ENGINEERING
TOMORROW

Application Guide

PVED-CLS
Start-up guide

www.danfoss.com

Revision history

Table of revisions

Date	Changed	Rev
November 2019	Corrected wording for clarity	0102
October 2018	First edition	0101

Contents

Introduction

PVED-CLS overview

This application guide will detail setting parameters for configuring the PVED-CLS as well as troubleshooting when the PVED-CLS goes into safe-state mode. There are other literature references in this document and it is recommended to have them read before configuration.

Literature references

- PVED-CLS user manual (included in firmware release package `/technical manuals` folder)
- Communication protocol (included in firmware release package `/technical manuals` folder)
- PLUS+1® Service Tool user guide (found in firmware release package `/Service tool` folder)
- PVED-CLS safety manual (must be requested from local eSteering Product Application Engineer or sales representative)

Additional resources

- PLUS+1® Service Tool

Introduction

Downloading the required software

1. Download the desired or latest firmware release package on the *PVED-CLS web page*
2. Optional: Request and download the *PLUS+1® Service Tool* under **Service Tool: Request** heading.

Introduction

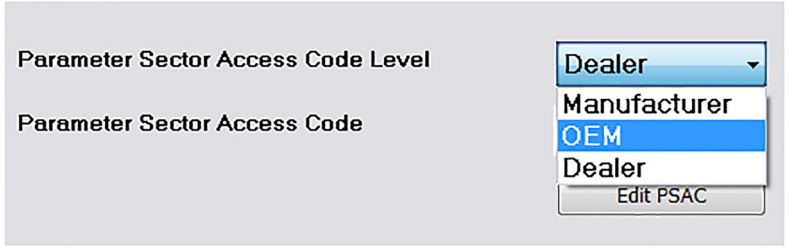
PVED-CLS initial steps

1. Open the Service Tool
2. Optional: If changing the firmware to a different revision, flash the Main and Safety Controller (**Release Package** > **Software**)

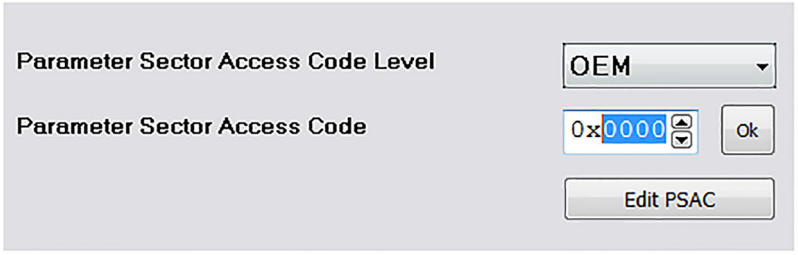
   See Section 6.2 (pages 23-27) of the PLUS+1® Service Tool user guide. When changing to a newer firmware revision, please look at the Firmware Release Note found in the Firmware Release Package of the selected revision for additional steps.

   Reverting to an early revision of firmware may not be possible with the Service Tool depending on the specific revisions. Please contact the Danfoss technical representative if you have concerns about changing firmware.
3. Install Diagnostic Data Files of selected Firmware Revision (**Release Package** > **Diagnostic data files**).

   See Section 6.1 (pages 21-22) of the PLUS+1® Service Tool user guide found in the Firmware Release package under `/Service tool` folder.
4. Open *.P1D* file in the Service Tool (**Release Package** > **Service Tool**)
5. Select **OEM** on the info page



6. Click **Edit PSAC** and enter correct hexadecimal number



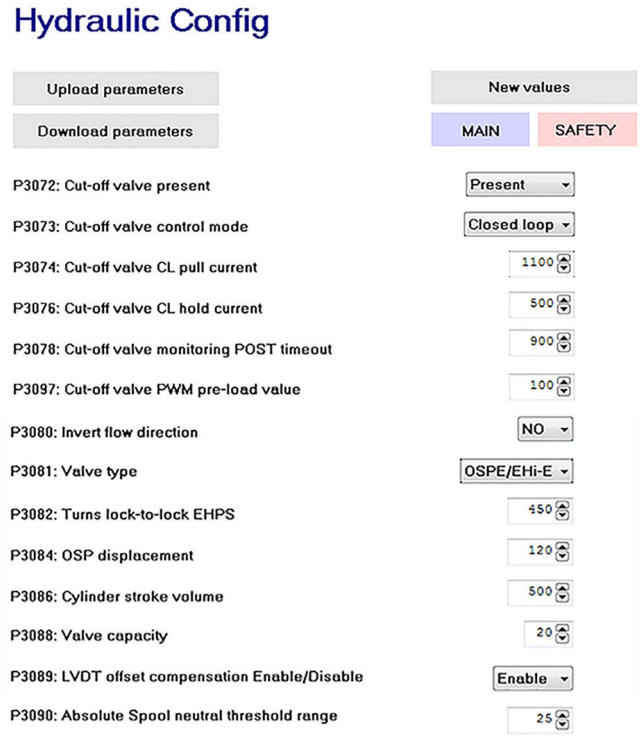
7. Click **OK**

Parameter setting

PVED-CLS hydraulic configuration P3072-P3097

Navigate to the hydraulic configuration section via **System Navigator** > **Configuration** > **Hydraulic Config**

Example parameter settings



If the parameter change is not described below or conditions are not met, use the default values.

Parameter settings

Parameter	Conditions for value changes
P3072	Not present if there is no cut-off valve (usually with EHPS)
P3078	Set to 0 if PVED-CLS is part of desk setup
P3097	Set to 50 if using 12V coil on a 24V system
P3080	Set to "YES" if using EHPS
P3081	Set to match the valve type used
P3082	If using EHPS, enter desired turns lock-to-lock x100 that matches the hydraulic system
P3084	Set to match OSP displacement in cubic centimeters
P3086	Set to match volume needed to turn lock-to-lock. If using unbalanced cylinder, set to average of left and right.

The default parameters are based on 12V coil. Depending on the voltage, the following parameters may need to be changed:

Parameter	12V coil	24V coil
P3074	1100mA	550mA
P3076	500mA	250mA

The pre-load parameter P3097 is a PWM signal and it must be set to scale the input voltage down to the rated current of the spool:

Parameter setting

P3097 input voltage scaling

Input voltage	12V coil	24V coil
12V	100%	N/A
24V	50%	100%
36V	33%	67%

PVED-CLS parameter acceptance

Use the following steps to save and approve the parameters that have been set.

1. Press **Download** and wait for the script to complete.
2. Click **Close**.
   It is mandatory to confirm that the parameters have been downloaded by the user.
3. Press **Approve Parameters**.
   The text will change to **Approved** and the page can then be closed.

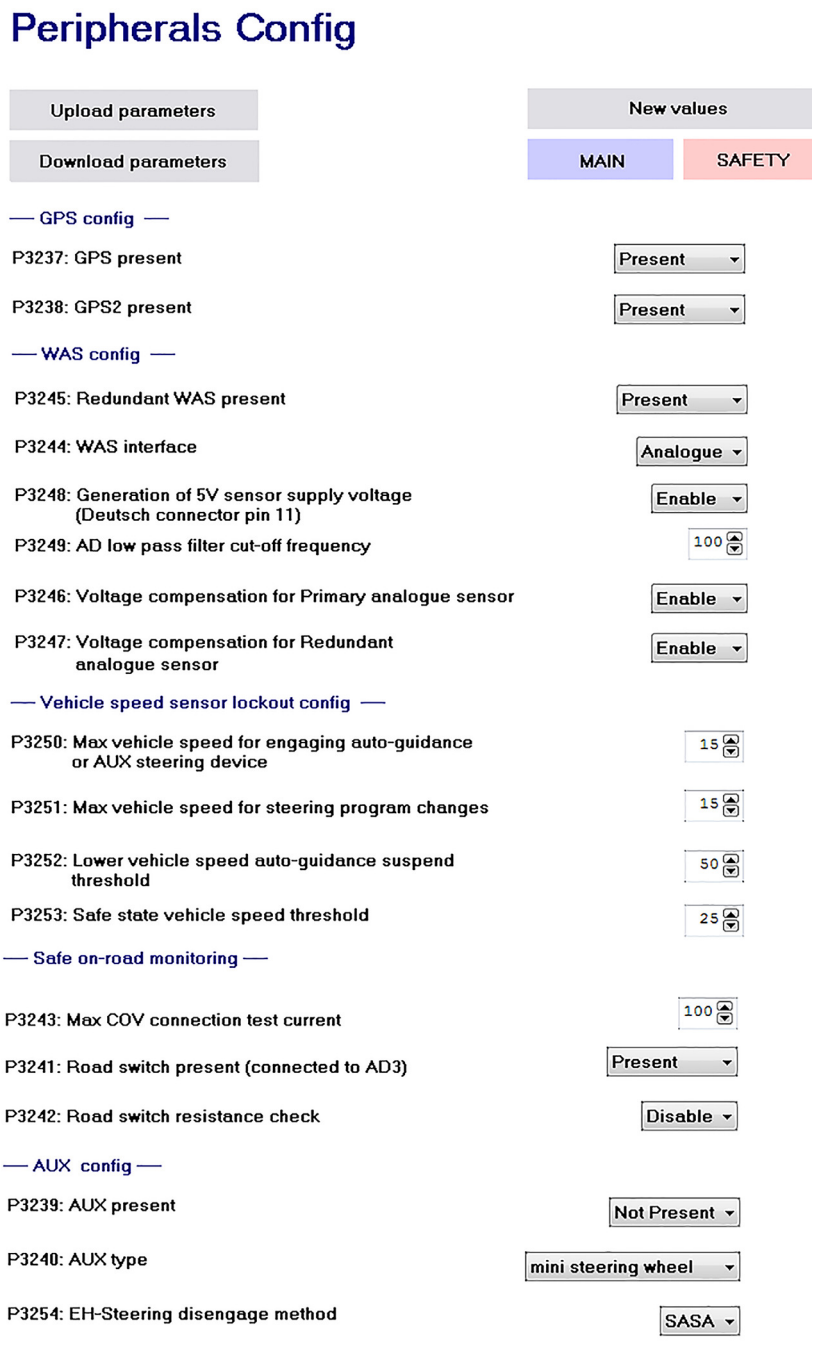
Leaving the page before parameters are accepted will cause an EEPROM fault and the PVED-CLS will go to safe-state mode.

Parameter setting

PVED-CLS peripherals configuration P3237-P3254

Navigate to the peripherals configuration section via **System Navigator** > **Configuration** > **Peripherals Config**

Example parameter settings



If the parameter change is not described below or conditions are not met, use the default values.

Parameter	Conditions for value changes
P3237	Set to match presence of GPS/auto-guidance controllers in system
P3238	Set to match presence of GPS/auto-guidance controllers in system

Parameter setting

Parameter	Conditions for value changes
P3245	Set to match presence of redundant WAS signal
P3244	Set to match type of WAS signal: Analog, CAN, or None
P3246	Enable only if using uncompensated Analog WAS
P3247	Enable only if using uncompensated Analog WAS
P3250	Vehicle speed must be below this threshold to allow auto-guidance or AUX device to be enabled (speed measured in km/h)
P3251	Vehicle speed must be below this threshold to allow for switching steering wheel programs (speed measured in km/h)
P3252	Vehicle speed must be above this threshold to use auto-guidance
P3253	PVED-CLS will go into safe-state mode if vehicle speed is above this threshold
P3241	Set to match presence of Safe On-Road Switch and electric architecture
P3239	Set to match presence of AUX device
P3240	Set to match type of AUX device
P3254	Set to IMD if using EHi-H

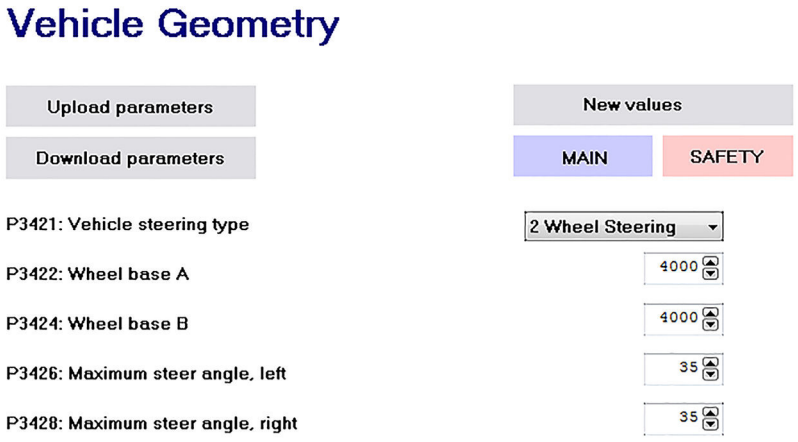
Approve the parameters by following the steps in *PVED-CLS parameter acceptance* on page 8.

