H-BRIDGE DRIVER

User's Guide

10/02/2016 Version 2.0 F

1. Introduction

TO DO

2. Build-In Functions

2.1 Overview

The driver can execute a series of basic test functions used to fully characterize a specific actuator.

Test Function	Purpose
SENSOR RANGE IDENTIFICATION	To measure the position sensor output range and detect invalid values.
RESPONSE TIME	To measure the time taken by the actuator to move from one end to the other (in both directions) under specific stimuli
HYSTERESIS	To characterize the position offset between

2.2 Sensor Range Identification

2.2.1 Description

The purpose of this process is to identify the effective output range of the actuator's position sensor by moving the valve to both mechanical ends and record the sensor output at these positions. This movement is induced by applying two PWM duty cycles sequentially forcing the valve to its full closed and full open positions.

The effective sensor range is required to calculate the valve's instant position ratio (expressed in % of the valve displacement range) as follow in the case of an analogue sensor:

$$Pos\_Ratio = \frac{V_{Sensor} - V_{Sensor\_PWM\_Min}}{V_{Sensor\_PWM\_Max} - V_{Sensor\_PWM\_Min}} \times 100$$

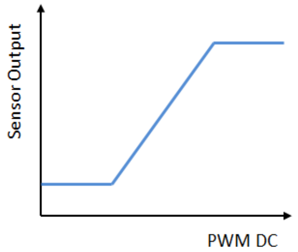
where Vsensor_PWM_Min and *Vsensor_PWM_Max* correspond respectively to the sensor outputs recorded when PWM duty cycle min. (valve fully closed) and max. (valve fully open) were applied.

With other position sensor types (PWM or SENT), the voltage is replaced in the above formula with the corresponding sensor output type (% or counts).

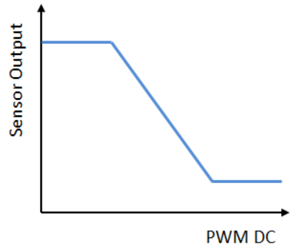
The position ratio is an essential data used by most of the other build-in functions. The sensor range identification test must therefore necessarily be executed prior to any other test and each time a new valve is connected to the driver.

The formula above is used only if *Vsensor_PWM_Min* is smaller than *Vsensor_PWM_Max,* which is the case for most of the position sensors assemblies. However, some position sensors provide an response inverted in regard to the valves opening (*Vsensor_PWM_Min* > *Vsensor_PWM_Max*). In this particular case, the formula used to calculate the position ratio is the following:

$$Pos\_Ratio = \frac{V_{Sensor} - V_{Sensor\_PWM\_Max}}{V_{Sensor\_PWM\_Min} - V_{Sensor\_PWM\_Max}} \times 100$$



Regular Sensor Output



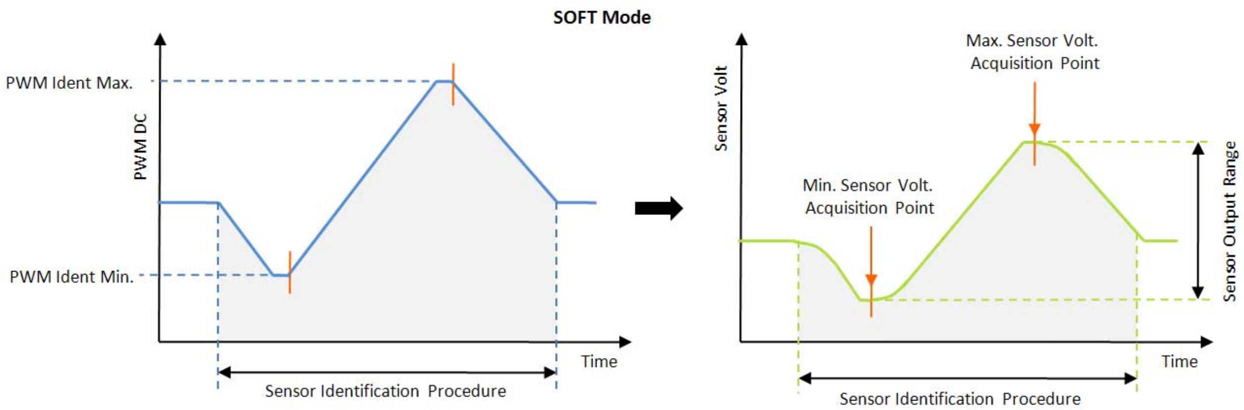
Inverted Sensor Output

At the end of the sensor identification test, the absolute difference between the two sensor readings is calculated to verify if it exceeds a given (user-adjustable) threshold (i.e. 500mV). A too narrow output range can indicate that the valve is either stuck or that sensor has become unresponsive due to a mechanical obstruction/rupture or an electrical failure. This threshold must be exceeded for the test to be considered as valid.

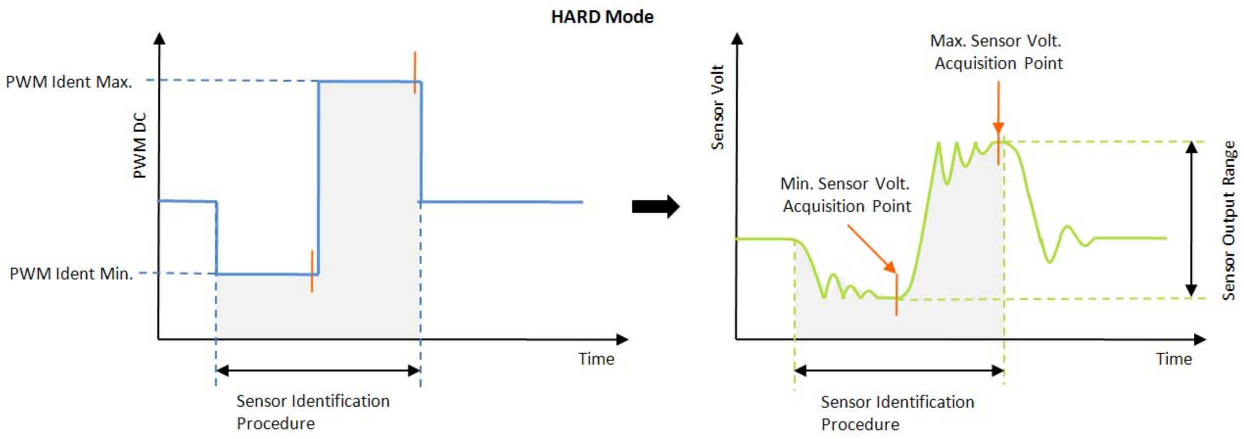
PWM DC min. and max. parameters used in the sensor identification test must be carefully selected to make sure that the valve will press firmly against the mechanical ends in any possible test circumstance.

Two PWM duty cycle transition modes are available:

1. **Soft Mode**: During the procedure, the PWM DC is gradually increased or decreased at a given rate, first from its initial pre-test value to the PWM DC min. Once the PWM DC min. is reached and after a given delay, the sensor voltage sample is recorded (Sensor Voltage Min.). The PWM DC is then gradually increased up to the PWM DC max. Once the PWM DC max. is reached and after a given delay, a second sensor voltage sample is recorded (Sensor Voltage Max.). The PWM is then increased or decreased back to its initial pre-test value.



2. **Hard Mode**: When the procedure starts, the PWM duty cycle min. is directly applied without transition and a sensor voltage sample (Sensor Voltage Min.) is recorded after a given delay. The PWM duty cycle max. is then directly applied without transition and a second sensor voltage sample is recorded (Sensor Voltage Max.) after a given delay. The initial duty cycle is then recalled.



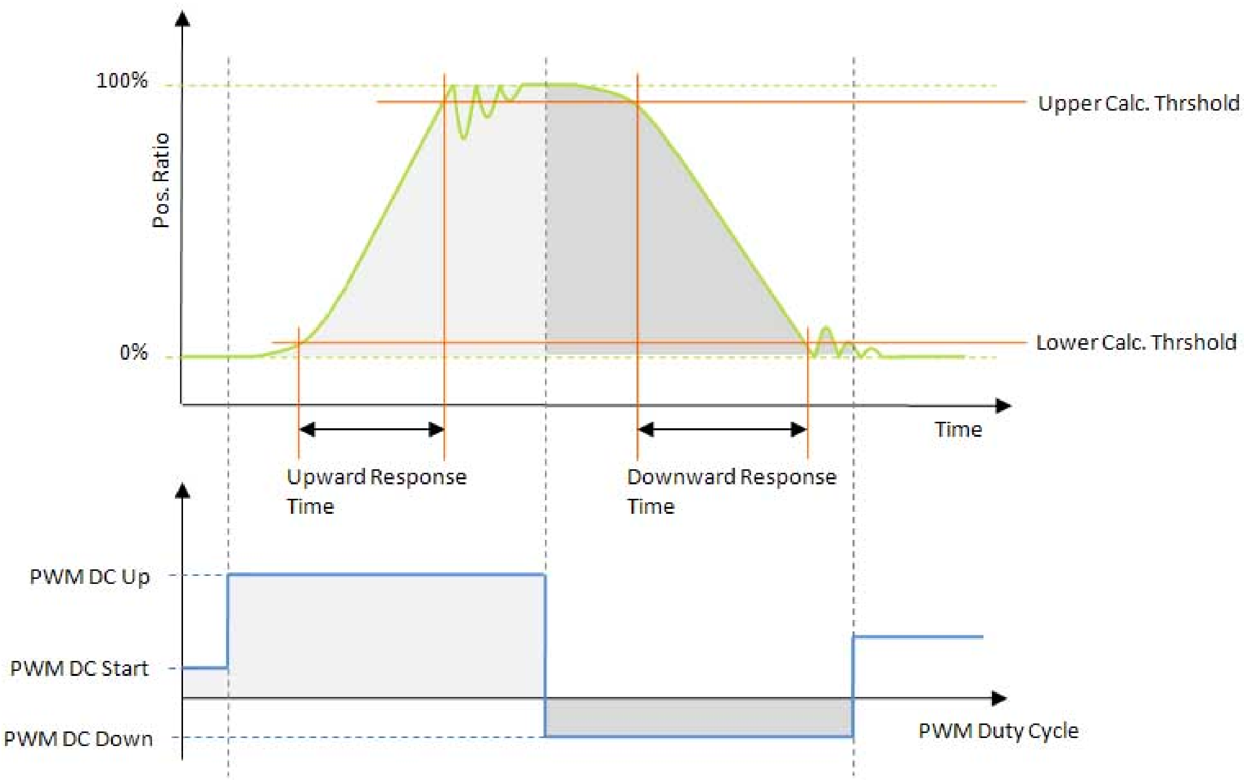
The soft mode offers a smoother and less mechanically stressful way to execute the sensor identification test, but at the cost of longer test durations. The hard mode is more stressful for the valve's components but offers minimum test time.

2.3 Response Time Test

2.3.1 Description

The purpose of this test is to analyse the dynamic performances of the valve by recording the time taken to move from one mechanical end to the other in both 'opening' and 'closing' directions under specific stimuli.

Response times are usually measured between two position ratio thresholds (one close to 0% (i.e. 3%), one close to 100% (i.e. 97%)).



Knowing the valve's angular or linear displacement range, one can calculate the valve's average linear or angular velocity in between position thresholds as follow:

$$Valve\text{\_Avg\_Velocity} = \frac{\text{Valve\_}D\text{isp\_Range} \times (\text{Upper\_Calc\_Thresh} - \text{Lower\_Calc\_Thresh})}{100\ \times \text{Response\_Time}}$$

Some additional features have been integrated in the response-time test scheme to increase its versatility:

- Upper and lower calculation thresholds can be specified distinctively for the upward and downward test phases.

- Additional upper and lower validation thresholds: those must imperatively be crossed to consider the response time test as valid. This feature is particularly useful if the calculation thresholds are set relatively far from the 0 and 100% levels, for instance: if calculation thresholds are set at 10% and 90%, validation threshold could be set a 3% and 97% to make sure that the valve has indeed moved through its full displacement range.

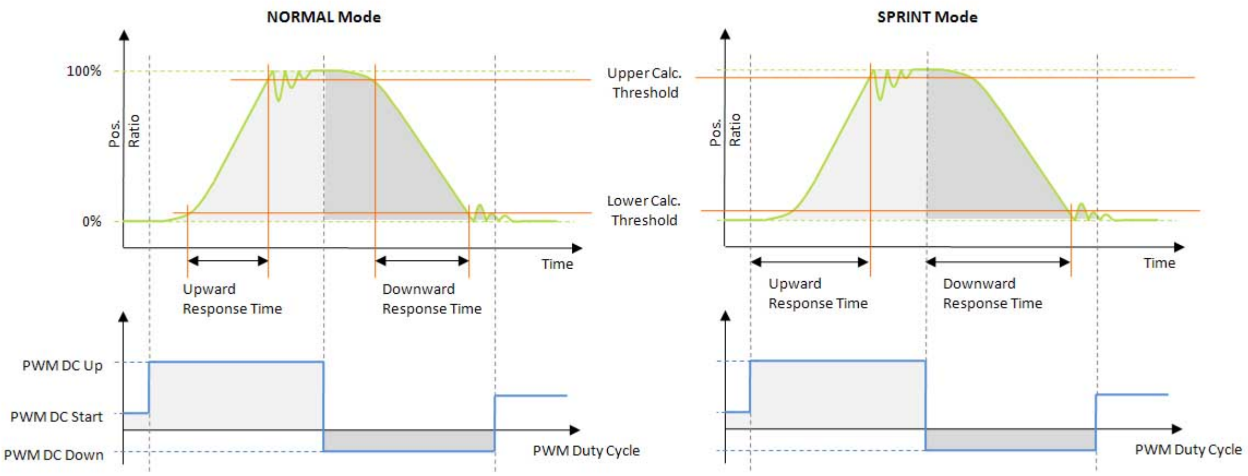
- As the test controller waits for the valve to cross the upper validation threshold in the upward direction and the lower validation threshold in the downward direction to switch to the next test phase, a validation thresholds crossing timeout feature has been implemented to avoid waiting endlessly for the phase switching events.

- A phase switching delay has been foreseen to allow the valve's movement to stabilize before the next test phase is launched.

Two response time calculations methods are available:

1. **Normal Mode**: The response time is measured from the time when the first calculation pos. ratio threshold is crossed to the time when the second calculation pos. ratio threshold is crossed.

2. **Sprint Mode**: The response time is measured from the time the PWM Duty Cycle is applied to the time to the time when the second calculation pos. ratio threshold is crossed.



The normal response time calculation method excludes the initial mechanical inertial response lag and does only take account of the dynamic part of the valve’s response to a given PWM stimulus. It does however offer highly accurate and repeatable results as the dynamic part is less subject to environmental conditions.

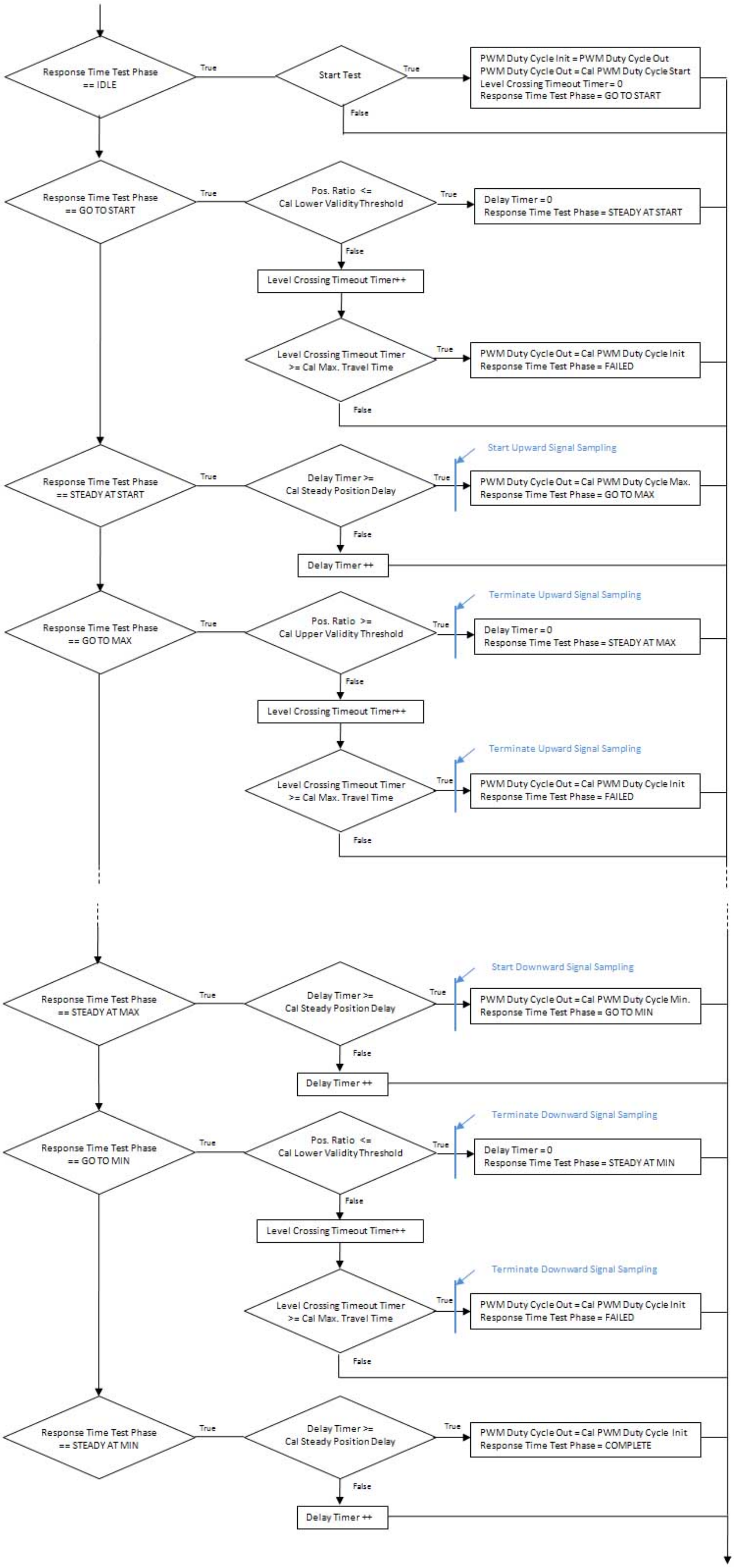
The sprint mode considers the complete response delay but provides much less repeatable results as the initial response is depending essentially on the valve’s internal friction which is related the environmental conditions and components wear. At low PWM frequencies, an additional inaccuracy appears from the fact that the exact time when the PWM duty cycle up/down is effectively updated and applied is unknown.

2.3.2 Response time test sequence

The response time test is controlled by a state machine which can have the following states:

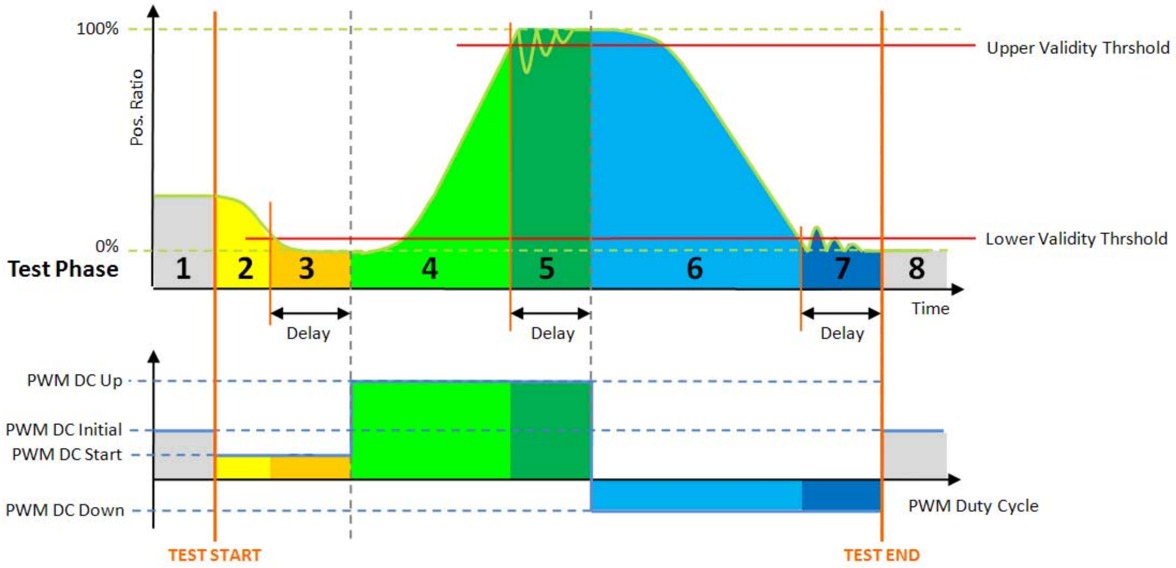
#	State	Description
1	IDLE (Default)	Response time test not running
2	GO TO START	PWM DC Start is applied, waiting until the lower validity pos. ratio threshold is crossed
3	STEADY AT START	Waiting for ‘steady position delay’ to expire then apply PWM DC Max.
4	GO TO MAX	Waiting until the upper validity pos. ratio threshold is crossed
5	STEADY AT MAX	Waiting for ‘steady position delay’ to expire then apply PWM DC Min.
6	GO TO MIN	Waiting until the lower validity pos. ratio threshold is crossed
7	STEADY AT MIN	Waiting for ‘steady position delay’ to expire then recall initial PWM DC
8	COMPLETE	Test complete
9	FAILED	Test failed because validity thresholds crossing timed-out.

