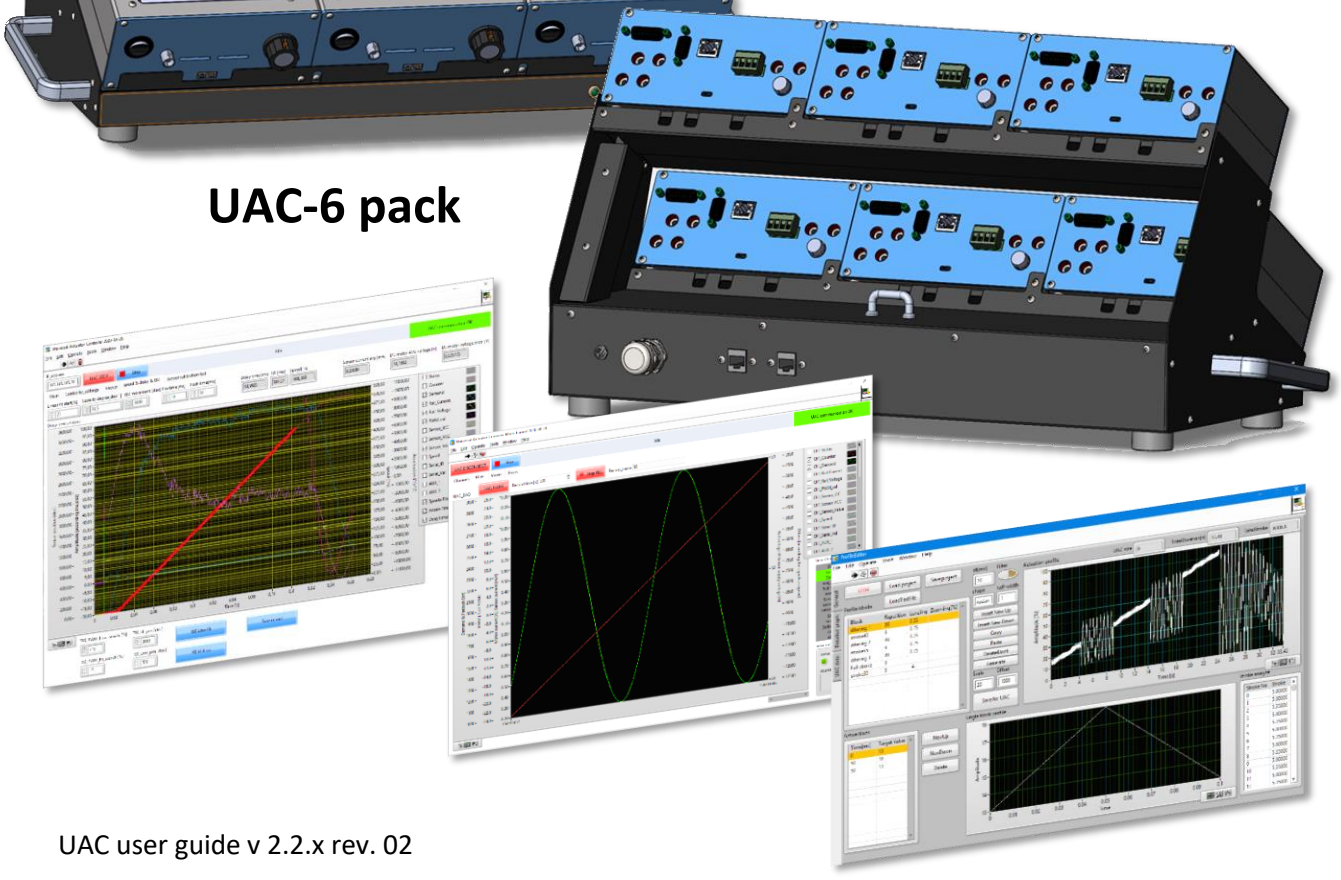
UAC Universal Actuator Controller

UAC-6 pack



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Disclaimer

1. Universal actuator controller (UAC) is device to control brushed motor-based actuators with voltage (0-5V), SENT or PWM signal feedback. UAC is designed to be operated by safe voltage only -under 24V with maximum current or 12.5A (maximum measurable range and power supply fuse).
2. UAC is intended as engineering tool for laboratory application, to set and test actuator functions.
3. UAC is not designed, intended or certified for:
    - Usage in medical systems.
    - Usage in life critical systems.
    - Usage in areas with flammable or explosive gas substances.
    - Usage in other applications in which mistake or device malfunction may cause death or personal injury or severe damage.
4. UAC described in this document is designed and intended for usage by authorized engineers and technicians only.
5. UAC internal FW and PC application software are developed in the best intention to provide expected functionality, but as is currently impossible to develop SW that is bug-free in all application is SW provided “AS IS”.
6. UAC is considered as ESD sensitive device and operator shall follow common rules to avoid ESD damage.
7. As UAC can be controlled remotely, users shall avoid potential injury caused by machinery operation without direct supervision.

Table of content

1. Introduction

UAC (Universal Actuator Controller) is controller developed to control primarily simple actuators with brushed DC motor and sensor position feedback with Voltage, SENT or PWM interface.
UAC functions may be expanded in future to drive also intelligent actuators due to embedded CAN&RS485 interface.

Main features of the UAC:

- **CONTROLLABILITY** - actuators can be controlled in open or closed loop manually by potentiometer knob, remotely by external voltage (0-5V), by CAN messages, by PC over Ethernet or by standalone motion profile uploaded to UAC. UAC can also generate sinusoidal or square movement profile defined by user.
- **USER INTERFACE** - all user control is done via 5" touch screen. Data are interpreted as text values and graphics charts. PID profiles and motion profiles must be created by dedicated SW and loaded to UAC in advance.
- **SD CARD SETTINGS** - All settings are located on SD card and contains PID profiles according to user settings for various actuators and actuation cycle definitions.
- **SINE / SQUARE MOTION GENERATOR** - UAC can generate sinusoidal or square movement defined in touch screen interface settings.
- **SOFT LANDING** - when approaching hard-stop, UAC can be set for soft landing parameters in order to limit speed of actuator. This is available in both directions where hard-stop contact may occur.
- **AUTOMATIC ALARMS -** In every UAC PID profile are also alarm definitions which defines key characteristics of the behavior and also time window for signal averaging.
  - Min & Max limit for position feedback
  - Time window for definition of average values for alarm limits
    - Time duration (max 300s)
    - Max average current limit
    - Max average position error
    - Min Pk-Pk movement

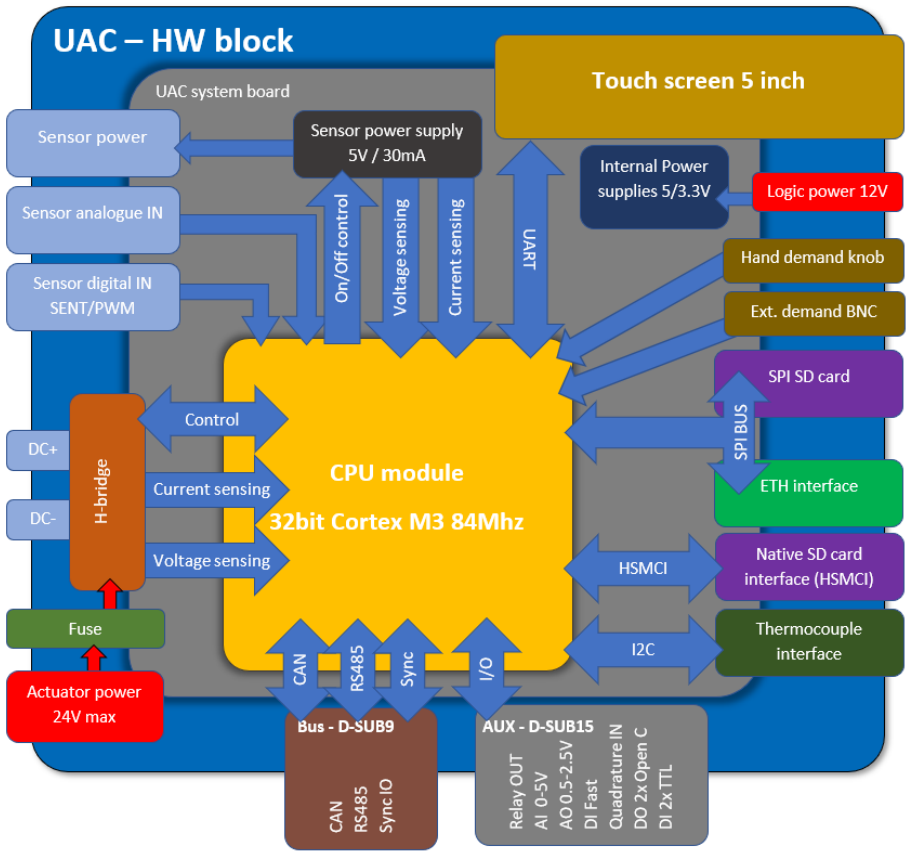
  These alarms may prevent damage of tested unit or equipment and stop test in case of error.
- **PWM ZONE LIMITATION** - control parameters contain also PWM limitation for operating zones according to actuator position (low / mid / high zone) and also different direction of the movement. It means we can set mid position limit to 100% of PWM then low limit to 30% of PWM (in order to be sure, we don't damage actuator when we can reach hard-stop), but when exiting low zone back to mid zone we can set 100% limit again as we don't risk hitting hard-stop. This function can be enabled in Closed loop and Open loop mode as well.
- **MISS WIRING PREVENTION** - To avoid miss connection of actuator cable harness is system checking sensor signal connection in order to identify correct sensor connection. Check is based on sensor feedback is in given range for passive diagnostics and current draw is also in requested range and in case of digital feedback SENT / PWM must be present before UAC apply power toH-bridge.
- **PID TEMPERATURE SCALING** - to control actuators under various temperature profile can UAC use external thermocouple to scale PID settings to be adopted according actual temperature. For this is equipped with 3 different PID settings for 3 programmable temperatures, which are scaled by linear formula according actual temperature.
- **POWER** - UAC uses separate power for logic of UAC and DC motor power, user can test any type of DC motor power without influence on UAC functionality.

- **AUXILIARY IN/OUT** - UAC can be used with other inputs and outputs (relay OUT, Quadrature encoder, analog in/out, digital IN/OUT and Thermo-couple measurement).

2. MAIN PARAMETERS MEASUREMENT - UAC measuring parameters

- DC motor power voltage 0-33Volt (over voltage up to 33V)
- DC motor power current (+/- 12.5A)
- Sensor power voltage (0-5V)
- Sensor current draw (0-30mA)
- Sensor position feedback (voltage / SENT / PWM)
- Other programmable channels:
    - SENT fast channel 2
    - Quadrature encoder signal
    - Temperature of thermo couple
    - External analog inputs
    - Controller P, I, D components, real PID demand with soft landing
    - For other channels see chapter 7.4.3.4 DAQ – (AUX channels).

3. Main features – HW schema



HW is structured as shown in the schema above, the UAC system board contains main components like power supplies for all subsystems, measurement sensors and amplifiers, H-bridge, input/output conditioning circuits and protections, bus drivers and all connectors for user interfaces. CPU module is based on 32bit Cortex M3 84MHz and is separated on dedicated board which enables simple replacement and possible upgrade to another MCU platform. Hi speed SPI bus connects Ethernet interface as main communication bus for PC interaction and also SPI mode SD card which contains all settings and calibration files of UAC. Dedicated HSMCI interface for SD card is option for future

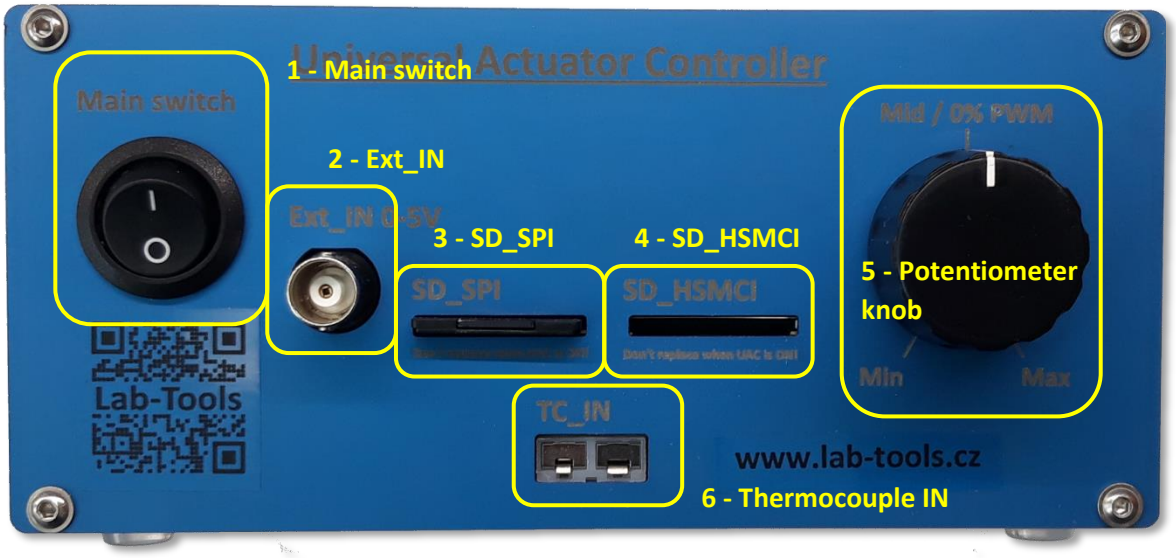
implementation of standalone recording data to SD card. I2C bus provides interface to thermocouple sensor and can be also used for future expansion with other sensors. Main user control interface is 5“touch screen which provides all necessary user controls and indicators including live charts of control position demand and feedback as well with DC motor current.

4. Main parameters

Operating voltage UAC logic	10-14V DC
DC motor power	7-24V DC
DC motor current (fused)	12.5A
DC motor PWM frequency	100Hz - 20kHz (UAC is designed for 1kHz nominal as switching time is fixed to nominal value 6.5us (error approx. 0.65% @ 1kHz). With higher frequency is timing impacted more as switching time is constant!)
Signal data acquisition frequency	All data channels 1000Hz
Control loop frequency	500Hz
Sensor feedback	Voltage / SENT / PWM
Sensor power	5V max 30mA
Control modes	Open loop + closed loop controlled by multiple inputs - see chapter Operating modes. Soft landing settings for controlled hard-stop contact - demand ramp (defining position and ramp of demand) - speed brake (imposed speed limitation)
PWM limiting	Over all limit + 3 zones according position (low, mid, high) with different setting for entering zone and exiting zone (low zone IN/OUT + high zone IN/OUT)
Sensor condition test before DC motor enable	- Voltage limit range to identify passive diagnostics - Current range to define correct current draw - SENT / PWM signal presence
Memory storage	**SD card (SPI)** - for PID profiles - motion profiles - UAC calibration - System settings **SD card HSMCI** (future implementation of standalone recording to SD card - not yet implemented)
UAC communication to PC	Ethernet 10/100 for control and data acquisition USB for service (new firmware installation)
UAC communication bus interfaces	CAN - Remote control of Master/Slave mode RS485 –Future option
Thermo couple interface	Temperature measurement can be added as auxiliary channel. PID scaling according the temperature.
UAC IO interface	- Analog input 0-5V, 12bit resolution - Analog output 0.5-2.5V, 12bit resolution - Digital in (fast counter input) - Quadrature encoder interface - Relay out (C, NO, NC) - 2x digital in - 2x digital out (open collector max 500mA) - 5V power supply 200mA
Dimension / Weight	165x80x135mm / 0,9kg

5. UAC inputs and outputs

5.1. Front panel



1 - Main switch.

Main switch is switching ON/OFF UAC logic power, but DC motor line is not under this switch circuit. As HI current line is switched by H-bridge and protected by fuse. For safety reason must be available power OFF on power source for DC motor.

2 - Ext_IN

Ext_IN is voltage input for remote control via external voltage source. Control voltage is in range 0-5V only!

3 - SD_SPI

SD_SPI is memory slot used for PID profiles, motion profiles, UAC calibration and settings. Normally is on SD card located also software for PC and appropriate windows runtime. As this SD card contains settings and calibrations is recommended to backup card content.

4 - SD_HSMCI

SD_HSMCI slot is used for future upgrade for standalone data acquisition directly on this SD card.

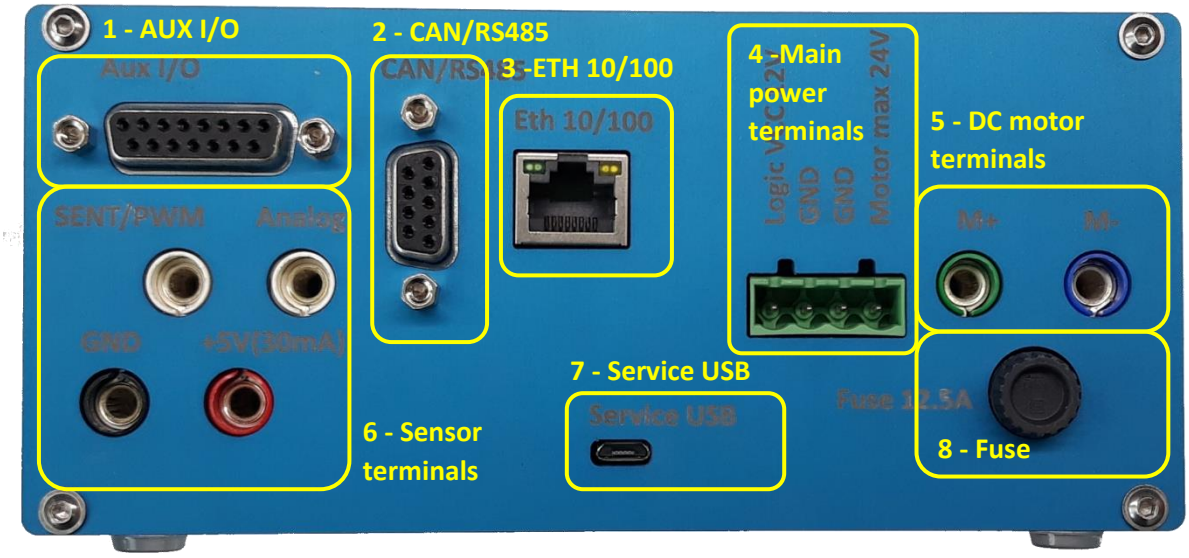
4 - Potentiometer knob

Potentiometer knob is main control for manual position or PWM adjustment in open lop mode (in open loop the zero PWM is logically in the middle while min and max sign corresponds to -100% and +100% PWM). Position demand in closed loop mode corresponds to sensor feedback.

5 - Thermo couple interface

Thermocouple interface is set for standard K-type thermocouple. Measured temperature is displayed in text mode on display, can be send over Aux channel to PC and is used to scale PID settings with temperature to achieve better control. In Master/Slave mode is temperature broadcasted from master to all slaves, but in case of need may be connected sensor to slave as well, which takes priority before CAN temperature.

5.2. Rear panel



1 -AUX I/O

AUX I/O is D-SUB 15 connector for additional inputs and outputs.

PIN No.	Function	PIN No.	Function
1	Relay NO	9	Analog OUT
2	Relay NC	10	Analog IN
3	Relay COM	11	Digital IN Fast
4	Digital OUT_1	12	Quadrature I
5	Digital OUT_2	13	Quadrature B
6	Digital IN_1	14	Quadrature A
7	Digital IN_2	15	GND
8	+5V	Shell	GND

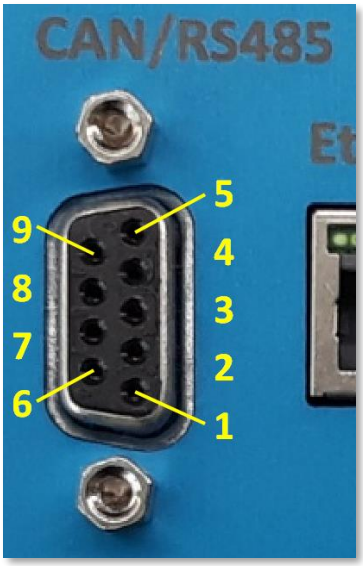
Note: Digital OUT_1 and 2 are open collector outputs capable to switch max 500mA.

Currently supported functions are:

- Relay output is switching when UAC is in operating state (can be used to control other test equipment with relation to actuation condition).
- Analog input can be assigned to one of Aux DAQ channels
- Quadrature encoder input can be assigned to one of AUX DAQ channels
- Digital input 1 can be used to stop controller by external signal. In case of master/slave operation is master sending stop command to all slave units as well. Log 1 is external stop, log 0 is continue. Input to be activated by +5V TTL logic (preferred to use +5V from UAC in connector pin 8)
- Digital outputs are used to control relays for calibration interface (connecting between calibration interface for sensor and UAC Analog or Digital input). Outputs are open collector with 500mA max current (load to be connected between +5V and output).

- Analog output contains sensor signal feedback (analog/SENT/PWM) in range equal to 0.5 to 2.5V (equal to 0-4095Bit or 0-5V or 0-100%)

2 -CAN/RS485



CAN/RS485 is D-SUB 9 connector for CAN bus and RS485 bus communication.

PIN No.	Function	PIN No.	Function
1	RS485B	6	CAN Low
2	120 Ohm RS485	7	120 Ohm CAN
3	120 Ohm RS485	8	120 Ohm CAN
4	RS485A	9	CAN High
5	SYNC	Shell	GND

Currently supported functions are:

- CAN communication is available in Master & Slave mode and allows one UAC in Master mode controls other UACs in slave mode. CAN bus signal is send every 1ms to trigger measurement and transfer operating mode and demand to slaves.

  Note: when UAC is in slave mode, the master UAC is triggering measurement of slave. If no signal is present – slave appears to be stacked as no timing is provided!

3 - ETH 10/100

ETH 10/100 is Ethernet connector used as main interface to communicate with PC. Default IP address is set to 192.168.100.20. Is expected to operate under the same subnet so netmask is set to **255.255.255.0** and no GW settings is needs.

4 - Main power terminals

Main power terminals consist from 12V power of UAC logic and separated Motor H-bridge power for DC motor with common ground. Logic voltage input of 12V (max 14V) has diode to prevent reverse polarity damage. Motor H-Bridge power (Min. 9V Max. 24V) is protected by fuse 12.5A and ground connected diode. In case of reverse polarity as minimum will be damaged protecting fuse!
Please take special care when connecting power to UAC!

This allows to use any voltage for DC motor control and as well current source for specific testing. Overloading of the power supply will also not case reset of the UAC. For simple operation may be powered from single power supply as well. In this case connect logic and motor power to single power supply 10-14V.

Reverse polarity connection may damage UAC!

5 - DC motor terminals

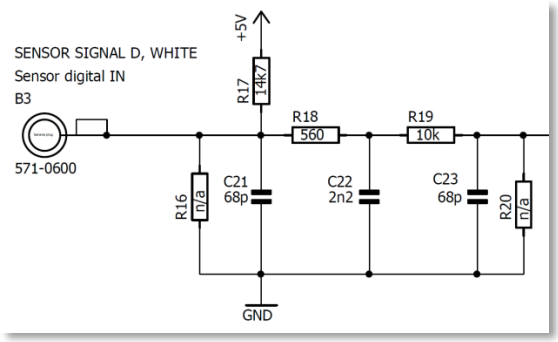
DC motor terminals are located on hi power side of the main board, on other side from sensor terminals. The logic of controller follows the sense of position feedback. Polarity is defined to movement direction when increasing PWM in positive direction is imposing movement of actuator in rising direction. In case of opposite connection must be reversed to follow sense of PID closed loop control.

6 - Sensor terminals

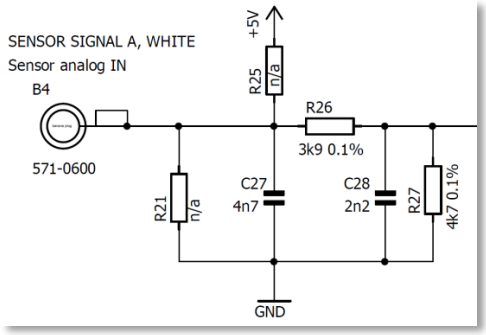
Sensor terminals are separated for voltage input and digital (SENT/PWM). Both requires different input load circuit. Specific values of components may be used upon agreement until are compatible with PCB layout. Sensor power voltage provides 5V limited to 30mA. Both can be measure and captured. Sensor power can be switched On/Off programmatically when needed.

Incorrect connection may lead to UAC damage!

Default load circuits:



Load circuit of SENT/PWM input



Load circuit of voltage input

7 - Service USB port

Service USB port is dedicated for firmware upgrade in UAC. Firmware flashing is available through UAC software.

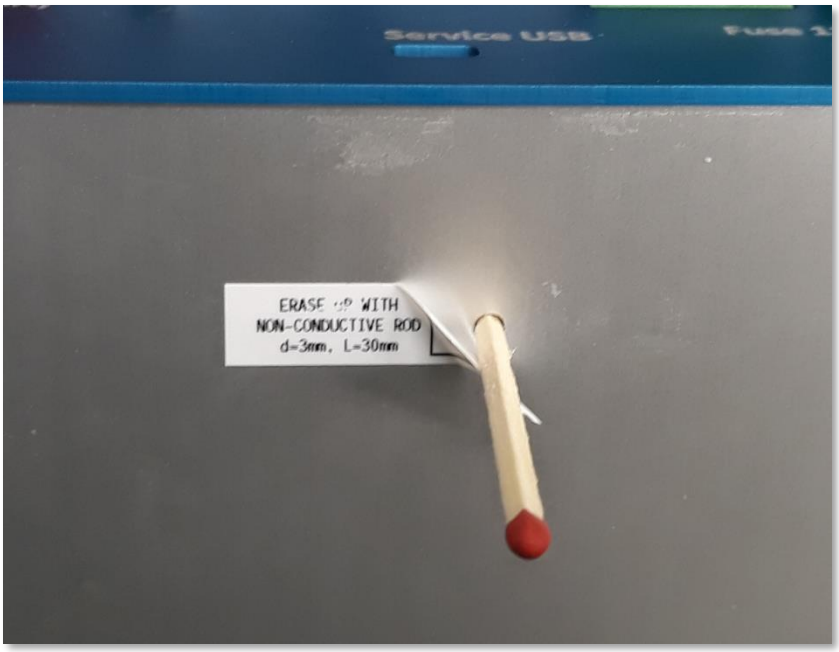
8 - Fuse

Fuse is protecting UAC Motor power from over current and also from reverse polarity. Use only compatible fuse for 12.A (medium time-lag) only.