Parameter setting

PVED-CLS vehicle geometry configuration P3421-P3428

Navigate to the vehicle geometry configuration section via **System Navigator** > **Configuration** > **Vehicle Geometry**

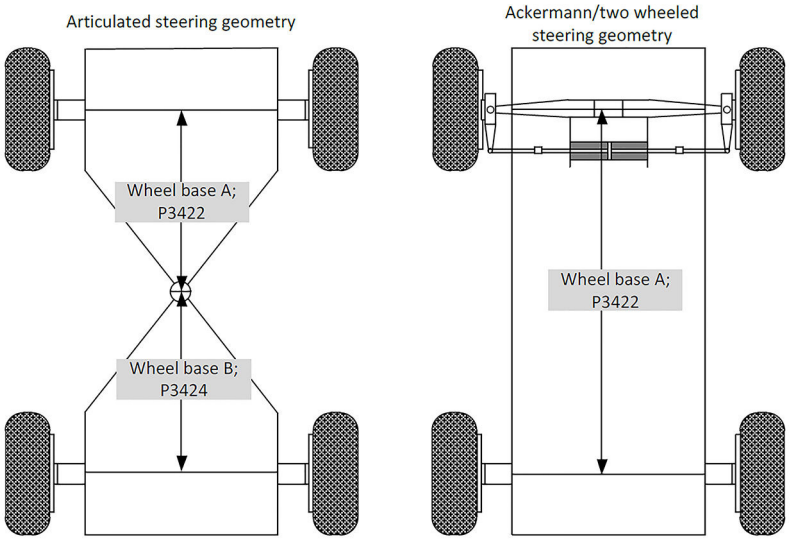
Example parameter settings



If the parameter change is not described below or conditions are not met, use the default values.

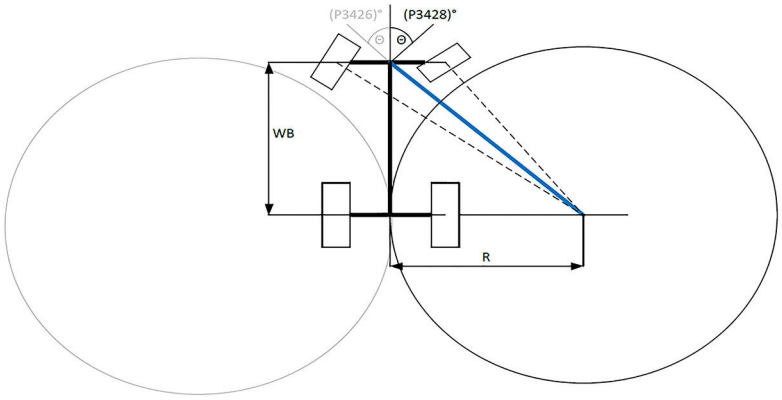
Parameter	Conditions for value changes
P3421	Set to match type of steering
P3422	Change according to wheel base figure shown below (dimensions measured in mm)
P3424	Change according to wheel base figure shown below (dimensions measured in mm)
P3426	Change according to steer angle figure and formula shown below (measured in degrees)
P3428	Change according to steer angle figure and formula shown below (measured in degrees)

Wheel base



Parameter setting

Steer angle



Formula $Ø = \tan^{-1}(WB/R)$

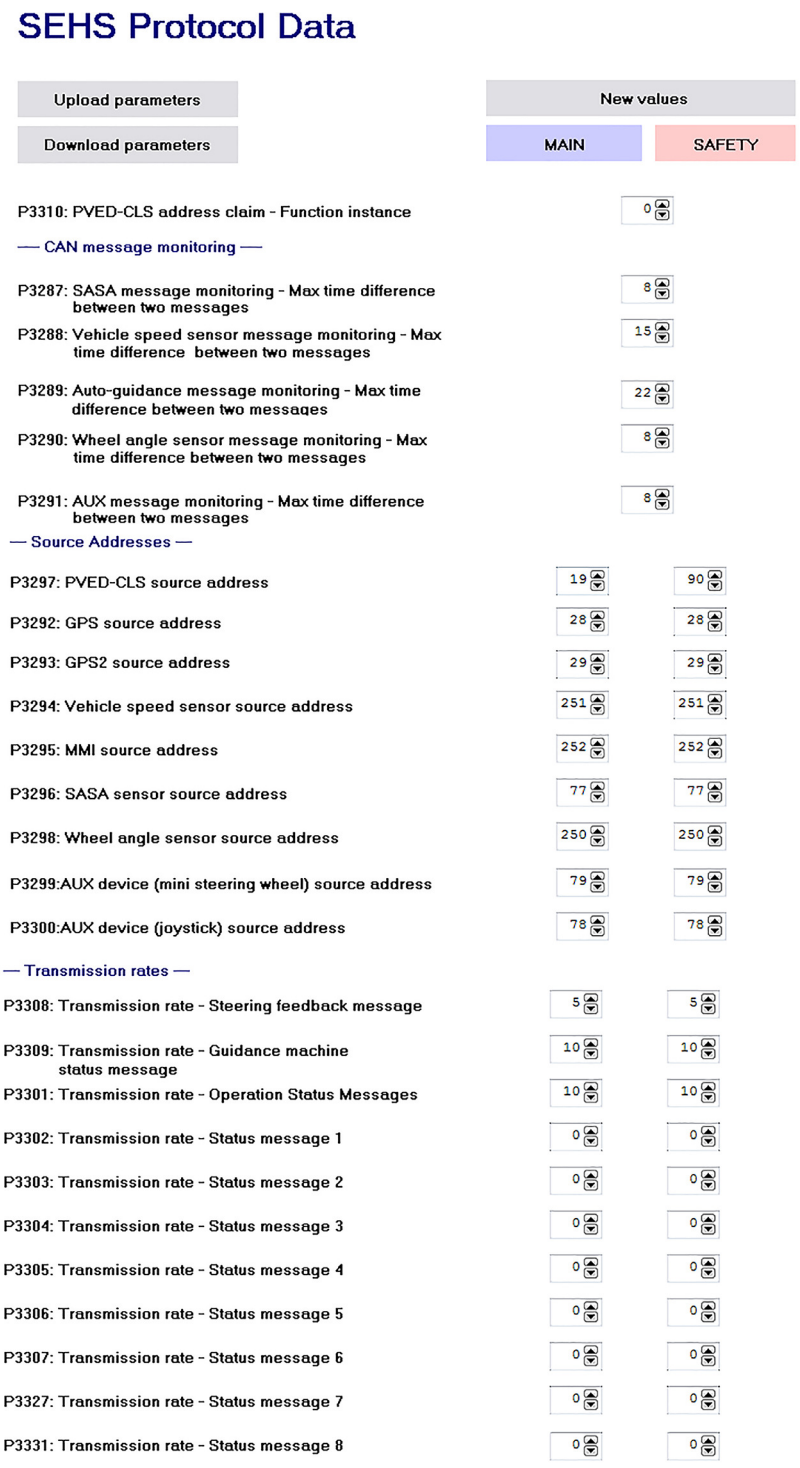
Approve the parameters by following the steps in *PVED-CLS parameter acceptance* on page 8.

Parameter setting

PVED-CLS SEHS protocol data P3292-P3331

Navigate to the SEHS protocol data section via **System Navigator** > **Configuration** > **SEHS Protocol Data**

Example parameter settings



If the parameter change is not described below or conditions are not met, use the default values.

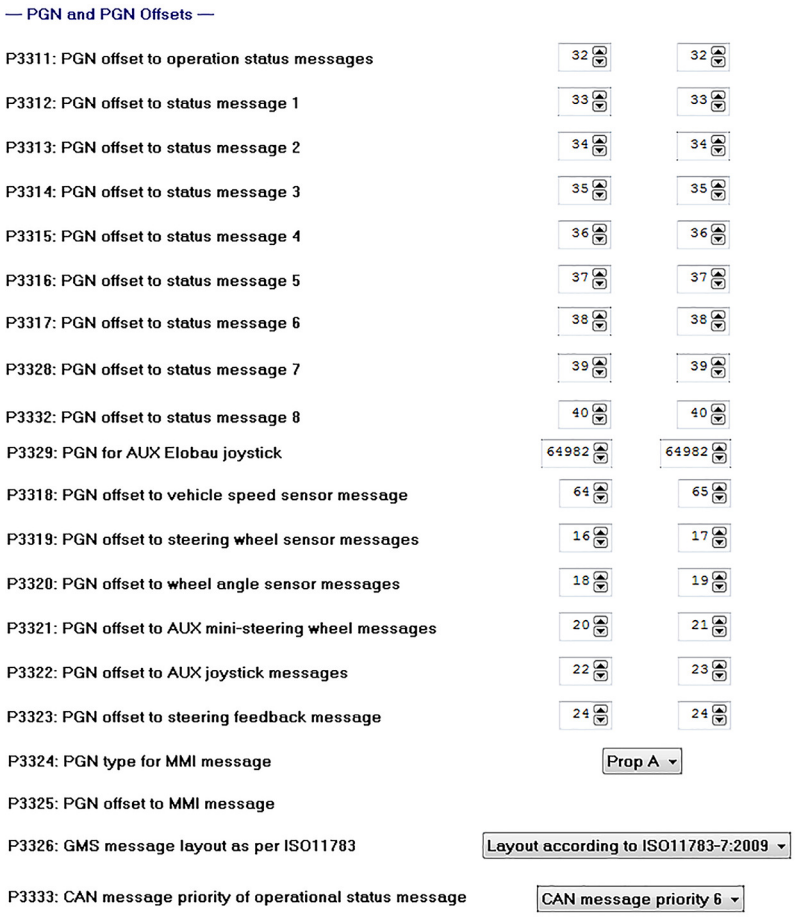
Parameter setting

Parameter	Condition for value change
P3292-P3300	Leave at default value unless source addresses conflict with other nodes on the CAN bus or another addressing scheme is desired
P3301	Data is sent at the rate of "value" x 10ms
P3308-P3309	Set to 0 if not using messages, otherwise data is sent at the rate of "value" x 10ms
P3302-P3307	Set to over 0 if using messages to send data at the rate of "value" x 10ms, otherwise messages are disabled
P3327	Set to over 0 if using messages to send data at the rate of "value" x 10ms, otherwise messages are disabled
P3331	Set to over 0 if using messages to send data at the rate of "value" x 10ms, otherwise messages are disabled

Parameter setting

PVED-CLS SEHS protocol data P3311-P3333

Example parameter settings



If the parameter change is not described below or conditions are not met, use the default values.

Parameter	Condition for value change
P3311-P3317	Leave at default unless PGN's conflict with others on the CAN bus or another addressing scheme is desired
P3328	Leave at default unless PGN's conflict with others on the CAN bus or another addressing scheme is desired
P3332	Leave at default unless PGN's conflict with others on the CAN bus or another addressing scheme is desired
P3329	Leave at default unless PGN's conflict with others on the CAN bus or another addressing scheme is desired
P3318-P3323	Leave at default unless PGN's conflict with others on the CAN bus or another addressing scheme is desired
P3324	Leave at default unless "Proprietary B" message formatting of MMI is desired. If "Proprietary B" is chosen, PGN offsets can be edited via P3325.

Approve the parameters by following the steps in *PVED-CLS parameter acceptance* on page 8.

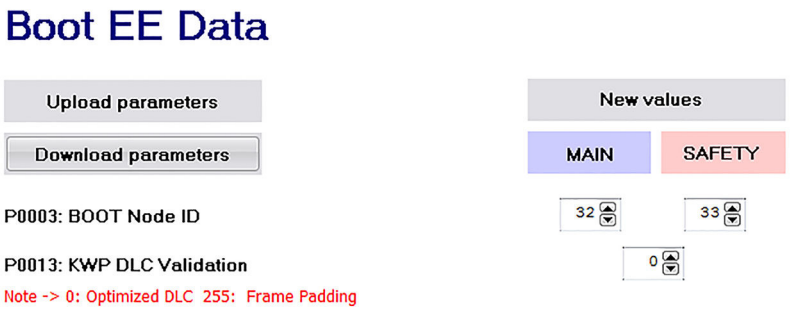
Parameter setting

PVED-CLS Boot EE data

Navigate to the boot EE data section via **System Navigator** > **Configuration** > **Boot EE Data**

Boot Node ID's set the Source Addresses of the Main and Safety micro-controllers which are used for Bootloader mode. These addresses are seen in the ECU list in the PLUS+1® Service Tool. By default, these are different than the Main and Safety Source Addresses that are set in the SEHS Protocol Data page.

If the default addresses conflict with other addresses on the bus or a different messaging scheme is desired, modify parameters as described.



Parameter	Condition for value change
P0003 (main controller)	Set to desired Bootloader Source Address for Main Controller
P0003 (safety controller)	Set to desired Bootloader Source Address for Safety Controller

Accept Boot Node ID parameters

1. Download the changed parameters by pressing **Download parameters**
2. After changing the Boot Node ID's, cycle power on the PVED-CLS for new ID's to take affect

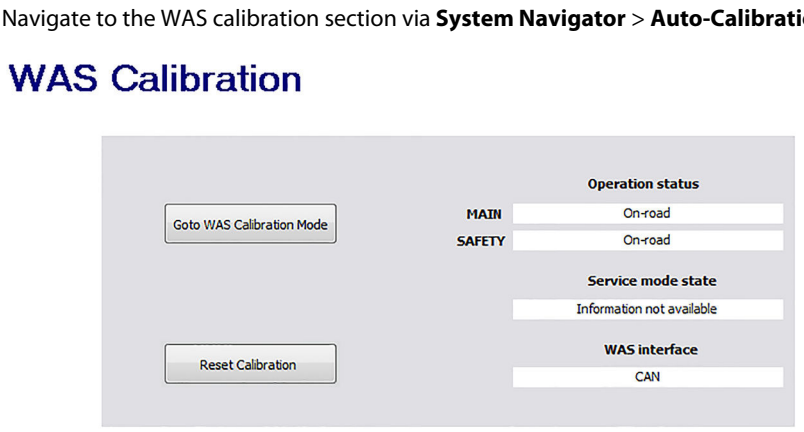
   The new ID's will show up in the ECU list; however, the Service Tool pages are still linked to the old addresses and will produce an error.
3. Start to fix the address error by clicking the **Replace Missing ECU** icon shown below:

   
4. Follow the prompts and replace the default Main (32) and Safety (33) Source Addresses with the new addresses and press **OK** to complete.

