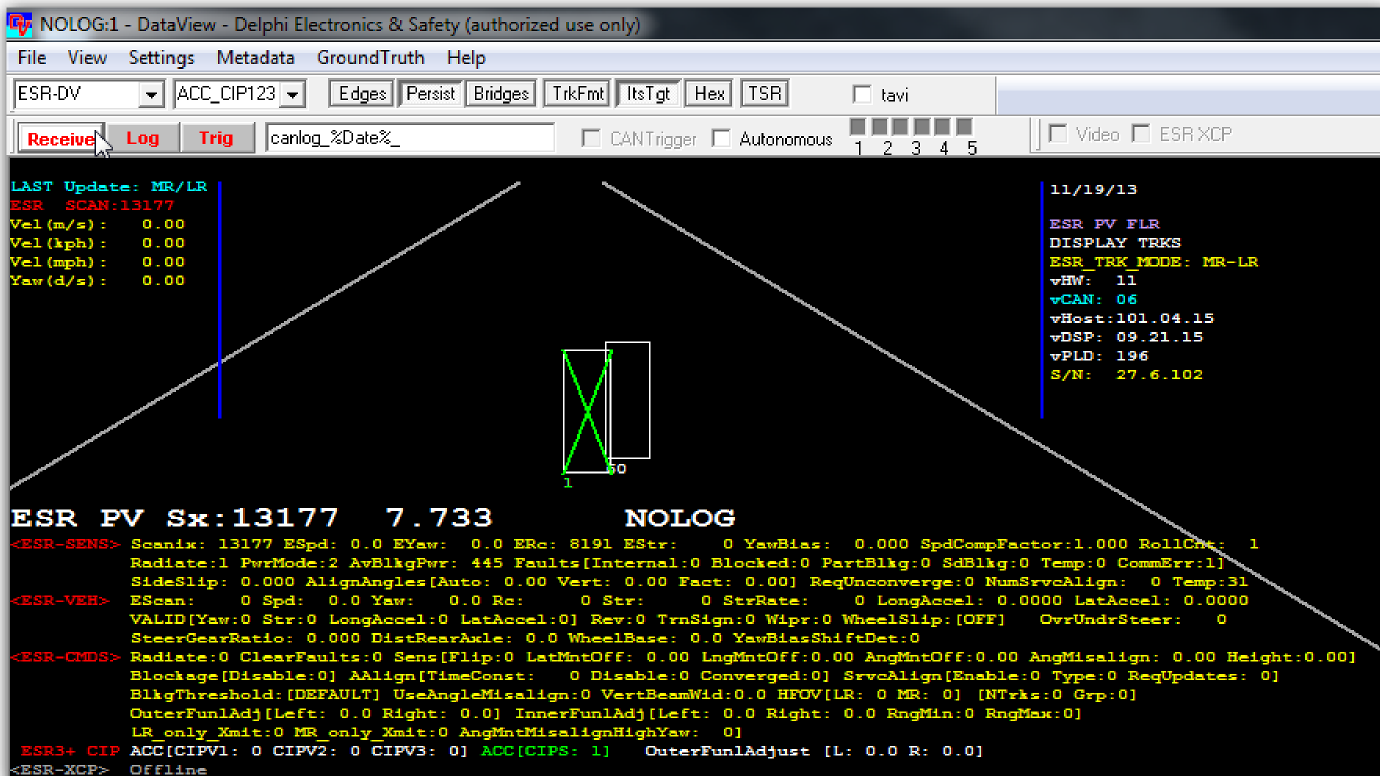
14. Under Settings, select CAN Bus



15. Configure the CAN Bus Settings to receive on 1 CAN channel.



16. Press <u>Receive</u>. You should begin receiving traffic and see animated ranging boxes.



Setup Conditions for ESR 2.5

(ESR v9.21.00, v9.21.15, v9.21.21 Setup Conditions found on page 5)
(24VDC ESR Setup Conditions found on page 22)

3.2 Setup Conditions (ESR 2.5)

3.2.1 Installation Wiring

	Pinout	Color
2	USB_VBUS	RED (USB)
4	GND	BLACK
9	Private CANL	GREEN
10	IGN 12VDC	WHITE
11	USB_DP	GREEN (USB)
12	USB_DM	WHITE (USB)
13	USB_GND	BLACK (USB)
18	Private CANH	ORANGE

ESR 2.5 Cable Part # AUT-CBL-ESR2.5-xxM

For this model a USB to Ethernet adapter is necessary. Below is an image of a tested interface that will work with this unit.

USB 2.0 Ethernet Adapter

3.2.2 Kvaser Leaf Light v2

1. Install the driver before attaching your Kvaser hardware to the PC
2. Run the driver installation CD included with your Kvaser product and follow the on-screen instructions.
3. Plug in your Kvaser hardware. Part # (KVS-LL-V2-00685-0)
4. The Found New Hardware Wizard will detect and complete driver installation.
5. Confirm hardware installation by opening the Control Panel applet “Kvaser Hardware” and checking that your hardware is listed in the device tab. On the Device tab, select a channel of your device to check the hardware’s firmware version to determine if an update is available.

3.2.3 Kvaser CanKing

1. Run the CanKing installation CD included with your Kvaser product and follow the on-screen instructions.

3.2.4 Delphi DataView (DV)

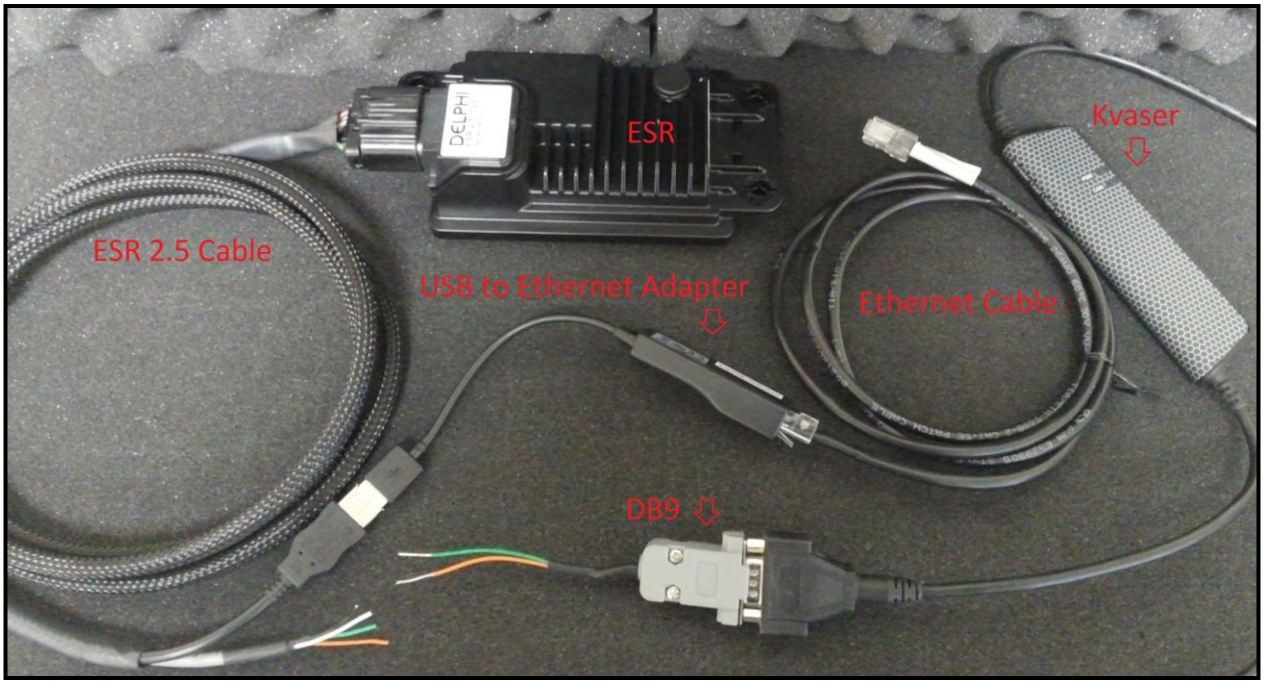
1. Unzip the latest version of DataView (DV_esr). (Located in the Customer Folder on the USB supplied with the ESR)
2. Launch DV from sub-directory ESRTools/bin/DV_esr.exe

3.2.5 Connecting ESR 2.5 to Computer for DataView (CAN)

1. Connect ESR 2.5 Cable (AUT-CBL-ESR-2.5) to ESR
2. Connect the green wire (CAN Low) to pin 2 of a DB9 connector.
3. Connect the orange wire (CAN High) to pin 7 of a DB9 connector.
4. Wire a 120 Ohm resister across CAN Low (pin 2) to CAN High (pin 7)
5. Supply 12v to the red and white wires of the ESR 2.5 Cable (AUT-CBL-ESR-2.5).
6. Connect the black wire to GND.
7. Plug the DB9 connector into the Kvaser LeafLight v2.
8. Plug the Kvaser LeafLight v2 into the USB of a Windows 7 or older Computer.

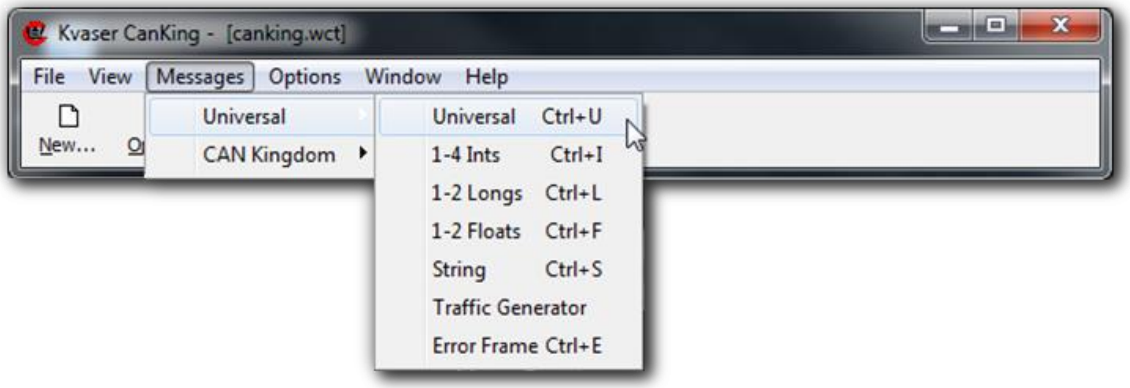
3.2.6 Connecting ESR 2.5 to Computer for DataView (Ethernet)

9. Plug USB to Ethernet adaptor into your computer.
10. Once driver has been installed on computer unplug adapter
11. Plug adapter into the ESR 2.5 Cable (AUT-CBL-ESR-2.5).
12. Plug Ethernet Cable into adapter
13. Plug other end of Ethernet Cable to your computer.

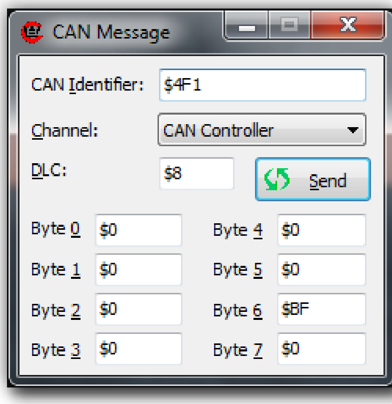


3.2.7 Establish ESR Communications

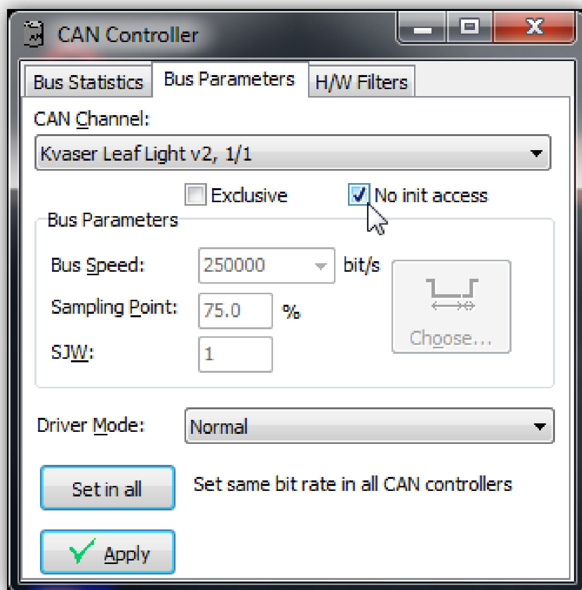
1. Start Kvaser CanKing.
2. Press Ok, I know what I'm doing
3. Create a new project using a template. Press OK
4. Select CAN Kingdom Basic template and press OK
5. OK the Tip of the Day.
6. Within the Kvaser CanKing main window, select Messages, Universal, Universal. Alternatively Ctrl+U



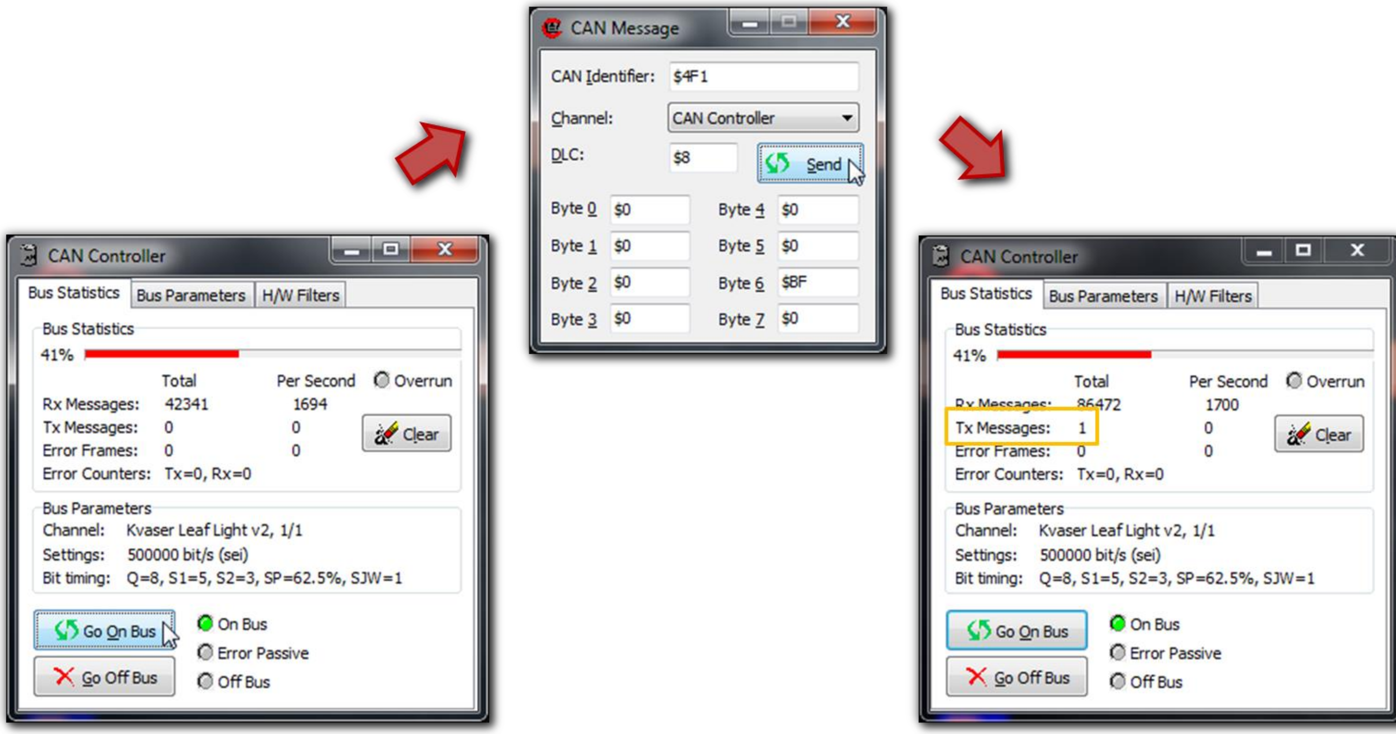
7. Prepare the RADIATE message in the CAN Message window as shown below. No need to press Send at this moment.
   - CAN ID: 4F1
   - DLC: 8
   - Byte 6: BF



8. In CAN Controller window under Bus Parameters check No init access



9. In CAN Controller Window under Bus Statistics press Go On Bus. You should begin receiving traffic.
10. Send RADIATE message.



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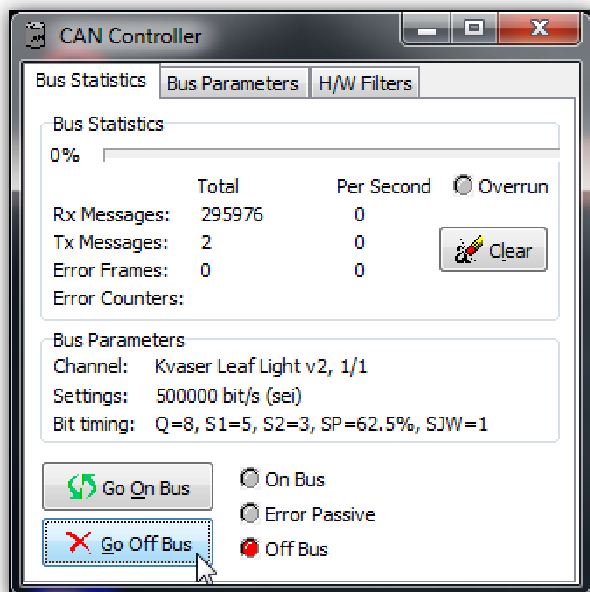
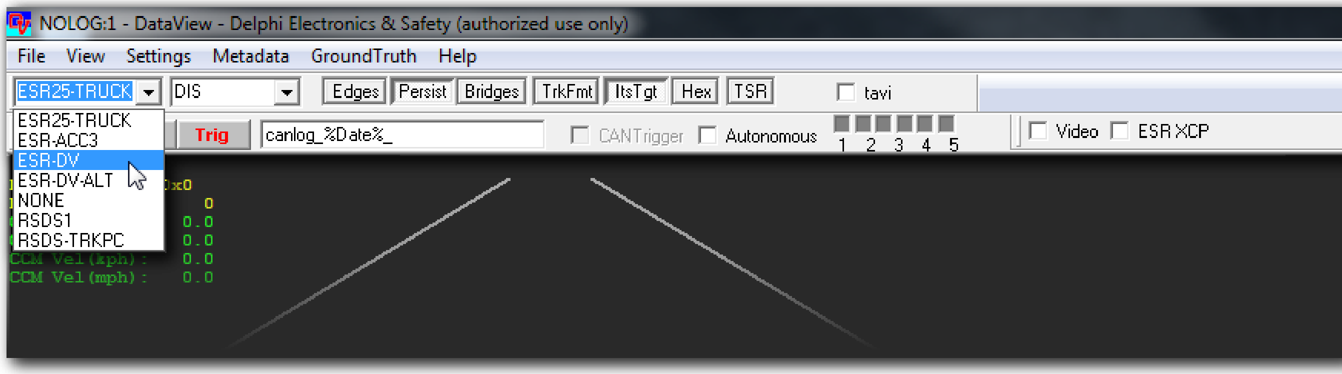
Users need send the RADIATE command only once per power cycle, not continuously. Radiate status may be confirmed by checking the ESR's current draw - it is < 200mA without radiating and over 500mA while radiating. There is an option to have the ESR auto-radiate on power up Please ask AutonomouStuff for details.

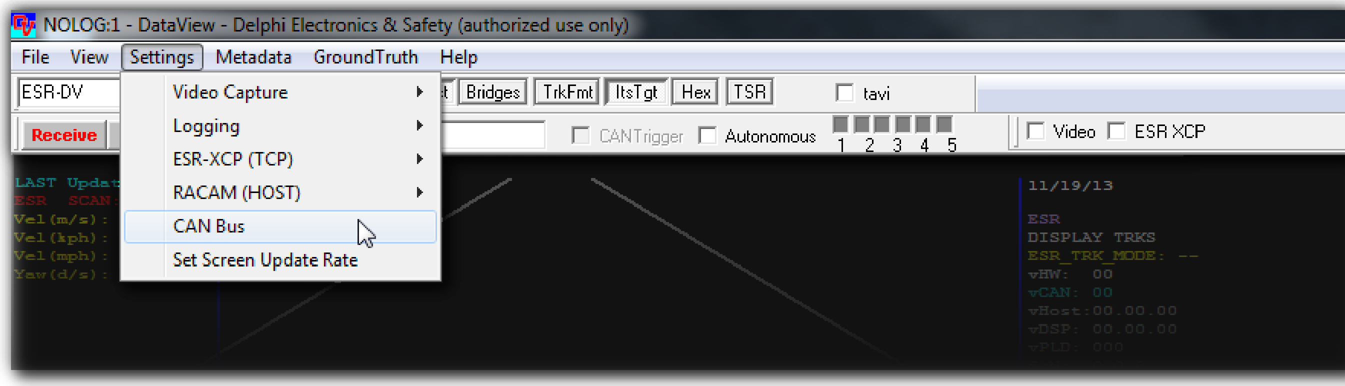
11. Press Go Off Buss to ensure DV tool functions properly.