This state machine follows the next transition rules:


Response Time Test Phase == IDLE
True
Start Test
True
PWM Duty Cycle Init = PWM Duty Cycle Out
PWM Duty Cycle Out = Cal PWM Duty Cycle Start
Level Crossing Timeout Timer = 0
Response Time Test Phase = GO TO START
False
Response Time Test Phase == GO TO START
True
Pos. Ratio <= Cal Lower Validity Threshold
True
Delay Timer = 0
Response Time Test Phase = STEADY AT START
False
Level Crossing Timeout Timer++
Level Crossing Timeout Timer >= Cal Max. Travel Time
True
PWM Duty Cycle Out = Cal PWM Duty Cycle Init
Response Time Test Phase = FAILED
False
Start Upward Signal Sampling
Response Time Test Phase == STEADY AT START
True
Delay Timer >= Cal Steady Position Delay
True
PWM Duty Cycle Out = Cal PWM Duty Cycle Max.
Response Time Test Phase = GO TO MAX
False
Delay Timer ++
Terminate Upward Signal Sampling
Response Time Test Phase == GO TO MAX
True
Pos. Ratio >= Cal Upper Validity Threshold
True
Delay Timer = 0
Response Time Test Phase = STEADY AT MAX
False
Level Crossing Timeout Timer++
Terminate Upward Signal Sampling
Level Crossing Timeout Timer >= Cal Max. Travel Time
True
PWM Duty Cycle Out = Cal PWM Duty Cycle Init
Response Time Test Phase = FAILED
False
Start Downward Signal Sampling
Response Time Test Phase == STEADY AT MAX
True
Delay Timer >= Cal Steady Position Delay
True
PWM Duty Cycle Out = Cal PWM Duty Cycle Min.
Response Time Test Phase = GO TO MIN
False
Delay Timer ++
Terminate Downward Signal Sampling
Response Time Test Phase == GO TO MIN
True
Pos. Ratio <= Cal Lower Validity Threshold
True
Delay Timer = 0
Response Time Test Phase = STEADY AT MIN
False
Level Crossing Timeout Timer++
Terminate Downward Signal Sampling
Level Crossing Timeout Timer >= Cal Max. Travel Time
True
PWM Duty Cycle Out = Cal PWM Duty Cycle Init
Response Time Test Phase = FAILED
False
Response Time Test Phase == STEADY AT MIN
True
Delay Timer >= Cal Steady Position Delay
True
PWM Duty Cycle Out = Cal PWM Duty Cycle Init
Response Time Test Phase = COMPLETE
False
Delay Timer ++

Position sensor output samples are acquired continuously during the test and stored into two distinct upward and downward data buffers at a user-adjustable sampling rate (default is 2 KSample/sec).

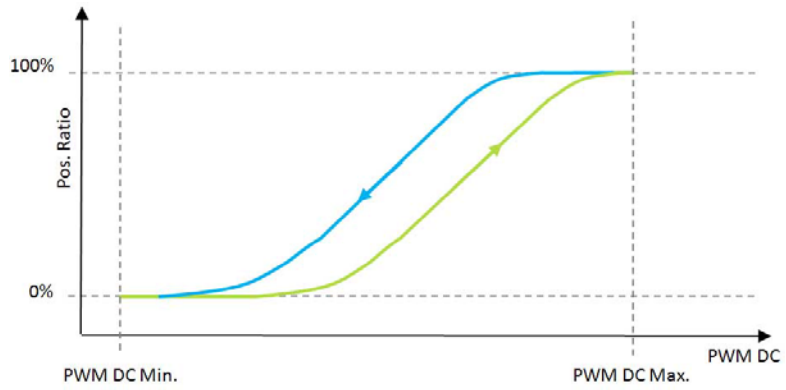
If the test completes successfully, the content of these buffers are processed and converted into position ratios using the informations from the sensor identification test. The times where the calculation thresholds are crossed are identified. To increase accuracy, these times are linearly interpolated between the previous and next acquisition samples around the thresholds.

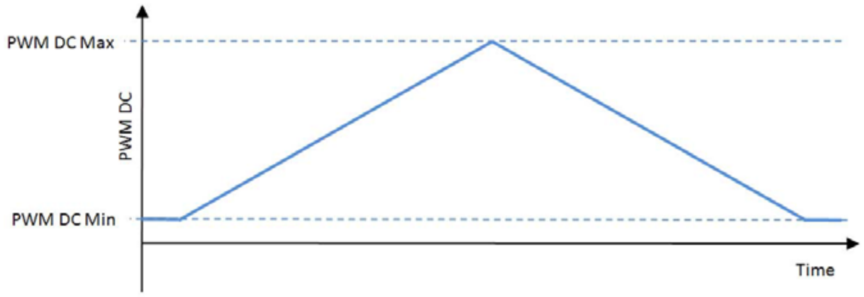


2.4 Hysteresis Test

2.4.1 Test Description

The purpose of this test is to analyse the valve's position lag in regard to the PWM applied between movements in the opening and the closing directions (hysteresis). It is performed by applying an increasing PWM duty cycle from min. to max., then back to min. while sampling the valve's position at a user –adjustable rate (default is 200 samples/s) stored in the acquisition buffer. The content of the buffer is post-processed to find the up- and downward PWM duty cycles at some pre-defined position ratio breakpoints.





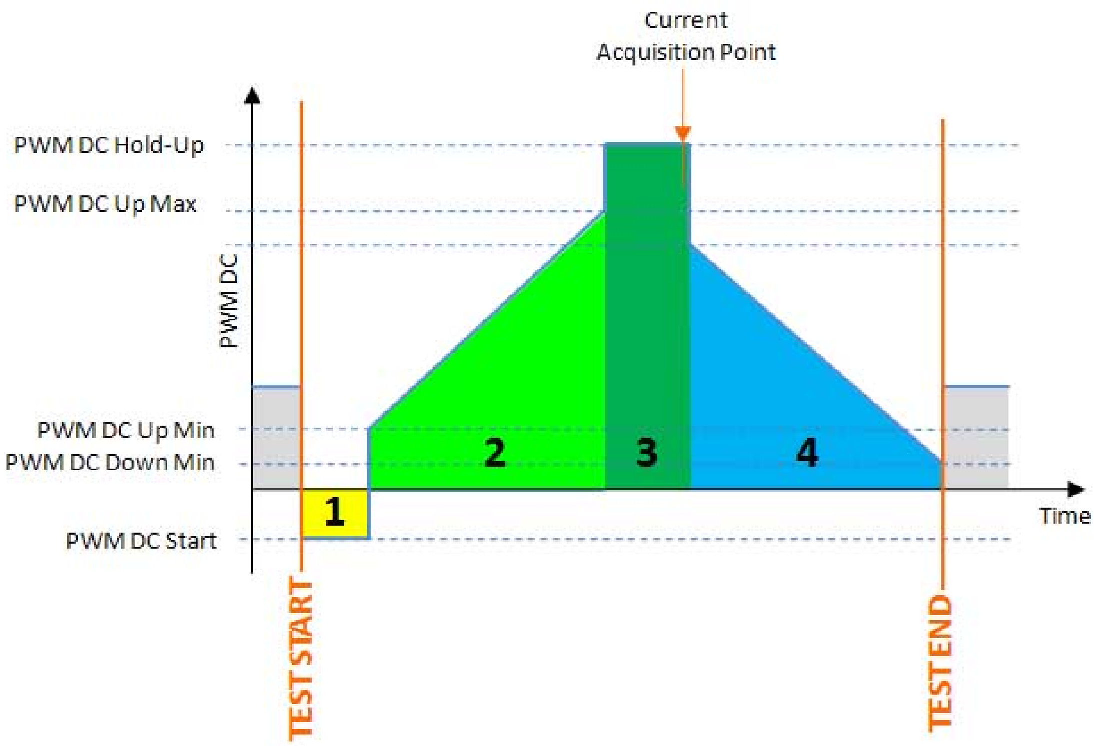
The original test scheme contained only a small number of parameters: PWM DC min., PWM DC max., PWM DC rate of change and the Position Ratio breakpoints. However, following some customer feedbacks and in order to increase the test's versatility and to optimize its execution time, some additional features were implemented:

- PWM DC min. and max can be specified distinctively for the upward and downward test phases. This allows skipping the dead-zones at the top and bottom of the curve.

- PWM DC rate of changes can be specified distinctively for the upward and downward test phases.

- A start-up PWM DC and start-up time are foreseen to allow the valve to move from any position to the test-start position.

- A hold-up PWM DC and hold-up time applied once the test has reached the end of the upward phase are foreseen to take a current sample in specific PWM DC conditions.



#	Phase	Description
1	START UP	PWM DC Startup is applied during a given period
2	UPWARD	PWM is increased from PWM DC Up min. to PWM DC Up max.
3	HOLD UP	PWM DC holdup is applied during a given period and a current sample is taken
4	DOWNWARD	PWM is decreased from PWM DC Down max. to PWM DC Down min.

2.5 Position control PID

2.5.1 Description

An integrated PID is used to control the valve's position in closed-loop mode. All its parameters can be adjusted to best match the valve's dynamic characteristics. The parameters must be carefully selected to achieve the best response-to-stability trade-off.

The generic PID equation is:

$$PWM\ DC\ Out = FF(Pos) + Kp(Err) \times Err + Kd(Err) \times \frac{dErr}{dt} + Ki(Err) \times \int Err\ dt$$

The equation is the sum of four terms:

- **Feed-forward (FF):** This parameter is the PWM duty cycle value defined experimentally which is known to lead to a position close to the target position. Its value is function of the target position. This parameter can be left zero but offers a significant response time improvement if properly calibrated.

  To take account of the valve's hysteresis, the Feed-Forward values can be specified individually for the upward and downward directions.

- **Proportional Term:** This term is the valve's position error times a gain which can be a single constant or (as implemented here) a value looked-up as a function of the position error.

- **Derivative Term:** This term is the valve's position error derivative times a gain which can be a single constant or (as implemented here) a value looked-up as a function of the position error.

The position error derivative can be filtered in software to avoid generating important reactions on position sensor output noise/spikes. However, calibrating the derivative term requires a very good knowledge and analysis of the valve dynamics or could easily lead to uncontrolled instabilities. It is thereby recommended to leave this terms unused (zero).

- **Integral Term:** This term is the valve's position error integral times a gain which can be a single constant or (as implemented here) a value looked-up as a function of the position error. The integral term authority is usually limited to a given range.

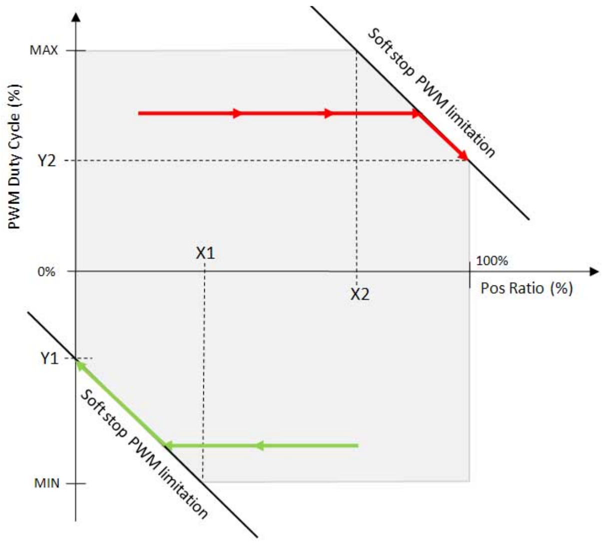
A valid sensor range identification test must have been executed before closed loop control can be activated

2.6 Soft-stop control

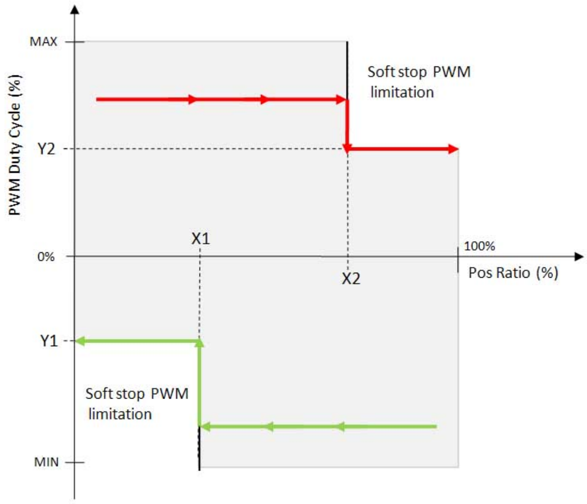
2.6.1 Description

This control function can be activated to prevent hard contacts between the valve and its mechanical ends which could cause important mechanical stress to the valve's drive chain and reduce its lifetime. Three different soft-stop logics are implemented:

1. Ramping PWM duty cycle reduction: the PWM duty cycle is progressively reduced below position X1 to Y1 and above X2 to Y2.

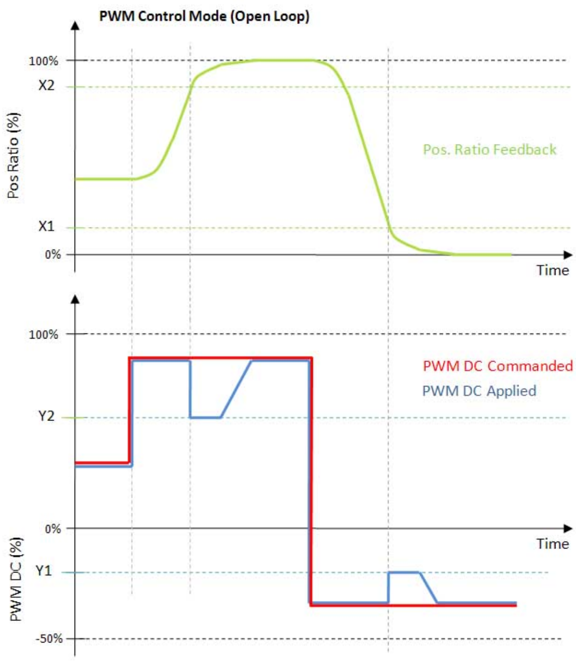


2. Direct PWM duty cycle reduction: the PWM duty cycle is directly limited to Y1 below X1 and to Y2 above X2.



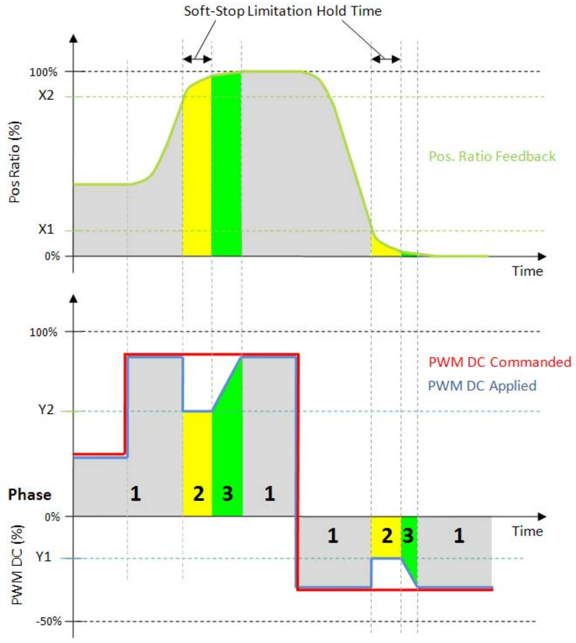
3. 'Smart' mode: this soft-stop logic is made of several control phases where PWM duty cycle or target position (depending on the control mode) are first limited then ramped-up/down to the desired value.

   If the valve is commanded in open-loop PWM Mode, the 'smart' soft-stop control logic will act on the valve's command as follow: once the valve's position ratio exceeds threshold position X2, the PWM duty cycle is temporarily limited to Y2 to allow the valve to slow down to avoid impact. After a given period de PWM is the progressively increased back to the commanded value. The action is similar in the opposite direction (with thresholds X1 and Y1 used instead).

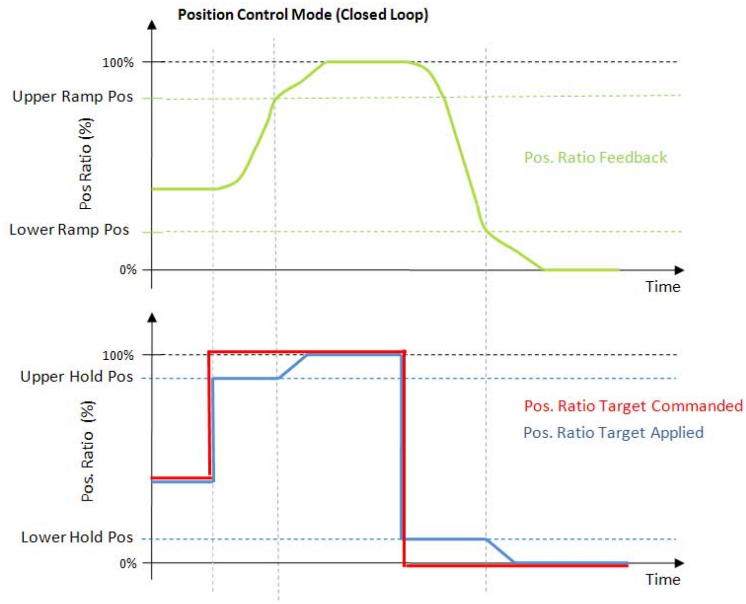


The soft-stop action in open-loop mode is made of the following phases:

#	Phase	Description
1	IDLE	No soft-stop PWM duty cycle limitation
2	HOLD	Soft-Stop temporary PWM duty cycle limitation
3	RAMP UP/DOWN	Soft-stop PWM duty cycle ramping up/down to target

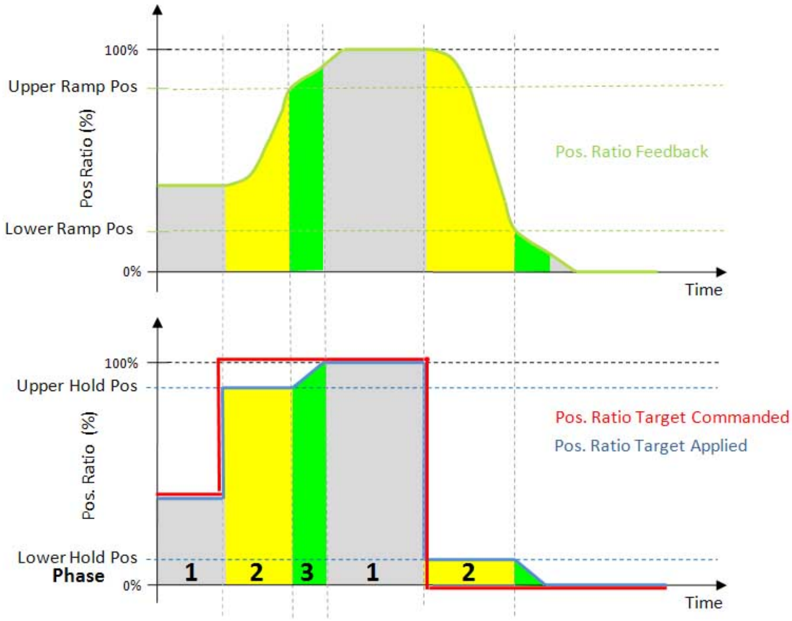


If the valve is commanded in **position mode** (closed-loop), the 'smart' soft-stop control logic will act on the position controller's target instead of acting directly on the PWM duty cycle. When the target position commanded by the user is above a threshold called 'Upper Hold Pos', the soft-stop controller will limit the position target provided to the position controller to that value until the position ratio feedback crosses through a second threshold called 'Upper Ramp Pos.', the position target will then be ramped up to the value commanded by the user at a given rate. The action is similar in the opposite direction.