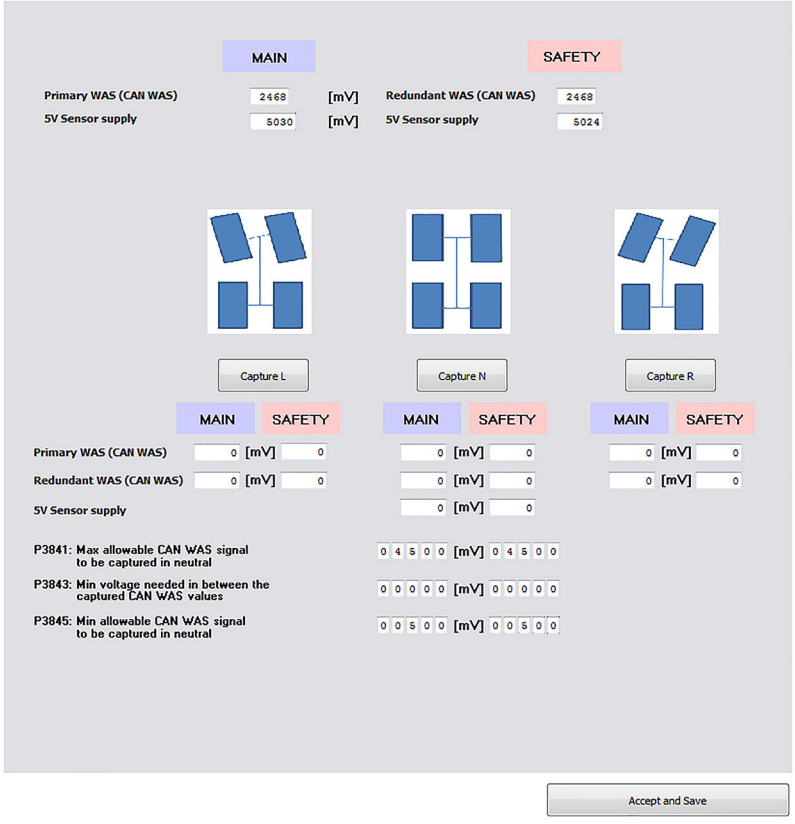
Parameter setting

PVED-CLS WAS calibration

Navigate to the WAS calibration section via **System Navigator** > **Auto-Calibration** > **WAS Calibration**



1. Select **Go to WAS calibration mode**
2. Steer left, straight (neutral) and right (in any order) using the steering wheel and press the appropriate button when wheels are at the desired angle.
3. Press **Accept and save**



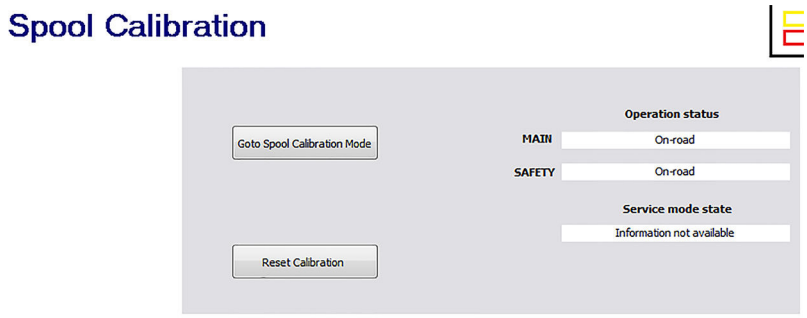
Values will automatically change in either the Analog Sensor Calibration Data or CAN WAS Calibration Data page, based on which type of WAS was selected in the Peripherals configuration.

Parameter setting

PVED-CLS Spool calibration

Navigate to the Spool calibration section via **System Navigator** > **Auto-Calibration** > **Spool Calibration**

Calibrate closed loop spool dead-band with the following steps.

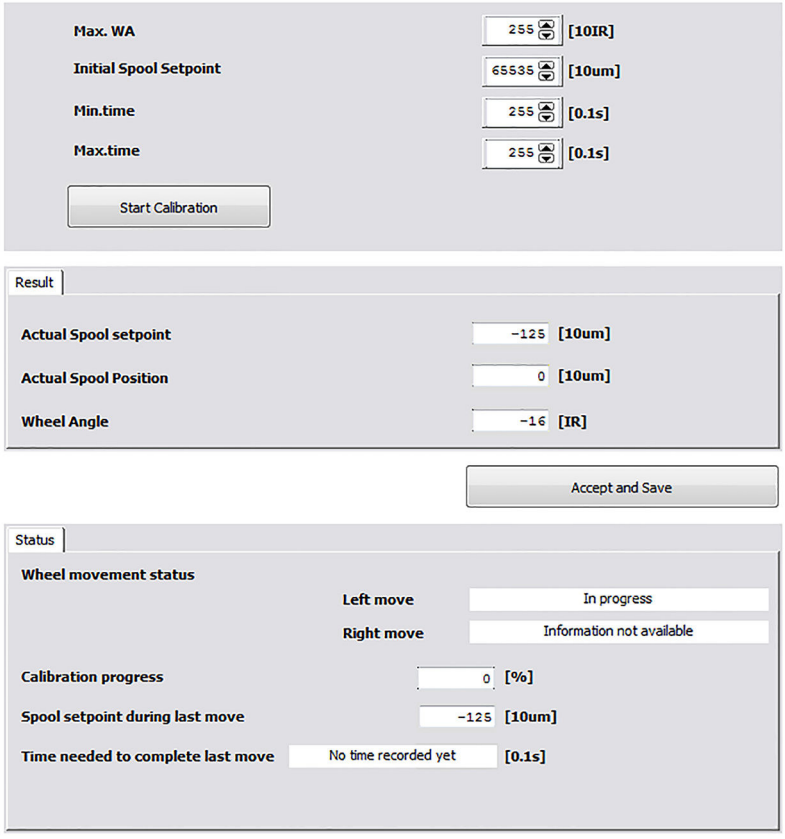


1. Select **Go to calibration mode**
2. Turn the steering wheel so that **Service Mode State** changes to **Spool Calibration Getting Armed**.
3. Stop turning the steering wheel and secure the wheels in a central position so that it changes to **Spool Calibration Armed**.
4. Turn the wheels so that they are positioned straight ahead and within the range specified in parameter P3804. Then press **Start Calibration**.

Wheels will turn back and forth (or machine will articulate).

Parameter setting

5. Watch the Left move and Right move progress info. When both have completed, press the **Accept and Save** button.



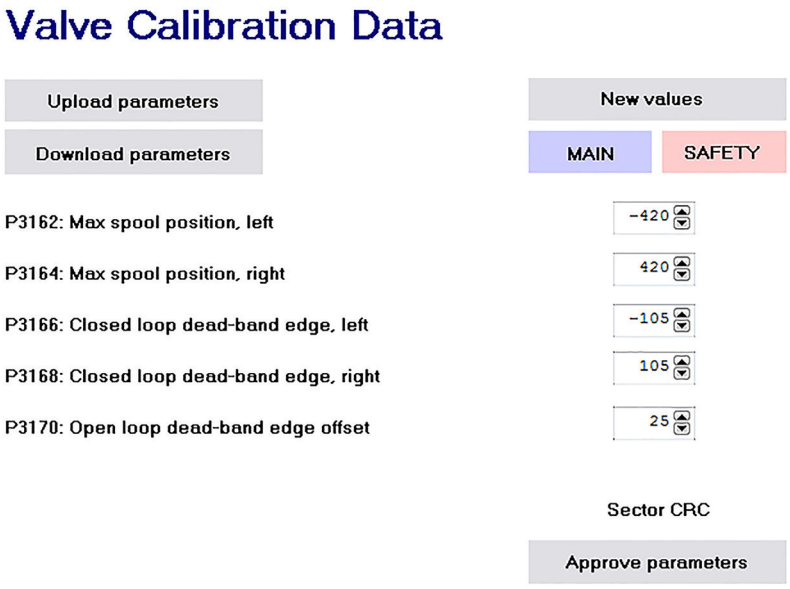
Values will automatically change in Valve Calibration Data page. If values need to be changed manually, go to Valve Calibration Data page.

Parameter setting

PVED-CLS valve calibration data

Navigate to the valve calibration section via **System Navigator** > **Configuration** > **Valve Calibration Data**

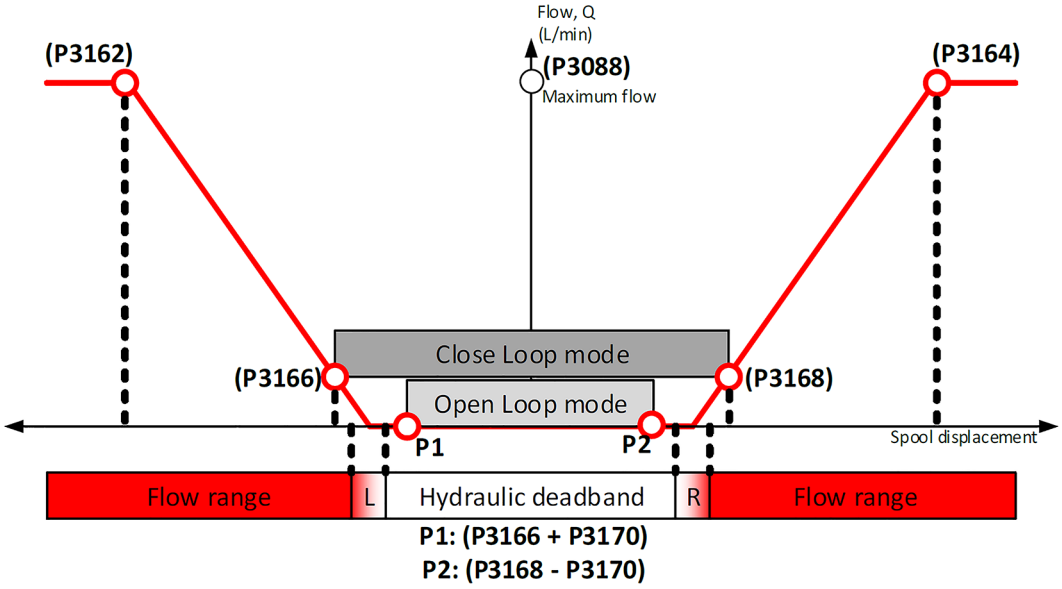
Example parameter settings



Parameter	Condition for value change
P3162	If using an EHPS, set the value to -700. Otherwise, use default value.
P3164	If using an EHPS, set the value to 700. Otherwise, use default value.
P3166	Adjust toward 0 for smaller minimum flow in Closed Loop modes (auto-guidance) and vice versa. See deadband figure below.
P3168	Adjust toward 0 for smaller minimum flow in Closed Loop modes (auto-guidance) and vice versa. See deadband figure below.
P3170	Can be decreased but do not increase.

Parameter setting

Deadbands



PVED-CLS parameter acceptance

Use the following steps to save and approve the parameters that have been set.

1. Press **Download** and wait for the script to complete.
2. Click **Close**.

   It is mandatory to confirm that the parameters have been downloaded by the user.
3. Press **Approve Parameters**.

   The text will change to **Approved** and the page can then be closed.

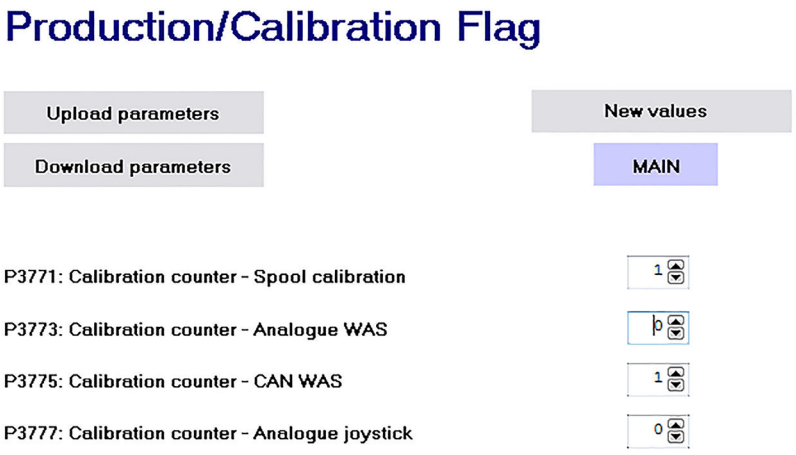
Leaving the page before parameters are accepted will cause an EEPROM fault and the PVED-CLS will go to safe-state mode.