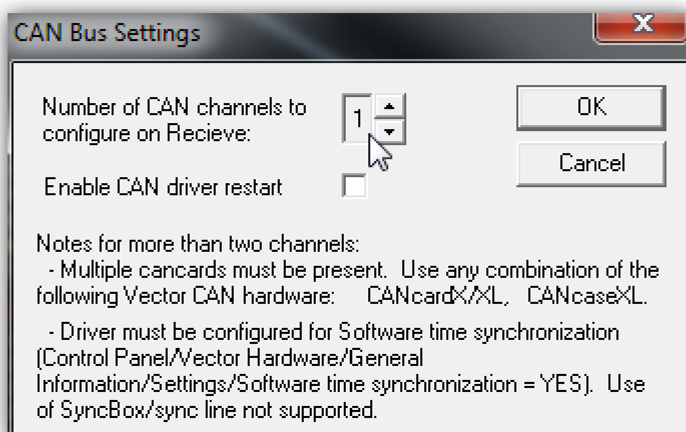
12. Start DV_esr from sub-directory ESRTools/bin/DV_esr.exe
13. Press ESR-DV from drop down list.



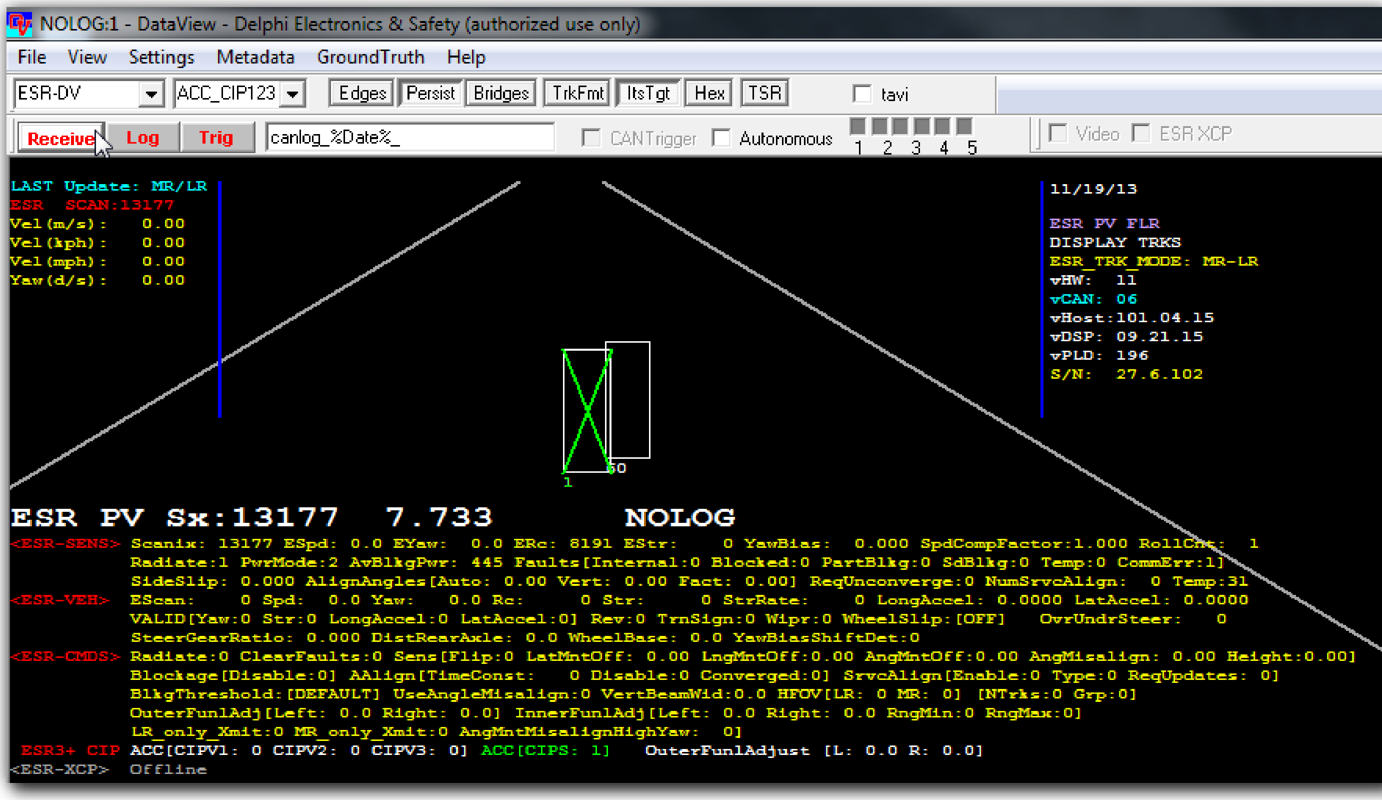
14. Under Settings, select CAN Bus



15. Configure the CAN Bus Settings to receive on 1 CAN channel.

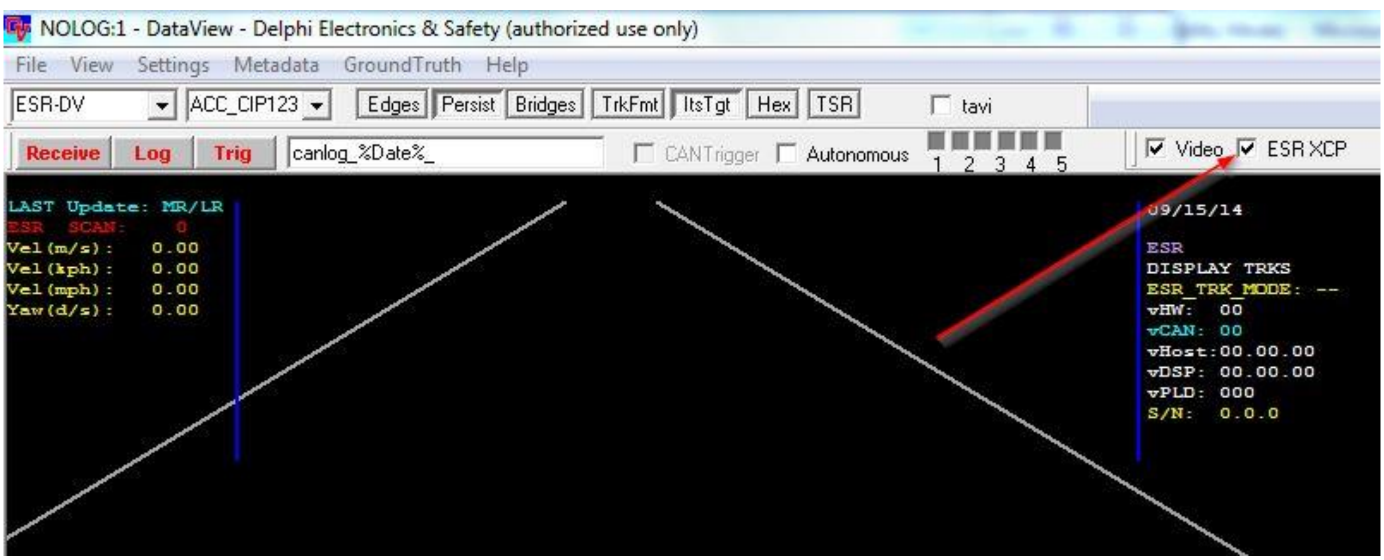


16. Press Receive. You should begin receiving traffic and see animated ranging boxes.



3.2.8 Ethernet Detection Data

1. Begin by ensuring that ESR/XCP is selected in DV before logging data.



2. This will generate a log file for the Ethernet traffic that can be played back using the CD42 DataView package.
3. To replay the detection data open the CD42 version of DV and make sure to select ESR-DV and XDET-TRK in the dropdown menus.

4. Locate and open the log file previously created.
5. Open the PlanView window to view detection data. (Note: The PlanView is the only screen within DV that will show the detection data that will display as ellipses)

Setup Conditions for 24VDC ESR with Integrated 3-Axis Accelerometer

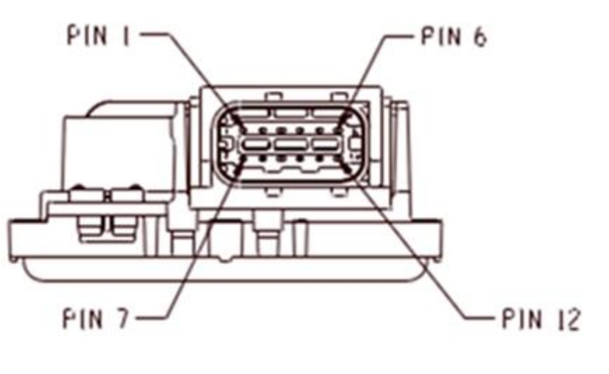
(ESR v9.21.00, v9.21.15, v9.21.21 Setup Conditions found on page 5)
(ESR 2.5 found on page 13)

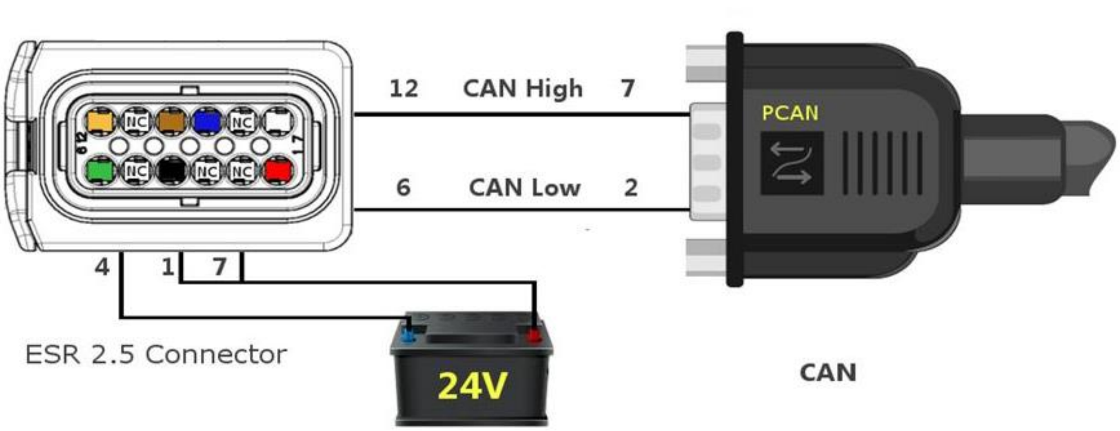
3.3 Setup Conditions (ESR 2.5 24V)

3.3.1 Installation Wiring

1. Provide 24V to Pin 1 (Battery) and Pin 7 (Ignition). If using the AUT-CBL cable Pin 1 (Battery) is the red wire and Pin 7 (Ignition) is the white wire.
2. Connect Pin 4 (CAN Ground) the black wire on the AUT-CBL to ground.

Pin #	Signal	Color
1	Battery (+24V)	Red
2	USB D+ (green wire)	Green (USB)
3	USB D- (white wire)	White (USB)
4	Ground	Black
5	USB Ground (black wire)	Black (USB)
6	PRVCANL	Green
7	Ignition (+24V)	White
8	USB +5V (red wire)	Red (USB)
9	VEHCANL	Blue
10	VEHCANH	Brown
11	VEHCAN Shield	
12	PRVCANH	Orange





Both VEHCAN and PCAN pins already have 120 ohm resistors internal to the radar.

3.3.2 Kvaser Leaf Light v2

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10. Plug in your Kvaser hardware. Part # (KVS-LL-V2-00685-0)
11. The Found New Hardware Wizard will detect and complete driver installation.
12. Confirm hardware installation by opening the Control Panel applet “Kvaser Hardware” and checking that your hardware is listed in the device tab. On the Device tab, select a channel of your device to check the hardware’s firmware version to determine if an update is available.

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3. Unzip the latest version of DataView (DV_esr). (Located in the Customer Folder on the USB supplied with the ESR)
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3.3.5 Connecting ESR to Computer for DataView

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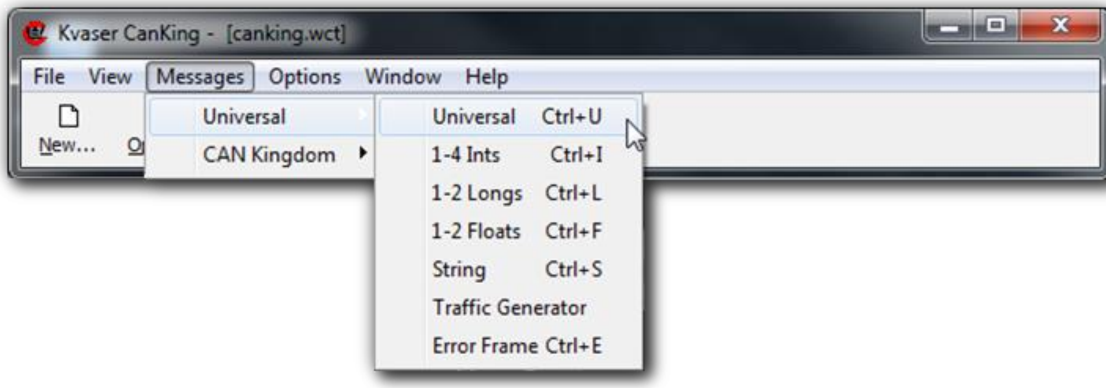
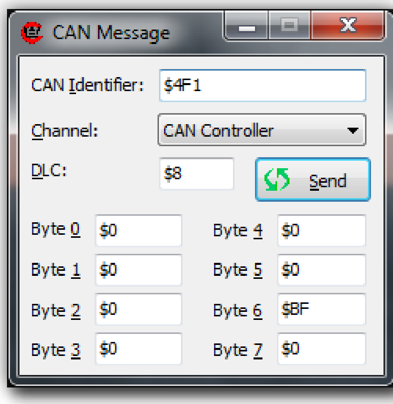
11. Connect the orange wire (CAN High) to pin 7 of a DB9 connector.
12. Wire a 120 Ohm resister across CAN Low (pin 2) to CAN High (pin 7)
13. Supply 12v to the red and white wires of the ESR Cable (AUT-CBL-ESR).
14. Connect the black wire to GND.
15. Plug the DB9 connector into the Kvaser LeafLight v2.
16. Plug the Kvaser LeafLight v2 into the USB of a Windows 7 or older Computer.

3.3.6 Establish ESR Communications

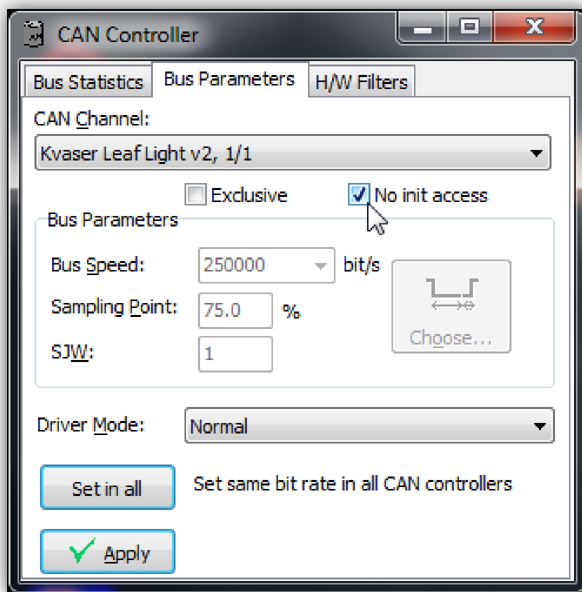
17. Start Kvaser CanKing.
18. Press Ok, I know what I'm doing
19. Create a new project using a template. Press OK
20. Select CAN Kingdom Basic template and press OK
21. OK the Tip of the Day.
22. Within the Kvaser CanKing main window, select Messages, Universal, Universal. Alternatively Ctrl+U



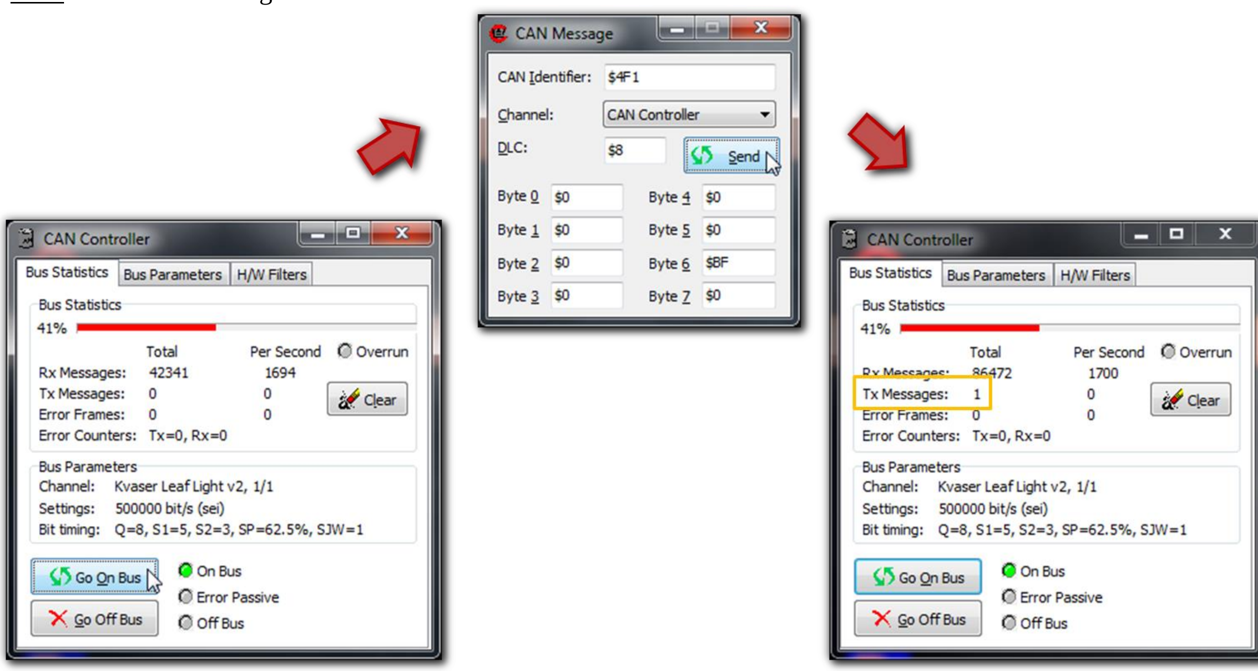
23. Prepare the RADIATE message in the CAN Message window as shown below. No need to press Send at this moment.
    - CAN ID: 4F1
    - DLC: 8
    - Byte 6: BF



24. In CAN Controller window under Bus Parameters check No init access



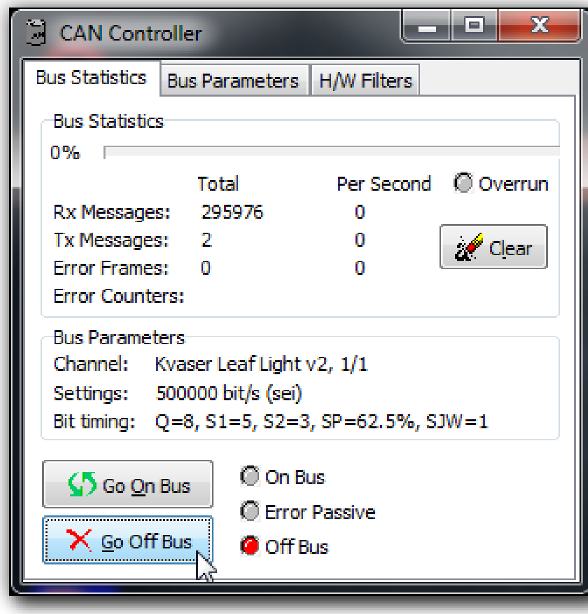
25. In CAN Controller Window under Bus Statistics press Go On Bus. You should begin receiving traffic.
26. Send RADIATE message.



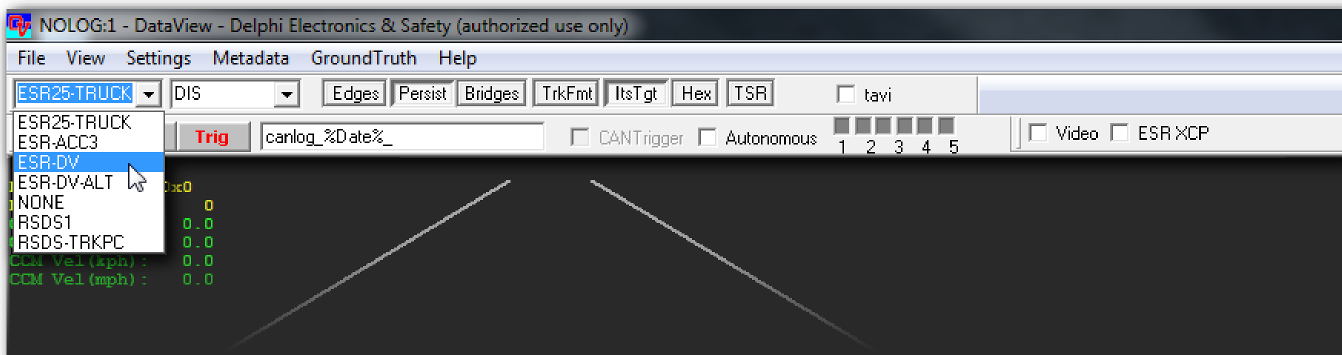
***

Users need send the RADIATE command only once per power cycle, not continuously. Radiate status may be confirmed by checking the ESR's current draw - it is < 200mA without radiating and over 500mA while radiating. There is an option to have the ESR auto-radiate on power up Please ask AutonomouStuff for details.

