
# VT-IRFTi / IRFTx

## Operator and Configuration Manual

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**Note:**

Subject to change without notice.

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# Introduction

The VT-IRFTx transmitter and a torsional resonating sensor combine to a system for measuring viscosity of liquids in reactors, tanks and pipes.

The system consists of a sensor and transmitter to measure the viscosity precisely. Dependent on the sensor style the viscometer is for in-line process measurement of low, medium or high viscosity fluids, however other versions are available. Shear dependent fluids also provide good results but need matching to the right sensor for shear and viscosity. Examples for viscometer uses in process are: Batch processes for polymerization, emulsion and dispersion. In-line mixing in pipes is another example.

The ViscoTron measurement system has been developed for maintenance free operation in process applications. The sensor does not have any moving parts. The torsional oscillation operating principal is being utilized for viscosity measurement. Torsional oscillating viscometers measure the viscosity as viscosity x density due to the acceleration of the molecules from the torsional motion. A typical measurement display would be in mPa·s x gr/cm3.

VT-IRFT transmitters are compatible with torsional resonating viscosity sensors. The transmitters work both with sensors built and designed recently, as well as with older versions from Viscotronics and other manufacturers. Older existing sensors may need rewiring and recalibration with the new transmitter. The calibration can be done entirely at site using only the transmitter connected to the sensor. Other external equipment is not required.

ViscoTron IRFT transmitters induce a natural resonance response into the sensor bulb. The resonant frequency response is intelligently analyzed. The system provides viscosity results within less than a second. Averaging for smoothing of erratic signals is selectable. Viscosity is related to the power at the resonance frequency. A calibration curve is applied to calculate the viscosity.

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# VT-IRFTx Operator Functions

## VT-IRFTx Operator Interface

- The transmitter display includes a touch panel for operation and configuration. Configuration from the touch panel is password protected to prevent unauthorized access. Accessible operator tasks are limited to changing the display type.
- Configuration and calibration can be done entirely using only the touch panel, no extra external devices are required. Additional connections via USB, RS485 or BlueTooth enable further actions via a command line interface and recording of data using a Modbus protocol. Generic BlueTooth apps are available for iOS and Android. A micro SD card can be inserted for data saving, which eliminates the requirement to connect via USB, BlueTooth or RS485.


Default Start-Up screen

Note: Viscosity is shown in Magenta until the selected moving average array has been completely filled

- The micro controller used for the VT-IRFTx is a single task computer, its main task being to measure viscosity.
- Displays and other tasks are secondary to the main task, so that viscosity measurement is not interrupted.
- To access the menus push anywhere in the top two thirds of any measurement display screens until the display blinks - some screens allow to push anywhere on the screen. The screen will change to a menu, dependent on the measurement cycle.

## Default screen display

Displays and other tasks are secondary to the main task and may require waiting for completion, viscosity and other measurements have priority.


Descriptor of viscosity units, the descriptor is configurable.

The green LED blinking indicates a measurement is generated.

The red LED blinking indicates that the measurement has automatically been rejected due to interference of vibration or other problems.

Viscosity displayed in calibrated range and selected units

Measured Resonance

Sensor Resonance

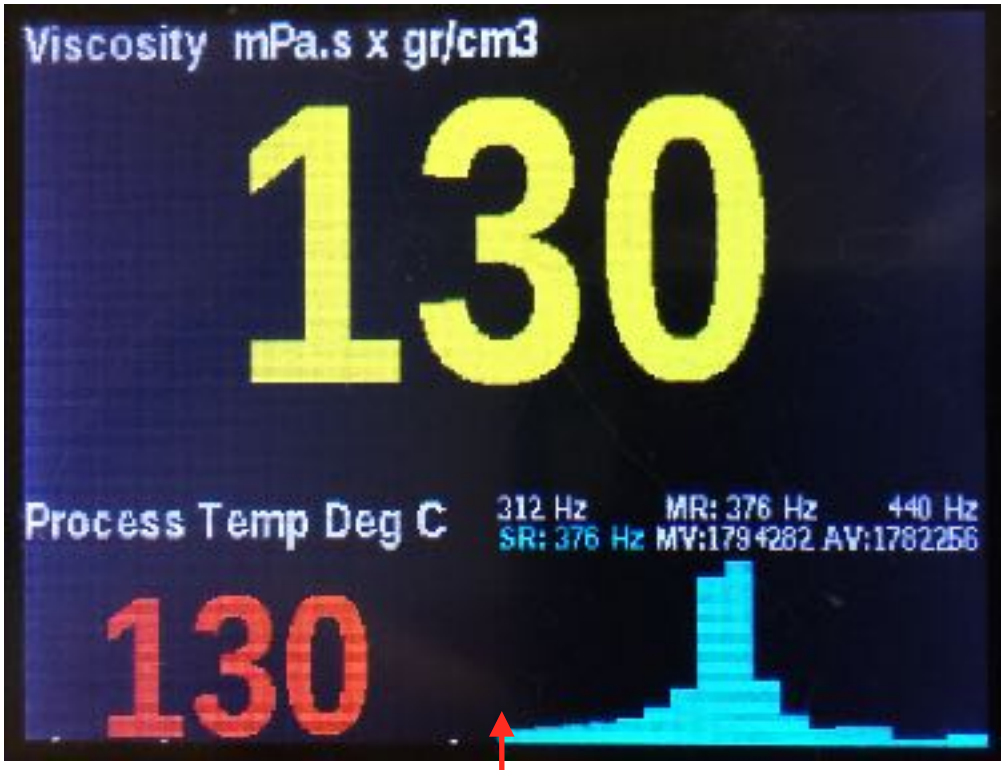
Temperature displayed in selected units

Descriptor of temperature units, can be changed via computer, BlueTooth interface or touch panel menu.

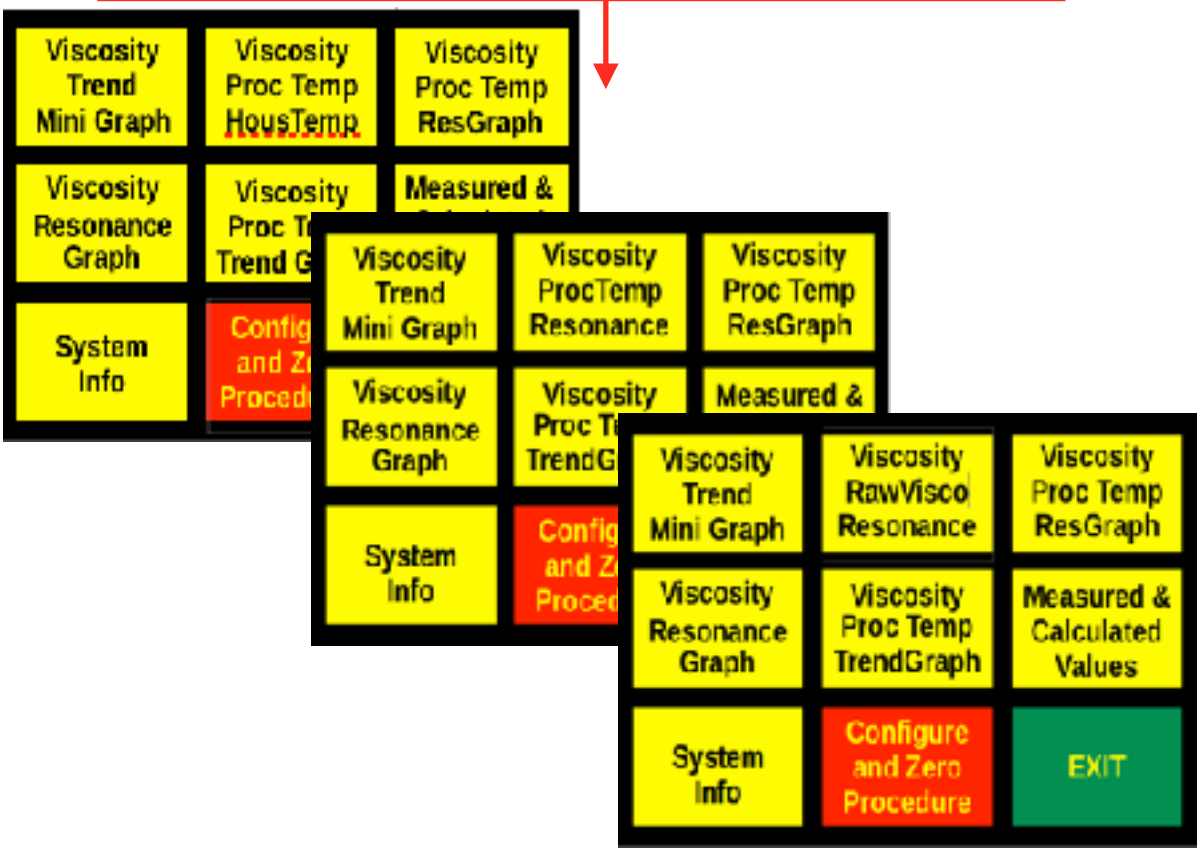
Sensor resonance graphically displayed.

FFT measurement range, resonant frequency, instant measurement values and the average value.

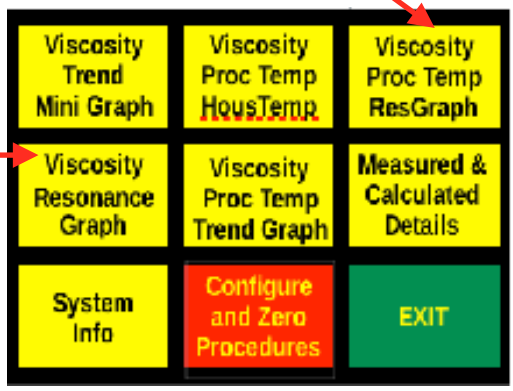
## Operator display screen actions and displays




Pushing anywhere in the top two thirds of any measurement display screens until the display blinks, opens one of the menus below dependent on hardware configuration. If the menu screen is left running it will timeout to the previous display after a predetermined time.

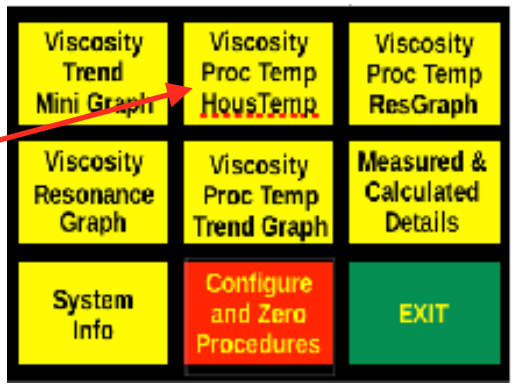


- Pushing on the Viscosity / Proc Temp / ResGraph button until the screen blinks opens the default display above. If process temperature measurement is not installed, the resonant frequency will be shown instead.
- Pushing on the Viscosity Trend Mini Graph button until the screen blinks will open the display below.



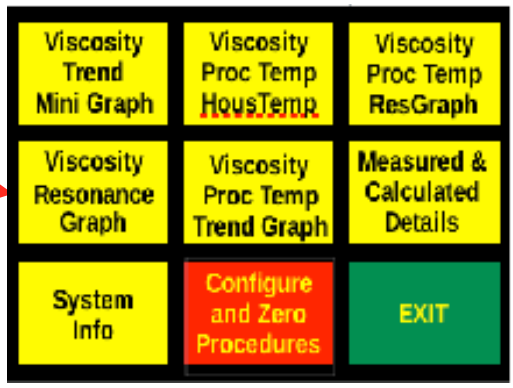

Displaying viscosity units the current value and a miniature trending graph.


The length of the trend can instantly be changed between about 5, 15, 60 minutes and 5 hours, depending on analysis time. The graph represents stored and averaged measurement values taken in about 1, 3, 12 and 60 second intervals. To change the length of time push in the lower 4 rectangles from left to right. The starting time and current time (last measurement) are indicated.
Scaling is done automatically, no intervention is needed or possible.




Pushing on the Viscosity / Proc Temp / Hous Temp button until the screen blinks opens the display below. If the housing temperature measurement is not installed, the resonant frequency will be shown instead. If the process temperature measurement is not installed either, the raw viscosity measurement will be shown instead.

- Pushing on the Viscosity / Resonance Graph button until the screen blinks opens the display below.

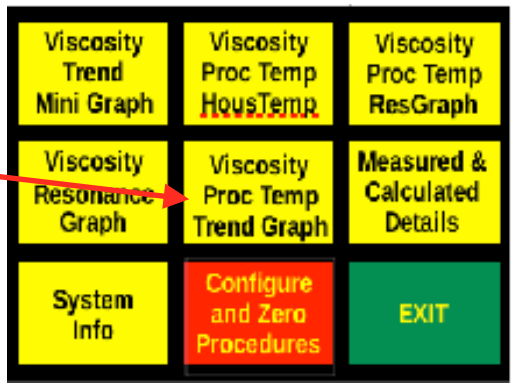



Displaying viscosity units


The graphical indication of the FFT analysis. The bottom row from left to right indicates the configured Sensor resonance, the bin width determined during setup (default 8 Hz), the measurement window width, the measurement value and the average value. The top row shows the measured resonant frequency of the peak and the lower and upper frequencies of the graph. The peak bar is automatically adjusted for indication only, enabling indication independent of the true peak value. The signal should be relatively stable, if it jumps side - especially by a wide margin - to side, it is an indication of external influence such as vibration.

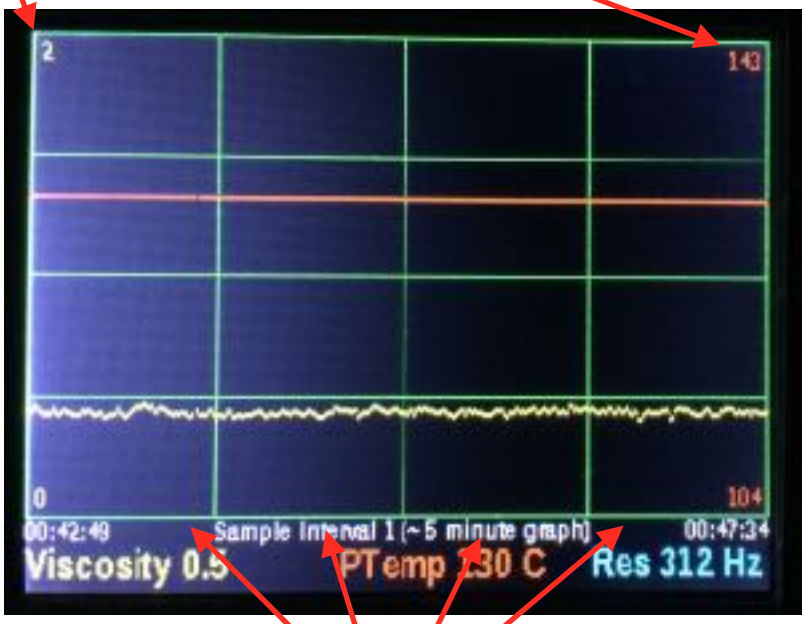
- The bottom part of the screen updates with the measurement cycle, the viscosity indication in the top updates at the preset display update timing cycle (default 2.0 sec).

Pushing on the Viscosity / Proc Temp / Trend Graph button until the screen blinks opens the display below.



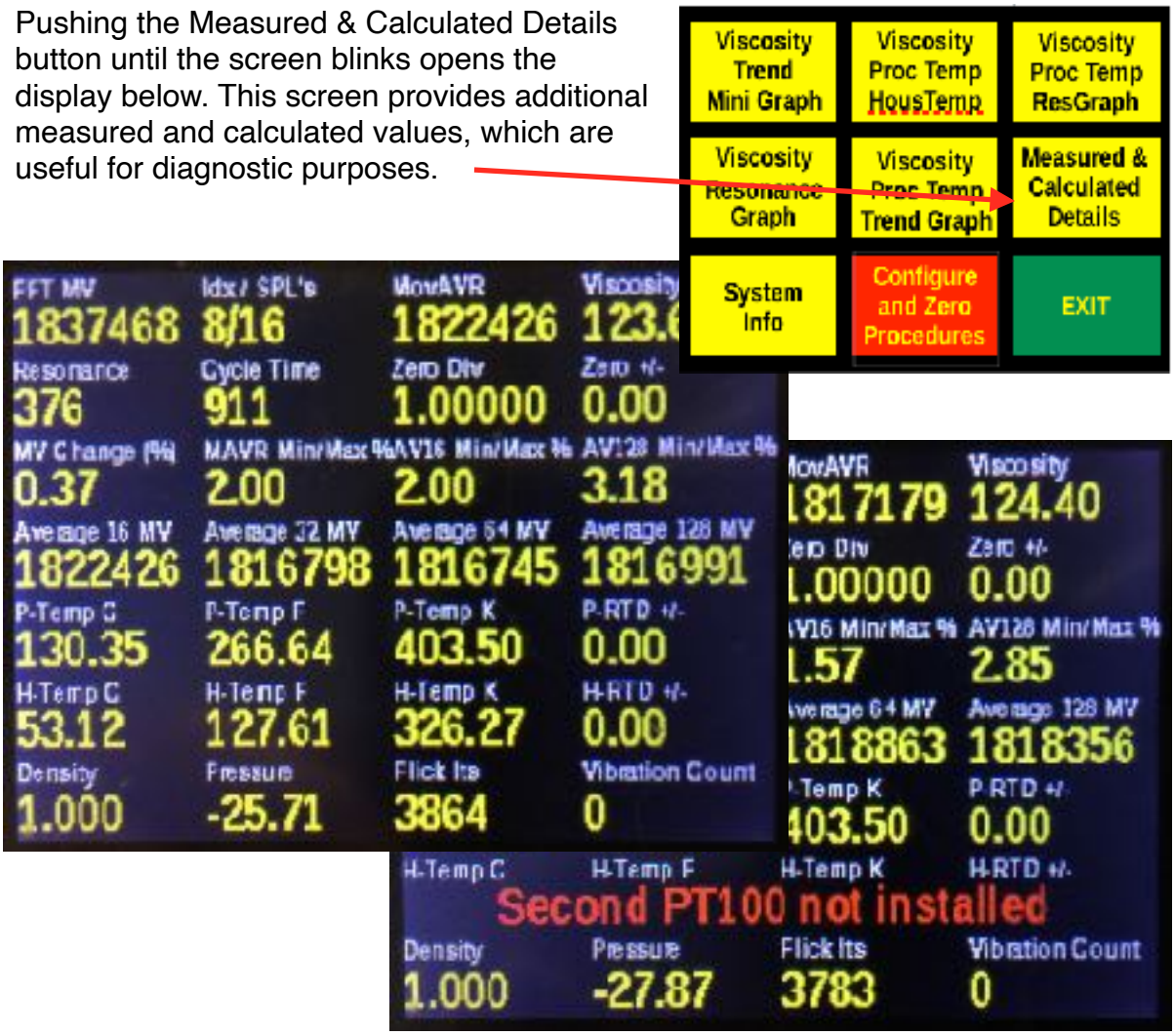

Display of the viscosity range for the graph.

Display of the process temperature range for the graph.




The length of the trend can instantly be changed between about 5, 15, 60 minutes and 5 hours, depending on analysis time. The graph represents stored and averaged measurement values taken in about 1, 3, 12 and 60 second intervals. To change the length of time push in the lower 4 rectangles from left to right. The starting time and current time (last measurement) are indicated.
Scaling is done automatically, no intervention is needed or possible.
The bottom of the screen shows the current values for viscosity, process temperature and resonant frequency.

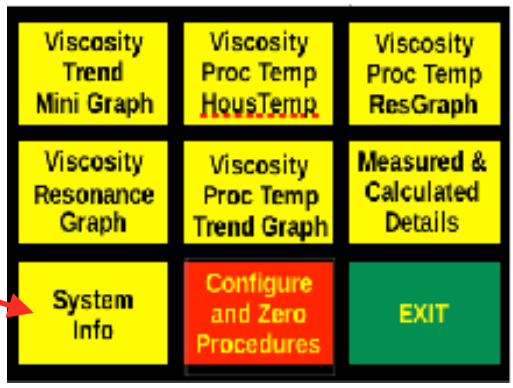
- Pushing the Measured & Calculated Details button until the screen blinks opens the display below. This screen provides additional measured and calculated values, which are useful for diagnostic purposes.




- Designations starting at the top left:
  - FFT MV > FFT value measured at the resonance peak. This is the equivalent for the viscosity.
  - Idx / SPL's > The left number shows the index of the current sample being updated, the right number shows the number of samples being averaged (array size).
  - MovAVR > Moving average used to calculate the viscosity.
  - Viscosity > Viscosity calculated from the moving average.
  - Resonance > Current resonance of the sensor.
  - Cycle Time > Time for one complete analysis cycle in milli seconds. The analysis time is dependent on setup and calibration, very low viscosities ranges may take longer to analyse.
  - Zero Div > Ratio being used to correct for a viscosity shift after installation. The number shown depends on the zero procedure used to create this number.
  - Zero +/- > Viscosity being subtracted or added to make the display show zero after installation. The number shown depends on the zero procedure being used to create this number.

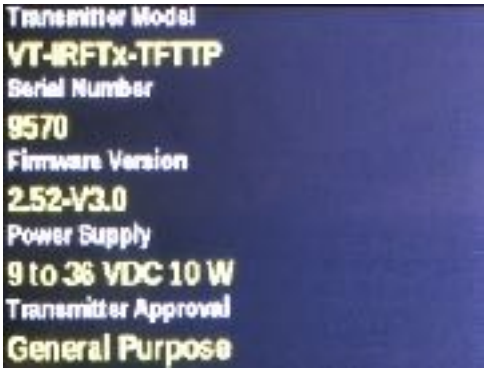
- Max Chng (%) > Maximum deviation from the previous raw FFT measurement. A measurement with a deviation larger than a percentage set, when comparing the last three samples, will be rejected as vibration.
- MAVR Min/Max % > The difference between the minimum and maximum raw values in the moving average array in percent.
- AV16 Min/Max % > The difference between the minimum and maximum raw values in the 16 average array in percent.
- AV128 Min/Max % > The difference between the minimum and maximum raw values in the 128 average array in percent.
- Average 16 MV > The average value in the 16 average array.
- Average 32 MV > The average value in the 32 average array.
- Average 64 MV > The average value in the646 average array.
- Average 128 MV > The average value in the 128 average array.
- P-Temp C > Process temperature in degrees Celsius.
- P-Temp F > Process temperature in degrees Fahrenheit.
- P-Temp K > Process temperature in degrees Kelvin.
- P-RTD +/- > Correction adder or subtractor in Celsius used for the process temperature display.
- H-Temp C > Housing temperature in degrees Celsius.
- H-Temp F > Housing temperature in degrees Fahrenheit.
- H-Temp K > Housing temperature in degrees Kelvin.
- H-RTD +/- > Correction adder or subtractor in Celsius used for the housing temperature display.
- Density > Density value being used if density compensation is being applied.
- Pressure > Pressure value being used if pressure compensation is being applied.
- Flick Its > The number of induced resonances analyzed for measurement or interference since power up.
- Vibration count > Number of samples rejected due to vibration, 1 vibration sample is being deducted for every good measurement sample since the last vibration sample.

- Pushing the System Info button until the screen blinks opens the screens below providing general information about the system.