Parameter setting

PVED-CLS production/calibration flag

Navigate to the production/calibration flag section via **System Navigator** > **Configuration** > **Production/Calibration Flag**

If WAS Calibration and Spool Calibrations were used, flags will be set automatically. If flags are not set, PVED-CLS will boot into WAS Calibration mode until one of the WAS counters has been set above 0. Then the PVED-CLS will boot into Spool Calibration mode until the Spool calibration flag has been set above 0. If an analog joystick has been selected in Peripherals Config, the Joystick Calibration will need to be run to set the calibration for this, too.



If the PVED-CLS is used in a desktop environment, then P3771, P3773, P3775 and P3777 must be set to 1 to avoid PVED-CLS from entering calibration mode. For more details, see the PVED-CLS User Manual.

If parameters are changed, be sure to select **Download parameters** to save parameter setting.

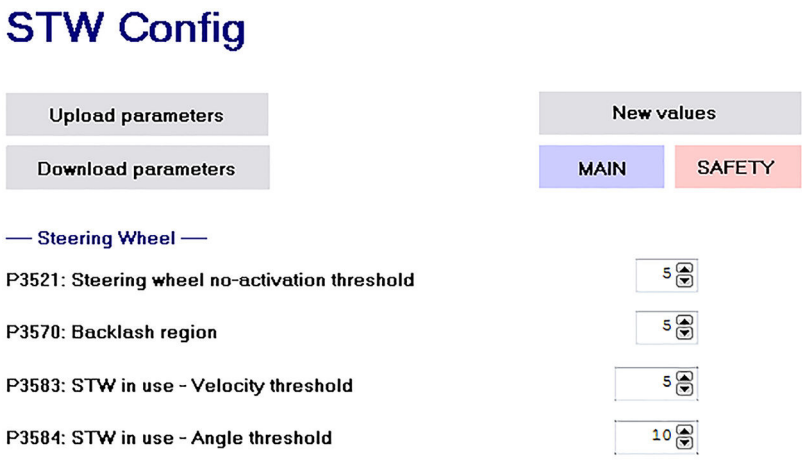
There is no **Approve parameters** option on this page.

Parameter setting

PVED-CLS STW configuration

Navigate to the STW configuration section via **System Navigator** > **Configuration** > **STW Config**

Example parameter settings



If the parameter change is not described below or conditions are not met, use the default values.

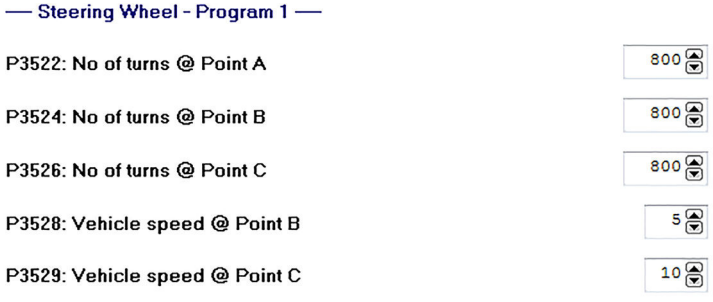
Parameter	Condition for value change
P3570	Change to 75 (7.5 degrees) to prevent amplifying re-centering of steering wheel.
P3583	Can be increased if auto-guidance or AUX devices are being disengaged too easily by the steering wheel.
P3584	Can be increased if auto-guidance or AUX devices are being disengaged too easily by the steering wheel.

There are four subsets of steering wheel configuration: *Steering Wheel Programs*, *Soft-stop*, *Anti-jerk*, and *Anti-drift*. Be sure to Download and approve parameters when complete with Steering Wheel configuration.

PVED-CLS Steering wheel programs

There are 5 steering wheel programs with identical parameters. Use the details below as a reference for all 5 programs.

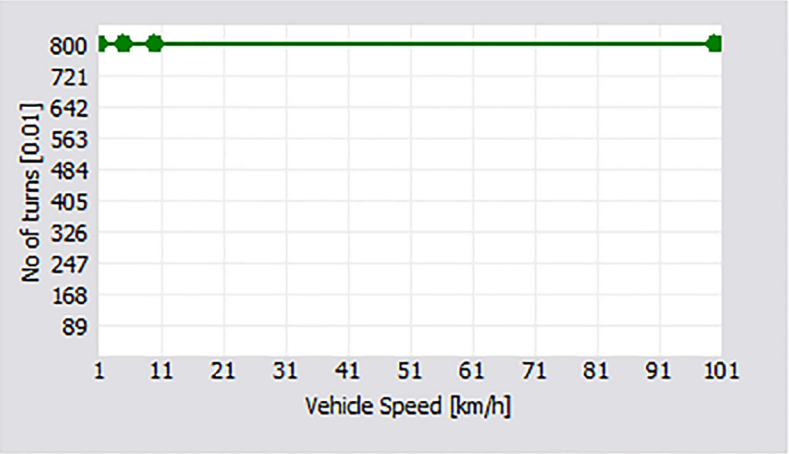
Example parameter settings (only Program 1 shown)



Parameter	Condition for value change
P3522	Set to desired turns lock-to-lock [x0.01] at 0 km/h (see graph below)
P3524	Set to desired turns lock-to-lock (y-axis) at desired vehicle speed in km/h (P3528)
P3526	Set to desired turns lock-to-lock (y-axis) at desired vehicle speed in km/h (P3529)
P3528	Set to desired vehicle speed in km/h (x-axis) at desired number turns lock-to-lock (P3524)
P3529	Set to desired vehicle speed in km/h (x-axis) at desired number turns lock-to-lock (P3526)

Parameter setting

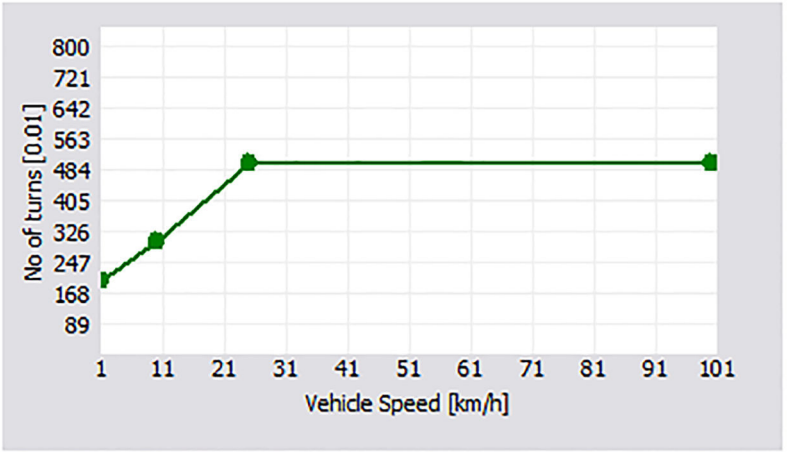
Default steering wheel program



No amplification if orbital produces less than 8 turns lock-to-lock.

If all parameters for turns lock-to-lock are equal, the steering wheel program will have a fixed number of turns lock-to-lock. Steering wheel programs can be set so that the number of turns lock-to-lock changes depending on the vehicle speed.

Example of vehicle speed dependent steering wheel program

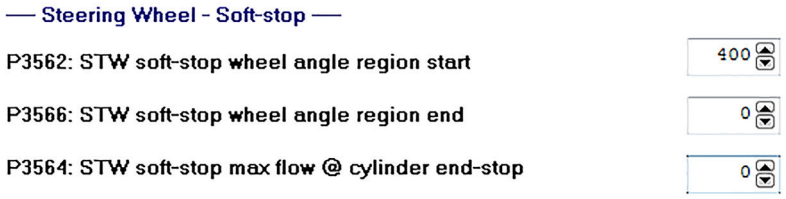


Parameter setting

PVED-CLS soft-stop

Soft-stop can decrease flow sent from the electro-hydraulic valve the to cylinders when wheels are close to end-stop to help prevent damage and jerk.

Example parameter settings



Parameter	Conditions for value change
P3562	Distance from end-stop flow starts to decrease [0.1%]
P3566	Distance from end-stop flow stops decreasing [0.1%]
P3564	Max allowed flow at cylinder end-stop [0.1%]

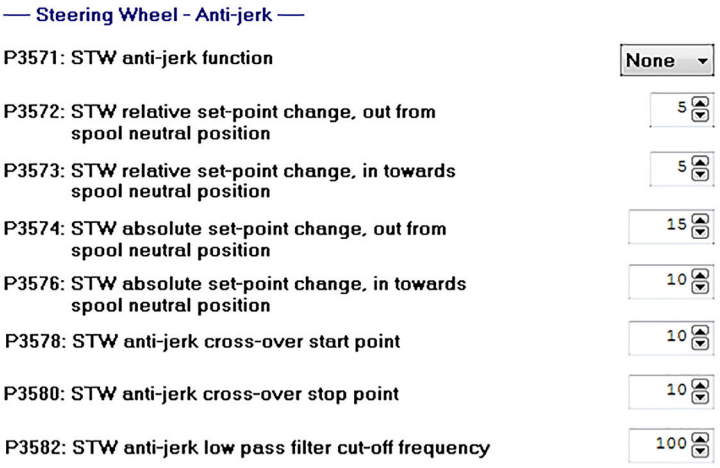
Example of soft-stop flow limitation

Parameter setting

PVED-CLS anti-jerk

Anti-jerk can be used to decrease jerk in articulated vehicles. Changing parameters only effect jerk originating from the EH spool. Any jerk caused by the orbital will still exist, but amplified flow from variable rate steering programs will have less jerk.

Example parameter settings

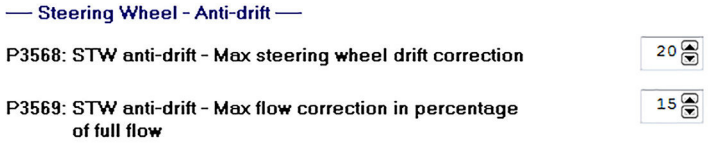


Parameter	Conditions for value change
P3571	Change to enable anti-jerk functionality
P3572-P3582	See section 10.6 Anti-Jerk in User Manual for details on setting parameters.

Tuning of anti-jerk will take trial and error. Set values low and increase them until articulated machine feels responsive but not jerky. The cross-over start and stop points (P3578 and P3580) can stay at defaults unless extra anti-jerk functionality is required.

PVED-CLS anti-drift

Anti-drift can be used to keep the steering wheel in the same position when driving straight ahead. This is adjusted by adding a percentage of full flow when the actual steering wheel angle doesn't match the ideal steering wheel angle.



Parameter	Conditions for value change
P3568	Angle at which maximum correction flow is applied
P3569	Maximum correction flow that can be applied

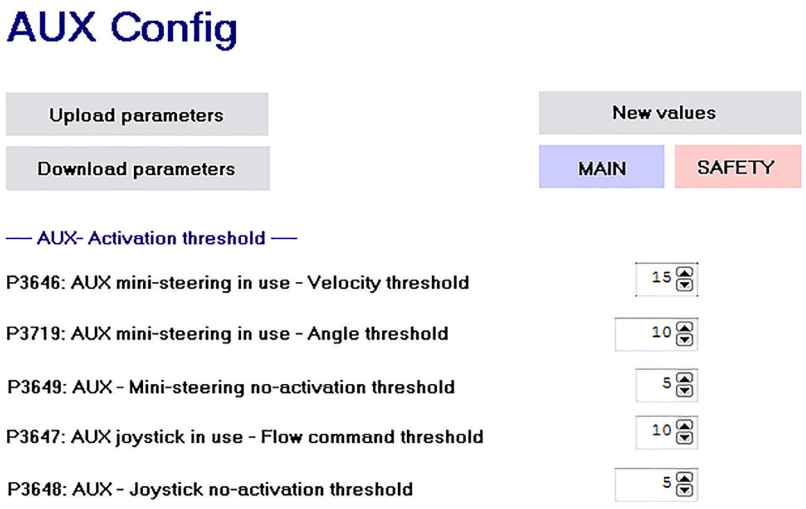
Default values are recommended for these parameters. See Section 10.5 in the User Manual for more details.

Parameter setting

PVED-CLS AUX configuration

Navigate to the AUX configuration section via **System Navigator** > **Configuration** > **AUX Config**

The following parameters only apply if AUX is enabled.



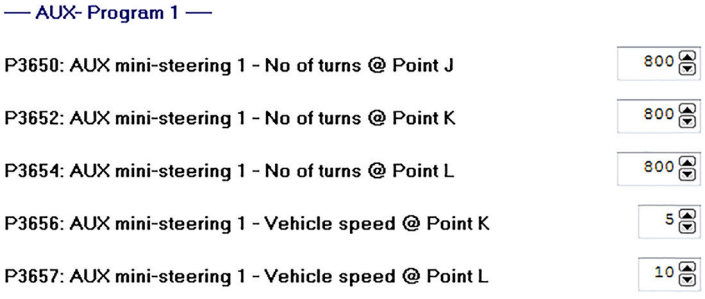
Parameter	Conditions for value change
P3646, P3719	See *PVED-CLS STW configuration* on page 23
P3647	Set to minimum joystick command in 0.1% needed to switch into joystick steering.