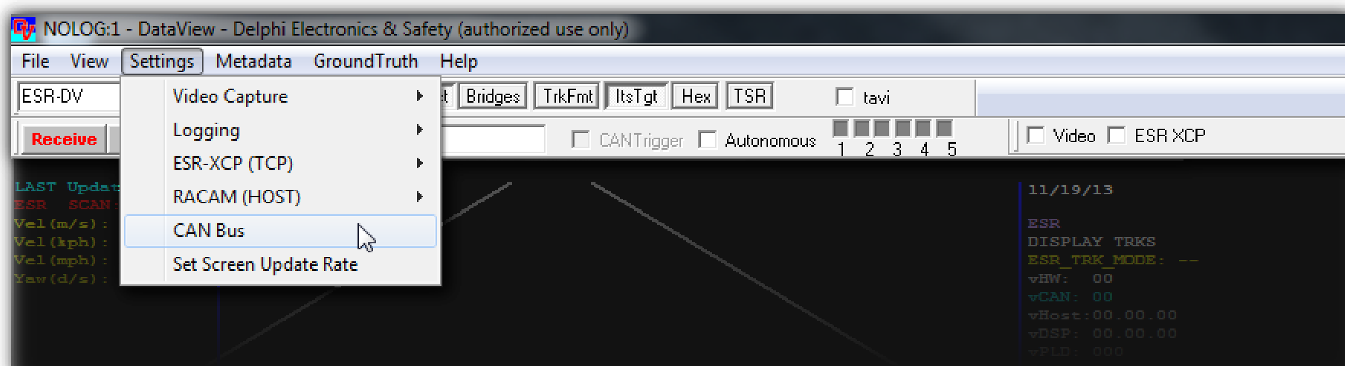
27. Press Go Off Buss to ensure DV tool functions properly.



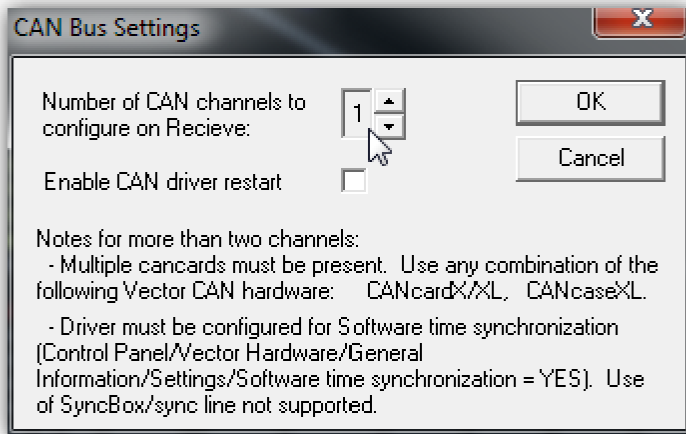
28. Start DV_esr from sub-directory ESRTools/bin/DV_esr.exe
29. Press ESR-DV from drop down list.



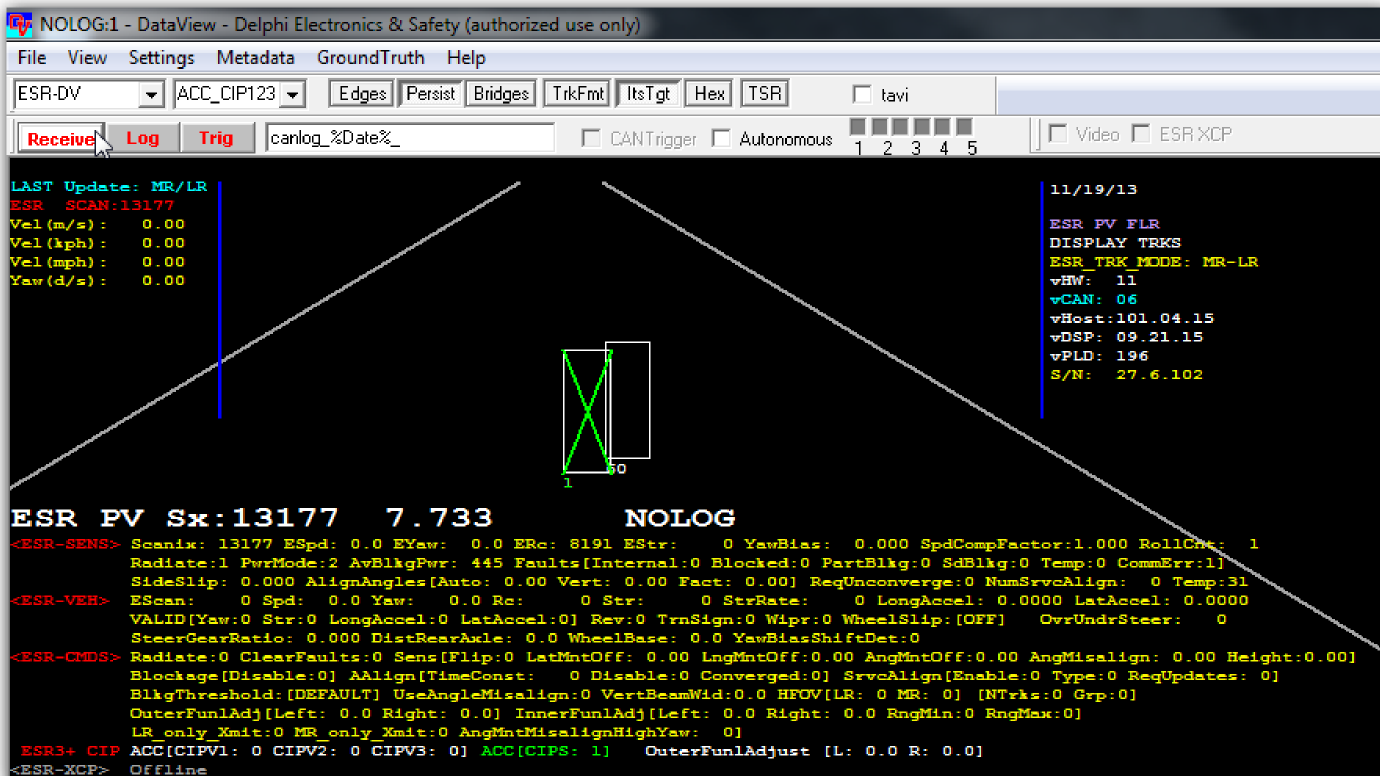
30. Under Settings, select CAN Bus



31. Configure the CAN Bus Settings to receive on 1 CAN channel.



32. Press Receive. You should begin receiving traffic and see animated ranging boxes.



3.3.7 ESR 2.5 24 Volt Accelerometer

Information can be found in ESR 24V folder under commercial vehicle.

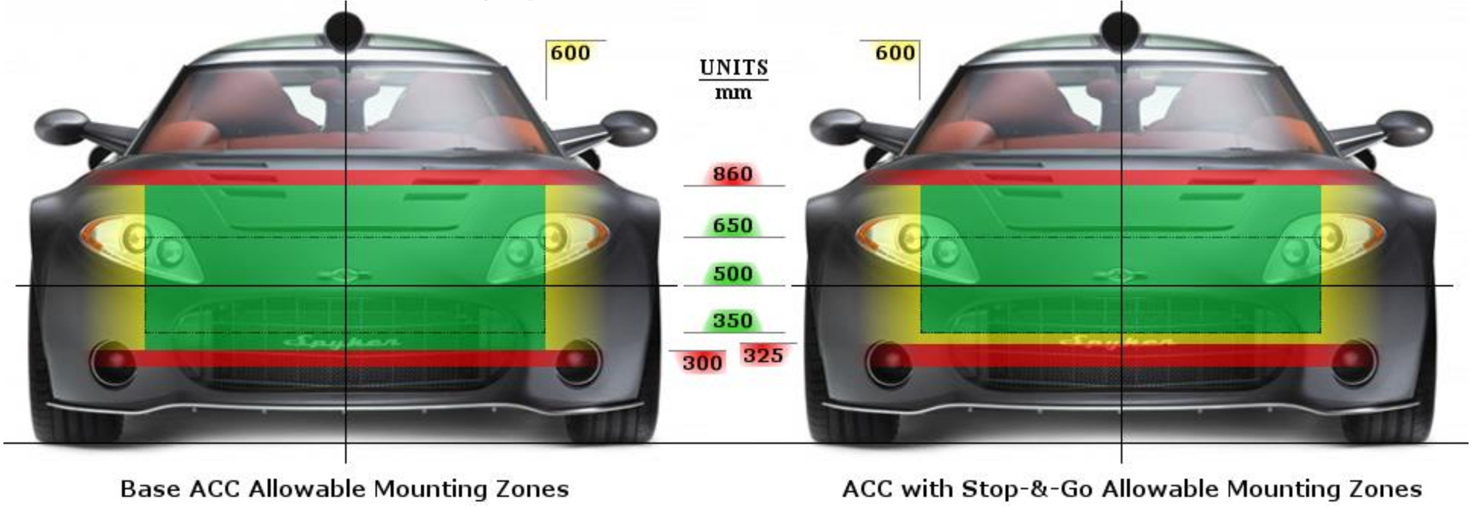
The .dbc file for the 24 Volt can also be found in the ESR 24 volt Folder.

4 ESR Installation

4.1 External Mechanical Interfaces

4.1.1 Mounting Height

For base ACC only applications, the mounting height of the center of the ESR on the vehicle should be 300mm to 860mm from the road surface. For ACC w/ Stop-and-Go applications, the mounting height of the center of the ESR on vehicle should be mm to 860mm from the road surface. The illustration below shows the allowable mounting zones in green. The zones in yellow indicate potential zones with extensive radar and vehicle testing required. The zones in red indicate zones that are not allowed.



4.1.2 Roll Alignment

A line bisecting the ESR radome horizontally will be aligned 180 degrees with respect to the driving surface. The tolerance on this is +/-0.6deg for FSRA applications and +/-2.0deg for Base ACC applications.

4.1.3 Mounting Lateral Offset

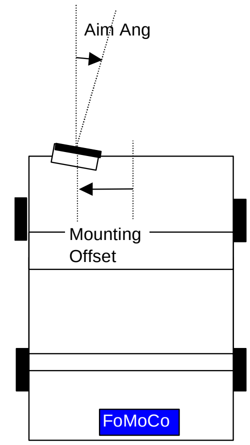
ESR mounting location will be in the front of the vehicle located with a lateral offset of no more than 0.6m from the vehicle centerline. Short-range cut-in performance will be validated by vehicle testing if ESR radar is mounted farther than 0.5m from the vehicle centerline.

4.1.4 Horizontal Alignment

If the ESR is mounted on the vehicle centerline, then the ESR mounting features should be aligned 90 degrees with respect to the vehicle centerline. If ESR is mounted off-center to either side of the vehicle centerline and if only long-range beam is used, then ESR should be mechanically rotated towards the center of the vehicle by an angle (i.e., intentional misalignment) that is a function of the mounting offset. The tolerance of the alignment is +/- 2.0 degrees. Refer to **Field of View Analysis Spreadsheet and Figure** for calculation of this intentional misalignment.

Path Width (m)	2
Short Range (m)	10
Long Range (m)	50
ROC (m)	250

Mounting Offset (m)	Total Field-of-View Required (deg)	Aiming Angle Required (deg)
0.00	13.8	0.0
0.10	13.8	0.1
0.20	13.8	0.2
0.30	13.9	0.4
0.40	14.4	0.8
0.50	14.8	1.1
0.52	14.9	1.2
0.60	15.3	1.5
0.70	15.7	1.8
0.80	16.2	2.1
0.90	16.6	2.5
1.00	17.0	2.8

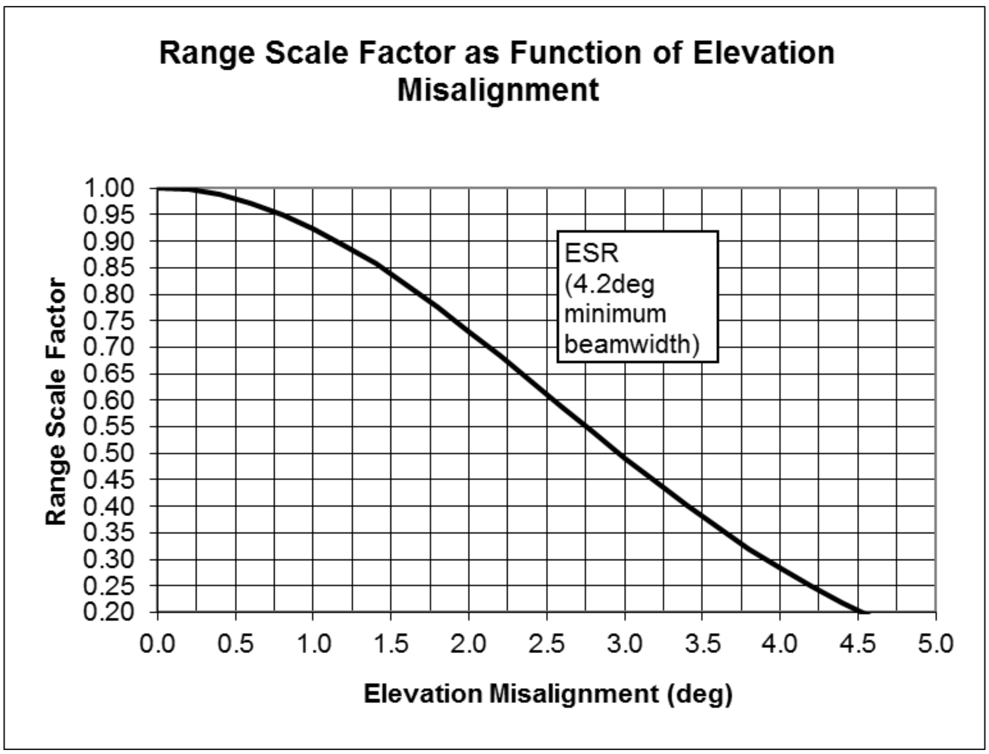


Field of View Analysis Spreadsheet and Figure

4.1.5 Vertical Alignment

The ESR mounting features should be aligned 90 degrees (+/- 1.0 degrees) with respect to the driving surface. An offset is defined from 90° to compensate for the average vehicle weight distribution, chassis settling, and any adjustment necessary to centralize the normal build variation.

The graph below illustrates the expected reduction in amplitude and range as a function of the vertical misalignment.



4.2 Software Interfaces

4.2.1 Vehicle Yaw Rate

The vehicle shall provide yaw rate over CAN to the ESR with the following requirements.

Vehicle Yaw Rate Requirements

Parameter	Specification
Bandwidth	> 7Hz
Filtering	Only anti-aliasing
Range	±100 deg/s maximum
Resolution	0.2 deg/s minimum
Update rate	20ms minimum
Bias compensation	Bias compensated for temperature to within ±0.3 deg/s Otherwise, bias does not change more than ±0.19 deg/s / degC
Failure detection	Yaw rate sensor self-detects failures and either rails yaw rate output or yaw rate diagnostic signal to be made available
Output noise	±0.4 deg/s
Linearity	±0.5% for less than 60 deg/s
Startup time	Less than 1 second until stable output

The yaw rate shall be updated as soon as the vehicle is turned on. Some vehicle yaw rate suppliers delay updating the reported yaw rate until the vehicle first moves after power on, in order to avoid issues with vehicle movement on ferries and turntables. However, this causes problems with the yaw rate bias compensation method used in the ESR.

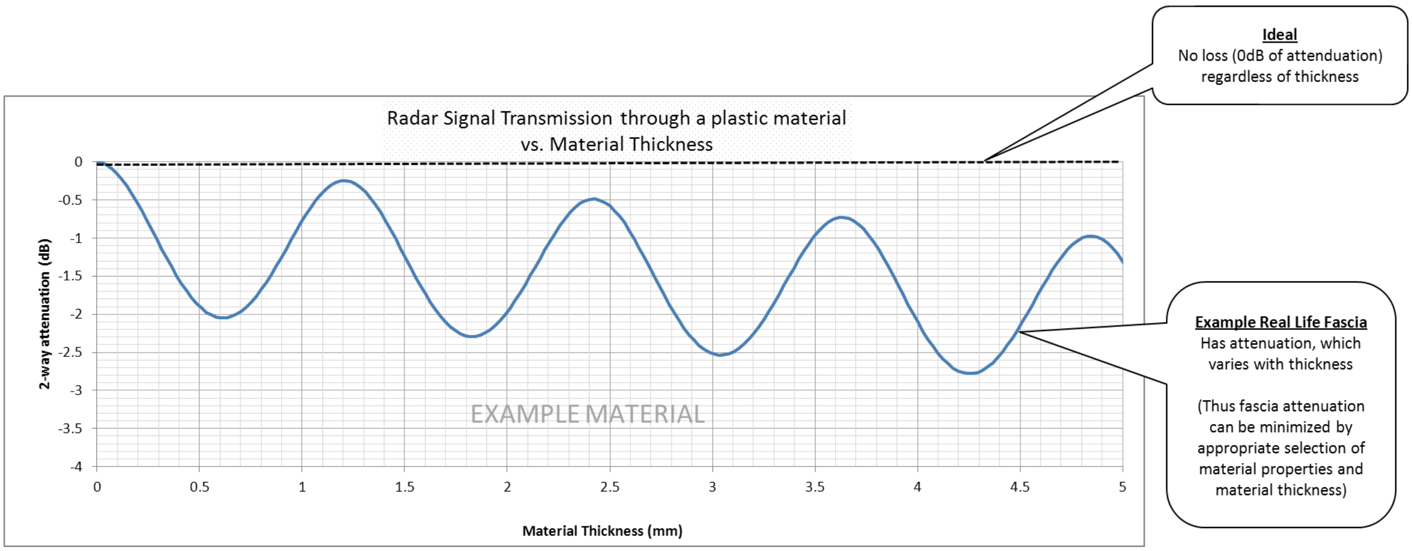
4.3 Fascia Design Guidelines

4.3.1 Size

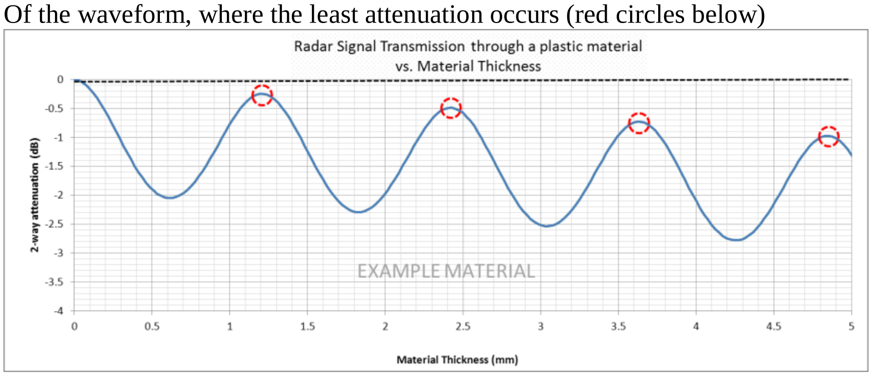
Fascia size should be larger than projection of radar fan-out.

4.3.2 Thickness

A plastic fascia's attenuation varies non-linearly with material thickness, as shown in the example below.



Since attenuation should be minimized, the best performance is achieved at the peaks
Of the waveform, where the least attenuation occurs (red circles below)



Since the attenuation is not linear with material thickness, to optimize a fascia's performance requires understanding the mechanisms involved.

4.3.3 Achieving Acceptable Performance for a Painted Fascia

Paint layers increase losses, mostly reflection loss. Guidelines below indicate acceptable ranges for the parameters of the plastic material and paint materials (if multibounce mitigation is accomplished by other means and if there are no significant features such as ribs in the fascia that could increase attenuation).

Stackup		Dielectric Constant (Dk) @ 76GHz	Loss Tangent (TanD) @ 76GHz	Thickness
1	Fascia Substrate Paint 1	<= 3.5 <= 5.0	<= 0.005 <= 0.1	<= 4.5 mm <= 0.050 mm
2	Fascia Substrate Paint 1 Paint 2	<= 3.4 <= 5.0 5.0 to 20	<= 0.005 <= 0.1 <= 0.1	<= 3.5 mm <= 0.035 mm <= 0.015 mm
3	Fascia Substrate Paint 1 Paint 2	<= 3.4 <= 5.0 20 to 50***	<= 0.005 <= 0.1 <= 0.1	T** +/- 0.25 mm <= 0.035 mm <= 0.015 mm

**Optimized thickness T specified by Delphi (dependent on fascia and paint parameters)

***Best solution for paint layer with dk > 50 is impedance matching layer specified by Delphi

Delphi has the capability measure the 76GHz characteristics of plastic and paints (see Parameter testing of plastics and paints below)

Parameters outside of those listed above may be also acceptable, including when there are features in the fascia, but will require working with Delphi to verify performance is required, and thickness optimization may be required (and as always, recommended). In this case, both painted and unpainted samples must be provided to Delphi for test.

Parameter testing of plastics and paints

When different paint layers have different properties (which is common), samples must be provided to Delphi for each step in the painting process:

Plastic
Plastic + Layer1
Plastic + Layer1+ Layer2
Plastic + Layer1+ Layer2+ Layer3
Etc...