5.3. Bottom panel

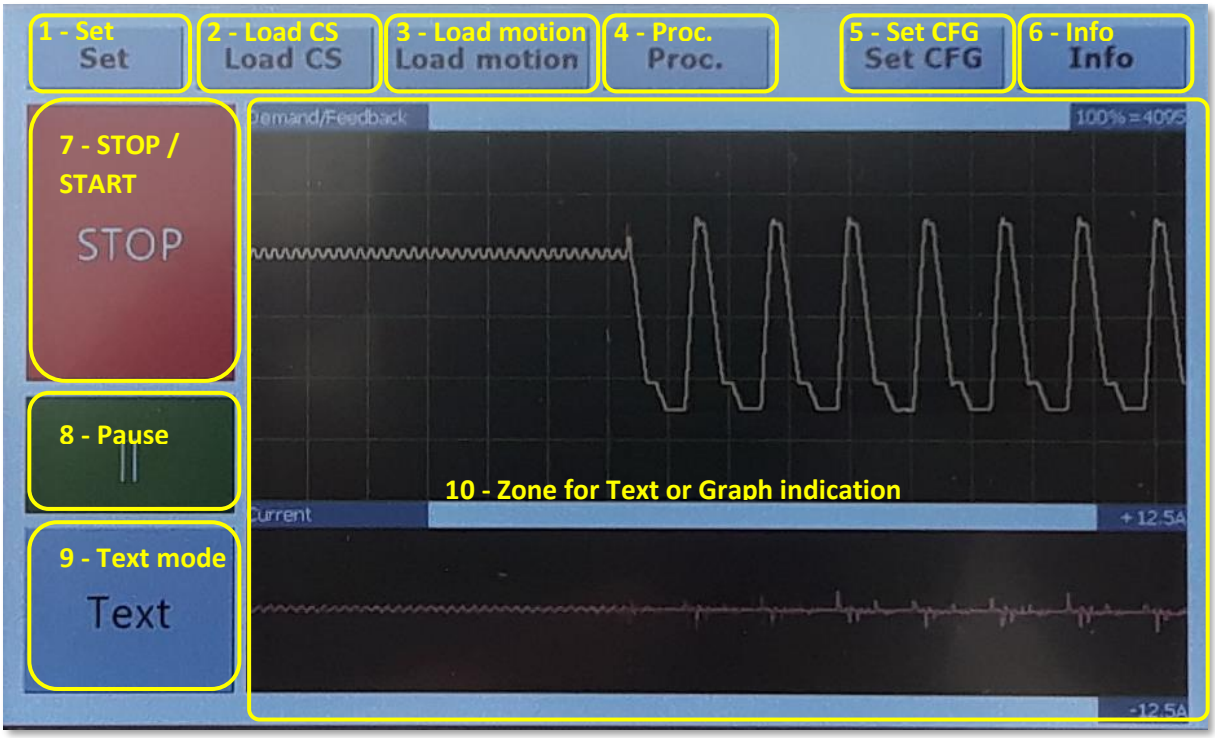
From bottom site is located sticker, which covers hole to access switch for memory erase.

In case of problems with SW flashing, can be un-sticked and pressed using some nonconductive stick (match stick for example).



6. UAC control

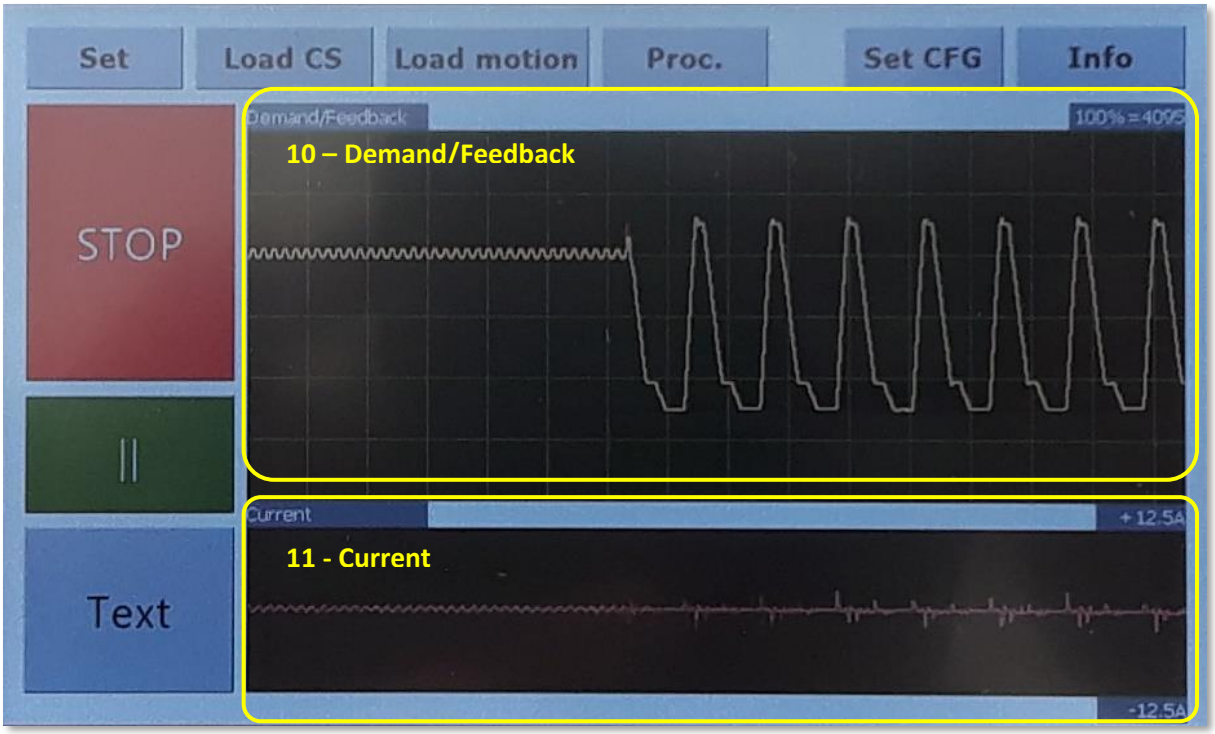
6.1. Main display layout



Zone for Text or Graph indication

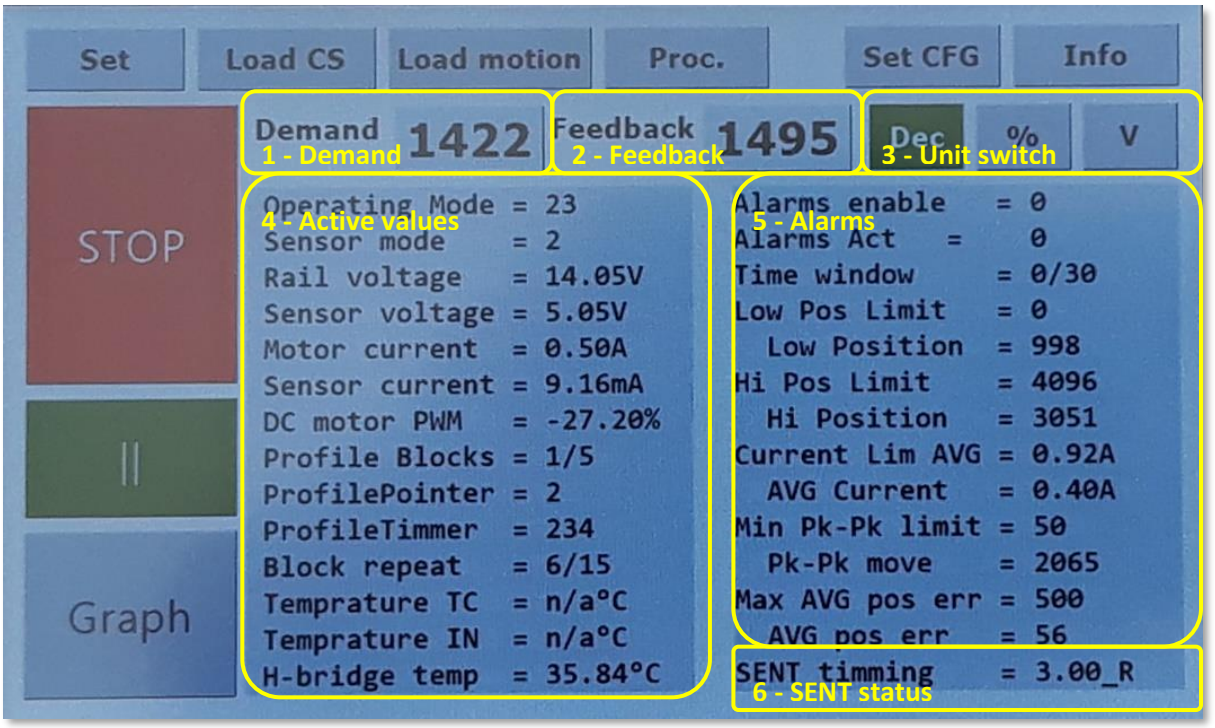
1. Set: Enter in to functional settings
2. Load CS: Load Controller Settings incl. PID settings, Limits & Alarms
3. Load motion: Load motion profile from SD card
4. Proc.: Standalone procedures (Extended functionality)
5. Set CFG: Main settings of UAC (IP address/SM mode/Bus ID and flashing mode)
6. Info: List of last events and active settings
7. START/STOP: main button to start or stop operating mode. New mode is applied always from STOP mode (for each change must be stopped and then started again to be applied)
8. Pause: Button applies pause to the automatic profiles, such a DS motion profile, sinus/square generator etc. Motion will be stopped at last demand position.
9. Text/Graph: Button to switch between charts and text values
10. Zone for Text or Graph indication

6.2. Graph view



1. Demand/Feedback: Graphics chart is showing live behavior of demand and feedback. Fix scale is between 0 to 4095. This is used also for 0-5V and 0-100%
2. Current: Current chart showing full range -12.5A to +12.5A (corresponding to full range of the current sensor).

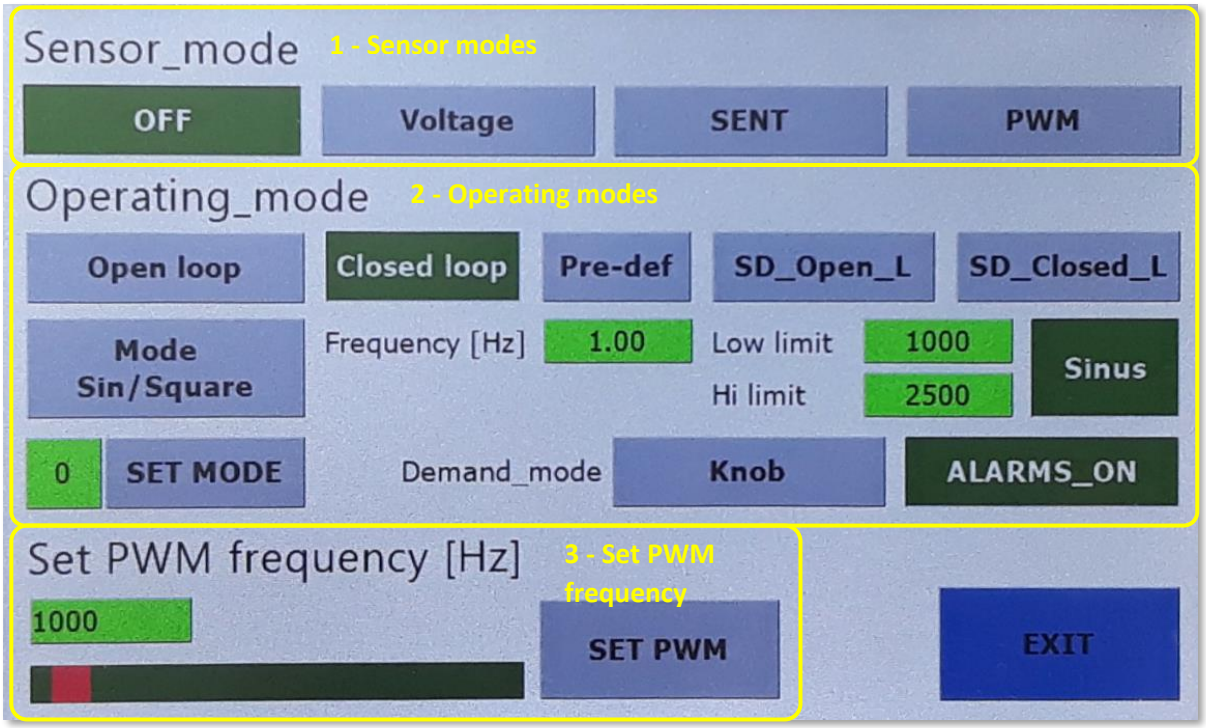
6.3. Text view



1. Demand: Demand value shown according to the unit selected in point 3
2. Feedback: Feedback value shown according to the unit selected in point 3

3. Unit switch: Allows change of units between Decimal / %of VCC and Volts. Default unit is selected according to selected sensor interface, but it can be changed by user.
4. Active values: Shows actual measurements.
    a. Operating mode: Active operating mode (see 6.4.2 for details)
    b. Sensor mode: Selected sensor interface (0=Off, 1=Voltage, 2=SENT, 3=PWM)
    c. Rail voltage: Actuator H-bridge input voltage
    d. Sensor voltage: Sensor supply voltage
    e. Motor current: DC motor current draw
    f. Sensor current: Sensor current draw
    g. DC motor PWM: Actual DC motor H-bridge PWM
    h. Profile blocks: Actual and total number of blocks of SD card motion profile
    i. Profile pointer: Actual segment of active block of SD card motion profile
    j. Profile trimmer: Actual timer value of active block of SD card motion profile
    k. Block repeat: actual and total number of block repetitions
    l. Temperature TC: Thermocouple temperature
    m. Thermocouple IN: Thermocouple cold junction temperature
    n. H-bridge temp: Temperature of H-bridge. Sensor controls internal fan and protects from overheating.
5. Alarm: Shows alarm settings and actual values. Alarms limits are defined in actuator CS (controller settings).
    a. Alarms enable: When alarms are enable = 1 off = 0
    b. Alarms Act: Alarm is active when is enabled and all buffers are loaded with valid data (as most of alarm parameters follows average values)
    c. Time window: actual time of buffer / length buffer (for averaging and min max calculations)
    d. Low position limit: Low position threshold to rise alarm
    e. Low position: Actual value of low position
    f. Hi position limit: Hi position threshold to rise alarm
    g. Hi position: Actual value of hi position
    h. Current limit AVG: Max value of average current
    i. Avg current: Actual value of average current
    j. Min Pk-Pk limit: Minimal actuator Pk-Pk movement definition over the alarm time window.
    k. Pk-Pk move: Actual actuator Pk-Pk movement
    l. Max AVG pos err: Maximum allowed position error demand vs. feedback average over the alarm time.
    m. AVG pos err: Actual value of average position error
6. SENT timing: Detected tick time of SENT (in us) and detected type of SENTCRC (L=Legacy, R=Recommended)

6.4. Set page



6.4.1. Sensor modes

a. **OFF (sensor power is OFF)**
b. **Voltage (power ON &analog voltage feedback 0-5V)**
c. **SENT (power ON & SENT feedback)**
d. **PWM (power ON & PWM feedback)**

6.4.2. Operating mode

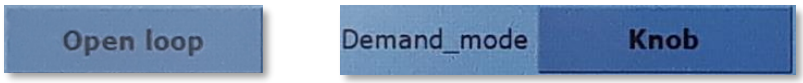
UAC supports multiple operating modes which defines state and behavior of UAC.
All open loop modes and all closed loop modes requires to be enabled valid sensor signal connection to meet limits set in CS profile (must be reached sensor current draw within limit, in case of analog voltage must be within limit or digital signal must be present). This is helping to avoid miss-connection of the cable harness as incorrect connection may lead to UAC damage!
Incorrect connection may lead to UAC damage!

Mode	Description	
0	Disabled (OFF)	
10	Manual Open Loop Knob	Open loop mode
11	Ext Input Open Loop	
12	Ext CAN demand Open Loop	
13	SD card demand Open Loop	
14	LAN demand Open Loop	
20	Manual Closed Loop Knob	Closed loop modes
21	Ext Input Closed Loop	
22	Ext CAN demand Closed Loop	
23	SD card demand Closed Loop	
24	Pre-defined 1	
25	Pre-defined 2	
26	Pre-defined mode_3 - Sin & Square	

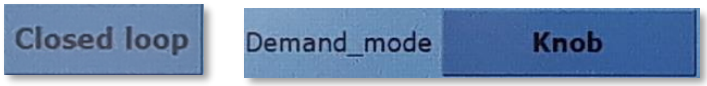
27	LAN demand Closed Loop	
48	Error supply voltage LOW (under 7V)	Error modes
49	Error CAN master signal missing	
50	Error_H-bridge over temp (in case is over 80°C)	
51	Error_sensor_ICC	
52	Error_sensor_value	
53	Error_sensor_SENT/PWM	
54	Error_TC disconnected	
55	Error alarm under position	
56	Error alarm over position	
57	Error AVG current over limit	
58	Error alarm Min Pk-Pk not reached	
59	Error alarm Position error over limit	
60	Error_ExtCAN	
63	Waiting for UAC/Display Flash	

The most common modes settings are coded under buttons in the settings.

e. **Open loop** defines mode 10 (in case the demand mode is set to Knob) or mode 11 (in case the demand mode is set to Ext IN). PWM limitation in selected CS profile from SD card is NOT active in open loop mode! This is valid in general for all open loop modes.

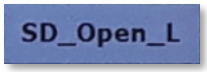


f. **Closed loop** mode 20 (in case the demand mode is set to Knob) or mode 21 (in case the demand mode is set to Ext IN). Closed loop control follows the selected CS profile from SD card. This is valid in general for all closed loop modes.



g. **Pre-def** is basic actuation profile for test activating mode 24.

h. **SD_Open_L** is activating mode 13. SD_Open_L using selected profile from SD card to define actuation cycle PWM. For this mode please select requested motion profile under "Load motion". Actuation profile must be generated for Open loop as is defining directly PWM demand.



i. **SD_Closed_L**is activating mode 23. SD_Closed_L using selected profile from SD card to define actuation profile based on position. For this mode please select requested motion profile under "Load motion". Actuation profile must be generated for Closed Loop as is defining position in closed loop.

j. **Mode Sin / Square** is open definition of periodic movement.

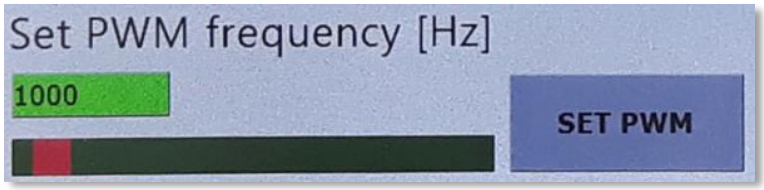
There is option to set frequency of the actuation cycle, low limit and high limit defines Pk-Pk movement and Sinus / Square switch selecting weather is needed sinusoidal movement or step response. Parameters can be changed on the fly.

k. **SET MODE** can set any of modes described in table above.

l. **ALARMS_ON/OFF** activates and deactivates alarm setting defend in selected CS profile. According the user needs can be activated or deactivated.

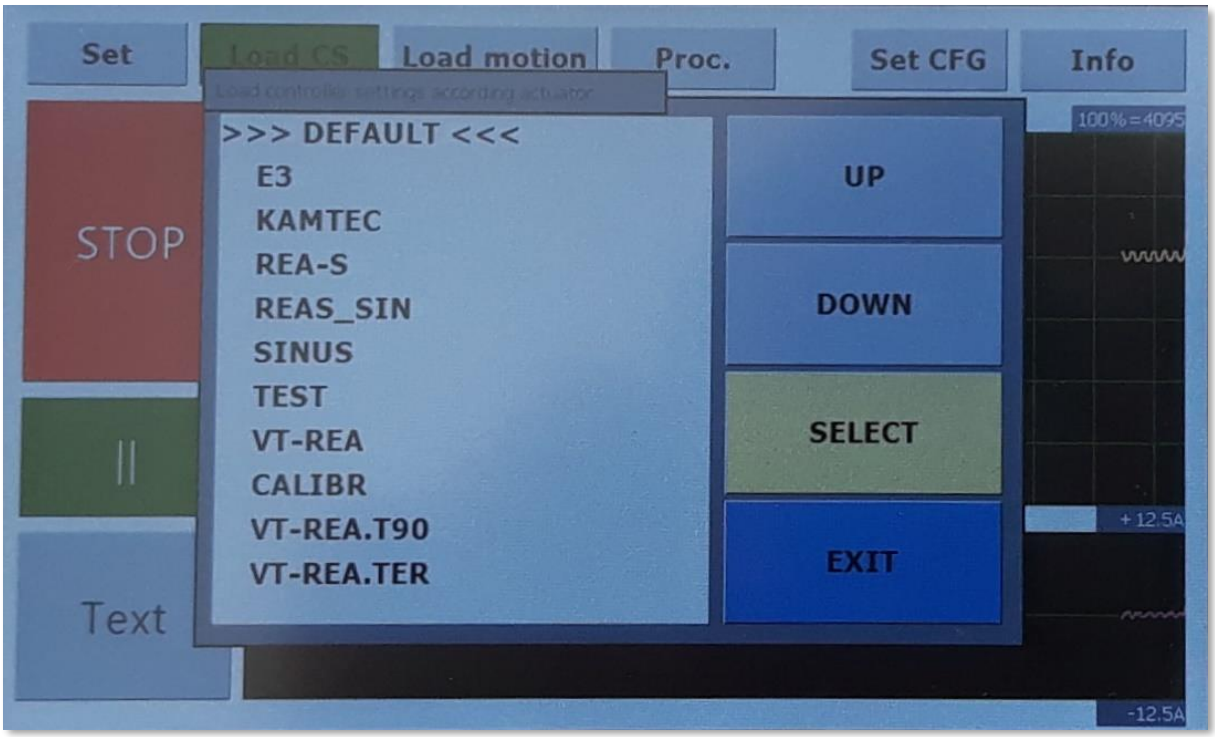
6.4.3. Set PWM frequency

Defines the DC motor PWM frequency. Maximum allowed is 20kHz, but optimum is 1-2kHz. H bridge switching time delay is constant, so the effect is lower with lower frequencies.



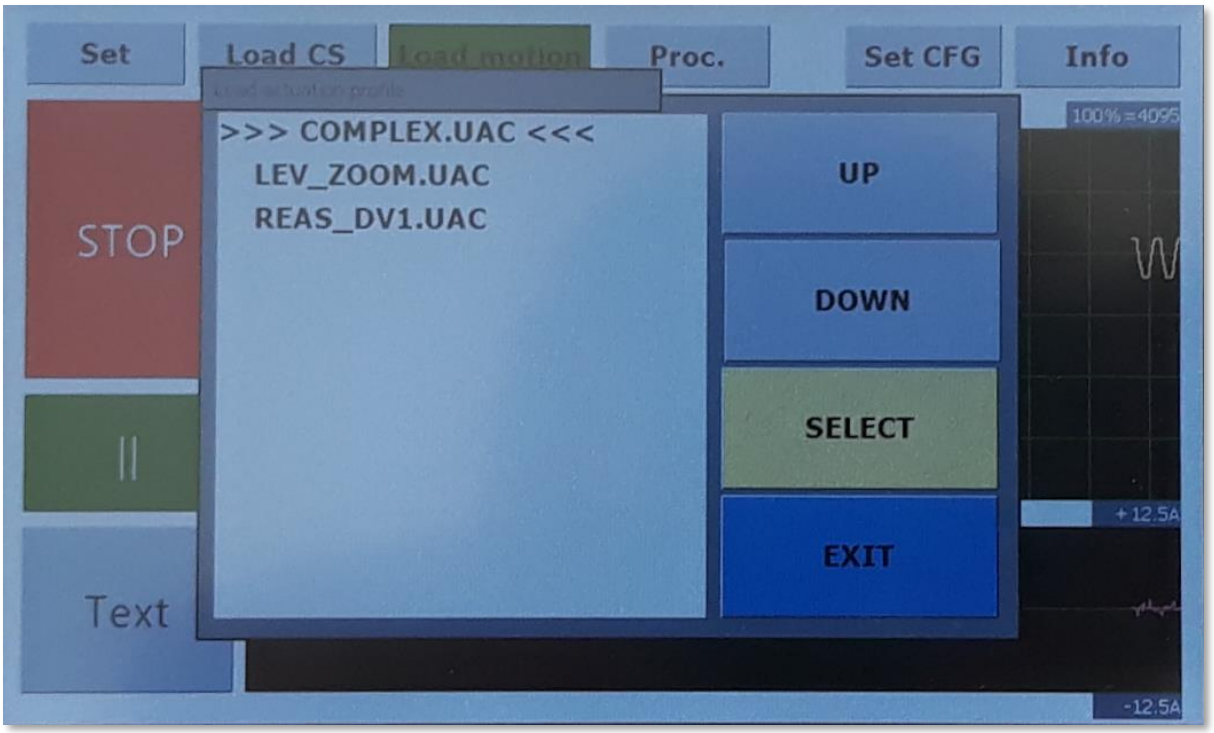
Applicable range is 100Hz - 20kHz. UAC is designed for 1kHz nominal as switching time is fixed to nominal value 6.5us (error approx. 0.65% @ 1kHz). With higher frequency is timing impacted more as the switching time delay is constant!

6.5. Load CS (Controller Settings)



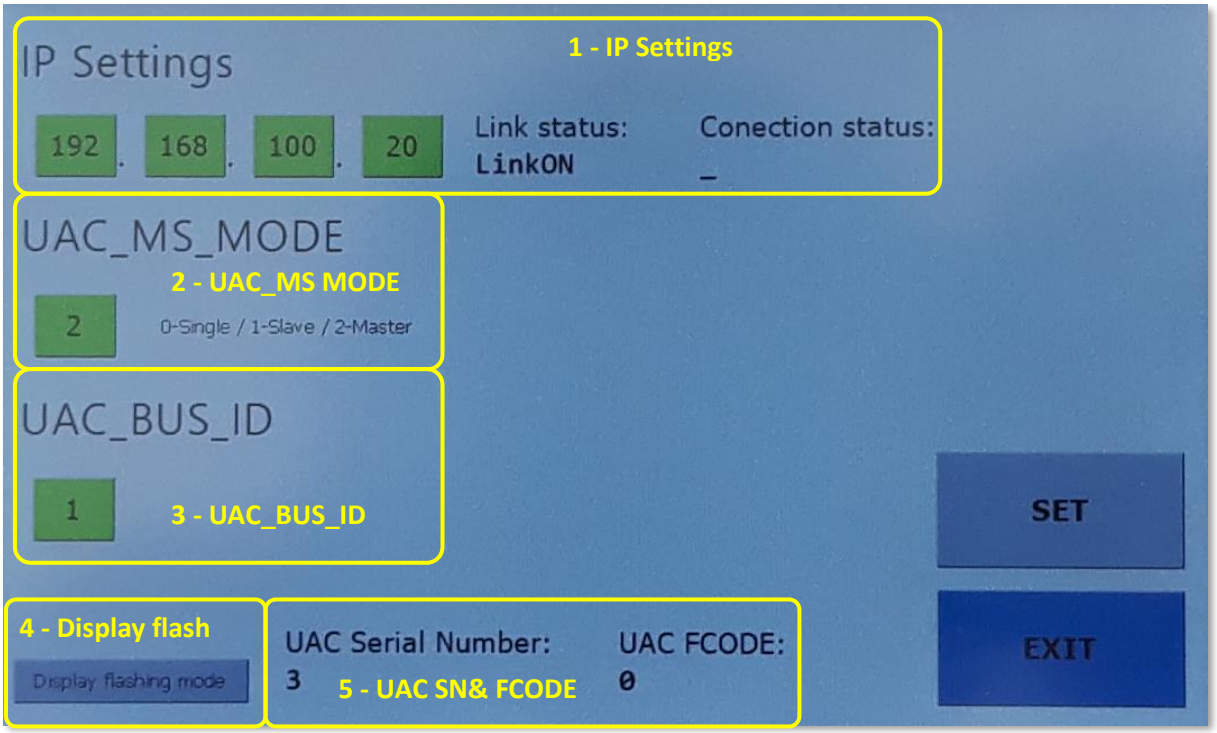
To select requested CS profile, use UP & DOWN keys to navigate file selector to the requested file name. Click to SELECT button will load profile to UAC. EXIT is used in case to just exit the page.