- Manufacture information


- Transmitter model information

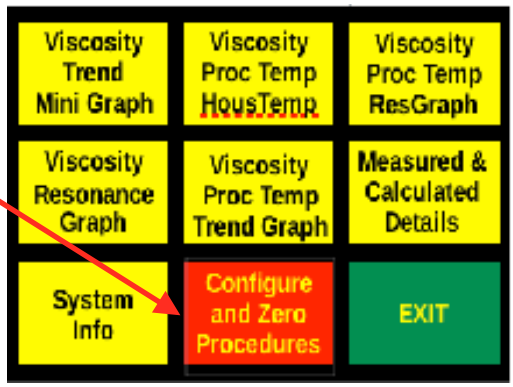


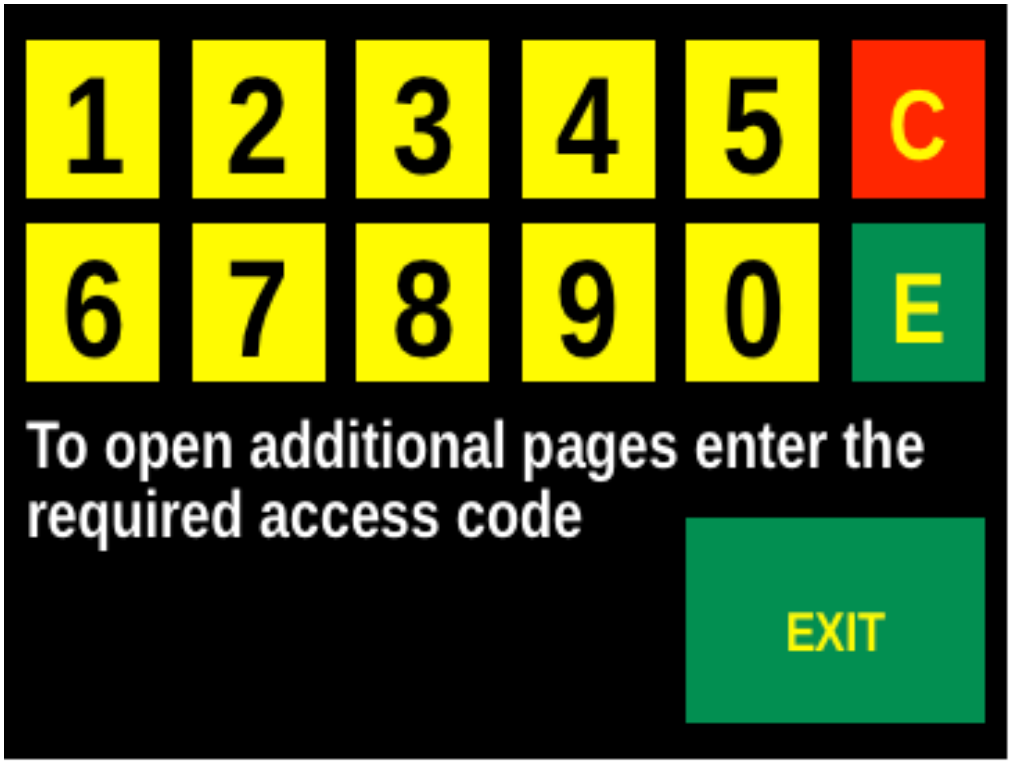

- Transducer model information


- Internal SD Card information, if a SD card has been inserted

# VT-IRFTx Configuration Functions

- Pushing on Configure / and Zero / Procedure opens the display shown below.



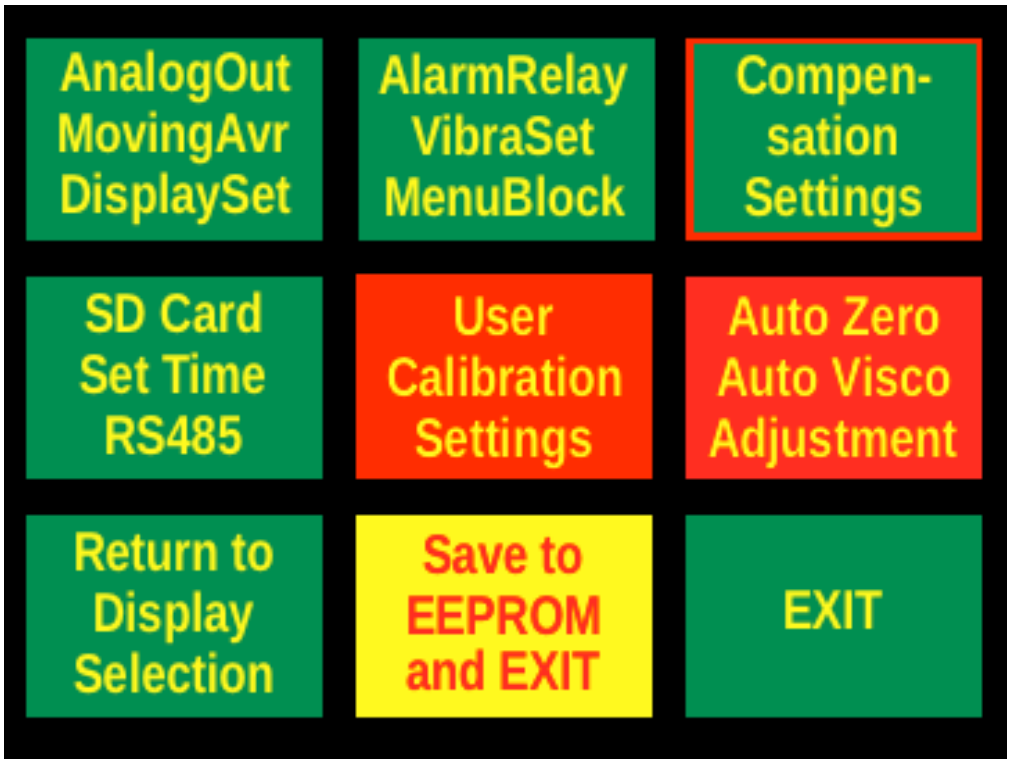

- Accessing the configuration screens or the viscosity adjustment screens requires access codes, which are shown in the calibration certificate.
- Pushing on any number until the screen blinks will enter that number and show it immediately in the bottom space.
- Pushing C until the screen blinks clears the entire entered number.
- Pushing E until the screen blinks will enter the number into the system and open the associated screen. If an invalid number has been entered the screen returns to the previous display.
- Pushing EXIT until the screen blinks will return to the previously displayed screen.

### General menu selection information

- Yellow buttons with black only descriptions generally indicate the possibility to enter a number via the number keypad.
- Yellow buttons which include black and red descriptions are either toggle buttons or an entry via the keypad can be made. Pushing the toggle button repeatedly will cycle through selections and the red description will change, indicating the selected function. If an entry via keypad has been made the entered values will be shown.
- Blue buttons with black description indicate analysis functions. **Please note: Measurement of viscosity and other measurements will be interrupted during analysis.**
- Green buttons with yellow descriptions are menu selections.

## Configuration procedures access

- After having entered the appropriate access code, the menu selection screen below appears.




- AnalogOut / MovingAvr / DisplaySet
  - Pushing on this button provides access to adjust analog output settings, select a moving average and display update times.
  - If the button is framed with a red line, a secondary access code is required.
- AlarmRelay / VibraSet / MenuBlock

- Pushing on this button provides access to alarm settings, including viscosity, process temperature, housing temperature, vibration and a control setting for housing temperature, if so equipped.
- Access to the menu blocking feature allows to selectively block access to the screens available via the green menu access buttons. If the button is framed with a red line, a secondary access code is required.

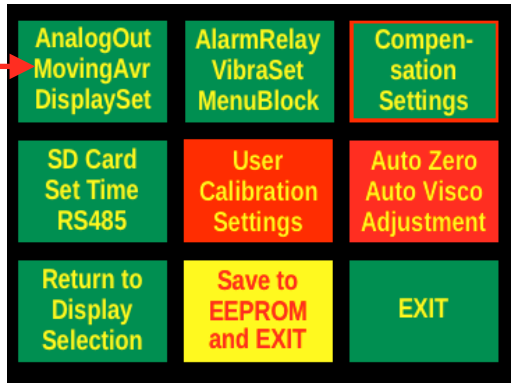
- Compen- / sation / Settings
  - Pushing on this button provides access to compensation settings for viscosity, including temperature, density and pressure compensation.
  - If the button is framed with a red line, a secondary access code is required.
- SD Card / Set Time / RS485
  - Pushing on this button provides access to the SD card features for saving preselected data to files. A time based default name can be selected or alternatively a file name can be input via the numbers key entry. The real time clock can be set from this menu. RS485 Modbus settings are available in this menu.
  - If the button is framed with a red line, a secondary access code is required.
- User / Calibration / Settings
  - Access to calibration settings requires a special access code, which is stated in the calibration sheet.
  - The menu provides access to multiple calibration pages.
  - Please refer to the VT-IRFTx Calibration Functions section for further information.
- Auto Zero / Auto Visco / Adjustment
  - Access to auto zero and auto viscosity procedures requires a special access code, which is stated in the calibration sheet.
  - Please refer to the VT-IRFTx Calibration Functions section for further information.
- Return to / Display / Selection
  - Pushing on this button returns to the display selection screen.
- Save to / EEPROM / and Exit
  - Pushing on this button will save all current settings to EEPROM and exit to the previous viscosity display screen.
- EXIT
  - Pushing on this button returns to the previous viscosity display screen.

- AnalogOut / MovingAvr / DisplaySet, AlarmRelay / Settings / MenuBlock, Compen- / sation / Settings and Save to / SD Card / Set Time access can be individually blocked or given permission to access using the menu blocking

function in the AlarmRelay / Settings / MenuBlock menu. Once access has been blocked a secondary access code is required to access those menus.

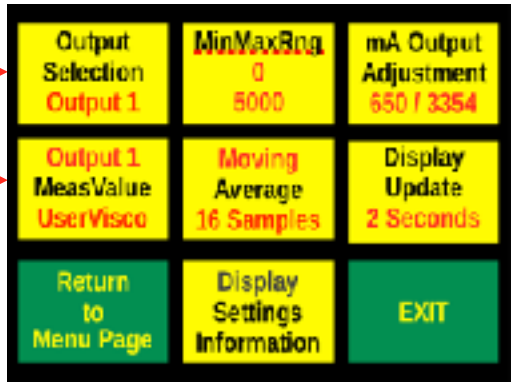
## Analog Output, Moving Average and Display Settings

- The menu provides access to set analog outputs, select the number of samples to average, set the display update cycle and display the current settings.



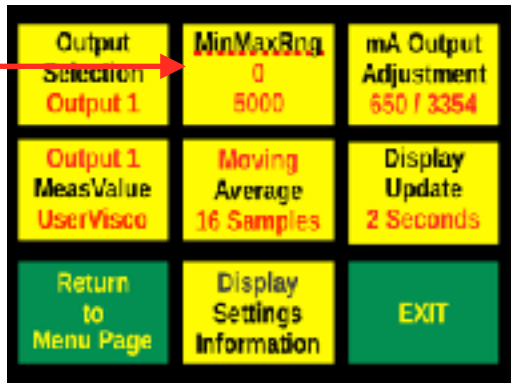

### Analog output selection and settings

- Pushing the Output Selection button until the screen blinks repeatedly will cycle through the available output selections.
- Pushing the Output MeasValue button until the screen blinks repeatedly, will cycle through the output measurement value selections.

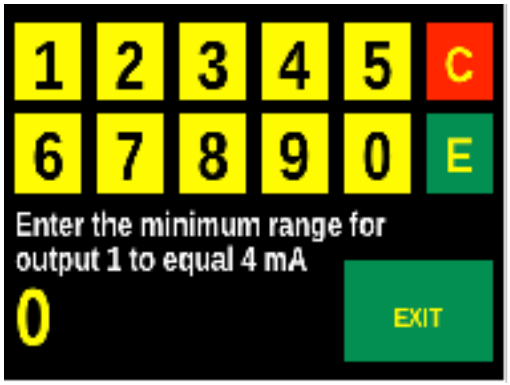



- Pushing repeatedly or continuously on the Output Selection button cycles through the available choices of analog outputs for the transmitter. At each screen update the next choice will be shown. A maximum of 2 optional outputs are available. Available choices are:
  - Analog output 1 Selectable, default user viscosity
  - Analog output 2 Selectable, default process temperature
  - The parameters for outputs 1 and 2 can be assigned by selecting the measurement value with the MeasValue button. The selection parameters are cycled in the order shown below. Available options are:
    - Raw user viscosity
    - Zeroed viscosity
    - Dynamic viscosity
    - Kinematic viscosity
    - User viscosity (includes all applied compensations, such as temperature and pressure)
    - Process temperature
    - Housing temperature
    - Selctd AVR ( this is the moving average of the FFT measurement value , which is used to calculate the viscosity)

- Pushing on the MinMaxRng button after selecting an output to be set, opens the numeric keypad below.

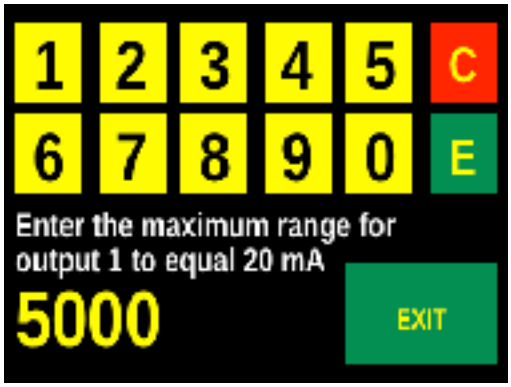



- Enter an integer number to equal the minimum for the range of the selected output and measurement value by pushing on the numbers consecutively. The entered value will appear in yellow directly below the comment.



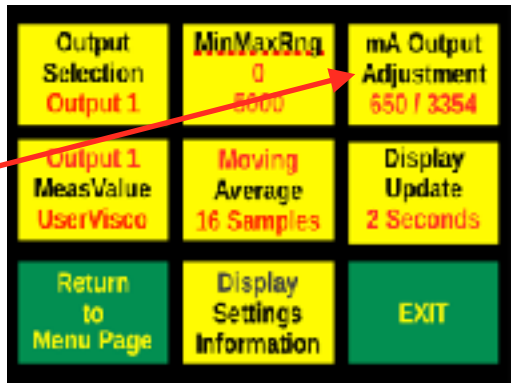

  - Pushing on E will enter the chosen number and advance to the screen below.
  - Pushing on C will clear all entered digits.
  - Pushing on Exit will return to the previous viscosity display

- Thereafter enter an integer number to equal the maximum for the range of the selected output and measurement value by pushing on the numbers consecutively. The entered value will appear in yellow on the bottom.

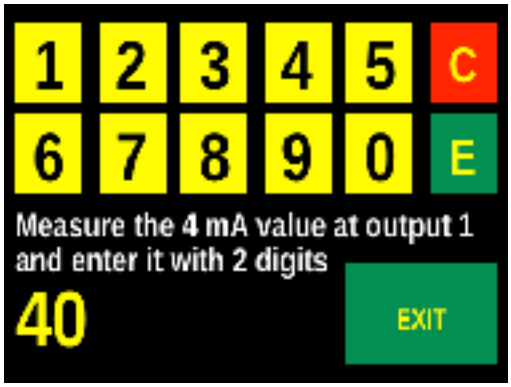



  - Pushing on E will enter the chosen number and return to the analog selection screen.
  - Pushing on C will clear all entered digits.
  - Pushing on Exit will return to the previous viscosity display

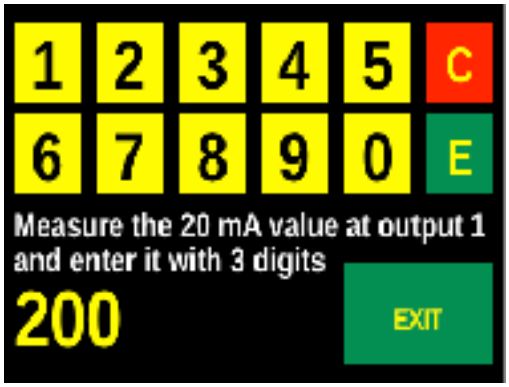
- Pushing on the ma Output/ Adjustment button after selecting an output to be set, cycles through three keypad selections. The three selections provide instructions to measure the mA value at the selected output and enter the measured number in integers to create a correction for the selected output if required. The three selections are required to be entered consecutively. The entered numbers will automatically be divided by 10 to provide a decimal.



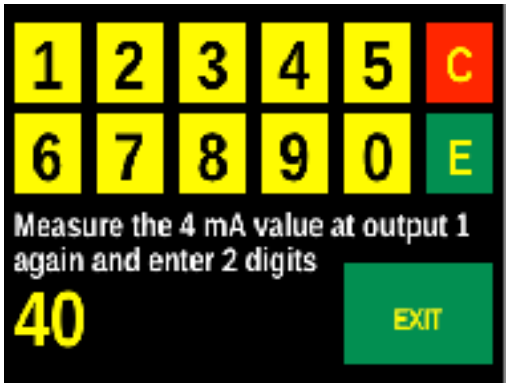

  - Measure the 4 mA value at the selected output and enter it with 2 digits, then press on E to enter it.
  - Pressing on C will delete the entire entered number, so a new one can be entered.
  - Do not press on Exit but make sure to go through the next selection by entering a number.



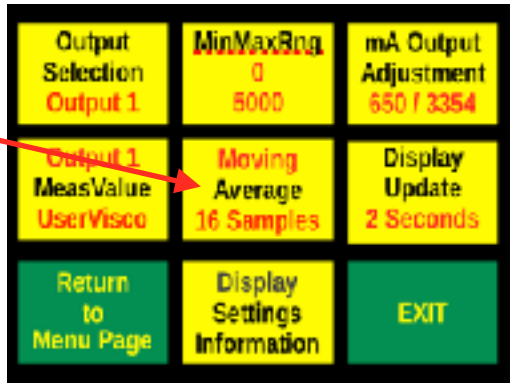

  - Measure the 20 mA value at the selected output and enter it with 3 digits, then press on E to enter it.
  - Pressing on C will delete the entire entered number, so a new one can be entered.
  - Do not press on Exit but make sure to go through through the next selection by entering a number.




  - Measure the 4 mA value at the selected output again and enter it with 2 digits, then press on E to enter it.
  - Pressing on C will delete the entire entered number, so a new one can be entered.
  - Do not press on Exit but make sure to enter a number and press on E. A correction factor will be created to correct any offsets of the mA output.



### Selecting a moving average



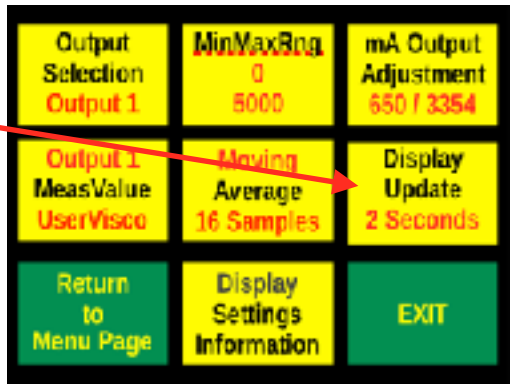

- Pushing on the Moving Average button repeatedly, cycles through the available averaging choices to be used for for the moving average. At each screen update the next choice will be shown. The displayed number of samples will be used to generate a viscosity value to be displayed. A sample is typically generated in less than one second but it is dependent on the viscometer style and range. Switching between the available averaging choices is instant. The default is 16 samples, which means all 16 averaging samples will have been updated during the previous 10 to 20 seconds when using the default setup. The following choices are available:

  - 4 samples
  - 8 samples
  - 16 samples (typical average of about the previous 15 seconds)
  - 32 samples (typical average of about the previous 30 seconds)
  - 64 samples (typical average of about the previous 60 seconds)
  - 128 samples (typical average of about the previous 2 minutes)
  - 256 samples (typical average of about the previous 4 minutes)

- In case of a lot of measurement noise (vibration) a sample may be rejected based on the settings,  a complete averaging update will take correspondingly longer.

### Selecting a display update interval

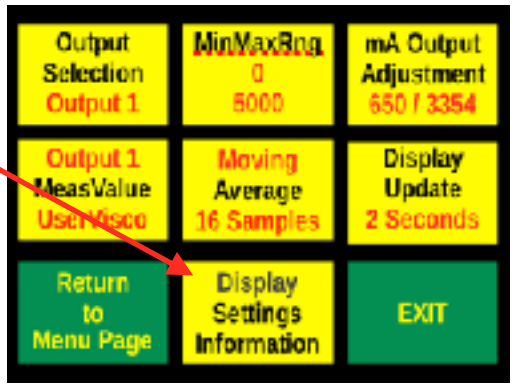
- Pushing on the display update button repeatedly cycles through the available display update choices. The screen and values will be updated per the selected interval.




- The display screen update is independent from the measurement and averaging cycle and has no influence on those either. The screen update is an approximate time only and depends on the measurement cycle. Available approximate intervals are:
  - 2 seconds
  - 5 seconds
  - 10 seconds
  - 15 seconds
  - 30 seconds
  - 60 seconds

## Display Setting Information

- Pushing on the display settings information button opens the screen shown below.



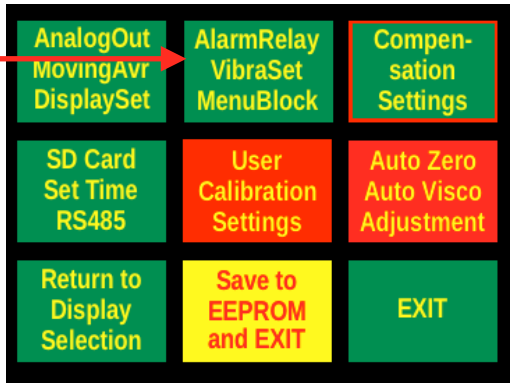


- Descriptions:
  - Out 1 MeasValue — Measurement value for analog output 1
  - Out 2 MeasValue — Measurement value for analog output 2
  - Available selections:
    - RawVisco — Raw viscosity
    - ZerodVisco — Zeroed viscosity
    - DynVisco — Dynamic Viscosity
    - KinVisco — Kinematic Viscosity
    - Viscosity — User Viscosity
    - P Temp C — Process temperature in degrees C
    - H Temp C — Housing temperature in degrees C

  - Out 1 Min — Minimum range equivalent (4 mA) for output 1
  - Out 1 Max — Maximum range equivalent (20 mA) for output 1
  - Out 2 Min — Minimum range equivalent (4 mA) for output 2
  - Moving Average — Number of averages used for moving average
  - DspUpd(sec) — Display update interval in seconds
  - Cycle Time(msec) — One analysis cycle in milli seconds

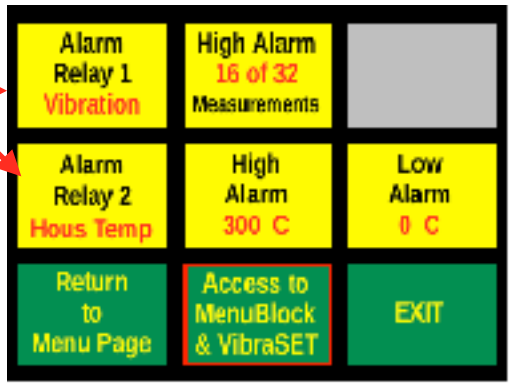
## Alarm, Alarm Relay and Menu Block Settings

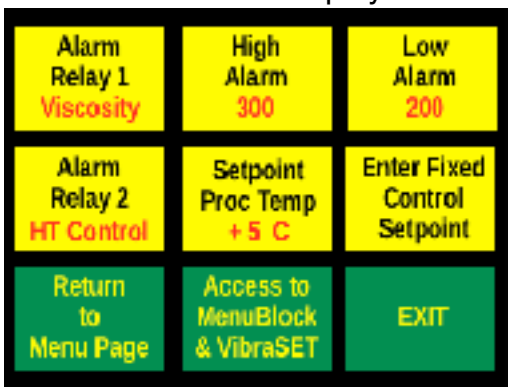
- The menu provides access to set alarm limits, settings to filter out external influences like vibrationand block access to menu selections.
- Alarms can be configured and displayed independent of whether they are physically available in the hardware.