The soft-stop action in closed-loop mode is made of the following phases:

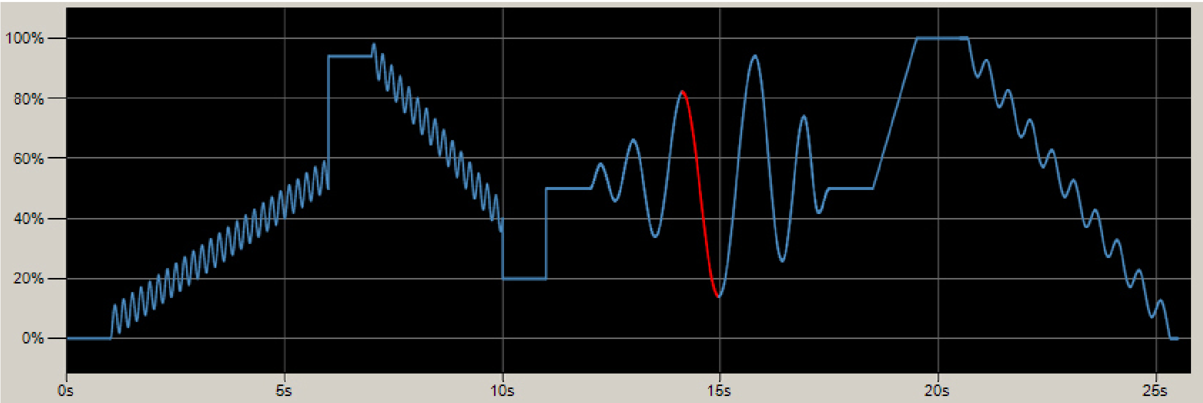
#	Phase	Description
1	IDLE	No soft-stop position target limitation
2	HOLD	Soft-Stop position target limitation active
3	RAMP UP/DOWN	Soft-stop position target ramping up/down



2.7 Profiles and Sequences

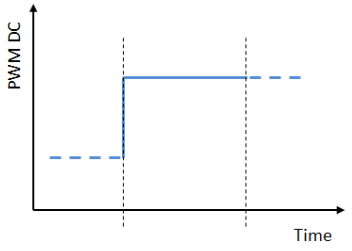
2.7.1 Profiles: description

Each driver contains an integrated PWM and Position shapes engine to automatically generate complex command profiles. Profiles are a combination of predefined basic elements/shapes (sine, ramp, sine-on-ramp, etc.) which can be edited from the PC interface and downloaded to the driver's sequencer memory for real-time execution.

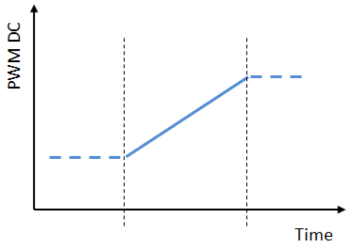


The following profile elements are available:

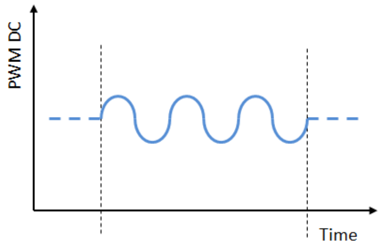
- **Direct PWM or Position** : immediate transition to a given PWM or Position



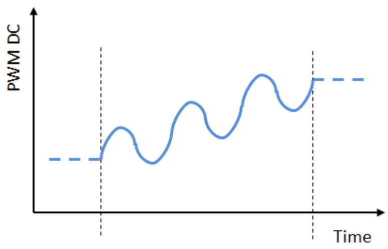
- **PWM or Position Ramp** : transition to a given PWM or Position at a given rate



- **PWM or Position Sine** : PWM or Position sine shape of given period and amplitude



- **PWM or Position Sine-on-Ramp** : PWM or Position sine shape of given period and amplitude combined with a ramp transition



Profiles and profile elements can be repeated multiple times to generate long durability test profiles for instance.

A trigger pulse can be generated at a driver’s discrete output at the beginning and/or the end of one or more elements, or at the beginning and/or end of the profile for external data acquisition purposes.

The internal profile generator engine runs at a frequency of 1KHz, offering a profile generation accuracy of 1ms.

As multiple drivers running profiles in parallel can slightly shift in time over long period (typically around 0.2s every 24h) because of the internal oscillators production tolerances, a periodic re-synchronization process can be activated to always limit the amount of timing shift between drivers.

Sensor range identification tests can be scheduled to occur periodically during profile executions to cope with the deviations of the valve’s mechanical and electrical characteristics over long periods (for instance during durability tests)

Note: a profile can only be executed as part of a sequence.

2.7.1 Sequences: description

A sequence is a list of functions (Response Time, Sensor Identification, Hysteresis, Profile) to be executed sequentially by the driver. Each sequence element can be repeated multiple times before moving to the next. The whole sequence can be repeated a given number of times.

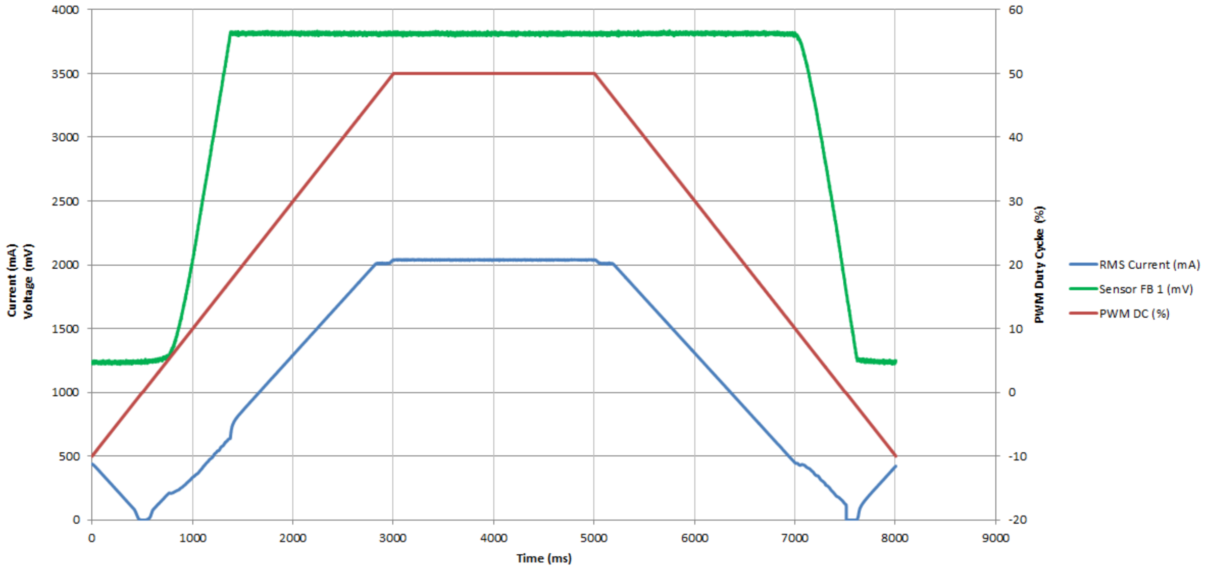
The driver can be configured to receive a sequence execution command from one of the discrete input (ex. Signal from a thermal chamber controller).

2.8 Data Logging

2.8.1 Description

Each driver contains an integrated data logger which can record samples of important internal variables (position, current, PWM DC, PID target, …) at a user-adjustable frequency. The amount of recording time available depends on the internal memory size (which depends on the hardware version: 128Kb, 512Kb or 2 Mb) and the number of variables to be recorded.

Sampling frequencies can go as high as 400KSamples/s, but at the cost of a very short acquisition time (few seconds).



Hysteresis test data @ 2KSamples/s

The internal variables which can be recorded simultaneously are:

- Position Sensor Feedback (in volts)
- Position Ratio (in %)
- Direct Current (in Amps)
- RMS Current (in Amps)
- PWM Duty Cycle (in %)
- PID Target (in %)

Data logging frequencies available are: 10 Hz, 20 Hz, 50 Hz, 100 Hz, 200 Hz, 400 Hz, 500 Hz, 800 Hz, 1.0 KHz, 1.2 KHz, 1.5 KHz, 2.0 KHz, 4.0 KHz, 5.0 KHz, 8.0 KHz, 10.0 KHz, 20.0 KHz, 40.0 KHz, 50.0 KHz, 80.0 KHz, 100.0 KHz, 120.0 KHz, 140.0 KHz, 150.0 KHz, 180.0 KHz, 200.0 KHz, (300.0 KHz), (400.0 KHz)

Position Ratio and PID Target can be useful to record during the PID calibration phase to analyse the PID position control performances.

Once the data logging session is complete, data can be uploaded to the PC and save to a file.

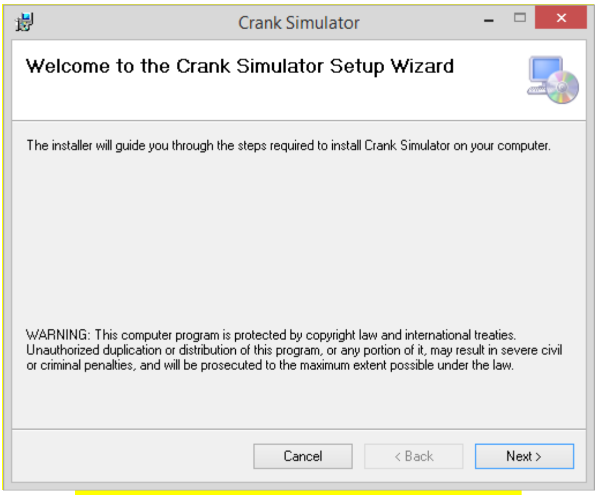
Data logging frequency and data type cannot be selected by the user during response time and hysteresis test as these processes make their own use of the data logging function.

The data logging function is only available with FULL hardware versions

3. User interface

3.1 PC Software installation

This software has been successfully tested on Microsoft Windows XP, 7, 8.0 and 8.1. Installation on any other Windows versions has to be attempted with care.
To install the software, login as administrator or as a user having administrator permissions. Locate and run the file named *CrankSimSetup.msi*, which will launch the installation wizard. Follow the instructions until installation completes.

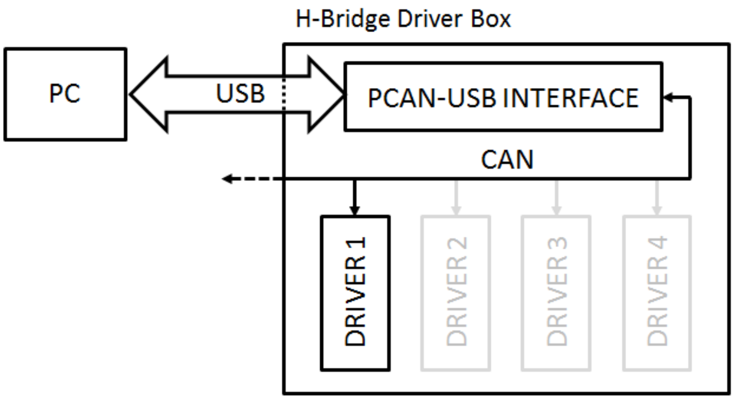


Crank Simulator Setup welcome message

If a previous version of the Crank Simulator is installed, it is required to uninstall the previous version (typically through Control Panel/Program and Features/) before the new version can be installed.
After successful installation, a new program shortcut called Crank Sim will appear in the Start Menu under Programs/EmTroniX/Crank sim.

3.2 CAN Interface Device Drivers Installation

The PC software communicates with the H-Bridge driver(s) using the CAN bus.



The driver(s) can receive commands from a CAN interface of any brand, but the PC software was designed to work solely with a PCAN-USB driver of manufacturer Peak-System which can be purchased at http://www.peak-system.com.

The driver's references can be found here: http://www.peak-system.com/PCAN-USB.199.0.html?&L=1

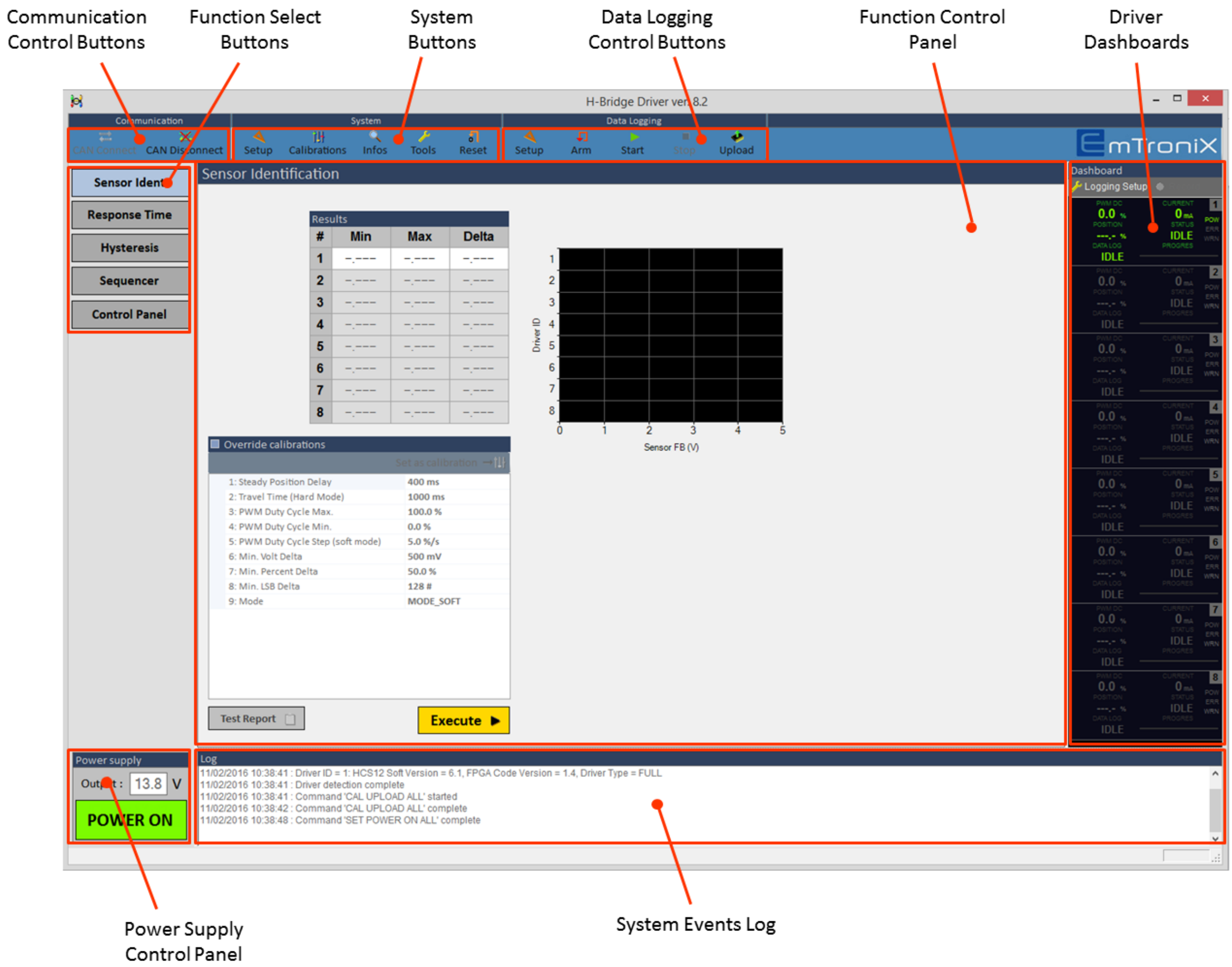
The Peak-CAN USB drivers have to be installed on the host computer before any attempt can be made to communicate with the driver(s).

The PCAN USB drivers can be downloaded here: http://www.peak-system.com/Support.55.0.html?&L=1

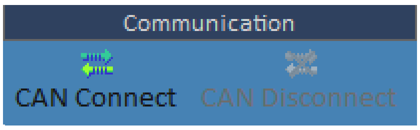
3.3 Overview

3.3.1 Main window layout and functions

The main window can be divided into different areas with specific functions:



- Communication Control Buttons :



CAN Connect: use this button to initialize the CAN communication interface and start the driver(s) detection sequence. If the Windows PCAN-USB CAN drivers have been properly installed and the CAN link with driver(s) is established, the following message will appear in the Systems Event Log window:

11/02/2016 11:27:52 : CAN hardware initialized successfully
11/02/2016 11:27:52 : [Driver 1] Driver detected ID = 1
11/02/2016 11:27:52 : Driver ID = 1: HCS12 Soft Version = 6.1, FPGA Code Version = 1.4, Driver Type = FULL
11/02/2016 11:27:52 : Driver detection complete
11/02/2016 11:27:52 : Command 'CAL UPLOAD ALL' started
11/02/2016 11:27:52 : Command 'CAL UPLOAD ALL' complete

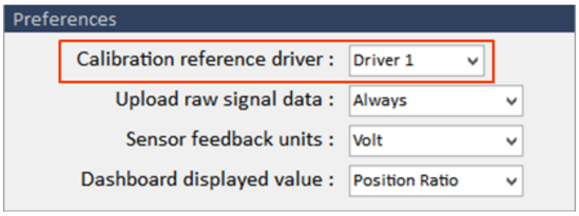
The drivers detection sequence consists in sending a broadcasted identification request message on the CAN bus, all the drivers present on the bus will then answer with their slot ID (from 1 to 8, depending on their slot position in the housing rack), system characteristics and software versions. Ex.:

11/02/2016 11:45:44 : [Driver 1] Driver detected ID = 1
11/02/2016 11:45:44 : Driver ID = 1: HCS12 Soft Version = 6.1, FPGA Code Version = 1.4, Driver Type = FULL

means that a driver with slot ID 1 has answered to the identification request. This driver has the firmware (HCS12) version 6.1, FPGA version 1.4 and is of type FULL.

As it is impossible for the system to distinguish messages coming from drivers with same ID, each driver present on the CAN bus must have a unique ID. Failed to do so can have unpredictable results.

Once the maximum answer delay has expired (1 second), the calibrations will be automatically uploaded from the driver selected in the System Menu->Preferences->Calibration Reference Driver:



If the selected reference driver was not detected during the detection sequence, an alternative driver will be used as calibration reference. Ex.:

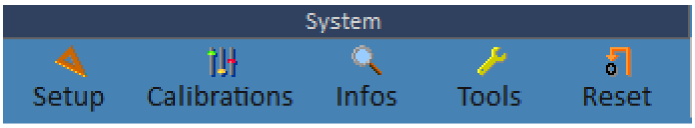
11/02/2016 11:45:44 : WARNING : Selected calibration reference driver 4 is not present, using driver 1 instead

At the end of the detection sequence, the PC sends a command to all the detected drivers to activate their CAN data stream (drivers then send system data such as PWM DC, Current, Position Ratio, errors, etc.. periodically on the CAN). The dashboard panels corresponding to the detected drivers will be activated and update periodically with the streamed data received.