6.6. Load motion



To select requested motion profile, use UP & DOWN keys to navigate file selector to the requested file name. Click to SELECT button will load profile to UAC. EXIT is used in case to just exit the page.

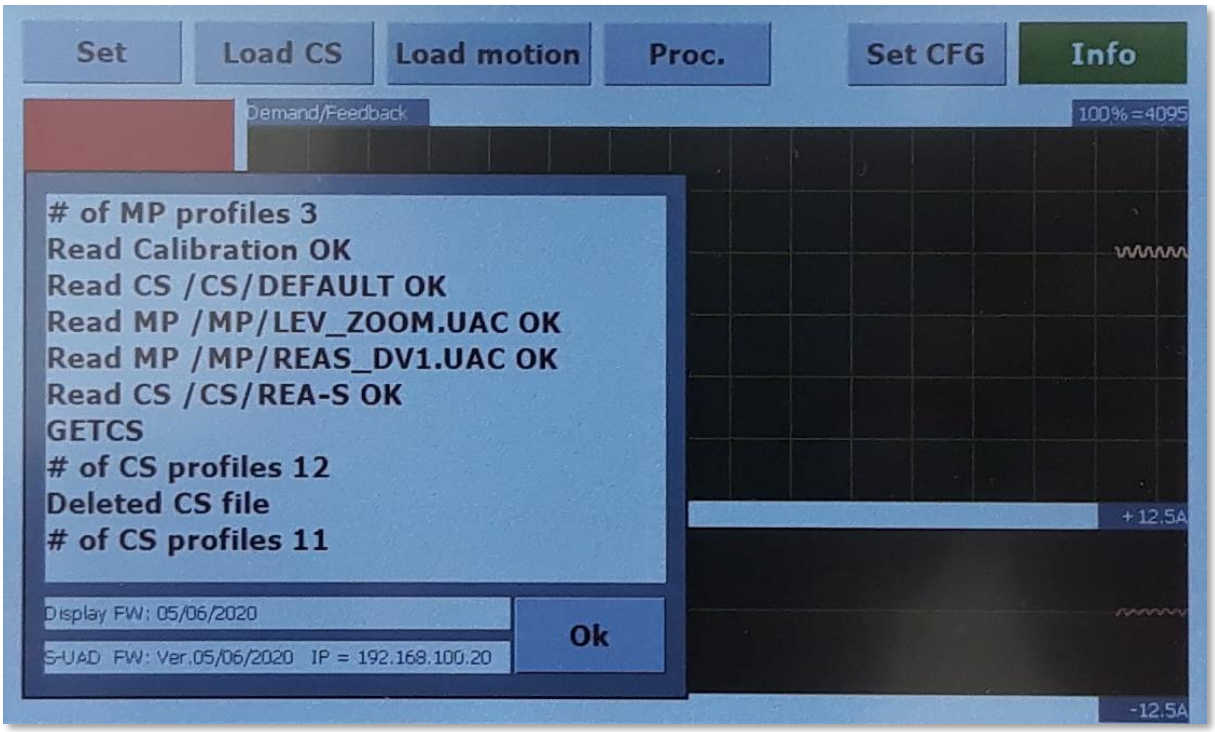
6.7. Set CFG



1. IP settings
   IP address to be set according the network requirements
   Mask is hard coded to be 255.255.255.0
   GW and DNS are not used. UAC can operate in local network only
2. UAC _MS_Mode
   Defines operating as Single/Slave or Master
   0=single 1=slave 2=master
   For master & slave operation is necessary to connect other UAC via CAN bus. In this configuration is Master controlling all slaves connected to the CAN bus.
3. UAC_BUS_ID
   Defines ID on bus (channel number - for identification of channel in case of error is shown)
4. Display flash
   To enter display flashing mode, press this button. This mode is preferred for flashing in general also to flash UAC firmware itself.
5. UAC SN & FCODE
   Indication of UAC serial number and function code

Pressing the SET button will save settings in UAC and perform soft restart of UAC.

6.8. Info



This page indicates last 10 events and versions of the firmware and active IP address.

6.9. CAN_Smart Mode

Additional mode of UAC is CAN_Smart mode. In this mode UAC acts as smart actuator driven over CAN bus. This functionality was implemented to allow function like "Smart actuator", but using simple actuator with UAC. The functions and communication protocol can be adjusted based on customer request.

Position control and feedback in range 0-1000 (2bytes Intel little endian).

Activation of this mode:
Set UAC_MS_MODE to value 11 (this enables this mode)

CAN settings

- CAN2.0 @ 500kbit
- Control over CAN in demand/feedback range 0-1000 equivalent to CS settings Controller_min_range to Controller_max_range.
- Demand frame ID 0xA1
    - demand byte 0&1 (0-1000, Intel little endian)
- Feedback frame ID 0xA2
    - Byte 0&1 Position (0-1000, Intel little endian),
    - Byte 3&4 Current (0.001A/bit, Intel little endian)
    - Byte 6 Errors
        - bit 7 Sensor error (error range/ current ERR51+52+53)
        - bit 4 Control failure (ERR55+56+57+58+59)
        - bit 2 Temperature error (overheated UAC ERR50)
        - bit 0 Power supply error (voltage under 7V ERR48)
    - Byte 7 Actuator status
        - 1 in case of correct CAN close loop mode / ==0 other states

Functionality:

- After power ON activated analog sensor settings and loaded CS " CAN_VOLT" automatically.
- Then is controller set to wait for CAN demand.
- First demand frame will activate closed loop control.
- When CAN demand is not present actuator will keep last valid CAN demand position

7. UAC PC utilities

PC software for UAC is based on LabVIEW version 2011. The installation of appropriate runtime is required.

For UAC are currently available 2 tools:

- **UAC control SW single UAC** allows connection with controller, settings of the actuator profiles (PID, limits, alarms etc.), generation of actuation profiles for standalone operation without PC, measurements, recording, response time analyses, sensor calibration test and UAC firmware upgrade. Records are saved in to the .tdms file format.
- **UAC multi-channel recorder** for data recording from up to 6 UACs with selectable channels to record and record viewer. Records are saved in to the .tdms file format.

National Instruments tdms format can be simple read by Excel add-on, which is available for download at NI page.

7.1. SW versions

Available SW version is 1-x-x and 2-x-x. Version 2-x-x is not back compatible with 1-x-x, as contains new functions and settings not present in version 1-x-x.

Note:
Before upgrade to version 2-x-x is necessary to backup Controller Settings, by creating screen shots as in the new version must be created again. Then is needed to delete all Controller Settings including default one. Then can be upgraded UAC core firmware and display to version 2-x-x.
Using new version of UAC single channel utility create again requested profiles, mainly profile "default" which is loaded at start of UAC.

7.2. Minimum PC requirements

Processor: Intel core i5 or higher

RAM: 8 GB Minimum

OS: Windows 7 or Windows 10

Screen resolution: Full HD (1920x1080)

7.3. SW install and network settings

Latest SW is available to download at www.Lab-Tools.cz.

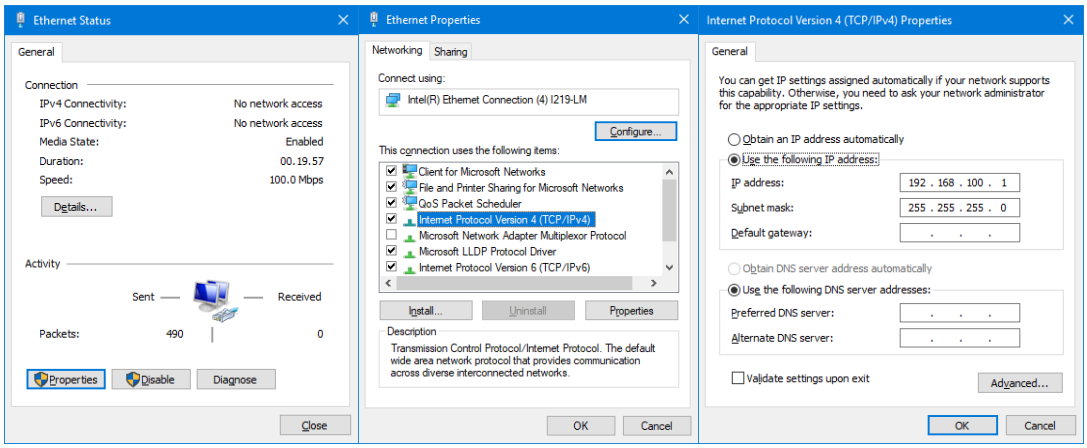
To run these SWs is necessary to install LabVIEW runtime. Then is possible only unzip SW in to requested destination directory and should be fully functional.

On UAC side is necessary for function SD card with settings.

By default, SD card contains 3 folders:

- CFG – Configuration files for UAC to set IP settings, calibration and CAN communication.
- CS – Controller settings files contains Alarms, PWM limitation, PIDs and soft-landing setting.
- MP – Motion profile files contain user defined motion profiles.

For proper communication with UAC is necessary to manually set static network IP address in your computer. Go to your Ethernet connection settings of the Ethernet interface intended for UAC connection, select properties then select IPv4 protocol and click on properties – Set IP address from the same range as UAC but different (the last of 4 group numbers to be different from UAC) and subnet mask to be always 255.255.255.0.



UAC uses fix mask 255.255.255.0 - means all IP addresses must have same first 3 group of numbers.

IP address of PC must be different from UACs IP addresses!

Example:

PC - IP address = 192.168.100.254

UAC_1 IP address = 192.168.100.001

UAC_2 IP address = 192.168.100.002

UAC_3 IP address = 192.168.100.003

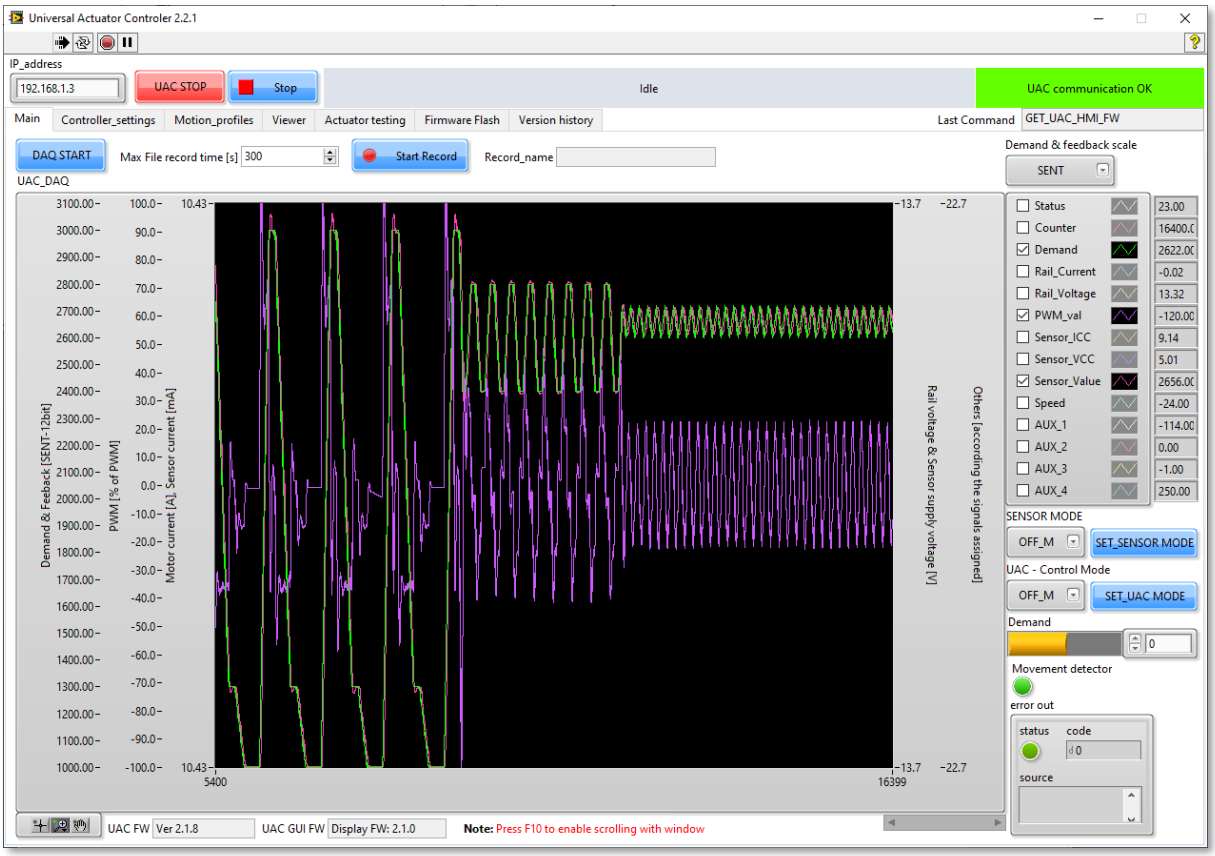
...

Rule is: the first 3 numbers must be same and last numbers must be unique (1-254).

In the same network cannot be 2 same addresses!

If you are not sure about the settings, please ask your IT department for support!

7.4. Universal Actuator Controller SW

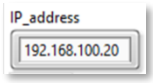


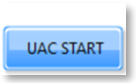
UAC measurement channels can provide data from 14channels.

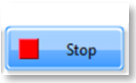
Parameter	Description	Unit
Status	Operating status of UAC	1[bit]
Counter	DAQ counter (1kHz)	1[bit]
Demand	Demand and sensor feedback are always defined as 12bit value. By demand & feedback scale is shown in scale according to actuator - right after connection but can be changed on the fly.	1[bit] [V] [PWM]
Rail_Current	H-bridge motor power current	1[A]
Rail_Voltage	H-bridge motor power voltage	1[V]
PWM_val	H-bridge motor PWM	1[%]
Sensor_ICC	Sensor power supply current	1[mA]
Sensor_VCC	Sensor power supply voltage	1[V]
Sensor_Value	Sensor feedback 12b 0-4095	1[bit]
Speed	Movement speed	0.1[bit/sec]
AUX_1	Programmable auxiliary channel 1. Data according to the controller settings	According channel
AUX_2	Programmable auxiliary channel 2. Data according to the controller settings	According channel
AUX_3	Programmable auxiliary channel 3. Data according to the controller settings	According channel
AUX_4	Programmable auxiliary channel 4. Data according to the controller settings	According channel

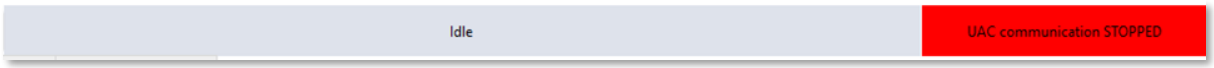
Each channel can be activated or deactivated using standard LabVIEW chart controls.

7.4.1. SW controls

<table>
<tr>
<td> 

Setting of UAC IP address</td>
<td> 

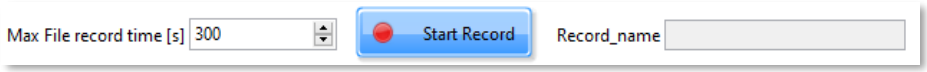
UAC connect / disconnect</td>
<td> 

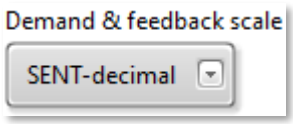
STOP SW</td>
</tr>
<tr>
<td colspan="3"> 

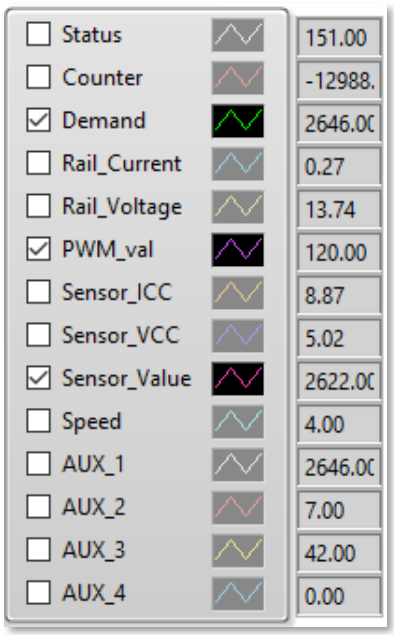
Status indicator - indication of action in progress and UAC communication</td>
</tr>
</table>

7.4.2. Page - Main

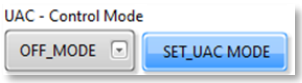
<table>
<tr>
<td> 

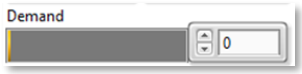
START/STOP live view in chart</td>
<td colspan="2"> 

Recording control - record files will be spitted according the record time in separate files. Reasonable maximum is 300s (5min)</td>
</tr>
<tr>
<td> 

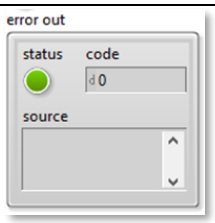
Selector of scale for demand and actuator feedback signal (SENT/Voltage/PWM)</td>
<td> 

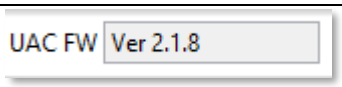
Live channels plots 14x</td>
<td> 

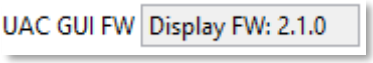
Remote settings of sensor mode


Remote settings of UAC mode
Every mode must be canceled by OFF mode before entering another one!


Remote demand control (open & closed loop)</td>
</tr>
<tr>
<td> 

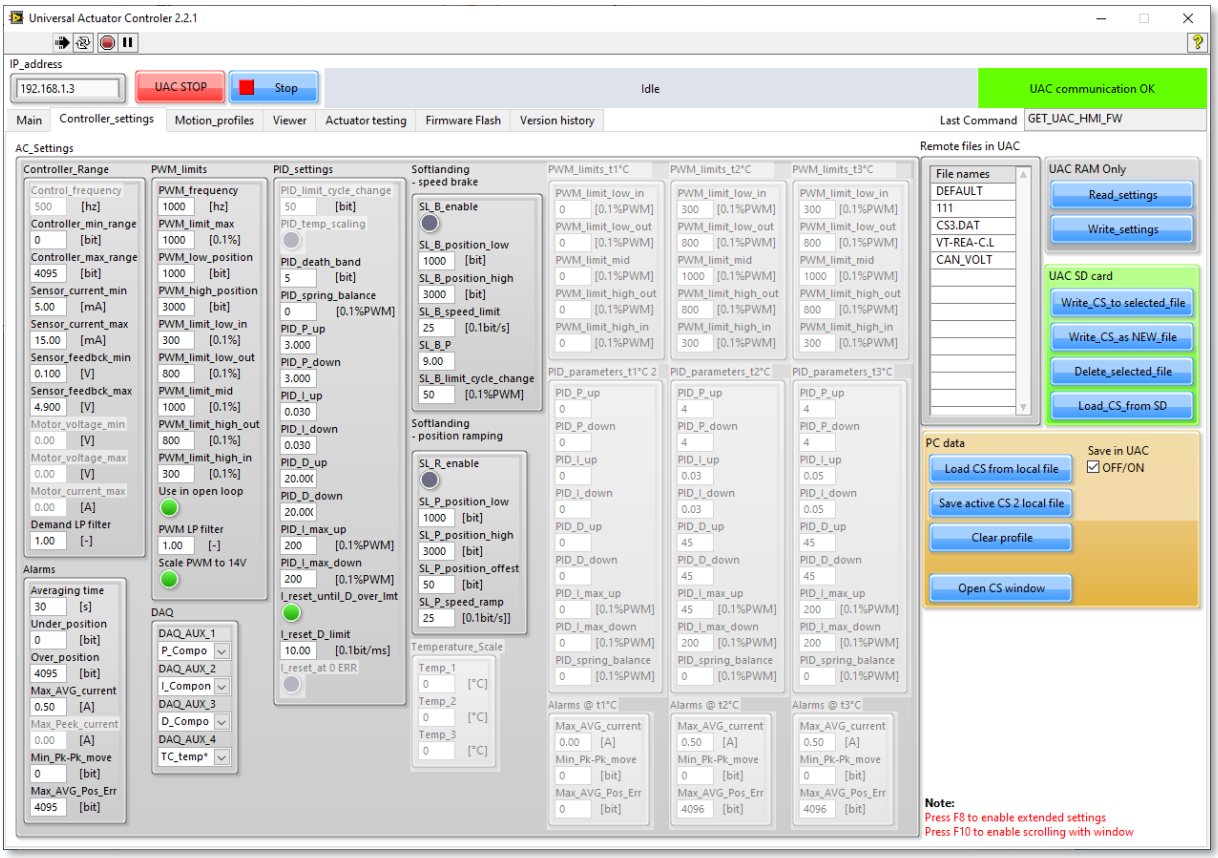
Indicates movement of the actuator</td>
<td> 

Error indication</td>
<td> 



SW versions of UAC Core & GUI</td>
</tr>
</table>

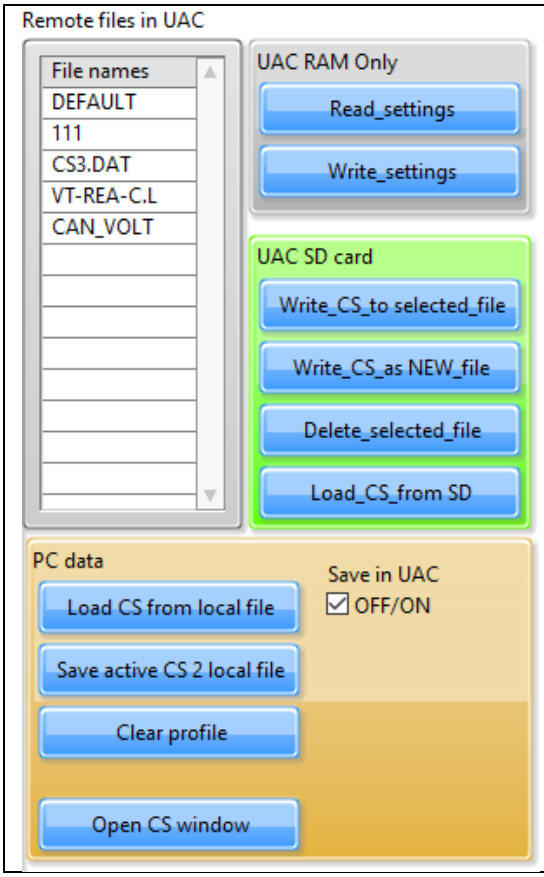
7.4.3. Page - Controller Settings



Page controller settings contains functions to read and write CS files for each application. The settings is modified directly in UAC memory to take imediate effect. CS can be saved in UAC internal SD card and used as needed.

CS consists from multiple blocks of parameters and extra settings temperature scaling with 3 diferent temperature settings. 3 temperatures are needed due to usualy nonlinear behaviour of geared DC actuators.
Usually lowest effort is needed at room temperature, but at low temp is needed to compensate increased friction and at high temerature is needed to compensate significant increase of motor resistance.

To control settings (loading, changing, deleting ...) is described in following table:



CS profiles in UAC SD card and appropriate functions for manipulation.

The controls are divided in to 3 areas according the data location. UAC RAM, UAC SD card and PC data.

First the profiles are written to RAM only as active settings of UAC, then when behavior is as expected we can save this active profile to UAC SD card for future usage.

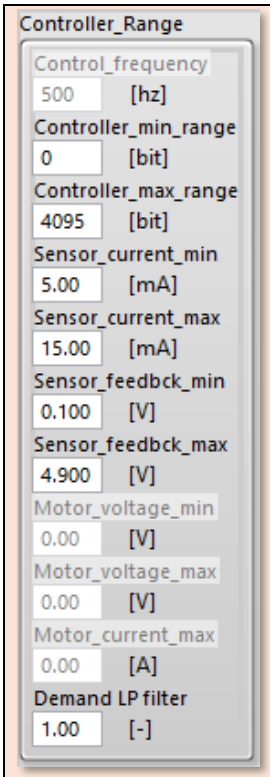
According the buttons we can also load profile from SD card, import settings from file in PC and many others.

- Read settings
  - Function to reload active settings in UAC (all parameters) and update list of files on SD card
- Write settings
  - Function to send parameters in to UAC memory
- Write CS to selected file
  - Function to save CS on SD card to selected file (re-write)
- Write CS as NEW file
  - Function to save CS on SD card as a new file
- Delete selected file
  - Function to delete files on SD card
- SET CS from SD
  - Function to load settings from file on SD card. Same function is double click on file in list box
- Load CS from local file
  - Function to load local file settings to UAC. With selected "Save in UAC" the file will be saved on SD card as well.
- Save active CS 2 local file
  - Active CS in UAC memory is saved as file locally in PC
- Clear profile
  - Function to clear parameter definition to start from clean file.
- Open CS window

Function to open independent window for CS settings. This is especially handy for PID tuning when secondary screen is available.

7.4.3.1. Controller range

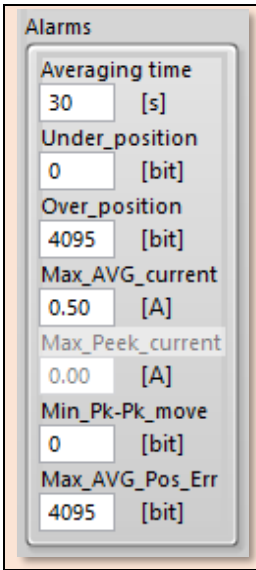
Controller_Range defines min and max close loop movement limits for control (in case the limitation is needed). Then sensor current draw range for detection of correct operation and min and max range for definition of valid voltage signal. This are important limits to identify correctness of sensor connection before motor activation. These functions may save UAC from damage due to miss-wiring. Additional is Demand LP filter which is smoothing demand changes (0-1range). The effect can be seen in PID_setPoint parameter available within AUX channels. Controller_min_range and Controller_max_range are parameters used also for control range definition in smart mode with CAN control. Then this range us equal to 0 to 1000bits.



Parameter	Description	Unit
Controller_min_range	Demand clamping to limit min range (and range for CAN smart mode)	1[bit]
Controller_max_range	Demand clamping to limit max range (and range for CAN smart mode)	1[bit]
Sensor_current_min	Sensor check min current range	[mA]
Sensor_current_max	Sensor check max current range	[mA]
Sensor_voltage_min	Sensor check min voltage range	[V]
Sensor_voltage_max	Sensor check max voltage range	[V]
Demand LP filter	Low Pass filter of demand signal. Can be used to smooth movement. Filter parameter to be in range over 0 to 1. Effect of the filter can be seen as PID set point change (available in AUX channels) $PID_{set\ point}$ = Demand*LP_filter + $PID_{set\_point-1}$*(1-LP_filter)	[-]

7.4.3.2. Alarms

Alarms defines run check of the actuator behavior in order to avoid damage by overheating or identify broken component in case of over or under movement. Detection of blocked actuator if minimum movement is not achieved or average position error over limit.