### Alarm relay output selection and settings

- Alarm output settings and selections.
  Most of the available selections are identical for alarm relay 1 and alarm relay 2, however alarm relay 2 has one extra selection. Some alarms are also shown on the display



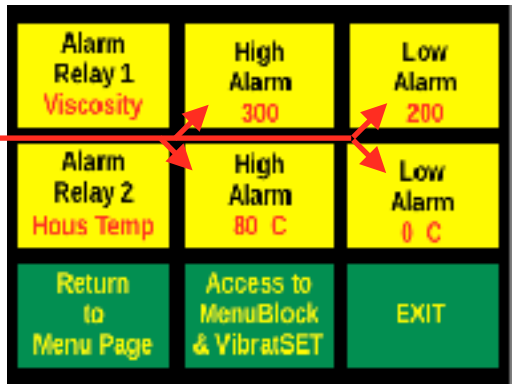



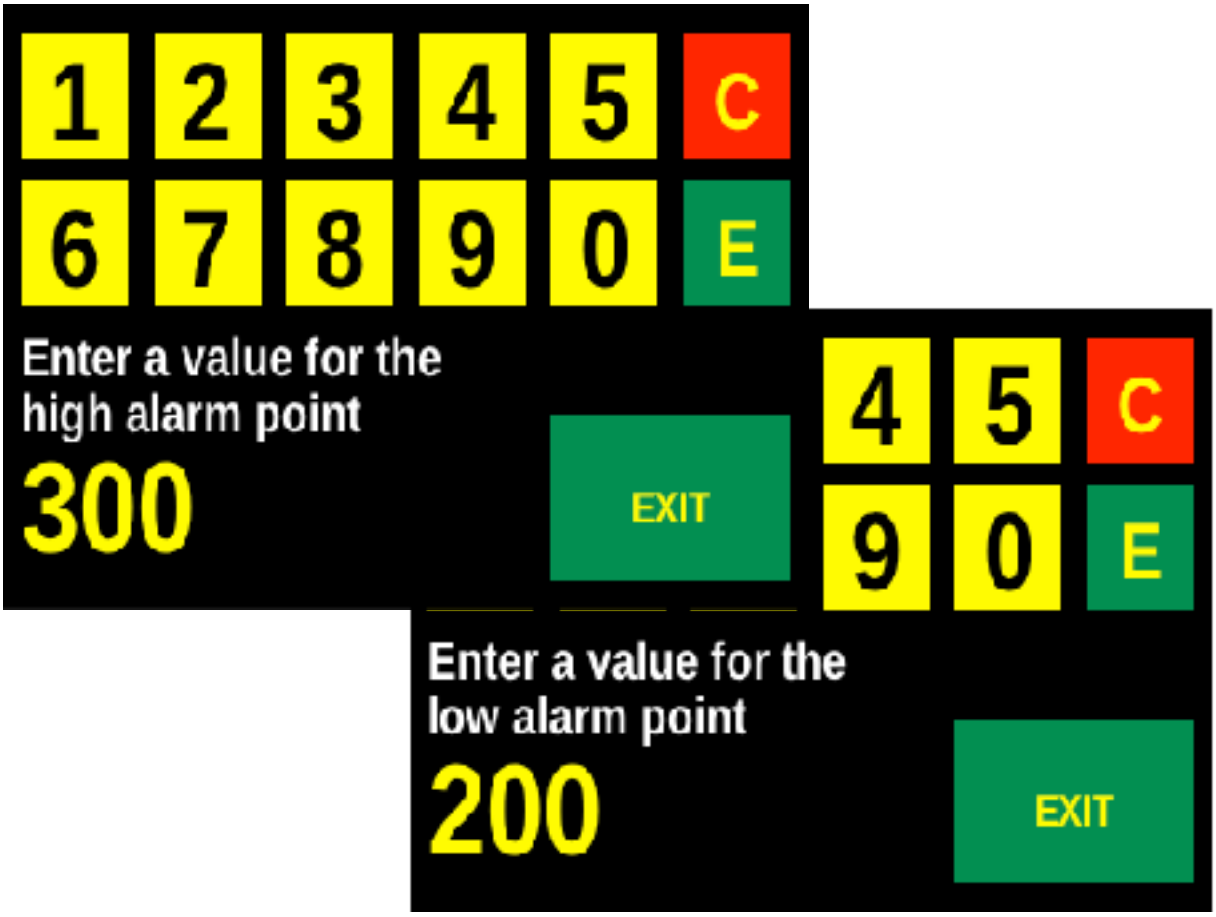

- Pushing repeatedly on alarm relay 1 or alarm relay 2 cycles through the available alarm selection. Available selections are:
  - Vibration — Alarm actuates when the number of vibrations exceeds 50% of the averaging samples selected. This is set automatically in the system. 1 sample will be subtracted from the vibration count for every good measurement sample. Criteria to identify vibration can be set on the next page. This functionality works for alarm 1 and alarm 2. Vibration alarms are also displayed on the screen.
  - Viscosity — Alarm actuates when viscosity has exceeded the high alarm setting or is lower than the low alarm. This functionality works for alarm 1 and alarm 2.
  - Proc temp — Alarm actuates when process temperature has exceeded the high alarm or is lower than the low alarm. Note: the alarm is set in degrees C. This functionality works for alarm 1 and alarm 2.
  - Hous Temp — Alarm actuates when housing temperature has exceeded

the high alarm or is lower than the low alarm. Note: the alarm is set in ℃. This functionality works for alarm 1 and alarm 2.

- HT Control — This functionality is available only for alarm 2. It is a simple on/off control, which can be set to 2, 5 or 10 °C above process temperature. Alternatively a fixed set point can be entered.

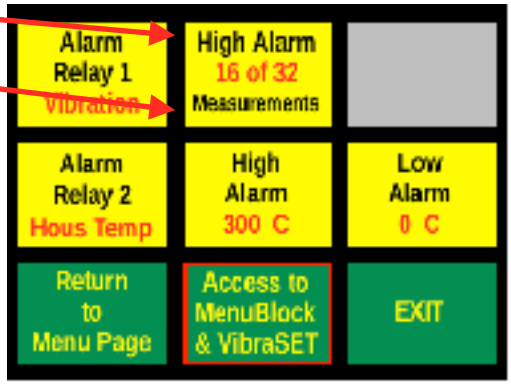
- If high alarm or low alarm is selected by pushing the low or high alarm buttons for alarm 1 or 2, a virtual keypad opens and a number can be entered for the associated alarm point.



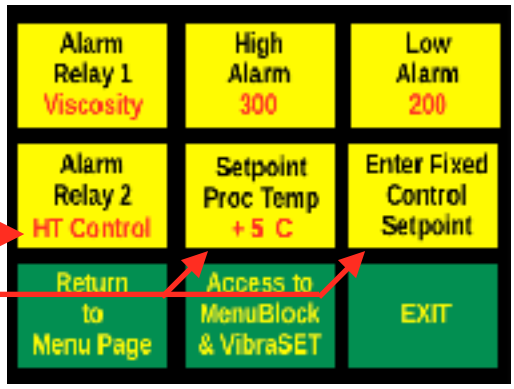




- The high alarm for vibration is set automatically at 50% of the number of averages selected.

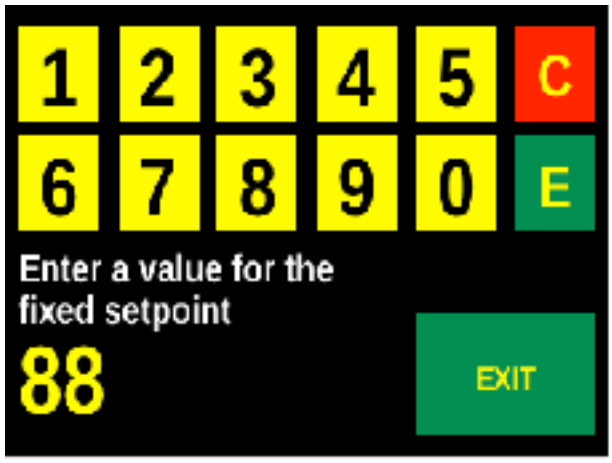
If the Access to MenuBlock & VibraSet is framed red a secondary access code is required.



- Alarm relay 2 includes HT Control (housing temperature control), which is a simple on / off controller. This can be used for control of any temperature measured with the housing RTD. As an example the control can be used to control the housing temperature of Viscotronics FT sensors. Thus the temperature in the housing can be set higher or lower than the process temperature by a small amount to prevent accumulation of product on the wall of the sensor tube due to a cooling or warming effect.



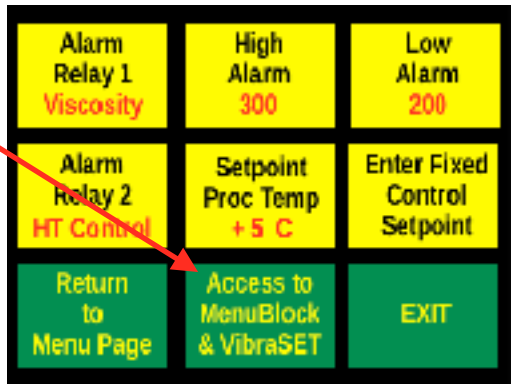

- After cycling through the choices of alarm relay 2 to reach HT Control the fields “Setpoint Proc Temp” and “Enter Fixed Control SetPoint” are shown. The following selections are are available for the setpoint proc temp button by cycling through it when pushing on that button:
  - + 2 C — Setpoint will be 2 °C higher than the current process temperature.
  - + 5 C — Setpoint will be 5 °C higher than the current process temperature.
  - + 10 C — Setpoint will be 10 °C higher than the current process temperature.
  - Fixed + 63 C — A fixed setpoint can be entered as the control point by pushing on the “Enter Fixed Control Setpoint” button. A virtual Keypad opens and a number for the setpoint can be entered.




  - - 2 C — Setpoint will be 2 °C lower than the current process temperature.
  - - 5 C — Setpoint will be 5 °C lower than the current process temperature.
  - - 10 C — Setpoint will be 10 °C lower than the current process temperature.

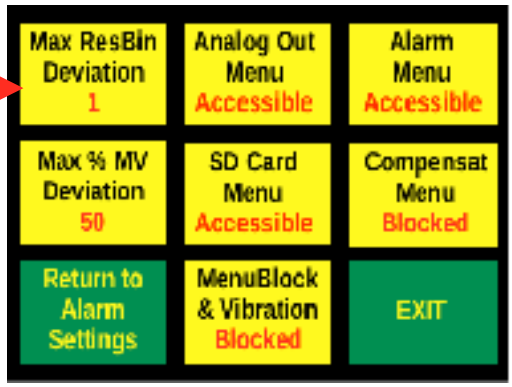
### Access to MenuBlock & VibraSet

The menu provides access to set vibration counting criteria and the menu blocking function. After pushing this button the menu below opens.




### Vibration criteria settings

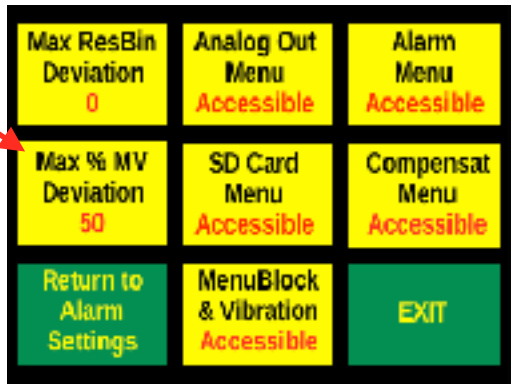
Pushing the Max Res Bin Deviation button repeatedly cycles through the available choices of 1, 2, 3, 4 and 5. A vibration count will be initiated, when the resonant frequency exceeds the width of the number of analysis bins chosen. If a vibration is counted the measurement will be bypassed and the previous measurement will be used for display and outputs.

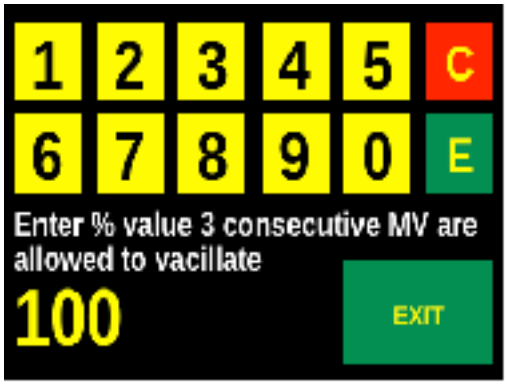



Example: If the bin width is 8 Hz (bin width is shown in the “Viscosity / Resonance / Graph” display as BW) and the maximum resonance bin width deviation is set to 1, the resonance has to stay within the bin width of 8 Hz of the previously measured sensor resonance. If the sensor had a resonance of 312 Hz during the previous measurement cycle, the resonance limits would be a maximum of 320 Hz and a minimum of 304 Hz. If those limits are exceeded, one vibration count is is added to the total vibration count. The default value for the maximum resonance bin deviation is 2 for a total of 16 Hz deviation with an 8 Hz bin width. If the bin width is 4 Hz the corresponding maximum deviation is 8 Hz.

The maximum resonance bin deviation should be set according to process behaviour. If the process is running without producing much mechanical vibration the maximum resonance bin deviation can be reduced to identify smaller vibrations, which may influence the measurement. For processes with high occurring vibration the maximum resonance bin deviation may need to be increased. Excessive vibration in the process cannot be handled by this deviation and needs to be taken care of in the process.

Pushing the Max % MV Deviation button opens the virtual keypad below.




Enter a number for a percentage, which 3 consecutive measurement values are allowed to vacillate, when the 3 values are compared. Example: If the second value is smaller than the first and the third value is larger than the second than the percentage margin allowed, a vibration count will be initiated and added to the total. The value used for the calculation is the raw measurement value of the FFT analysis. If a vibration is counted, the measurement will be bypassed and the previous measurement will be used for display and outputs.

Example: The percentage value is set to 50% and the 2nd raw measurement value is 2,500,000.

Based on the above measurement value vibration would be counted, if the 1st raw measurement value was smaller than 1,250,000 or larger than 3,750,000 than the 2nd measurement value and the 3rd (current) measurement value is smaller than 1,250,000 or larger than 3,750,000 than the 2nd measurement value.

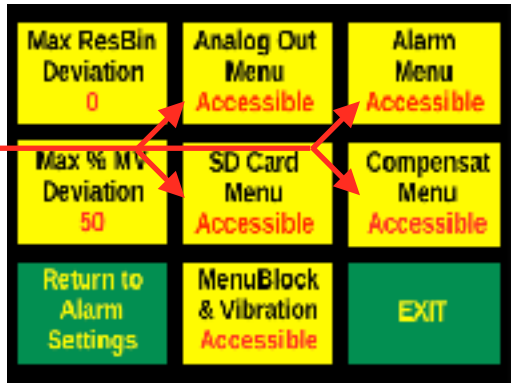
If either the 1st or the 3rd measurement value fall within the margins allowed the vibration count will **not** be initiated.

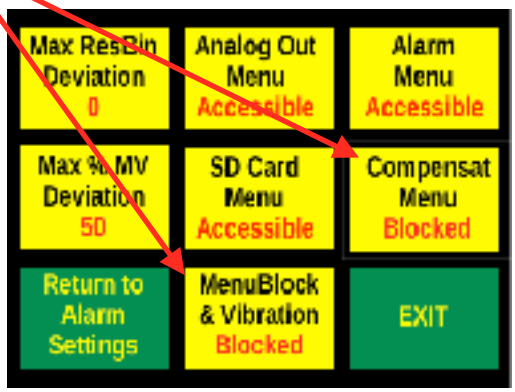
This setting is very dependent on the process conditions and may not be usable dependent on the process. Therefore the default margins are set to 100% vacillation, which is rarely reached. For the above conditions that would be 0 for the smallest measurement value and 5,000,000 for the largest measurement value during 3 consecutive measurements.

In tightly controlled processes and slowly changing viscosities the margins can be set to a smaller vacillation percentage to eliminate measurements, which may be an outlier due to rare solids in the fluid or very occasional external vibration as an example and therefore eliminating erroneous measurements.

## Menu Block settings

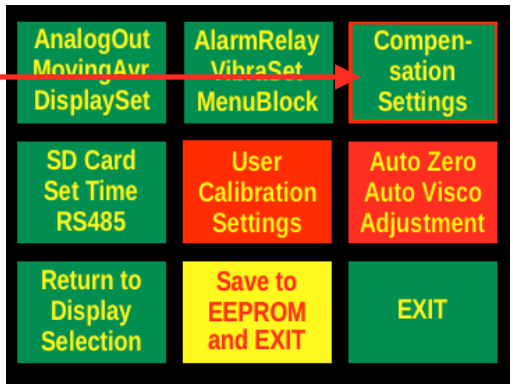
- Pushing any one of the four menu buttons Analog Out / Menu, Alarm / Menu, SD Card / Menu or Compensat / Menu repeatedly will cycle through Accessible and Blocked for each button, therefore allowing individual blocking of access to the four functions.
- If any of the four buttons show Blocked the MenuBlock / & Vibration field will also change from Accessible to Blocked. This prevents access to this page from the previous alarm settings page and thus unauthorized changes of the menu blocking settings.
- The MenuBlock / & Vibration menu field will change to accessible again, if all blocking has been removed.



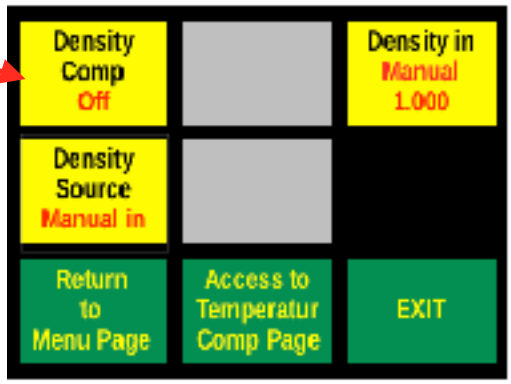
## Compensation Settings

- The menu provides access to density, temperature and pressure compensation settings. The default for all compensation settings is no influence on the measured viscosity value.
- If the menu button is framed in red, a secondary access code is required to access the menu.
- The first compensation page to open is the density compensation page.

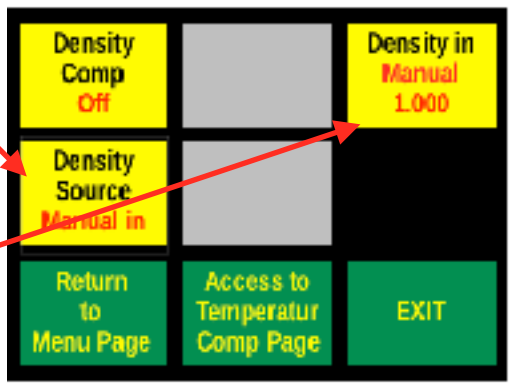



### Manual density compensation settings

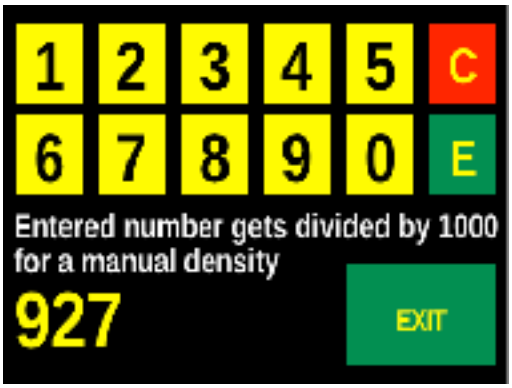
- Pushing Density / Comp repeatedly cycles between Off, Dynamic and Kinematic.
  - Off
    No density compensation is applied
  - Dynamic
    Measured viscosity divided by the density.
  - Kinematic
    Measured viscosity divided by the density squared

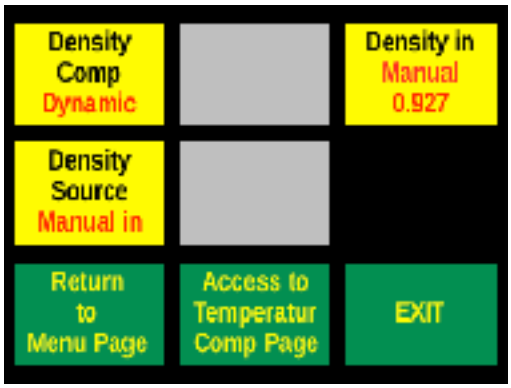



- Pushing Density Source repeatedly cycles between Manual in and Analog in.
- Manual in allows a density value to be input by pushing on the Manual / Density in button and opening the virtual keypad. Input a number with a minimum of 3 digits. The input number is automatically divided by 1000 to generate a manual density setting with 3 decimals.



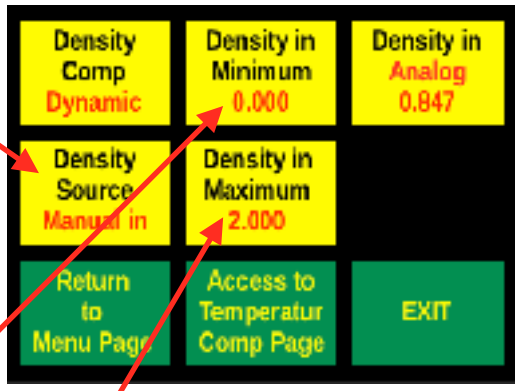

Example: Enter 927 to use a manual density setting of 0.927



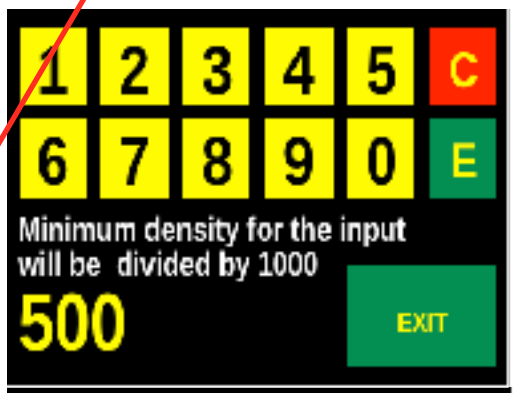



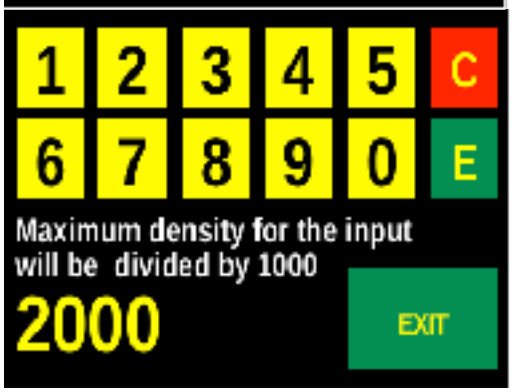
- The entered manual density will be applied to the viscosity, if either Dynamic or Kinematic has been selected in Density / Comp by pushing the Density / Comp button repeatedly.

### Analog in density compensation settings

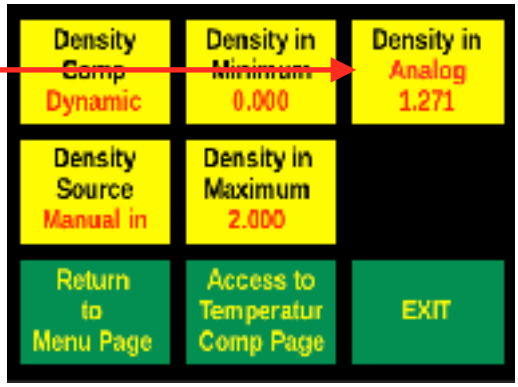



- Pushing the Density / Source repeatedly cycles between Manual in and Analog in.
- Analog in utilizes analog input 1 to generate a density based on the Density in / Minimum and the Density in / Maximum setting for the 1st analog input.
- If Density in / Minimum is pushed a virtual keypad as shown below will open and a 3 digit number can be input to generate a minimum density value equivalent to 4 mA for the analog density input. If no number is entered the value will 0.000. Only values larger than 0.100 will be used for calculation to prevent divisions by 0.
- If Density in / Maximum is pushed a virtual keypad as shown below will open and a 3 digit number can be input to generate a maximum density value equivalent to 20 mA for the analog density input. If no number is entered the value will 0.000. Only values larger than 0.100 will be used for calculation to prevent divisions by 0.