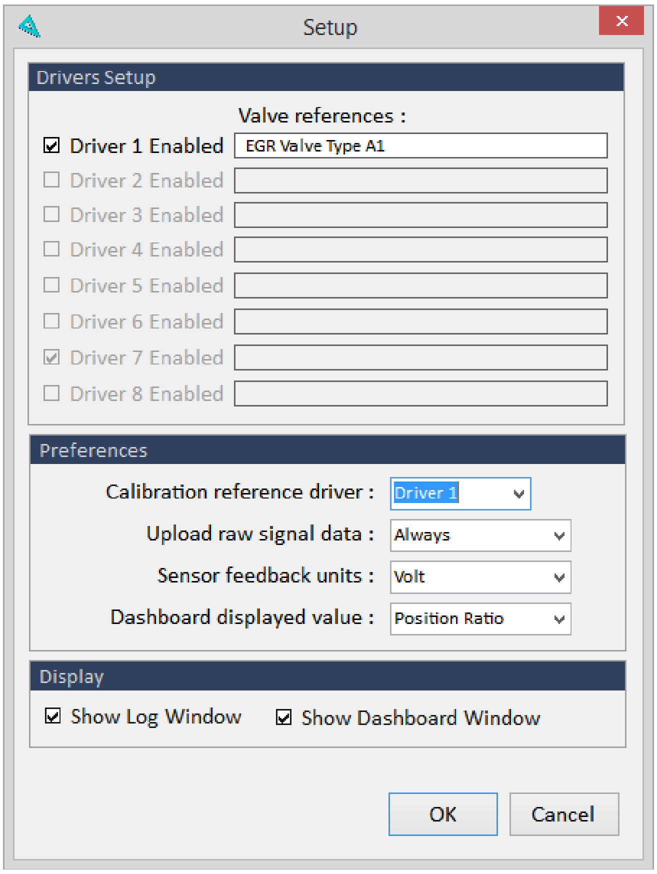
If for some reason one of the drivers is powered down and back up again after the communication initialization has been complete, the former would have to be executed again to re-activate the driver's CAN data streaming (by executing CAN Disconnect, then CAN Connect)

CAN Disconnect: use this button to close the CAN communication interface

- System Buttons :



Setup : Press this button to open the system setup dialog window



The following parameter can be set though this window:

Valve References: Short description of the valve connected to the corresponding driver. This description will appear in the header of test report documents.

Driver X Enabled: Active status of the corresponding driver. A powered-up driver present on the CAN bus can be disabled or enabled.

Calibration Reference Driver: ID of the driver which will be used to upload calibrations from during the communication initialization sequence (see description of CAN Connect function). These calibrations will be used as base for edition.

Upload raw signal data: during response time or hysteresis test, signals such as current, PWM DC and position ratio are logged into memory (FULL driver version only!) and processed inside the drivers CPUs. The user can select to automatically upload these data at the end of these tests along with the processed test results for display or file storage. However, as the amount of data to upload can be quite large and require a significant upload time, different conditions for upload are foreseen:

> **Never**: Test raw data are never uploaded
>
> **Manual tests only**: Raw data are uploaded only if the response time or hysteresis is commanded manually by the user (by pressing the execute button in the corresponding test panel), they will be displayed in the panel graphs. Data are not uploaded in case the test is commanded by the sequencer.

Always: Raw data are always uploaded, regardless if the response time or hysteresis test was initiated by the user or by the sequencer.

LIGHT version of the drive has no internal acquisition memory and can thereby not save test data. With these driver version, data are never uploaded.

While the raw data are being uploaded, the sequence will be paused and the total sequence time will be increased consequently. This option is thereby not recommended when accurate sequence timings are required.

Sensor feedback units: here should be set the valve position sensors FB units. The valve position informations are sent by the drivers in a format which depends on the position sensor type. The user needs to provide this format to the PC software so it can decode the information appropriately.

Volts: if the position sensors are of analogue type
Percent: if the position sensors are of PWM type
LSB 8 bit, 12 bit, or 16 bit: if the position sensors are of SENT type

Only position sensors of the same type are allowed for now.

Dashboard displayed value: regardless the type of the position sensor(s), the user can select in which format the position informations are displayed in the driver's dashboards:

Position Ratio: Percentage of the sensor total position range
Sensor feedback: Unformatted sensor position feedback (Volt, Duty cycle or LSB)

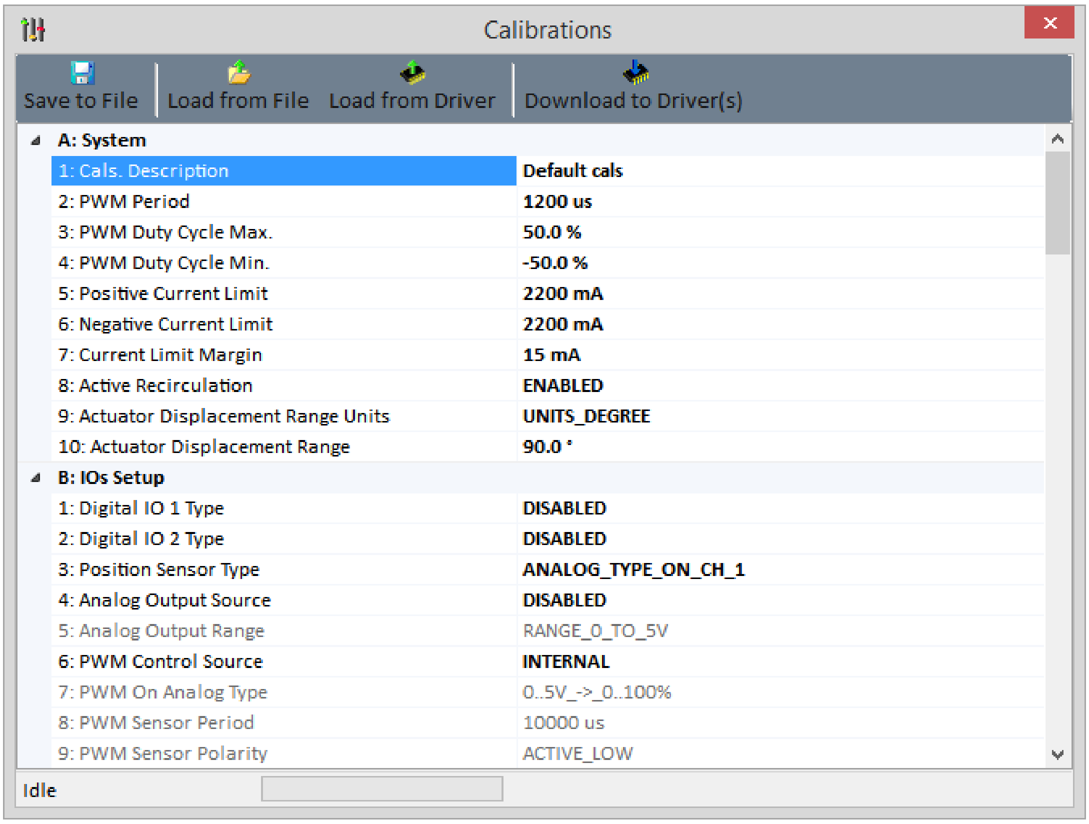
Show Log Window: Check this option if the log window should be permanently displayed

Show Dashboard Window: Check this option if the dashboards window should be permanently displayed

Calibrations: Press this button to open the calibrations editor

Unless unusual conditions occurred, calibrations are normally automatically uploaded from the selected reference driver during communication initialization sequence. Calibrations can however be uploaded from any active driver using the "Load from Driver" button located in the calibration editors toolbar.

The calibrations are a series of function-related user-adjustable parameters which are stored in the driver's non-volatile memory and are recalled during each power ups.



Calibrations can be saved to and loaded from files using the "Save to File" and "Load from File" buttons located in the calibration editors toolbar.

Calibration changes remain local to the PC and thereby ineffective until they are downloaded (and consequently stored in non-volatile memory) using the "Download to Driver(s)" button. The previous calibrations are overwritten by the newly downloaded ones in the selected driver's memory, and are thereby lost.

Calibrations are sorted in different function-related categories:

System:

Calibration parameters:

A: System	
1: Cals. Description	Default cals
2: PWM Period	1200 us
3: PWM Duty Cycle Max.	50.0 %
4: PWM Duty Cycle Min.	-50.0 %
5: Positive Current Limit	2200 mA
6: Negative Current Limit	2200 mA
7: Current Limit Margin	15 mA
8: Active Recirculation	ENABLED
9: Actuator Displacement Range Units	UNITS_DEGREE
10: Actuator Displacement Range	90.0 °

ID	Name	Units	Description
A1	**Cals. Description**	/	Short description of the this calibration set
A2	**PWM Period**	Us	Period of the PWM (Pulse Width Modulation) valve drive signal. Ex. If the PWM frequency should be 800 Hz, this parameter should be set to 1250 us
A3	**PWM Duty Cycle Max.**	%	Upper limit of the commanded PWM duty cycle
A4	**PWM Duty Cycle Min.**	%	Lower limit of the commanded PWM duty cycle
A5	**Positive Current Limit**	mA	Upper limit of the commanded current in current control mode
A6	**Negative Current Limit**	mA	Lower limit of the commanded current in current control mode (unsigned!)
A7	**Current Limit Margin**	mA	Current regulation hysteresis around the selected target. Standard values are between 50 and 200mA. Values smaller than 50mA should be selected carefully depending on the valve characteristics to avoid overheating of the current regulation electronics.
A8	**Active Recirculation**	/	Enabled : H-Bridge current recirculation type Disabled : Diode current recirculation type.
A9	**Actuator Displacement Range Units**	/	Units of the actuator displacement (degree, radian, mm or inch).
A10	**Actuator Displacement Range**	°, rad, mm, inch	Actuator displacement range (in the selected units) used to calculate up/down speeds in response time tests (°/s, rad/s, mm/s or inch/s)

IOs Setup: A driver contains always the following standard IOs:

- Two multi-function digital ports which can be used as inputs or outputs
- Two analogue position sensor inputs
- One multi-function analogue output

The functions of these IO's are adjusted the IO's setup calibration section:

PWM Generation Modes: The integrated PWM generator can work in three different modes:

- INTERNAL MODE (default) : the PWM duty cycles and frequency are generated by internal logic
- ANALOG CONTROL MODE: the generator uses one of the analogue inputs to control the PWM duty cycle. All internal control logics are disabled, PWM frequency set from calibrations.
- PWM CONTROL MODE: the driver acts as a feedthrough power amplifier, it replicated PWM duty cycle and frequency from a digital input port. All internal control logics are disabled.

The driver can be used as a feedthrough power amplifier, the internal PWM generator is then disabled and the PWM driving the valve is replicated from a digital IO.

Calibration parameters:

B: IOs Setup	
1: Digital IO 1 Type	DISABLED
2: Digital IO 2 Type	DISABLED
3: Position Sensor Type	ANALOG_TYPE_ON_CH_1
4: Analog Output Source	DISABLED
5: Analog Output Range	RANGE_0_TO_5V
6: PWM Control Source	INTERNAL
7: PWM On Analog Type	0..5V_->_0..100%
8: PWM Sensor Period	10000 us
9: PWM Sensor Polarity	ACTIVE_LOW

ID	Name	Description
B1	**Digital IO 1 Type**	Function of the digital IO 1 : - DISABLED : port not used - SENT_INPUT : this port is used a SENT sensor input - PWM_CONTROL_SIGN_INPUT : when the PWM generator is in PWM CONTROL mode, this port should be used as the PWM sign input (low : positive, high : negative) - SEQ_TRIGGER_ACTIVE_HI_INPUT : port configured to trigger a sequence when the input signal is high - SEQ_TRIGGER_ACTIVE_LO_INPUT : port configured to trigger a sequence when the input signal is low - PWM_ON_ANALOG_SIGN_INPUT : when the PWM is configured to be controlled by an external source, this port can be used a sign bit to generate negative PWMs - PWM_SENSOR_INPUT: if the position sensor if of type PWM, this port can be used as a sensor PWM input.
B2	**Digital IO 2 Type**	Function of the digital IO 2 : - DISABLED : port not used - TRIGGER_OUTPUT: trigger pulses can be generated at starts and/or ends of sequence elements for external equipment synchronization. This port can be configured as the trigger output. - PWM_CONTROL_INPUT: when the PWM generator is in PWM CONTROL mode, this port should be used as the PWM input. - SEQ_TRIGGER_ACTIVE_HI_INPUT: port configured to trigger a sequence when the input signal is high - SEQ_TRIGGER_ACTIVE_LO_INPUT : port configured to trigger a sequence when the input signal is low - PWM_ON_ANALOG_SIGN_INPUT : when the PWM generator is in ANALOG INPUT CONTROL mode, this port should be used as the PWM sign input (low : positive, high : negative) - PWM_SENSOR_INPUT: if the selected sensor type is PWM, this input should be used as the position sensor input.
B3	**Position Sensor Type**	This is the type of the position signal provided by the sensor mounted on the valve : - ANALOG_TYPE_ON_CH_1 : analogue position signal type provided at analogue input 1 - ANALOG_TYPE_ON_CH_2 : analogue position signal type provided at analogue input 2 - SENT_TYPE : SENT position signal type - PWM_TYPE : PWM position signal type
B4	**Analog Output Source**	The Analog output can be used to replicate the value of an internal signal :

		- DISABLED : Function disabled - PWM_DUTY_CYCLE : PWM duty cycle - SENSOR_FB : Position sensor feedback - CURRENT : Direct current - POS_ERROR : Position error calculated by the PID - POS_TARGET : Position target for the PID - POS_FEEDBACK : Position ratio
B5	**Analog Output Range**	Output range of the analog output : - RANGE_0_TO_5V : depending on the analogue output source : PWM_DUTY_CYCLE : 0V = -100%, 2.5V = 0%, 5V = 100% SENSOR_FB : depends on sensor type (TODO..) CURRENT : 0V = -15A, 2.5V = 0A, 5V = 15A POS_ERROR : 0V = -100%, 2.5V = 0%, 5V = 100% POS_TARGET : 0V = 0%, 5V = 100% POS_FEEDBACK : 0V = 0%, 5V = 100% - RANGE_0_TO_10V : depending on the analogue output source : PWM_DUTY_CYCLE : 0V = -100%, 5V = 0%, 10V = 100% SENSOR_FB : depends on sensor type (TODO..) CURRENT : 0V = -15A, 5V = 0A, 10V = 15A POS_ERROR : 0V = -100%, 5V = 0%, 10V = 100% POS_TARGET : 0V = 0%, 10V = 100% POS_FEEDBACK : 0V = 0%, 10V = 100%
B6	**PWM Control Source**	Selection of the PWM generator control mode : - INTERNAL : Internal control mode - ANALOG_INPUT_CH_1 : Analog control mode, analog control signal on channel 1 - ANALOG_INPUT_CH_2 : Analog control mode, analog control signal on channel 2 - PWM_INPUT: PWM control mode.
B7	**PWM On Analog Type**	When the PWM generator mode is in Analog control mode, this parameter selects the range of the input and output : - 0..5V_->_0..100% : input range from 0V to 5V corresponding respectively to 0% and 100% PWM duty cycles, negative duty cycles not used. - 0..10V_->_0..100% : input range from 0V to 10V corresponding respectively to 0% and 100% PWM duty cycles, negative duty cycles not used. - SIGNED_0..5V_->_-100%..100% : input range from 0V to 5V along with the sign digital input, covering a range of duty cycles from -100% to 100% - SIGNED_0..10V_->_-100%..100% : input range from 0V to 10V along with the sign digital input, covering a range of duty cycles from -100% to 100%
B8	**PWM Sensor Period**	If the position sensor signal type is PWM, this parameter must be used to set the PWM period (must be known to detect 0% and 100% duty cycles)
B9	**PWM Sensor Polarity**	If the position sensor signal type is PWM, this parameter must be used to set the active level of the PWM

Soft Stop: see above

Parking lock: this function can be used to make the valve press firmly against its mechanical stops.

As there can be command conflicts with the soft-stop function, the parking lock function should be enabled only if the soft-stop function is disabled.

Calibration parameters:

D: Parking lock	
1: Parking-lock control	DISABLED
2: Upper parking-lock pos. ratio	98.0 %
3: Upper parking-lock PWM duty cycle	30.0 %
4: Lower parking-lock pos. ratio	2.0 %
5: Lower parking-lock PWM duty cycle	-10.0 %

ID	Name	Units	Description
D1	**Parking-lock control**	/	Activation of the parking lock function
D2	**Upper parking-lock pos. ratio**	%	Position ratio above which the upper PWM duty cycle will be applied continuously
D3	**Upper parking-lock PWM duty cycle**	%	PWM duty cycle to force the valve against its upper mechanical stop
D4	**Upper parking-lock pos. ratio**	%	Position ratio below which the lower PWM duty cycle will be applied continuously
D5	**Upper parking-lock PWM duty cycle**	%	PWM duty cycle to force the valve against its lower mechanical stop

Sensor identification:

3.3.2 Sensor Identification Calibration Parameters

⊟ E: Sensor identification	
1: Steady position delay	200 ms
2: Travel time (hard mode)	500 ms
3: PWM Duty Cycle Max.	50.0 %
4: PWM Duty Cycle Min.	-20.0 %
5: PWM Duty Cycle Step (soft mode)	10.0 %/s
6: Min. volt delta	500 mV
7: Mode	MODE_SOFT

1. **Steady position delay (Soft Mode) (ms):** This parameter is the time during which min. and max. PWM duty cycles are held in SOFT mode before the sensor voltage samples are recorded and the next phase test is started. Its purpose is to slightly delay the voltage acquisitions to take account of the valve mechanical response.

2. **Travel Time (Hard Mode) (ms):** This parameter is the maximum time taken by the valve to move from one end to the other under the min. and max. PWM duty cycles specified. It is also the time these duty cycles will remain applied in hard mode.

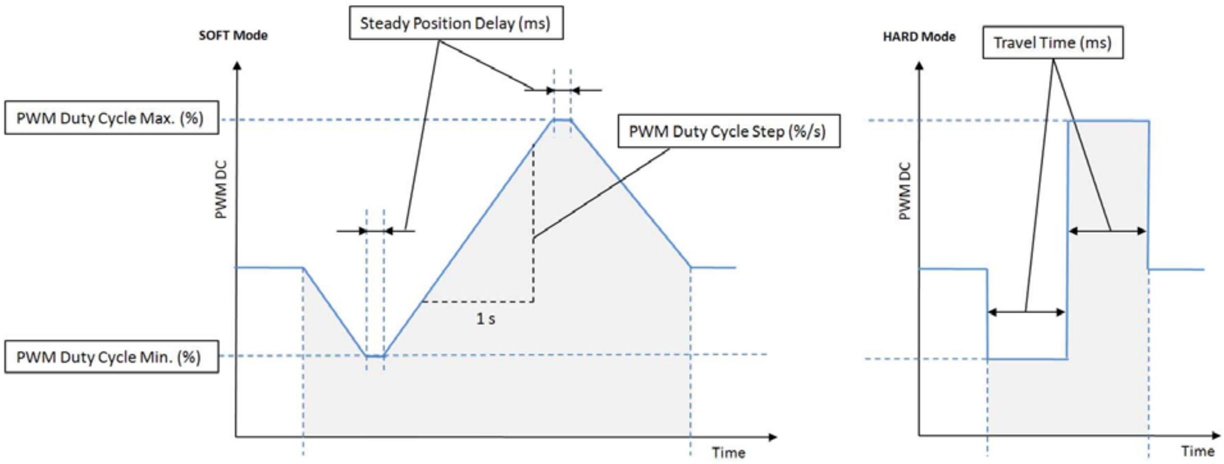
3. **PWM Duty Cycle Max. (%):** This parameter is the maximum PWM duty cycle applied during the sensor identification procedure. The Sensor voltage max. will be recorded in these PWM conditions.

4. **PWM Duty Cycle Min. (%):** This parameter is the minimum PWM duty cycle applied during the sensor identification procedure. The Sensor voltage min. will be recorded in these PWM conditions.

5. **PWM Duty Cycle Step (Soft Mode) (%/s):** This parameter is the PWM duty cycle increase/decrease rate in Soft Mode.

6. **Min. Volt Delta (V):** This parameter is the minimum absolute voltage difference between min. and max. sensor voltages to consider the sensor identification procedure as valid.

7. **Mode:** Sensor identification mode (Soft or Hard).



3.3.1 Response Time Calibration Parameters

F: Response Time	
1: Steady position delay	200 ms
2: PWM Duty Cycle start	-10.0 %
3: PWM Duty Cycle Max.	40.0 %
4: PWM Duty Cycle Min.	-20.0 %
5: Soft-stop control	DISABLED
6: Active Recirculation	ENABLED
7: Lower validity position threshold	3.0 %
8: Upper validity position threshold	97.0 %
9: Upward lower calc. position threshold	5.0 %
10: Upward upper calc. position threshold	95.0 %
11: Downward lower calc. position threshold	5.0 %
12: Downward upper calc. position threshold	95.0 %
13: Max. travel time	1000 ms
14: Resp. time calc. mode	MODE_NORMAL

1. **Steady position delay (ms):** This parameter is the time during which the start, min. and max. PWM duty cycles are held once the corresponding validation pos. ratio thresholds are crossed. Its purpose is to allow the valve's movement to stabilize before the next phase is started.