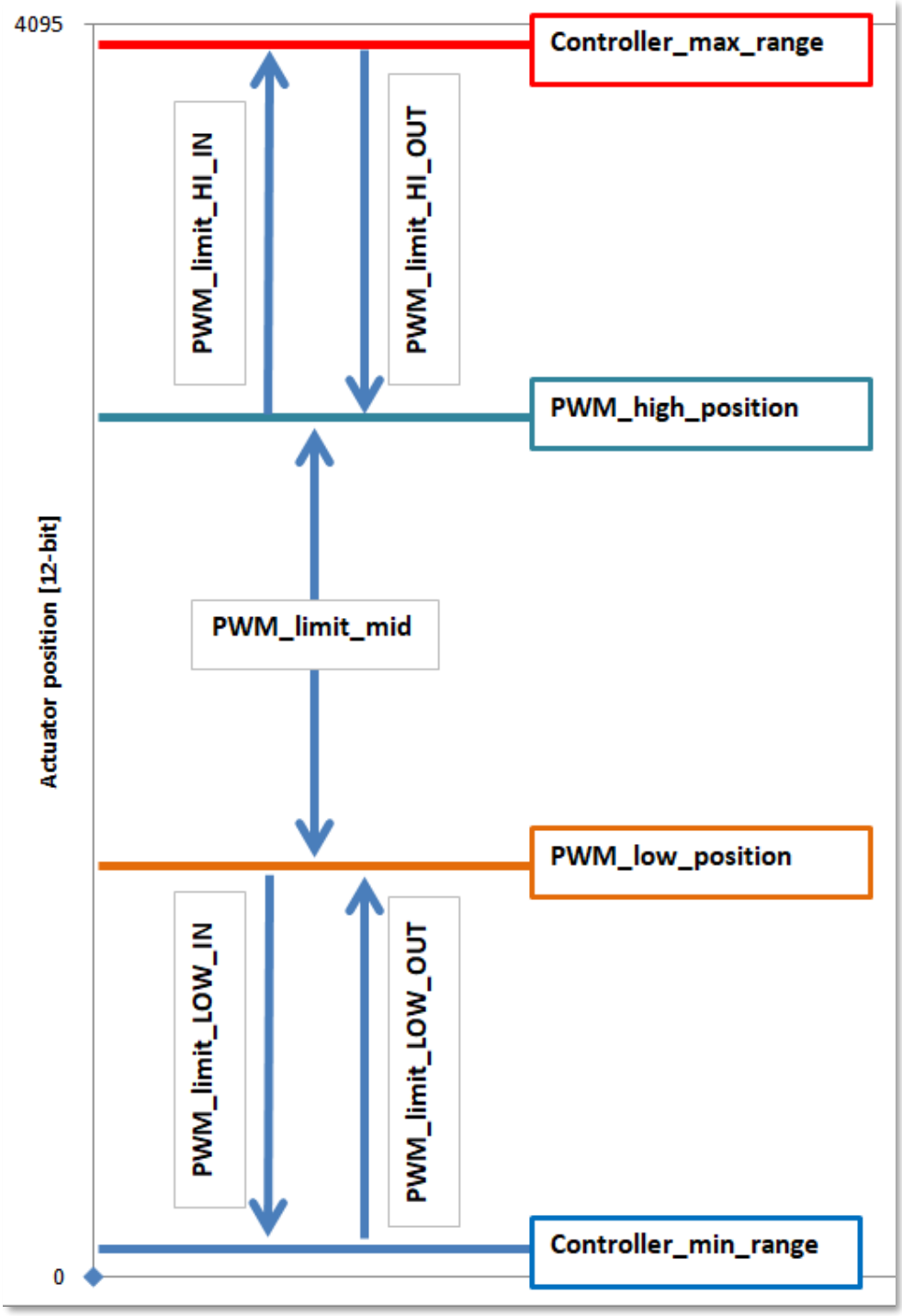


Parameter	Description	Unit
Averaging time	Alarm floating time window	1[sec]
Under position	Low threshold limit to rise alarm	1[bit]
Over_position	High threshold limit to rise alarm	1[bit]
Max_AVG_current	Max AVG current limit over the averaging time	[A]
Min_Pk-Pk_move	Min_Pk-Pk movement detected over the averaging time	1[bit]
Max_AVG_POS_ERR	Max allowed position error over the averaging time	1[bit]

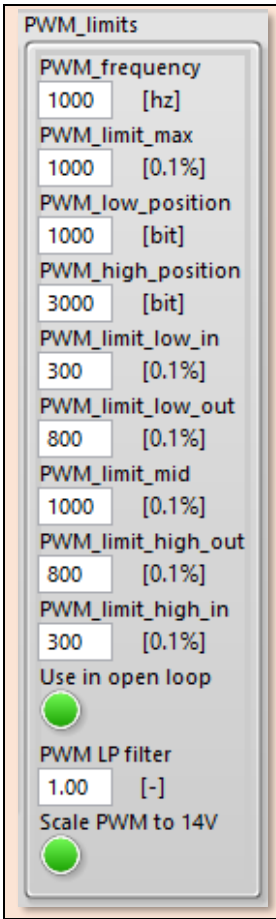
7.4.3.3. PWM limits

PWM_limits define overall limitation as well as 3 zones (Low/Mid/Hi) to restrict motor PWM and also PWM direction limitation in entering these zones. Also contain switch to enable limits under open loop mode, scaling of PWM with voltage (may be important for repeatability of control with PWM < 100%). PWM_LP_filter can smooth PWM demand changes but introduces time delay which may cause oscillation or instability of control (0-1range).

PWM limitation



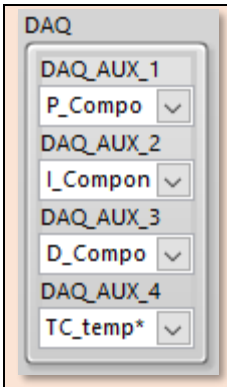
PWM limits are always valid for closed loops modes and may be activated for open loop modes as well.



Parameter	Description	Unit
PWM_frequency	PWM modulation frequency (1000 optimum max 20k)	1[Hz]
PWM_limit_max	Overall PWM limit for all zones	0.1[%PWM/bit]
PWM_low_position	Threshold position (sensor feedback) defining low zone	0.1[%PWM/bit]
PWM_high_position	Threshold position (sensor feedback) defining hi zone	0.1[%PWM/bit]
PWM_ limit_low_in	PWM limit in low zone in descending direction	0.1[%PWM/bit]
PWM_ limit_low_out	PWM limit in low zone in ascending direction	0.1[%PWM/bit]
PWM_limit_mid	PWM limit in mid zone	0.1[%PWM/bit]
PWM_limit_high_out	PWM limit in hi zone in descending direction	0.1[%PWM/bit]
PWM_limit_high_in	PWM limit in hi zone in ascending direction	0.1[%PWM/bit]
Use in open loop	Activates limits also in open loop mode	[-]
LPW LP filter	Low pas filter for PWM change smoothening 0-1	[-]
Scale PWM to 14V	Function for scaling of PWM according actual power voltage to 14V	[-]

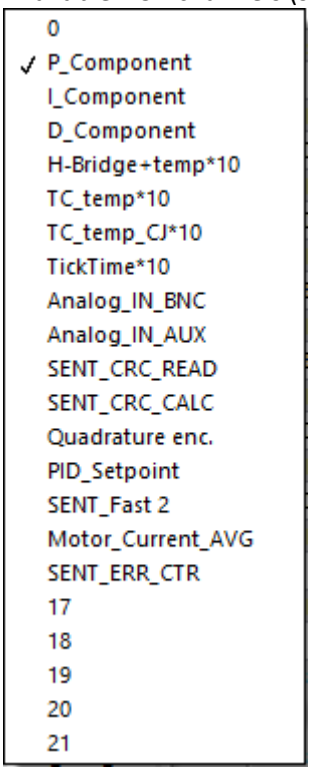
7.4.3.4. DAQ – (AUX channels)

DAQ defines inputs on 4 auxiliary channels to capture required variables according to user requirements.



Parameter	Description	Unit
DAQ_AUX_1	Definition of what data to be shown on the channel	n/a
DAQ_AUX_2	Definition of what data to be shown on the channel	n/a
DAQ_AUX_3	Definition of what data to be shown on the channel	n/a
DAQ_AUX_4	Definition of what data to be shown on the channel	n/a

Available AUX channels (selection menu)

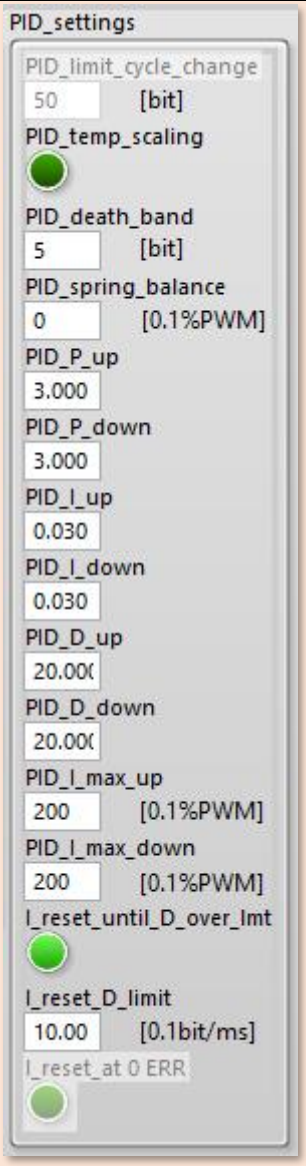


AUX channels definitions

Channel data	Description	Unit
P_Component	Actual value of P component of the PID regulator	0.1[%PWM]
P_Component	Actual value of I component of the PID regulator	0.1[%PWM]
D_Component	Actual value of D component of the PID regulator	0.1[%PWM]
H-Bridge temp*10	H bridge temperature x10	0.1[°C/bit]
TC_temp*10	Thermocouple temperature x10	0.1[°C/bit]
TC_temp_CJ*10	Thermocouple cold junction temperature x10	0.1[°C/bit]
TickTime*10	SENT actual signal tick time	0.00238095[bit/us]
Analog_IN_BNC	Analog input voltage of BNC input	0.001221[V/bit]
Analog_IN_AUX	Analog input voltage of AUX input (D-sub)	0.001221[V/bit]
SENT_CRC_READ	SENT message CRC read	1[bit]
SENT_CRC_CALC	SENT message CRC calculated	1[bit]
Quadrature enc.	Quadrature encoder value	1[bit]
PID_Setpoint	Real demand for PID (incl. soft-landing)	1[bit]
SENT_Fast 2	Send fast channel 2	1[bit]
Motor_current_AVG	Average value of current using alarm settings	0,006105[A/bit]
SENT_ERR_CTR	SENT error counter	1[bit]

7.4.3.5. PID settings

PID_settings define bi directional parameters for all parameters and anti-windup functions and temperature scaling control. Temperature scaling functions are available only when settings is enabled, or by activation hitting F8 key, it will activate parameters with definitions for each temperature as well.

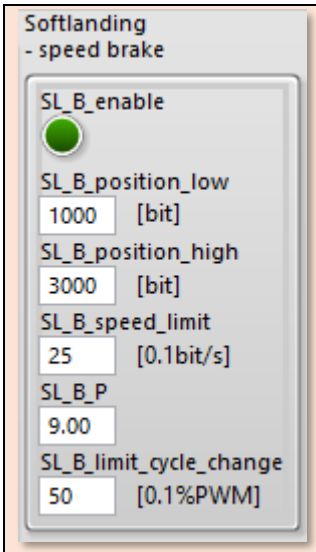


Parameter	Description		Unit
PID_limit_cycle_chnge	Deactivated		n/a
PID_temp_scaling	Deactivated		0/1
PID_death_band	Death band definition to avoid oscillation of actuator without spring when it should keep position. In case of smooth actuation without stops don't use		1[bit]
PID_spring_balance	PWM offset to compensate spring load		0.1[%/bit]
PID_P_up	Proportional parameter of regulator for ascending direction of movement		
PID_P_down	Proportional parameter of regulator for descending direction of movement		
PID_I_up	Integration parameter of regulator for ascending direction of movement		
PID_I_down	Integration parameter of regulator for descending direction of movement		
PID_D_up	Derivative parameter of regulator for ascending direction of movement		
PID_D_down	Derivative parameter of regulator for descending direction of movement		
PID_I_max_up	Integration limit parameter of regulator for ascending direction of movement	Anti-windup settings	0.1[%/bit]
PID_I_max_down	Integration limit parameter of regulator for descending direction of movement		0.1[%/bit]
I_reset_until_D_over_lmt	Option to avoid saturation of the Integration part. Integrator is kept in zero while Derivative (speed equivalent) is over value set in I_reset_D_limit		0/1
I_reset_D_limit	Derivative limit of speed to enable Integration part of PID		0.1[bit/sec]

7.4.3.6. Soft landing

7.4.3.6.1. Soft-landing - speed brake

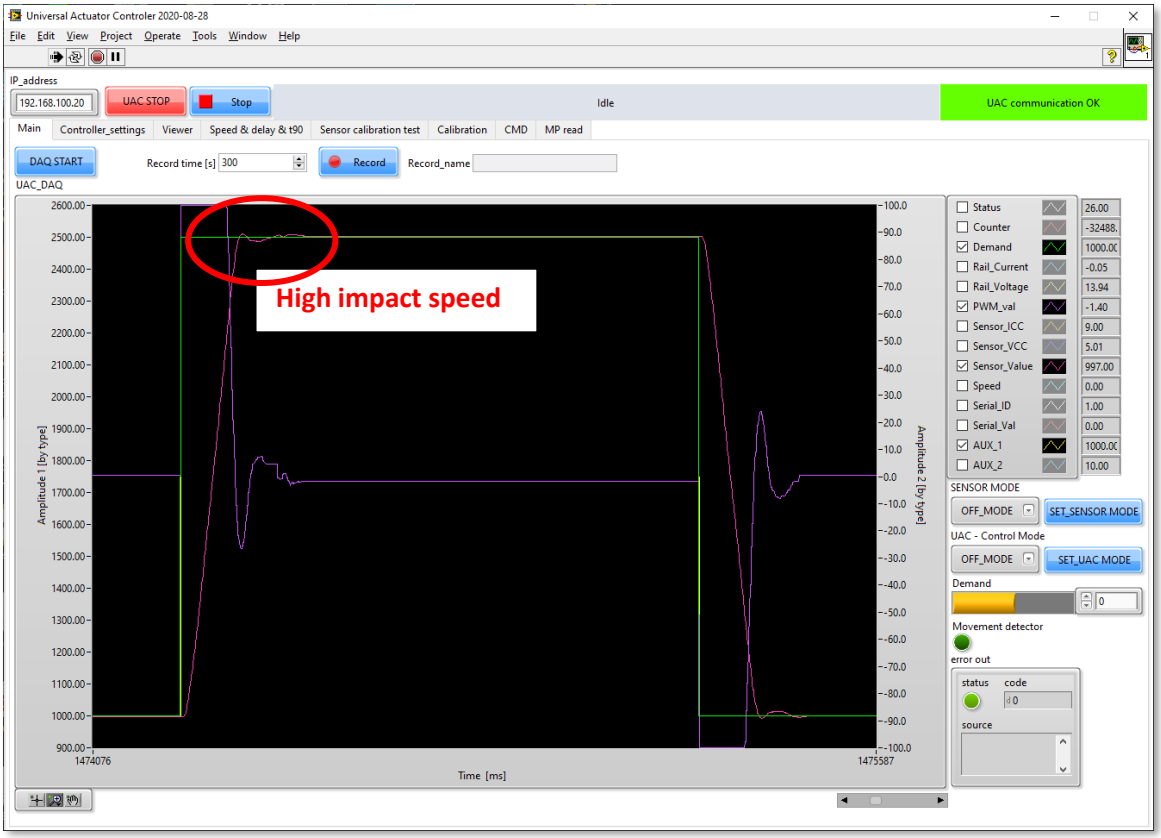
Soft landing-speed brake defines one way to reduce impact speed by proportional speed regulator acting against position PID



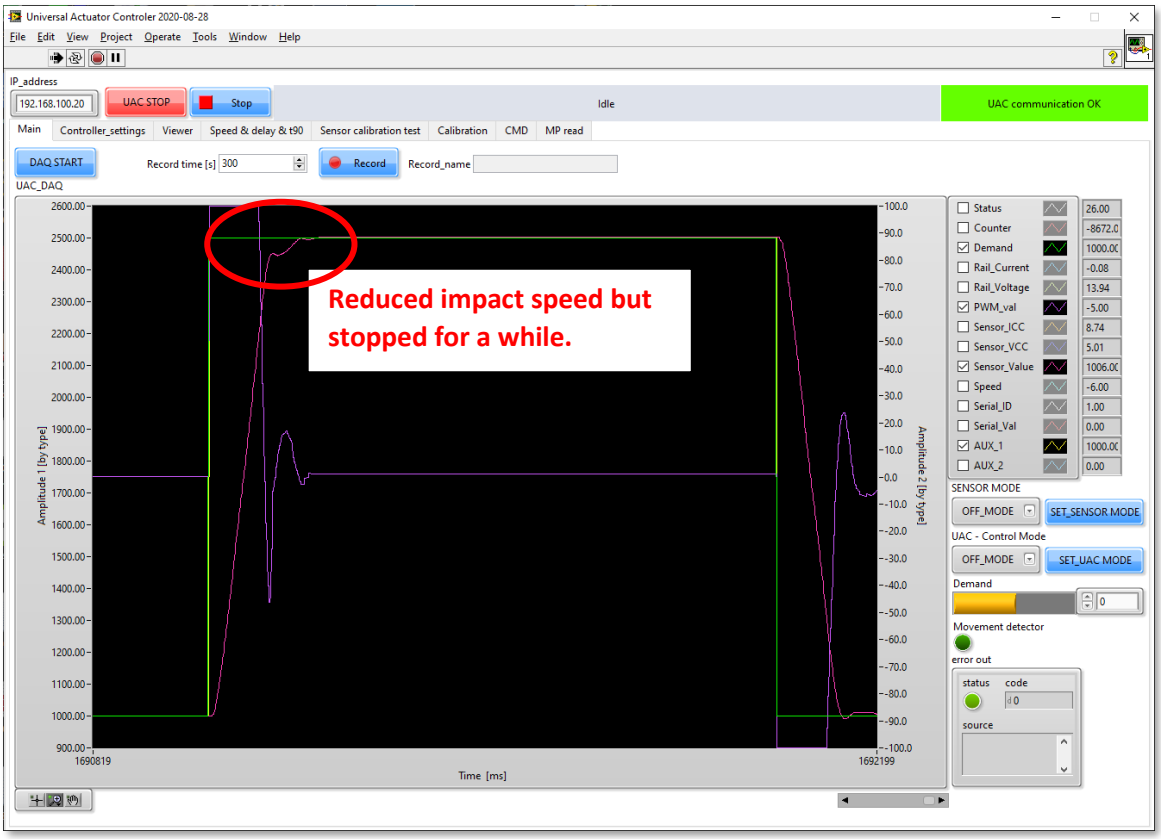
Parameter	Description	Unit
SL_B_enable	Speed brake is function which intends to reduce speed when is movement over high limit or under low limit position defined in the following parameters. Act as a speed controller assumed to position loop controller.	0/1
SL_B_position_low	Low threshold position to engage speed brake function	1[bit]
SL_B_position_high	High threshold position to engage speed brake function	1[bit]
SL_B_speed_limit	Demanded speed when speed brake is active	0.1[bit/sec]
SL_B_P	Proportional constant of the speed regulator	
SL_B_limit_cycle_change	To avoid shock response this parameter defines maximum step change of the PWM per one regulation cycle	0.1[%PWM]

Soft landing functionality is to manage impact against the hard-stop of actuator to avoid damage of the actuator gears and other components due to high inertia of rotating parts.

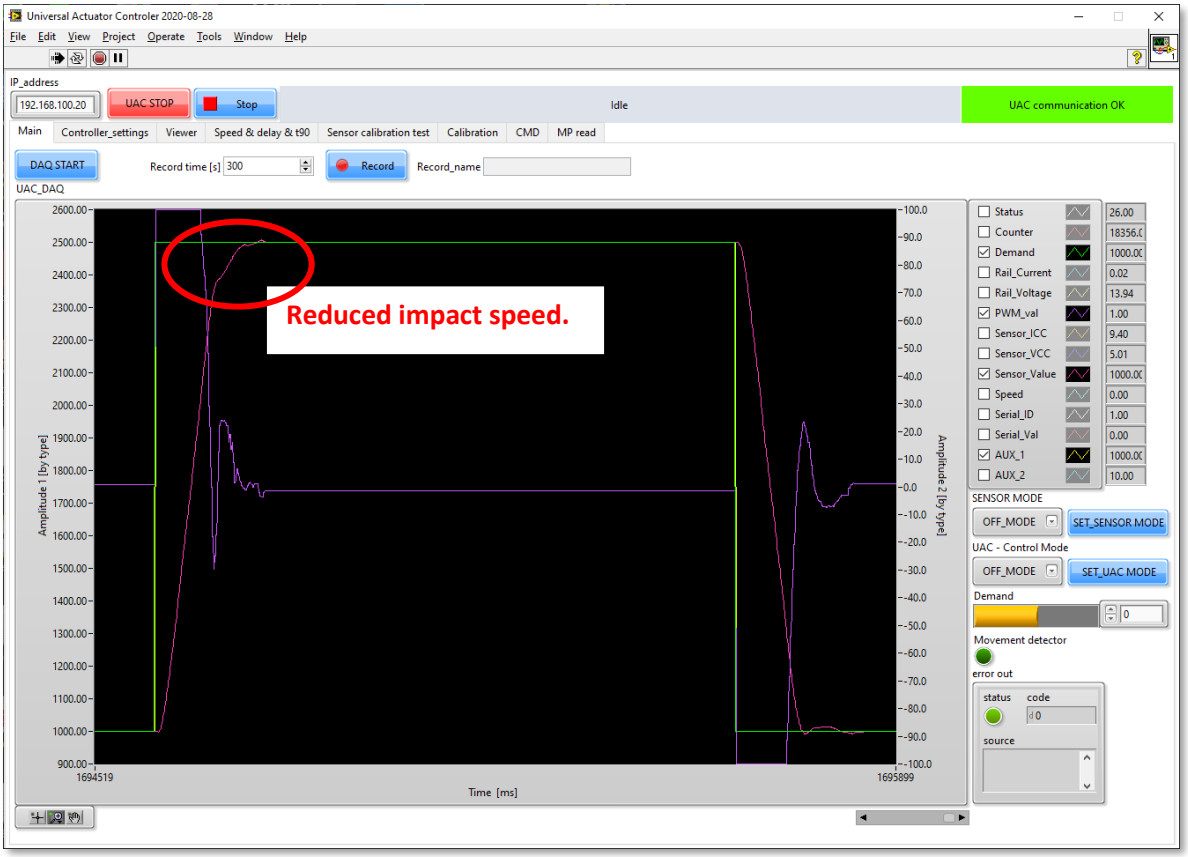
No soft-landing control – standard step response of PID.



Speed brake example at 2200.



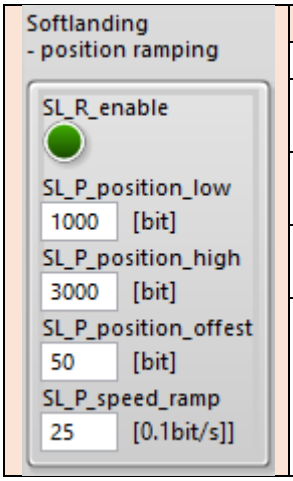
Speed brake example at 2000.



7.4.3.6.2. Soft-landing - position ramping

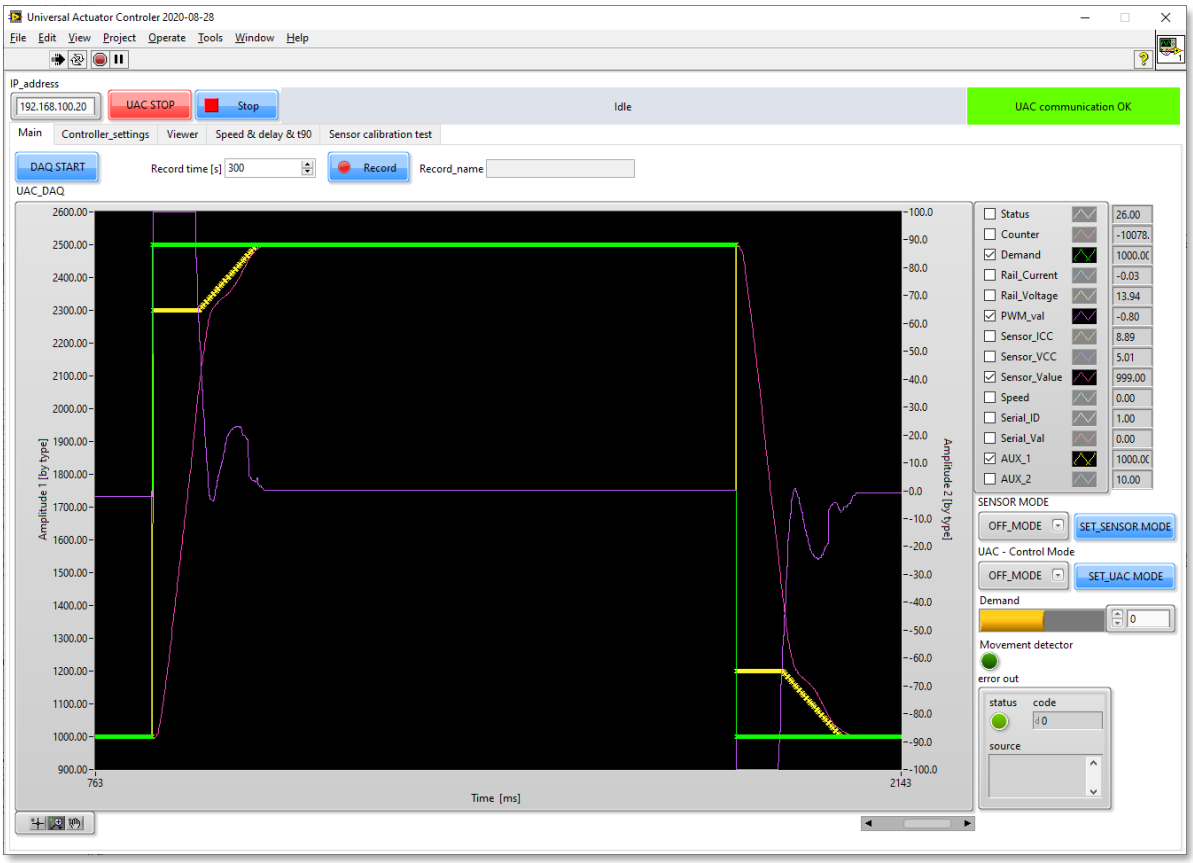
Soft landing-position ramping defines speed reduction using background change of demand value for PID in order to create ramp to reduce impact speed.

Position ramping works on background of controller which defines ramp of change instead of step change requested by input demand. Is limited by low, high position threshold and the position offset so the generated ramped demand always in front of real position. It is preferred way of the soft-landing limitation.