As in the previous section, samples should be:

- **3mm x 100mm x 150mm** minimum size (4mm thick is preferable)
- **Flat**
- **Uniform in thickness**

4.3.4 Material Content

Material should be homogeneous and free of metal or carbon fibers to prevent distortion and attenuation of radar beam.

Impact of non-compliance: Non-homogeneous material mat result in antenna pattern distortion. Metal or carbon fibers may result in excessive loss, resulting in reduced maximum range.

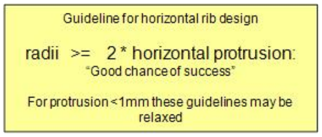
4.3.5 Shape

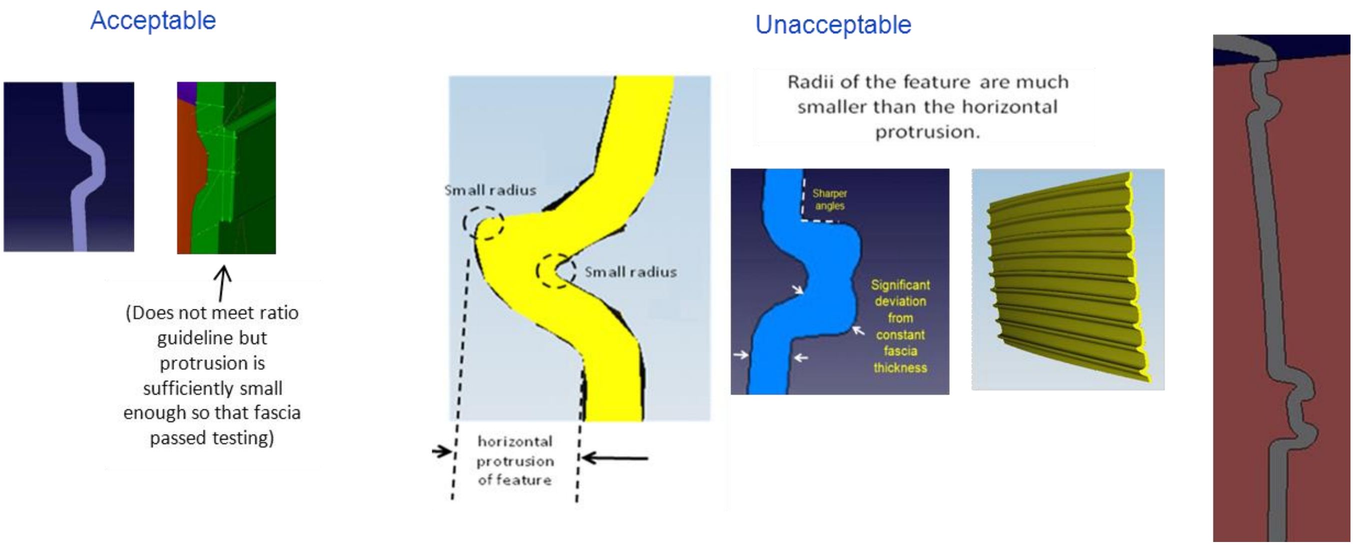
Ideally, the surface of the fascia should be smooth without ribs, bumps, large indentations, writing, or abrupt changes in order to prevent distortion and attenuation of radar beam. When it is not possible, curved features should have as large a radius as allowable with minimum radius of curvature of 50 mm in either the horizontal or vertical plane.

In regions of minimal curvature as described above, the fascia thickness should be maintained constant. The thickness shall be measured normal to the fascia surface, which will minimize phase distortion of the radar signal. Note that constant thickness measured normal to the fascia can be thought of as rolling a ball over one surface and using its path to generate the 3D solid of the fascia. (See exception to this method in the next section).

4.3.6 Horizontal Ribs and other horizontal fascia features

Horizontal rib patterns on the fascia are typically acceptable (from the standpoint of antenna pattern distortion) if the radius of each rib is >= 2 x the horizontal protrusion.





Horizontal ribs that meet the above guidelines are expected to be acceptable from the standpoint of antenna pattern distortion. However, ribs and other geometries added to fascia can increase the attenuation, so attention may need to be paid to selection of material with a low enough loss tangent and/or optimization of material thickness, as necessary, to achieve acceptable attenuation.

<u>Open mesh not OK:</u>
Fascias with an open mesh-pattern are not OK for radar operation (zero thickness in some places). There are many variants of this design using honeycombs, squares, etc., but they are all not OK. The cells must be filled in with plastic to provide a continuous thickness surface for the radar.

4.3.6.1 Thickness of horizontal ribs

For horizontal ribs and other features -- especially as radii become tighter -- it is not possible to avoid phase distortion no matter what approach is used.

There are different approaches possible for creating the B-surface of a rib, given a particular A-surface. The number of possible A-surface geometries is infinite, and the theory currently available to determine the best shape for a B-surface is limited. The set of experience available to draw on also has its limits.

Delphi does have recommendations as outlined below, but due to the limitations in knowledge mentioned above, both simulation and antenna pattern testing are always required for fascias with ribs or other added geometries, regardless of the approach that is taken for generating rib thickness.

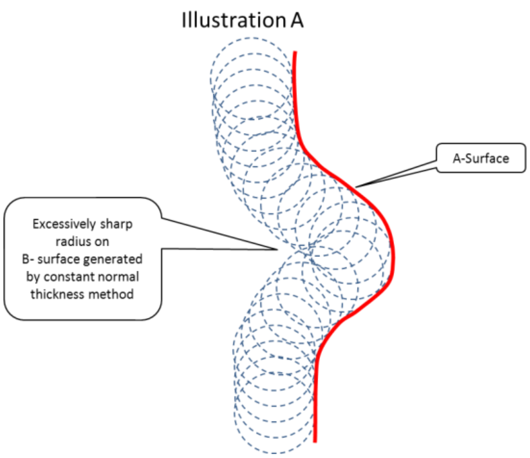
- <u>Not recommended: Constant normal thickness alone</u>
  Attempting to maintain constant thickness normal to the fascia surface in the region of a rib can generate excessively sharp radii on one surface, so generally it is not the best approach (see illustration A. below)

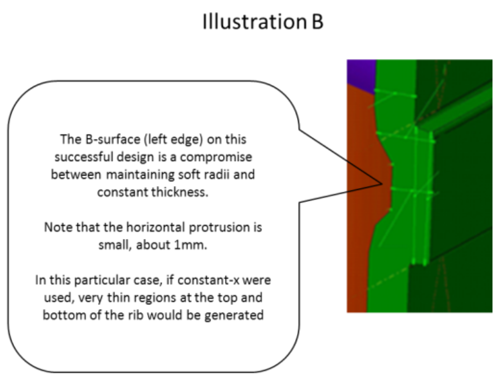
- <u>Often good: Constant-x thickness</u>
  In many cases, maintaining a constant "x-thickness" will yield acceptable performance (assuming of course that the A-surface radii are acceptable). It does not suffer from the problem of generating sharper radii like constant-normal does. One vehicle manufacturer prefers this method. However, note that while it is often acceptable, there are a few types of cases where it can generate regions that are potentially too thin in the normal direction
  - Constant-x consists of maintaining a constant thickness in the forward direction of the vehicle. That is, it is created simply by making an exact copy of A-surface and placing the copy a certain distance directly behind it
  - See note under illustration B. below

- <u>Delphi's suggestion: Compromise between soft radii and constant normal thickness</u>
  This approach attempts to avoid the problems of both of the approaches above (constant-normal's serious problem of sharp radii, and constant-x's smaller problem of thin regions.)
  - See illustration B. below
  - This is of course a subjective criterion; Delphi can make specific suggestions given a particular geometry

<u>Illustration A.</u> Excessively sharp radius on a rib generated by constant normal method

<u>Illustration B</u>. Recommended approach -- a <u>compromise between soft radii and constant normal thickness</u>
Note that constant-x (in this particular case) would generate some rather thin spots (as measured normal) at top and bottom of rib





4.3.7 Vertical Ribs and other vertical fascia features

Vertical rib patterns are generally not acceptable. Vertical features with low relief and gentle radii may be acceptable but testing is required to confirm.

4.3.8 Molded-in Writing on Fascia

Writing on the fascias tends to generally distort the antenna pattern a small amount. Writing less than 0.5mm in relief results in a small additional attenuation and a slight degradation in both horizontal vertical and horizontal sidelobes. Therefore, it should only be used for designs that have sufficient attenuation and sidelobe margin without writing. Writing with less than 0.25mm in relief does not show degradation in either horizontal or vertical sidelobes

Impact of non-compliance:

- Horizontal ribs and abrupt horizontal changes that exceed guidelines typically cause vertical pattern distortion, that is, elevation sidelobes which increase the likelihood of false targets caused by objects above or below the field of view, such as bridges or potholes.
- Vertical ribs and abrupt vertical changes that exceed guidelines typically cause horizontal pattern distortion, that is, horizontal sidelobes that increase the likelihood of false targets caused by objects to the left or right of the field of view.

4.3.9 Metal Painting / Plating

Fascia should be free of metal plating.).
Often, paints with metallic flakes are acceptable, but require testing and may require fascia thickness optimization.

Impact of non-compliance: Metal plating blocks the radar energy. Maximum range may be reduced with metal particles in the paint. Delphi has tested several types of “metallic” paints that have acceptable attenuation because of the relatively low density of the metal flakes in the paint.

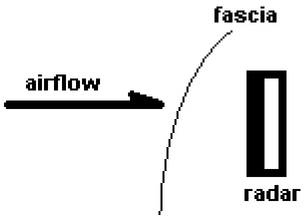
4.3.10 Temporal Variation of Position

Fascia should be constrained to minimize temporal variation of position.

4.3.11 Tendency to Stick with Rain Drops

Fascia surface (front and rear) should have low tendency for water adhesion. This is normally achieved in three different ways:

- The fascia should generally have a convex design to maximize the use of aerodynamic force to avoid water buildup.



- The fascia surface should be smooth. A rough surface (as shown below) allows small amounts of water to become trapped on the surface.

- The plastic material should be hydrophobic to allow water to bead rather than form a film.

Impact of non-compliance: Surface water has a major impact on radar performance. A design that allows water to adhere to the surface, even with aerodynamic force, Therefore, there will have poor maximum range performance during and after wet driving conditions.

4.3.12 Chrome-Like Material Usage

Delphi has tested various chrome-like paints and platings for radar performance and noted one acceptable material and several unacceptable materials. The acceptable material was Collins & Aikman FlexBright material. It is a microscopic layer of discrete Indium islands applied onto a base plastic substrate like TPO to give it a chrome like finish. The nature of the process makes the surface non-conductive and transparent to radar.

Delphi has also tested plastic-encapsulated chrome-looking emblem materials (as shown on Acura RL grille picture below) with acceptable results for radar performance.

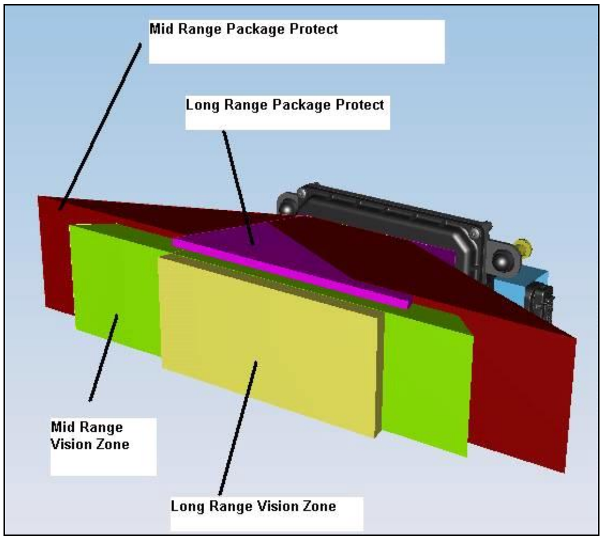
4.3.13 Low Material and Paint Radar Loss

Samples of fascia material should be provided early to perform attenuation testing. If the fascia material will be painted instead of molded-in color, then plastic plates of known attenuation should be painted with sample paint colors to perform attenuation testing.

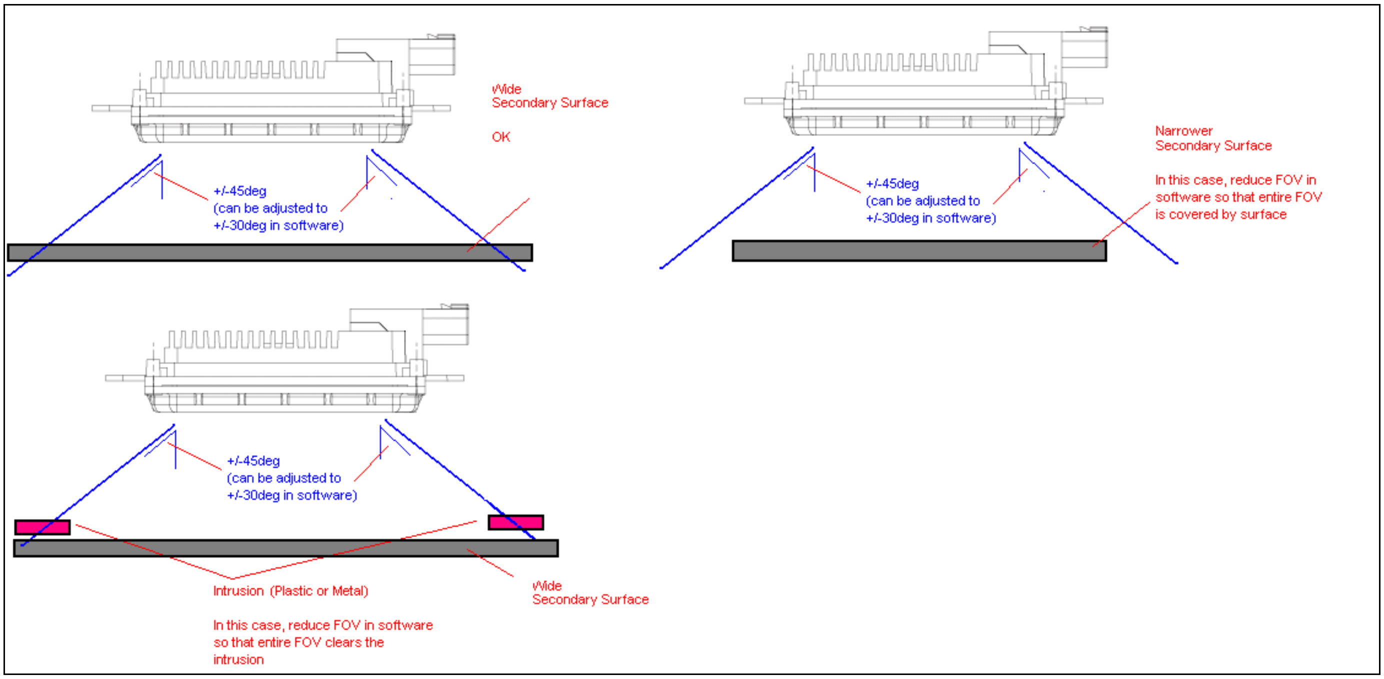
Impact of non-compliance: Fascia material may have higher loss than allowed by radar link budget. This will directly affect maximum detection range and may impact other functions, such as blockage detection.

4.3.14 Fan-out Coverage

The fascia material should cover the entire fan-out of the ESR without discontinuities. The fan-out is shown on the CAD data because it is referenced to the antenna location within the ESR. Note that it is slightly asymmetrical to the radar outline. For both long-range and mid-range, the CAD data shows the 4 different areas: “mid-range package protect”; “long-range package protect”; “mid-range vision zone” and “long-range vision zone”. The vehicle packaging should observe the “mid-range vision zone” area (only if mid-range operation is required) and the “long-range package protect” area.



Testing has shown the “mid-range package protect” area is too conservative and can be ignored. Further testing has shown that it is possible to reduce the mid-range vision zone in the radar software from current +/-45deg to +/-30deg. It should be possible to further reduce the vision zone if required for a specific application. Refer to picture below on how to handle various cases of packaging the “mid-range vision zone” area.

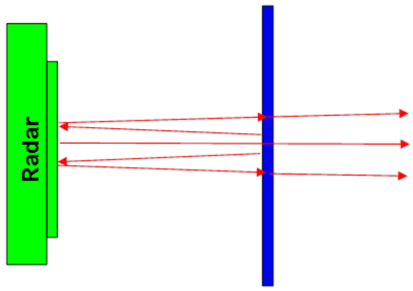


Impact of non-compliance: If these zones are not observed, the outcome will generally be antenna pattern distortion that could result in reduced maximum range or higher vertical or horizontal sidelobes. Higher vertical sidelobes will result in more overhead target detections, causing more bridges to be detected as in-lane stationary targets. Higher vertical sidelobes may also result in ground clutter being detected as in-lane stationary targets and may also impact blockage detection and other algorithms that utilize road clutter data. Higher horizontal sidelobes will cause false in-lane targets when passing larger adjacent-lane targets.

For CW blockage detection, the DSP software may use the elevation sidelobes to detect the road. Usage of elevation sidelobes by the CW blockage algorithm can be enabled or disabled by DSP software calibration. The elevation sidelobes are used to prevent false blockage detection in desolate environments by allowing the sensor to detect the road surface in scenarios where there is no roadside clutter.
Without a fascia, the elevation sidelobes are at +/-15deg, +/-30deg, +/-45deg, and +/-60deg from the boresight of the radar. A fascia using horizontal ribs may change the angles and amplitudes of these elevation sidelobes. If these elevation sidelobes are able to able to detect the ground (i.e., their line-of-sight is not obstructed by metal or significantly attenuated by plastic or their amplitude is greatly increased by the fascia design), then they may impede the detection of real blockage. Therefore, it should be checked in the particular vehicle packaging location if the radar's elevation sidelobes will have a line-of-sight to the ground and this information should be used to judge if elevation sidelobes are used for CW blockage detection.

4.3.15 Multibounce mitigation

Multibounce is a consequence of multiple RF reflections from the fascia. A fascia surface parallel to the radar can induce multibounce between the radar and fascia. Multibounce can substantially distort the antenna pattern (amplitude and phase) leading to regions of degraded detection range and/or degraded angle accuracy. Multibounce distortion can be significant even when the loss due to reflection is at an acceptable level.



Multibounce can be mitigated by:

1) Relative tilt between radar and fascia surface in the vertical plane >= 5 deg
    a. Note, however, the vertical tilt of the fascia surface relative to the radar radome should not exceed 35 degrees

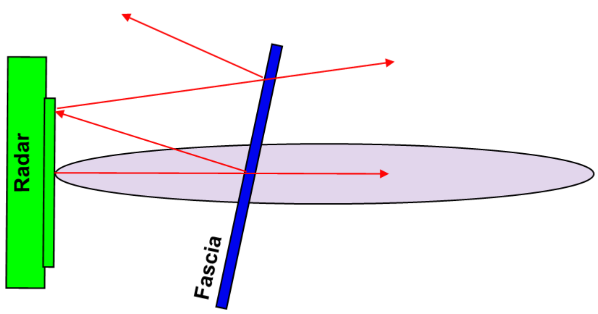
Or

2) Distance between radar and fascia <= 10 mm

Or

3) Optimized fascia thickness and/or (in the case of certain paint layers that cannot be optimized by fascia thickness selection) a matching layer on inside of fascia surface to be specified by Delphi

Although multibounce can be mitigated by one of the methods above, it is recommended that either method 1 be combined with fascia thickness optimization, or method 2 be combined with fascia thickness optimization.



Vertical tilt >= 5 deg mitigates multi-bounce

5 DataView

5.1 Introduction

5.1.1 Supported CAN Interfaces

DV will automatically search for supported CAN cards on the host computer. Detected cards will be selected in the order indicated in the table below.

Each interface requires that the CAN hardware and drivers be correctly installed. For each supported card, the dll indicated in the table is supplied with DV, and must be located in the directory containing the DV executable (or in the library search path, which usually includes winnt\system32).

For best performance under high busload situations, Vector hardware is recommended.

Table I: Supported CAN Interfaces

Brand	Search Order	Supported Cards	Required Library
Vector	1	CANCard-X CANCard-XL CANCard-XL (USB)	vcand32.dll
Softing	2	CANAC104 card (PC104)	canac104.dll
	3	CANcard-2 CANcard-SJA	cancard.dll
Kvaser	4	CANLap (PCMCIA and USB)	canlib32.dll
Kvaser	5	Leaf Light v2	

If more than two CAN channels are to be used simultaneously, then Vector hardware must be used and the driver must be configured for Software time synchronization. Use the Vector Hardware tool in the Control Panel to set the synchronization method (use the tool to set General Information/Settings/Synchronize Hardware = YES). Hardware time-base synchronization and use of SyncBox and sync line not supported.

5.1.2 Minimum System Requirements

Processor Speed: 1.6GHz or higher
RAM Memory: 512MB or higher
Operating system: Windows 2000 or XP
Hard Disk: 1Gbyte free and relatively un-fragmented

5.2 Layout

5.2.1 Menus

DV's main menu appears in the upper left corner of the main display window.