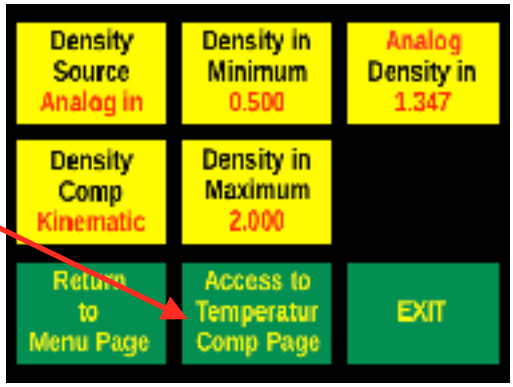




- The field Density in / Analog shows the current value of the analog density input. pushing on it has no effect.
- Density compensation will only take place, if either dynamic or kinematic density compensation is chosen by pushing on the Density / Comp button repeatedly.



## Temperature compensation settings

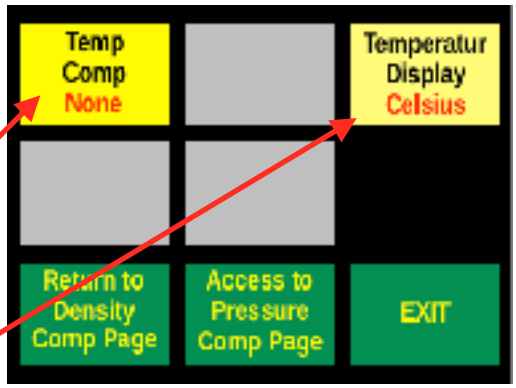
- Push on the Access to / Temperatur / Comp Page button to open the temperature compensation menu below.




- The default page for temperature compensation shows selections for Temp / Comp and Temperatur / Display.

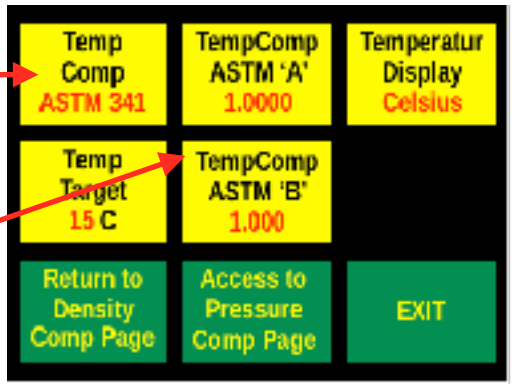
  Pushing repeatedly on Temp / Comp cycles through None, ASTM 341 and Equal Rate.

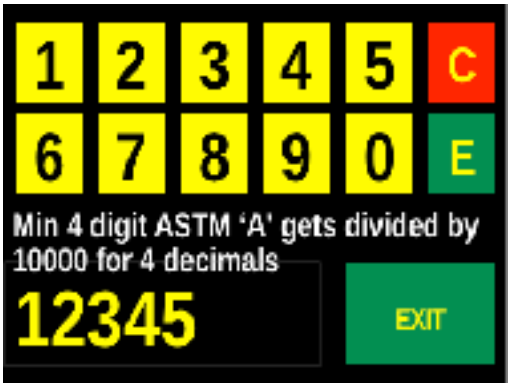
  Pushing repeatedly on Temperatur / Display cycles through Celsius, Fahrenheit and Kelvin. This will only effect the display all entries for calculations are required to be in Celsius.

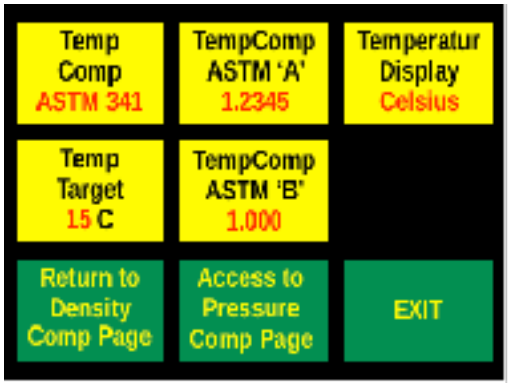



## ASTM 341 temperature compensation

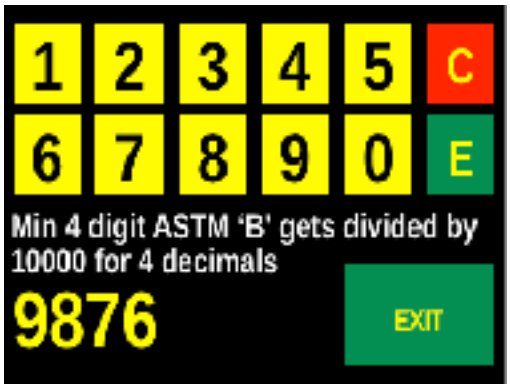
- When ASTM 341 temperature compensation is chosen 3 extra buttons become active.
- Pushing on TempComp / ASTM ‘A’ opens a virtual keypad and a number with a minimum of 4 digits can be entered. The number automatically gets divided by 10000 to create an ASTM ‘A’ value with 4 decimals.

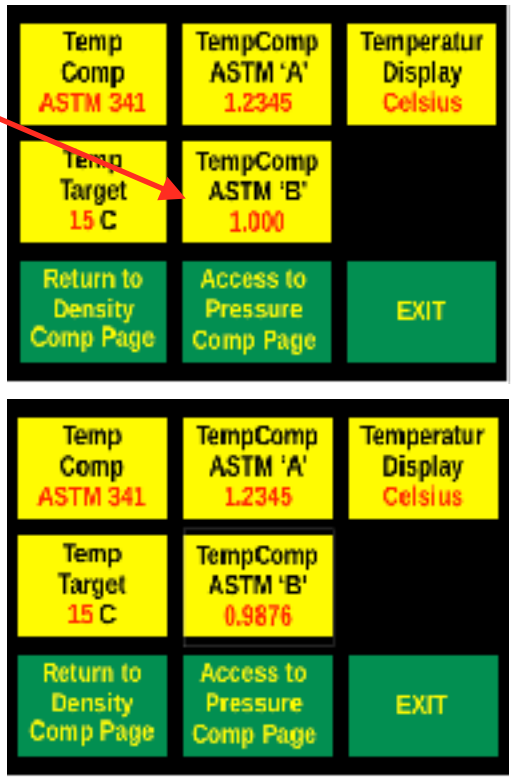


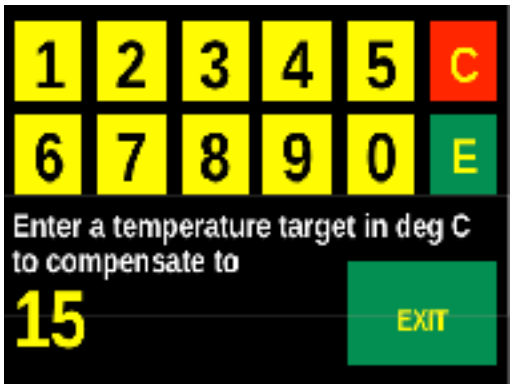



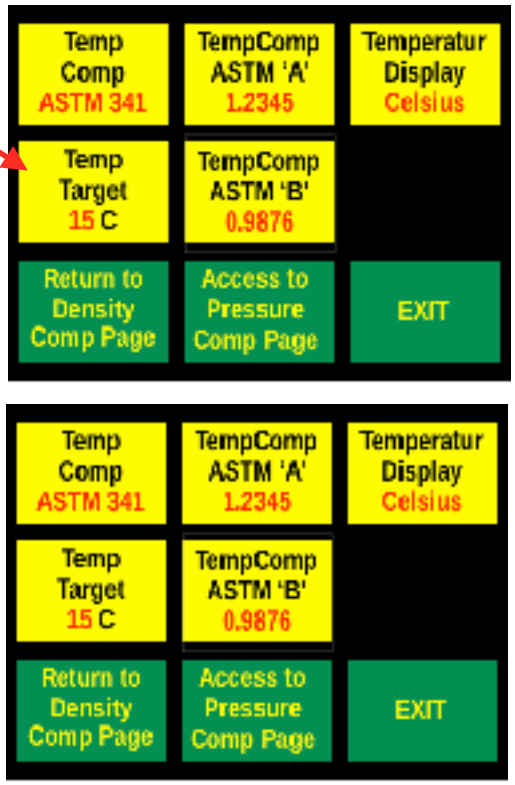
Pushing on TempComp / ASTM ‘B’ opens a virtual keypad and a number with a minimum of 4 digits can be entered. The number automatically gets divided by 10000 to create an ASTM ‘B’ value with 4 decimals.




Pushing on the Temp / Target button opens a virtual keypad and an integer number can be input for the temperature target to be compensated to.




Any integer number can be entered, however it is recommended for the target temperature to be within 10 deg C of the current measured temperature. The compensation curve is a log/log curve and large temperature differences can lead to large discrepancies.

The default is 15 C.

## Calculation of ASTM 341 ‘A’ and ‘B’

- The ASTM ‘A’ and ASTM ‘B’ numbers need to be calculated externally of the transmitter.
  - To calculate the numbers, two pairs of viscosity / temperature correlations are required, example:

    1) Viscosity 1109 cP  Temperature 20 °C

    2) Viscosity 750.6 cP  Temperature 25 °C

| | A | B | C | D |
|---|---|---|---|---|
| 1 | **ASTM 341** | | | |
| 2 | | | | |
| 3 | V1 mPa.s | 1109.0 | V2 mPa.s | 750.6 |
| 4 | T1 Deg C | 20.0 | T2 Deg C | 25.0 |
| 5 | T1 Deg K | 293.16 | T2 Deg K | 298.16 |
| 6 | ASTM ‘A’ | 8.8328 | ASTM ‘B’ | 3.3842 |
| 7 | | | | |
| 8 | | | | |
| 9 | **ASTM ‘A’** | | **ASTM ‘B’** | |
| 10 | **8.8328** | | **3.3842** | |

  - Viscosity V1 is the viscosity at temperature T1
  - Viscosity V2 is the viscosity at temperature T2
  - For the ASTM 341 calculation the temperatures are converted to Kelvin as shown in cells B5 and D6 (add 273.16)
  - The formulas in cell B6 and D6 are:

    B6: =LOG10(LOG10(B3+0.7))+(LOG10((LOG10(D3+0.7))/(LOG10(B3+0.7)))/(LOG10(B5/D5)))*LOG10(B5)

    D6: =(LOG10((LOG10(D3+0.7))/(LOG10(B3+0.7)))/(LOG10(B5/D5)))
  - ASTM ‘A’ and ASTM ‘B’ Need to be entered as integer numbers in the IRFTx and will be divided by 10,000:

    88328 entered into the transmitter becomes 8.8328 internally

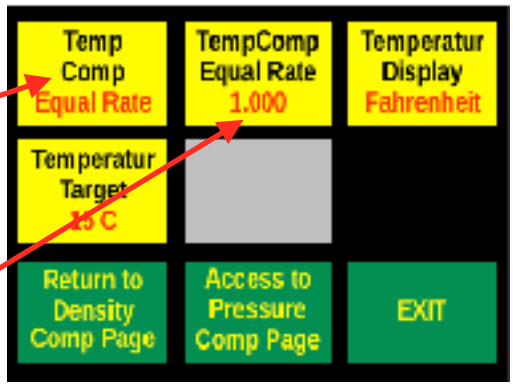
    33842 entered into the transmitter becomes 3.3842 internally

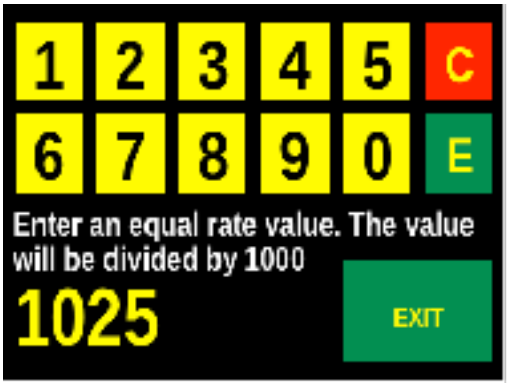
## Equal Rate temperature compensation

- When equal rate temperature compensation is chosen 2 extra buttons buttons become active.
- Pushing on TempComp / Equal Rate opens a virtual keypad and a number with a minimum of 3 digits can be entered, however in most cases the number will be 4 digits. The number gets divided automatically by 1000 to create an Equal Rate value with 3 decimals. As shown in the example on the pictures below 1025 becomes 1.025 as the equal rate.

  A value larger than 1.000 will generate higher viscosities for decreasing process temperatures and lower viscosities for increasing process temperatures.

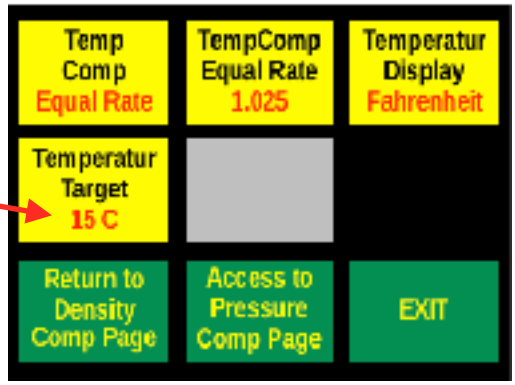
  A value smaller than 1.000 will generate higher viscosities for increasing process temperatures and lower viscosities for decreasing process temperatures.

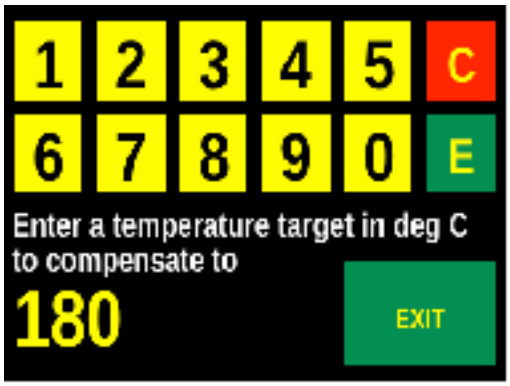


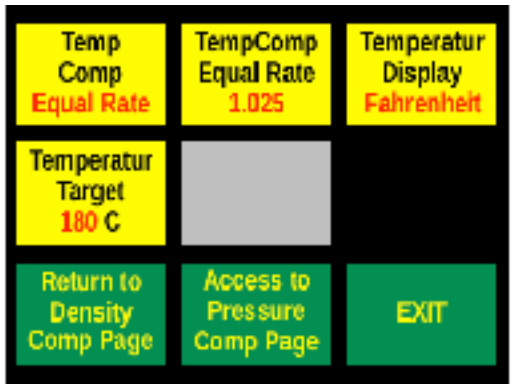




- Pushing on the temperature target button opens a virtual keypad and an integer number can be input for the temperature target to be compensated to.
- Any integer number can be entered, however it is recommended for the target temperature to be close to the current measured temperature. Large temperature differences can lead to large discrepancies.

  The default is 15 C.



The equal rate number is used to calculate the change in viscosity per degree Celsius. It is calculated based on the following formula:

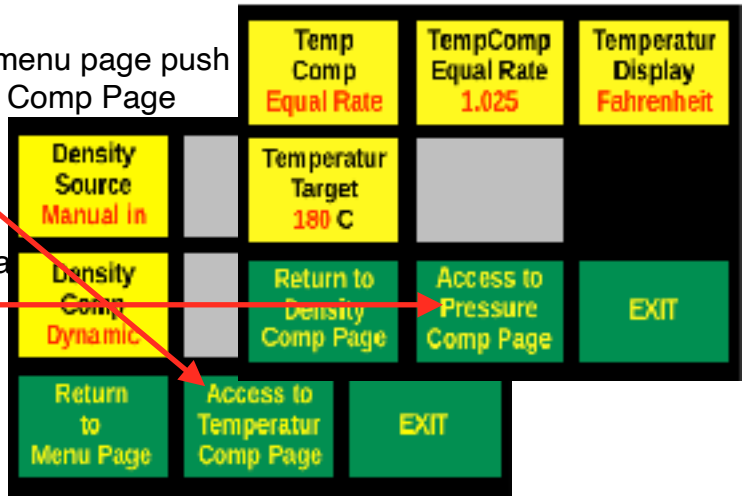
$V_T = V_C * (1 + (E_R / 100)) ^ (T_C - T_T)$

Where:

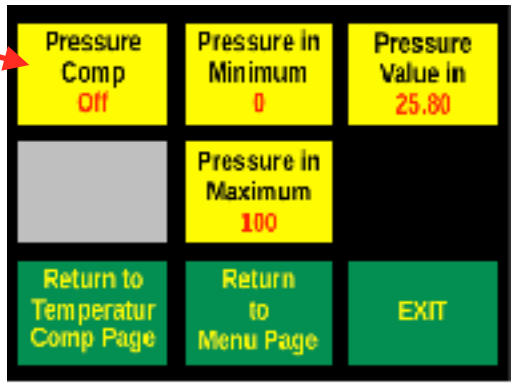
| | |
|---|---|
| $V_T$ | Temperature compensated viscosity |
| $V_C$ | Current measured viscosity |
| $E_R$ | Equal Rate |
| $T_C$ | Current measured temperature |
| $T_T$ | Target temperature |

## Pressure compensation settings

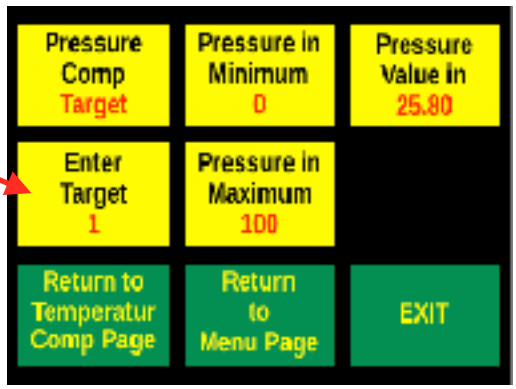
- From the initial default density menu page push on the Access to / Temperatur / Comp Page button to open the temperature compensation menu.
- Subsequently push on the Access to / Pressure / Comp Page to open the pressure compensation menu below.

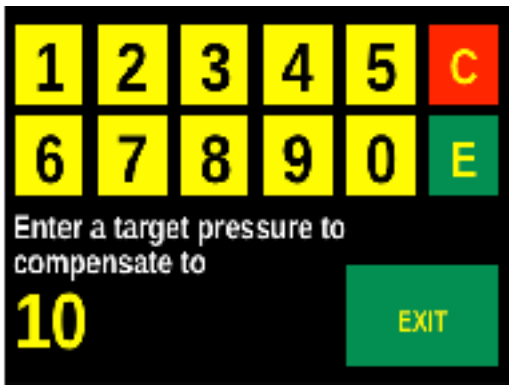


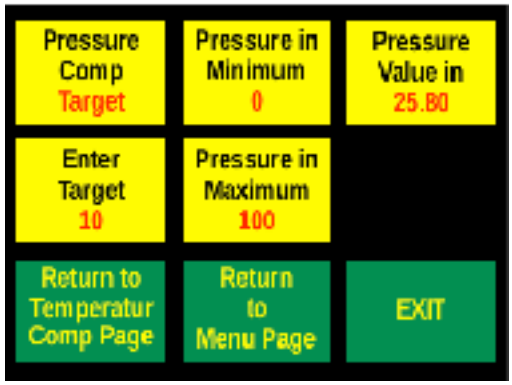

- Pushing on Pressure / Comp repeatedly will cycle through Off, Target, Rate and On.



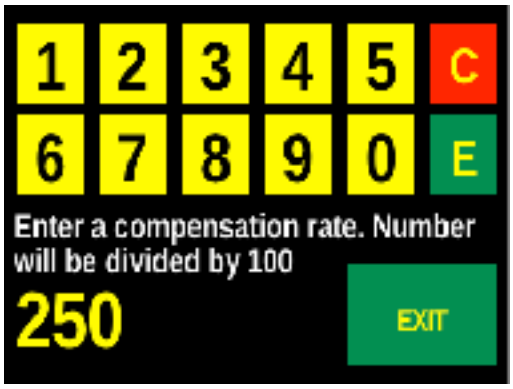

- When Pressure Comp Target is displayed; pushing on Enter / Target opens a virtual keypad and an integer number can be input as a target for pressure compensation.

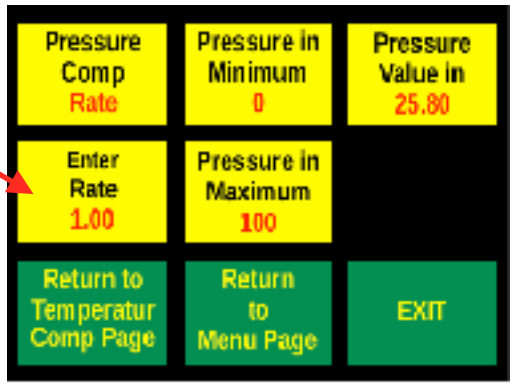


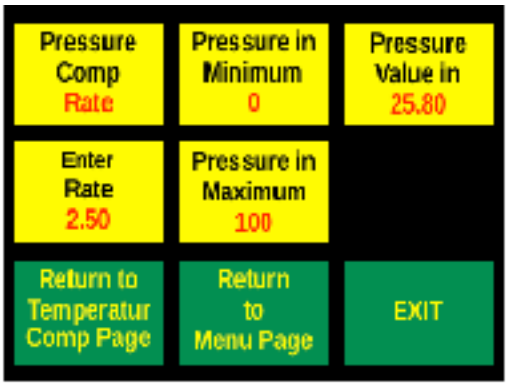



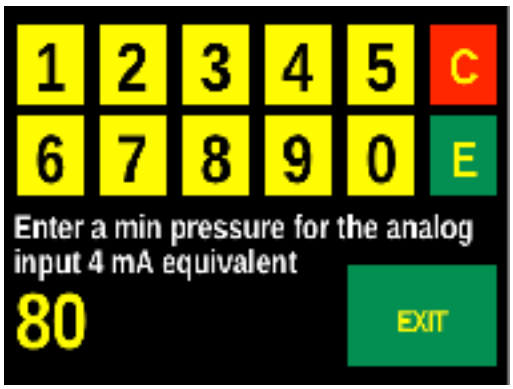
When Pressure Comp Rate is displayed; pushing on Enter / Rate opens a virtual keypad and a number with a minimum of 2 digits can be input as a rate for pressure compensation. The number will be automatically divided by 100 to provide a rate with two decimals.

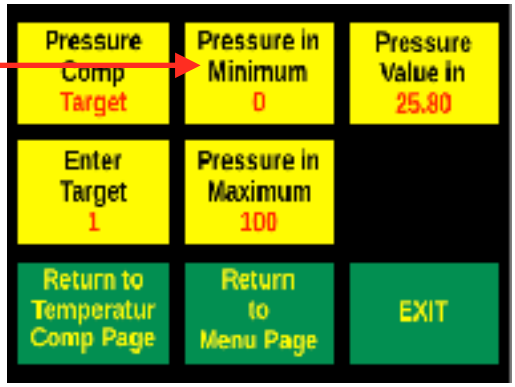


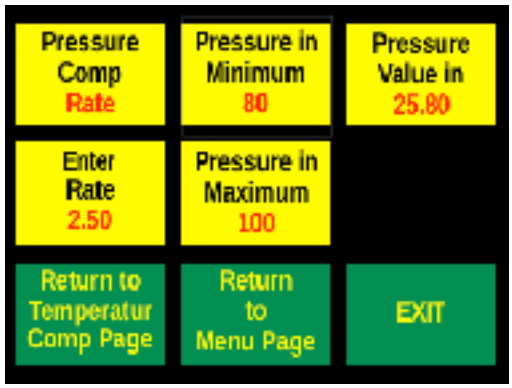



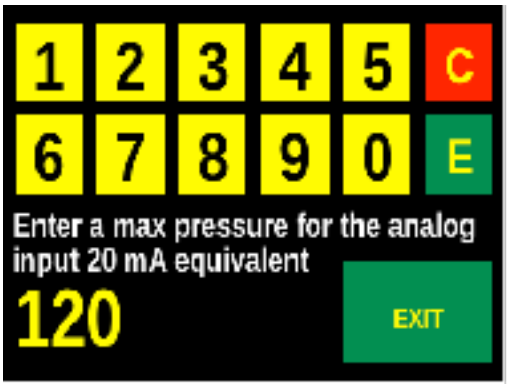

Pushing on Pressure in / Minimum opens a virtual keypad and an integer number can be input as a minimum (equivalent to 4 mA) for pressure compensation.