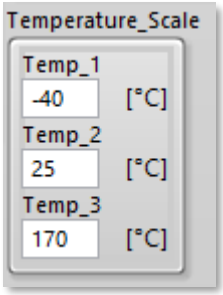
Parameter	Description	Unit
SL_R_enable	Enable/Disable this function	[-]
SL_P_position_low	Low threshold position to engage position ramping	1[bit]
SL_P_position_high	Low threshold position to engage position ramping	1[bit]
SL_P_position_offset	Offset to the low and hi threshold to activate function in advance	1[bit]
SL_P_position_speed	Ramp definition of the speed	0.1[bit/sec]

Soft-landing – position ramping – Controller is on background imposing the yellow shape of the demand (PID_set_point - can be shown as AUX channel) even when real demand (green) is asking for step response. Slope of the yellow ramp defines the speed and offset triggers when the ramp is applied to avoid actuator to stop when achieving the demand position. This creates offset demand to avoid jerking movement. **This is preferred soft-landing techniques as is more robust and easier to set.**

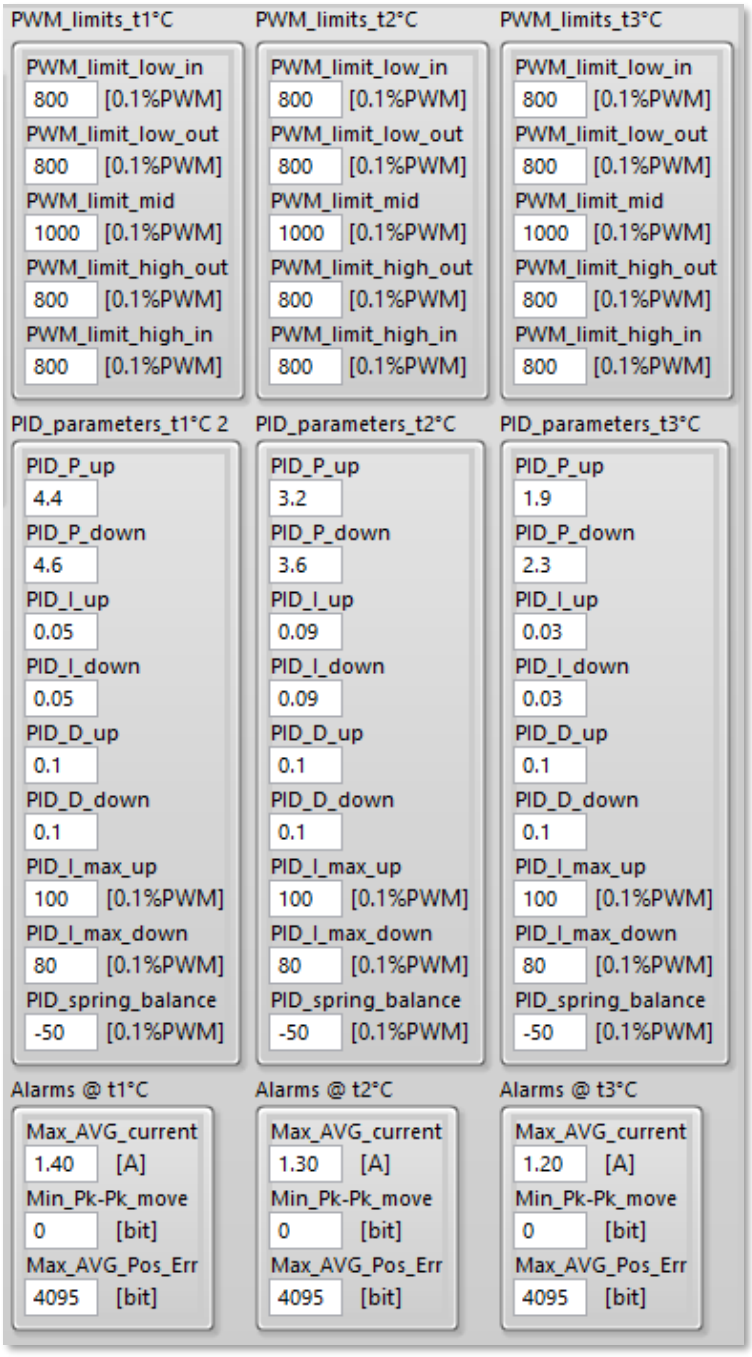


7.4.3.7. Temperature_Scale

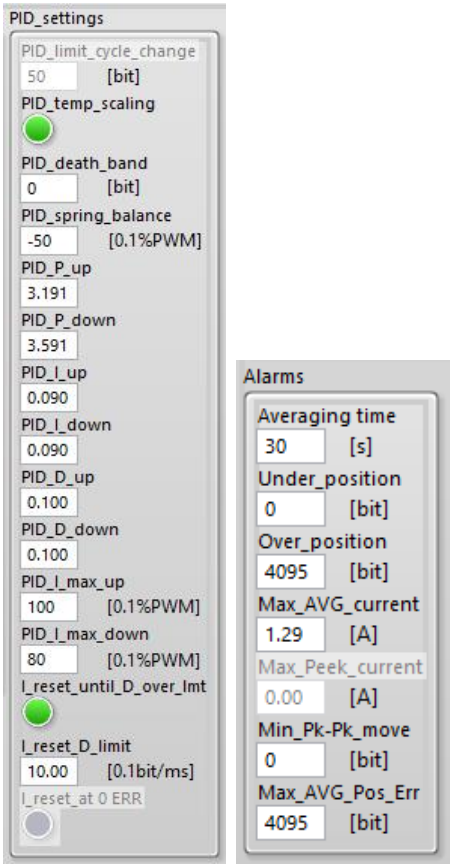
Temperature_Scale defines 3 temperatures for 3 sets of PID parameters for its scaling.



PWM_limits_t1°C/PID_parameters_t1°C/Alarms @t1°C
PWM_limits_t2°C/PID_parameters_t2°C/Alarms @t2°C
PWM_limits_t3°C/PID_parameters_t3°C/Alarms @t3°C



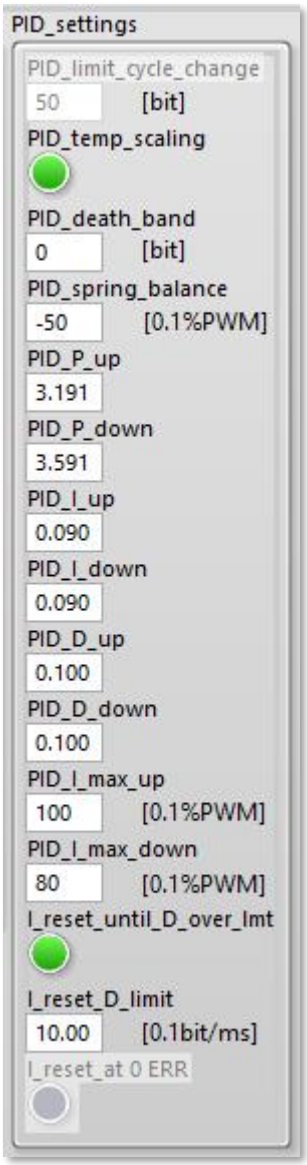
Notice: When Temperature scaling is activated - is actual PID settings in "PID_settings" and "Alarms" overwritten with actual dynamically calculated values!



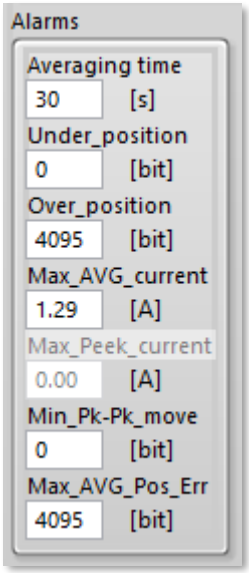
These are definitions of parameters and limits for each temperature. From these parameters are then scaled working parameters and limits, when temperature scaling is enabled. Normally these settings is deactivated, but by pressing F8 key is enabled. In case UAC is loaded with CS including temperature scaling is enabled automatically.

When temperature scaling is activated, UAC is calculating actual control parameters based on temperature and these can be read as the standard operating parameters. When reading CS can be seen "on the fly" how are changing according to the temperature. To calculate parameters is used linear scaling based on the actual temperature. If the temperature is between t1 and t2 are used parameters for temp t1&t2. If is the temperature is between t2 and t3 are used parameters for t2 & t3.

Example of dynamically calculated PID according the temperature 26.1°C:



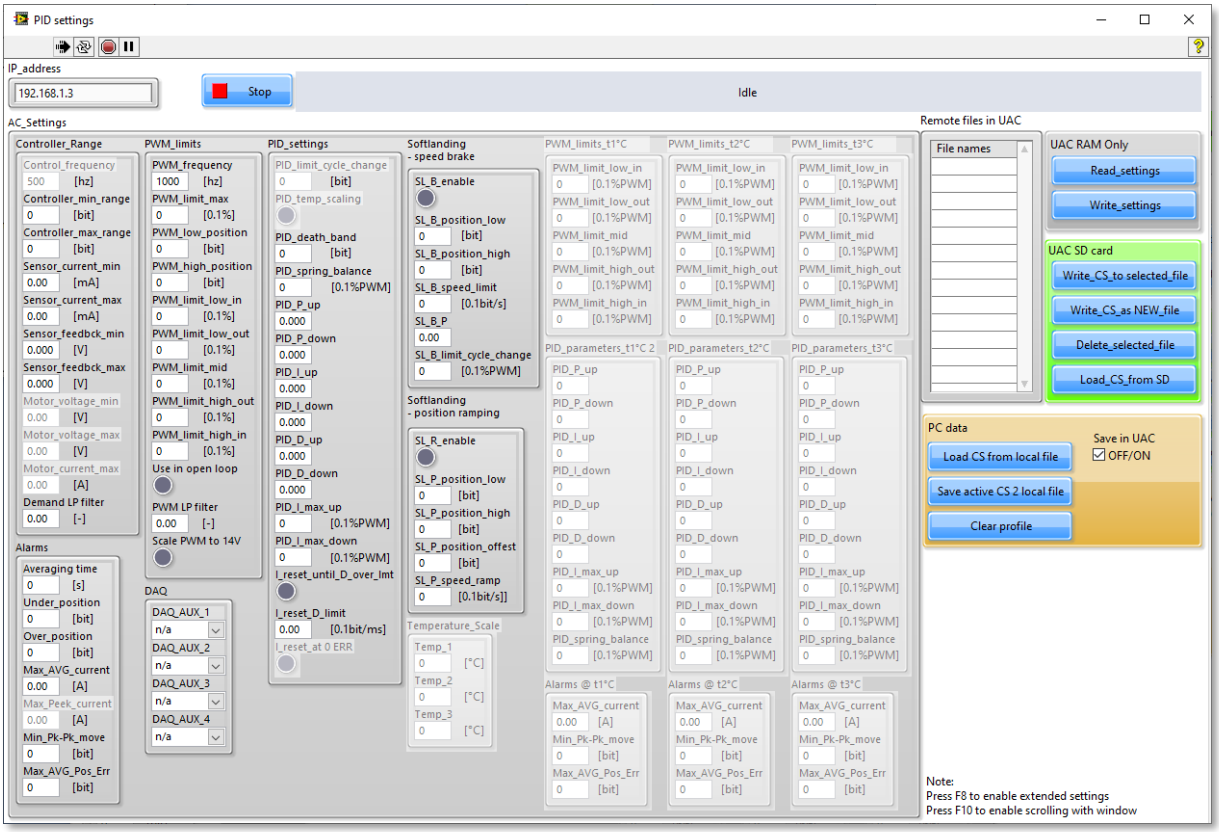
Example of dynamically calculated alarm limits:



7.4.3.8. Controller settings - standalone window

For more handy CS tuning is available also independent window for CS setting. Functionality is same but can be used in case of secondary screen is available.

Note: this mode is not automatically reloading settings from controller - so it may be used to rewrite settings of other controllers (read from one UAC and save for other UAC), but be careful as you can rewrite entire settings by incorrect or default zero values!



Temperature scaling is based on temperature captured by thermocouple connected to UAC.

In case of slave operation can be used temperature reading broadcasted by master UAC over CAN bus (so only one thermo couple is needed in case of operation on master & slaves).

If thermocouple is connected also to slave UAC, then this temperature reading is used also for PID temperature scaling (connected sensor has priority before CAN temperature from master UAC).

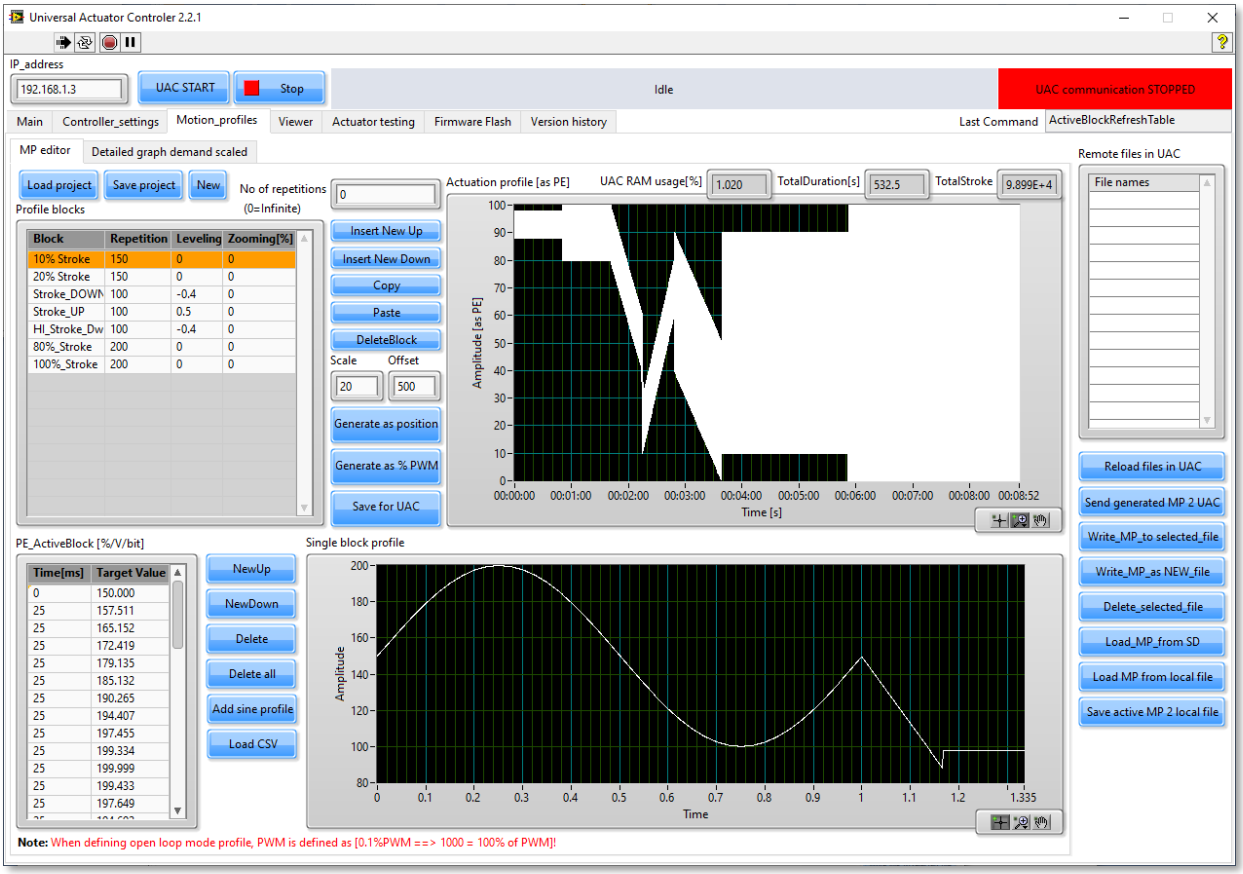
7.4.4. Page - Motion_profiles

Profile editor is since version 1.1.0 part of UAC SW. These functions are used to generate motion or PWM profile saved on SD card in UAC for standalone operation without PC. When profile is loaded by UAC, it is applied to control actuator in infinite loop or using specific name of profile (single.000 up to single.009) is executed just ones.

Since version 2-1-x can profile contain also requested number of profile repetitions, so requested run time/mileage can be already defined in motion profile. Added was also sinus profile generator so is easy to implement also sinusoidal movements. Parts of the motion profile blocks can be imported from CSV files with defined time and value columns (use text file with tab separated columns).

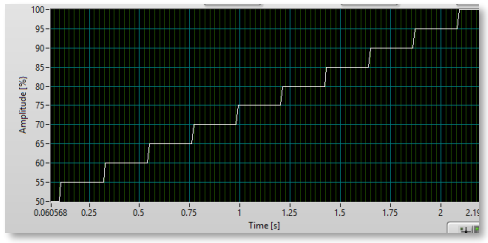
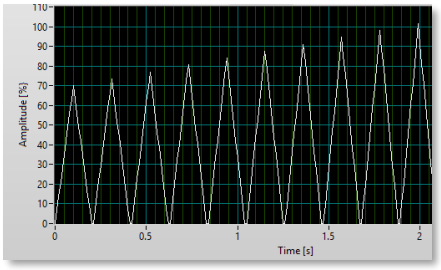
In version 2.2.1 was added for position profiles recalculation of the scale and offset at PC, so UAC does not have to do scale and offset of the profile. As result can be profile defined also in small units - like Volts with number of decimal places without influence on generated profile resolution.

Profiles can define motion profile definition in closed loop mode or also in open loop mode as PWM profile generator.



The motion profile editor uses projects to construct motion profile from blocks with defined elementary movements, for which is possible to define number of repetitions and Leveling and Zooming. These projects can be saved/loaded and using functions "generate" transformed in to the UAC motion profile. With specific scaling and offsetting sent to UAC and stored on SD card. Generate as %PWM is then used for open loop PWM generation and in this case scale and offset not used.

Leveling – Increase Amplitude value for each repetition by specified value [% of Amplitude value] – example block with cycling from 50-55%	**Zooming [%]** - Increase each step of the block by % of Initial value. Example block with 0-70% Initial Amplitude values, 10 Repetitions, 0

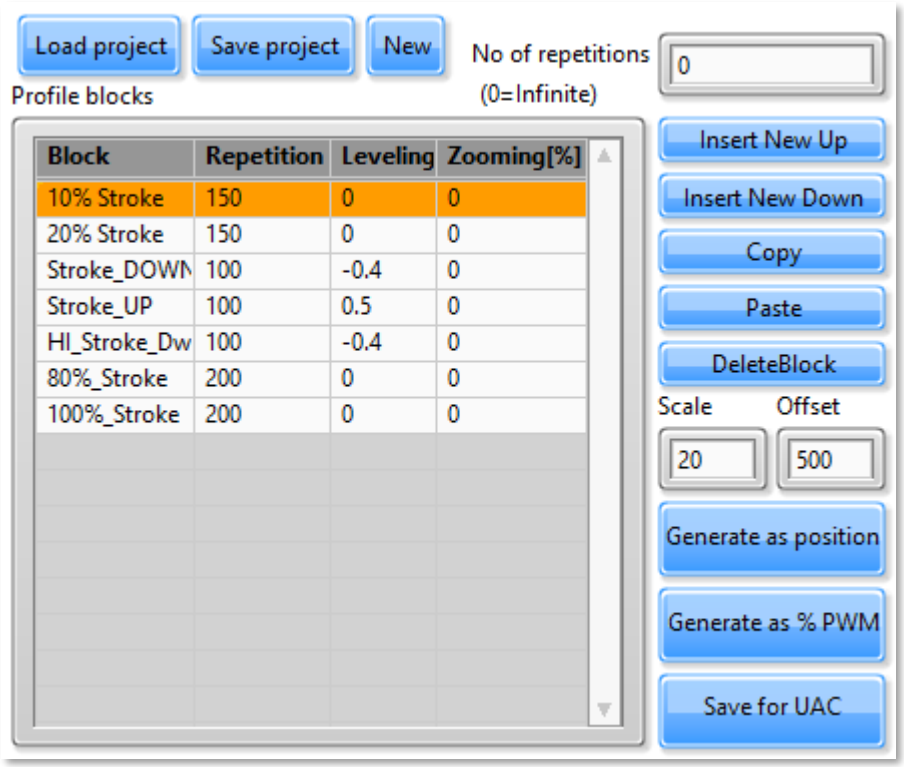
Amplitude (Initial value), 10 repetitions and 5 leveling value = 5% Amplitude increase each step.	Leveling and 5% Zooming = 3.5% Amplitude increase each step.
	

This way we can define virtually any profile with saw like profile which increases amplitude or dithering movement on the slow linear movement as shown in the picture example above.

For position control profile the idea is to define profile as abstract movement 0 to 100% of the movement as shown in picture above.

The real demand can be then simply scaled according to real actuator and its position sensor calibration when hitting "Generate as position". This command is re-scaling and offsetting profile form abstract 0-100% to real demand using scale and offset (in example scale 20 and offset 500 we create demand profile which is in range 500 to 2500). Scaled demand can be seen in Tab "Detailed graph demand scaled". There is shown real profile which will be used by UAC.

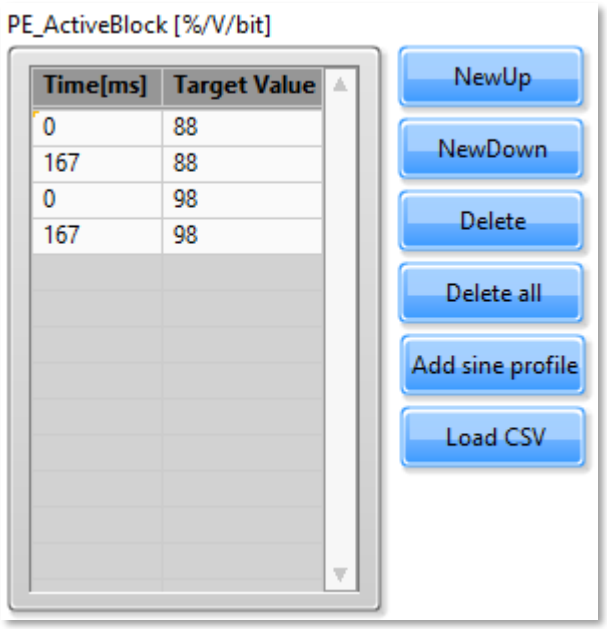
UAC accepts position demand always in range 0-4095 as 12-bit value corresponding to 0-5V or SENT or 0-100% of PWM position feedback signal.



- Load project and save project
  - Is used to save or load into PC actuation project. This project is then used to generate motion profile for UAC.
- New - to delete all points to start from scratch
- No of repetitions - defines limit of repetitions until UAC will stop actuation automatically. UAC is counting down until 0 to stop profile. If profile is stopped and run again UAC continues to

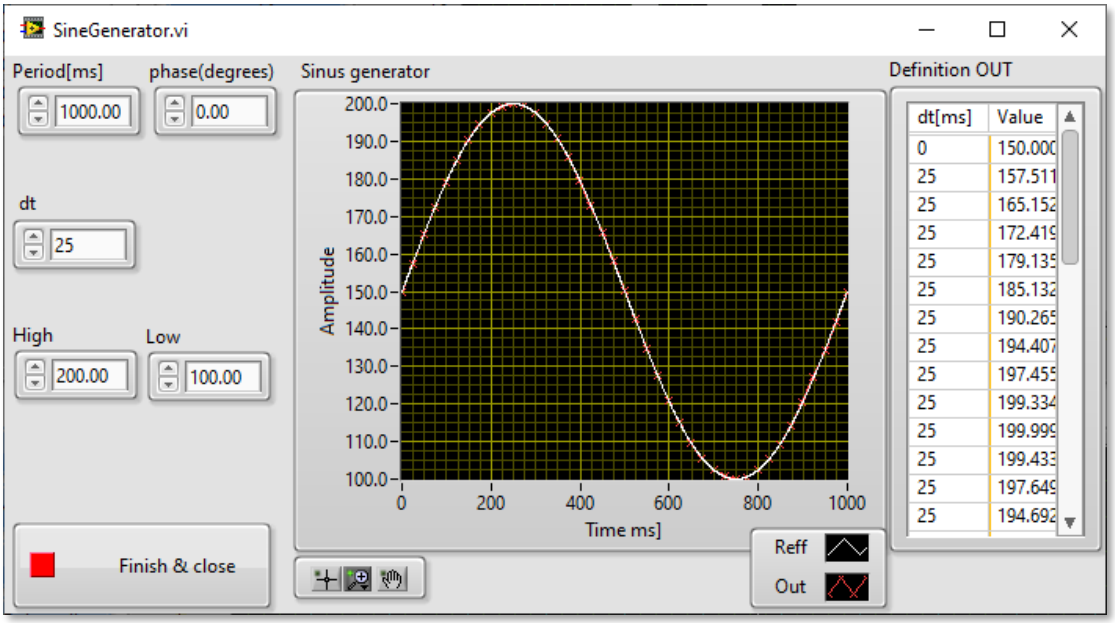
countdown until 0, so this functionality can coop with remote pause of actuation (using external input). After reaching 0 is actuation stopped. Actuation can be started again - but it will repeat without limitation as the requested number of repetitions is already 0. To reload limit of cycles, must be reloaded motion profile.

- Insert New Up
  - Is adding new block up relative to selected block in the list box
- Insert New Down
  - Is adding new block down relative to selected block in the list box
- Copy
  - Will copy selected block
- Paste
  - Will paste block from memory in to selected position of list box
- Delete Block
  - Will delete selected block
- Scale & Offset (see example in following page)
  - Is valid for command "Generate as position" to scale profile according requested sensor/mechanic calibration. Scaled demand can be seen in Tab "Detailed graph demand scaled".
- Generate as position
  - Function to generate actuation profile and show in the plot. Un-scaled shape is shown in chart next to it. Scaled profile then is located "Detailed graph page" with better resolution and saved in memory
- Generate as % PWM
  - Function to calculate PWM demand in % for open loop control. Scaling and offset is not applied as we define directly PWM for motor. The profile is shown in next chart next to it and saved in memory.
- Save for UAC
  - Function to save generated data for position or PWM control in to motion profile file, locally in PC.



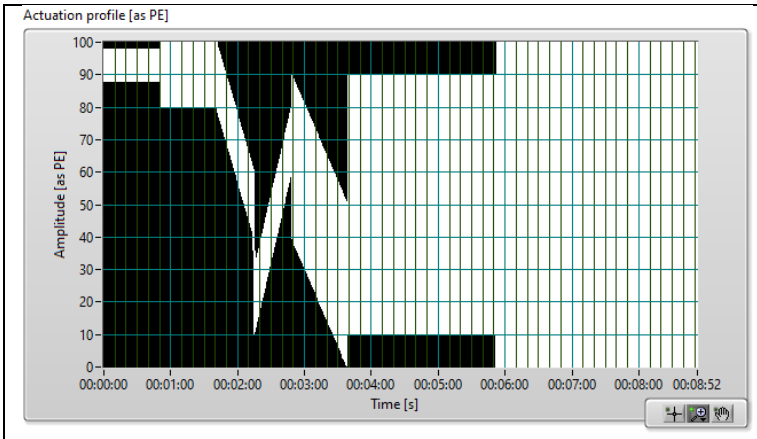
Block editor to define each block.

- NewUp
  - Adding new point of the block above the selected point of list box
- NewDown
  - Adding new point of the block under the selected point of list box
- Delete
  - Delete selected point of the block
- Delete all
  - Will clear entire active block
- Add sine profile
  - Will open sinus profile generator window to define requested movement



  - Period [ms] defines the sinus function period
  - Phase defines starting point of the sinus by degree (can be used to adjust connection to previous or following profile shape)
  - dt defines profile discretization in to small lines in this case each 25ms of the sinus is replaced by little line
  - High & Low defines min and max value of the sinus function
- Load CSV
  - This function can import text file with TAB separated columns of "Time" and Target Value" (no headings to included - just values tab separated).