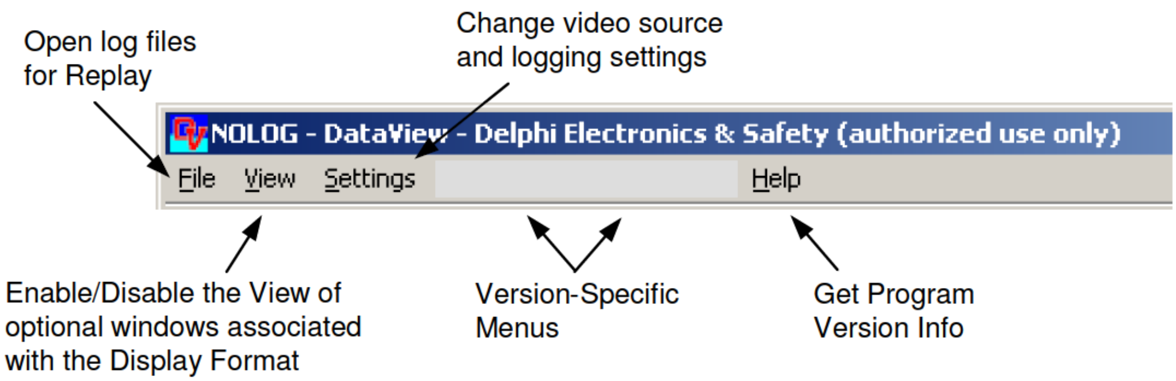


Figure 1. Main Menu

5.2.2 Toolbars

5.2.2.1 Receive / Logging

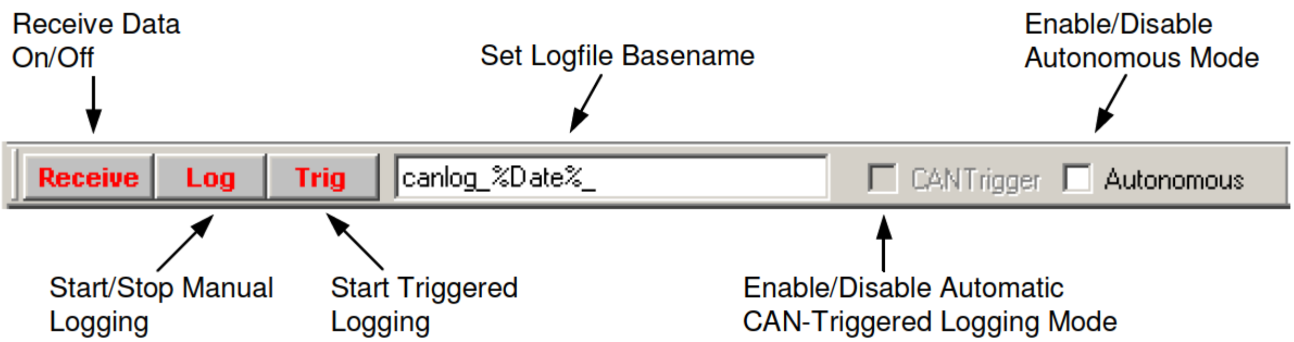


Figure 2. Receive/Logging Toolbar

5.2.2.2 Display Options

The display options toolbar controls how raw data is interpreted and displayed in both the Receive/Logging and Playback modes. The left-most drop-down box contains a list of the available Data Format interpretations (the sensor ACC3 is selected in the example below). The second box contains a list of the Display Formats or Views available for the selected Data Format. The remaining controls on this toolbar are specific to each particular Data/Display Format combination, and are documented elsewhere.

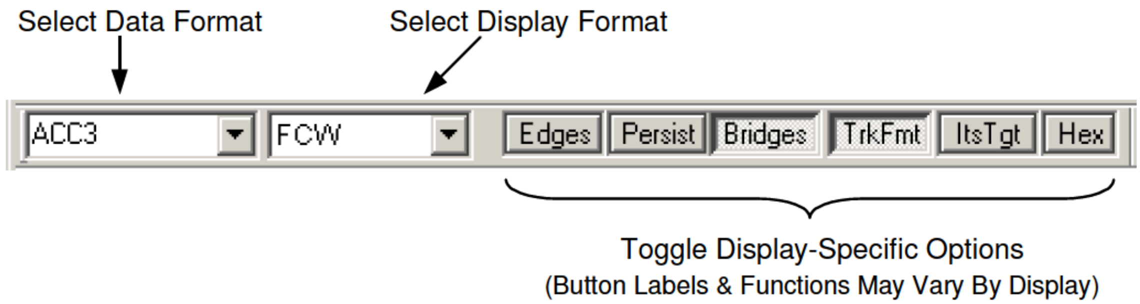


Figure 3. Display Options

5.2.2.3 Playback

This toolbar is visible only when a file is open for playback (e.g., the result of File/Open). The controls are self-explanatory, allowing one to move forward and back through the open file.

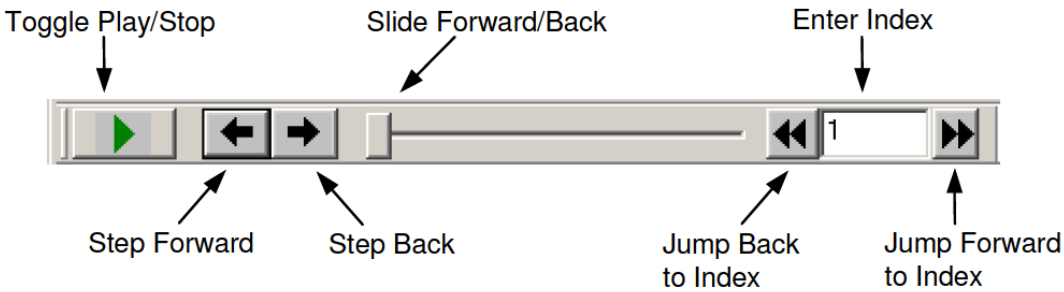


Figure 4. Replay Toolbar

For the Step Forward/Back buttons, the definition of one "step" depends on the Data/Display Format selections made on the Display Options toolbar. For example, for a single radar sensor one step might be one scan, while for a multi-sensor system one step might move to the end of the next scan of either sensor. All data collected with DV has some associated Index – either a native quantity supplied by the observed system (such as a scan or frame index), or one assigned by DV (such as a message or cycle counter). The nature and source of this index is dependent on the selected Data/Display Format. To account for possible rollovers in the Index, the "Jump" buttons allow one to search for a desired index in either direction.

5.2.2.4 Status Bar

DV's main Status Bar is located at the bottom of the main program window. It contains separate regions for Help, Receive Status, and CAN, Video and XCP Logging Status.

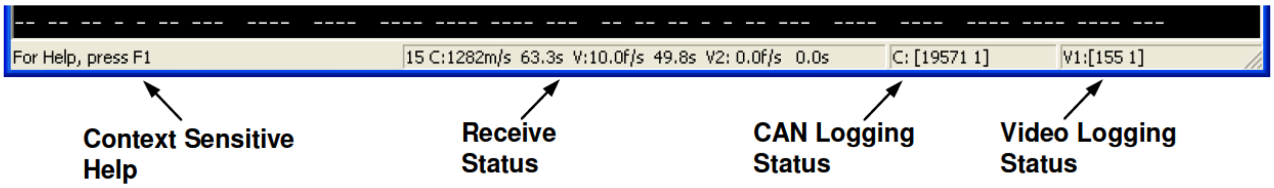


Figure 5. Main Status Bar

The help pane displays concise help information about the DV control (menu or toolbar element) the mouse is currently pointed at. Contrary to the text in the display, pressing F1 will not produce useful help. The content of the other panes is described in the next sections.

5.2.2.5 Receive Status Pane

The Receive Status Pane shows current statistics for CAN, Video and XCP receiving. The line below is a sample of the Receive status information for CAN plus one Video and one XCP source:

15 C: 1282m/s 63.3s V: 10.0f/s 49.8s V2: 0.0f/s 0.0s X: 40.0m/s 38.4s

The left-most element is a running counter of updates of this pane since receiving began. This counter is followed by four data blocks that provide information about the receipt of CAN (C:), Video (V:) and XCP (X:) data. Each data block contains the following information:

- Data rate (messages or frames) received per second (including any "generated" by DV)
- Data amount currently held in the queue (in seconds)

The Receive Status Pane is updated once every 4 seconds.

5.2.2.6 Logging Status Panes

Three Logging Status Panes show current statistics for CAN, Video and XCP logging. The example below is a snapshot of CAN (C:) logging information (video (V:) and XCP (X:) information is similar):

C: 104235 16

The two numbers in each CAN or Video block describe:

- The total number of messages or frames logged (written to file)
- The number of messages or frames remaining to be written (to catch up to receive)

The Logging Status Pane is updated once every 4 seconds.

While logging (systems with a constant average data rate), the number of messages/frames remaining will be constant or decreasing if the logging task is able to keep up with the receive task. If this number is increasing, the logging may eventually fall so far behind that new data will overwrite old data before it is written to the log file.

5.3 Settings

5.3.1 Log File Options

Log file name, location, and max duration can be selected with the menu item Settings/Log/Options. The resulting dialog box is shown below.

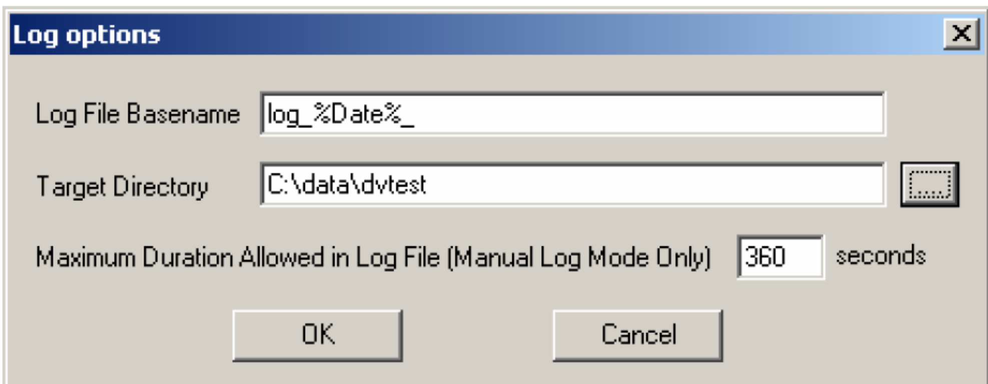


Figure 6. Log Options Dialog

5.3.1.1 Log Filename & Location

The user specifies the base filename and the directory where logs should be stored. DV automatically creates log filenames by appending a three-digit integer to the specified base name (e.g., mylog005.dvl). This integer increases by one for each new log file (logging event). If the specified base filename includes any of the special key strings shown in Table II, these will automatically be expanded to their respective quantities when the files are created.

Table II. Log Filename Auto-Expand Keystrings

Key string	Auto-Expands to
%Date%	Current date: yyyymmdd
%Time%	Current time: hhmmss

5.3.1.2 Log File Maximum Duration

The default maximum log file duration is 360 seconds (6 minutes). Once the log time has exceeded the specified duration, the current log file is closed and a new log file with incremented number is automatically started. Data during this transition period (1-2 seconds) are not logged.

5.3.2 CAN Bus

CAN bus options may be configured with the dialog reached via menu item Settings/CAN Bus. Currently, only the number of CAN channels to use can be selected. Verification and configuration of the channels is not performed until Receiving is started.

5.3.2.1 Channel Usage

Two or four channels may be selected for use. For PCMCIA card channels, a transceiver must be connected before channel initialization (on Receive), or the channel will not be activated.

5.3.2.2 Bus Parameters

CAN channel settings such as bus bit rate are currently hard-coded and not configurable. The bit rate on all configured channels is set to 500Kbps.

5.3.3 Video

DV can log video data up to two video sources simultaneously: one is called the Main video, the other Auxiliary video. The Main video is used as the primary video data, while the Auxiliary video is used for a second camera for ground truthing purposes.

The video data is stored in AVI files. The data from the Main video source is written to AVI files with the following naming convention: "*dvl_basename.avi*". Data from the Auxiliary video source is written to AVI files with "*dvl_basename_**v2**.avi"* naming convention.

To enable video logging, select the menu item Settings / Video Capture / Enable to enable video logging. Then select the menu Settings / Video Capture / Options to see available video sources for the Main and Auxiliary Video. Figure 7 and Figure 8 show the Main and Auxiliary video settings dialog tabs, respectively.

5.3.3.1 Main Video Settings

The Main Video Settings dialog box shown in Figure 7 is typically used to configure primary video logging interface. Some video sources are used specifically for customer specific programs, while others may be used for general video logging purposes.

On the dialog box, first the user selects the type of video source. Sub-options such as available video compressors (Codec) and frame rate vary depending of the video source selected.

For general video data logging purposes (e.g. to capture the driving scene), the user may select one of the following video sources: ImperX, ImperX Pro and Web Cam.

5.3.3.1.1 ImperX & ImperX Pro cards

There are three codec options available for these cards (uncompressed, Indeo and JpegLS). The user selects Quality for Indeo or Loss Level for JpegLS codec. In addition, the users must select the maximum logging frame rate. The recommended frame rate is 5 fps for ImperX card and 10 fps for the newer more efficient ImperX Pro card.

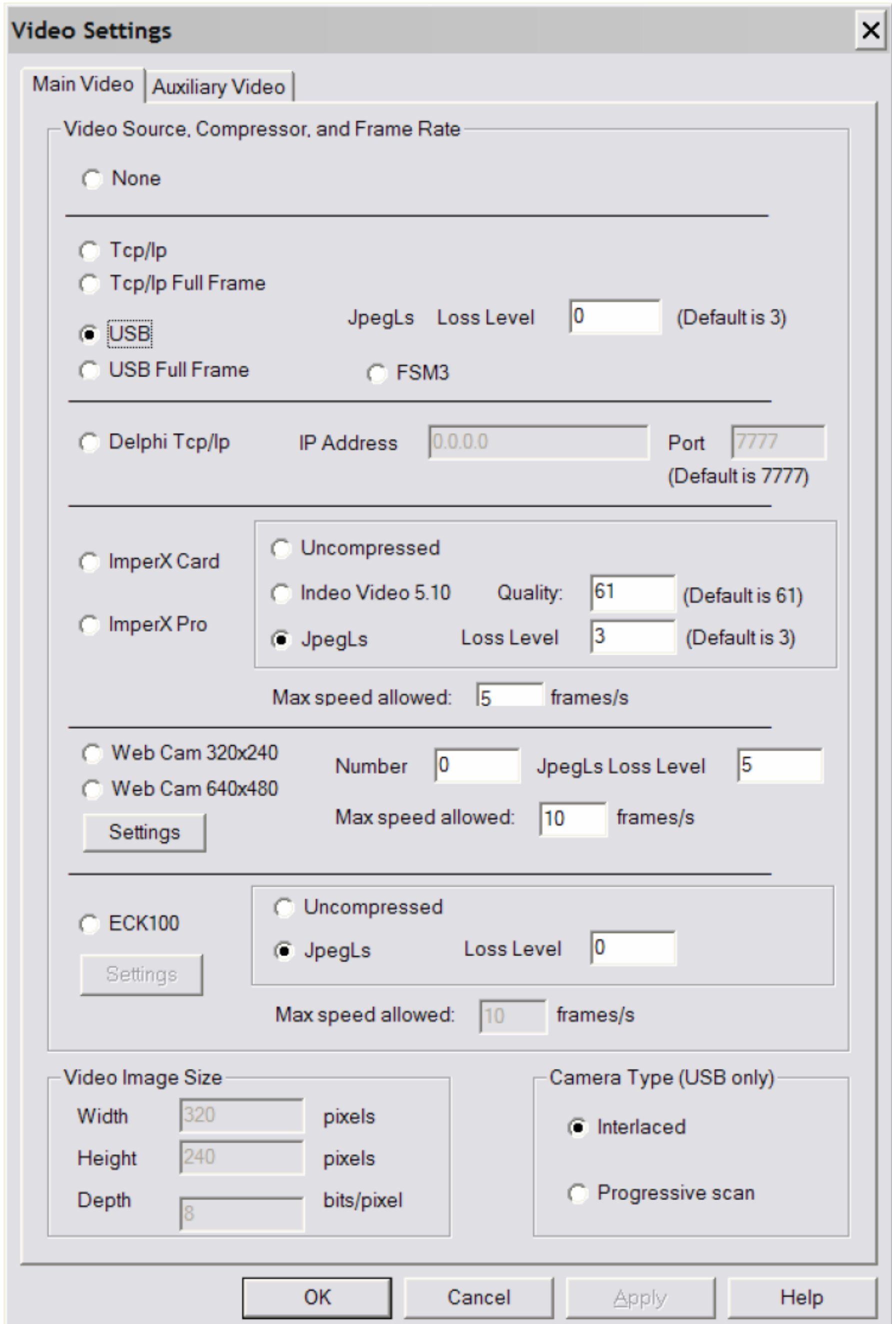


Figure 7. Main Video Settings

5.3.3.1.2 Web Cam

A web cam which supports VFW (Video for Window) interfaces can be used to log video data in DV. To use the web cam, follow the following steps:

1. Connect the web cam to the laptop
2. On the Main video settings dialog box, select Web Cam with your choice of image size, either 320x240 or 640x480, as the video source.
3. Click on the “Settings” button under the Web Cam radio box.

4. On the popup dialog box (should be the same or similar to the one shown in Figure 8) select the image resolution that matches your choice of image size. If there are codec options available, select RGB or uncompressed. If neither RGB nor uncompressed is available, select any of the codecs (a faster one is better) and make sure that the selected codec has been installed on the machine.
5. Leave the Number to 0.
6. Select a JpegLS loss level. Default is 3.
7. Choose a frame rate. Recommended frame rate is 10 – 15 fps. The user can verify the actual frame rate received during logging by watching DV status bar (see Status Bar section for details).
8. To lower the video file size, the user can either increase the loss level (the image quality become lower) or decrease the frame rate or both.

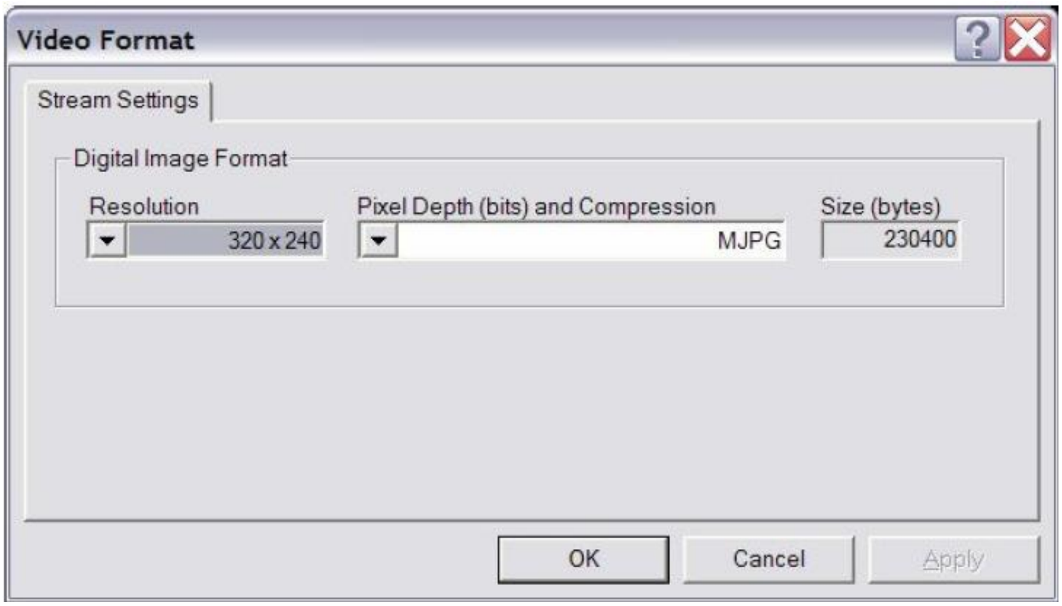


Figure 8. Web Cam Settings Dialog

5.3.3.2 *Auxiliary Video Settings*

The Auxiliary Video Settings dialog box shown in Figure 9 is typically used to configure a second camera for ground truthing purposes. There are less video sources supported for the Auxiliary video. Select "Not used" as the video source if there is data from a second camera to be logged.

ImperX and ImperX Pro can be used to log the secondary video data for general purposes. For the settings of these cards, see ImperX and PmperX Pro in the Main Video Settings section.