2. **PWM Duty Cycle Start (%):** This parameter is the PWM duty cycle which is applied during the start phases (2 & 3).

3. **PWM Duty Cycle Max. (%):** This parameter is the PWM duty cycle which is applied during the upward phases (4 & 5).

4. **PWM Duty Cycle Min. (%):** This parameter is the PWM duty cycle which is applied during the downward phases (6 & 7).

5. **Soft Stop Control (Enabled/Disabled):** Use this parameter to select if the soft-stop control logic should be enabled/disabled during the response time test

6. **Active Recirculation (Enabled/Disabled):** Use this parameter to select if active current recirculation should be enabled/disabled during the response time test

7. **Lower validity position threshold (%):** This parameter is the position ratio threshold which must necessarily be crossed during test phases 2 and 6 to consider the response time test as valid.

8. **Upper validity position threshold (%):** This parameter is the position ratio threshold which must necessarily be crossed during test phase 4 to consider the response time test as valid.

9. **Upward lower calculation position threshold (%):** This parameter is the position ratio threshold from which the response time counting starts in the upward direction. This parameter is not used in SPRINT mode.

10. **Upward upper calculation position threshold (%):** This parameter is the position ratio threshold from which the response time counting end in the upward direction.

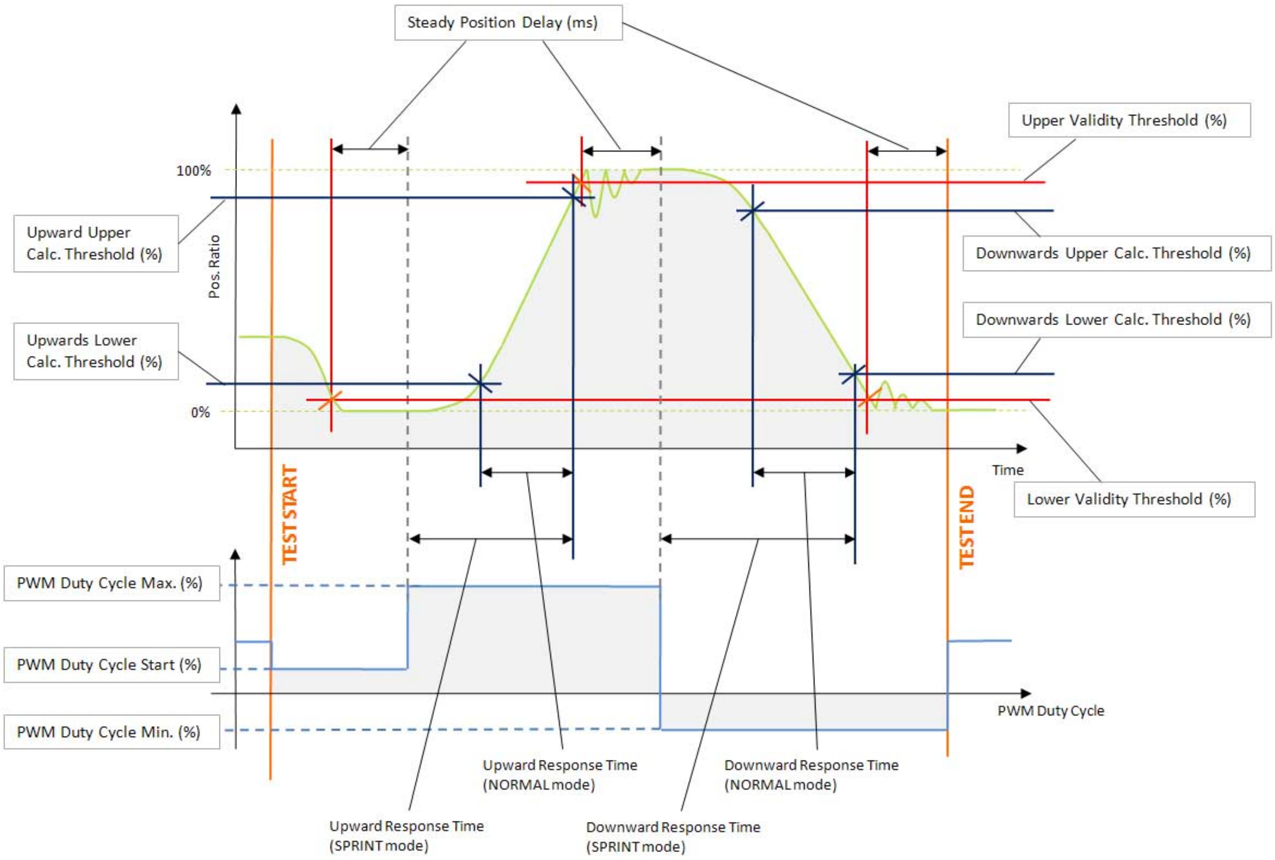
11. **Downward lower calculation position threshold (%):** This parameter is the position ratio threshold from which the response time counting ends in the downward direction. This parameter is not used in SPRINT mode.

12. **Downward upper calculation position threshold (%):** This parameter is the position ratio threshold from which the response time counting starts in the downward direction. This parameter is not used in SPRINT mode.

Position sensor signals often contain relatively high levels of electrical noise and generate thereby positions ratio readings which can fluctuate by a few percents around an average in steady conditions. This is also due to the fact that the sensor hardware interface does only very lightly filter the sensor signal to get the best timing accuracies. Response time calculation and validation thresholds must therefore necessarily be located out of the noise level to avoid erroneous threshold crossing detections. Values under 1.5..2% and above 98..98.5% must be avoided.

13. **Max. travel time (ms):** This parameter is the maximum time allowed to reach the opposite validation threshold in test phases 2, 4 and 6., otherwise a timeout fault is generated and the response time test is aborted.

14. **Response Time Calculation mode (NORMAL/SPRINT):** Use this parameter to select the response time calculation method (see calculation modes description above)



3.3.2 Hysteresis Calibration Parameters

G: Hysteresis	
1: Startup delay	100 ms
2: PWM Duty Cycle Startup	-15.0 %
3: PWM Duty Cycle Up Min.	0.0 %
4: PWM Duty Cycle Up Max.	25.0 %
5: PWM Duty Cycle Down Min.	-10.0 %
6: PWM Duty Cycle Down Max.	10.0 %
7: PWM Duty Cycle Up Speed	5.0 %/s
8: PWM Duty Cycle Down Speed	5.0 %/s
9: PWM Duty Cycle Hold Up	100.0 %
10: Hold Up Time	100 ms
11: Pos ratio breakpoints	0.0 %, 10.0 %, 20.0 %, 30.0 %, 40.0 %, 50.0 %, 60.0 %, 70.0 %
12: Pos ratio breakpoints num.	11

1. **Startup delay (ms):** This parameter is the time during which the startup PWM duty cycle is applied

2. **PWM Duty Cycle Startup (%):** This parameter is PWM duty cycle which is applied during the start-up phase (1)

3. **PWM Duty Cycle Up Min. (%):** This parameter is PWM duty cycle from which the upward phase (2) starts

4. **PWM Duty Cycle Up Max. (%):** This parameter is final PWM duty cycle for upward phases (2)

5. **PWM Duty Cycle Down Min. (%):** This parameter is final PWM duty cycle for downward phases (4)

6. **PWM Duty Cycle Down Max. (%):** This parameter is PWM duty cycle from which the downward phase (4) starts

7. **PWM Duty Cycle Up Speed (%/s):** This parameter is PWM duty cycle rate of change during the upward phase (2) starts

8. **PWM Duty Cycle Down Speed (%/s):** This parameter is PWM duty cycle rate of change during the downward phase (4) starts

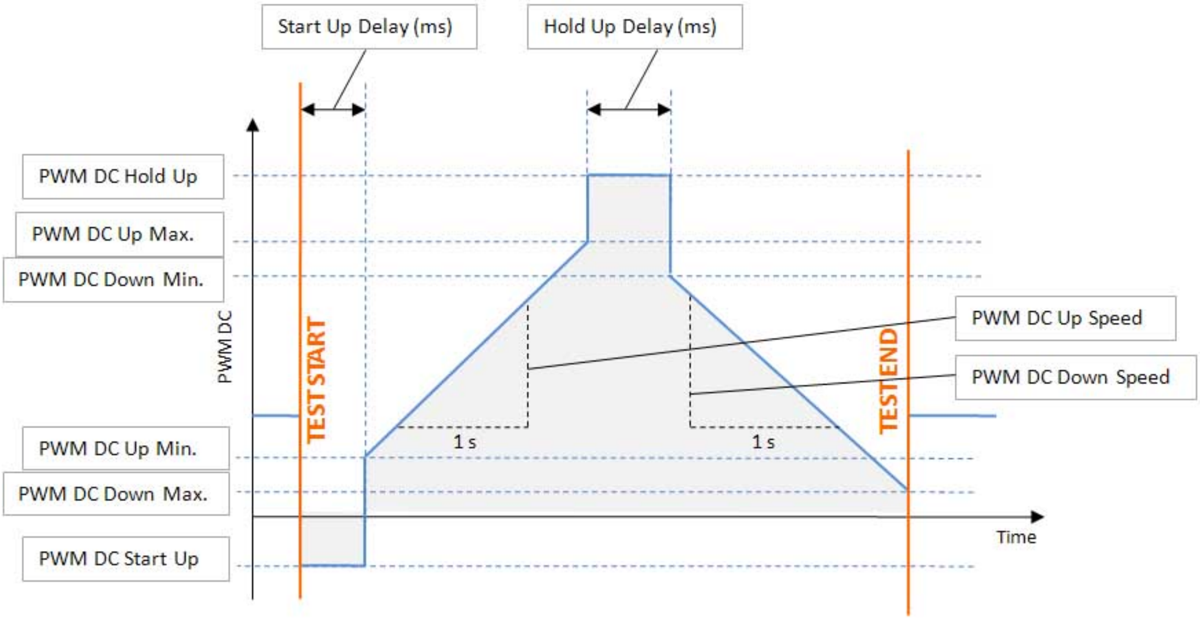
9. **PWM Duty Cycle Hold Up (%):** This parameter is PWM duty cycle which is applied during the hold-up phase (3)

10. **Hold Up delay (ms):** This parameter is the time during which the hold-up PWM duty cycle is applied and after which a current sample is acquired This phase can be skipped by setting this parameter to zero.

11. **Pos. ratio breakpoints (%):** This parameter is the list of position ratio breakpoints where PWM duty cycles and current samples are acquired during the upward and downward phase (2 & 4)

The position ratio breakpoints must have unique and monotonously increasing values.

12. **Pos. ratio breakpoints num. (#):** This parameter is the number of pos. ratio breakpoints defined (max. 21)



3.3.3 Soft Stop Calibration Parameters

C: Soft-stop	
1: Soft-stop control	ENABLED
2: Soft-stop type	TYPE_SMART
3: Soft Stop X1	25.0 %
4: Soft Stop X2	92.0 %
5: Soft Stop Y1	1.0 %
6: Soft Stop Y2	1.0 %
8: Smart mode upper hold position ratio	85.0 %
9: Smart mode lower hold position ratio	10.0 %
10: Smart mode upper ramp position ratio	65.0 %
11: Smart mode lower ramp position ratio	45.0 %
12: Smart mode post-hold pos. ratio step	314.0 %/s
13: Smart mode PWM hold time	10 ms
13: Smart mode post-hold PWM DC step	40.0 %/s

1. **Soft-Stop Control (Enabled/Disabled):** Use this parameter to enable/disable the soft-stop control logic

2. **Soft-Stop Type (RAMP, DIRECT, SMART)** : Use this parameter to select the soft-stop mode (see description of soft-stop modes above)

3. **Soft-Stop X1 (%):** Lower position ratio threshold triggering soft-stop PWM duty-cycle limitation used in RAMP, DIRECT and Open-Loop SMART modes.

4. **Soft-Stop X2 (%):** Upper position ratio threshold triggering soft-stop PWM duty-cycle limitation used in RAMP, DIRECT and Open-Loop SMART modes.

5. **Soft-Stop Y1 (%):** Upper PWM duty cycle limit used in RAMP, DIRECT and Open-Loop SMART modes.

6. **Soft-Stop Y2 (%):** Lower PWM duty cycle limit used in RAMP, DIRECT and Open-Loop SMART modes.

7. **Smart mode upper hold position ratio (%):** Upper position ratio target limit used in closed-loop SMART mode

8. **Smart mode lower hold position ratio (%):** Lower position ratio target limit used in closed-loop SMART mode

9. **Smart mode upper ramp position ratio (%):** Upper position ratio target threshold from where the position target is ramped-up in closed-loop SMART mode

10. **Smart mode lower ramp position ratio (%):** Lower position ratio target threshold from where the position target is ramped-down in closed-loop SMART mode

The value of upper ramp. pos. ratio must be smaller or equal to the value of upper hold pos. ratio, otherwise the ramping-up might never be generated. Identically, the value of lower ramp. pos. ratio must be greater or equal to the value of lower hold pos. ratio

11. **Smart mode post-hold pos. ratio step (%/s):** Rate at which the position ratio target is increased/decreased after the hold phase in closed-loop SMART mode
12. **Smart mode PWM hold time (ms):** Time during which the PWM duty-cycle is held limited to Y1 or Y2 in open-loop SMART mode

13. **Smart mode post-hold PWM DC step (%/s):** Rate at which the PWM duty cycle is increased/decreased after the hold phase in open-loop SMART mode

Position control PID: each driver contains an integrated position control regulator (PID) running at a loop time of 1ms, active when the driver is in to closed-loop position control mode.

Before the PID can be activated, a successful sensor range identification procedure must have been performed

The PID regulator output is the sum of four elements:

$$PID_{out} = \underline{K_P \cdot Err(t)} + \underline{K_d.\frac{dErr(t)}{dt}} + \underline{K_i \cdot \int Err(t) \cdot dt} + \underline{FF(Pos.target)}$$

Where Err(t) = Pos. feedback(t) – Pos. target

The first term of the equation above if the proportional term, the second is the derivative term, the third is the integral term and the last is the feedforward term. The first three terms depend on the position error, whereas the feedforward term depends on the position target. To provide greater control precision, the Kp, Kd and Ki terms are calculated from lookup tables based on the position error.

Feedforward term:

The feedforward term can be regarded as the PWM duty cycle which has to be applied to the valve to get roughly to the desired position without further regulation. As the required duty cycle can be different if the movement is initiated from a position above or under the desired position (due to the action of the return spring for instance), two separated tables have been foreseen to cover the two cases.

The feedforward tables must be filled with zeros in particular case of valves having no return spring and staying at their position if no command is applied.

Proportional term:

The proportional term is directly related to the position error and is thereby always zero when the valve is at its desired position. The action of the proportional term can be very responsive far from the target and must thereby be choses carefully to avoid oscillations.

Derivative term:

This term is related to the derivative of the error over time and is there to make the system react to fast changes in position error.

It is often very hard to find a trade-off between Kp values offering a fast system response without inducing very high sensitivity to sensor noise. It is therefore recommended in most case to leave this term to zero.

Integral term:

This term is related to the integral of the error over time and is there to compensate (slowly) for small deviations from the reference control model. As the action of the integral term is shifted in time, it should only be used when the position error is small (i.e. close to the target) and left to zero for large errors to avoid induced instabilities. As for the feedforward term, the integral table must be left to zero in particular case of valves having no return spring and staying at their position if no command is applied.

Movement impairment detection:

The driver contains an integrated function which will permanently monitor the position error to detect stuck valve or defective position sensors (function useful on durability test stands).

Calibration parameters:

H: Position control PID	
1: Position error table	-100.0 %, -40.0 %, -20.0 %, -10.0 %, -5.0 %, 0.0 %, 5.0 %, 10
2: Proportional gain table	0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
3: Integral gain table	0.09999999, 0.09999999, 0.09999999, 0.09999999, 0.09
4: Derivative gain table	0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
5: Position table	0.0 %, 10.0 %, 20.0 %, 30.0 %, 40.0 %, 50.0 %, 60.0 %, 70.0
6: Upward feedforward table	0.0 %, 0.0 %, 0.0 %, 0.0 %, 0.0 %, 0.0 %, 0.0 %, 0.0 %, 0.0 %,
7: Downward feedforward table	0.0 %, 0.0 %, 0.0 %, 0.0 %, 0.0 %, 0.0 %, 0.0 %, 0.0 %, 0.0 %,
8: Intergral term limit max.	10.0 %
9: Intergral term limit min.	-10.0 %
10: Deriv. filter coef	0.100
11: Feedforward Pos. Error Deadband (+/-)	0.0 %
12: Movement Monitoring	DISABLED
13: Movement Fault Pos. Error Threshold (abs)	10.0 %
14: Movement Fault Pos. Error Delay	1000 ms
15: Movement Fault Severity	SEVERITY_WARNING

ID	Name	Units	Description
H1	**Position error table**	%	Position error breakpoints table used to look-up the Kp, Kd and Ki gains. Valid range is from -100% to +100% **Values in the table must be monotonically increasing**
H2	**Proportional gain table**	/	Proportional term breakpoints corresponding to the position error breakpoints used to lookup the Kp gain. Values are interpolated in between breakpoints. **Kp = LoopUp(Err, Error Table, Prop. Gain Table)***
H3	**Integral gain table**	/	Integral term breakpoints corresponding to the position error breakpoints used to lookup the Ki gain. Values are interpolated in between breakpoints. **Ki = LoopUp(Err, Error Table, Int. Gain Table)***

H4	**Derivative gain table**	/	Derivative term breakpoints corresponding to the position error breakpoints used to lookup the Kd gain. Values are interpolated in between breakpoints. **Kd = LoopUp(Err, Error Table, Der. Gain Table)***
H5	**Position table**	%	Target position breakpoints table used to look-up the Feedforward terms. Valid range is from 0% to +100% **Values in the table must be monotonically increasing**
H6	**Upward feedforward table**	%	Feedforward PWM DC breakpoints corresponding to the target position breakpoints used to lookup the FF term when the movement is initiated from a position below the target position (upward movement). Values are interpolated in between breakpoints. **FF = LoopUp(Target Pos, Pos. Table, Upward FF Table)***
H7	**Downward feedforward table**	%	Feedforward PWM DC breakpoints corresponding to the target position table breakpoints used to lookup the FF term when the movement is initiated from a position above the target position (downward movement). Values are interpolated in between breakpoints. **FF = LoopUp(Target Pos, Pos. Table, Downward FF Table)***
H8 **H9**	**Integral term limit max.** **Integral term limit min.**	/	Upper and lower limit of the integral term. Integral terms values must be limited to avoid endless accumulation in cases where the target position cannot be reached.
H10	**Derivative filter coef.**	/	The error derivative filter coefficient.
H11	**Feedforward pos. error deadband.**	%	Margin around the target position wherein the upward and downward tables switching is inhibited (to avoid continuous direction switching and mechanical stress)
H12	**Movement monitoring**	/	Activation of the valve movement monitoring function
H13	**Movement Fault Pos. Error Threshold (abs)**	%	Position error threshold (absolute) above which movement fault time is counting (reset under)
H14	**Movement Fault Pos. Error Delay**	ms	Fault time which must be exceeded to generate an effective movement fault.
H15	**Movement fault severity**	/	Action following the detection of a movement fault : - SEVERITY_WARNING: a warning message is displayed in the corresponding driver's dashboard, the ongoing sequence is continued. - SEVERITY_ERROR: an error message is displayed in the corresponding driver's dashboard, the ongoing sequence is aborted.