Example of the profile definition:

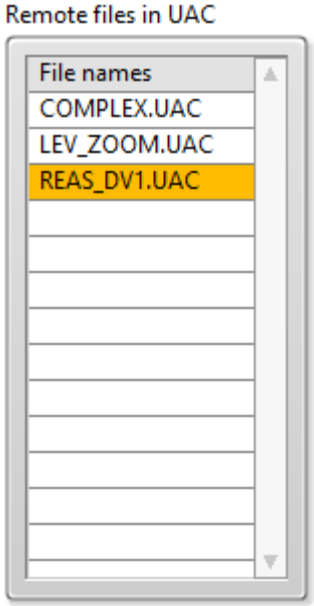


This profile was defined as abstract movement in range 0-100%.
To scale to the real demand, we need to consider actuator sensor calibration and requested angular movement.
For example, we need this profile to be equal to **70°** of mechanical movement out of **120°** of the total actuator stroke and centered. Calibration of the position sensor is equal to **0° = 500bit**, **120°=3500bit**.
Then we simply scale profile to this request using scale & offset parameter:

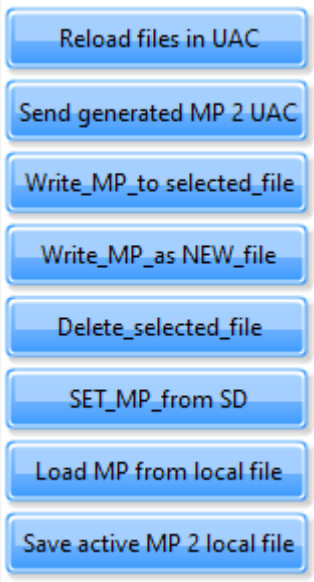
Scale will be then = (3500-500)*(70/120))/100=3000*(70/120)/100=**17.50**
(Then peak movement at 100% is 1750bit.)
Offset to center movement in the middle is 25° ((120-70)/2). This is equal to =25*(3500-500)/120=**625bit**

Note: the demand is always considered as 12-bit number equal to SENT,0-5V or 0-100% of PWM.

Motion profile sending to/from UAC and associated functions:



List of remote files located in UAC on SD card.



Functions to manipulate with profiles in UAC and sending in to the UAC as well as reading active profile back to PC

- Reload files in UAC
  - Function to renew list of files shown in the list box
- Send generated MP 2 UAC
  - Function to send generated profile into memory of UAC. After this it can be directly tested in UAC as is active in memory, but not saved on SD card
- Write_MP_to_selected_file
  - Function to save profile inside UAC memory to rewrite file on SD card
- Write_MP_as_NEW_file
  - Function to save profile inside UAC memory to be saved as new file on SD card
- Delete_selected_file
  - Function to delete selected file inside UAC on SD card
- SET_MP_from_SD

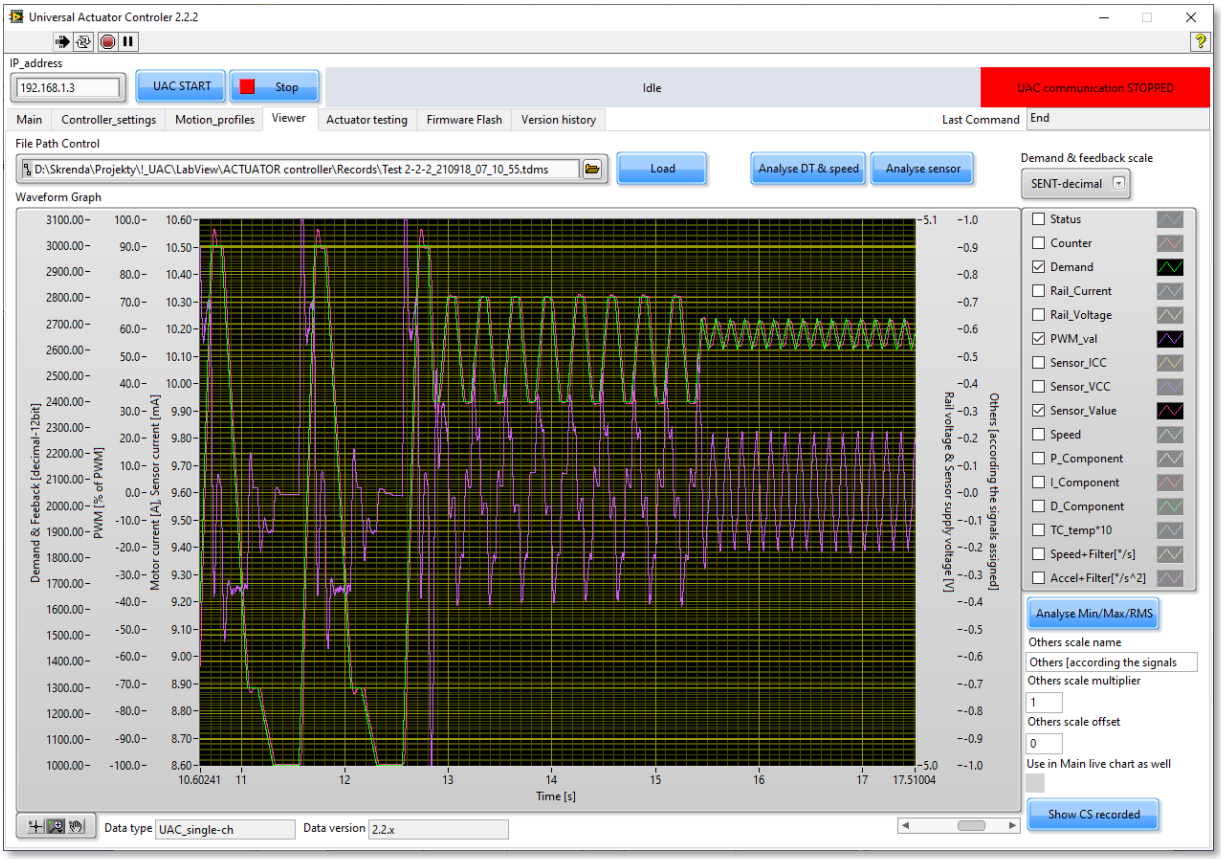
    - Function to load motion profile from SD card into UAC memory. Same effect is also double click on selected motion profile in the list.
- Load MP from local file
    - Function to load motion profile from PC into UAC memory and save on SD card of UAC as well.
- Save active MP 2 local file
    - Function to read active MP in UAC memory and save as local file in PC

7.4.5. Page - Viewer

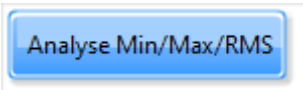
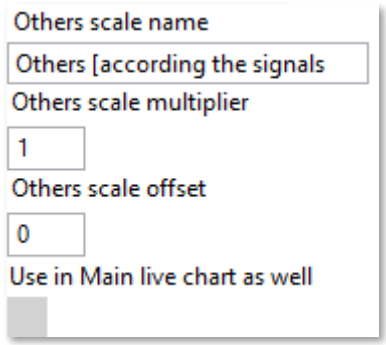
Record viewer is created to review and analyze records created by UAC utility. Contains same Y-axes as live window and signals can be activated and deactivated according to subject of interest.

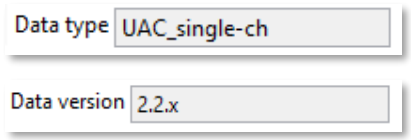
Recorded signals may be processed for "response time analyses" and "sensor analyses". For these functions select in the chart region of interest to be analyzed (rising or sinking part of movement) and function will extract data automatically. Settings if the function is defined in the tab “Speed & delay & t90”. For details see next chapter.

New functionality is analysis of signals for Min/Max & RMS. Also records now contain also controller setting used during recording, so AUX channels are now automatically assigned according to the setting of controller.



Load	**Button to load record**
Analyse DT & speed	**Button to load data in selected view into the tool for response time**
Analyse sensor	**Button to load data into sensor analyze tool**
Demand & feedback scale SENT-decimal	**Switch to select units of Demand & feedback (will set also the scale units and description)**

<table>
<tr>
<td> 
</td>
<td>Button to perform analysis on selected range of data.
See the example:
Analyse_RMS.vi
Data statistics
<table>
<tr><th>Parameter</th><th>Min</th><th>Max</th><th>AVG</th><th>ABS-AVG</th><th>RMS</th></tr>
<tr><td>Status</td><td>23.000</td><td>23.000</td><td>23.000</td><td>23.000</td><td>23.000</td></tr>
<tr><td>Counter</td><td>-31033.0</td><td>-24126.0</td><td>-27579.5</td><td>27579.500</td><td>27651.501</td></tr>
<tr><td>Demand</td><td>1000.000</td><td>3000.000</td><td>2354.503</td><td>2354.503</td><td>2427.596</td></tr>
<tr><td>Rail_Current</td><td>-1.465</td><td>1.435</td><td>-0.004</td><td>0.162</td><td>0.250</td></tr>
<tr><td>Rail_Voltage</td><td>12.878</td><td>13.547</td><td>13.468</td><td>13.468</td><td>13.469</td></tr>
<tr><td>PWM_val</td><td>-100.000</td><td>100.000</td><td>0.259</td><td>19.487</td><td>26.814</td></tr>
<tr><td>Sensor_ICC</td><td>8.727</td><td>10.508</td><td>9.231</td><td>9.231</td><td>9.235</td></tr>
<tr><td>Sensor_VCC</td><td>5.011</td><td>5.020</td><td>5.016</td><td>5.016</td><td>5.016</td></tr>
<tr><td>Sensor_Value</td><td>1001.000</td><td>3065.000</td><td>2354.009</td><td>2354.009</td><td>2427.790</td></tr>
<tr><td>Speed</td><td>-154.000</td><td>178.000</td><td>1.971</td><td>29.813</td><td>46.731</td></tr>
<tr><td>AUX_1</td><td>-771.000</td><td>906.000</td><td>2.115</td><td>167.154</td><td>238.035</td></tr>
<tr><td>AUX_2</td><td>-46.000</td><td>75.000</td><td>0.371</td><td>4.032</td><td>9.514</td></tr>
<tr><td>AUX_3</td><td>-186.000</td><td>210.000</td><td>0.476</td><td>28.267</td><td>41.355</td></tr>
<tr><td>AUX_4</td><td>0.000</td><td>0.000</td><td>0.000</td><td>0.000</td><td>0.000</td></tr>
<tr><td>Speed+Filter[°/s]</td><td>-132.312</td><td>154.865</td><td>2.042</td><td>28.692</td><td>44.391</td></tr>
<tr><td>Accel+Filter[°/s^2]</td><td>-3203.80</td><td>3672.613</td><td>-12.458</td><td>578.348</td><td>833.571</td></tr>
</table></td>
</tr>
<tr>
<td> 
</td>
<td>Control of Y scale "Others". This scale is used for signals from AUX channels which may have very different scaling and purpose. This allows to change description, scale and offset, in order to present data linked to this scale.

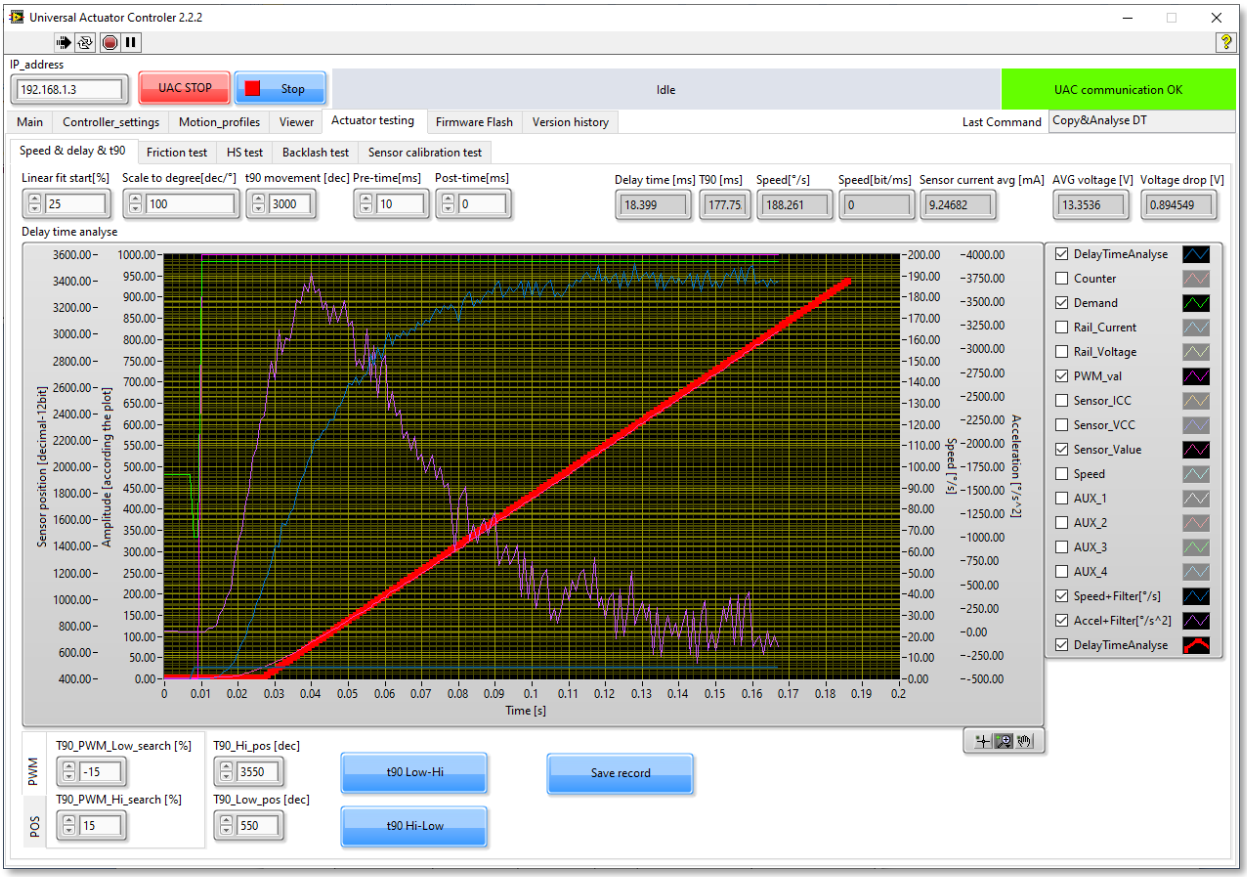
This setting is common also for live chart in "Main" tab if is activated.</td>
</tr>
<tr>
<td> 
</td>
<td>Starting by version 2-2-1 record files contain data type description for identification and also version description. This way may be ensured the processing of data for compatibility.</td>
</tr>
</table>

7.4.6. Page - Actuator testing

In the SW is already implemented number or tests for actuator condition verification. These tests were moved under this tab and will be expanded with new functionalities in the future

7.4.6.1. Page - Speed & Delay & t90 (response time measurements)

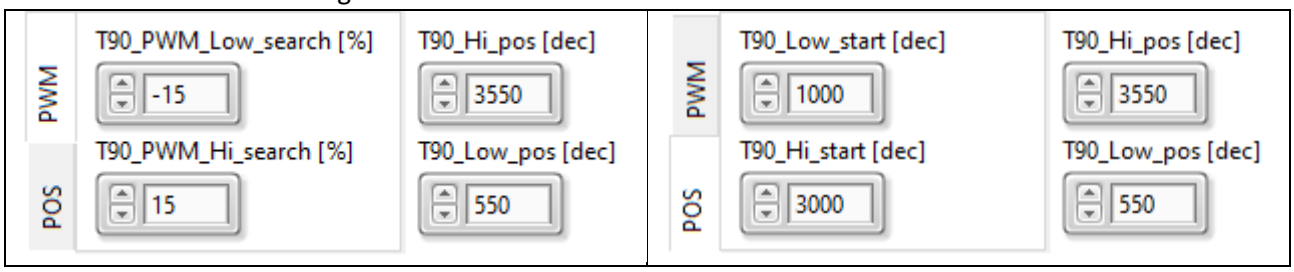
This function is used for measurement of the speed, mechanical delay of the actuator and t90 movement time of the actuator. For measurement is necessary set aggressive P coefficient in PID settings and disable soft landing functions in order to keep 100% PWM for most of the movement. Start point of the test can be defined at HS (using open loop with fixed PWM) or by requested position. Then is perform movement in closed loop as big as possible without hitting the second HS. Please verify first behavior before the measurement to be sure no damage of actuator can occur (for HS damage). After the movement SW analyses data to calculate required values. Red curve indicates the starting delay and slope of the speed. SW also prints average sensor current draw and DC motor rail voltage (as important parameter affecting the speed) and also acceleration voltage drop due to high current draw of DC motor.



Linear fit start [%] = cut_off percentage for speed evaluation (of the position Pk-Pk to remove acceleration) the rest of the curve is best fitted by line to obtain slope of the speed.
Scale to degree [dec/°] = calibrated range [dec] / actuator_stroke [°] (according to the sensor calibration)
T90 movement [dec] = value of stroke [in dec] for time and speed evaluation
Pre-Time & Post-Time = include pre and post section of the event for better understanding
T90_PWM_low_search [%] = % PWM for HS finding
T90_Hi_pos[dec] = Hi position demand in closed loop. The operator should select the position which will not damage the actuator by overshoot. Recommendation is to measure value of the overshoot far from internal HS and based on the value set the T90_Hi_pos.

Proper controller setting needs to be selected – no PWM limitation, sufficient P regulation, soft landing turned off and PWM voltage scaling to be deactivated as well. Setting must be selected to maintain 100% PWM for all evaluated range (red curve on the picture above). In first step actuator is demanded to go for starting point and then switched to closed loop to perform step response.

Test can start from actuator HS which is reached in open loop mode by fix PWM value, or may be commanded in closed loop to the starting point - for example when sensor is clamped within the mechanical movement range.



T90_PWM_Low_search [%] = % PWM for HS finding**.**
T90_PWM_hi_search [%] = % PWM for HS finding**.**

T90_Low_start [dec] = Closed loop decimal definition of the test start point**.**
T90_Hi_start [dec] = Closed loop decimal definition of the test start point**.**

T90_Hi_pos[dec] = Closed loop decimal definition of the test end point**.**
T90_Low_pos[dec] = Closed loop decimal definition of the test end point**.**

7.4.6.2. Page - Friction test

Friction test is designed to verify effort needed to actuate slow profile with actuator. Test is performed by triangular movement with period of 0.2s and repeated 2x (see above in the picture).

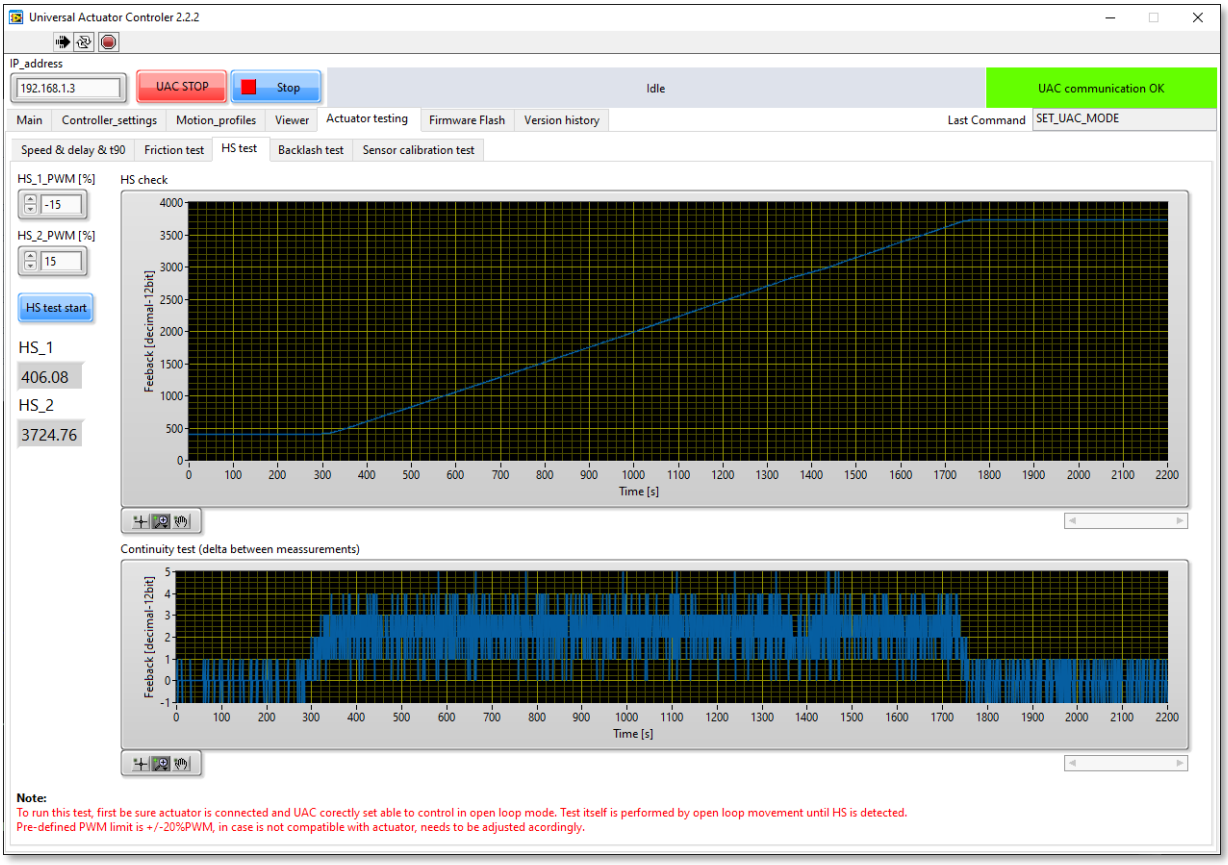
For this test must be used controller settings set according to each actuator for smooth and stable closed loop control.

From the movement may be removed all current/PWM spikes during motor reversing - using parameter “Reverse points length to delete[ms]".

Triangle_Start and Triangle_End defines low and high points of the profile demand (by default 20-80% of the range 0-4095).

Most important output is current, but can be used also Power and PWM indication of charts and mean value of absolute value and RMS of all values.

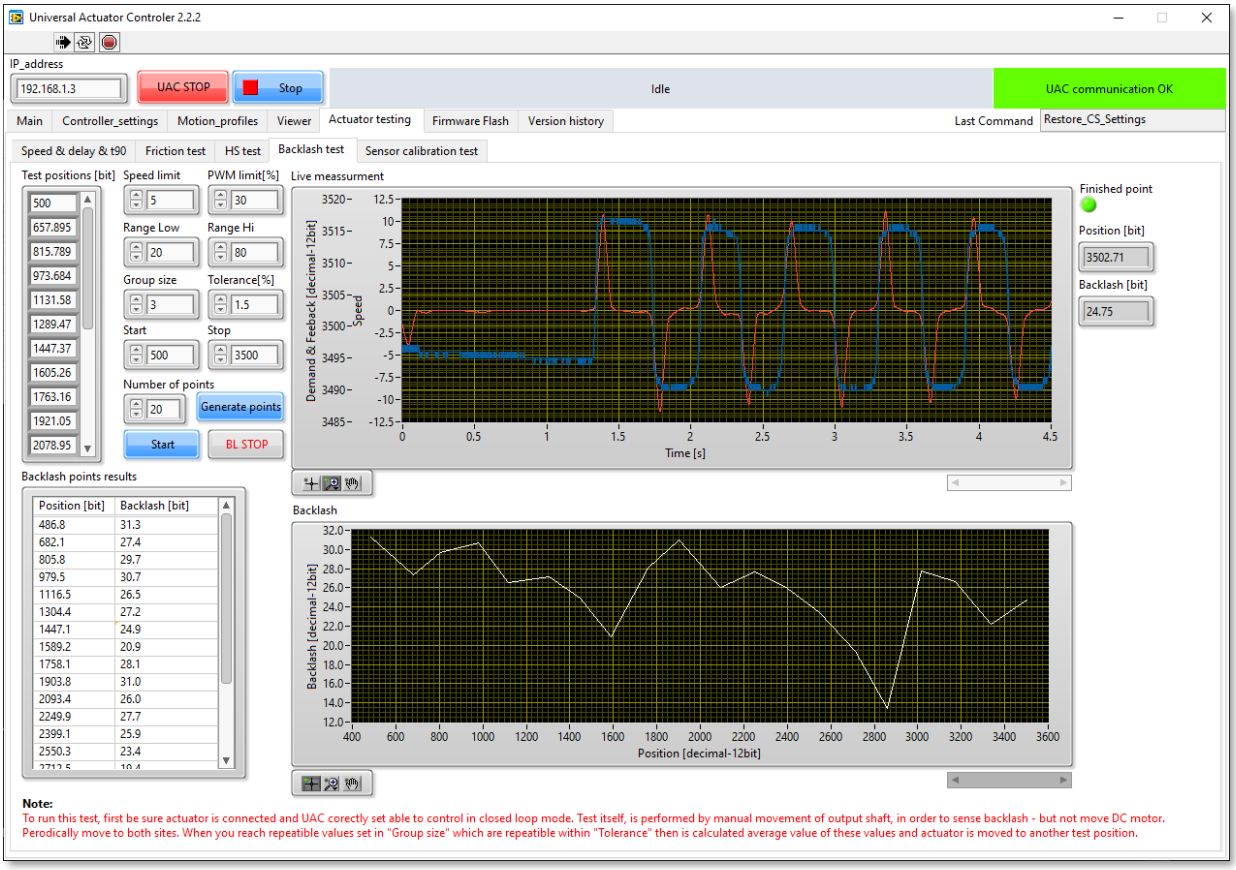
7.4.6.3. Page - HS test



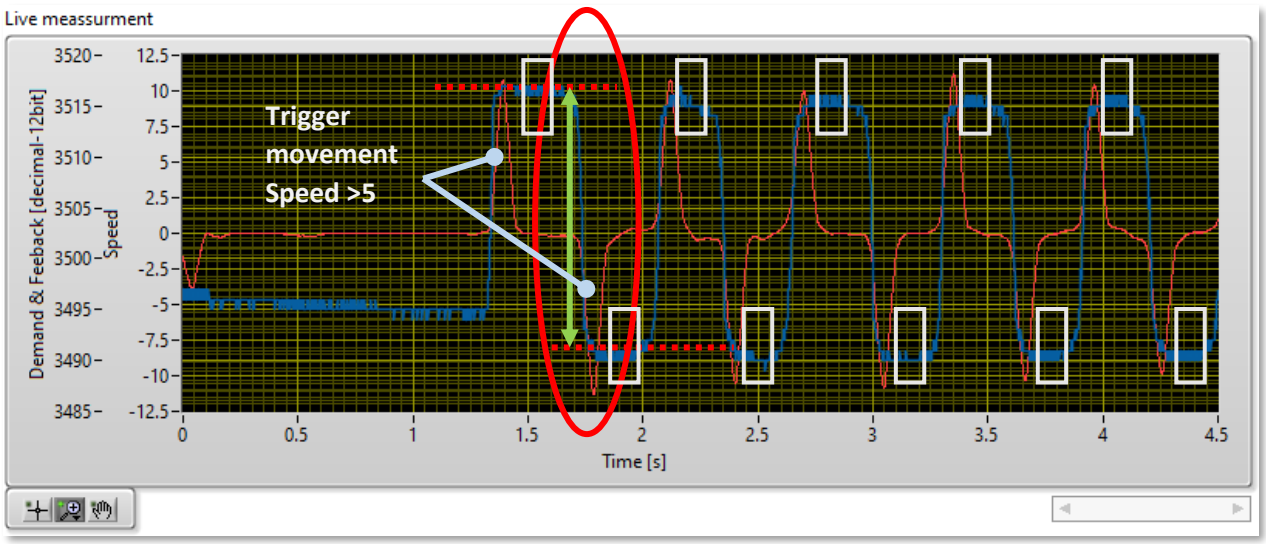
Hard Stop test is check of HS positions using open loop movement until HS is detected. For both directions can be set PWM to be used in open loop to approach hard stop.