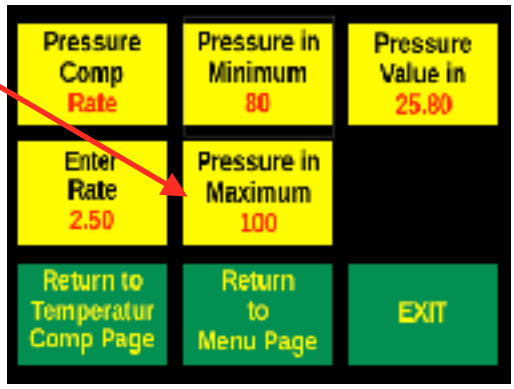


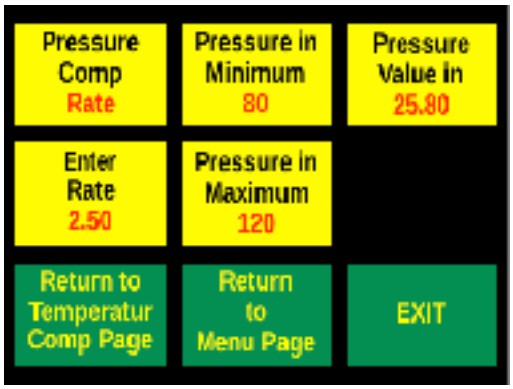



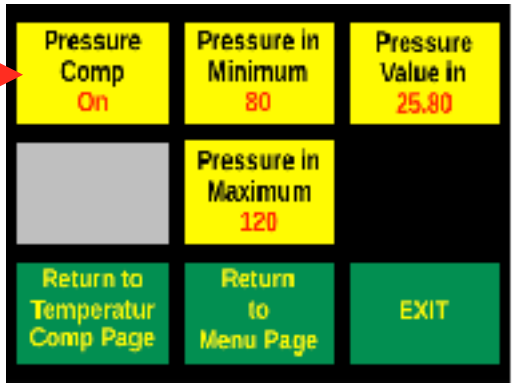
- Pushing on Pressure in / Maximum opens a virtual keypad and an integer number can be input as a maximum (equivalent to 20 mA) for pressure compensation.




- Pushing on Pressure / Comp until Pressure / Comp / On is shown will engage pressure compensation using the target, rate and analog input value based on the minimum and maximum pressure settings for the analog input to calculate a pressure compensated viscosity.




- Pressure compensation is a linear compensation and analog input minimums and maximums are unit independent. This compensation method can be used for other compensation parameters, which change viscosity linearly.

- The pressure compensated viscosity is calculated using this formula:

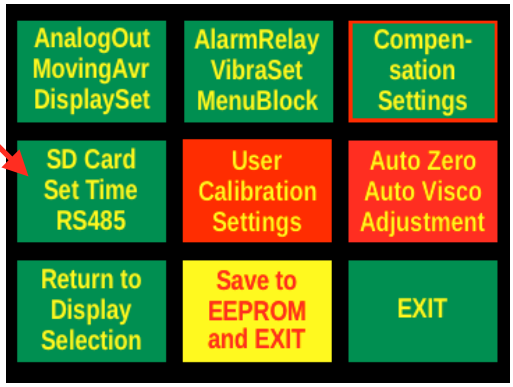
$$V_P = V_C + (V_C 1 * (P_T - P_C) * R_L)$$

Where:

| | |
|---|---|
| $V_P$ | Pressure compensated viscosity |
| $V_C$ | Current measured viscosity |
| $P_T$ | Pressure target |
| $P_C$ | Current pressure |
| $R_L$ | Linear rate |

## Save to SD Card, Set Time, RS485

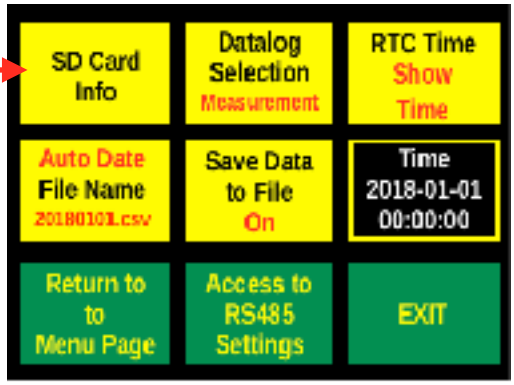
- The menu provides access to saving files on an internal SD card, setting time for the real time clock and access to the RS485 interface
- If the menu button is framed in red, a secondary access code is required to access the menu.




### SD Card Settings

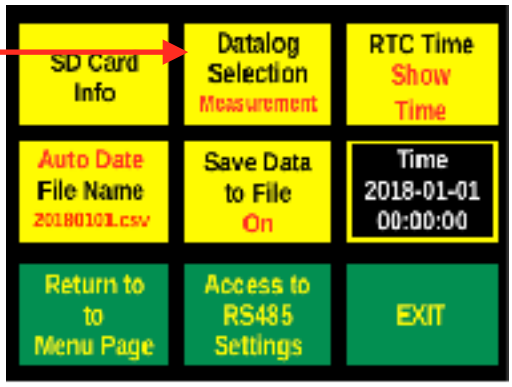
- Pushing on SD Card / Info opens an information page showing details of the SD card, if a card is inserted. If a SD card is not inserted an error message will be displayed.

  If a SD card is not inserted, the menu button Save Data / to File changes to No / SD Card.



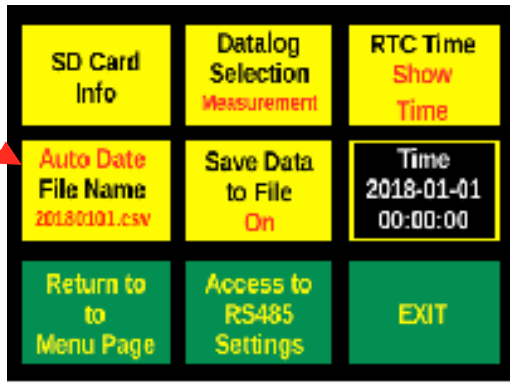

- Save Data to File needs to be off, when inserting or removing the SD card.

- Pushing on Datalog / Selection repeatedly cycles through 5 selections: Each Measurement, Each 15 sec Measurement, Each 60 sec Measurement, Factory TS and FFT values.




  - Measurement stores time, viscosity, process temperature and housing temperature in Celsius, resonance of the sensor, time for one analysis and the current analysis number.
  - Factory TS stores raw values, averages of raw values, vibration counts and the firmware version in addition to the above Measurement values. This data is primarily for fault analysis.
  - FFT Values stores the raw values of the FFT analysis and is only for trouble shooting and fault analysis.

- Pushing on the File Name button repeatedly cycles through Auto Date and Stored file name.




  - Auto Date uses the current date as a file name to store data to file provided the real time clock (RTC) has been set. If the RTC has not been set Auto Date will start at 19700101.csv. The date changes daily from the RTC date onward.
  - Pressing on Auto Date opens a virtual keypad and a number with a maximum of up to 8 digits can be input to generate a file name. The csv extension is added automatically. If a new file name is not desired, entered or cleared by pushing on 'C', a previously entered file name will be preserved. Pushing on 'E' without entering a number the system will return to a previously entered file name. If a number has been entered the number will become the new file name after pressing 'E'.

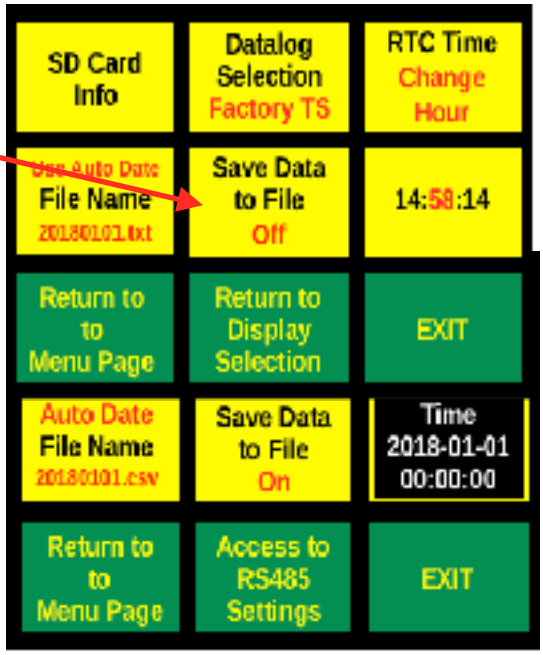


The default for the Entered File Name is 00000000.csv.
If more than 8 digits are entered the Stored File Name will revert to the default or preserved file name.

  - Stored File Name uses the entered file name to store data to file. The default file name 00000000.csv will be used, if a new file name has not yet been entered.

- Pushing on the Save Data / to File repeatedly cycles through Save Data / to File / Off and Save Data / to File / On, provided a SD card is inserted. If a SD card has not ben inserted the button does not have any function.

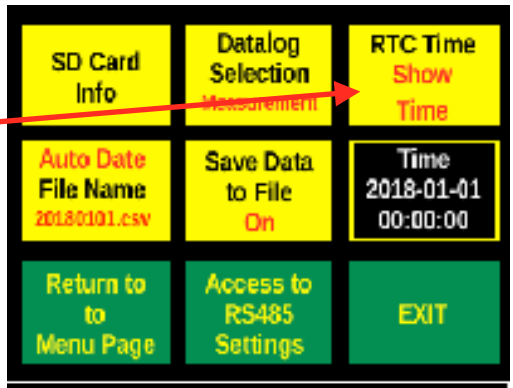
Once Save Data / to File / On has been chosen, the Datalog / Selection data will be saved to the SD card using the selected file name. If a previous file name is being used new data will be added to the existing data in the file.



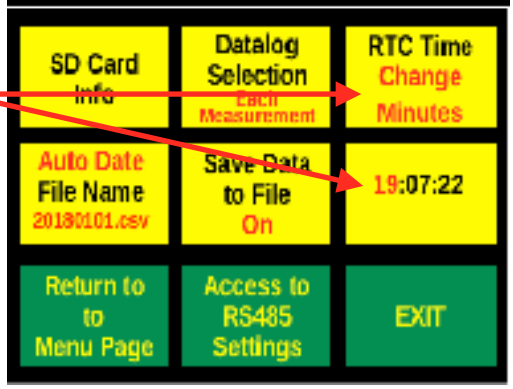
## Real Time Clock Settings

- Pushing on the RTC Time button repeatedly cycles through Show Time, Change / Hour, Change / Minute, Change / Second, Change / Year, Change / Month, Change / Day.

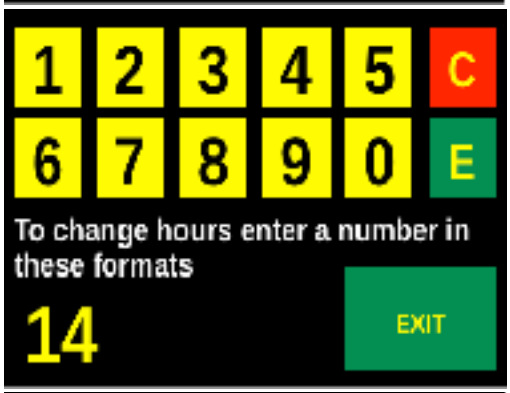
  Only when Show / Time is selected are the time and date displayed in the field below.



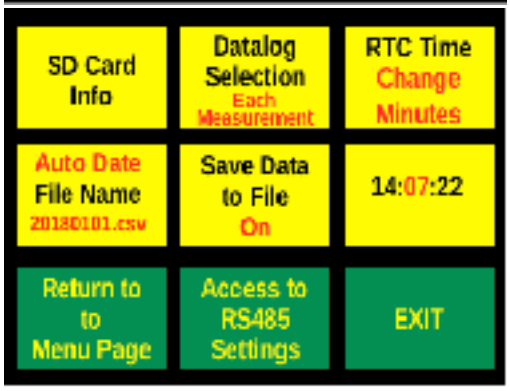

- After the RTC / Show / Time button has been pushed once Change Hour is displayed and the field below changes to a yellow background with the hour highlighted in red. The red highlight indicates that the hour can now be changed by pushing on that yellow time display button.




- A virtual keypad will open and a 1 or 2 digit number for the current hour can be entered. After pressing on ‘E’, the hour will appear in black and the minute will be displayed in red.

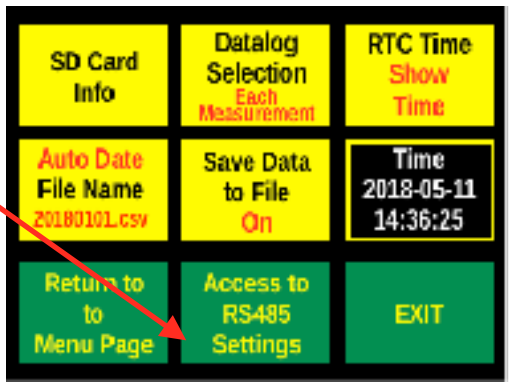



- Using the same procedure by pushing on the yellow time display button, the minute value can be changed. Once the minutes have been input it cycles to seconds, year, month and day. After the day has been input the display changes to showing the time again.




- The RTC Time button can be used at any time to jump to the next choice, if an entry is not to be changed.

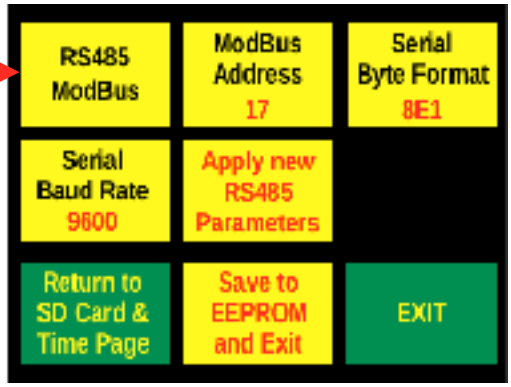
- Pushing on the Access to RS485 Settings button opens the selection page for RS485 settings below.



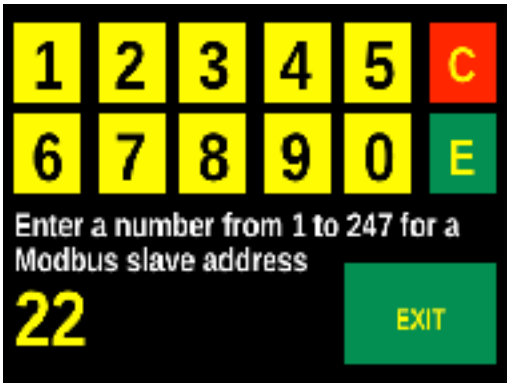
## RS485 Settings

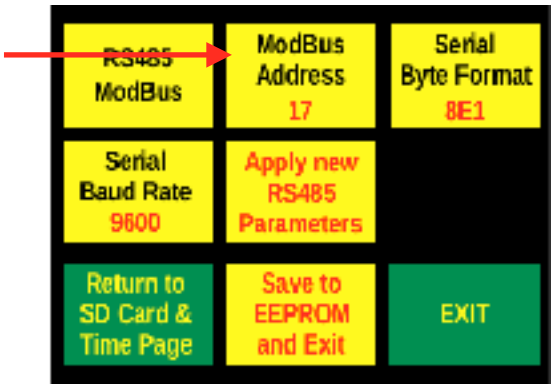
- The top left button has no function. Modbus is the only selection possible.

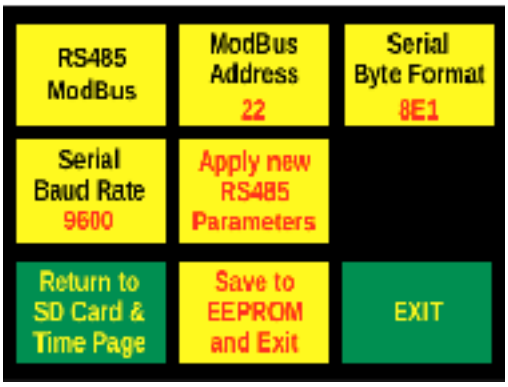
  The Modbus setting allows retrieval of data and setting of parameters per the ModBus table in the appendix.




- Pushing on the Modbus / Address opens a keypad and a number between 1 and 247 can be input as a slave address.

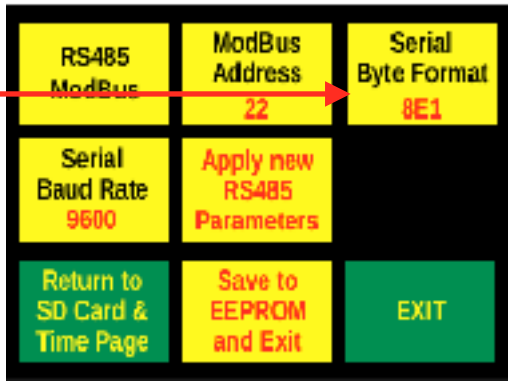


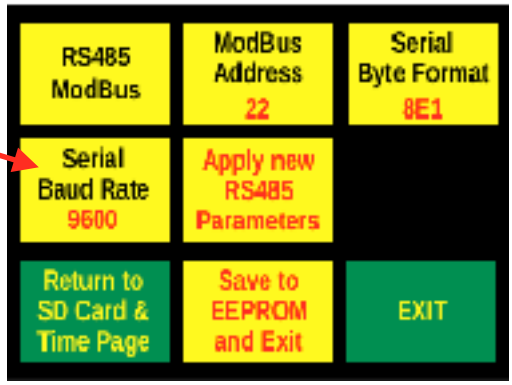




- Pushing repeatedly on the Serial / Byte Format button cycles through 8E1 and 8O1.

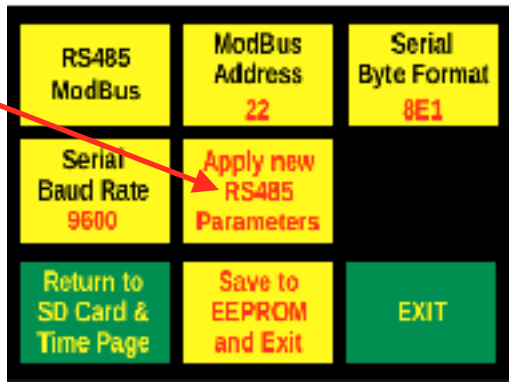
  8E1 setting for 8 bits, even parity, 1 stop bit,
  8O1 setting for 8 bits, odd parity, 1 stop bit,



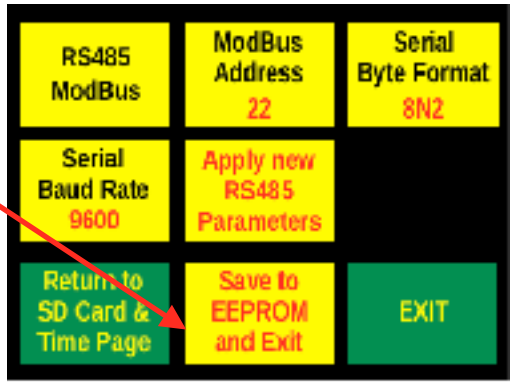
- Pushing repeatedly on the Serial / Baud Rate button cycles through 9600, 19200, 38400, 57600 and 115200 baud.




- The Apply new / RS485 / Parameters button requires to be pushed after all settings have been chosen to apply them as new settings. If the button is not pushed the new settings will not be activated.

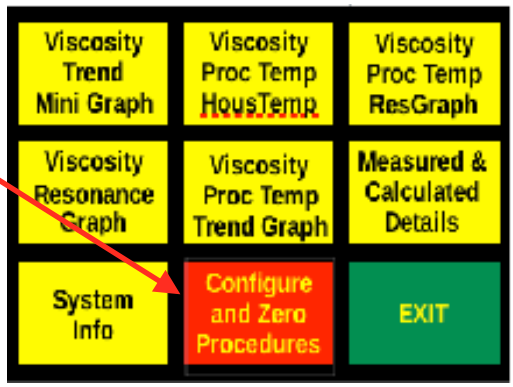


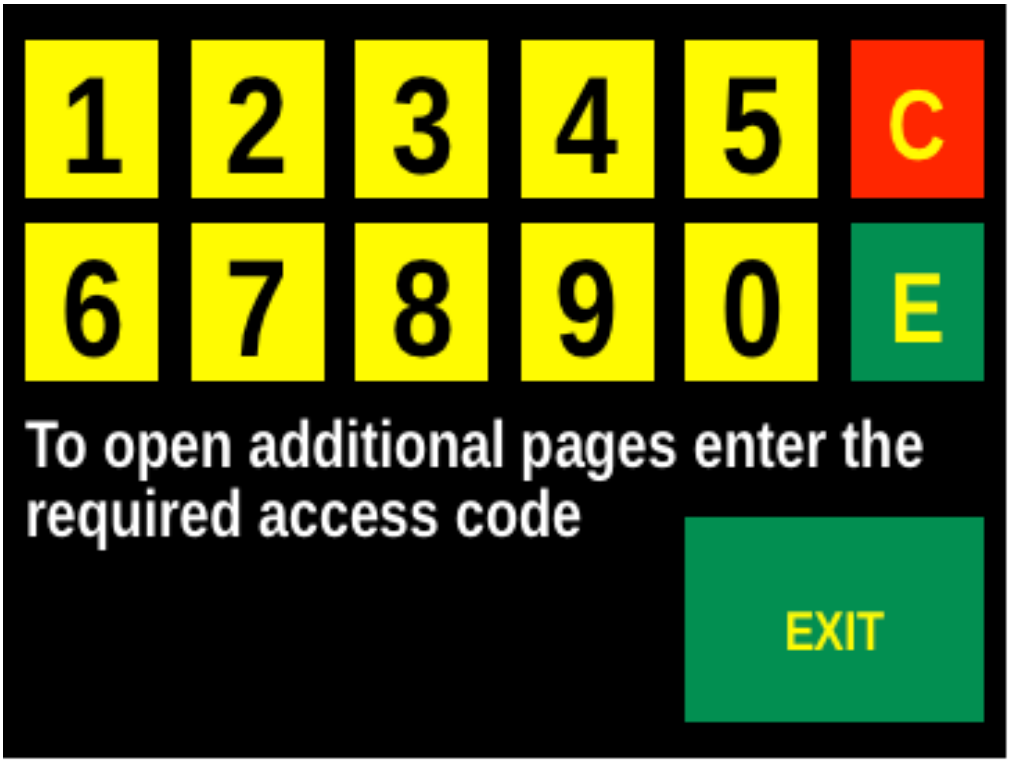

- Pushing the Save to / EEPROM / and Exit button saves the applied settings to EEPROM, the settings are preserved and become active again after a power failure or restart.



# VT-IRFTx Calibration Functions

- Pushing on Configure / and Zero / Procedure opens the display shown below.