There are seven subsets of AUX configuration that apply only if an AUX device is selected in parameter P3240 in the Peripherals Config page: *AUX Mini-wheel programs*, *Soft-stop*, *Anti-jerk*, *Anti-drift*, *Flow limitation*, *Closed loop joystick*, and *Open loop joystick*.

Approve the parameters by following the steps in *PVED-CLS parameter acceptance* on page 8.

PVED-CLS AUX mini-wheel programs

There are 5 AUX programs for mini steering wheels that each have a similar set of parameters. These are only used if a mini steering wheel is present.

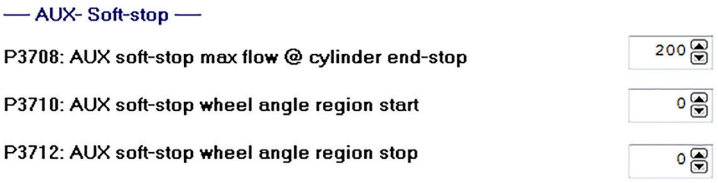


Parameter	Conditions for value change
P3650-P3657	See *PVED-CLS Steering wheel programs* on page 23 for configuration details.

Parameter setting

PVED-CLS AUX— soft-stop

AUX soft-stop can decrease flow to cylinders when wheels are close to end-stop to help prevent damage and jerk. This parameter is used for mini steering wheel and open loop joystick devices.

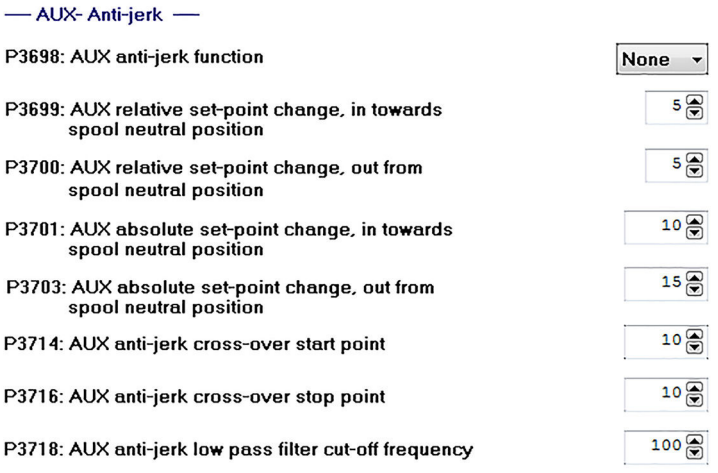


Parameter	Conditions for value change
P3708-P3712	See *PVED-CLS soft-stop* on page 25 for configuration details.

Wheels may not return from end-stops or will do so slowly if flow is set too low.
Do not decrease P3708 below 200.

PVED-CLS AUX— anti-jerk

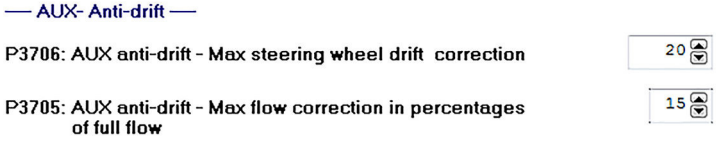
Anti-jerk can be used to decrease jerk in articulated vehicles. These parameters can be applied with a mini steering wheel or open-loop joystick.



Parameter	Conditions for value change
P3698-P3718	See Section 11.6 Open Loop Anti-Jerk in the User Manual for configuration details.

PVED-CLS AUX— anti-drift

Anti-drift can be used to keep the mini steering wheel in the same position when driving straight ahead by adding a percentage of full flow when the actual mini steering wheel angle does not match the ideal angle.

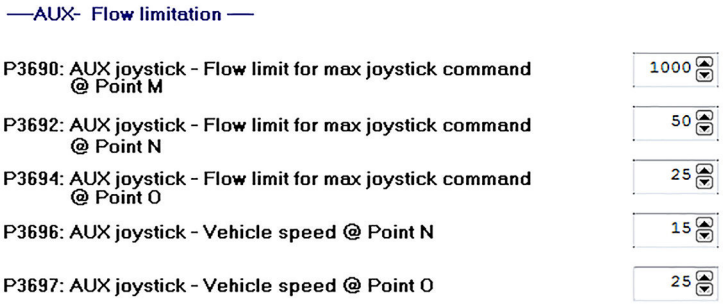


Parameter	Conditions for value change
P3706, P3705	See Section 11.5 Open Loop Mini Wheel Anti-Drift in User Manual for details on setting parameters.

Parameter setting

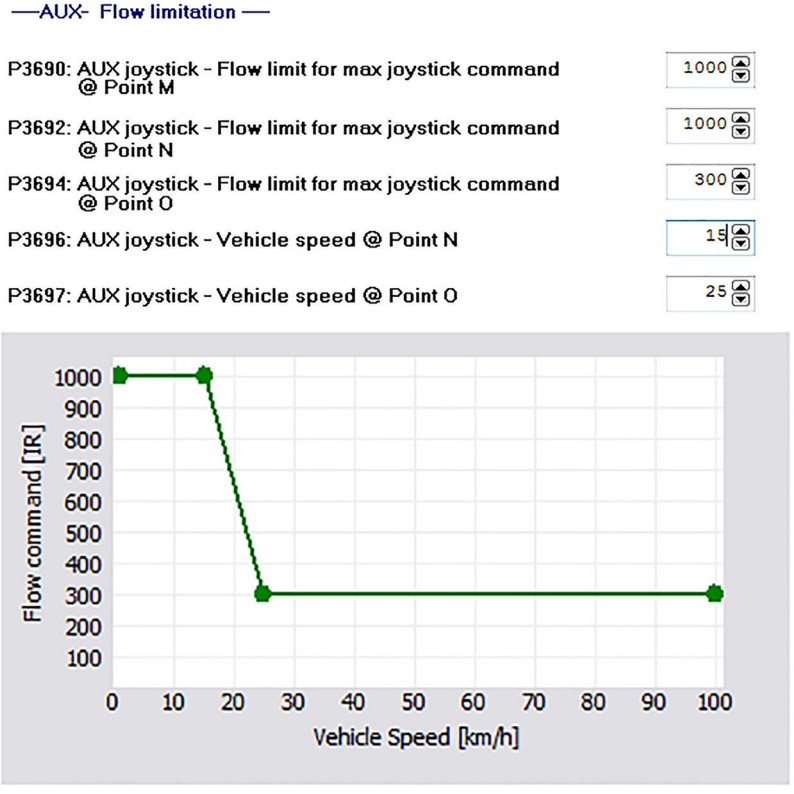
PVED-CLS AUX— flow limitation

AUX Flow Limitation is used with Open Loop Joysticks to restrict the maximum flow to steering cylinders as the vehicle speed increases. This function scales all joystick flow commands based on vehicle speed. Don't set flow limit below 200 (20%). See Section 11.9 Open Loop Joystick – Vehicle Speed Dependent Flow Scaling in the User Manual for more info.



Parameter	Conditions for value change
P3690	Set to desired flow limit [1000 = 100%] at 0 km/h (see graph below)
P3692	Set to desired flow limit (y-axis) at desired vehicle speed in km/h (P3696)
P3694	Set to desired flow limit (y-axis) at desired vehicle speed in km/h (P3697)
P3696	Set to desired vehicle speed in km/h (x-axis) at desired flow limit (P3692)
P3697	Set to desired vehicle speed in km/h (x-axis) at desired flow limit (P3694)

Example of AUX flow limitation



Parameter setting

PVED-CLS AUX— flow limitation tuning advice

1. Remove flow limitation (1000 for all 3 flow limits) and drive the machine first slowly and then at increasing speeds.
2. On each trial, steer full left or right with the joystick.

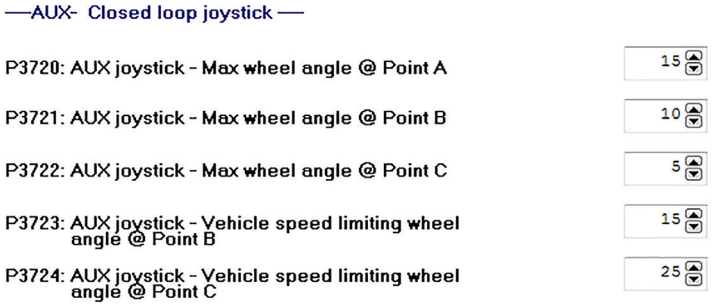
   Vehicle tipping hazard!
   Operate carefully to avoid tipping the vehicle.

   If the machine does not feel controllable at a given vehicle speed, use the flow limitation to begin to decrease flow allowed at that speed.
3. Iterate until the operator can move the joystick as quickly as possible at any speed and avoid tipping.

   CAN logging can also be implemented to monitor vehicle speed and flow set-points from the Vehicle Speed message and Status Message 4 which are described in the PVED-CLS Communication Protocol document. Scatter plotting flow set-points vs. vehicle speed should yield a curve that can be reflected with the AUX Flow Limitation.

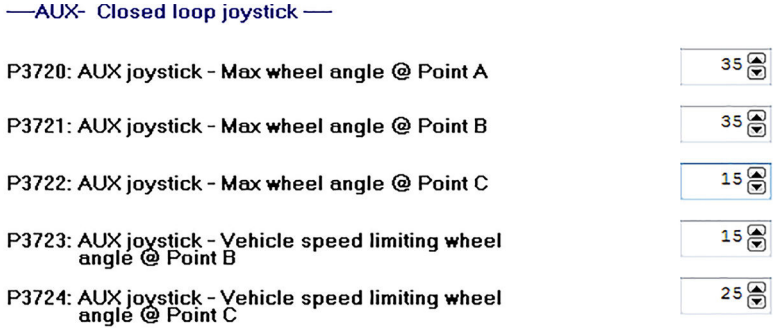
PVED-CLS AUX— closed loop joystick

AUX Wheel Angle Limit is used with Closed Loop Joysticks to limit the maximum wheel angle as the vehicle speed increases. This function scales all joystick wheel angle commands based on vehicle speed. See Section 11.10 Closed Loop Joystick – Vehicle Speed Dependent Wheel Angle Limitation in the User Manual for more info.

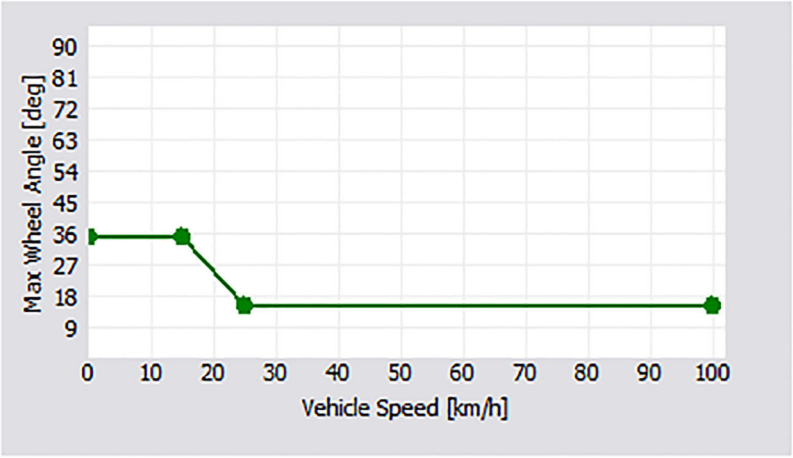


Parameter	Conditions for value change
P3720	Set to desired wheel angle limit [degree] at 0 km/h (see graph below)
P3721	Set to desired wheel angle (y-axis) at desired vehicle speed in km/h (P3723)
P3722	Set to desired wheel angle (y-axis) at desired vehicle speed in km/h (P3724)
P3723	Set to desired vehicle speed in km/h (x-axis) at desired wheel angle (P3721)
P3724	Set to desired vehicle speed in km/h (x-axis) at desired wheel angle (P3722)

Example of AUX wheel angle limitation



Parameter setting



Closed loop joystick tuning advice

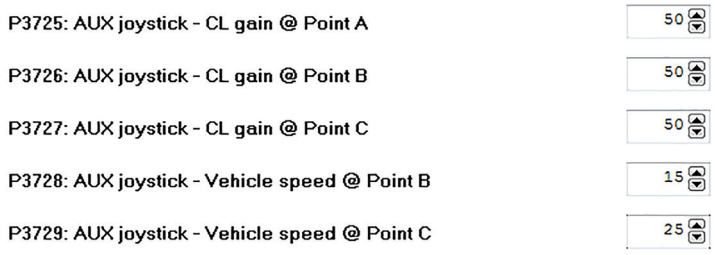
1. Remove wheel angle limitation (raise all 3 wheel angle limits to maximum angle of vehicle), then steer full left or right with the joystick and keep the wheel angle in place.
2. Slowly increase the speed of the machine while driving in a circle until the machine starts to feel tipsy or unsafe.

   Vehicle tipping hazard!
   Operate carefully to avoid tipping the vehicle.
3. Use the wheel angle limitation to decrease the allowed wheel angle at that speed.
4. Iterate until the operator can move the joystick full left or right at any speed and avoid tipping.

   CAN logging can also be used to monitor vehicle speed and wheel angle set-points from the Vehicle speed message and Status Message 5, which are described in the PVED-CLS Communication Protocol document. Scatter plotting wheel angle set-points vs. vehicle speed should yield a curve that can be mimicked with the AUX Wheel Angle Limitation function.