Values are then show in indicators and curve of the time vs. position is shown for review. Additional to this is calculated also continuity cart to indicate signal errors as well as fold-back condition.

7.4.6.4. Page - Backlash test



Test for verification of output shaft angular backlash. Test is moving actuator in closed loop in to measurement positions and then is manually measured backlash angle in each of the position and generated chart of position vs. backlash.



By manual hand movement of the output shaft without rotation of the DC motor. Test must be done gently to sense backlash without rotating by DC motor.

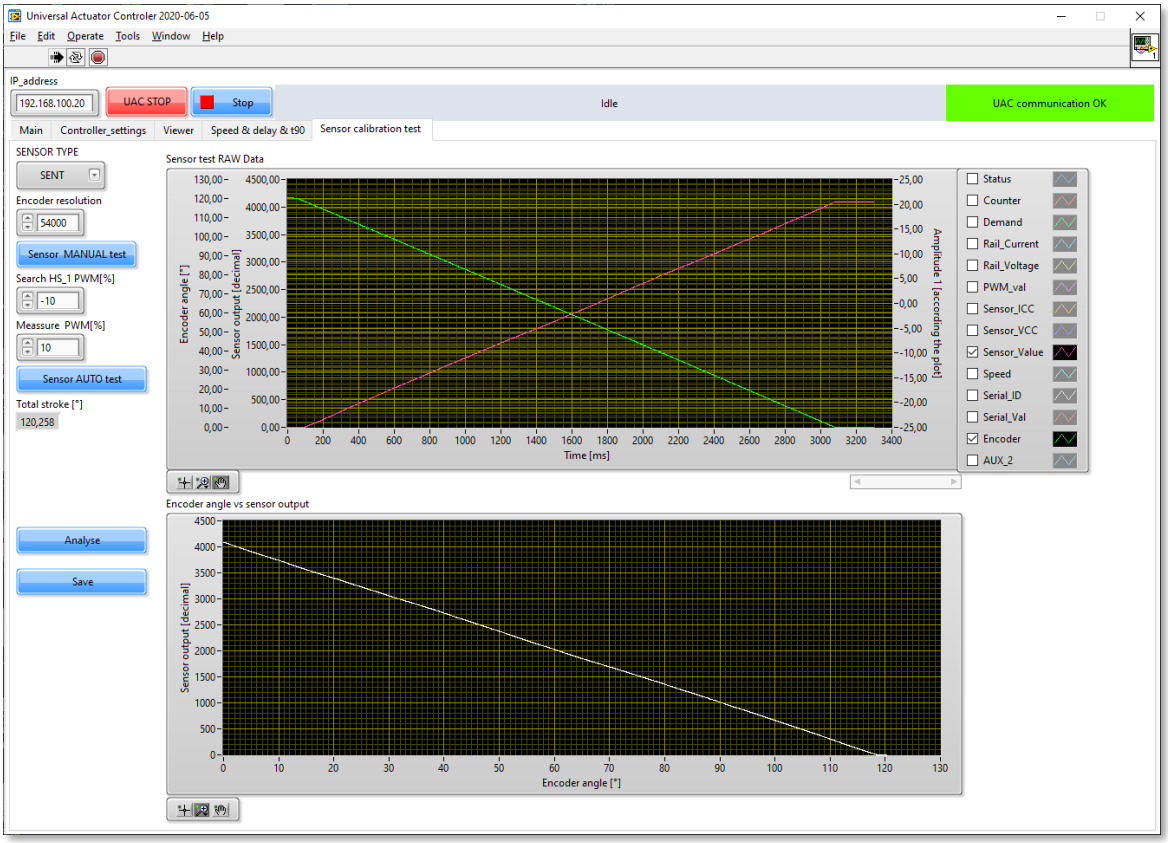
Each movement is s separated using calculation of derivation from position as speed, which using "Speed limit" parameter separates movements to blocks for calculation of the peak to peak value. This indicates start and stop times for extraction of the position for calculation.

Range Low and High then defines value extracted only in time between indication of movement Up and Down to remove rising and sinking part for stable readout. This range is then extracted and used to calculate average value.

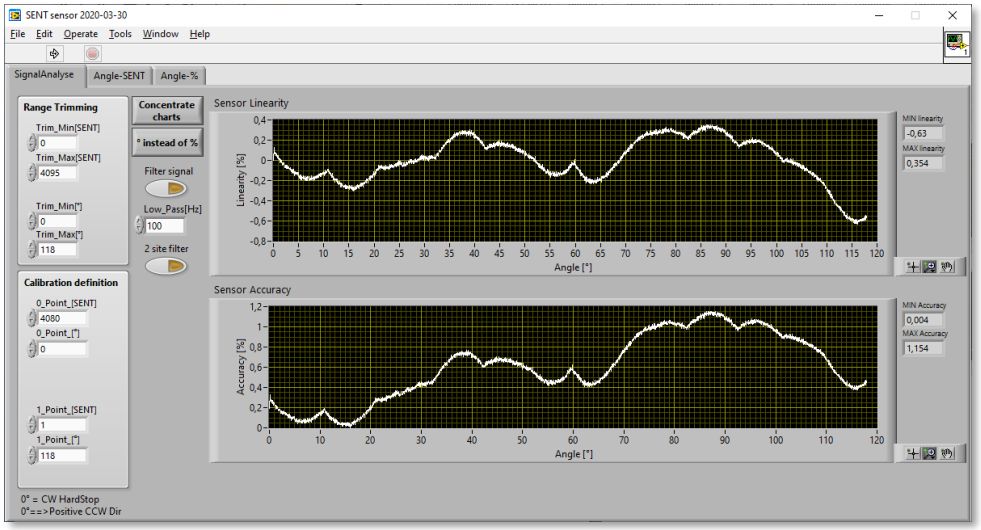
From Hi and Low couples are then calculated Pk-Pk values which may vary by the operator skills, so for verification of the correctness is used statistical approach defined by "Group size" and "Tolerance". This calculates if number of measurements defined by group is within tolerance parameter between each other. When this is reached, measurement point is considered as finished and these valid group values are used to calculate average of them as backlash at the measured point.

7.4.6.5. Page - Sensor calibration test

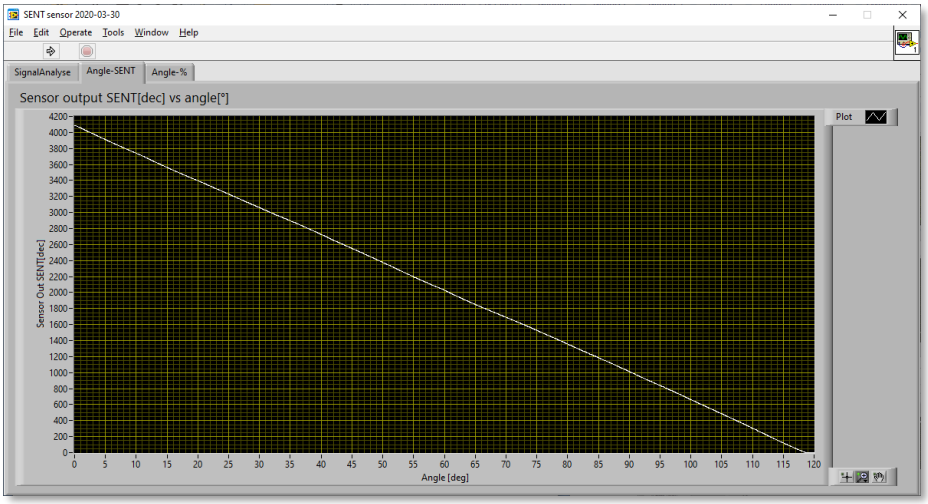
With combination to external rotary encoder can UAC measure sensor output and compare with signal from encoder. **For this function AUX_1 channel must be set to the Quadrature Encoder to capture encoder position.**
Signal can be compared with requested calibration definition and by default is analyzed for linearity of the sensor calibration. Actuator is actuated between both HSs in open loop by “Search” and “Measure” PWM. Search PWM is defining the starting HS and measure PWM defines the measurement direction and speed. PWM should be set in order to be sure actuator will move until the HS, but low enough to moderate low speed of the movement. In case of motor malfunction can be used also “Sensor MANUAL test” and actuate measurement by hand. First go to starting HS, start measurement and manually actuate until next HS and stop the test.
Before the test must be also selected correct sensor signal type and set encoder resolution according to the model used (set just nominal resolution – number of pulses per 1 revolution).
Signal is then captured in



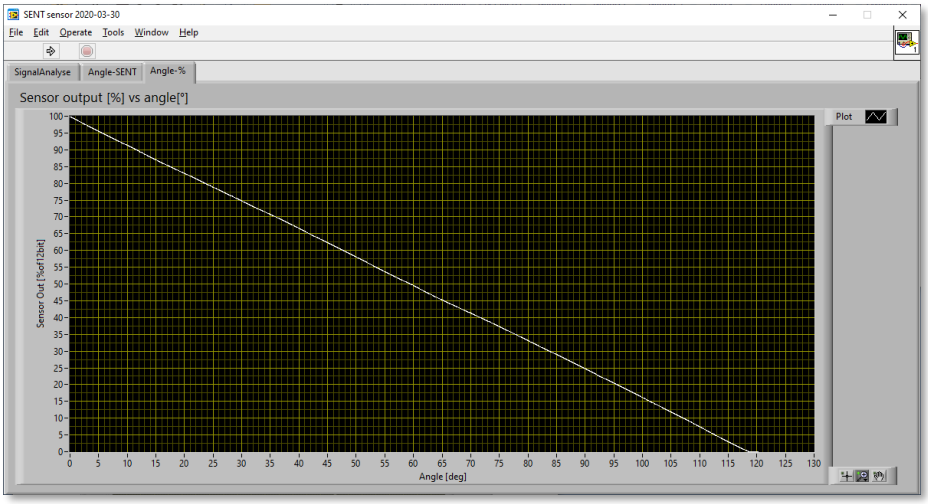
7.4.6.6. Page sensor Linearity & accuracy review



7.4.6.7. Page angle vs. SENT chart



7.4.6.8. Page angle vs. percentage chart

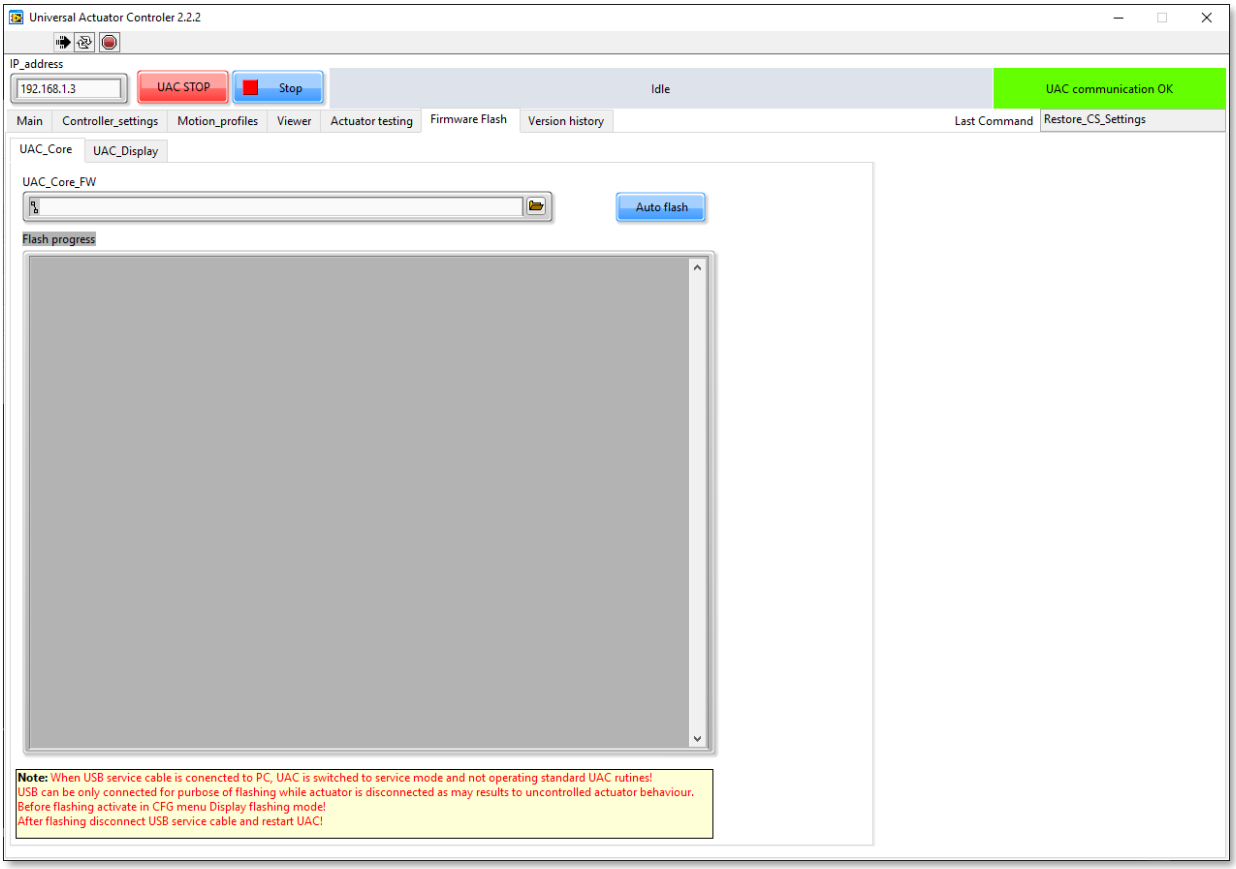


7.4.7. Page –Firmware Flash

This page is used for update of UAC internal SW. Is spitted for UAC_core FW and UAC_Display FW (as HMI interface).
Micro USB cable is necessary to perform flash.
ALL flashing to be performed by setting UAC into the "Display flashing mode". This mode to be set on touch display in Set CFG menu by pressing button Flashing display mode (bottom left site).

UAC_core FW

UAC core firmware is available at www.lab-tools.cz packed as .zip file.
File must be unzipped and contains *.bin file with compiled FW for UAC core.
Select this file in UAC_Core_FW and hit Auto flash. SW will be uploaded automatically.
After successful flash, turn OFF UAC, disconnect USB and turn ON UAC again.



Note: If flashing procedure keeps failing, it may be necessary to reset UAC memory before flashing.

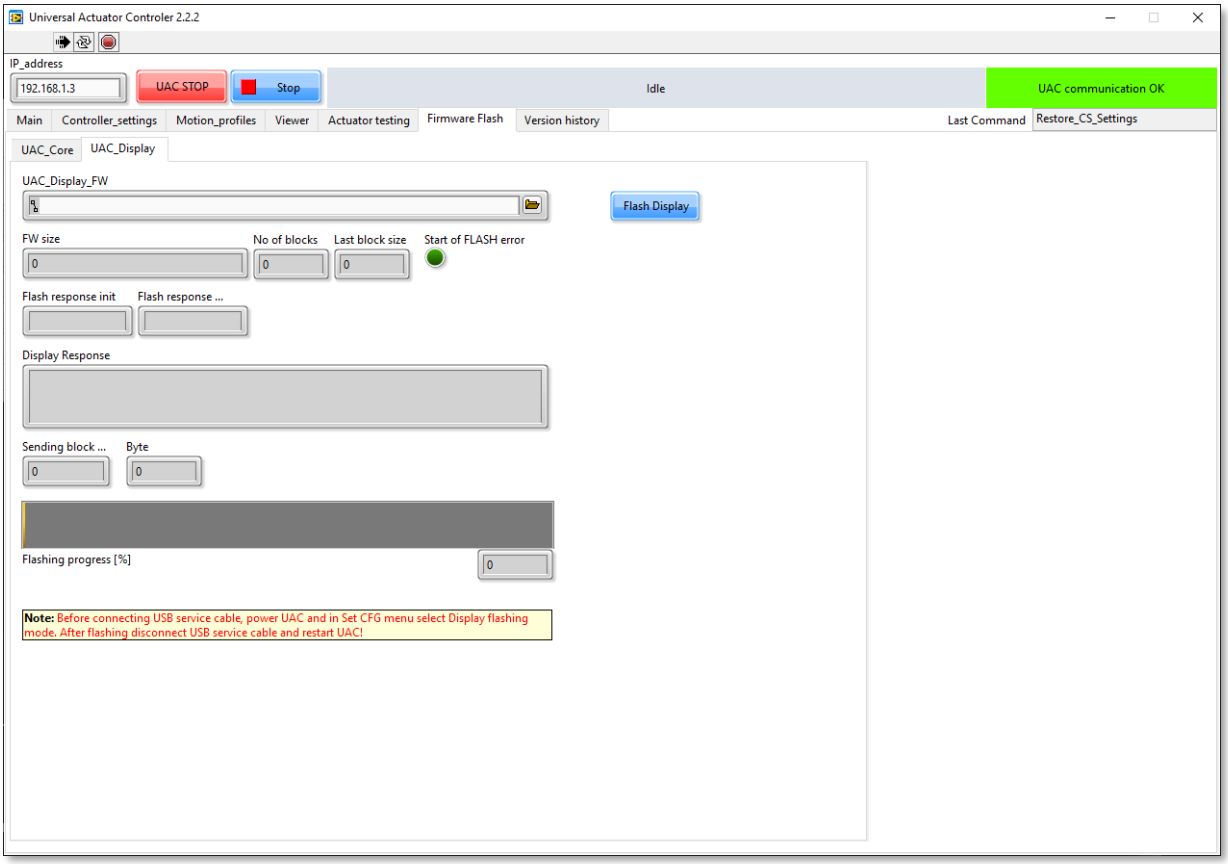
To do this un-stick label on bottom site covering memory reset switch hole of UAC and using some nonconductive stick - like plastic or wooden reset UAC memory (when UAC is powered press button for 1s).
Older version of UAC without hole for reset button needs to be reset in other way. Remove rear panel and use longer non-conductive stick to approach memory reset switch from site.

UAC_Display FW

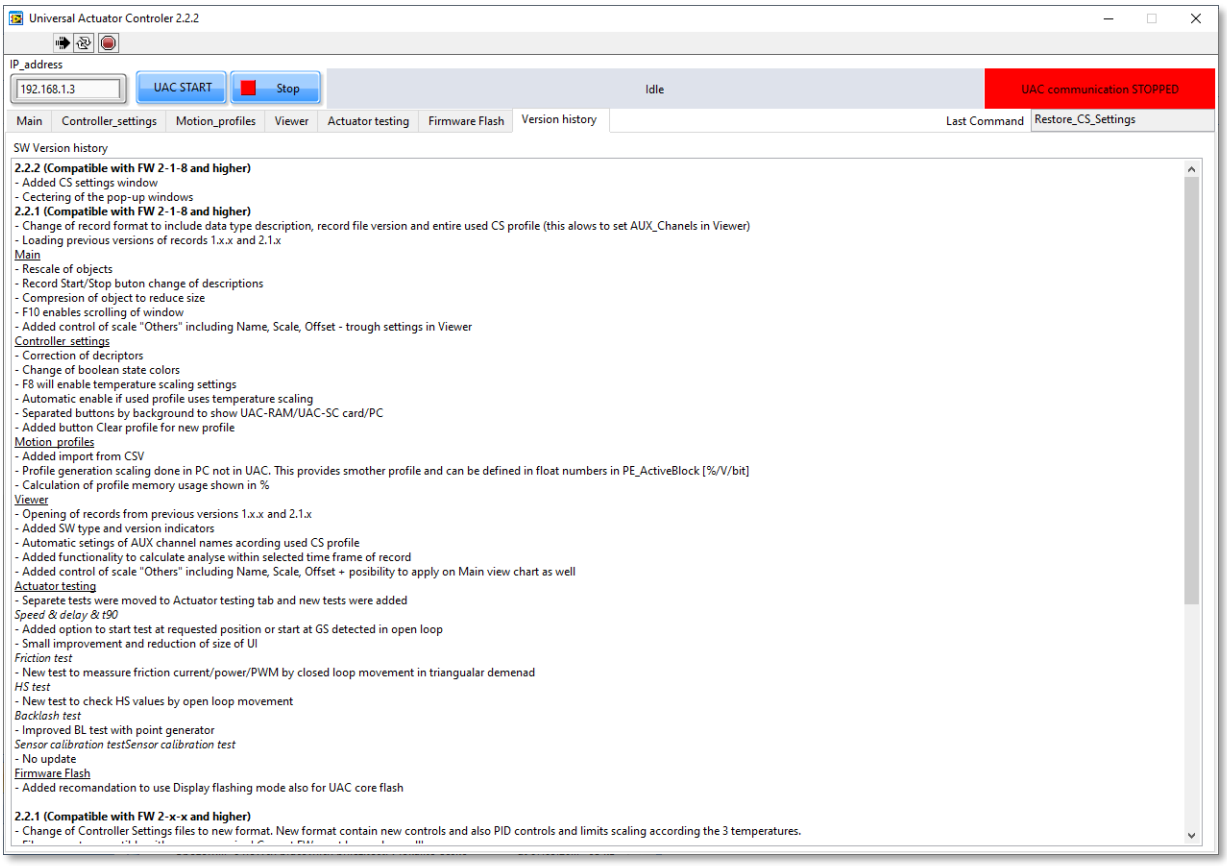
HMI interface contains specific FW and must be flashed separately. FW is available at www.lab-tools.cz to download as .zip file. FW must be unzipped and contains *.tft file with compiled FW for display.

First start to power UAC, but USB cable must be **unplugged**! Go to menu of UAC "Set CFG" and hit button "Display flashing mode".

In this mode connect USB service cable, select UAC_Display_FW file and hit "Flash Display" button. FW will be uploaded automatically.
After successful flash, turn OFF UAC, disconnect USB and turn ON UAC again.



7.4.8. Page – Version history



Page with indication of the upgrades and new features.

7.5. Universal Actuator Controller SW – multichannel

This utility is designed to record signal from multiple UACs and view recorded files. SW contacts multiple UACs over TCP connection in order to receive signals measured from each of them.

As the connection to each UAC is independent, the time shift between channels may occur.

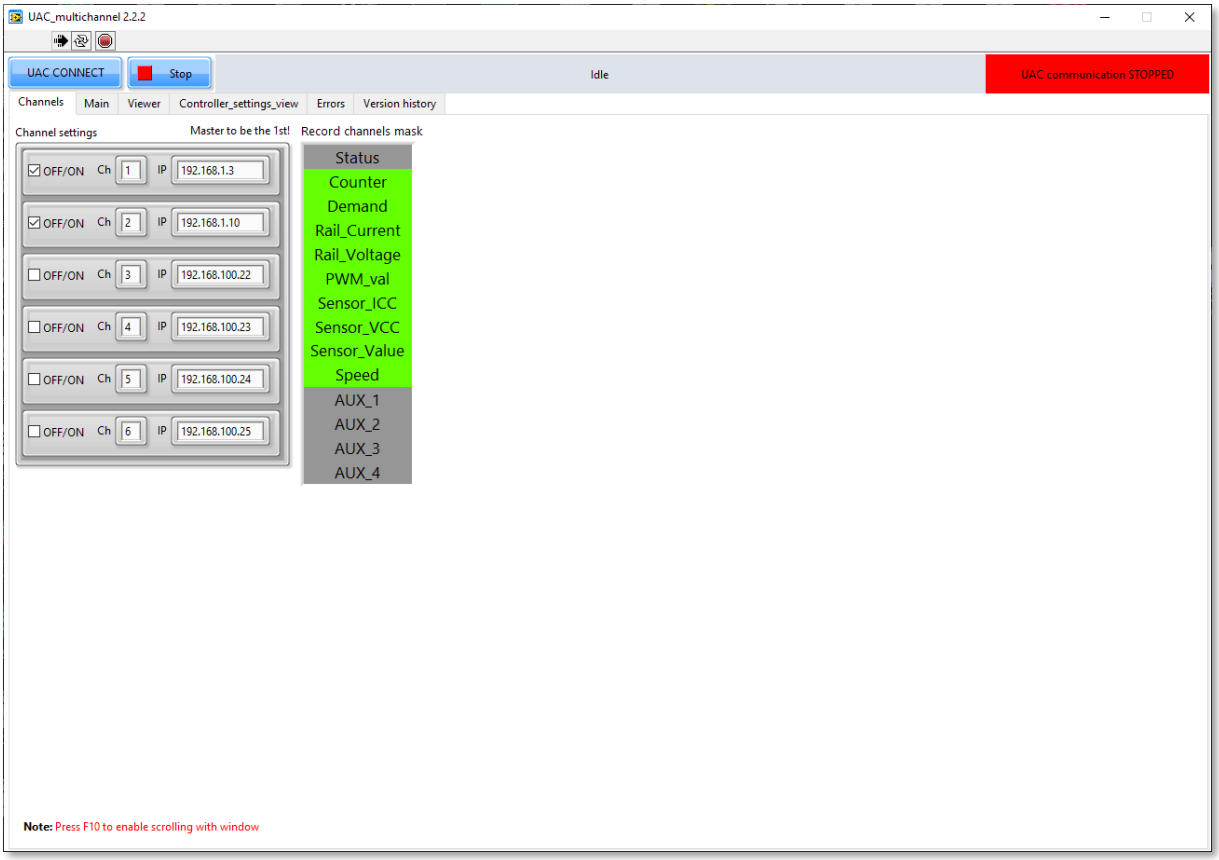
SW is using multiple panels to set and operate this application.

The quantity of data recorded can be set for all UACs connected by setting only channels required for recording.

7.5.1. Panel - Channels

Main settings, simple enable UACs and assign IP address of each UAC. Record channels mask defines which channels will be recorded. In the live view are anyway always showed all channels.

Available are 6 UACs at the same time (6x14 channels = 84 channels total).