(*) Y = Lookup(X, X Table, Y Table)

3.3.4 Position PID Calibration Parameters

H: Position control PID	
1: Position error table	-100.0 %, -40.0 %, -20.0 %, -10.0 %, -5.0 %, 0.0 %, 5.0 %, 10.0
2: Proportional gain table	0.1, 0.2, 0, 0, 0.5, 0, 0.5, 0, 3, 2, 1
3: Integral gain table	0.1, 0.2, 0.4, 0.5, 0.8, 1, 0.8, 0.5, 0.4, 0.2, 0.1
4: Derivative gain table	0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
5: Position table	0.0 %, 0.5 %, 20.0 %, 30.0 %, 40.0 %, 50.0 %, 60.0 %, 70.0 %,
6: Upward feedforward table	3.6 %, 3.8 %, 7.0 %, 7.7 %, 8.4 %, 9.1 %, 9.9 %, 10.7 %, 11.7 %
7: Downward feedforward table	-4.3 %, -3.1 %, -2.8 %, -2.0 %, -1.3 %, -1.1 %, -0.4 %, 0.3 %, 4.0
8: Intergral term limit max.	20.0 %
9: Intergral term limit min.	-20.0 %
10: Deriv. filter coef	0.100

1. **Position Error Table (%):** This table should contain the different position error breakpoints where proportional, derivative and integral gains are defined. Acceptable values range from -100% to 100%

The position error breakpoints must have unique and monotonously increasing values.

2. **Proportional Gain Table (/):** This table should contain the values of the proportional gains corresponding to the position error breakpoints defined in (1). The values are linearly interpolated in between breakpoints.

3. **Integral Gain Table (/):** This table should contain the values of the integral gains corresponding to the position error breakpoints defined in (1). The values are linearly interpolated in between breakpoints.

4. **Derivative Gain Table (/):** This table should contain the values of the derivative gains corresponding to the position error breakpoints defined in (1). The values are linearly interpolated in between breakpoints.

5. **Position Table (%):** This table should contain the different position breakpoints where feed-forward values are defined. Acceptable values range from 0% to 100%

The position breakpoints must have unique and monotonously increasing values.

6. **Upward Feed-forward Table (%):** This table should contain the values of feed-forward terms corresponding to the position breakpoints defined in (5) applied when the valve is moving the upward direction. The values are linearly interpolated in between breakpoints.

7. **Downward Feed-forward Table (%):** This table should contain the values of feed-forward terms corresponding to the position breakpoints defined in (5) applied when the valve is moving the downward direction. The values are linearly interpolated in between breakpoints.

8. **Integral term limit max (%):** This parameter is the upper value from which the integral term will be clamped.

9. **Integral term limit max (%):** This parameter is the lower value from which the integral term will be clamped.

10. **Derivative Filter Coefficient (/):** This parameter is the filter coefficient applied to the position error derivative calculation (1= no filtering)

Calibration tips: It is recommended to follow the next steps when starting a new calibration procedure:

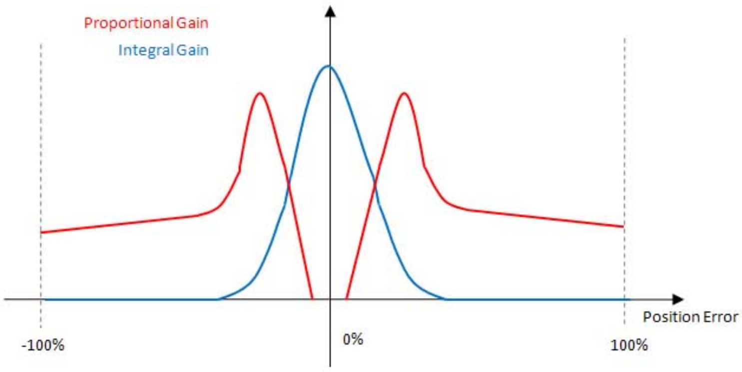
1. Set all feed-forward terms to zero, all Integral, Proportional and Derivative gains to zero. Fill the position breakpoints table (usually at equidistant intervals such as 0%, 10%, 20%, 30%, 40%, 50 %, 60%, 70%, 80%, 90%, 100%) and position error breakpoint tables (it is advised to define narrower breakpoint ranges around the target with a symmetric pattern i.e. -100%, -50 %, -20%, -10%, -5%, -2%, 0%, 2%, 5%, 10%, 20%, 50%, 100%) .

2. Fill the integral gain table with very small identical values (but must be sufficient to cause the valve to move very slowly). From the position control panel, command the valve to move to the first breakpoint defined in the position table. Note the corresponding PWM duty cycle generated by the driver when the position is reached and stabilized. Repeat the process for all the breakpoints in the position table in the direction of increasing position ratios. WARNING: do not come back to a previous breakpoint, otherwise the hysteresis effect will alter the measurement process. Once the last breakpoint is reached, repeat the process in the other direction (direction the decreasing position ratios) noting each time the value of the PWM generated. Fill in the Upward and Downward Feed-Forward tables with the values measured during the procedure above.

3. Fill in the integral gains table: the purpose of the integral term is to correct for small control inaccuracies around the target, not to cause important valve responses far from the position target. Thereby integral terms are usually left at zero in the range of important position errors (i.e. above 30% and below -30%), only close to the target can the integral gain be set to none zero values.

4. Fill in the proportional gains table: unlike the integral term, the proportional term should be set to higher values away from the target to enhance the response. A barrier effect can also be set around the target to hold the valve firmly in place once at the target position.

5. Derivative term should be left to zero.



SENT input : TODO

Calibration parameters:

I: SENT input	
1: Nibbles Per Message	SENT_NIBBLE_PER_MSG_8
2: Data 1 Start Nibble	2
3: Data 1 End Nibble	4
4: Data 2 Start Nibble	5
5: Data 2 End Nibble	7
6: CRC Mode	MODE_LEGACY
7: Ignore CRC Errors	DISABLED
8: Max. CRC Error Rate	100 %
9: Transmission Trigger	DISABLED
10: Transmission Trigger Pulse Low Time	0 us
11: Transmission Trigger Pulse Repeat Period	0 us

ID	Name	Units	Description
I1	Nibbles per message	/	
I2	Data 1 Start Nibble	/	
I3	Data 1 end Nibble	/	
I4	Data 2 Start Nibble	/	
I5	Data 2 end Nibble	/	
I6	CRC Mode	/	
I7	Ignore CRC Errors	/	
I8	Max. CRC Error Rate	%	
I9	Transmission Trigger	/	
I10	Transmission Trigger Pulse Low Time	us	
I11	Transmission Trigger Pulse Repeat Period	us	

Hi-Res IOs Setup: This set of calibration parameters are only relevant for drivers which have the high resolution IO board option installed.

Only the four high-resolution data-to-analogue outputs have been implemented for now.

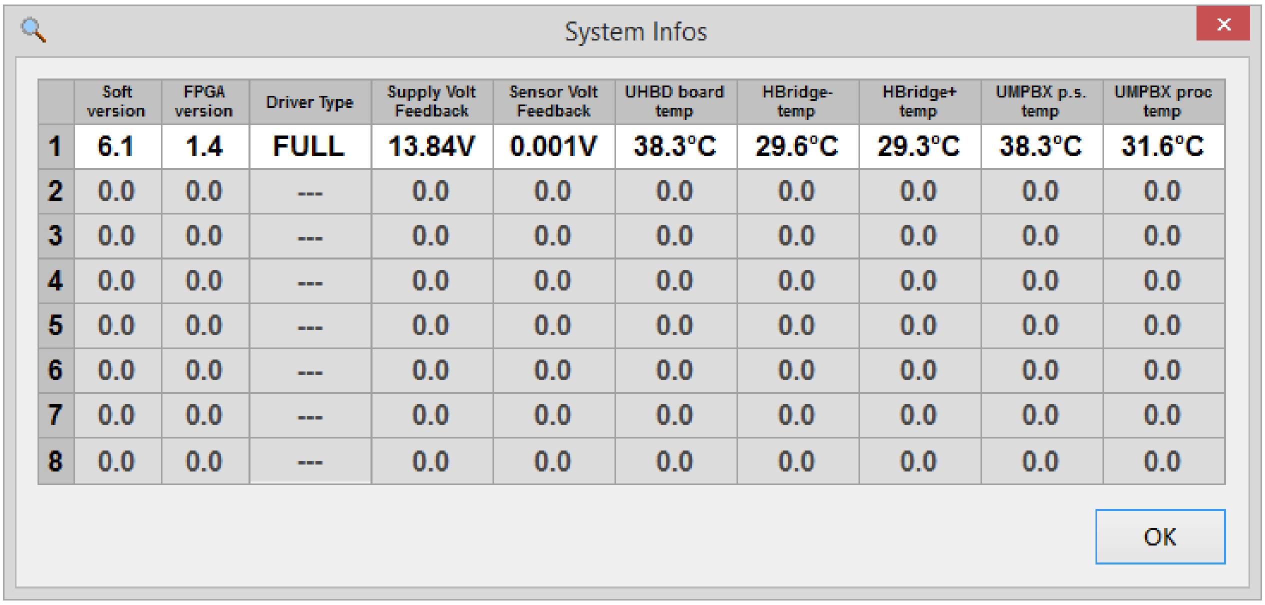
The following four internal data are computed to the high-speed high-resolution (16 bits) analogue outputs: PWM Duty Cycle, Current (direct or RMS), PID Position Ratio Target and Position Ratio Feedback.

Calibration parameters:

J: Hi-Res IOs Setup	
1: PWM to Analog Output Range (-100% -> 100%)	-10.0V to 10.0V
2: Current to Analog Range :	-15.0A to 15.0A
3: Current to Analog Output Range	-10.0V to 10.0V
4: Pos. Ratio to Analog Outputs Range (0% -> 100%)	0.0V to 10.0V

ID	Name	Units	Description
J1	**PWM to Analog Output Range (-100%->100%)**	V	Voltage output range corresponding to -100% to +100% duty cycle
J2	**Current to Analog Range**	A	Current input range
J3	**Current to Analog Output Range**	V	Voltage output range corresponding to the selected current input range
J4	**Pos. Ratio to Analog Outputs Range (0%->100%)**	V	Voltage output range corresponding to 0% to 100% position ratios (applied to the position target and position feedback outputs)

Infos: Press this button to open the system infos dialog window

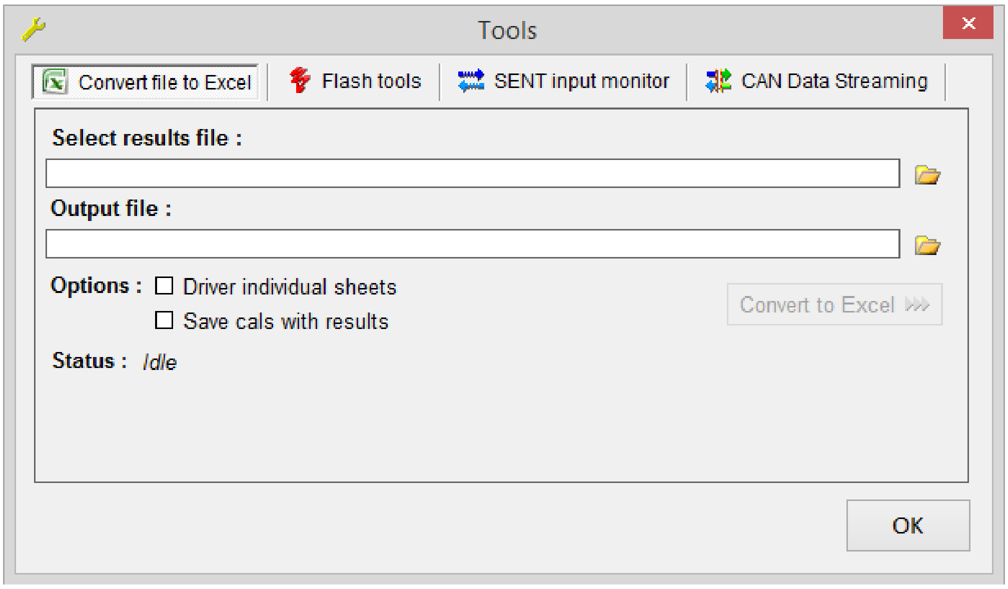

System Infos

	Soft version	FPGA version	Driver Type	Supply Volt Feedback	Sensor Volt Feedback	UHBD board temp	HBridge- temp	HBridge+ temp	UMPBX p.s. temp	UMPBX proc temp
1	6.1	1.4	FULL	13.84V	0.001V	38.3°C	29.6°C	29.3°C	38.3°C	31.6°C
2	0.0	0.0	---	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	---	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	---	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	---	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	---	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	---	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	---	0.0	0.0	0.0	0.0	0.0	0.0	0.0

OK

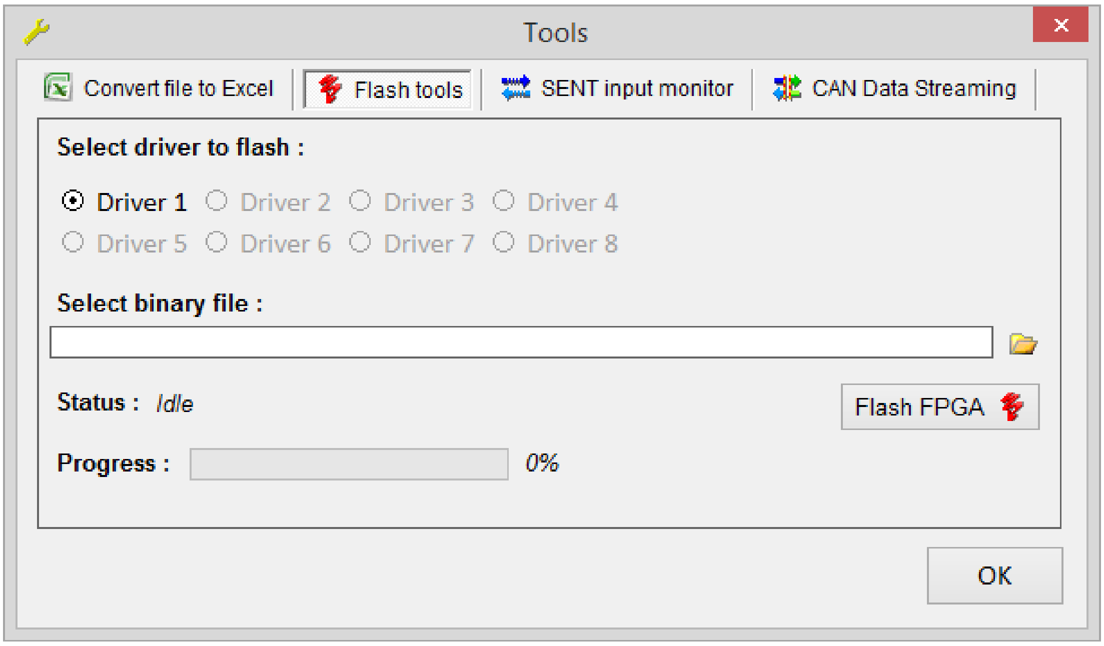
This window contains some important informations about each driver connected to the CAN bus (firmware and FPGA versions, hardware type, input voltages and internal temperatures) updated periodically.

Tools: Press this button to open the system tools dialog window



- Convert file to Excel: disabled function for now.

- Flash tools :



Reprogramming the driver's FPGA is a critical process which must be executed with care. The name of the binary fill must be selected along with the target driver ID.

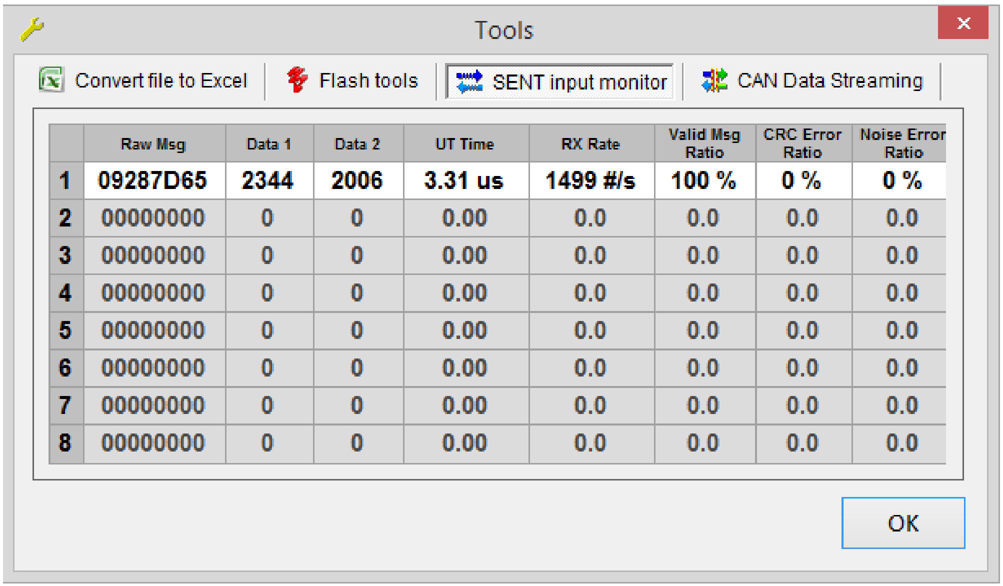
There exist two hardware variants of the H-Bridge drive containing different FPGA's. The corresponding binary files are not compatible. The right binary file must be selected for each FPGA type. In case of doubt, please contract EmTroniX for help.

The FPGA reprogramming procedure takes about 10 minutes.

The reprogramming procedure must not be interrupted; Failing to do so can cause a permanent brain-death of the driver, situation offering no other alternative than to ship the driver back to EmTroniX for servicing.

-   SENT input monitor

This panel's main function is to show the different real-time SENT sensor signal decoding parameters



	Raw Msg	Data 1	Data 2	UT Time	RX Rate	Valid Msg Ratio	CRC Error Ratio	Noise Error Ratio
1	09287D65	2344	2006	3.31 us	1499 #/s	100 %	0 %	0 %
2	00000000	0	0	0.00	0.0	0.0	0.0	0.0
3	00000000	0	0	0.00	0.0	0.0	0.0	0.0
4	00000000	0	0	0.00	0.0	0.0	0.0	0.0
5	00000000	0	0	0.00	0.0	0.0	0.0	0.0
6	00000000	0	0	0.00	0.0	0.0	0.0	0.0
7	00000000	0	0	0.00	0.0	0.0	0.0	0.0
8	00000000	0	0	0.00	0.0	0.0	0.0	0.0

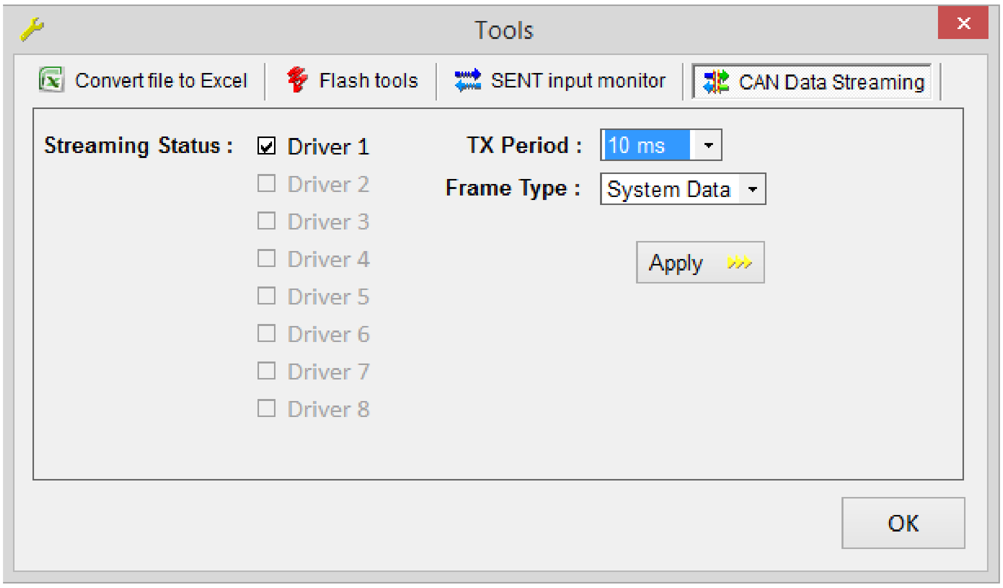
-   CAN Data Streaming :

Driver's internal data such as Current, PWM DC, position ratio, PID parameters, etc. can be periodically sent on the CAN bus to be monitored or processed by a third party equipment. Internal data are sorted in two different categories:

1. System Data : Sensor FB, RMS Current, PWM DC, Pos. Target, Pos. Feedback, Pos. Error, Test loop counter, Sequence loop counter, Sequence element loop counter

2. PID Data : Prop term, Deriv term, Int. Term, Kp, Ki, Kd, FF, Error, Output, Target, Feedback

System and PID data are encoded in a series of can messages sent every selected transmission period. Only one type of data can be streaming (System or PID, not both)



System data CAN messages encoding:

Depending on the driver's slot ID, the first messages ID will be:

Slot position	1	2	3	4	5	6	7	8
TX CAN ID	**0x400**	**0x410**	**0x420**	**0x430**	**0x440**	**0x450**	**0x460**	**0x470**

A series of three messages are sent periodically:

	Value
ID	**TX CAN ID**
B0..B1	**Sensor FB** (mV is analog sensor, % x 10 if PWM sensor, counts if SENT sensor)
B2..B3	**RMS Current** (mA, signed)
B4..B5	**Position Target** (% x 10, signed)
B6..B7	**PWM Duty Cycle** (% x 10, signed)

	Value
ID	**TX CAN ID + 1**
B0..B1	**PID Position Error** (% x 10, signed)
B2..B3	**Position Feedback** (% x 10, signed)
B4..B5	**Test in progress flag** (0 : Idle, 1 : In Progress)
B6..B7	**Unused**

	Value
ID	**TX CAN ID + 2**
B0..B3	**Sequence loop counter**
B4..B7	**Sequence element loop counter**

PID data CAN messages encoding:

Depending on the driver's slot ID, the first messages ID will be:

Slot position	1	2	3	4	5	6	7	8
TX CAN ID	**0x500**	**0x510**	**0x520**	**0x530**	**0x540**	**0x550**	**0x560**	**0x570**

A series of five messages are sent periodically:

	Value
ID	**TX CAN ID**
B0..B3	**Proportional term** (%, floating point format)
B4..B7	**Integral term** (%, floating point format)

	Value
ID	**TX CAN ID + 1**
B0..B3	**Filtered derivative term** (%, floating point format)
B4..B7	**Feedforward term** (%, floating point format)

	Value
ID	**TX CAN ID + 2**
B0..B3	**Kp** (floating point format)
B4..B7	**Ki** (floating point format)

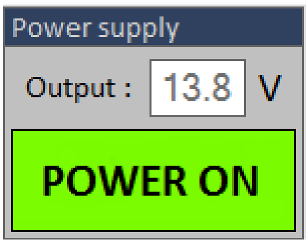
	Value
ID	**TX CAN ID +3**
B0..B3	**Kd** (floating point format)
B4..B7	**Position Error** (%, floating point format)

	Value
ID	**TX CAN ID + 4**
B0..B3	**PID Output** (%, floating point format)
B4..B5	**Position Target** (% x 10, signed)
B6..B7	**Position Feedback** (% x 10, signed)

Reset: Press this button to abort any ongoing driver action.