PVED-CLS AUX— closed loop gain

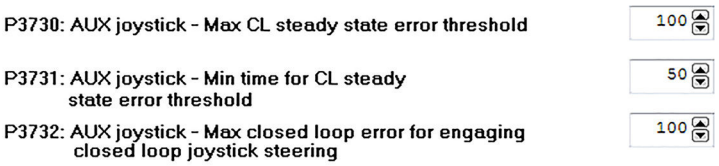
AUX Closed Loop Gain sets the gain used by the Closed Loop Joystick algorithm to a static value or to vary based on vehicle speed. See section 11.11 Closed Loop Joystick – Vehicle Speed Dependent Closed Loop Control in the User Manual for more information.



Parameter	Conditions for value change
P3725	Set to desired closed loop gain [%] at 0 km/h
P3726	Set to desired closed loop gain (y-axis) at desired vehicle speed in hm/h (P3728)
P3727	Set to desired closed loop gain (y-axis) at desired vehicle speed in hm/h (P3729)
P3728	Set to desired vehicle speed in km/h (x-axis) at desired closed loop gain (P3726)
P3729	Set to desired vehicle speed in km/h (x-axis) at desired closed loop gain (P3727)

Tuning advice: keep gains constant and as high as possible without causing overshoot or instability.

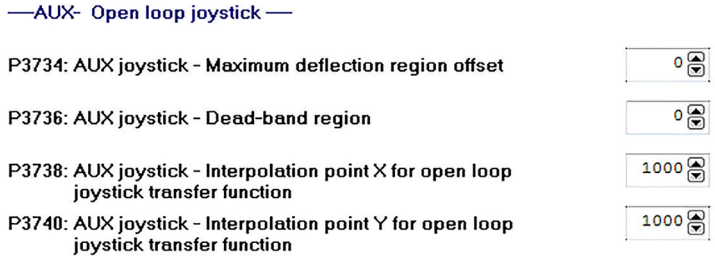
Parameter setting



Parameter	Conditions for value change
P3730	Max closed loop error [IR, 100=10%] allowed when switching device from AUX to Auto-guidance.
P3731	Minimum time [x10ms] where steady state threshold can't be exceeded to switch device from AUX to Auto-guidance.
P3732	Max closed loop error [IR, 100=10%] before closed loop joystick steering is enabled.

PVED-CLS AUX— open loop joystick transfer function

Open Loop Joystick transfer function scales the position of the open loop joystick to a requested flow.



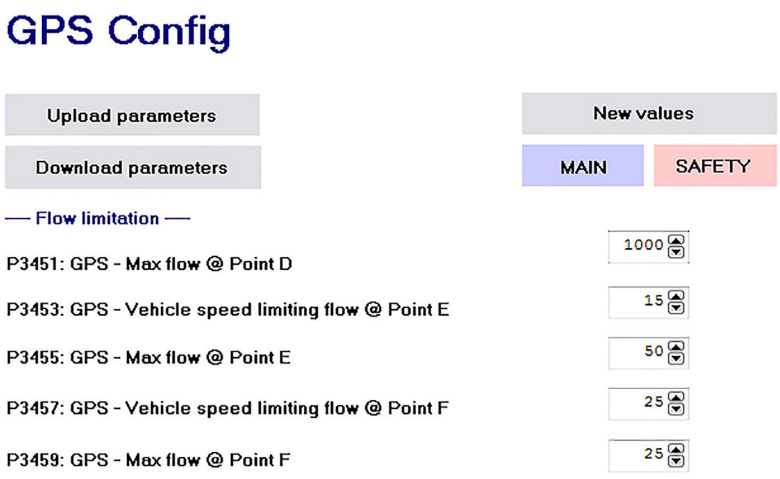
Parameter	Conditions for value change
P3734-P3740	See Section 11.8 in the User Manual for more information

Parameter setting

PVED-CLS GPS configuration

Navigate to the GPS configuration section via **System Navigator** > **Configuration** > **GPS Config**

These parameters only apply if GPS is enabled. GPS Flow Limitation is used with auto-guidance to restrict the maximum flow to steering cylinders as the vehicle speed increases. See Section 12.5 Vehicle Speed Dependent Flow Command Limitation in the User Manual for more info.

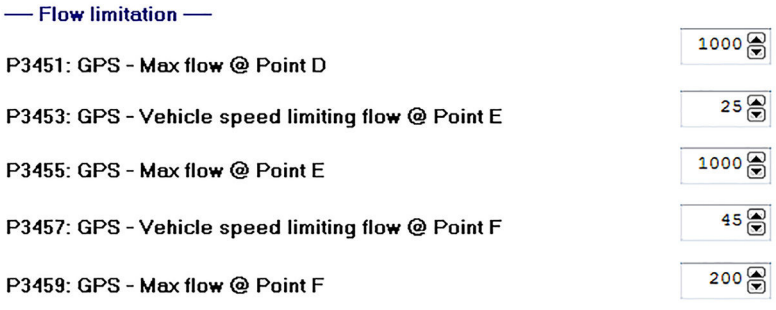


Parameter	Conditions for value change
P3451	Set to desired flow limit [IR, 1000=100%] at 0 km/h (see graph below)
P3453	Set to desired vehicle speed in km/h (x-axis) at desired flow limit (P3455)
P3455	Set to desired flow limit (y-axis) at desired vehicle speed in km/h (P3453)
P3457	Set to desired vehicle speed in km/h (x-axis) at desired flow limit (P3459)
P3459	Set to desired flow limit (y-axis) at desired vehicle speed in km/h (P3457)

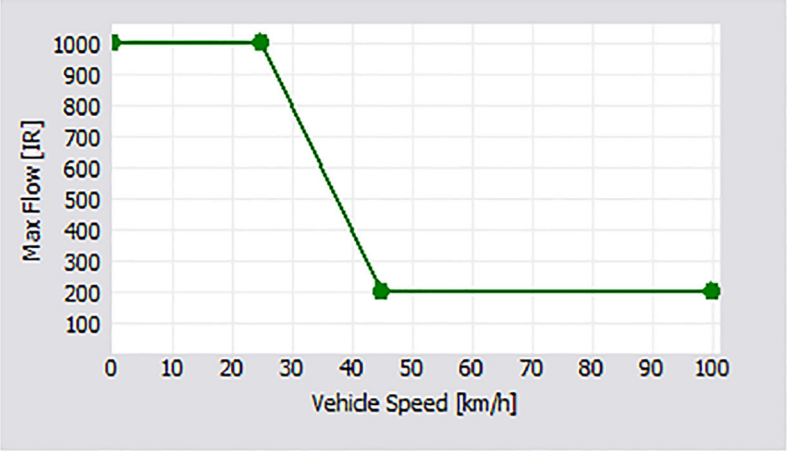
There are three subsets of GPS tuning that will need configuring if GPS is enabled.

Approve the parameters by following the steps in *PVED-CLS parameter acceptance* on page 8.

PVED-CLS example of GPS flow limitation



Parameter setting



PVED-CLS GPS flow limitation— tuning advice

1. Remove flow limitation (1000 for all 3 flow limits) and drive the machine first slowly and then at increasing speeds.
2. On each trial, command full left or right.

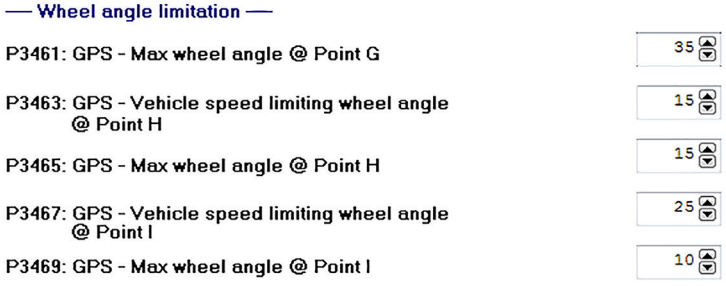
   Vehicle tipping hazard!
   Operate carefully to avoid tipping the vehicle.

   If the machine does not feel stable steering that quickly at that speed, use the flow limitation to begin to decrease flow allowed at that speed.
3. Iterate until the auto-guidance can command full left or right at any speed and avoid tipping.

   CAN logging can also be implemented to track vehicle speed and flow set-points from the Vehicle Speed message and Status Message 4, which are described in the PVED-CLS Communication Protocol document. Scatter plotting flow set-points vs. vehicle speed should yield a curve that shows the demands from the auto-guidance controller and that can be mimicked with the GPS Flow Limitation function.

PVED-CLS GPS— wheel angle limitation

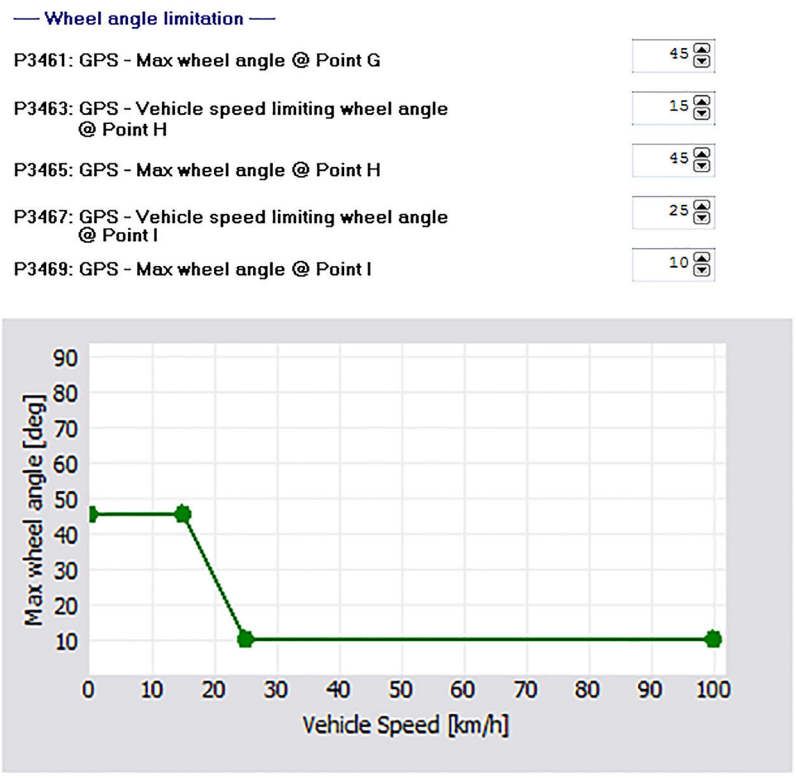
GPS Wheel Angle Limitation decreases the allowed maximum wheel angle as the vehicle speed increases. See Section 12.3 Vehicle Speed Dependent Wheel Angle Limitation in the User Manual for more info.



Parameter	Conditions for value change
P3461	Set to desired angle limit [deg] at 0 km/h (see graph below). Should be the same as max wheel angles in *Vehicle Geometry*.
P3463	Set to desired vehicle speed in km/h (x-axis) at desired wheel angle limit (P3465)
P3465	Set to desired wheel angle limit (y-axis) at desired vehicle speed in km/h (P3464)
P3467	Set to desired vehicle speed in km/h (x-axis) at desired wheel angle limit (P3469)
P3469	Set to desired wheel angle limit (y-axis) at desired vehicle speed in km/h (P3467)

Parameter setting

Example of GPS wheel angle limitation



PVED-CLS GPS— wheel angle limitation tuning advice

1. Remove wheel angle limitation (raise all 3 wheel angle limits to maximum angle of vehicle), then steer full left or right with the steering wheel or auto-guidance controller and keep the wheel angle there.
2. Slowly increase the speed of the machine while driving in a circle until the machine starts to feel tipsy or unsafe.

   Vehicle tipping hazard!
   Operate carefully to avoid tipping the vehicle.
3. Use the wheel angle limitation to decrease the allowed wheel angle at that speed.
4. Iterate at faster speeds until an appropriate wheel angle limit is created for all vehicle speeds.

   CAN logging can also be implemented to track vehicle speed and wheel angle set-points from the Status Messages while auto-guidance is engaged. Scatter plotting wheel angle set-points vs. vehicle speed should yield a curve that shows the demands from the auto-guidance controller and that can be mimicked with the GPS Wheel Angle Limitation function.

Parameter setting

PVED-CLS GPS—vehicle speed dependent closed loop control

GPS Vehicle Speed Dependent Closed Loop Control sets the closed loop gain for the auto-guidance commands. There are 2 different sets of gain values, 1 for each possible auto-guidance device. It is best to keep the gain values static rather than vary them with speed.

Parameter	Condition for value change
P3473-P3478	Set all Closed Loop gains to same desired value [%] unless speed dependent gain is desired. If that is the case then set desired gains for each point which corresponds with a vehicle speed below.
P3479-P3483	If keeping all Closed Loop gains the same, these values can remain at defaults, otherwise match the desired vehicle speed [km/h] at each point corresponding to CL gains above. The vehicle speeds cannot be the same value or an EEPROM error will be triggered. Set the speeds so that they increase with increasing parameter number.

P3484: It is highly recommended that Flow Command filter is left at the default setting.

P3496: GPS- Algorithm Type can be changed if desired. Please see Sections 12.2, 12.6 and 12.7 in the PVED-CLS User Manual for an overview of the benefits of both and how to set other parameters accordingly.