7.5.2. Panel - Main

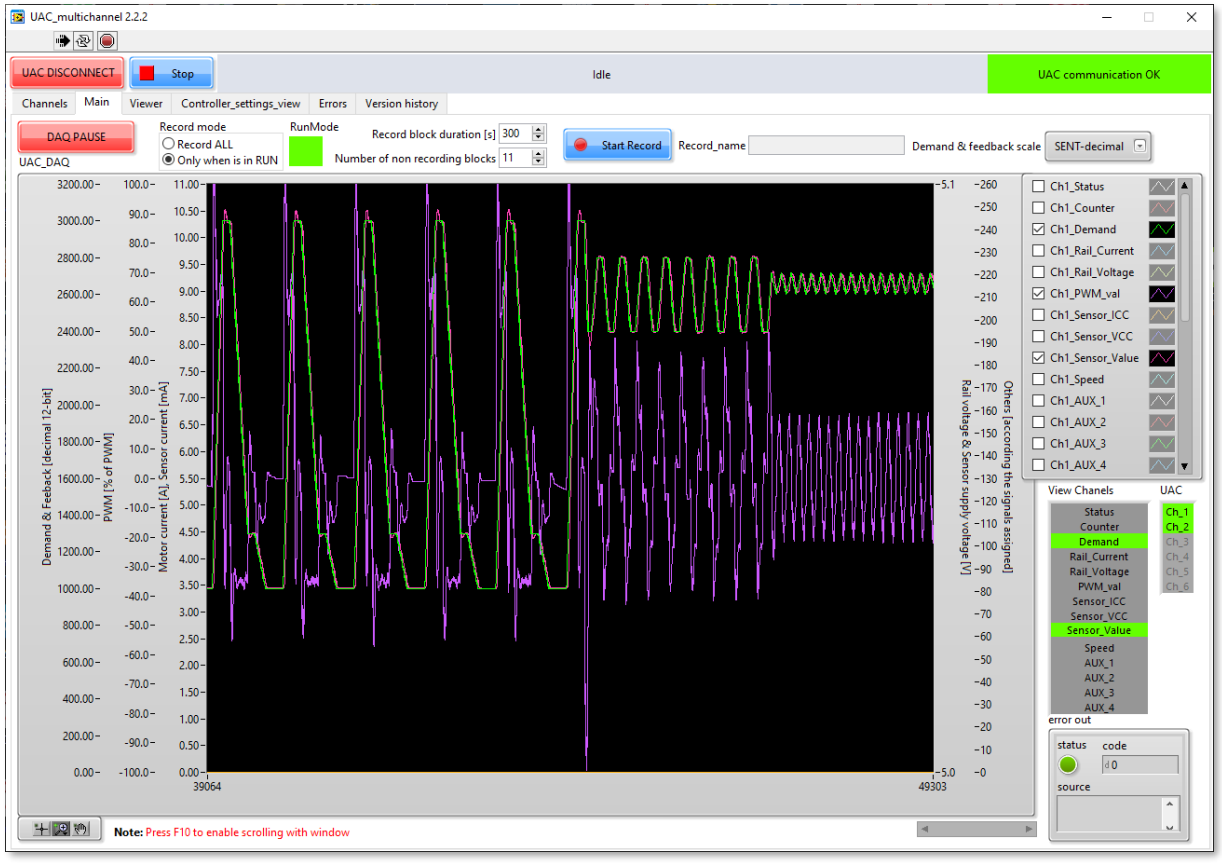
Main view with live data. Each UAC provides 14 channels, which is for 6 UACs 84 signals. To simplify orientation is possible enable/disable signals and UACs by View channels and UAC settings. More detailed settings can be done in signal list to enable/disable each signal.

SW provides multiple options for recording:

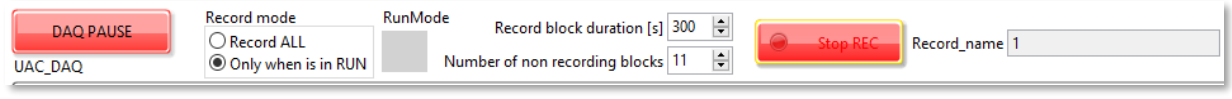
Record mode defines option to record under all condition or use UAC status to stop recording in case paused or deactivated.

Record file duration is set by the block duration (max 300s). Next to this can be set number of blocks to not recording.

In reality SW records also non recording blocks, which are deleted after finish. In case there is some reason to stop recording before it is normally finished and deleted - like error indicated or external stop etc. record is kept on the disk.

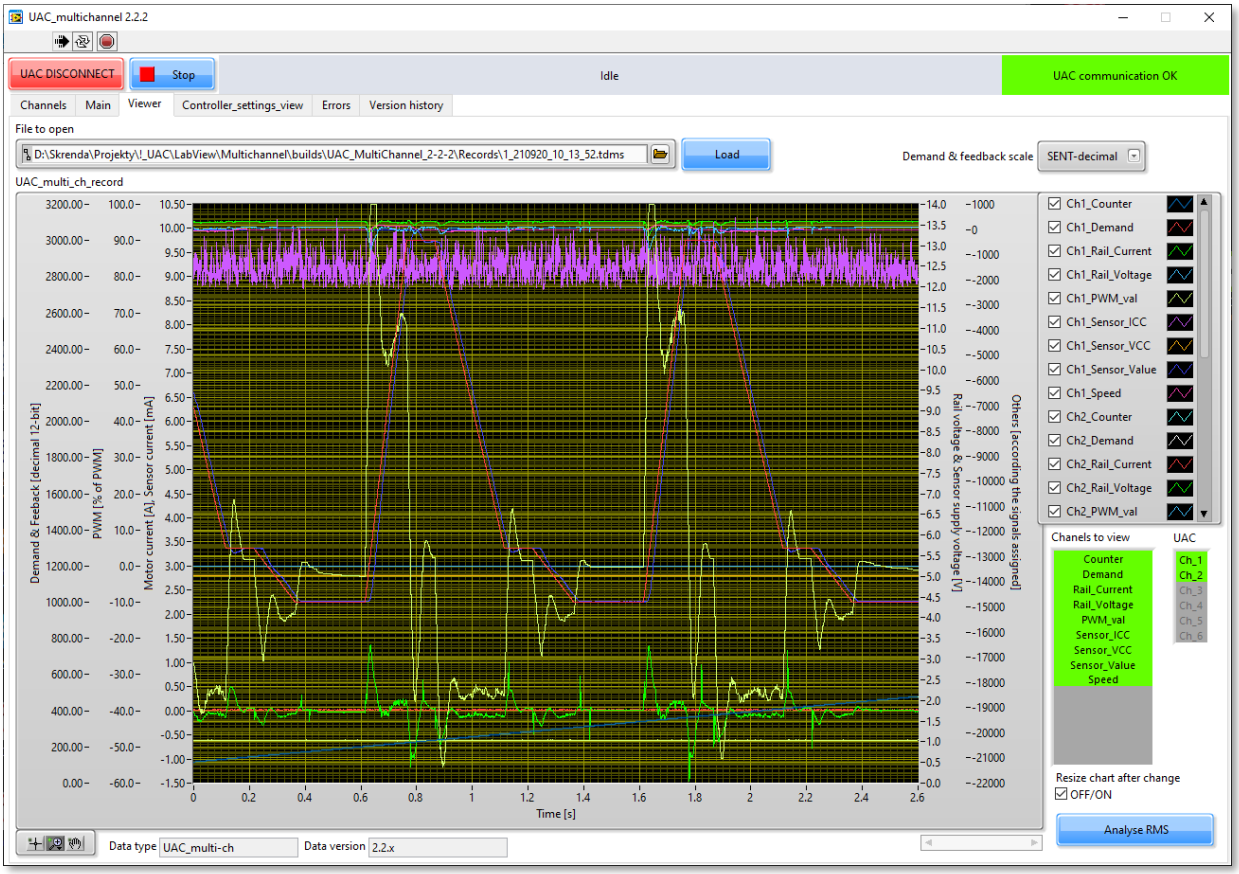


Recording may be waiting for Run mode to start recording. This is indicated by flashing Record control button with yellow border.



7.5.3. Panel - Viewer

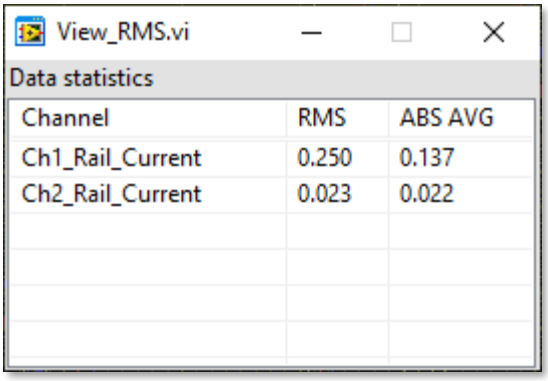
Data viewer can open all .tdms files saved by UAC multichannel SW, similar logic is applied also for channel viewing by “Channels to view” and “UAC” selections to enable/disable UACs or channels at the same time. Switch “Resize chart after change” can impose re-zooming after change of signal view or just hide or show requested signals.



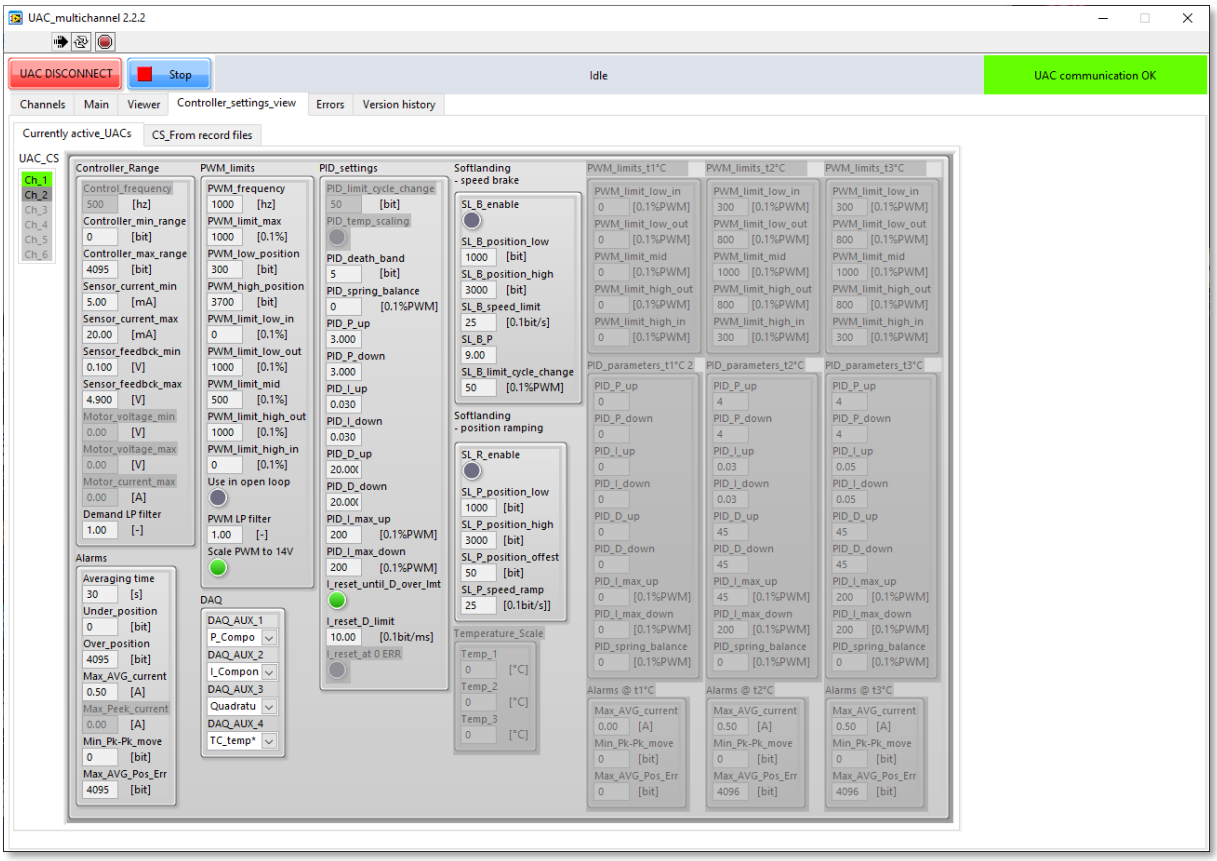
The Controller Settings used at the start of the recording (not with each new file) is available for version 2-2-x and higher. When is loaded record with compatible data, CS is loaded in tab Controlle_settings_view\CS_From record files (see next chapter}.

Analysis RMS is new function which calculates RMS of motor current and mean of current absolute value on recorded channels.

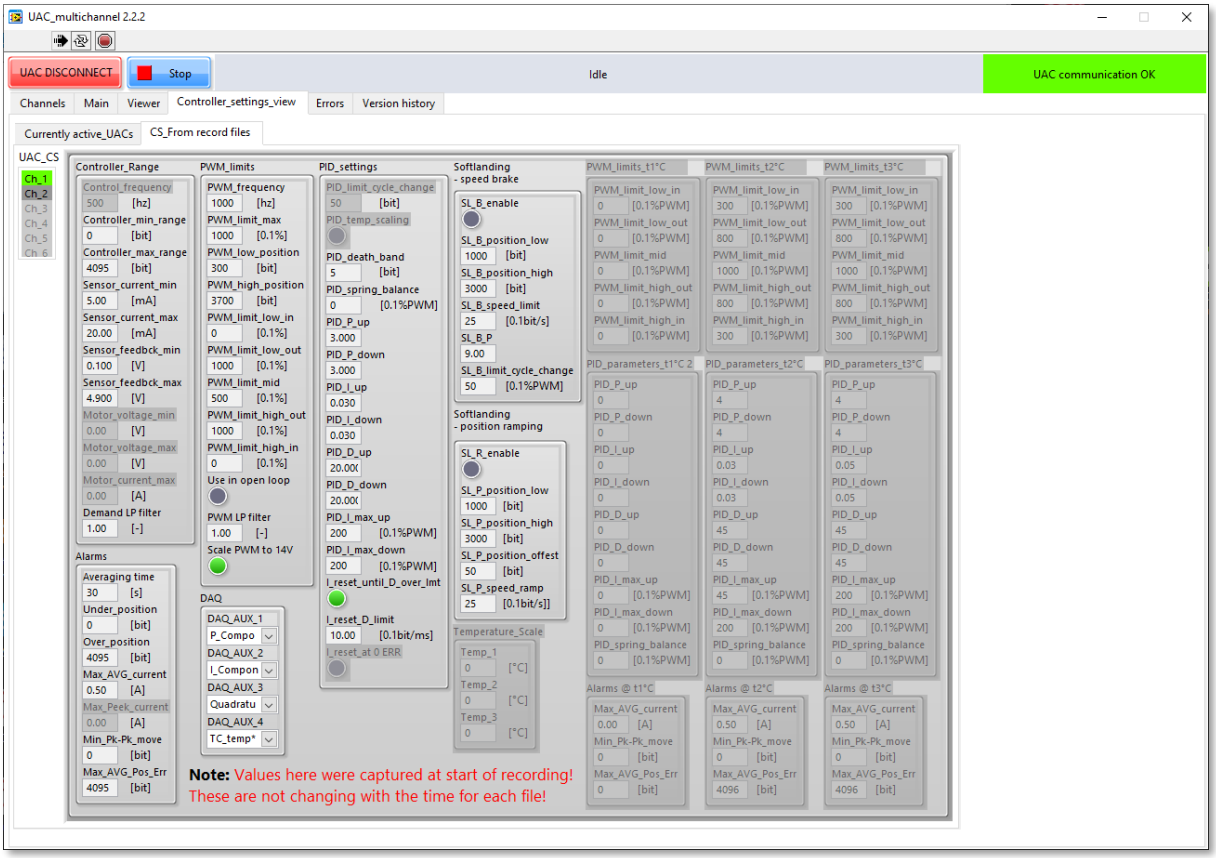
Analyze is performed on active chart view, so by zooming we can analyze only required time interval of the record.



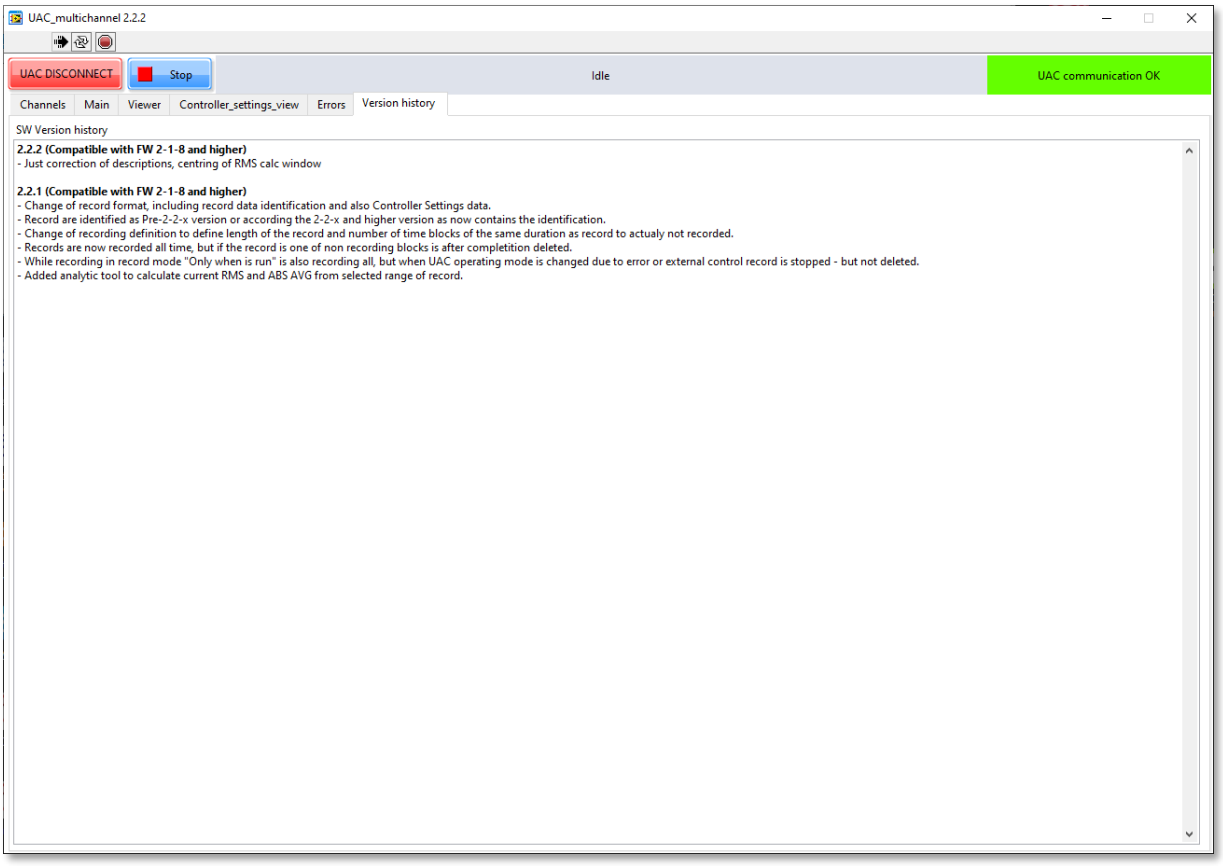
7.5.4. Panel - Controller_settings_view



To see active Controller Settings, go to tab "Controller_settings_view". Under this tab are separated sub tabs for active CS values and also data from record files if these data are available.



7.5.5. Panel - Controller_settings_view



Version history tab contains new changes and function descriptions.

8. Record files definition

Record files of UAC and UAC multichannel are based on TDMS v1 format. This format is supported by LabVIEW and other related products like Diadem and National instruments provides also Excel plug-in for direct import to Excel.

Within the versions evolutions there is number of changes - see next chapters.

8.1. UAC (single channel)

Data	**v 1-x-x**	**v 2-1-x**	**V 2-2-x**
Root Name (file name)	X	X	x
Record_type (UAC_single-ch)			X
Record_version (2.2.x)			X
Signal Groups			
UAC_CS (Controller Settings used)			X
UAC_data (14 meassurement channels)			X
Untitled	X	X	

UAC_signal signals are fixed with all channels

V **v 1-x-x**	Scale to unit	**v 2-1-x / v 2-2-x**	Scale to unit
Status	UAC status	Status	6 bits UAC status + 2 bits sensor status
Counter	[-]	Counter	[-]
Demand	[12-bit]	Demand	[12-bit]
Rail_Current	[A]	Rail_Current	[A]
Rail_Voltage	[V]	Rail_Voltage	[V]
PWM_val	[%]	PWM_val	[%]
Sensor_ICC	[mA]	Sensor_ICC	[mA]
Sensor_VCC	[V]	Sensor_VCC	[V]
Sensor_Value	[12-bit]	Sensor_Value	[12-bit]
Speed	0.1[bit/ms]	Speed	0.1[bit/ms]
Serial_ID	[n/a]	AUX_1	[according signal]
Serial_Val	[n/a]	AUX_2	[according signal]
AUX_1	[according signal]	AUX_3	[according signal]
AUX_2	[according signal]	AUX_4	[according signal]

Note: UAC_signal channel values are written as Double

8.2. UAC-multi-channel

Data	v 1-x-x	v 2-1-x	V 2-2-x
Root Name (file name)	X	X	x
Record_type (UAC_multi-ch)			X
Record_version (2.2.x)			X
Signal Groups			
UAC_CS (Controller Settings used)			X
UAC channel naming	1 up to 6	1 up to 6	UAC_Ch-1 up to UAC_Ch-6

UAC signals are flexible - records contains only selected signals

v 1-x-x	Scale to unit	v 2-1-x / v 2-2-x	Scale to unit
Status	UAC status	Status	6 bits UAC status + 2 bits sensor status
Counter	[-]	Counter	[-]
Demand	[12-bit]	Demand	[12-bit]
Rail_Current	(X-2047)*0.006105[A]	Rail_Current	(X-2047)*0.006105[A]
Rail_Voltage	X*0.008059[V]	Rail_Voltage	X*0.008059[V]
PWM_val	X*0.1[%]	PWM_val	X*0.1[%]
Sensor_ICC	X*0.008058608[mA]	Sensor_ICC	X*0.008058608[mA]
Sensor_VCC	X*0.001221[V]	Sensor_VCC	X*0.001221[V]
Sensor_Value	[12-bit]	Sensor_Value	[12-bit]
Speed	0.1[bit/ms]	Speed	0.1[bit/ms]
Serial_ID	[n/a]	AUX_1	[n/a]
Serial_Val	[n/a]	AUX_2	[n/a]
AUX_1	[according signal]	AUX_3	[according signal]
AUX_2	[according signal]	AUX_4	[according signal]

Note: UAC_signal channel values are written as short (signed 16bit) to save size of the record files.

9. SW Revision history

Note: Version 2-x-x is not compatible with 1-x-x (meaning firmware 1-x-x with Windows SW 2-x-x and vice versa). New version contains more features, so configuration files contains more parameters then used in version 1-x-x. For this reason, is necessary to backup controller profiles before upgrade (ideally as screen shots) and then delete all profiles from controller. Then upgrade UAC FW, then display firmware. With new single channel utility SW 2-x-x then create all profiles again, including profile **"default"** which is loaded at boot of UAC!

9.1. Revision history of UAC firmware

UAC FW 2-1-8

- Add Analog output for SENT/PWM/Analog Sensor feedback
- Fixed temp scaling to work with CAN temp as well

UAC FW 2-1-7

- Fixed crashing of operation due to timing rollover

UAC FW 2-1-6

- Fixed SD motion timing to add cycle when switching block (now frequency is correct)

UAC FW 2-1-5

- CAN smart mode final commands and responses

UAC FW 2-1-3

- Added CAN control as smart actuator

UAC FW 2-1-1

- New AC PID file structure.
    - Added -40 parameters
    - Changed to 3 temperatures
    - change of variables to float to match units
    - Added some of the controls (motor voltage min, motor voltage max, Motor current max,
    - Change of AUX channels
    - Spring offset compensation for each temp
- Restart after settings change
- Update of SD profile generator with correct starting values
- Added Sensor settings in status (bit 7+8)
- Added read Sensor mode for automatic settings of chart
- Added read Operating mode
- Fixed Control Eth problem (demand string after array conversion with additional character)
- Added low pass filter for PWM and PID_set_point
- Added CAN communication error 49
- Added Low power supply error 48 (<7V)
- Added PID err out for AUX channels
- Programmable PWM limitation for open loop mode

UAC FW 1.1.1

- Added remote motion profile reading/manipulation
- Activated temperature CS scaling using local or remote TC in master
- Motion profile single run using specific name "single.000 up to single.009"
- External input control to pause UAC run. Slave units are stopped as well.

9.2. Revision history of UAC single channel SW

UAC SW 2.2.2 (Compatible with FW 2-1-8 and higher)

- Added CS settings window
- Centering of the pop-up windows

UAC SW 2.2.1 (Compatible with FW 2-1-8 and higher)

- Change of record format to include data type description, record file version and entire used CS profile (this allows to set AUX_Chanels in Viewer)
- Loading previous versions of records 1.x.x and 2.1.x

- Main
  - Rescale of objects
  - Record Start/Stop button change of descriptions
  - Compression of object to reduce size
  - F10 enables scrolling of window
  - Added control of scale "Others" including Name, Scale, Offset - trough settings in Viewer
- Controller_settings
  - Correction of descriptors
  - Change of Boolean state colors
  - F8 will enable temperature scaling settings
  - Automatic enable if used profile uses temperature scaling
  - Separated buttons by background to show UAC-RAM/UAC-SC card/PC
  - Added button Clear profile for new profile
- Motion_profiles
  - Added import from CSV
  - Profile generation scaling done in PC not in UAC. This provides smother profile and can be defined in float numbers in PE_ActiveBlock [%/V/bit]
  - Calculation of profile memory usage shown in %
- Viewer
  - Opening of records from previous versions 1.x.x and 2.1.x
  - Added SW type and version indicators
  - Automatic settings of AUX channel names according used CS profile
  - Added functionality to calculate analyze within selected time frame of record
  - Added control of scale "Others" including Name, Scale, Offset + possibility to apply on Main view chart as well
- Actuator testing
  - Separate tests were moved to Actuator testing tab and new tests were added
- Speed & delay & t90
  - Added option to start test at requested position or start at GS detected in open loop
  - Small improvement and reduction of size of UI
- Friction test
  - New test to measure friction current/power/PWM by closed loop movement in triangular demand

- HS test
  - New test to check HS values by open loop movement
- Backlash test
  - Improved BL test with point generator
- Sensor calibration test
  - No update
- Firmware Flash
  - Added recommendation to use Display flashing mode also for UAC core flash

UAC SW 2.1.1 (Compatible with FW 2-x-x and higher)

  - Change of Controller Settings files to new format. New format contains new controls and also PID controls and limits scaling according the 3 temperatures.
  - Files are not compatible with previous version! Correct FW must be used as well!
  - Added last command indication
- Main
  - Rescale of objects
  - Controller_settings
  - Added many new control parameters
  - Change of parameter units to avoid recalculation from bits
  - Implemented 3 temperature scaling to allow compensate Low and High temperature as well
- Motion_profiles
  - Change of control tables to simplify editing of cells to single click
  - Added button New to create new profile
  - Added definition of profile repetitions
- Viewer
  - No update
- Speed&delay t90
  - No update
- Sensor calibration test
  - No update
- Backlash test
  - New test for manual measurement of backlash
- Firmware Flash
  - No update

UAC SW 1.1.0

- Adding motion profile editor to be part of the SW
- Added independent CS window for usage with secondary screen
- Adjusted scales on signals plots to be same with multichannel version
- Added demand/sensor feedback scale selector for SENT/Voltage/PWM
- Improved flashing of FW in automatic way

9.3. Revision history of UAC multi-channel SW

UAC-MultiCh 2.2.2 (Compatible with FW 2-1-8 and higher)

- Just correction of descriptions, centering of RMS calc window

UAC-MultiCh 2.2.1 (Compatible with FW 2-1-8 and higher)

- Change of record format, including record data identification and also Controller Settings data.
- Record are identified as Pre-2-2-x version or according the 2-2-x and higher version as now contains the identification.
- Change of recording definition to define length of the record and number of time blocks of the same duration as record to actually not recorded.
- Records are now recorded all time, but if the record is one of non-recording blocks is after completion deleted.
- While recording in record mode "Only when is run" is also recording all, but when UAC operating mode is changed due to error or external control record is stopped - but not deleted.
- Added analytic tool to calculate current RMS and ABS AVG from selected range of record.

UAC-MultiCh 1.1.0

- Added demand/sensor feedback scale selector for SENT/Voltage/PWM
- Fixed call of system library kernel32.dll