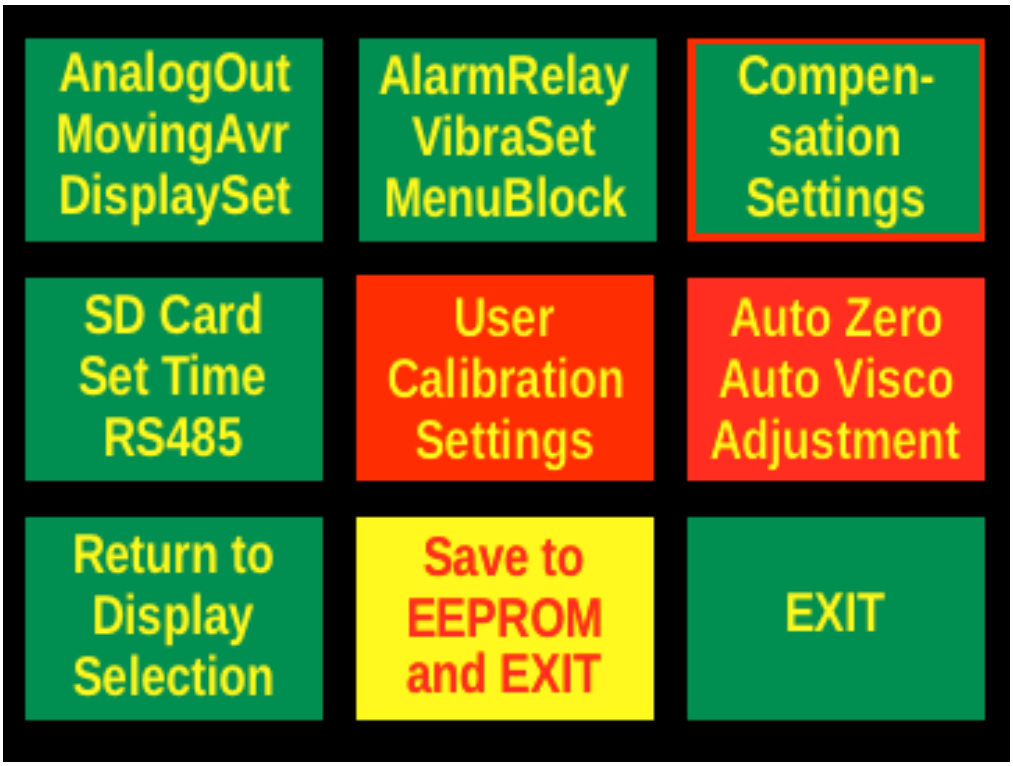



- Accessing the configuration screens or the viscosity adjustment screens requires access codes, which are shown in the calibration certificate.
- Pushing on any number until the screen blinks will enter that number and show it immediately in the bottom space.
- Pushing C until the screen blinks clears the entire entered number.
- Pushing E until the screen blinks will enter the number into the system and open the associated screen. If an invalid number has been entered the screen returns to the previous display.
- Pushing EXIT until the screen blinks will return to the previously displayed viscosity display.

## Configuration procedures access

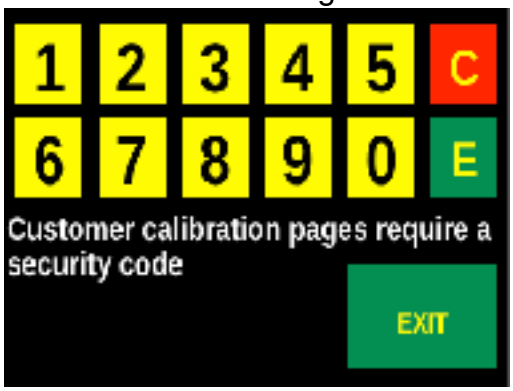
- After having entered the appropriate access code, the menu selection screen below appears.

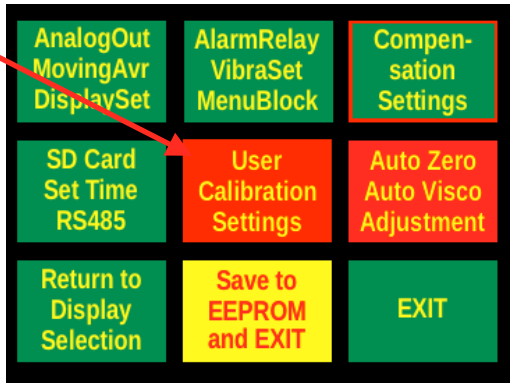



- User / Calibration / Settings
  - Access to calibration settings requires a special access code, which is stated in the calibration sheet.
  - The menu provides access to multiple calibration pages.
- Auto Zero / Auto Visco / Adjustment
  - Access to auto zero and auto viscosity procedures requires a special access code, which is stated in the calibration sheet.
- Return to / Display / Selection
  - Pushing on this button returns to the display selection screen.
- Save to / EEPROM / and Exit
  - Pushing on this button will save all current settings to EEPROM and exit to the previous viscosity display screen.
- EXIT
  - Pushing on this button returns to the previous viscosity display screen.

## User Calibration Settings

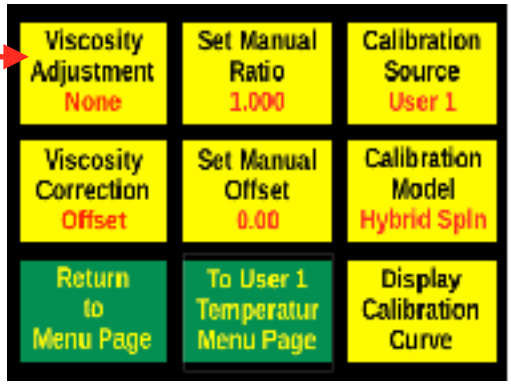
- The menu provides access to viscosity adjustment, calibration selection and calibration settings. Additionally analysis functions are available. After pushing on the User / Calibration / Settings button an calibration access code is required to be entered on the keypad to open the first page shown below on the right.



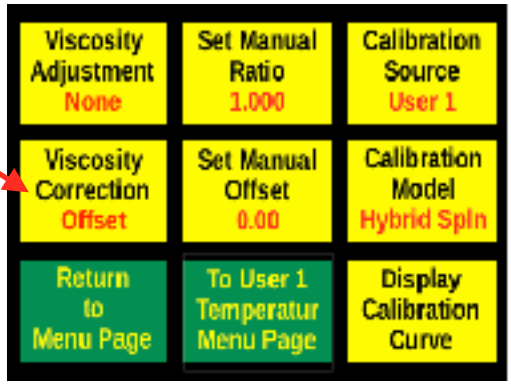




### Viscosity Adjustment and Correction

- Pushing the Viscosity / Adjustment button repeatedly cycles through None, Auto Set and Manual.
  - None is the default and no adjustments to the measured or calculated viscosity are made.
  - Autoset will use values generated during an auto zero or auto visco procedure (see the button above).
  - Manual will use the values entered via the Set Manual Ratio and Set Manual Offset buttons.

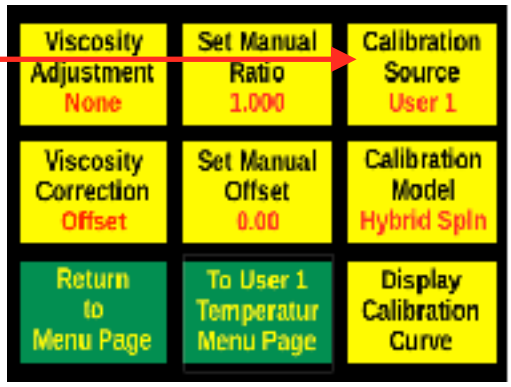



- Pushing the Viscosity / Correction button repeatedly cycles through Offset, Ratio and Ratio+Offs.
  - Offset uses a zero correction from auto set or the manual offset entry to adjust the viscosity.
  - Ratio recalculates the viscosity using the ratio created with Auto Visco Adjustment or the manually entered Ratio.
  - Ratio+Offs first recalculates the viscosity using the selected ratio and thereafter applies the associated offset



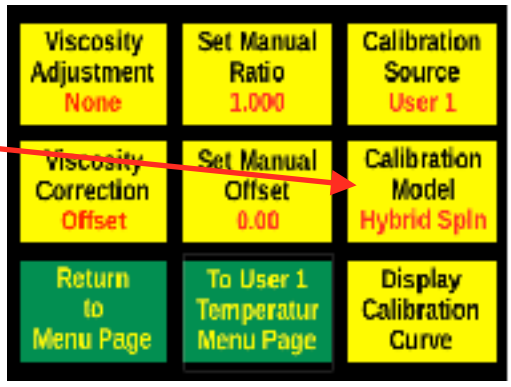
### Calibration Source and Model

- Pushing the Calibration / Source button repeatedly cycles through User 1, 2, 3 and Factory.



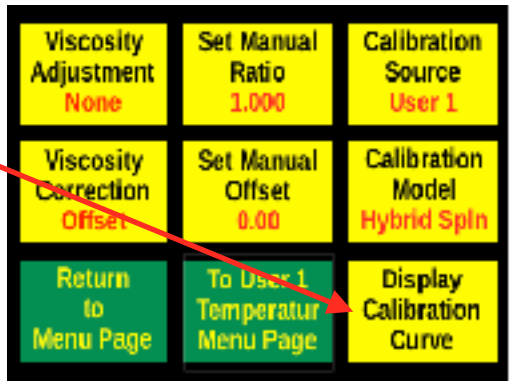

  - User 1, 2 and 3 apply user generated calibration curves for the viscosity calculation. The three user curves operate completely independent of each other but are all applied to the same sensor. Thus the set resonant frequency is the same for all user generated calibration curves.
  - Factory applies calibration curves generated at the factory for the viscosity calculation. They cannot be changed by the user.

- Pushing the Calibration / Model button repeatedly cycles through through multiple calibration models. The number of models is dependent on the number of calibration points and the calibration source. The available models are: FFT MV, linear spline, hybrid spline, cubic spline, hyperbolic and rational model.

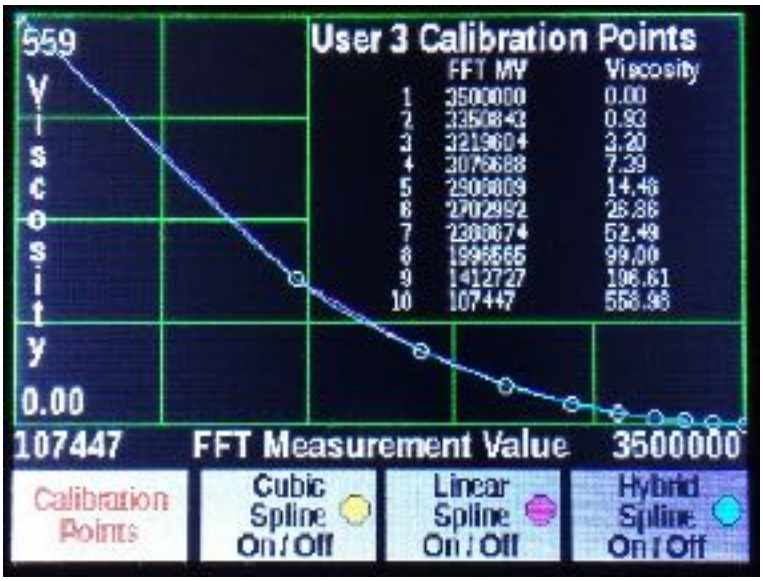



  - FFT MV is the raw measurement signal derived from the Fast Fourier Transfer method. It is not converted in any manner.
  - Linear Spline applies a linear interpolation between all available calibration points. The minimum number of calibration points is 2.
  - Hybrid Spline applies a linear interpolation between the first and second calibration point. Interpolation between any other two calibration points is done using the cubic spline method. This allows using fewer calibration points than usually required for a cubic spline and prevents erroneous values near zero. A minimum of 3 calibration points are required.
  - Cubic Spline applies an interpolation between any two points using the cubic spline method. A minimum of 3 calibration points are required. Using more than 3 calibration points provides better accuracy often enables a much smoother cubic spline curve.
  - Hyperbolic decline interpolation is only available with a factory calibration. It often provides a nice fit and can often be used with only a few calibration points.
  - Rational model interpolation is only available with a factory calibration. It is an alternative model used with factory calibration, if the hyperbolic decline model does not provide a good fit.

- Pushing the Display / Calibration button shows the calibration curve for the selected calibration source.
  - For a factory calibration all entered calibration points will be displayed.
  - For user calibration all consecutively smaller FFT MV calibration points will be displayed.

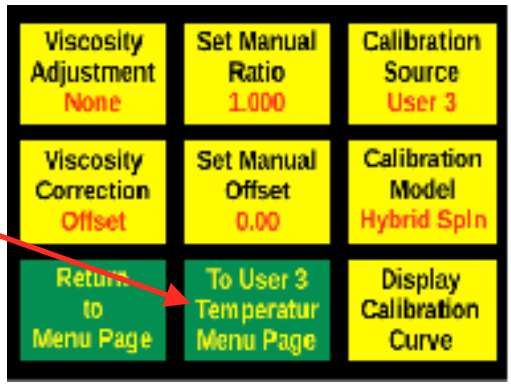




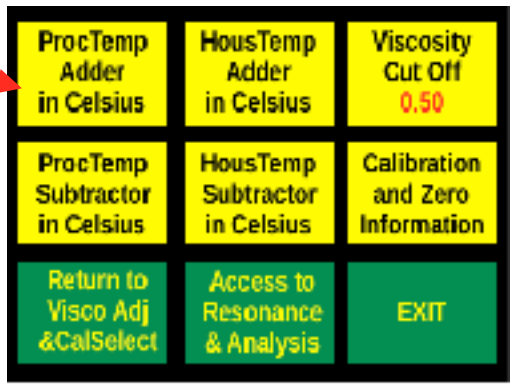


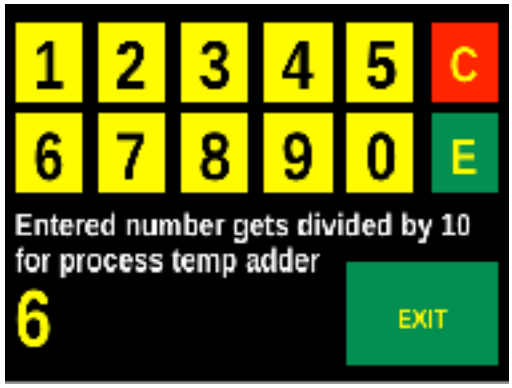
## Process Temperature correction

- Pushing the Access to / Temperatur / Menu Page button opens the menu page shown below.

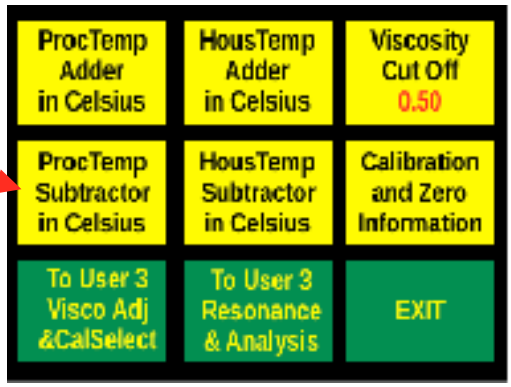


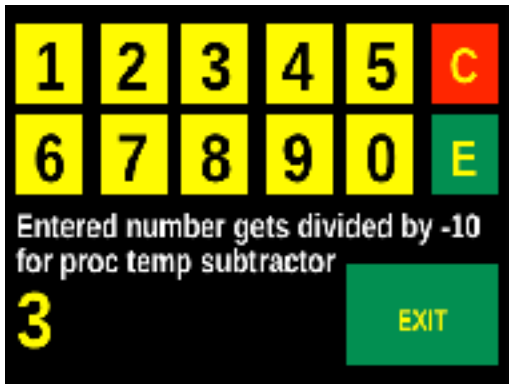

- Pushing the ProcTemp / Adder / in Celsius button opens the keypad and a number can be entered. The number will be divided by 10 to provide a positive process temperature correction with 1 decimal.



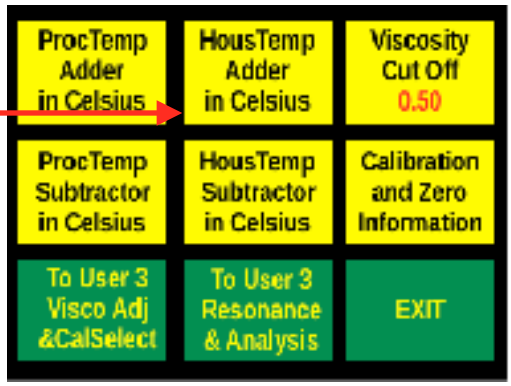

- Pushing the ProcTemp / Subtractor / in Celsius button opens the keypad and a number can be entered. The number will be divided by -10 to provide a negative process temperature correction with 1 decimal.



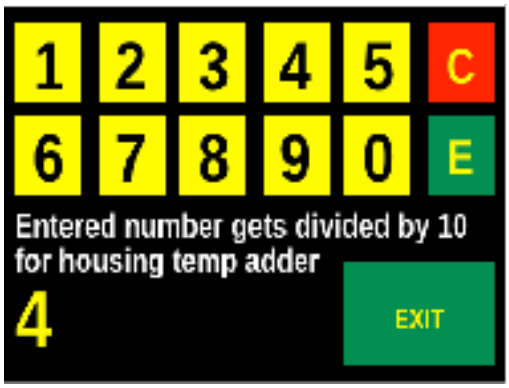



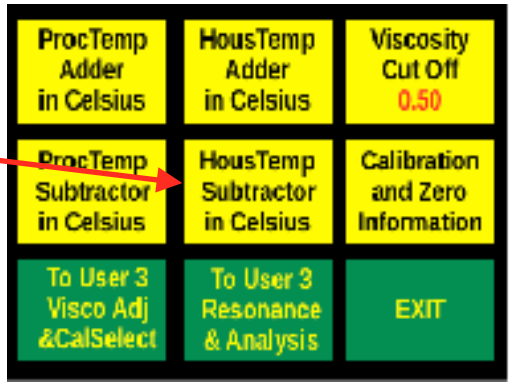

- The last temperature correction entry will take precedence.

### Housing Temperature correction

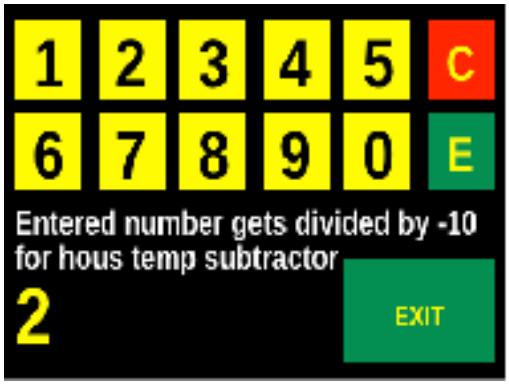



- Pushing the HousTemp / Adder / in Celsius button opens the keypad and a number can be entered. The number will be divided by 10 to provide a positive correction with 1 decimal.



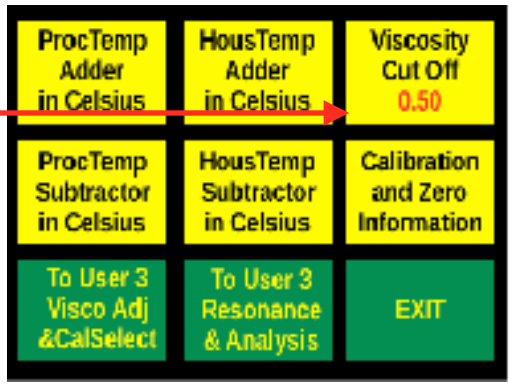

- Pushing the HousTemp / Subtractor / in Celsius button opens the keypad and a number can be entered. The number will be divided by -10 to provide a negative correction with 1 decimal.

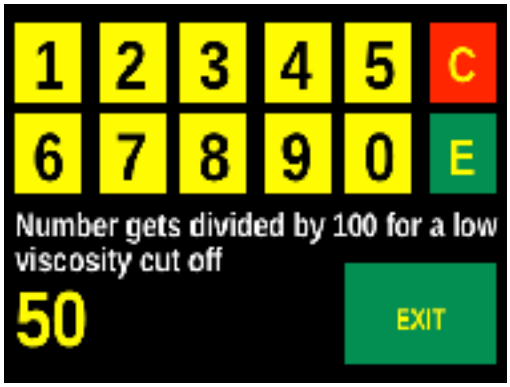



- The last temperature correction entry will take precedence.

### Viscosity Cut Off

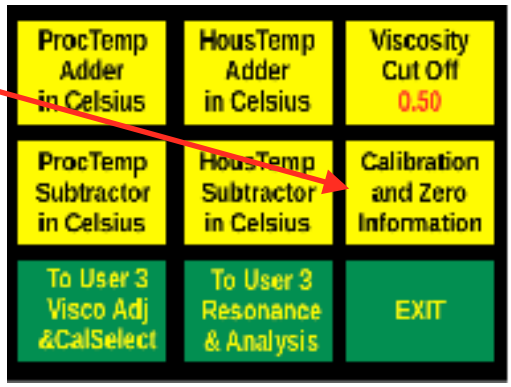
- Pushing the Viscosity / Cut Off button opens the keypad and a number can be entered. The number gets divided by 100 to create a low viscosity cut off with 2 decimals. Any viscosity smaller than the viscosity cut off will be forced to zero to prevent small variations near zero.

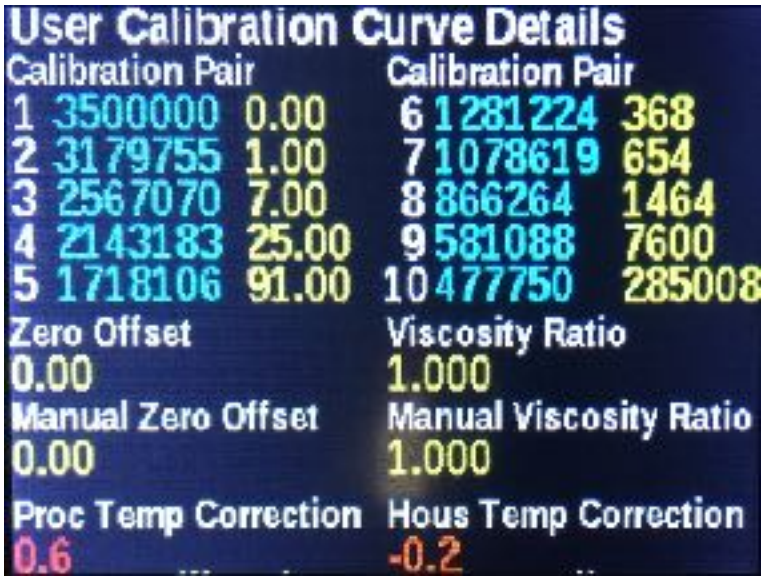



### Calibration and Zero Information

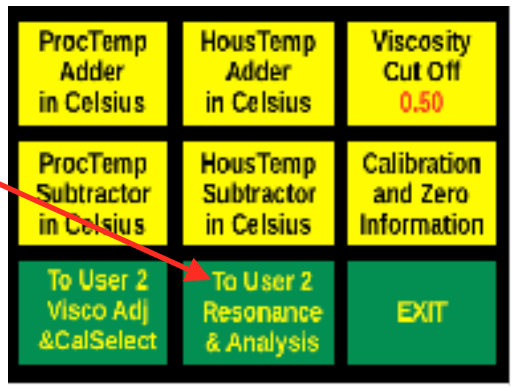
- Pushing the Calibration / and Zero / Information button opens a display with relevant calibration and adjustment information.