PVED-CLS GPS— CL control tuning advice

1. Tuning Advice: Start with default gain.
2. Using CAN logging, look at the curvature command and estimated curvature found respectively in the Guidance System Command and Guidance Machine Status messages described in the Communication Protocol.

   If estimated curvature is taking too long to approach the commanded curvature, increase the gain.

   If estimated curvature is overshooting the commanded curvature, decrease the gain.

   The spool auto-calibration may also influence the auto-guidance performance.

Parameter setting

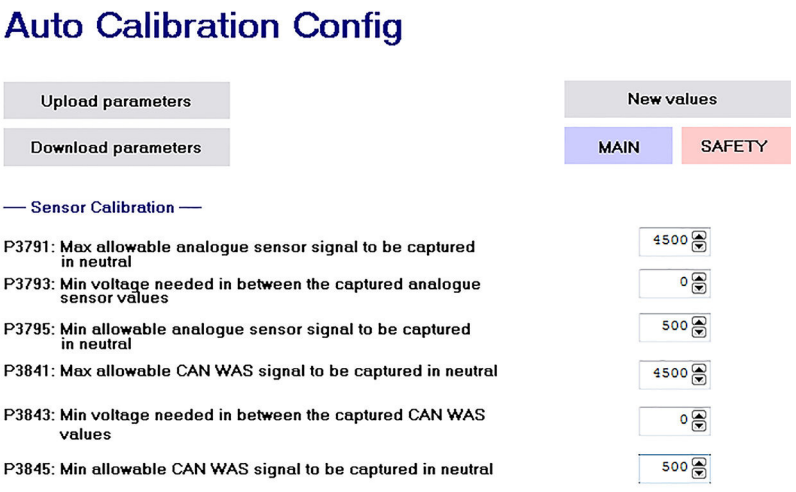
Auto calibration configuration

Navigate to the Auto calibration configuration section via **System Navigator** > **Configuration** > **Auto Calibration Config**

PVED-CLS auto calibration— sensor

Sensor Calibration parameters can define a window of allowed neutral positions to be captured during Analog sensor and/or CAN WAS calibration, as well as a required voltage offset between captured neutral and left/right values.

These do not need to be changed for CLS to function.



PVED-CLS auto calibration— cylinder stroke and max steer angles

Automatically adjusted cylinder stroke and max steer angle values are used for vehicles where changing tires may affect the maximum steering angles (decreasing because larger wheels or duals may impact the vehicle if the same end-stops are used).

This is a set of parameters to map the voltage of the WAS to left/right cylinder stroke volume and max steer angle. These should be set by the OEM using the actual steering geometry to determine values. For more information on setting these parameters see Section 9.1.1 Automatic Adjustment of Maximum Steer Angles and Cylinder Stroke Volume in the User Manual.

Parameter setting

— Automatically adjusted cylinder stroke and max steer angle-values —	
P3815: Mapped cyl. str. vol. (steering left) at 33% VB	333
P3817: Mapped cyl. str. vol. (steering left) at 67% VB	667
P3819: Mapped cyl. str. vol. (steering left) at 100% VB	1000
P3821: Mapped VB for cyl. str. vol. (steering left)	2000
P3823: Mapped cyl. str. vol. (steering right) at 33% VB	333
P3825: Mapped cyl. str. vol. (steering right) at 67% VB	667
P3827: Mapped cyl. str. vol. (steering right) at 100% VB	1000
P3829: Mapped VB for cyl. str. vol. (steering right)	2000
P3831: Mapped max WA (steering left) at 33% VB	30
P3832: Mapped max WA (steering left) at 67% VB	60
P3833: Mapped max WA (steering left) at 100% VB	89
P3834: Mapped VB for max WA (steering left)	2000
P3836: Mapped max WA (steering right) at 33% VB	30
P3837: Mapped max WA (steering right) at 67% VB	60
P3838: Mapped max WA (steering right) at 100% VB	89
P3839: Mapped VB for max WA (steering right)	2000

PVED-CLS auto calibration— spool dead-band

If the parameter change is not described below, use the default values.

Spool Dead-band Calibration values set the behavior of the Auto Spool Calibration routine which finds the Closed Loop dead-band edges for the spool calibration.

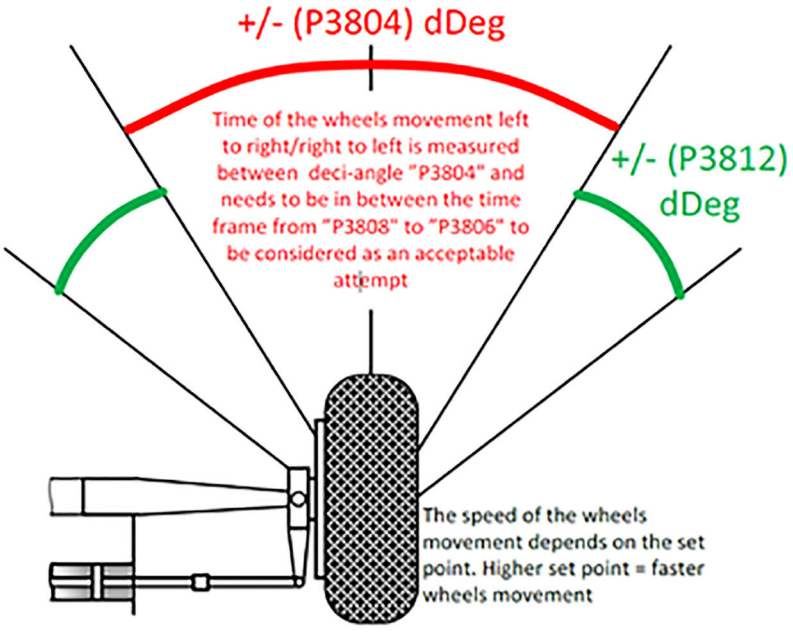
See Section 9.4.1.1 in the User Manual for more detailed descriptions of the parameters.

Example parameter settings

— Spool dead-band calibration —	
P3797: Spool calibration - Max closed loop dead-band edge	300
P3799: Spool calibration - Min closed loop dead-band edge	0
P3801: Spool calibration - Activation timeout	20
P3802: Spool calibration - Initial spool position	125
P3804: Spool calibration - +/- turn range sweep	25
P3806: Spool calibration - Max time for acceptable CL dead-band edge	110
P3808: Spool calibration - Min time for acceptable CL dead-band edge	60
P3810: Spool calibration - Vector sample size	7
P3811: Spool calibration - Min valid samples	5
P3812: Spool calibration - +/- turn range sweep add-on	25
P3814: Spool calibration - Spool set-point increase/decrease step	10

Parameter setting

Parameter	Conditions for value change
P3797	Set max value of captured Closed Loop Dead-Band edges [x10µm]
P3799	Set min value of captured Closed Loop Dead-Band edges [x10µm]
P3801	Time [sec] after turning the steering wheel before calibration can no longer be activated
P3802	Initial spool set-point [x10µm] for calibration routine
P3804	Angle [0.1 deg] on both sides of neutral that wheels move through while being timed (see figure below)
P3806	Upper time limit [0.1 sec] for wheels to move through angle specified in P3804
P3808	Upper time limit [0.1 sec] for wheels to move through angle specified in P3804
P3810	Number of attempted spool set-points attempts kept in memory
P3811	Minimum number of spool set-point attempts that must match in memory to complete calibration



PVED-CLS auto calibration— spool dead-band tuning advice

1. During machine startup, use default Auto Spool Calibration parameters as described in the calibration section.
2. Manually adjust closed loop dead-band edges while tuning GPS steering.
3. Change Auto Spool Calibration parameters to achieve similar closed loop dead-band edges under end-of-line conditions.
4. Iterate on parameters until the Auto Spool Calibration can consistently achieve good GPS steering performance from end-of-line calibration.

   The main parameters of interest are P3806 and P3808 which define the time limits for the wheels to turn through the turn range sweep set in P3804 (5 degrees by default). By increasing or decreasing the times, the closed loop dead-band edges will be smaller or larger (absolute value) respectively. By decreasing the gap between the values, the captured dead-band edges will be more consistent from machine to machine.

PVED-CLS advanced parameter setting

Read section 8 (pages 38-55) of the PLUS+1® Service Tool User Guide found in firmware release package under Service Tool to learn how to use the following pages:

- Parameter File Interface_OEM
- Parameter File Interface_VPS
- Clone PVED-CLS

These files are used to export and import parameter configurations.

Troubleshooting

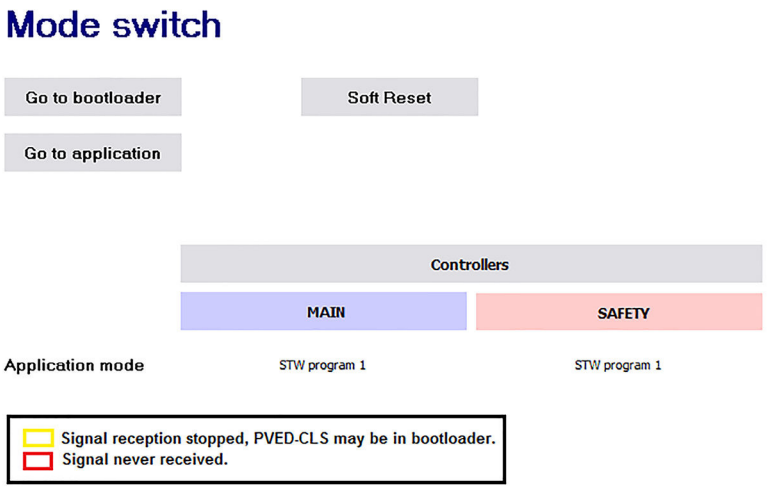
Resolving safe-state mode by soft reset

If the PVED-CLS is in safe-state mode, it is possible that a soft reset will resolve the underlying issue.

1. Open the **Mode switch** page.

   The Mode Switch page is used to change between Bootloader and Application modes. When a **Config** page is entered while in Normal View in the Service Tool, the PVED-CLS enters Bootloader mode. To return to Application mode go to the **Mode switch** page and press the “Go to application” button.

   If the PVED-CLS is already in application mode (there is no red or yellow box around the Main and Safety states) the "Go to application" button does not need to be pressed.



2. Press the "Soft Reset" button to reboot the PVED-CLS.

   This may clear the Safe State if it was caused by exceeding a speed threshold or a temporarily missing message.

If the PVED-CLS remains in safe-state mode, proceed to the *Resolving safe-state mode with SPN and FMI codes* on page 42 section for further troubleshooting.

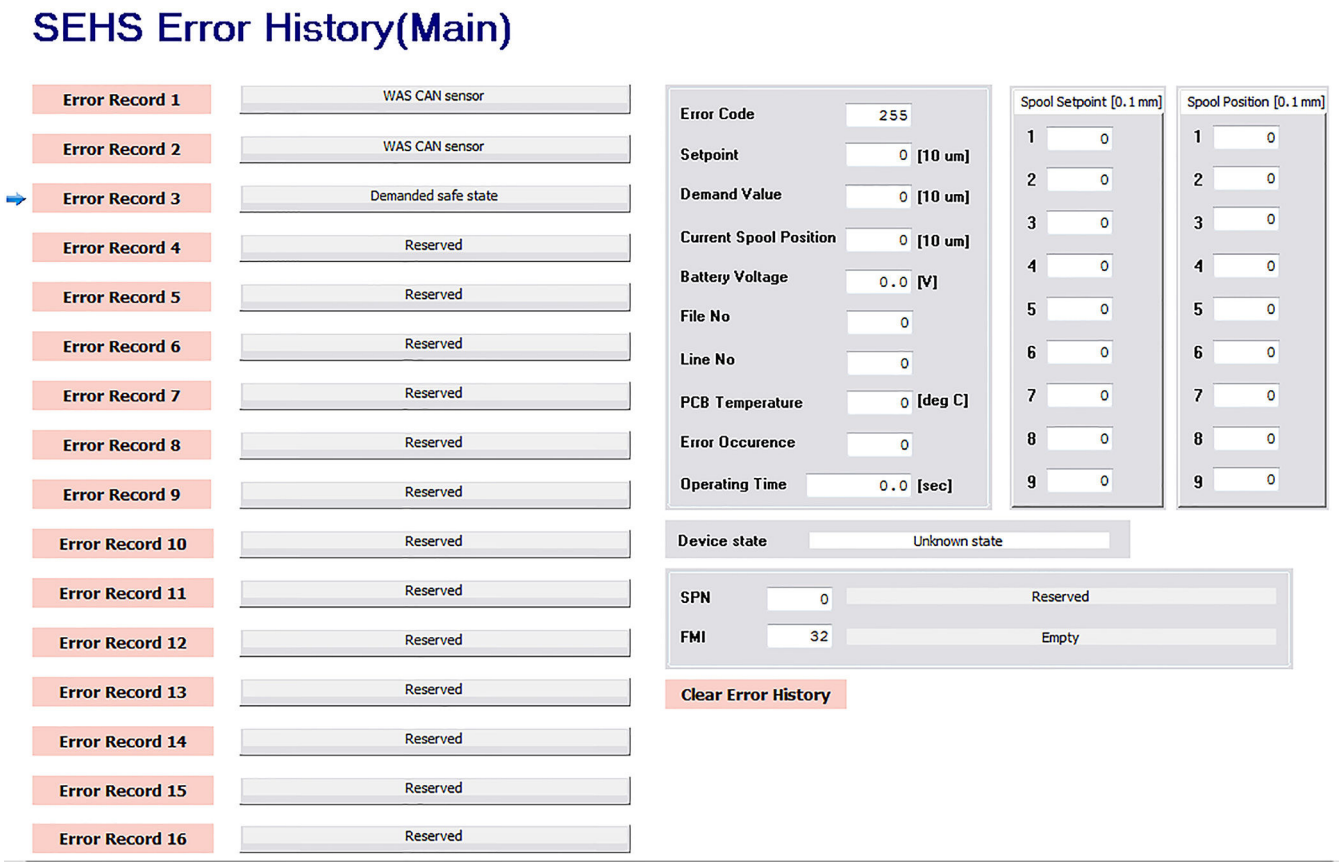
Troubleshooting

Resolving safe-state mode with SPN and FMI codes

In order to resolve safe-state mode with this method, SPN and FMI codes must be obtained and referred to in the User Manual. There are two ways to obtain SPN and FMI codes: through the error history pages or the error occurrence counter page.