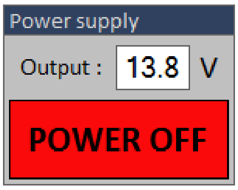
- Power Supply Control Panel

  At the bottom left side of the main application window is located the Power Supply Control Panel. It allows the user to adjust the output voltage of the variable voltage power supplies (for drivers fitted with this hardware option) and to enable/disable all the driver's power supplies at once.

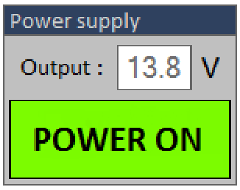


The application automatically detects during the communication initialization procedure if drivers present are fitted with fixed or variable power supplies. In case of fixed power supplies, the voltage edition window will always remain disabled. In case of variable power supplies, the voltage edition window will be enabled when the power supplies are disabled.

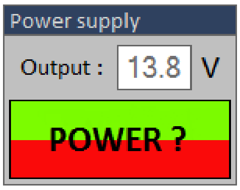
Pressing the Power On/Off button will send a CAN command to all the drivers to enable or disable their power supply. The colour of the button will reflect the overall status the power supplies feedback by the drivers (green: all enabled, red: all disabled, half green, half red: some enabled, some disabled)



All power supplies disabled



All power supplies enabled



Some power supplies enabled, some disabled

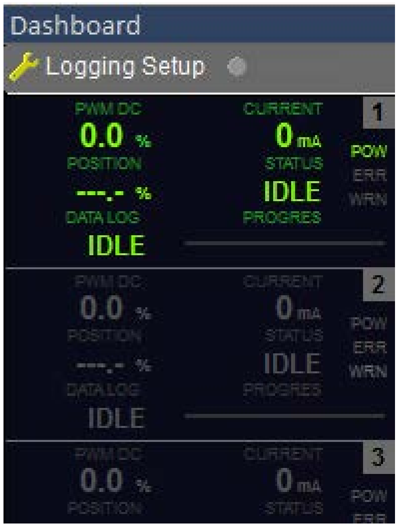
A driver can reject the 'enable power supply' command in case of internal error(s) (ex. internal component over-temperature), the effective drivers individual power supply status are displayed in their respective dashboard panels:

Driver 1 power supply is disabled

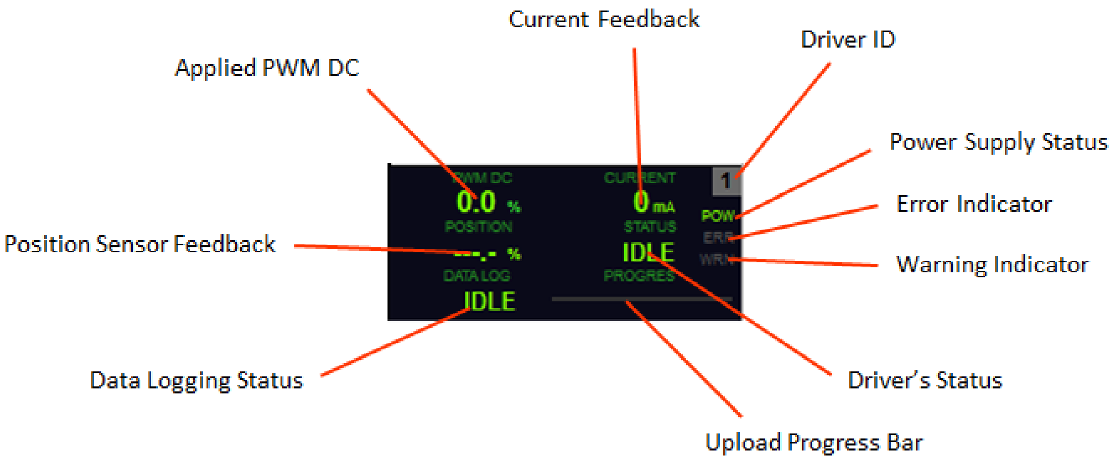
Driver 1 power supply is enabled

- Driver Dashboards

  Each driver identified during the communication initialization procedure will have a dashboard assigned in the left-hand side of the application window (if the "Show Display Dashboard" option has been selected in the system setup dialog window).

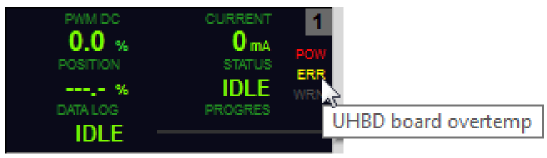


A dashboard is a concentrated display of the most relevant driver's data and status updated every 100ms. These informations can be logged and saved to a file using the Dashboard logging function.

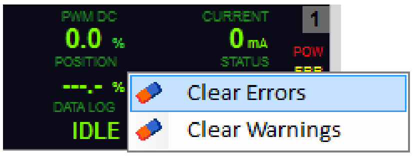


Displayed informations:

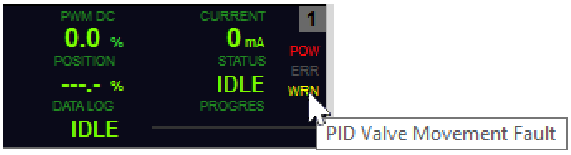
- **Driver ID**: Slot ID of the driver to which the dashboard panel belongs
- **Power Supply Status**: driver's individual status of its power supply (Green : Power Supply Enabled, Red : Power Supply Disable)
- **Error Indicator**: indication of the presence of internal system error(s) (Grey: no error, blinking yellow: error(s) present). Move the mouse pointer over the error label to display the details of the error message.



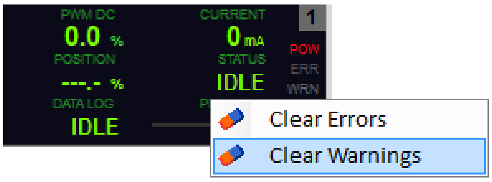
Some errors can be cleared, right-click on the dashboard panel to open the error/warning clear pop-up menu



- **Warning Indicator**: indication of the presence of internal system warning(s) (Grey: no warning, blinking yellow: warning(s) present). Move the mouse pointer over the warning label to display the details of the warning message.



Warnings can be cleared, right-click on the dashboard panel to open the error/warning clear pop-up menu



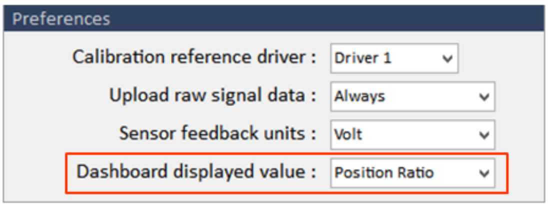
- **Driver's Status**: This label indicates the task that is being executed by the driver. The different task indictors can be :

  IDLE: No task executed
  SENS IDENT: sensor identification test in progress
  RESP TIME: Response time test in progress
  FLASHING: FPGA reprogramming in progress
  SEQUENCE: Sequence in progress
  HYSTERE: Hysteresis test in progress
  UPLOADING: Data are being uploaded

- **Upload Progress Bar**: Indication of the progression of the data upload procedure
- **Data Logging Status** : This label displays the status of the driver's internal data logger, it can have the following value :

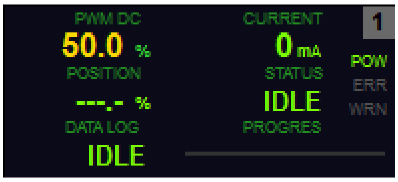
  IDLE: Data logging is inactive
  ARMED: Data logging has been armed and is waiting for a sensor identification, response time or hysteresis test to start
  LOGGING: Data logging is in progress
  DONE: Data logging is complete
  FAILED: Indicates that the data logging (which was launched using the START LOGGING command) was interrupted by a sensor identification, a response time or a hysteresis test.
  UPLOAD: Indicates that logged data are being uploaded

- **Position Sensor Feedback**: Valve position displayed either in raw sensor values (Volt, PWM DC, Counts) or in position ratio (%) depending on the display option selected in the system setup dialog

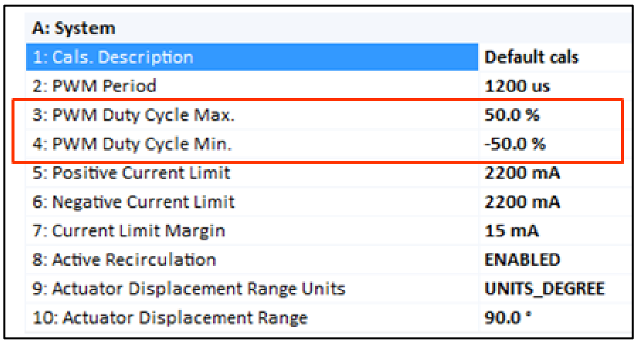


The value ---.-% will be displayed until a successful sensor identification test has been executed (min. and max. sensor outputs need to be known to calculate the position ratio).

- **Applied PWM DC**: This is the value of PWM duty cycle which is effectively applied to the valve. An amber text colour indicates that the requested PWM DC is being limited because the min. or max. PWM DC value (specified in the calibrations) has been reached



Limited PWM duty cycle (amber text)



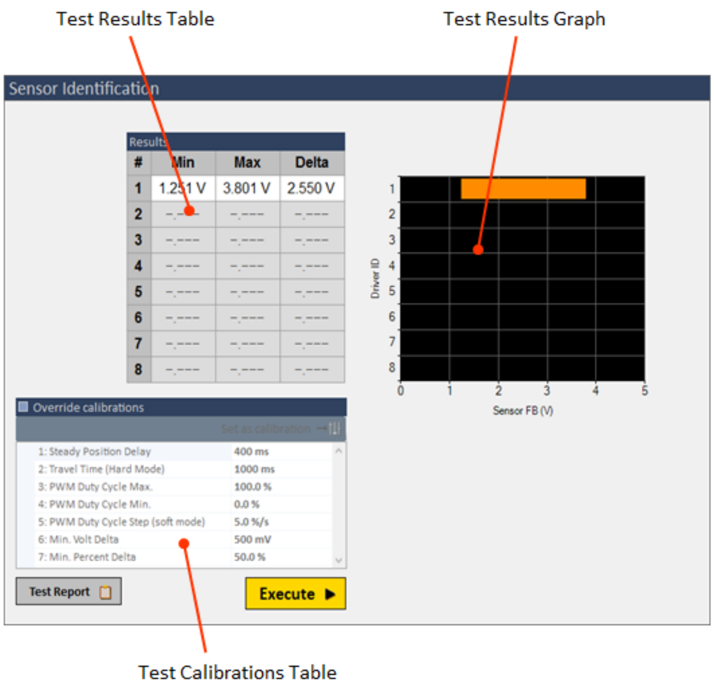
A: System	
1: Cals. Description	Default cals
2: PWM Period	1200 us
3: PWM Duty Cycle Max.	50.0 %
4: PWM Duty Cycle Min.	-50.0 %
5: Positive Current Limit	2200 mA
6: Negative Current Limit	2200 mA
7: Current Limit Margin	15 mA
8: Active Recirculation	ENABLED
9: Actuator Displacement Range Units	UNITS_DEGREE
10: Actuator Displacement Range	90.0 °

- **Current Feedback**: Real-time measured current feedback.

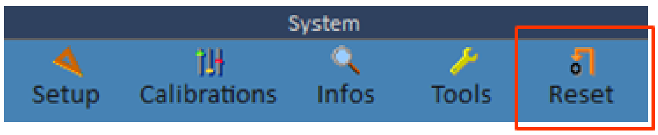
FUNCTION CONTROL PANELS:

SENSOR IDENTIFICATION CONTROL PANEL:

Sensor range identification is an essential procedure which must be performed before any other test (see chapter XXX).



The procedure can be launched by pressing the "Execute" button (which becomes enabled only if the Power Supply is on) in the Sensor Identification Control Panel; all active drivers will then start their sensor identification. The procedure can be aborted anytime by pressing the Reset button in the application toolbar



Once the procedure is complete, the drivers will automatically send their sensor identification results to the application which will be displayed in the control panel in tabular and graphical format.

The procedure is as considered successfully only if the absolute difference between min. and max. sensor values is larger than the value specified in the calibrations (parameter depends on the sensor type):

E: Sensor identification	
1: Steady Position Delay	400 ms
2: Travel Time (Hard Mode)	1000 ms
3: PWM Duty Cycle Max.	100.0 %
4: PWM Duty Cycle Min.	0.0 %
5: PWM Duty Cycle Step (soft mode)	5.0 %/s
6: Min. Volt Delta	500 mV
7: Min. Percent Delta	50.0 %
8: Min. LSB Delta	128 #
9: Mode	MODE_SOFT

For analogue sensors

E: Sensor identification	
1: Steady Position Delay	400 ms
2: Travel Time (Hard Mode)	1000 ms
3: PWM Duty Cycle Max.	100.0 %
4: PWM Duty Cycle Min.	0.0 %
5: PWM Duty Cycle Step (soft mode)	5.0 %/s
6: Min. Volt Delta	500 mV
7: Min. Percent Delta	50.0 %
8: Min. LSB Delta	128 #
9: Mode	MODE_SOFT

For PWM sensors

E: Sensor identification	
1: Steady Position Delay	400 ms
2: Travel Time (Hard Mode)	1000 ms
3: PWM Duty Cycle Max.	100.0 %
4: PWM Duty Cycle Min.	0.0 %
5: PWM Duty Cycle Step (soft mode)	5.0 %/s
6: Min. Volt Delta	500 mV
7: Min. Percent Delta	50.0 %
8: Min. LSB Delta	128 #
9: Mode	MODE_SOFT

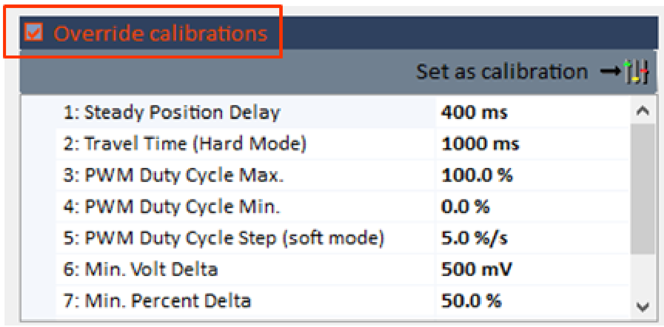
For SENT sensors

If this condition is not met, an error message will appear in the Events Log Window:

16/02/2016 14:59:58 : [Driver 1] Test 'SENSOR IDENT' failed, err = Invalid sensor voltage range

A valid sensor identification procedure must have been made before position ratios can be calculated, and thereby Response Time and Hysteresis tests can be executed.

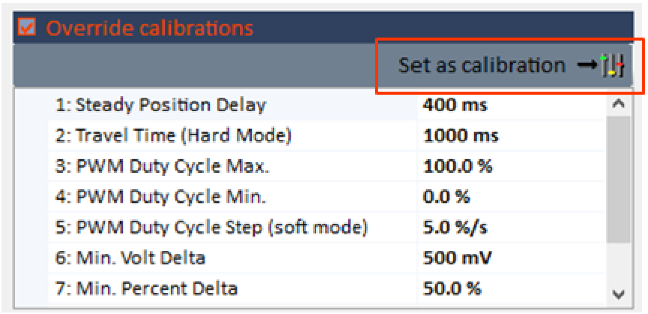
The procedure normally uses calibration parameters read from non-volatile memory. These parameters can however be temporarily modified by checking the “Override Calibrations” checkbox located in the header of calibrations table.



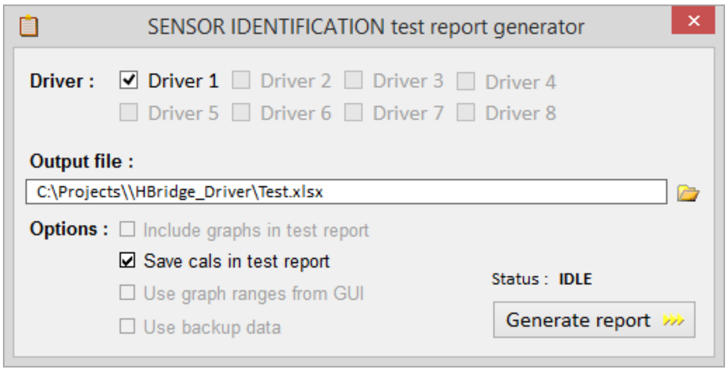
While the calibrations are being overridden, a red frame will appear around the sensor identification Execute Button and the corresponding Control Panel Selection Button to remember the user of this particular condition.

The edited calibrations will be sent to the driver prior to the execution of the sensor identification procedure. Unchecking the “Override Calibrations” checkbox cause the next sensor identification to be made with original calibrations.

To make the modified calibration values become permanent, press the “Set as calibrations” button in the calibrations panel header; the modified sensor identification calibration values will be copied to the Calibrations Editor, which can then be downloaded and written to non-volatile memory.



A sensor identification test report in MS Excel format containing the results of the last executed sensor identification can be generated by pressing the Test Report button:



Select the driver(s) which should have a report generated and the option of having calibrations included in the report. One test report file will be generated per selected driver (the suffix _CHX will be automatically added to the provided file name). Press the "Generate Report" button to start the report generation.

A sensor identification test report contains the following informations:

	A	B	C	D
1	**Test Type :**	SENSOR_IDENT		
2	**Date :**	16/02/2016 16:08:08		
3	**Driver index :**	1		
4	**References :**			
5	**Power supply volt (V) :**	13.840		
6	**Results :**	**Sensor FB up (V) :**	3.821	
7		**Sensor FB down (V) :**	1.264	
8	**Calibrations :**	**PWM duty cycle max. (%) :**	100.00	
9		**PWM duty cycle min. (%) :**	0.00	
10		**PWM duty cycle step (%/s) :**	5.000	
11		**Sensor ident. mode :**	MODE_SOFT	
12		**Steady pos. delay (ms) :**	400.0	
13				
14				

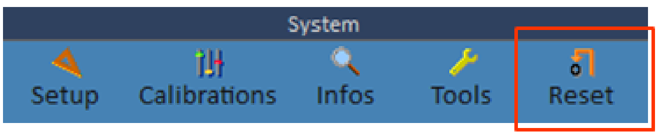
RESPONSE TIME TEST CONTROL PANEL:

The response time test measures and analyses the dynamic performances of the tested valve (see chapter XXX).