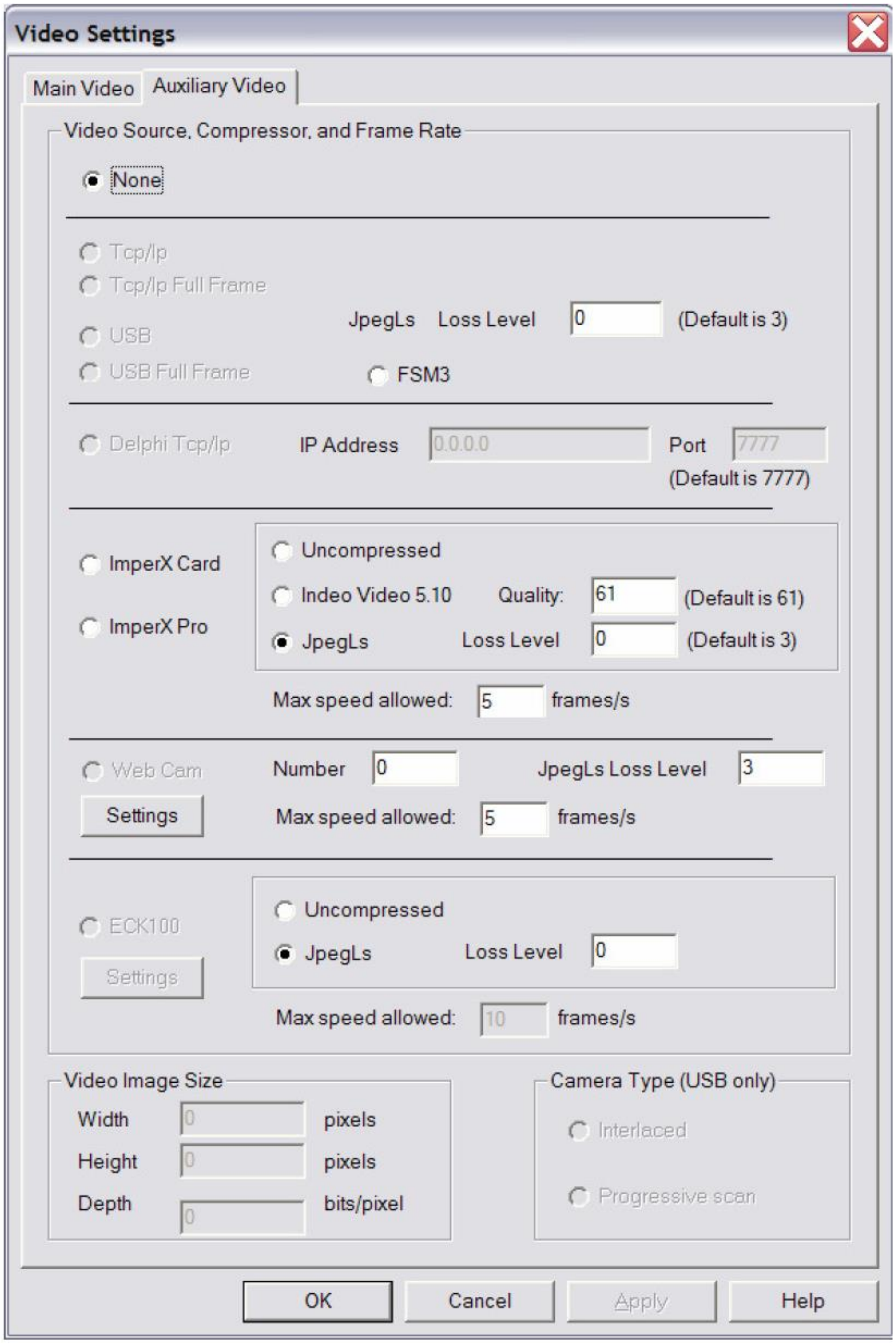


Figure 9. Auxiliary Video Settings

5.4 Automatic Logging (CAN Trigger)

DV has the ability to automatically initiate logging when certain user-specified conditions are met in the received CAN data. For instance, one could identify the Signal *Warning* as certain bits of a particular CAN message, and then define a trigger condition that is signaled each time Warning=1 occurs.

The current implementation initiates a fixed-length triggered log every time a defined trigger condition transitions from false to true.

5.4.1 Enable / Disable

Status of the Automatic Logging feature is reported by the CANTrigger checkbox on the Receive/Logging Toolbar. This function is available only if DV is launched with the command line option **/t**. In addition, a specially formatted trigger configuration file is required to define the CAN Signals and Trigger Conditions for the function. This file must be in the directory with the DV executable. Upon launch, DV will parse the configuration file, and construct a CAN Signal and Trigger Condition database. If no errors are detected, then Autologging will be made available (CANTrigger checkbox will be un-grayed) and the function will immediately be active/enabled (checkbox checked).

☐ CANTrigger	Not Available
☑ CANTrigger	Available, Enabled
☐ CANTrigger	Available, Disabled

When available, operation of the Automatic Logging feature can be enabled or disabled by the user. Disabling the feature will cause DV to ignore all trigger conditions and prevent autologging. This setting is not remembered from one launch to the next (use of the **/t** switch always enables auto-logging). When logging is not desired, the function must be manually disabled or receiving stopped.

5.4.2 Auto-Logging Modes

DV is intended to support the Auto-logging modes shown in Table III. Each of these modes is controlled by one of the following Trigger Objects:

- CAN Message Receipt – Monitors receipt of CAN messages with specified CAN Id and channel. Does not monitor data in the CAN message except possibly to determine that the correct message has been received (e.g., particular value in first data byte might signal the first of a sequence of same-Id messages).
- CAN Trigger Condition – A trigger Condition is defined as a list of one or more *Primitives*, each of which performs a single logical comparison on a defined Signal on the CAN bus. For example, a primitive might represent the comparison Speed > 30, or Warning = 1. The trigger Condition is *set* or *true* only when all of its primitives evaluate to true (e.g., TrigCondition = Primitive1 AND Primitive2 AND… PrimitiveN).

Table III. Description of Autonomous Logging Modes

Mode	Trigger Object	Log Type	Description
ID	CAN Message Receipt	Fixed-length (pre+post trigger seconds) Triggered Log	Initiate a log when a particular CAN Message is received. The data in the message is not consulted. (not yet / no longer implemented)
EDGE	CAN Trigger Condition	Fixed-length (pre+post trigger seconds) triggered log	Initiate a log when the Condition transitions from false to true.
LEVEL	CAN Trigger Condition	Variable-length Continuous Log	Initiate a continuous log when Condition becomes true. Continues logging while Condition remains true.

The current system implements only the EDGE mode, designed to trigger on the rising edge of a Trigger Condition. It triggers when the Condition becomes true, and cannot re-trigger until the Condition becomes true again (necessarily becoming false in-between).

The various modes produce one of two types of logs:

- Fixed-length Triggered Log – Log collected as if the user pressed the Trig button on the Receive/Logging toolbar. The length of the log is pre+post trigger seconds.
- Variable-length Continuous Log – Log collected as if the user pressed the Log button on the Receive/Logging toolbar. The log begins at the time of the event (no pre-trigger), and continues until the trigger Condition is no longer satisfied.

In all modes, the system will mark the location in the data where the trigger occurred.

5.4.3 CAN Trigger Definition File

The CAN trigger definition file contains the specification of CAN Signals in a way similar to how one might define a Signal in a Canalyzer Database (e.g. which message ID, which bits, etc.). The file also allows the specification of conditions or tests on these Signals that will trigger logging.

5.4.3.1 Format

The CAN trigger definition file is a text file consisting of three parts: the Version Identification Block, the Signal Definition Block, and the Trigger Condition Definition Block. These blocks must appear in the order listed. The beginning of each block is marked by a line containing a specific key string, and followed by subsequent lines that contain the signal or trigger definitions. The key string and format of each block are described in the following paragraphs, in which the sample definition file shown in Figure 10 is used as an example.

Any line beginning with a pound sign (#) denotes a comment. The parser ignores both comment and blank lines. All key strings and names (e.g., signal and trigger names) are case-sensitive.

```
#DV_CAN_TRIGGER V1.1
#
# Configuration: Sample Project X
# Version: 2.1
# Author: Lisa Hamilton
# Date: 21 Sept 2006
# Source: Project X Canalyzer Database V4.5 (projX.dbc)

CAN_SIG_DEF
# SIGNAL_NAME = CH, ID, START, SIZE, MASK, SIGN, FACTOR,
OFFSET
Warning = 2,074,3,1,10,U,1,0
# true speed = signal/16 m/s
Speed = 1,600,0,2,ffff,U,0.0625,0.0
# true yaw rate = signal/16 d/sg
Yawrate = 1,600,2,2,ffff,S,0.0625,0.0
Scan = 1,601,0,2,ffff,U,1,0
ScanLow = 1,601,0,2,1fff,U,1,0

CAN_TRG_ENA
# TRIG_NAME = SIGNAL, LOGIC, VALUE; SIGNAL, LOGIC, VALUE;
...
# 30 m/s
HighSpeedWarn = Speed,GE,30.0; Warning,EQ,1
LowSpeedWarn = Speed,LT,30.0; Warning,EQ,1
Every6Min = ScanLow,EQ,4096
# 5 d/s
HighYawRight = Yawrate,GT,5.0
HighYawLeft = Yawrate,LT,-5.0
```

Figure 10. Sample CAN Trigger Definition File

5.4.3.1.1 Version Identification

The first line of the configuration file must contain the specific Version Identification Key String that tells DV how to interpret the rest of the file. The current version string is: *#DV_CAN_TRIGGER V1.1*. Comments should be used in this block to provide custom version, date, author, and source information.

5.4.3.1.2 CAN Signal Definition

The CAN Signal Definition Block defines the CAN signals that DV will extract and monitor. Its beginning is denoted by a line containing the key string *CAN_SIG_DEF*. Subsequent lines provide the signal definitions, one per line.

Each signal is described by a unique name followed by a series of comma-separated descriptors as follows:
SIGNAL_NAME = CH, ID, START, SIZE, MASK, SIGN, FACTOR, OFFSET
A description of the parameters used to define the signal is presented below:

SIGNAL_NAME: Unique, descriptive name of CAN signal

CH: CAN channel to monitor, "CH1" or "CH2" (range: 1, 2).

ID: CAN message ID containing the desired signal, written as a 3-digit hexadecimal value (range: 0-7ff)

START: Byte offset to the byte containing the msb of the signal in the message (range: 0-7). Note that the byte numbering begins with 0 to match that used in the Message Layout view in Canalyzer.

SIZE: Size of the signal in bytes (range: 1-4). Single-bit boolean flags shall use a size of '1' byte with the unused bits masked off using the MASK parameter.

MASK: Hexadecimal value used to mask 'don't care' bits from the defined signal. The signal will be created by AND'ing this mask with the selected signal bytes and then shifting the result so that the least significant bit of the signal corresponds to the least significant high-bit in the mask. To use entire byte, set mask to "FF" for a 1-byte value, "FFFF" for a 2-byte value, etc. A mask of "A0" will result in a 3-bit signal created from the three high bits of the byte (but the value of the middle bit will be ignored, or treated as zero, when computing the signal value).

SIGN: Signal value should be treated as signed (S) or unsigned (U).

FACTOR: Multiplier used to compute actual signal value from CAN message bits(s). Equivalent to Vector CANdb++ Editor definition of signal FACTOR.

OFFSET: Constant offset applied after scale FACTOR to compute actual signal value. Equivalent to Vector CANdb++ Editor definition of signal OFFSET.

Comments should be used in this block to clarify the meaning or units of signals and to note other useful information such as scale factors. See Table V for limits imposed on the number of Messages and Signals defined.

Examples

EX #1: Define the single-bit warning signal as bit 4 of the fourth byte of CAN message 0x074, channel 2.

```
Warning = 2,074,3,1,10,U,1,0
```

EX #2: Define Speed as the first two bytes of CAN message 0x600 on channel 1.

```
# true speed = byte_value/16 m/s
Speed = 1,600,0,2,ffff,U,0.0625,0.0
```

EX #3: Define the signed16-bit Yawrate as the third and fourth bytes of CAN message 0x600 on channel 1.

```
# true yaw rate = byte_value/16 d/s
Yawrate = 1,600,2,2,ffff,S,0.0625,0.0
```

EX #4: Define Scan as the first two bytes of CAN message 0x601 on channel 1. Also define ScanLow as the lower 13 bits of the same quantity.

```
Scan = 1,601,0,2,ffff,U,1,0
ScanLow = 1,601,0,2,1fff,U,1,0
```

5.4.3.1.3 CAN Trigger Condition Definition

The CAN Trigger Condition Block begins with the key string CAN_TRIG_ENA and defines the trigger conditions that DV will monitor. Following the key string line are trigger conditions, one per line. Each trigger condition is defined according to the following syntax that specifies one or more primitives separated by semicolons:
TRIGGER_NAME = SIGNAL, LOGIC, VALUE; SIGNAL, LOGIC, VALUE; ...
The trigger condition descriptions are as follows:

TRIGGER_NAME: Unique, descriptive name of CAN trigger condition
SIGNAL: Name of signal defined in Signal Definition Block
LOGIC: Name of logical test to perform. The valid tests are:
- EQ : Equal to VALUE
- NE : Not equal to VALUE
- LT : Less than VALUE
- LE : Less than or equal to VALUE
- GT : Greater than VALUE
- GE : Greater than or equal to VALUE

VALUE: Comparison value defining scaled signal value (expressed in engineering units, e.g. m/s) that will initiate trigger.

Comments can be used in this block to clarify the meaning of triggers and to note other useful info such as scale factors.

Examples

EX #1: Trigger when a warning is issued (Warning bit set to 1) and the Speed >= 30m/s. Speed comparison value includes scale factor of 128 needed to compensate for un-scaled signal.

```
# 30 m/s
HighSpeedWarn = Speed, GE, 30.0; Warning, EQ, 1
```

EX #2: Trigger when a warning is issued (Warning bit set to 1) and the Speed < 30m/s.

```
# 30 m/s
LowSpeedWarn = Speed, LT, 30.0; Warning, EQ, 1
```

EX #3: Trigger every six minutes (6.8 minutes measured using low bits of a 100ms counter present in CAN data).

```
Every6Min = ScanLow, EQ, 4096
```

EX #4: Trigger when yaw rate exceeds 5 degrees/sec.

```
# 5 d/s
HighYawRight = Yawrate, GT, 5
HighYawLeft = Yawrate, LT, -5
```

5.4.3.2 File Parse Errors

DV cannot validate the data in the trigger configuration file, but the parser can detect the various syntactical and file errors shown in Table IV. Additionally, certain limits are imposed on how many Messages, Signals, and Triggers are defined and used (see Table V). All error details (including line number, where applicable) are reported to the user via DV's regular error reporting methods.

Table IV. Errors detected in CAN trigger configuration files.

Error Text	Subtext
Cannot open trigger specification file <filename>.	
Error in Signal specification on line <#> of <filename>. {Subtext} Signal skipped.	Incorrect sign specification <string>.
	Incorrect number of valid tokens found <# found>.
Error in Trigger specification on line <#> of <filename>. {Subtext} Trigger Skipped.	Cannot find trigger name.
	Incorrect number of valid tokens found <# found>.
	Invalid relation specification <string>.
{Message/Signal/Trigger Limit Errors, see Table V}	
Multiple Signals defined with the name <name>.	
Trigger condition <name> refers to undefined Signal <name>.	
Failed post-processing of trigger data in file <filename>.	

Table V. Limits imposed on Signal and Trigger definitions.

Quantity	Limit	Limit Description
MAX_MESSAGES	20	Total number of CAN message ID's referenced.
MAX_SIGNALS_PER_MESSAGE	20	Number of signals defined for one message.
MAX_PRIMITIVES_PER_SIGNAL	20	Number of primitives that depend on each Signal.
MAX_PRIMITIVES_PER_TRIGGER	5	Number of primitives allowed per trigger.
MAX_TRIGGERS	45	Total number of triggers defined.

5.5 Remote Control

DV allows trigger and some other requests to be input remotely. Currently, one must have a particular piece of hardware installed in the data-logging machine (usually a PiP computer) for this function. In the future, a switch/LED circuit connected to the logging laptop parallel port will do. Remote operations include start/stop manual logging, enable/disable CAN triggered logging, request triggered log, etc. System pulse and other diagnostic signals can be displayed to the driver via LED.

5.6 Command Line Options

The supported command line options are shown in Table VI. These can be used on the command line of a DOS shell window, or they can be specified in the Properties page of a shortcut to DV.

Table VI. Command Line Options.

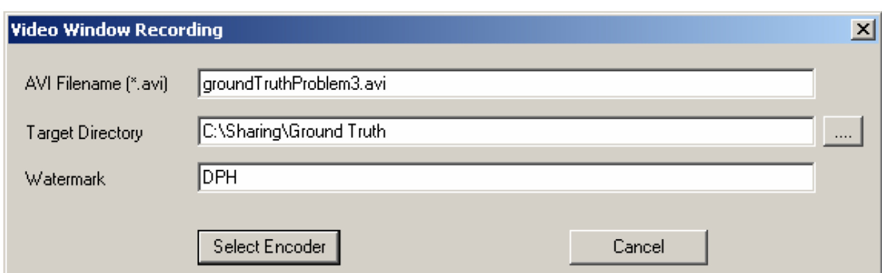
	Option	Description
Receive / Logging	/r	Start receiving immediately on launch.
	/l	Start logging immediately on launch. (Use with /r)
	/t	Enable Automatic Logging (CANTrigger) mode. (See Section 5)
Replay	*.dvl	Open the specified log file on launch.
	/snnn	Automatically jump forward to the first instance of the index specified by "nnnn". Must be used with the filename option above. (Note, there is no "space" between the /s characters and the index number).

5.7 Data Replay

5.7.1 Main Video Display

5.7.1.1 Creating Video Clips with Overlay

Recording the main video display to a video will output a selection of both the underlying video file and the DV-generated overlay. This output will be a separate video file that can be viewed in any media player, without the need for DV. Recording a video is initiated by selecting Record Main Video Display/Start in the right-click menu of the main video display. Filename, target directory, and watermark can be selected. The ".avi" must be included at the end of the chosen file name; the watermark is an optional text overlay of the video.



After an encoder is selected, recording begins. Any frame viewed is added to the recording; moving backwards will cause a reversal of action in the recording, rather than change its overall stopping point. Recording is terminated through the same right-click menu through which it was begun.

The recommended encoder is "x.264" used with default settings, which will generate a recording with reasonable image quality as well as small file size. It can be found on *http://www.freecodecs. com/x264_Video_Codec_download.htm*.

5.7.1.2 Creating Video Clips with Overlay

8.1.2 Saving Single Images with Overlay
Recording the main video display to a picture will output a single frame of both the underlying video file and the DV-generated overlay, which can then be opened in any image program.

Recording an image is initiated by selecting Output Window in the right-click menu of the main video display. The image can be saved as a bitmap file or exported to the clipboard, where it can be pasted into any image program and subsequently saved. If bitmap is selected, filename, target directory, and watermark can again be specified; the ".bmp" extension must be included at the end of the chosen file name.

6 Design Specifications

6.1 Design Assumptions

6.1.1 Roadway Conditions

The ESR will operate on two lane roadways as well as multi-lane divided highways. Situations that the ESR may encounter include straight and curved roadways, dense traffic situations with vehicles in all lanes traveling at various speeds (including stopped vehicles), oncoming traffic in adjacent lanes, other vehicles changing lanes and cutting into or out of the host vehicle path, as well as lane changes by the host vehicle. Particular multi-target situations include a small in-path vehicle (e.g., a motorcycle) behind or adjacent to a large vehicle (e.g., a truck), a small in-path vehicle between two large adjacent lane vehicles, and two large adjacent lane vehicles with no in-path vehicle. The nominal lane width is 3.65m.
The ESR is capable of tracking an object while the host vehicle is driving under rough road conditions producing vibration and momentary vehicle pitch angles not in excess of ± 2 degrees and below 2 seconds.

6.1.2 Targets of Interest

The targets of interest include all licensable motor vehicles allowed to operate on U.S. interstate highways and European motorways or highways. These include cars, buses, trucks, motorcycles, recreational vehicles, etc., and items being towed including trailers, campers, boats, small utility trailers, etc. The smallest radar target of interest is a motorcycle assumed to be 1m2 RCS at 76.5GHz. A midsize passenger car is typically on the order of 10m2. The largest vehicle RCS is assumed to be 40dBsm (10,000m2). The RCS distribution is assumed to be Swerling III.

6.1.3 Clutter

The road environment includes distributed road surfaces and roadside clutter and stationary clutter discretizations consisting of guard rails, sign posts, trees, and overhead bridges. The clutter discretizations are typically on the order of 1 to 10m2 at 76.5GHz with the upperbound assumed to be 10,000m2 (40dBsm). The approximate minimum height of overhead bridges and signs is assumed to be 3.65m. Adverse weather conditions include rain, snow, and fog. Radar performance is specified for heavy rain up to 16mm/hr, heavy snow with equivalent water content up to 10mm/hr, and heavy fog with water density up to 1gm/m3 (8m visibility).

6.2 Power Up and Control

6.2.1 Power Up

The ESR is capable of safe functional operation within 7 seconds of power being applied to the system.

6.2.2 RF Transmission Control

ESR is able to disable and enable radiating. ESR radiating is fully operational within 200ms after commanded to radiate by the ESR controller.

6.2.3 Mutual Interference

The ESR is designed to be immune from appreciable effects of other range measuring sensors operating in the same vicinity.
ESR performs self-diagnostics for sensor blockage, sensor misalignment, and sensor internal failures. Examples of such mechanisms are fake targets that are artificially injected in the beginning of the radar echo reception chain and checked at the end for correctness.