SEHS error history

1. Go to **System Navigator** > **Diagnostics** > **SEHS Error History_Main (or _Safety)**.



The blue arrow shows the most recent error in the list.

After 16 errors are recorded, new errors are written over previous errors starting at Error Record 1.

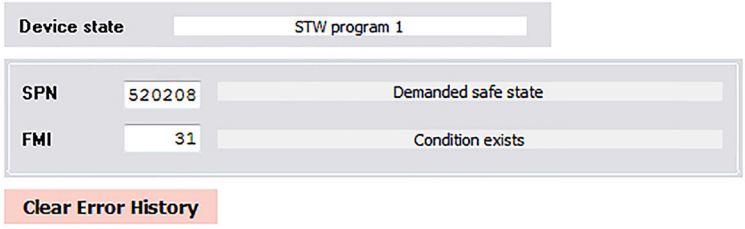
2. Click the corresponding "Error Record" button to see more details on the error. This will display the Suspect Parameter Number (SPN) and the Failure Mode Identifier (FMI) of the error.
3. Search the SPN in the User Manual and then look for the correct FMI to learn more about the error and find possible root causes.

Troubleshooting

PVED-CLS clear error history

Once all errors have been dealt with or it is desired to clear the history buffer.

Press the **Clear Error History** Button to clear all recorded errors in the controller's memory and press **OK** on the prompt. Each controller (Main and Safety) has its own error buffer.



Warning
Clearing the error history will erase all records of fault codes which are used for troubleshooting and for warranty purposes.
Ensure that all errors have been taken care of properly before clearing the error history.

SEHS error occurrence

The SEHS error occurrence page is the second method used to troubleshoot safe-mode in PVED-CLS.

Go to the SEHS error occurrence page via **System Navigator** > **Diagnostics** > **SEHS Error Occurrence Counter** to see the total number of each error that has occurred in both controllers.

This page can display more than the 16 errors in the error history of each controller to be displayed.

When the error history is cleared on the Main or Safety Error History pages, it clears the information in the SEHS Error Occurrence Counter as well.

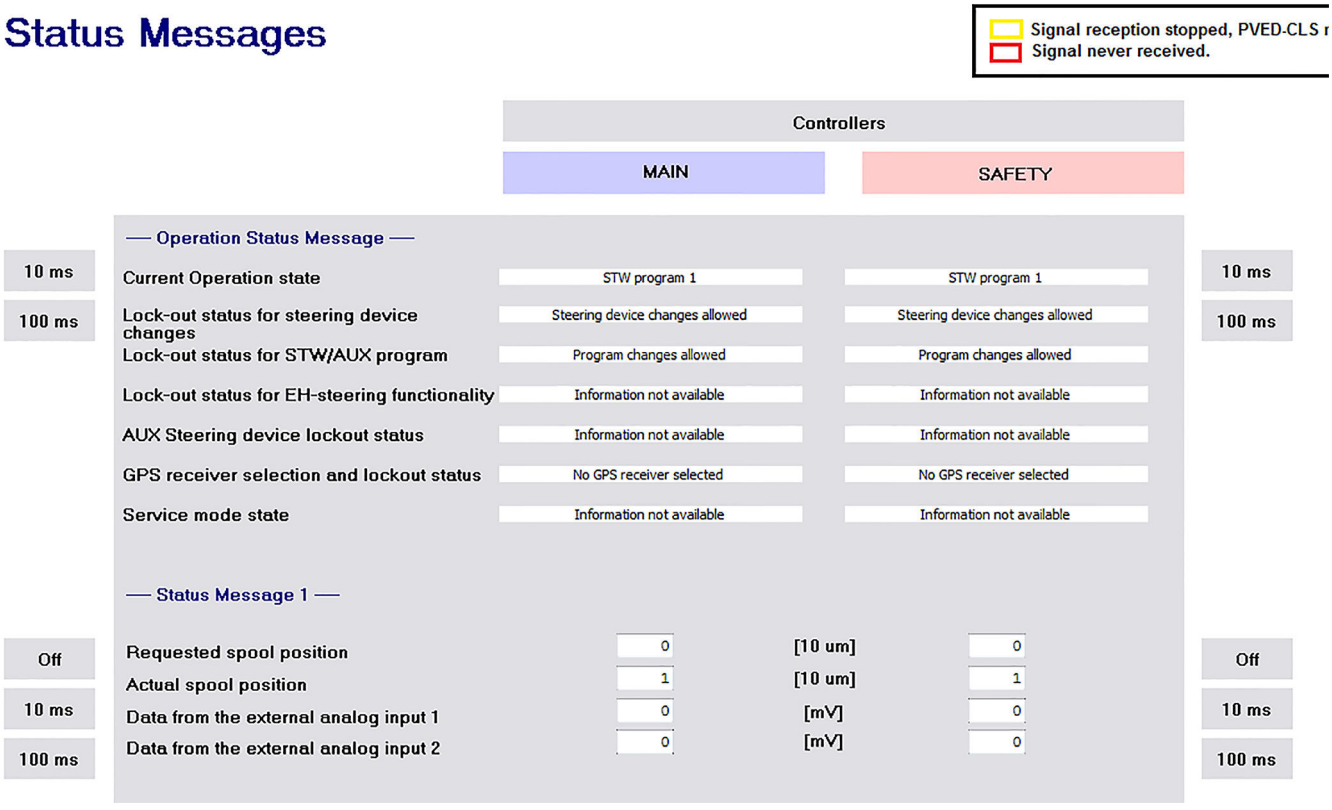
SEHS Error Occurrence Counter

	Description				MAIN	SAFETY
	SPN	FMI	SPN	FMI	Error Occurrence Counter	
0	Software Initialization	Unknown root-cause	299005	11	0	0
1	Division by zero	Unknown root-cause	299004	11	0	0
2	Variable truncation	Unknown root-cause	299002	11	0	0
3	Interpolation	Unknown root-cause	298968	11	0	0
4	Vbat	Voltage above normal or short-circuit to high source	627	3	0	0
5	Vbat	Voltage below normal or short-circuit to low source	627	4	0	0
6	+5V	Data erratic, intermittent or incorrect	520582	2	0	0
7	LVDT calculation	Data erratic, intermittent or incorrect	520583	2	0	0
8	Vref generation	Data erratic, intermittent or incorrect	520585	2	0	0
9	GND level	Voltage above normal or short-circuit to high source	520586	3	0	0
0	LVDT demod A	Data erratic, intermittent or incorrect	520588	2	0	0
1	LVDT demod B	Data erratic, intermittent or incorrect	520589	2	0	0
2	Soft error	Condition exists	520229	31	0	0
3	LVDT sinus signal	Abnormal frequency or pulse width or period	520212	8	0	0
4	Safe ON-Road Monitoring	Stuck Closed	520206	30	0	3
5	Safe ON-Road Monitoring	Data erratic, intermittent or incorrect	520206	2	0	0
6	Safe ON-Road Monitoring	Message missing	520206	22	0	0
7	EEPROM STW config	Data erratic, intermittent or incorrect	520243	2	0	2
8	EEPROM STW config	Special instructions	520243	14	0	0
9	EEPROM AUX config	Data erratic, intermittent or incorrect	520244	2	0	0
20	Cut-off solenoid	Received network data in error	520210	19	0	0
21	Coil supply switch	Received network data in error	299023	19	0	0

Troubleshooting

Status messages

Go to the status messages page via **System Navigator** > **Diagnostics** > **Status Messages** to view the contents of status messages.



If a yellow or red box appears around any messages of interest, they are not currently being received or transmitted. Follow these sub-steps to resolve the issue:

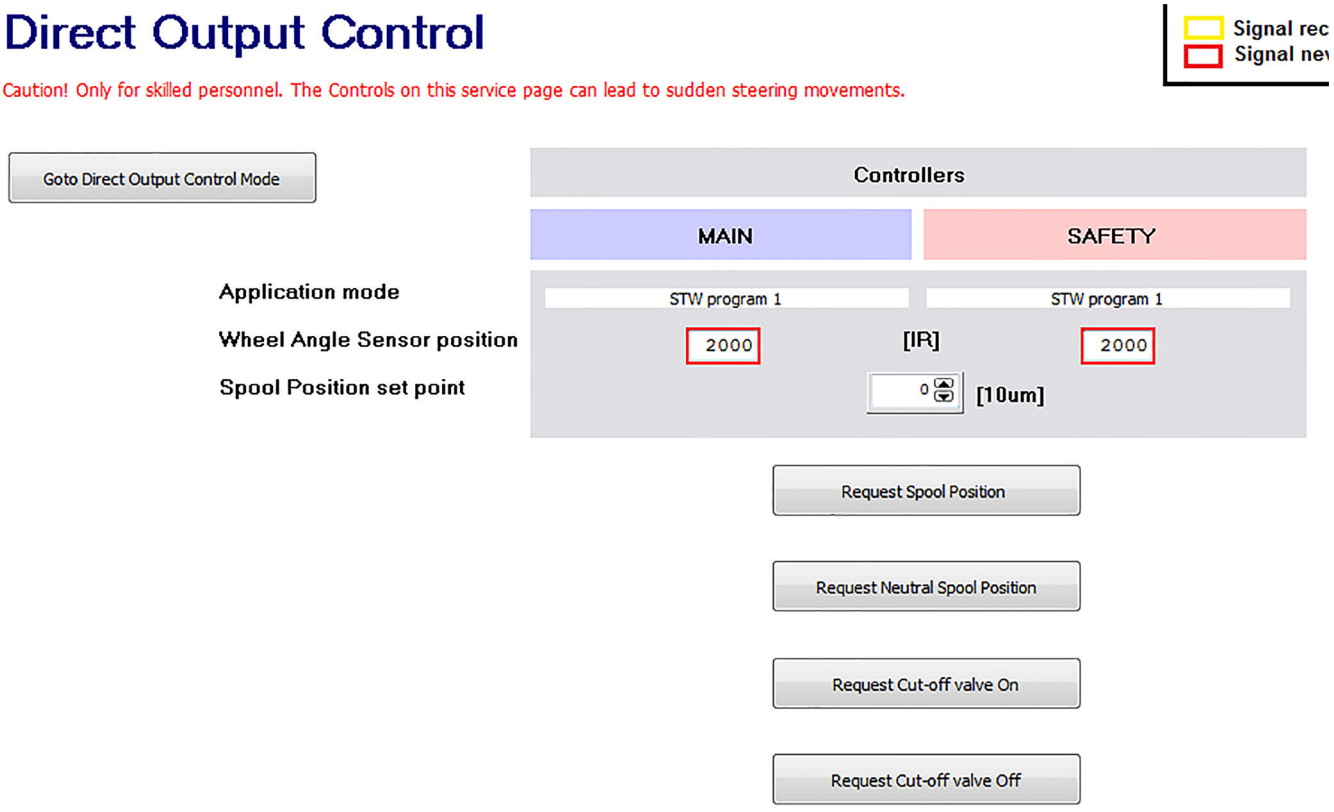
Troubleshooting

a) Press the "10ms" or "100ms" buttons to request the messages be sent at the respective frequency.
b) Press the "Off" button to request that the message stop sending.

Direct output control

Direct Output Control can be used to set the directional spool to a given set-point. This will send flow to the steering cylinders. Direct Output Control is therefore useful for verifying the hydraulic circuit is working, that the electronics can send flow, and for doing a rough spool calibration.

Go to the direct output control page via **System Navigator** > **Diagnostics** > **Direct Output Control**



a) Press the “Go to Direct Output Control Mode” button.
b) Press the “Request Cut-off Valve On” button to enable the directional spool to move and flow to be sent to the steering cylinder.
c) Enter a number into the Spool Position set point field. Negative numbers move the spool left and should steer the wheels left. Positive numbers move the spool right and should steer the wheels right
d) Press the “Request Spool Position” button to make spool move to set point.
e) Press the “Request Neutral Spool Position” button to make the spool move back to neutral.
f) Press the “Request Cut-off Valve Off” button when finished with Direct Output Control Mode.

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