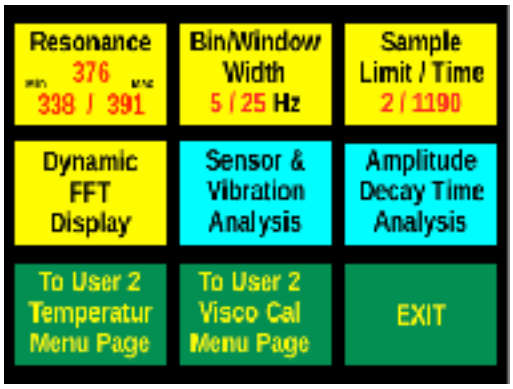


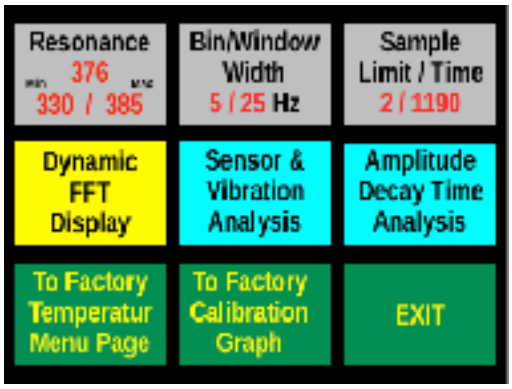
### Access to resonance and Analysis

Pushing the Access to / Resonance / & Analysis button opens the next page. The page includes resonance settings, sample limits, bin width settings, a dynamic FFT display, sensor and vibration analysis display and an amplitude decay time analysis display as shown below for factory and user calibration selected. The display pages are accessible with user or factory calibration selected. The resonance, sample limit and bin width settings are only accessible with user calibration selected.




User resonance and analysis page

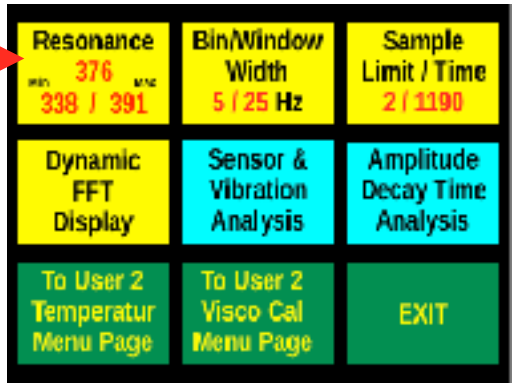



Factory resonance and analysis page

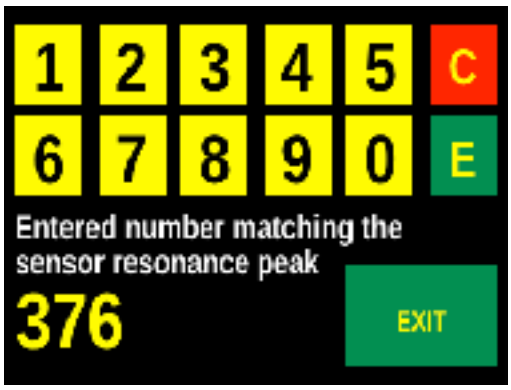
## Resonance, Sample Limit and Bin Width settings

- Pushing the Resonance button opens the keypad and a known sensor resonance can be entered. The sensor resonance to be input in Hz should be from the sensor resonating in air and at ambient temperature.

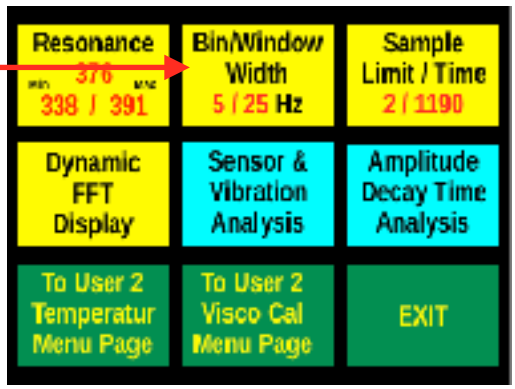
  If the sensor resonance is not known refer to the Sensor & Vibration Analysis to analyze the sensor resonance.




After the resonance of the sensor has been input press on E, the entered resonance will be shown just below the name Resonance and the minimum and maximum limits for the sensor will be calculated and shown below the resonance.

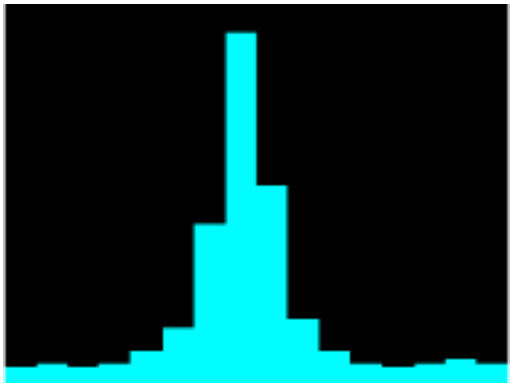



- Pushing the Bin Width / Window button repeatedly will cycle through 12 choices from a minimum of 1 Hz bin width and 3 Hz window width to a maximum of 10 Hz bin width and 30 Hz window width. The default is 8 Hz bin width and 24 Hz window width. Larger bin width take less time to be analyzed.




  - Bin width are combined with the following window width choices: 1 / 3 Hz, 1 / 5 Hz, 1 / 9 Hz, 1 / 15 Hz, 2 / 6 Hz, 2 / 10 Hz, 2 / 14 Hz, 4 / 12 Hz, 4 / 20 Hz, 5 / 15 Hz, 5 / 25 Hz, 8 / 24 Hz and 10 / 30 Hz.

  - With increasing viscosity the resonance peak amplitude becomes smaller and the window widens as illustrated in the examples below.



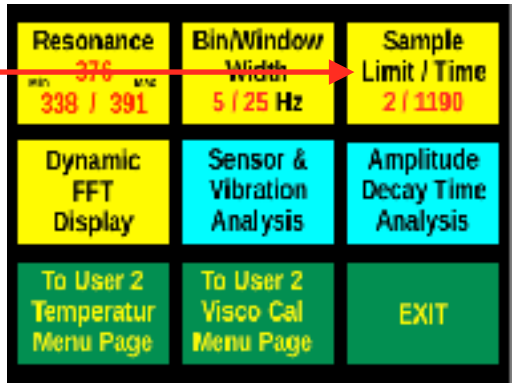
Simulated typical FFT response in air

Simulated typical response in high viscosity

Dependent on the on the bin width and window width chosen more or less of the side bins will be taken into account for the measurement. For a typical setting of 5 Hz bin width with 25 Hz window width the peak (largest) bin plus 2 bins on each side will be used for the measurement signal. For a setting of 8 Hz bin width and 24 Hz window width the peak (largest) bin plus 1 bin on each side will be used for the measurement signal.

- The setting also depends on external influences like vibration and other interference. A clean signal will always provide the best measurement experience.

- Pushing the Sample / Limit / Time button repeatedly will cycle thorough multiple choices for the sample limit dependent on the bin width setting.



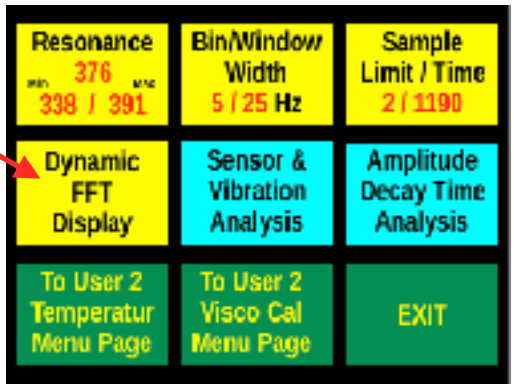

  - The first (left) red number indicates how many consecutive samples are being taken from the decaying resonance response. A faster analysis allows more samples of the decaying signal to be taken.

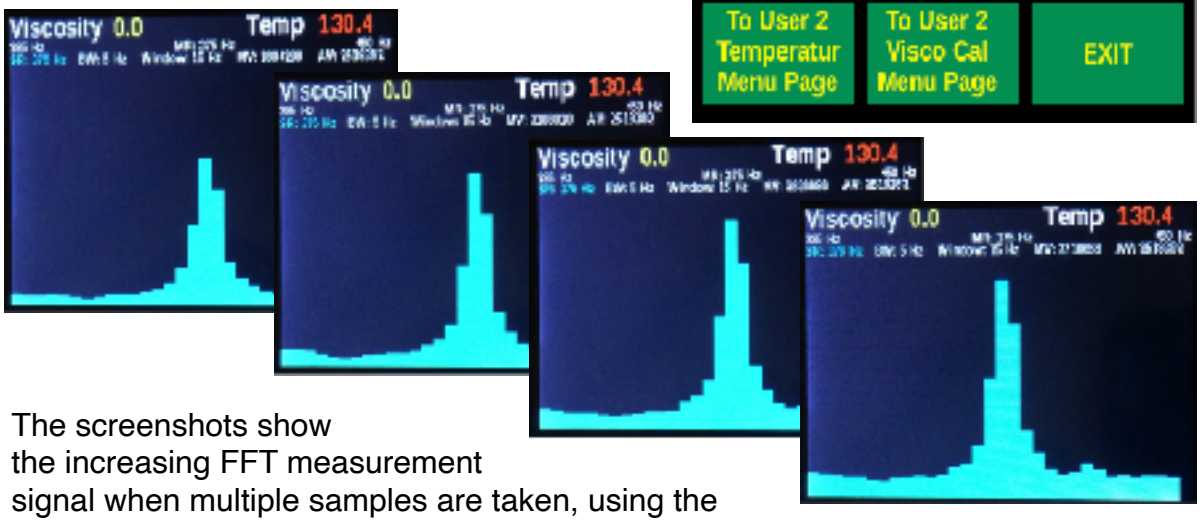
  - The second (right) red number is the total time taken for creating the resonance response and the analysis of the consecutive samples (left number). The time response is created by the number of samples taken and cannot be changed, the system dynamically returns the time used for each measurement.

# Dynamic FFT Display and Analysis functions

## Dynamic FFT Display

- Pushing the Dynamic / FFT / Display opens a window to show the current FFT response during measurement. If multiple samples from a single measurement are analyzed, the increasing total FFT signal can be observed. The measurement continues and is not interrupted by this display.




The screenshots show the increasing FFT measurement signal when multiple samples are taken, using the decaying resonance response.

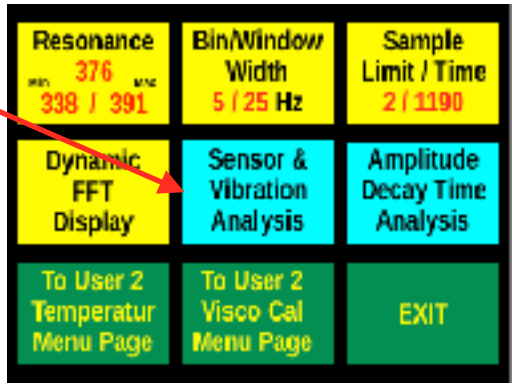
## Graphical FFT display height adjustment

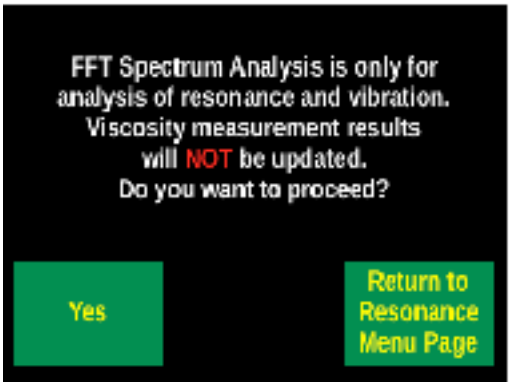
- The default height of the FFT display is set to full height for a single sample, when the sensor is resonating in air. If a calibration curve is created in which multiple samples are taken, push in the bottom left corner of the display and hold until the last sample has been calculated, i.e. for one full cycle, when the sensor is resonating in air. The system will automatically recalculate the height of the display to fit the maximum height and apply the ratio for the height to all other displays.


  - The information is independently stored for each calibration curve.
  - Perform a Save to EEPROM procedure to preserve the display height information in case of a power cycle restart.

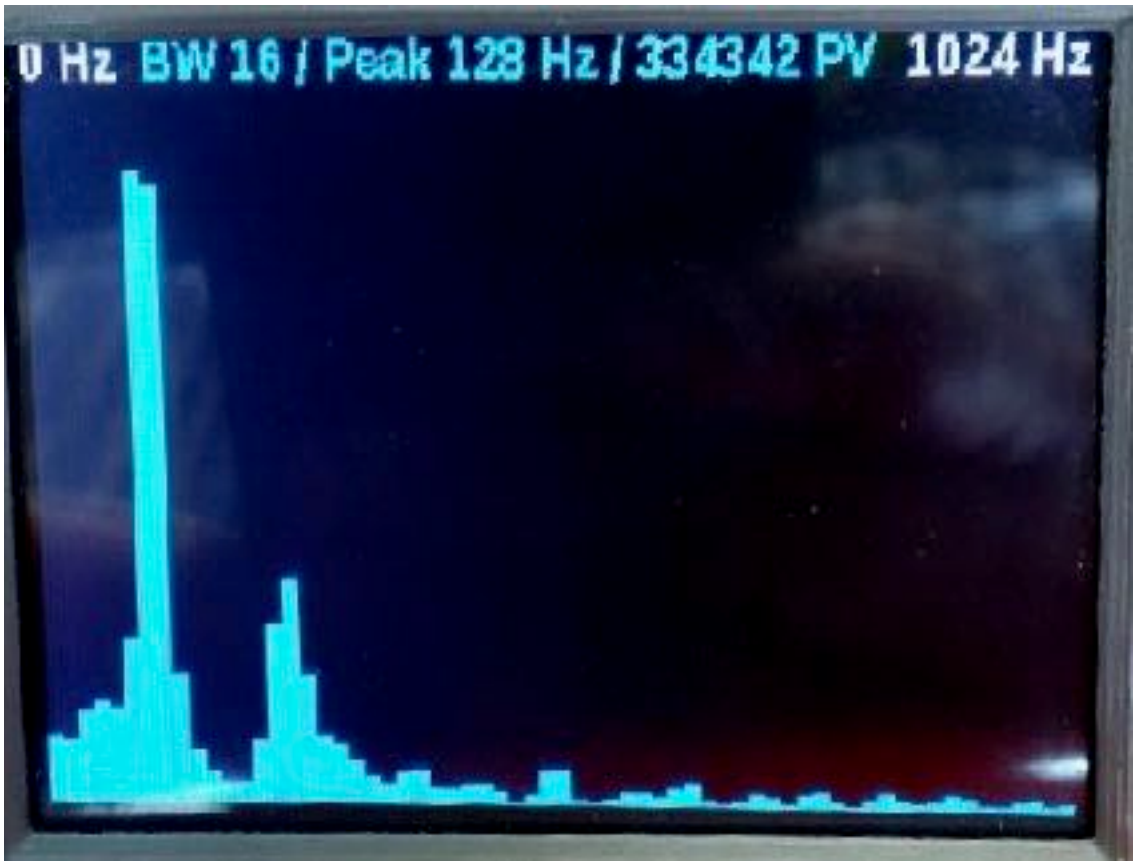
## FFT analysis for sensor resonance and external vibration

Pushing the Sensor & / Vibration / Analysis button opens the windows below.




Pushing on Yes opens the analysis window below. Analysis happens at a rapid rate, which is faster than the measurement. The faster rate allows occasional interference to be analyzed.



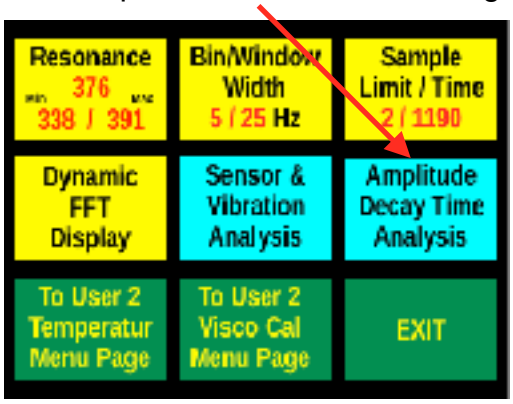

The above window is showing all frequencies between 0 and 1024 Hz divided into 16 Hz bin width (BW). The sensor peak is at 128 Hz with a peak value of 334342. The graphical display is automatically adjusted for maximum height. It is therefore important to note the signal strength, so it can be compared to other signals, which may also create peaks.

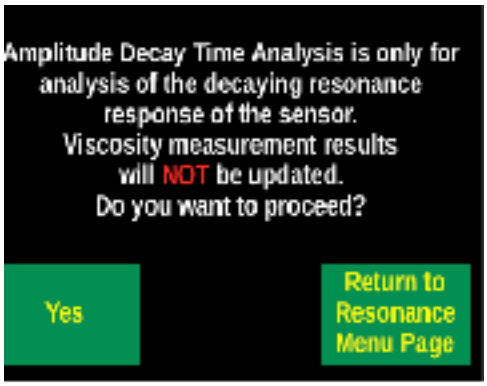
There is a potentially interfering signal at about 272 Hz, however it is about about a quarter to a third of the measurement peak and about 144 Hz away from it. The standard measurement settings are a bin width (BW) between 4 and 8 Hz with only 1 side peak on either side added to the measurement result. Thus there will be no influence on the measurement from the potentially interfering signal shown above.

Interfering signals closer to resonant frequency of the sensor can have a large influence on the measurement, especially if the interfering signal has a similar measurement value as the sensor. Even smaller values very close to the resonant frequency of the sensor can have a large influence. Any external vibration or other interference having such influence should be mitigated or eliminated. To identify sources of interference other measurement instruments may be required.

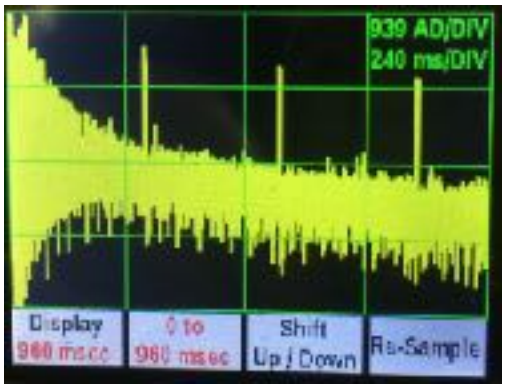
## Amplitude decay time analysis (oscilloscope function)

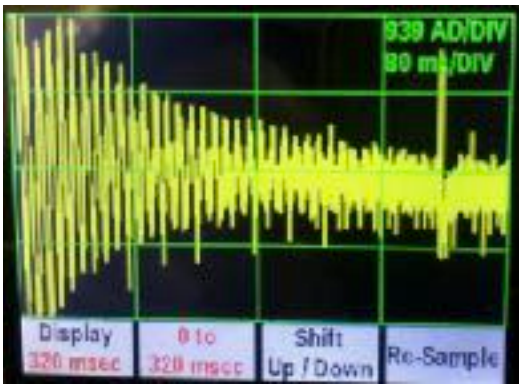
Pushing the Amplitude / Decay Time / Analysis button opens the window on the right.



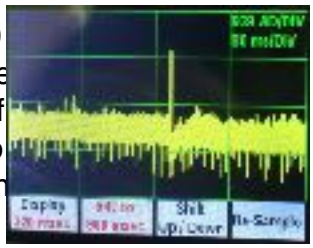

Pushing on Yes opens the analysis window below. Only a single resonance response is generated.



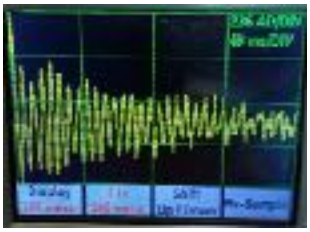




In this instance the response decays from more than 4 divisions to a little more than one division within about 240 msec, as shown in the left picture. The right picture is a zoomed version of the same signal. The signal is being expanded by repeatedly pushing on the far left button. The second button from the left allows to shift the display to a different time of the signal by repeatedly pushing the button. The third button from the left shifts the amplitude up, down and back to the centre to better observe clipping of the sinusoidal wave. The fourth button from the left generates a new curve. The numbers in the first and second button show the total time of the display and the start and end time of the current picture. The numbers in the top right provide information for the amplitude and time per division.

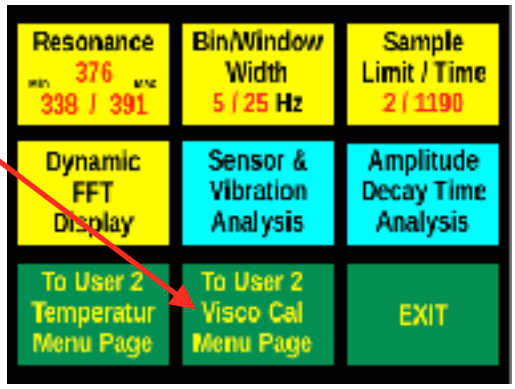
The picture on the right the expanded curve from 640 to 960 msec. Since there is basically no change in overall amplitude size, that part is not worth it to analyze. The determination of the viscosity would in this case happen within the first 240 to 320 msec. The analysis time is dependent on the type of sen



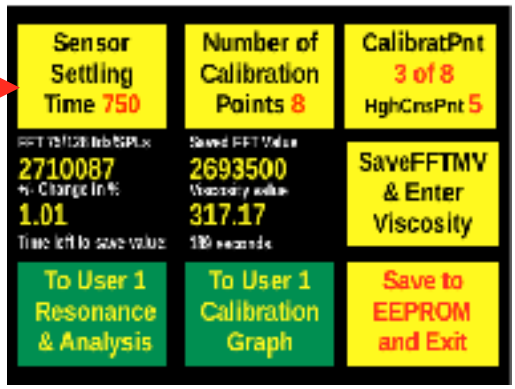
The picture on the right shows a sensor with a very short resonance time of about 160 msec.



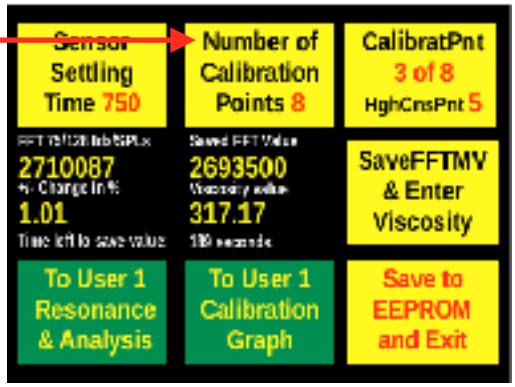
## Access to Viscosity Calibration Menu Page



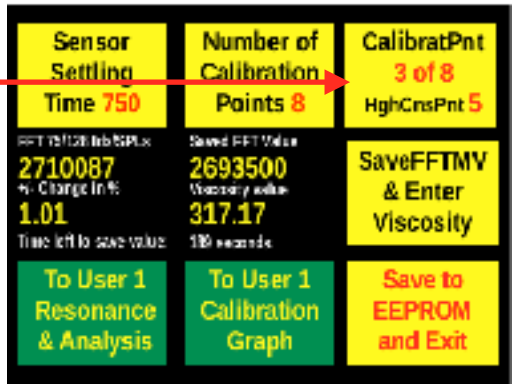

- Pushing the Access to / Visco Cal / Menu Page opens the page shown below.
  Important: Prior to attempting any calibration the resonance, bin and window width and sample limits need to be established.
  Those parameters influence the calibration, therefore subsequent changes would make any previous calibration void.




- Pushing the Sensor / Settling / Time button repeatedly cycles through 10 coil engagement times from 500 msec to 5,000 msec. Larger and heavier measurement bulbs measuring low viscosity require longer times to settle due to a larger inertia of the sensor, smaller and lighter bulbs for higher viscosities require correspondingly less time.
  +/- Change % provides a guide for the time required. A +/- change % of less than 10% works well with a moving average of 16, longer settling times may not require any averaging at all. A typical standard settling time for many sensors is 750 msec.