6.3 Electrical Specifications

6.3.1 Power Moding

Range Name	Range ID	Description	Lower Limit Value	Upper Limit Value	Acceptance Requirements *	Hysteresis
Max Overvoltage Range	VR_H	Damage allowed	26V for 1 minute 18V for 1 hour	∞	Damage allowed	None
Overvoltage Range	VR1	No damage	16V with Hysteresis	Lower limit of VR_H	No damage allowed High-voltage related diagnostics allowed Functions may not be fully operational during or after exposure	16.5V to set high voltage flag and 16.0V to clear high voltage flag
Normal Operating Range	VR2	Full-specified operation	9V with Hysteresis	Lower limit of VR1	No damage allowed No voltage-related diagnostics allowed Functions are fully operational	8.5V to set low voltage and 9.0V to clear low voltage flag
		CAN communication only	8V with Hysteresis		No damage allowed No voltage-related diagnostics allowed CAN communications are fully operational	7.5V to set low voltage and 8.0V to clear low voltage flag
Low Voltage Operating Range	VR3	No damage allowed No function required No corruption of any non-volatile memory	8V	Lower limit of VR2	No damage allowed Low-voltage related diagnostics allowed Functions may not be fully operational during or after exposure	None
Under Voltage Range	VR4	No damage allowed No function required	0	8V	No damage allowed Low-voltage related diagnostics allowed Functions may not be fully operational during or after exposure	None
Reverse Voltage Range	VR5	No damage allowed No function required	-13.5V for 2 minutes	0	No damage allowed Low-voltage related diagnostics allowed Functions may not be fully operational during or after exposure	None
Max Reverse Voltage Range	VR_L	Damage allowed	-∞	-13.5V for 2 minutes	Damage allowed	None

* These acceptance requirements also apply to conditions. For example, for a voltage dropout transient to 0V, the acceptance requirements for VR4 shall be applied, even though the nominal voltage was within range VR2.

6.3.2 Normal Operating Range Voltage / Current / Power

6.3.2.1 Voltage

ESR operates within the supply voltage range of +8V through +16V. ESR is fully functional within +9V through +16V and have CAN communications between +8V through +9V. The ESR will not malfunction when exposed to an input voltage less than 8 Volts and operate normally when a voltage within the operating range is restored.

6.3.2.2 Current

Parameter	Unit	Maximum Value
OFF Current	uA	100
Switching ON Current	mA	3
ON Current	A	2
ON Power	W	18

6.3.3 Power Supply Dropout

Starting at 12.0 volts, a voltage dropout up to 20 milliseconds when the vehicle supply voltage (Vbatt) drops to 0 VDC should not cause the ESR to corrupt memory, locking of ECU, incorrect ECU state, or incorrect features. Outputs may dropout during this period though will recover without user intervention. During the time that the ESR is recovering from the reset back to full operation, the ESR will indicate to the ESR controller or driver that the radar detection capability is unavailable.

During this dropout, the ESR will reduce current draw through various countermeasures (i.e., turning off the radar transceiver and stopping CAN message transmission) to extend the time (up to 1.38ms) before a reset occurs.

6.4 Mechanical Specifications

6.4.1 Size and Mass

Parameter	Unit	Maximum Value
Height	mm	90.2
Width	mm	173.7
Depth	mm	49.2
Mass	g	575

6.4.2 Durability

Parameter	Unit	Minimum Value
Functional Life	Miles	150,000
Functional Life	years	10
Module Activation	cycles	60,000
Ignition ON Time	hours	8,000

6.4.3 Storage Conditions

The ESR is designed for storage conditions of -10 °C to +55 °C at 85 % maximum relative humidity for a minimum of 5 years.

7 CAN Message Details and Attributes

Ident	Message	Byte. Bit	Description	Range	Units	Scaling	Default	Cycle Time	Source *
000 – 4DF	(Avoid using messages in this range to avoid higher priority messages than transmitted radar messages)								
4E0	CAN_TX_SCAN_INDEX	(See DBC File)	Scan Index	0 to 65535	n/a	1	0	50ms	MMR
4E0	CAN_TX_ROLLING_COUNT_1		Rolling Count Make this the lower 2 bits of "Scan Index" above	0 to 3	n/a	1	0	50ms	MMR
4E0	CAN_TX_DSP_TIMESTAMP		Upper 7 bits of lower byte of DSP timestamp in ms	0 to 254	ms	2	0	50ms	MMR
4E0	CAN_TX_VEHICLE_SPEED_CALC		Contains the compensated vehicle speed used within the ESR. The ESR internally compensates based on range rate of stationary targets.	0 to 127.9375	m/s	0.0625	0	50ms	MMR
4E0	CAN_TX_YAW_RATE_CALC		Contains the bias-compensated yaw rate used within the ESR	-128 to 127.9375	deg/s	0.0625	0	50ms	MMR
4E0	CAN_TX_RADIUS_CURVATURE_CALC		Contains the calculated radius-of-curvature used within the ESR	-8192 - 8191	m	1	8191	50ms	MMR
4E0	CAN_TX_COMM_ERROR		Indication that the sensor has detected a communication error	False/True	bool	0: False 1: True	False	50ms	MMR
4E1	CAN_TX_ROLLING_COUNT_2		Rolling Count Make this the lower 2 bits of "Scan Index" above	0 to 3	n/a	1	0	50ms	MMR
4E1	CAN_TX_STEERING_ANGLE_ACK		Steering Angle ACK ACK of CAN_RX_STEERING_ANGLE Unsigned	0 to 2047	deg	1	0	50ms	MMR
4E1	CAN_TX_XCVR_OPERATIONAL		Sensor Status Radiating 0 = not radiating 1 = radiating	0 to 1	n/a	1	0	50ms	MMR
4E1	CAN_TX_INTERNAL_ERROR		Sensor Status Failed 0 = not failed 1 = failed	0 to 1	n/a	1	0	50ms	MMR
4E1	CAN_TX_RANGE_PERF_ERROR		Sensor Status Blocked 0 = not blocked 1 = blocked	0 to 1	n/a	1	0	50ms	MMR
4E1	CAN_TX_OVERHEAT_ERROR		Sensor Status Temperature Shutdown 0 = not overtemperature 1 = overtemperature	0 to 1	n/a	1	0	50ms	MMR
4E1	CAN_TX_MAXIMUM_TRACKS_ACK		Maximum Number of Objects of Interest to Report ACK Note that maximum number of tracks is 1 more than CAN value	1 to 64	n/a	1	64	50ms	MMR
4E1	CAN_TX_RAW_DATA_MODE		Raw Data Mode 0 = Outputting Filtered Radar Data 1 = Outputting Raw Radar Data	0 to 1	n/a	1	0	50ms	MMR
4E1	CAN_TX_GROUPING_MODE		Grouping Mode 0 = No grouping of stationary or moving targets 1 = Grouping moving targets only 2 = Grouping stationary targets only 3 = Grouping stationary and moving targets	0 to 3	n/a	1	0	50ms	MMR
4E1	CAN_TX_TEMPERATURE		Internal Temperature	-128 to 127	degC	1	25	50ms	MMR
4E1	CAN_TX_SW_VERSION_DSP		DSP Software Version	0x0000 to 0xFFFF	n/a	1	0	50ms	MMR
4E1	CAN_TX_YAW_RATE_BIAS		Yaw rate bias Internal values may be up to +/-20deg/s. Therefore these values may be saturated	-16 to 15.875	deg/s	0.125	0	50ms	MMR

4E1	CAN_TX_VEH_SPD_COMP_FACTOR		Vehicle speed compensation factor An offset of 1.0 is assumed	0.9375 to 1.060546875	n/a	0.001953125	1	50ms	MMR
4E2	CAN_TX_SW_VERSION_HOST		Host Software Version	0x000000 to 0xFFFFFF	n/a	1	0	50ms	MMR
4E2	CAN_TX_HW_VERSION		Hardware Version Make equivalent to CAN_RADAR_LEVEL from ACC3 mode	0 to 15	n/a	1	0	50ms	MMR
4E2	CAN_TX_INTERFACE_VERSION		Interface Version Number 0 = TDP ESR mode with 64 tracks 1 = ADP DV1 ESR mode with 64 tracks 2 = ADP DV1 ESR mode for DV1 MOART delivery 3 = ADP DV2 ESR mode 4 = ADP DV3 ESR mode 5 = ADP PV ESR mode 6 = ADP PV ESR mode (MY2011) … 15 = TBD	0 to 15	n/a	1	0	50ms	MMR
4E2	CAN_TX_SERIAL_NUM		Serial Number Make equivalent to CAN_MMR_SERIAL_NUM from ACC3 mode	0x000000 to 0xFFFFFF	n/a	1	0	50ms	MMR
4E2	CAN_TX_SW_VERSION_PLD		PLD Software Version	0 to 255	n/a	1	0	50ms	MMR
4E3	CAN_TX_ROLLING_COUNT_3		Rolling Count Make this the lower 2 bits of "Scan Index" above	0 to 3	n/a	1	0	50ms	MMR
4E3	CAN_TX_PATH_ID_ACC_STAT		In-path ACC target ID (stationary or oncoming) (Only 0 through 64 used but full byte used for simplified packing)	0 to 255	n/a	1	0	50ms	MMR
4E3	CAN_TX_PATH_ID_ACC		In-path ACC target ID (moving or moveable) (Only 0 through 64 used but full byte used for simplified packing)	0 to 255	n/a	1	0	50ms	MMR
4E3	CAN_TX_PATH_ID_CMBB_MOVE		In-path moving CMbB target ID (Only 0 through 64 used but full byte used for simplified packing)	0 to 255	n/a	1	0	50ms	MMR
4E3	CAN_TX_PATH_ID_CMBB_STAT		In-path stationary CMbB target ID (Only 0 through 64 used but full byte used for simplified packing)	0 to 255	n/a	1	0	50ms	MMR
4E3	CAN_TX_PATH_ID_FCW_MOVE		In-path moving FCW target ID (Only 0 through 64 used but full byte used for simplified packing)	0 to 255	n/a	1	0	50ms	MMR
4E3	CAN_TX_PATH_ID_FCW_STAT		In-path stationary FCW target ID (Only 0 through 64 used but full byte used for simplified packing)	0 to 255	n/a	1	0	50ms	MMR
4E3	CAN_TX_AUTO_ALIGN_ANGLE		Automatic alignment angle (+) = clockwise	-8 to 7.9375	deg	0.0625	0	50ms	MMR
4E3	CAN_TX_MR_LR_MODE		Indicator of what types of tracks are being output by the ESR 0 = reserved 1 = MR-only 2 = LR-only 3 = MR and LR	0 to 3	n/a	1	0	50ms	MMR
4E3	CAN_TX_PARTIAL_BLOCKAGE		Flag indicating that partial sensor blockage has been detected (does not include CW ground clutter)	False/True	bool	0: False 1: True	False	50ms	MMR
4E3	CAN_TX_SIDELOBE_BLOCKAGE		Flag indicating that partial blockage based on sidelobe detections has been detected	False/True	bool	0: False 1: True	False	50ms	MMR

4E3	CAN_TX_LR_ONLY_GRATING_LOBE_DET		Flag indicating that the track that would otherwise be ACC CIPV target has been classified as a grating lobe target and therefore may not be classified as ACC CIPV by the ESR	False/True	bool	0: False 1: True	False	50ms	MMR
4E3	CAN_TX_TRUCK_TARGET_DET		Flag indicating that the track that would otherwise be ACC CIPV target has been classified as a forward truck target and therefore may not be classified as ACC CIPV by the ESR	False/True	bool	0: False 1: True	False	50ms	MMR
4F0	CAN_RX_VEHICLE_SPEED		Host Vehicle Speed (+) = positive	0 to 127.9375	m/s	0.0625	0	20ms	ACM (required)
4F0	CAN_RX_VEHICLE_SPEED_DIRECTION		Host Vehicle Direction 0 = Forward 1 = Reverse	0 to 1	n/a	1	0	20ms	ACM (optional)
4F0	CAN_RX_YAW_RATE		Vehicle Yaw Rate (+) = clockwise	-128 to 127.9375	deg/s	0.0625	0	20ms	ACM (required)
4F0	CAN_RX_YAW_RATE_VALIDITY		Vehicle Yaw Rate Validity 0 = No vehicle yaw rate or invalid 1 = vehicle yaw rate available and valid	0 to 1	n/a	1	0	20ms	ACM (required)
4F0	CAN_RX_RADIUS_CURVATURE		Radius of Curvature (+) = clockwise	-8192 - 8191	m	1	8191	20ms	ACM (optional)
4F0	CAN_RX_STEERING_ANGLE		Steering Angle 0 = Steering wheel centered	0 to 2047	deg	1	0	20ms	ACM (optional)
4F0	CAN_RX_STEERING_ANGLE_SIGN		Steering Angle Sign 0 = Steering wheel velocity left (Counterclockwise) 1 = Steering wheel velocity right (Clockwise)	0 to 1	n/a	1	0	20ms	ACM (optional)
4F0	CAN_RX_STEERING_ANGLE_RATE		Steering Angle Rate	0 to 2047	deg/s	1	0	20ms	ACM (optional)
4F0	CAN_RX_STEERING_ANGLE_RATE_SIGN		Steering Angle Rate Sign 0 = Left turn (Counterclockwise) 1 = Right turn (Clockwise)	0 to 1	n/a	1	0	20ms	ACM (optional)
4F0	CAN_RX_STEERING_ANGLE_VALIDITY		Steering Angle Validity 0 = No steering angle sensor or invalid 1 = steering angle sensor data available and valid	0 to 1	n/a	1	0	20ms	ACM (optional)
4F1	CAN_RX_SCAN_INDEX_ACK		Scan Index ACK ACK of CAN_TX_SCAN_INDEX	0 to 65535	n/a	1	0	20ms	ACM (required)
4F1	CAN_RX_LATERAL_MOUNTING_OFFSET		Lateral Mounting Offset (+) = to the right from driver's perspective Excessive range to indicate that variable does not require range check. ACM will internally limit this value to –1 .. 1. A value from -1.9375 to 1.9375 may be used for engineering development. Larger values should not be used due to an overflow in the Tracker	-1.9375 to 1.9375	m	0.015625	0	20ms	ACM (required)
4F1	CAN_RX_ANGLE_MISALIGNMENT		Alignment Angle Offset (+) = clockwise	-8 to 7.9375	deg	0.0625	0	20ms	ACM (required)
4F1	CAN_RX_MAXIMUM_TRACKS		Maximum Number of Objects of Interest to Report Note that maximum number of tracks is 1 more than CAN value	1 to 64	n/a	1	64	20ms	ACM (required)
4F1	CAN_RX_RADAR_CMD_RADIATE		Sensor Mode Command 0 = Do not radiate 1 = Radiate	0 to 1	n/a	1	0	20ms	ACM (required)
4F1	CAN_RX_WIPER_STATUS		Windshield Wiper Status 0 = Off 1 = On	0 to 1	n/a	1	0	20ms	ACM (optional)
4F1	CAN_RX_RAW_DATA_ENABLE		Raw Data Enable 0 = Filtered Radar Data 1 = Raw Radar Data	0 to 1	n/a	1	0	20ms	ACM (optional)

4F1	CAN_RX_GROUPING_MODE		Grouping Mode 0 = No grouping of stationary or moving targets 1 = Grouping moving targets only 2 = Grouping stationary targets only 3 = Grouping stationary and moving targets	0 to 3	n/a	1	0	20ms	ACM (optional)
4F1	CAN_RX_MMR_UPSIDE_DOWN		Flag indicating that the MMR is upside down. Therefore all angles should be reported with opposite sense 0 = right-side-up / 1 = upside-down	0 to 1	n/a	1	0	20ms	ACM (required)
4F1	CAN_RX_VEHICLE_SPEED_VALIDITY		Vehicle Speed Validity 0 = No vehicle speed or invalid 1 = vehicle speed available and valid	0 to 1	n/a	1	0	20ms	ACM (required)
4F1	CAN_RX_TURN_SIGNAL_STATUS		Turn signal status 0 = None 1 = Left 2 = Right	0 to 2	n/a	1	0	20ms	ACM (optional)
4F1	CAN_RX_BLOCKAGE_DISABLE		Blockage disable flag. Used to disable blockage during certain scenarios, such as vehicle dyno testing and EMC testing 0 = blockage not disabled 1 = blockage disabled	0 to 1	n/a	1	0	20ms	ACM (required)
4F1	CAN_RX_USE_ANGLE_MISALIGNMENT		Flag to allow controller to initialize the auto alignment angle 0 = Off 1 = On	0 to 1	n/a	1	0	20ms	ACM (required)
4F1	CAN_RX_CLEAR_FAULTS		Flag to command clearing codes 0 = Off 1 = On	0 to 1	n/a	1	0	20ms	ACM (required)
4F1	CAN_RX_HIGH_YAW_ANGLE		Angle misalignment used for Applications where the radar is mounted at very high yaw angles	-32 to 31	deg	1	0	20ms	ACM (required)
4F1	CAN_RX_LR_ONLY_TRANSMIT		Flag indicating that the radar should only transmit LR. Using LR-only transmit allows reduction of mutual interference	0 to 1	n/a	1	0	50ms	ACM (required)
4F1	CAN_RX_MR_ONLY_TRANSMIT		Flag indicating that the radar should only transmit MR. Using MR-only transmit allows reduction of mutual interference	0 to 1	n/a	1	0	50ms	ACM (required)
4F1	CAN_RX_Edit_SHORT_TRACK_ROC		Radius of curvature of the Volvo short-track 0 = straight (ROC = infinity) For Gent, this would be -1500m For Torslanda, this would be 0 (infinity ROC)	-4000 to 3500	M	500	0	50ms	ACM (required)
4F9h – 4FAh	(Do not use this range. Reserved for CADS2 / CADS3 development)								
500 – 53F	CAN_TX_TRACK_ROLLING_COUNT		Rolling Count must = rolling count of all messages in this burst	0 to 1	n/a	1	0	50ms	MMR
500 – 53F	CAN_TX_TRACK_RANGE		Range (+) = away from sensor set at 204.7 if > 204.7	0 to 204.7	m	0.1	200	50ms	MMR
500 – 53F	CAN_TX_TRACK_RANGE_RATE		Range Rate (+) = away from sensor set at 81.91 if > 81.91 set at -81.92 if < -81.92	-81.92 to 81.91	m/s	0.01	81.91	50ms	MMR
500 – 53F	CAN_TX_TRACK_RANGE_ACCEL		Range Acceleration (+) = away from sensor set at 25.55 if > 25.55 set at -25.6 if < -25.6	-25.6 to 25.55	m/s/s	0.05	0	50ms	MMR

500 – 53F	CAN_TX_TRACK_ANGLE		Azimuth 0 = toward front of vehicle parallel to vehicle centerline (+) = clockwise set at 51.1 if > 51.1 set at -51.2 if < -51.2	-51.2 to 51.1	deg	0.1	0	50ms	MMR
500 – 53F	CAN_TX_TRACK_WIDTH		Width set at 7.5 if > 7.5	0 to 7.5	m	0.5	0	50ms	MMR
500 – 53F	CAN_TX_TRACK_GROUPING_CHANGED		Boolean indicator that number of detections associated with the track have changed 0 = no change 1 = change	0 to 1	n/a	1	0	50ms	MMR
500 – 53F	CAN_TX_TRACK_ONCOMING		Oncoming Flag 0 = not oncoming / 1 = oncoming	0 to 1	n/a	1	0	50ms	MMR
500 – 53F	CAN_TX_TRACK_LAT_RATE		Lateral Rate (+) = counter clockwise set at 7.75 if > 7.75 set at -8 if < -8	-8 to +7.75	m/s	0.25	0	50ms	MMR
500 – 53F	CAN_TX_TRACK_MED_RANGE_MODE		Indicates which mode updated the fused track 0 = No MR / LR update 1 = MR update only 2 = LR update only 3 = Both MR / LR update	0 to 3	n/a	1	0	50ms	MMR
500 – 53F	CAN_TX_TRACK_STATUS		Measurement Status 0 = no target 1 = new target 2 = new updated target 3 = updated target 4 = coasted target 5 = merged target 6 = invalid coasted target 7 = new coasted target	0 to 7	n/a	1	0	50ms	MMR
500 – 53F	CAN_TX_TRACK_BRIDGE_OBJECT		Indicates if target is a bridge or not 0 = not a bridge 1 = bridge	0 to 1	n/a	1	0	50ms	MMR
540	CAN_TX_TRACK_ROLLING_COUNT_2		Same as CAN_TX_TRACK_ROLLING_COUNT	0 to 1	n/a	1	0	50ms	MMR
540	CAN_TX_TRACK_CAN_ID_GROUP		CAN ID group 0 = Group 1 (Tracks 1 through 7) 1 = Group 2 (Tracks 8 through 14) 2 = Group 3 (Tracks 15 through 21) 3 = Group 4 (Tracks 22 through 28) 4 = Group 5 (Tracks 29 through 35) 5 = Group 6 (Tracks 36 through 42) 6 = Group 7 (Tracks 43 through 49) 7 = Group 8 (Tracks 50 through 56) 8 = Group 9 (Tracks 57 through 63) 9 = Group 10 (Track 64)	0-9	n/a	1	0	50ms	MMR
540	CAN_TX_TRACK_MOVING		Moving Flag 0 = stationary / 1 = moving	0 to 1	n/a	1	0	50ms	MMR
540	CAN_TX_TRACK_MOVABLE_FAST		Fast Movable Flag 0 = not movable / 1 = movable	0 to 1	n/a	1	0	50ms	MMR
540	CAN_TX_TRACK_MOVABLE_SLOW		Slow Movable Flag 0 = not movable / 1 = movable	0 to 1	n/a	1	0	50ms	MMR
540	CAN_TX_TRACK_POWER		Track amplitude This amplitude has an offset of -10dB. For example, CAN_TX_TRACK_POWER of 31 = 21dB set at 31 if > 21dB set at 0 if < -10dB	-10 to 21	dB	1	0	50ms	MMR
5D0	CAN_TX_VALID_LR_SN		Long-range Validation sensor serial number	0 to 255	n/a	1	0	50ms	MMR