The test can be started by pressing the “Execute” button (which becomes enabled only if the Power Supply is on) in the Response Time Control Panel; all active drivers will then start a response time test.

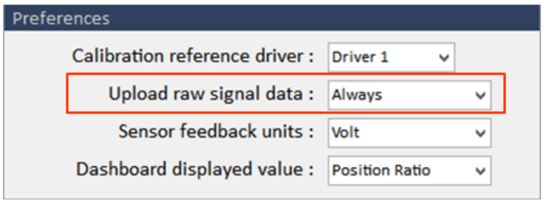
⚠ *A valid sensor identification procedure must have been made before a Response Time test can be executed.*

The test can be aborted anytime by pressing the Reset button in the application toolbar



Once the test is complete, the drivers will automatically send their response time results to the application which will be displayed in the control panel in tabular format.

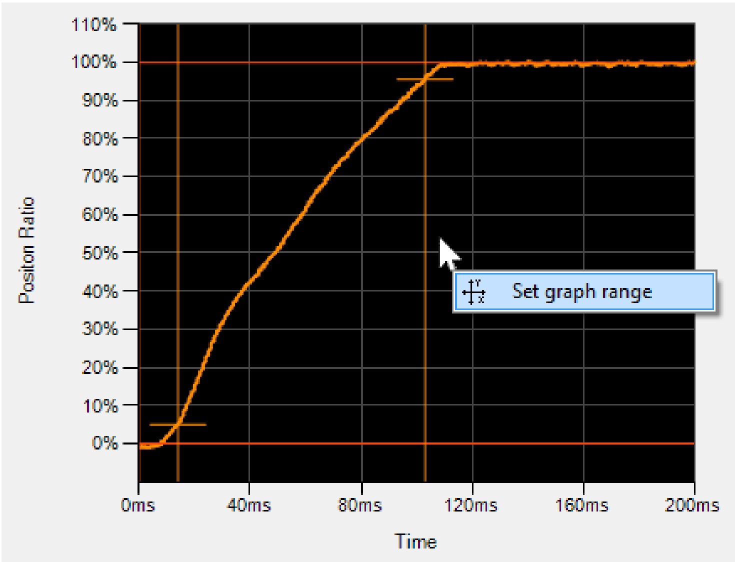
If the case of a FULL driver version and if the option “Upload raw signal data” is set to “Manual tests only” or “Always” in the System Setup Dialog, raw signal data acquired during the test will be automatically uploaded and displayed at the end of the test. LIGHT driver version cannot have graphs displayed.



Depending on the acquisition sampling frequency set in the test calibrations, the number of acquired data can be significant and can take a few seconds to process by the driver's CPU and a few minutes to upload.

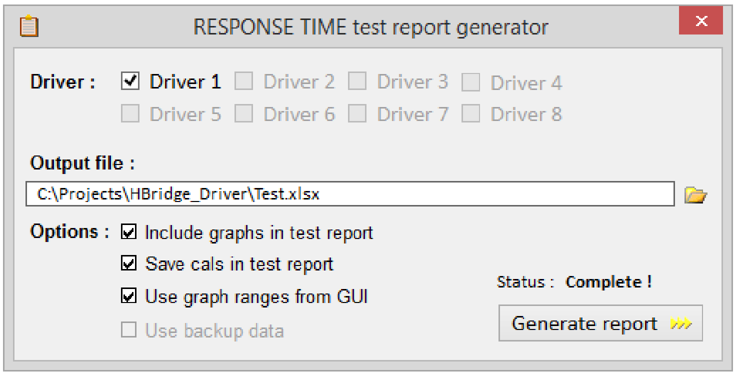
The test is considered as successfully only if valve has crossed the different test validity position thresholds (see chapter XXX)

Individual graph ranges can be modified by right-clicking on the graph areas:



Similarly as for the sensor identification procedure, the response time test calibrations can be temporarily modified (see chapter XXX).

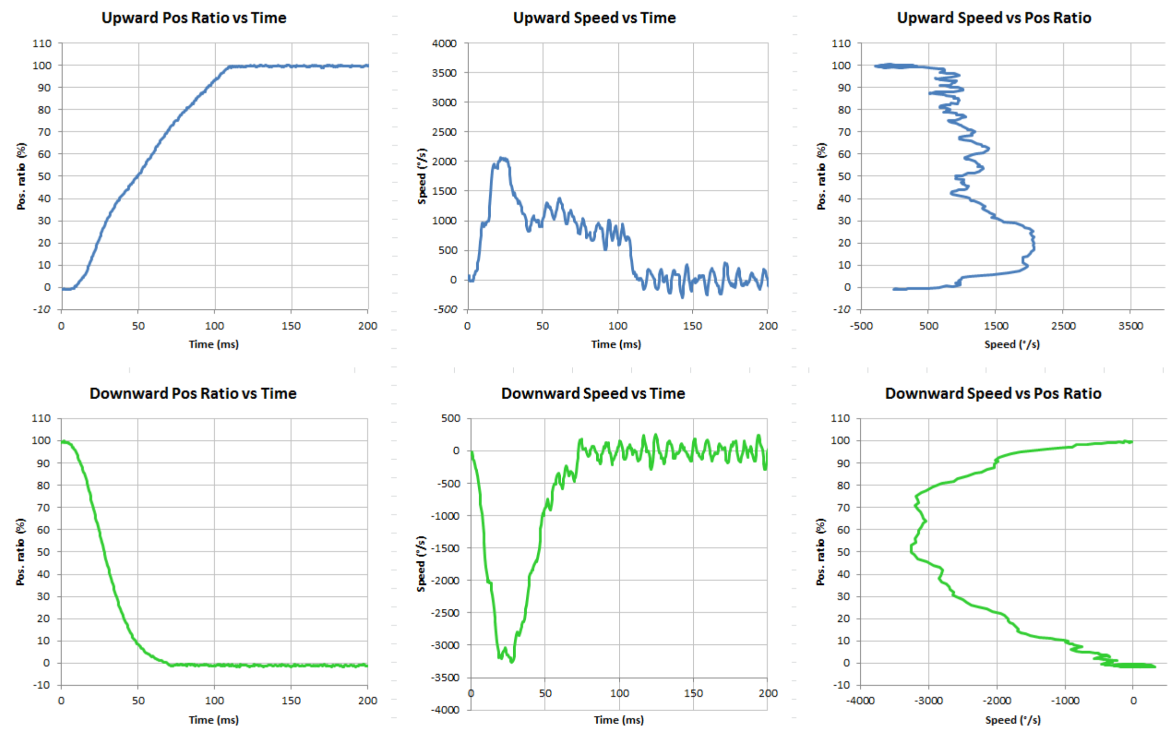
A response time test report in MS Excel format containing the results of the last executed response time test can be generated by pressing the Test Report button:



Select the driver(s) which should have a report generated and the different report generation options. One test report file will be generated per selected driver (the suffix _CHX will be automatically added to the provided file name). Press the "Generate Report" button to start the report generation.

A response time test report contains the following informations:

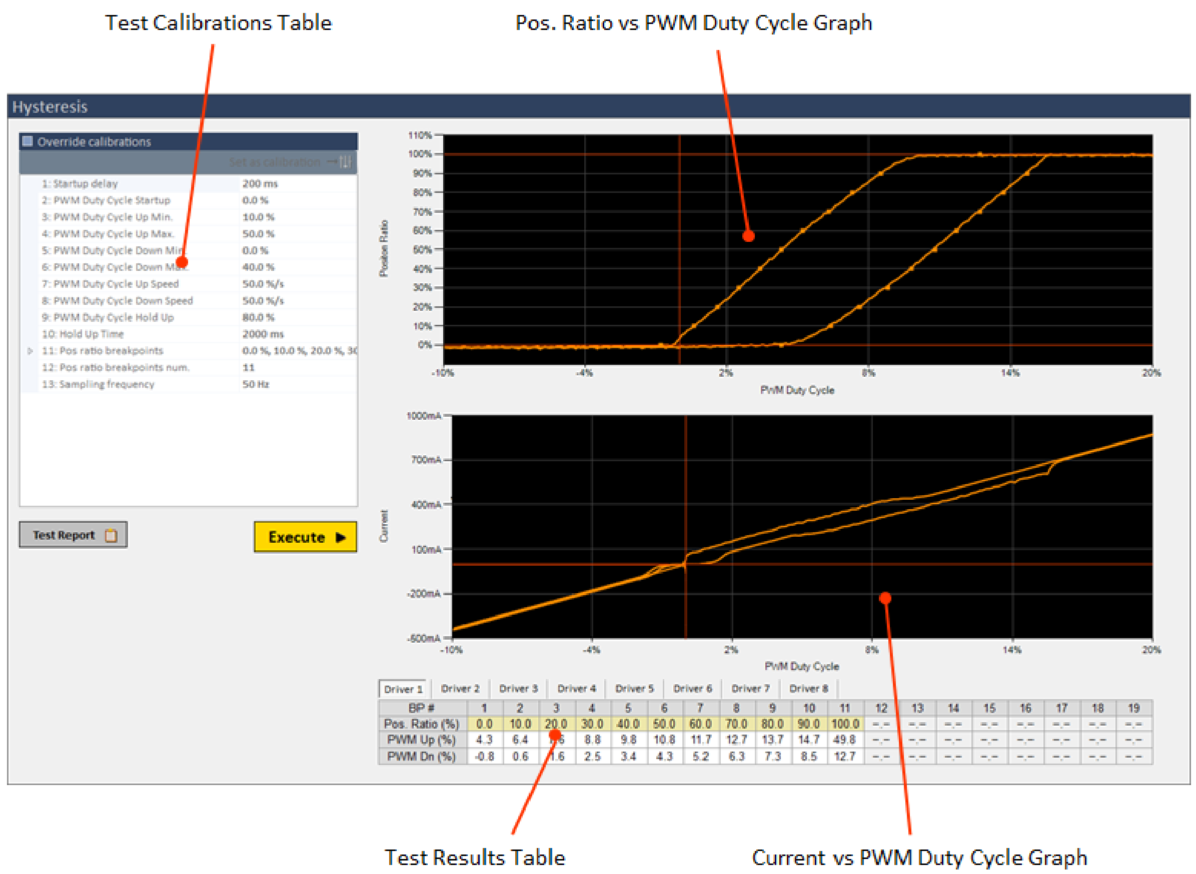
Test Type :	RESPONSE_TIME	
Date :	16/02/2016 16:17:17	
Driver index :	1	
References :		
Power supply volt (V) :	13.840	
Results :	**Response time up (ms) :**	89.0
	Response time down (ms) :	44.5
	Speed up (°/s) :	910.112
	Speed down (°/s) :	1820.225
Calibrations :	**PWM duty cycle max. (%) :**	30.00
	PWM duty cycle min. (%) :	-10.00
	PWM duty cycle startup (%) :	-10.00
	Soft stop enabled :	FALSE
	Steady pos. delay (ms) :	400.0
	Resp. time calc. mode :	MODE_NORMAL
	Upward lower calc. threshold (%) :	5.00
	Upward upper calc. threshold (%) :	95.00
	Downward lower calc. threshold (%) :	5.00
	Downward upper calc. threshold (%) :	95.00
	Range (°) :	90
	Acquisition Frequency :	2.0 KHz



Graphs can only be included in the test report if raw signal data were uploaded at the end of the response time test. These data will be saved in a separate worksheet in the test report file. LIGHT driver version have no acquisition memory and can therefore not have graphs included in their test reports.

HYSTERESIS TEST CONTROL PANEL:

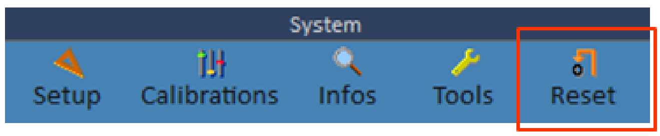
The hysteresis test measures the characteristics of the position hysteresis of the tested valve (see chapter XXX).



The test can be started by pressing the "Execute" button (which becomes enabled only if the Power Supply is on) in the Hysteresis Test Control Panel; all active drivers will then start a hysteresis test.

⚠ *A valid sensor identification procedure must have been made before a Response Time test can be executed.*

The test can be aborted anytime by pressing the Reset button in the application toolbar

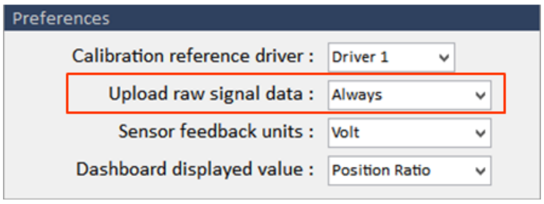


Once the test is complete, the drivers will automatically send their sensor identification results to the application which will be displayed in the control panel in tabular format.

Once the test is complete, the drivers will automatically send their hysteresis test results to the application which will be displayed in the control panel in tabular format and in graphical format (as a set of PWM vs pos. ratio points at the selected position breakpoints).

While the test in progress, the position and current vs PWM DC graph are update with (slow) data received through the CAN stream.

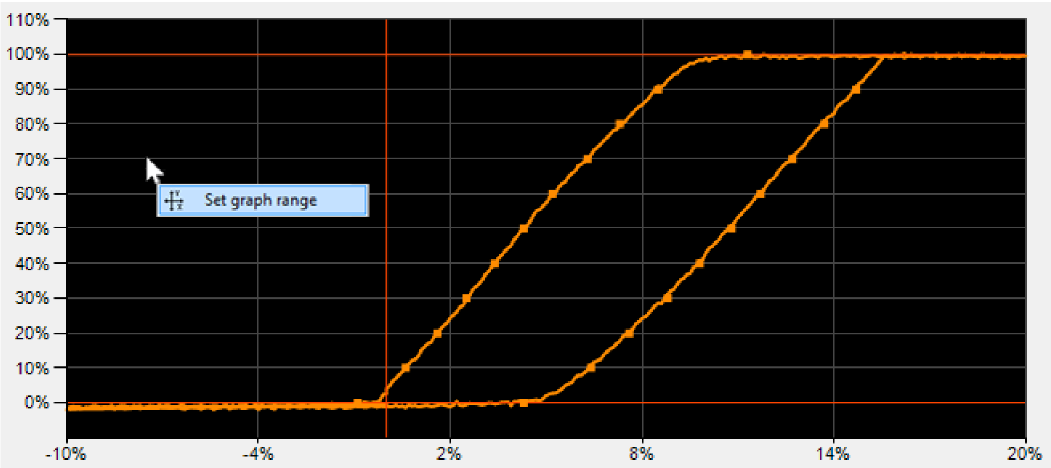
If the case of a FULL driver version and if the option "Upload raw signal data" is set to "Manual tests only" or "Always" in the System Setup Dialog, raw signal data acquired during the test will be automatically uploaded and displayed at the end of the test, replacing the graph drawn using the CAN stream data.



Depending on the acquisition sampling frequency set in the test calibrations, the number of acquired data can be significant and can take a few minutes to upload.

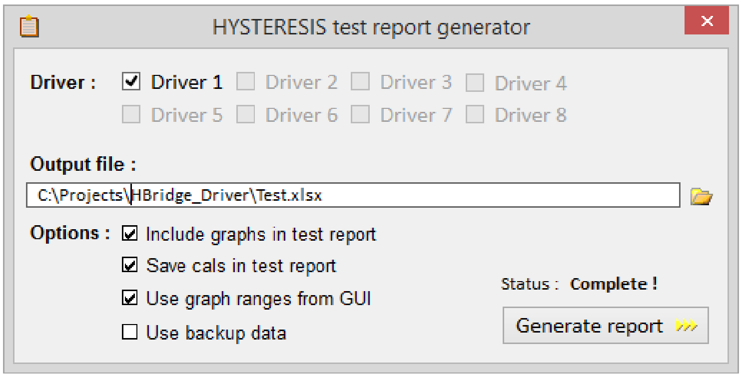
If some positions breakpoints were not crossed during the test, the symbol "---" will appear in the corresponding test results table cells.

Individual graph ranges can be modified by right-clicking on the graph areas:



Similarly as for the sensor identification procedure, the hysteresis test calibrations can be temporarily modified (see chapter XXX).

A hysteresis test report in MS Excel format containing the results of the last executed response time test can be generated by pressing the Test Report button:



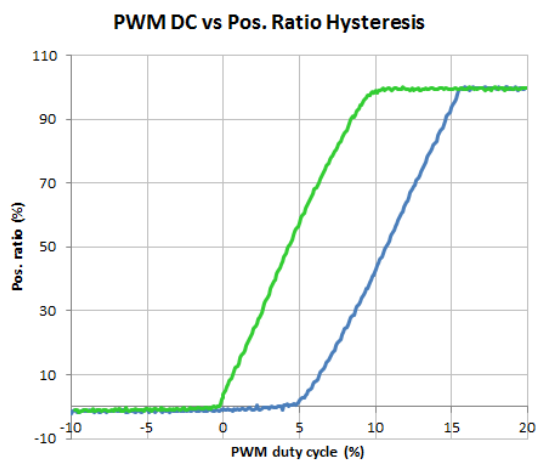
Select the driver(s) which should have a report generated and the different report generation options.

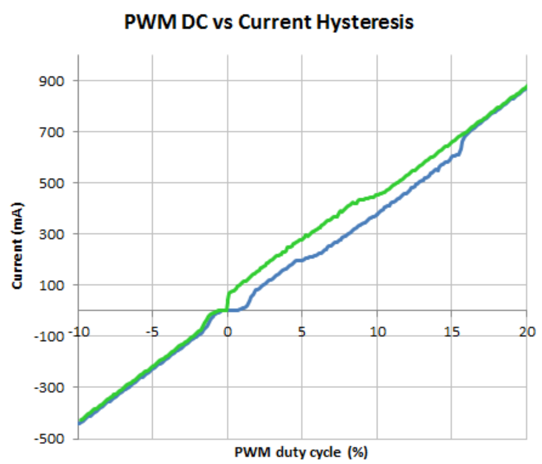
NOTE: The option “Use backup data” allows CAN streaming data (which were recorded during the test) to be used to draw the test results graphs. This option can be useful for LIGHT driver versions which have no acquisition memory and thereby cannot have hi-resolution graphs in their test reports.

One test report file will be generated per selected driver (the suffix _CHX will be automatically added to the provided file name). Press the “Generate Report” button to start the report generation.

A hysteresis test report contains the following informations:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	**Test Type :**	HYSTERESIS													
2	**Date :**	16/02/2016 18:40:03													
3	**Driver index :**	1													
4	**References :**														
5	**Power supply volt (V) :**	13.840													
6	**Results :**	**Pos. ratio b.p. (%) :**	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00		
7		**PWM duty cycle up (%) :**	4.30	6.40	7.60	8.80	9.80	10.80	11.70	12.70	13.70	14.70	49.80		
8		**PWM duty cycle down (%) :**	-0.90	0.60	1.60	2.50	3.40	4.30	5.20	6.30	7.30	8.50	11.30		
9		**Average hold current (mA) :**	2038												
10	**Calibrations :**	**Startup delay (ms) :**	200.0												
11		**PWM duty cycle startup (%) :**	0.00												
12		**PWM duty cycle min. up (%) :**	10.00												
13		**PWM duty cycle max. up (%) :**	50.00												
14		**PWM duty cycle min. down (%) :**	0.00												
15		**PWM duty cycle max. down (%) :**	40.00												
16		**PWM duty cycle step up (%/s) :**	50.000												
17		**PWM duty cycle step down (%/s) :**	50.000												
18		**PWM duty cycle hold up (%) :**	80.00												
19		**Hold up time (ms) :**	2000.0												
20		**Pos. ratio b.p. num. :**	11												
21		**Pos. ratio b.p. (%) :**	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00		





Graphs can only be included in the test report if raw signal data were uploaded at the end of the response time test. These data will be saved in a separate worksheet in the test report file. .