5D0	CAN_TX_VALID_LR_RANGE		Long-range Validation sensor range	0 to 200	m	1/128	0	50ms	MMR
5D0	CAN_TX_VALID_LR_RANGE_RATE		Long-range Validation sensor range rate	-128 to 127	m/s	1/128	0	50ms	MMR
5D0	CAN_TX_VALID_LR_ANGLE		Long-range Validation sensor angle	-64 to 63.9375	deg	1/16	0	50ms	MMR
5D0	CAN_TX_VALID_LR_POWER		Long-range Validation sensor power	-10 to 40	dB	1	0	50ms	MMR
5D1	CAN_TX_VALID_MR_SN		Mid-range Validation sensor serial number	0 to 255	n/a	1	0	50ms	MMR
5D1	CAN_TX_VALID_MR_RANGE		Mid-range Validation sensor range	0 to 200	m	1/128	0	50ms	MMR
5D1	CAN_TX_VALID_MR_RANGE_RATE		Mid-range Validation sensor range rate	-128 to 127	m/s	1/128	0	50ms	MMR
5D1	CAN_TX_VALID_MR_ANGLE		Mid-range Validation sensor angle	-64 to 63.9375	deg	1/16	0	50ms	MMR
5D1	CAN_TX_VALID_MR_POWER		Mid-range Validation sensor power	-10 to 40	dB	1	0	50ms	MMR
5E0h – 5E3h	(Do not use this range. Previously used with DV1 sensors)								
5E4	CAN_TX_SWBATT_A2D		Switched battery A/D reading (upper 8 bits of 10-bit A/D reading)	0 to 255	n/a	1	0	50ms	MMR
5E4	CAN_TX_IGNP_A2D		Ignition A/D reading (upper 8 bits of 10-bit A/D reading)	0 to 255	n/a	1	0	50ms	MMR
5E4	CAN_TX_TEMP1_A2D		Thermistor #1 A/D reading (upper 8 bits of 10-bit A/D reading)	0 to 255	n/a	1	0	50ms	MMR
5E4	CAN_TX_TEMP2_A2D		Thermistor #2 A/D reading (upper 8 bits of 10-bit A/D reading)	0 to 255	n/a	1	0	50ms	MMR
5E4	CAN_TX_SUPPLY_5VA_A2D		5VA supply A/D reading (upper 8 bits of 10-bit A/D reading)	0 to 255	n/a	1	0	50ms	MMR
5E4	CAN_TX_SUPPLY_5VDX_A2D		5VDX supply A/D reading (upper 8 bits of 10-bit A/D reading)	0 to 255	n/a	1	0	50ms	MMR
5E4	CAN_TX_SUPPLY_3P3V_A2D		3.3V supply A/D reading (upper 8 bits of 10-bit A/D reading)	0 to 255	n/a	1	0	50ms	MMR
5E4	CAN_TX_SUPPLY_10V_A2D		10V supply A/D reading (upper 8 bits of 10-bit A/D reading)	0 to 255	n/a	1	0	50ms	MMR
5E5	CAN_TX_SUPPLY_1P8V_A2D		1.8V supply A/D reading (upper 8 bits of 10-bit A/D reading)	0 to 255	n/a	1	0	50ms	MMR
5E5	CAN_TX_SUPPLY_N5V_A2D		-5V supply A/D reading (upper 8 bits of 10-bit A/D reading)	0 to 255	n/a	1	0	50ms	MMR
5E5	CAN_TX_WAVE_DIFF_A2D		Wave diff A/D reading (upper 8 bits of 10-bit A/D reading)	0 to 255	n/a	1	0	50ms	MMR
5E5	CAN_TX_SYSTEM_POWER_MODE		System power mode 0 = DSP_INIT 1 = RADIATE_OFF 2 = RADIATE_ON 3 = DSP_SHUTDOWN 4 = DSP_OFF 5 = HOST_SHUTDOWN 6 = TEST 7 = (invalid)	0 to 7	n/a	1	0	50ms	MMR
5E5	CAN_TX_RECOMMEND_UNCONVERGE		Recommendation from automatic alignment algorithm to unconverge the alignment 0 = Not recommended 1 = Recommended	0 to 1	n/a	1	0	50ms	MMR
5E5	CAN_TX_FACTORY_ALIGN_STATUS_1		State of the factory alignment process for 1-target factory alignment 0 = OFF 1 = BUSY 2 = SUCCESS 3 = FAIL_NO_TARGET 4 = FAIL_DEV_TOO_LARGE 5 = FAIL_VAR_TOO_LARGE	0 to 5	n/a	1	0	50ms	MMR

5E5	CAN_TX_FACTORY_ALIGN_STATUS_2		State of the factory alignment process for 2-target factory alignment 0 = OFF 1 = BUSY 2 = SUCCESS 3 = FAIL_NO_TARGET 4 = FAIL_DEV_TOO_LARGE 5 = FAIL_VAR_TOO_LARGE	0 to 5	n/a	1	0	50ms	MMR
5E5	CAN_TX_FACTORY_MISALIGNMENT		Misalignment angle from factory alignment algorithm (+) = clockwise	-5 to +5	deg	0.0625	0	50ms	MMR
5E5	CAN_TX_FOUND_TARGET		Indicates that at least one target which meets minimum criteria has been seen this ignition cycle 0 = 1 target not found 1 = 1 target found	0 to 1	n/a	1	0	50ms	MMR
5E5	CAN_TX_SERV_ALIGN_UPDATES_DONE		Number of service alignment updates done	0 to 255	n/a	1	0	50ms	MMR
5E5	CAN_TX_VERTICAL_MISALIGNMENT		Vertical misalignment of radar determined through factory alignment process Pointing up is positive	-6 to +6	deg	0.0625	0	50ms	MMR
5E5	CAN_TX_VERTICAL_ALIGN_UPDATED		Vertical alignment updated 0 = not updated 1 = updated	0 to 1	n/a	1	0	50ms	MMR
5E5	CAN_TX_SW_VERSION_DSP_3RD_BYTE		Lower nibble of 3rd byte of DSP software version	0 to 15	n/a	1	0	50ms	MMR
5E6	CAN_TX_ACTIVE_FAULT_0		Active fault byte 0	0 to 255	n/a	1	0	50ms	MMR
5E6	CAN_TX_ACTIVE_FAULT_1		Active fault byte 1	0 to 255	n/a	1	0	50ms	MMR
5E6	CAN_TX_ACTIVE_FAULT_2		Active fault byte 2	0 to 255	n/a	1	0	50ms	MMR
5E6	CAN_TX_ACTIVE_FAULT_3		Active fault byte 3	0 to 255	n/a	1	0	50ms	MMR
5E6	CAN_TX_ACTIVE_FAULT_4		Active fault byte 4	0 to 255	n/a	1	0	50ms	MMR
5E6	CAN_TX_ACTIVE_FAULT_5		Active fault byte 5	0 to 255	n/a	1	0	50ms	MMR
5E6	CAN_TX_ACTIVE_FAULT_6		Active fault byte 6	0 to 255	n/a	1	0	50ms	MMR
5E6	CAN_TX_ACTIVE_FAULT_7		Active fault byte 7	0 to 255	n/a	1	0	50ms	MMR
5E7	CAN_TX_HISTORY_FAULT_0		History fault byte 0	0 to 255	n/a	1	0	50ms	MMR
5E7	CAN_TX_HISTORY_FAULT_1		History fault byte 1	0 to 255	n/a	1	0	50ms	MMR
5E7	CAN_TX_HISTORY_FAULT_2		History fault byte 2	0 to 255	n/a	1	0	50ms	MMR
5E7	CAN_TX_HISTORY_FAULT_3		History fault byte 3	0 to 255	n/a	1	0	50ms	MMR
5E7	CAN_TX_HISTORY_FAULT_4		History fault byte 4	0 to 255	n/a	1	0	50ms	MMR
5E7	CAN_TX_HISTORY_FAULT_5		History fault byte 5	0 to 255	n/a	1	0	50ms	MMR
5E7	CAN_TX_HISTORY_FAULT_6		History fault byte 6	0 to 255	n/a	1	0	50ms	MMR
5E7	CAN_TX_HISTORY_FAULT_7		History fault byte 7	0 to 255	n/a	1	0	50ms	MMR
5E8	CAN_TX_AVG_PWR_CWBLKG		Average power of CW blockage algorithm (equal to the average power output with esr_dvls_lst –xblkg)	0 to 4095	n/a	1	0	50ms	MMR
5E8	CAN_TX_SIDESLIP_ANGLE		Sideslip angle at Vehicle Coordinate System	-64 to 63.875	deg	0.125	0	50ms	MMR
5E8	CAN_TX_SERIAL_NUM_3RD_BYTE		3rd byte of serial number which includes the leading 2 digits of the sequence number	0 to 255	n/a	1	0	50ms	MMR

5E8	CAN_TX_WATER_SPRAY_TARGET_ID		Target ID of closest water spray	0 to 64	n/a	1	0	50ms	MMR
5E8	CAN_TX_FILTERED_XOHP_ACC_CIPV		Filtered XOHP of ACC CIPV target	-8 to 7.96875	m	0.03125	0	50ms	MMR
5E8	CAN_TX_PATH_ID_ACC_2		2nd closest ACC CIPV target	0 to 64	n/a	1	0	50ms	MMR
5E8	CAN_TX_PATH_ID_ACC_3		3rd closest ACC CIPV target	0 to 64	n/a	1	0	50ms	MMR
5F0h – 5F1h	(Do not use this range. Previously used with DV1 sensors)								
5F2	CAN_RX_LAT_ACCEL		Vehicle lateral acceleration Moving right from driver's perspective is positive	-8 to +7.96875	m/s/s	0.03125	0	50ms	ACM optional
5F2	CAN_RX_LAT_ACCEL_VALIDITY		Vehicle lateral acceleration validity 0 = No vehicle lateral acceleration or invalid 1 = vehicle lateral acceleration available and valid	0 to 1	n/a	1	0	50ms	ACM (optional)
5F2	CAN_RX_LONG_ACCEL		Vehicle longitudinal acceleration Forward motion is positive	-8 to +7.96875	m/s/s	0.03125	0	50ms	ACM (optional)
5F2	CAN_RX_LONG_ACCEL_VALIDITY		Vehicle longitudinal acceleration validity 0 = No vehicle longitudinal acceleration or invalid 1 = vehicle longitudinal acceleration available and valid	0 to 1	n/a	1	0	50ms	ACM (optional)
5F2	CAN_RX_RADAR_FOV_LR		Total field of view of the long-range mode Used to potentially reduce FOV for specific vehicle packaging situations	0 to 30	deg	1	20	50ms	ACM (required)
5F2	CAN_RX_RADAR_FOV_MR		Total field of view of the mid-range mode Used to potentially increase or decrease FOV for specific vehicle packaging situations	0 to 120	deg	1	90	50ms	ACM (required)
5F2	CAN_RX_RADAR_HEIGHT		Radar height from ground to center of radar elevation field-of-view	0 to 125	cm	1	50	50ms	ACM (optional)
5F2	CAN_RX_WHEEL_SLIP		Wheel slip 0=no control 1=Brake Slip Control active 2=Traction Slip Control active	0 to 2	n/a	1	0	50ms	ACM (optional)
5F2	CAN_RX_ANGLE_MOUNTING_OFFSET								
5F2	CAN_RX_AUTO_ALIGN_DISABLE		Auto alignment disable 0 = alignment not disabled 1 = alignment disabled	0 to 1	n/a	1	0	50ms	ACM (required)
5F2	CAN_RX_AUTO_ALIGN_CONVERGED		Auto alignment converged 0 = alignment not converged 1 = alignment converged	0 to 1	n/a	1	0	50ms	ACM (required)
5F2	CAN_RX_AALIGN_AVG_CTR_TOTAL		Time constant of heavy filter on automatic alignment updates (Engineering value is 250 times CAN_RX_AALIGN_AVG_CTR_TOTAL + 250)	250 to 2000	n/a	250	1000	50ms	ACM (required)
5F2	CAN_RX_SERV_ALIGN_ENABLE		Service alignment algorithm enable flag 0 = SA disable 1 = SA enable	0 to 1	n/a	1	0	50ms	ACM (required)
5F2	CAN_RX_SERV_ALIGN_TYPE		Service alignment type 0 = AUTO_OR_DEALER 1 = VOLVO_SHORT_TRACK	0 to 1	n/a	1	0	50ms	ACM (required)

5F2	CAN_RX_SERV_ALIGN_UPDATES_NEED		Number of service alignment updates needed	0 to 255	n/a	1	0	50ms	ACM (required)
5F3	CAN_RX_FAC_ALIGN_CMD_1		0 = Disable factory alignment process #1 (single C/R target) 1 = Enable factory alignment process #1 (single C/R target)	0 to 1	n/a	1	0	50ms	ACM (required)
5F3	CAN_RX_FAC_ALIGN_CMD_2		0 = Disable factory alignment process #2 (two C/R targets) 1 = Enable factory alignment process #2 (two C/R targets)	0 to 1	n/a	1	0	50ms	ACM (required)
5F3	CAN_RX_FAC_ALIGN_MAX_NT		Number of missed targets in factory alignment process before failing	0 to 100	n/a	1	0	50ms	ACM (required)
5F3	CAN_RX_FAC_ALIGN_SAMP_REQ		Number of samples needed to evaluate factory alignment	0 to 100	n/a	1	0	50ms	ACM (required)
5F3	CAN_RX_FAC_TGT_MTG_OFFSET		Lateral distance from vehicle centerline that target is located. Used to account for target on radar centerline. Moving right from driver's perspective is positive	-100 to +100	cm	1	0	50ms	ACM (required)
5F3	CAN_RX_FAC_TGT_MTG_SPACE_HOR		Lateral distance left and right of CAN_RX_FAC_TGT_MTG_OFFSET that two corner reflectors are placed for multiple corner reflector factory alignment process	-100 to +100	cm	1	0	50ms	ACM (required)
5F3	CAN_RX_FAC_TGT_MTG_SPACE_VER		Vertical distance above and below of radar boresight that two corner reflectors are placed for multiple corner reflector factory alignment process	-100 to +100	cm	1	0	50ms	ACM (required)
5F3	CAN_RX_FAC_TGT_RANGE_1		Range of target used in factory alignment routine	2 to 10	m	0.0625	2	50ms	ACM (required)
5F3	CAN_RX_FAC_TGT_RANGE_M2T		Range from mirror to target used in two-target factory alignment routine	1 to 10	m	0.0625	1	50ms	ACM (required)
5F3	CAN_RX_FAC_TGT_RANGE_R2M		Range from radar to mirror used in two-target factory alignment routine	1 to 10	m	0.0625	1	50ms	ACM (required)
5F4	CAN_RX_OVERSTEER_UNDERSTEER		Amount of vehicle oversteering / understeering with oversteer is positive	-128 to +127	%	1	0	50ms	ACM (required)
5F4	CAN_RX_BEAMWIDTH_VERT		Vertical beamwidth accounting for secondary surface effects	0 to 6	deg	0.0625	4.4375	50ms	ACM (required)
5F4	CAN_RX_YAW_RATE_BIAS_SHIFT		Flag indicating that the controller has detected a shift in yaw rate bias and that auto alignment algorithm in ESR should be temporarily suspended	0 to 1	n/a	1	0	50ms	ACM (required)
5F4	CAN_RX_FUNNEL_OFFSET_LEFT		Target outer Path funnel offset to the left side	-2 to +10	m	0.1	0	50ms	ACM (required)
5F4	CAN_RX_FUNNEL_OFFSET_RIGHT		Target outer Path funnel offset to the right side	-2 to +10	m	0.1	0	50ms	ACM (required)
5F4	CAN_RX_CW_BLOCKAGE_THRESHOLD		CW blockage threshold factor 0 = use default threshold (1 in DSP software) 1 through 255 = blockage threshold 0.0078125 through 1.9921875	0 .. 1.9921875	n/a	0.0078125	0	50 ms	ACM (optional)
5F4	CAN_RX_DISTANCE_REAR_AXLE		Distance from front of radar to rear axle (used for slip-angle correction) 0 = no distance available 1 through 255 = distance is 202cm to 710cm	0..710	cm	2	0	50 ms	ACM (optional)
5F4	CAN_RX_WHEELBASE		Wheelbase (distance between the centers of the front and rear wheels) 0 = no distance available 1 through 255 = distance is 202cm to 710cm	0..710	cm	2	0	50 ms	ACM (optional)
5F4	CAN_RX_STEERING_GEAR_RATIO		Ratio of the steering wheel angle to the steer angle of the front wheels	0 to 31.875	n/a	0.125	0	50 ms	ACM (optional)
5F5	CAN_VOLVO_FA_AALIGN_ESTIMATE		Alignment estimate beyond which the estimate is considered invalid (only used for Volvo Factory alignment)	0 to 10	deg	0.0625	0	50 ms	ACM (optional)

5F5	CAN_VOLVO_FA_MIN_VSPEED_SHORT		Minimum speed to initiate an auto alignment estimate for shortened Service alignment (only used for Volvo Factory alignment)	0 to 20	m/s	0.125	0	50 ms	ACM (optional)
5F5	CAN_VOLVO_FA_RANGE_MAX_SHORT		Maximum range for beginning auto alignment processing for shortened Service alignment (only used for Volvo Factory alignment)	0 to 255	m	1	0	50 ms	ACM (optional)

8 Parts

8.1 Radar

8.1.1 ESR

On the back of each ESR it will be labeled with the version of firmware is on the ESR.

v9.21.21 Part # (DEL-ESR-21)

v9.21.0 Part # (DEL-ESR-00)

v9.21.15 Part # (DEL-ESR-15)

8.1.2 ESR 2.5 Part # (DEL-ESR-2.5)

On the back of the ESR 2.5 it will be labeled ESR 2.5 (12V)

8.2 Cables

8.2.1 ESR Cable Part # (AUT-CBL-ESR-2M) and (AUT-CBL-ESR-5M)

This cable is used to supply Power and output CAN high and CAN low from the ESR (v9.21.0, v9.21.15, and v9.21.21). These cables come in 2 or 5 meters.

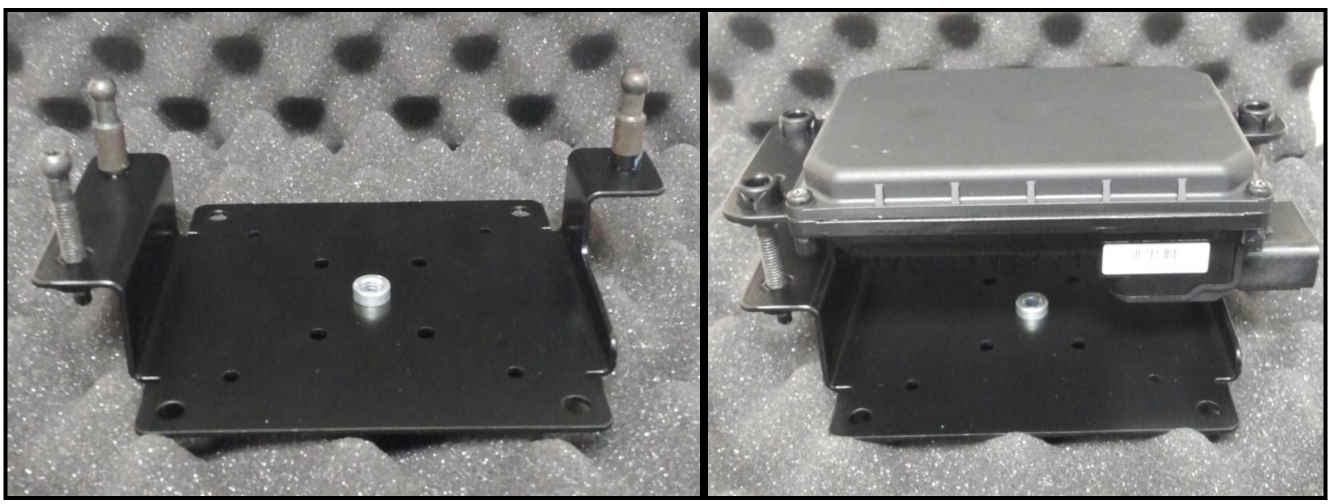
8.2.2 ESR 2.5 Cable Part # (AUT-CBL-ESR2.5-2M) and (AUT-CBL-ESR2.5-4.5M)

This cable is used to supply Power, output CAN high and CAN low, and output detection over Ethernet to USB interface for the ESR 2.5. These cables come in 2 or 5 meters.

8.3 Brackets

8.3.1 ESR Bracket Part # (HAR-BKT-ESR)

This bracket is compatible with all versions of the ESR.



8.4 Accessories

8.4.1 Kvaser Leaf Light v2 Part # (KVS-LL-V2-00685-0)

The Kvaser Leaf Light V2 supports high speed USB for CAN. Loss free transmission and reception of standard and extended CAN messages on the CAN bus is transmitted with a time stamp precision of 100 microseconds.

8.4.2 USB 2.0 Ethernet Adapter (Included with ESR 2.5 Cable)

This adapter plugs into any available USB port and provides an Ethernet connection, complying with the IEEE 802.3 and 802.3u standards.