- Pushing the Number of / Calibration / Points button repeatedly cycles from 2 to 10 and then repeats. The selected number indicates the maximum points to be used to establish a calibration curve. The minimum number of points is 2, the maximum number of points is 10.



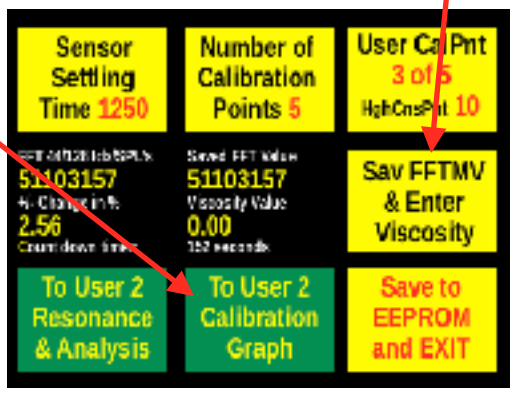

- Pushing the CalibratPnt button cycles through all available calibration points. Select a calibration point to be calibrated prior to pushing on the Sav FFTMV / & Enter / Viscosity button.

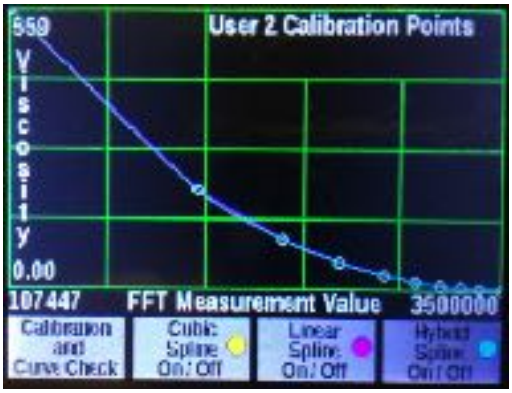
  All calibration points need to be in consecutive order. The value at HghCnsPnt indicates the highest calibration point in consecutive order. As an example: If the FFT MV value, which declines with increasing viscosities, does not decline or has an equal value to the prior one, the required consecutive order is not established. If a calibration has not yet been done, the highest calibration point in consecutive order would be 1!

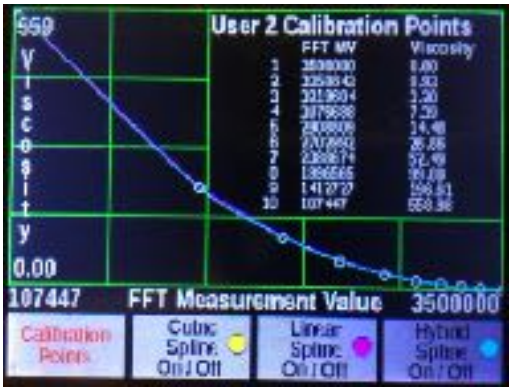
Wait until the FFT MV in the centre left is reasonably stable and then push on Save FFTMV / & Enter / Viscosity. The FFT MV value will be transferred to the virtual keypad and can be accepted by pushing on E on the keypad. A different FFT MV value can be entered simply by entering it via the number keypad prior to pushing on E. After the FFT MV value has been entered, a value for the viscosity needs to be entered. The entered value will be divided by 100 to establish a value with two decimals, thus a viscosity of 13.2 needs to be entered as 1320, which results in an entered viscosity of 13.20. If a calibration has already been entered for any point, it will be shown in the centre right, when it is selected with the CalibratPnt button. Any user calibration point can be over written.

The bottom line of the centre row shows the time left before a timeout occurs. Every time a button in the top row is pushed the time will be reset to 5 minutes.

Pushing the Calibration / Curve / Graph button opens the page shown below and the graph shows the calibration curve for the selected number of points.





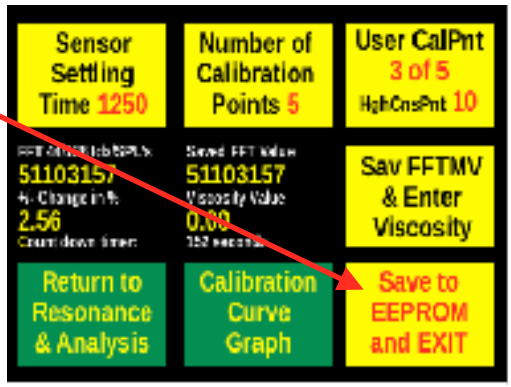
Pushing repeatedly on the left most button of the calibration curve graph will cycle through the three displays shown above. The top picture has all extra information removed to provide a graph without any interference. The second picture shows the calibration curve with the entered calibration points. The third shows evenly spaced FFT MV values at 10% apart and calculates the associated viscosities for the those values. This provides a check to see that all values are in consecutive order and above zero. Values below zero can happen with a cubic spline calculation, when the viscosities are close to zero. In such a

case utilizing the hybrid spline overcomes that problem in all cases.

The three buttons to the right offer the possibility to turn the graphical display of the linear, cubic and hybrid spline on or off.

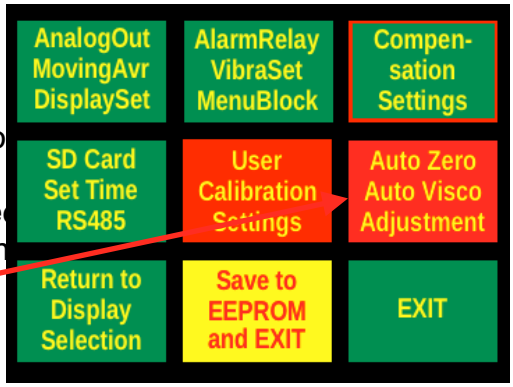
Pushing in the area above the buttons returns to the previous display.

Pushing the save to / EEPROM / and Exit button saves the entered data into EEProm, the system will then start up with the saved settings in case of a power failure or restart.

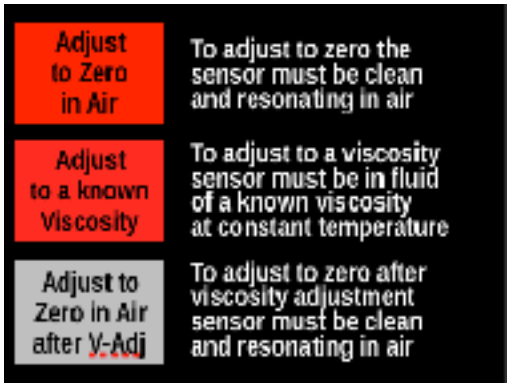


## Viscosity adjustment

- Pushing on the Auto Zero / Auto Visco / Adjustment button provides access to viscosity adjustments. The menu provides access to three viscosity adjustments, auto zero auto viscosity and auto zero post auto viscosity. Once the auto adjustments have been generated they have to be applied in the calibration section to take effect.



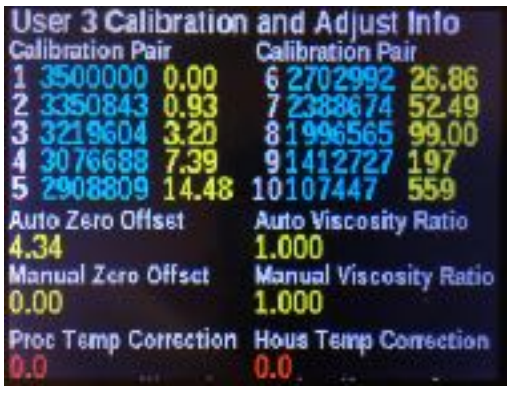

- Pushing the Adjust / to Zero / in Air button opens the page below showing the progress of the of auto zero.





  - The seconds shown in red is the remaining time until the zero offset is applied. The time is based on the required averaging time to cycle through the array at least two times and is chosen automatically based on the user selected averaging.
  - Moving average > Raw FFT measurement
  - AVR Index > Showing the current index of the average being updated on the left and the size of the array on the right.
  - Max % deviation > Deviation between the largest and smallest FFT measurement in the array expressed in percent.
  - Raw Viscosity > Viscosity measurement calculated from the FFT average using the calibration curve. No compensation functions are applied.
  - Zero offset > The offset number to be applied to zero the system.

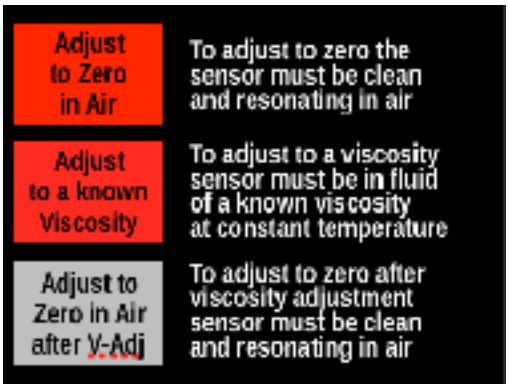
- After the averaging time has expired the screen on the right is shown.

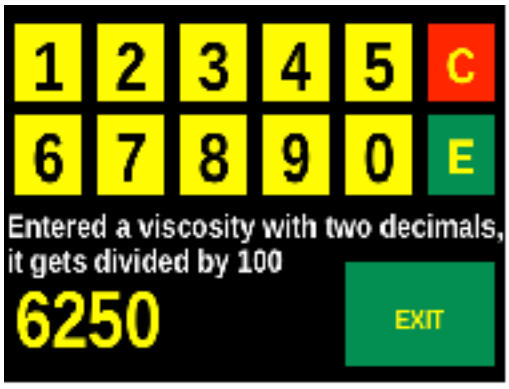



  - The screen provides information about the currently selected calibration curve. all viscosity related numbers are linked to this calibration curve.
  - Calibration Pair > Shows the entered calibration pairs for the selected calibration curve. If any calibration points have not been entered the field will be empty or show zero.

- Auto Zero Offset > The offset viscosity generated during this procedure.
- Auto Viscosity Ratio > A ratio to correct the viscosity to a known viscosity.
- Manual Zero Offset > An offset viscosity manually entered in the calibration section.
- Manual Viscosity Ratio > A manually entered ratio to correct viscosity entered in the calibration section.
- Proc Temp Correction > A manually entered temperature offset entered in the calibration section.
- Hous Temp Correction > A manually entered temperature offset entered in the calibration section.
- Pushing on the screen returns to the viscosity adjustment menu, where the auto or manual adjustments can be selected. For zero offset adjustment select Viscosity Correction Offset.
- The system returns to the previously used viscosity display after a time out.

- Pushing the Adjust / to a known / Viscosity button opens the keypad page below. Enter a known viscosity for the fluid currently being measured. The system will calculate a ratio based on measured viscosity and the entered known viscosity to correct to the known viscosity.



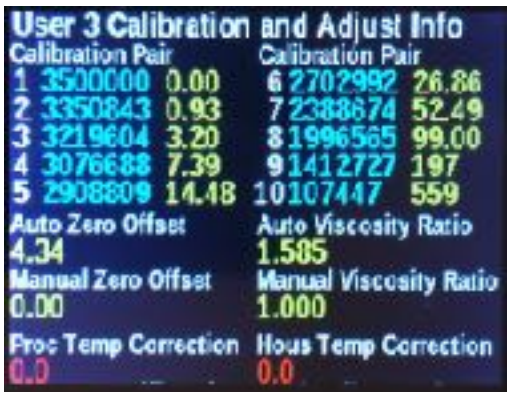


- Once the number has been entered the screen shown on the right will open.
- The seconds shown in red is the remaining time until the ratio is applied. The time is based on the required averaging time to cycle through the array at least two times and is chosen automatically based on the user selected averaging.
- Moving average > Raw FFT measurement
- AVR Index > Showing the current index of the average being updated on the left and the size of the array on the right.
- Max % deviation > Deviation between the largest and smallest FFT measurement in the array expressed in percent.
- Raw Viscosity > Viscosity measurement calculated from the FFT average

using the calibration curve. No compensation functions are applied.

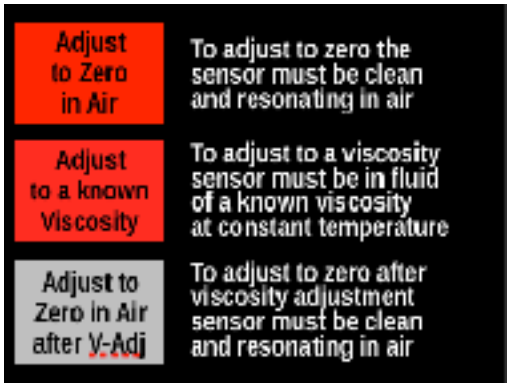
- Viscosity Ratio > The ratio to be applied to adjust the system to a known viscosity by dividing the measured viscosity by the ratio.

- After the time has expired the screen on the right is shown.




  - The screen provides information about the currently selected calibration curve. all viscosity related numbers are linked to this calibration curve.
  - Calibration Pair > Shows the entered calibration pairs for the selected calibration curve. If any calibration points have not been entered the field will be empty or show zero.
  - Auto Zero Offset > An offset viscosity generated during auto zero.
  - Auto Viscosity Ratio > The ratio to correct the viscosity to a known viscosity during this procedure.
  - Manual Zero Offset > An offset viscosity manually entered in the calibration section.
  - Manual Viscosity Ratio > A manually entered ratio to correct viscosity entered in the calibration section.
  - Proc Temp Correction > A manually entered temperature offset entered in the calibration section.
  - Hous Temp Correction > A manually entered temperature offset entered in the calibration section.
  - Pushing on the screen returns to the viscosity adjustment menu, where the auto or manual adjustments can be selected. For ratio adjustment select Viscosity Correction Ratio.
  - The system returns to the previously used viscosity display after a time out.

- Pushing the Adjust to / Zero in Air / after V-Adj button opens the page below. The system will calculate an offset, which may still be remaining after the ratio has been applied.



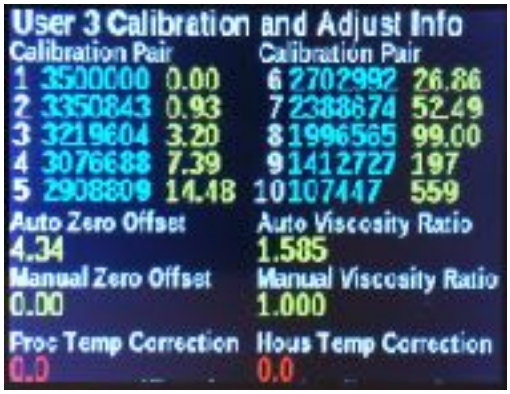


  - The seconds shown in red is the remaining time until the ratio is applied.

The time is based on the required averaging time to cycle through the array at least two times and is chosen automatically based on the user selected averaging.

- Moving average > Raw FFT measurement
- AVR Index > Showing the current index of the average being updated on the left and the size of the array on the right.
- Max % deviation > Deviation between the largest and smallest FFT measurement in the array expressed in percent.
- Viscosity Ratio > The ratio currently being applied to calculate the viscosity.
- Zero Offset > The offset still remaining from the currently calculated viscosity.

- After the time has expired the screen on the right is shown.




  - The screen provides information about the currently selected calibration curve. all viscosity related numbers are linked to this calibration curve.
  - Calibration Pair > Shows the entered calibration pairs for the selected calibration curve. If any calibration points have not been entered the field will be empty or show zero.
  - Auto Zero Offset > The offset viscosity generated after viscosity ratio has been applied.
  - Auto Viscosity Ratio > The ratio used to correct the viscosity for this procedure.
  - Manual Zero Offset > An offset viscosity manually entered in the calibration section.
  - Manual Viscosity Ratio > A manually entered ratio to correct viscosity entered in the calibration section.
  - Proc Temp Correction > A manually entered temperature offset entered in the calibration section.
  - Hous Temp Correction > A manually entered temperature offset entered in the calibration section.
  - Pushing on the screen returns to the viscosity adjustment menu, where the auto or manual adjustments can be selected. For zero after viscosity adjustment select Viscosity Correction Ratio+Offs.
  - The system returns to the previously used viscosity display after a time out.

# Appendix

## Modbus Information

### Function used from the Modbus protocol:

- Read holding registers (03h).
  - For 32 bit transfer per parameter 2 registers need to be read, i.e. dependent on the actual parameter twice as many values will need to be read, than the number of actual parameters requested. The answer for each parameter therefore consists of 4 bytes.

    All temperature and viscosity parameters are transferred with two extra digits to provide information for up to two decimals. Some results may not truly have two decimals and will therefore in that case simply have two zeros added to the end.

    *Please note: Even though there will always be 2 registers per parameter only one register may need to be read for some parameters (lower order one).*

### Holding Registers Operator Level:

| Holding Register | Description | Words | Decimals |
|---|---|---|---|
| 40001 | Serial Number | 1 | None |
| 40003 | Measured resonant frequency | 1 | None |
| 40005 | User viscosity | 2 | 2 |
| 40007 | User configured process temperature | 1 | 2 |
| 40009 | User configured housing temperature | 1 | 2 |
| 40011 | Pressure compensated viscosity | 2 | 2 |
| 40013 | Temperature compensated viscosity | 2 | 2 |
| 40015 | Dynamic viscosity | 2 | 2 |
| 40017 | Kinematic viscosity | 2 | 2 |
| 40019 | Zeroed viscosity | 2 | 2 |
| 40021 | User selected moving average | 2 | None |
| 40023 | Process temperature in Celsius | 2 | 2 |
| 40025 | Process temperature in Fahrenheit | 2 | 2 |
| 40027 | Process temperature in Kelvin | 2 | 2 |
| 40029 | Resistance of process temperature PT100 | 2 | 2 |
| 40031 | Fault indicator for process PT100<br>• 1 Indicates a fault<br>• 0 Indicates no fault | 2 | None |

| Holding Register | Description | Words | Decimals |
|---|---|---|---|
| 40033 | Housing temperature in Celsius | 2 | 2 |
| 40035 | Housing temperature in Fahrenheit | 2 | 2 |
| 40037 | Housing temperature in Kelvin | 2 | 2 |
| 40039 | Resistance of housing temperature PT100 | 2 | 2 |
| 40041 | Fault indicator for housing PT100<br>• 1 Indicates a fault<br>• 0 Indicates no fault | 2 | None |
| | | | |
| 40049 | Average of 8 FFT measurement values | 2 | None |
| 40051 | Average of 16 FFT measurement values | 2 | None |
| 40053 | Average of 32 FFT measurement values | 2 | None |
| 40055 | Average of 48 FFT measurement values | 2 | None |
| 40057 | Average of 64 FFT measurement values | 2 | None |
| 40059 | Average of 96 FFT measurement values | 2 | None |
| 40061 | Average of 128 FFT measurement values | 2 | None |
| 40063 | Average of 256 FFT measurement values | 2 | None |

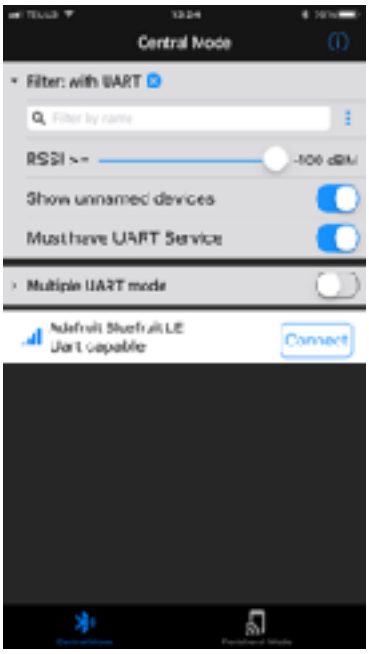
## VT-IRFTx USB Interface

- The VT-IRFTx can transfer data and be controlled via the USB plug interface.
  - The USB cable plugs directly into a micro USB socket on the controller board.
- A terminal program like Cool Term http://freeware.the-meiers.org can be used after connecting the VT-IRFTx to a computer using a USB interface cable between the micro jack on the VT-IRFTx and a computer.

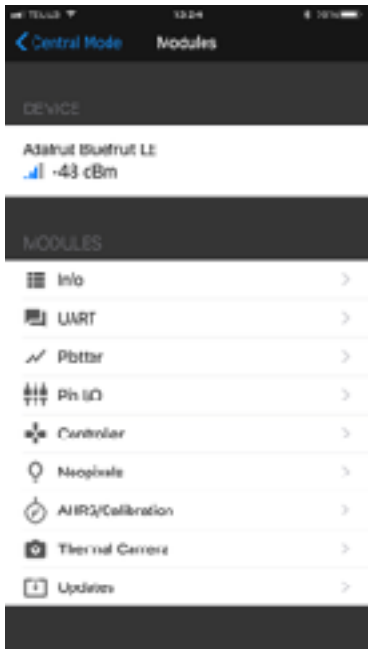

- Access is provided via commands and parameters and measurements can be read or sent to the VT-IRFT. The rate is fixed at 115200 Baud.
- Two basic commands are used to read or set parameters with the USB interface; examples:
  - Entering **“get user_viscosity;”** without the apostrophes will retrieve the current viscosity including all added compensations from the system.
  - Entering **“set user_avr_choice 5;”** without the apostrophes will set the moving average to 128 samples.
- The complete list of commands is shown in the tables following these pages.

## VT-IRFT BlueTooth Interface

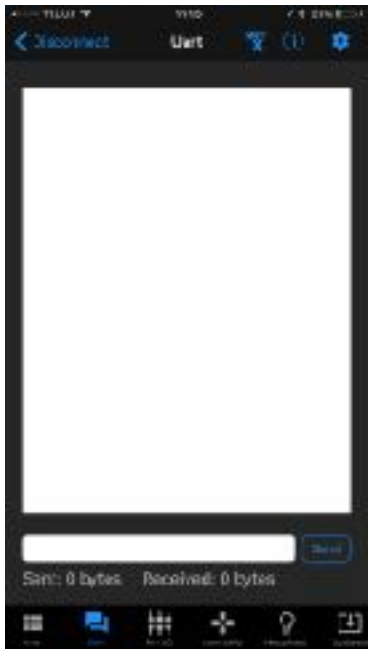
- The VT-IRFTx can transfer data and be controlled via the optional BlueTooth interface.
- For an iPhone using iOS 11.3 or later the Adafruit Bluefruit LE terminal program is available in the App store can be used to connect to the VT-IRFTx transmitter via the optional BlueTooth interface.
- For an Android phone using Android an Adafruit Bluefruit LE Connect terminal program is available at Google Play. It can be used to connect to the VT-IRFTx transmitter via the optional BlueTooth interface. Compatibility is dependent on version and device.




Opening screen of Bluefruit LE on iOS. Tab on Connect at Adafruit Bluefruit LE to link to the optional BlueTooth module.



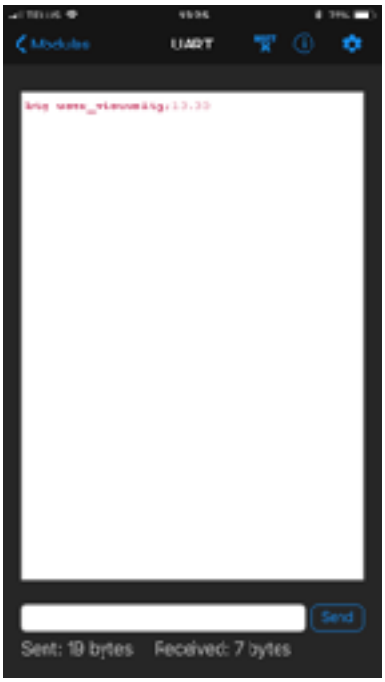

The screen will briefly show some messages and then the information screen for the module. Tapping on the UART button opens the screen shown on the right.




Only the Info, UART and Plotter buttons have any functions for the VT-IRFTx. The Update button is used, if the firmware of the Bluefruit LE module needs to be updated.

- Using such a terminal program information can be read from the VT-IRFTx or commands can be send to it. The rate is fixed at 9600 Baud
- Two basic commands are used to read and to set parameters via the BlueTooth interface; examples:
  - Entering **“btg USER_VISCOSITY;”** without the apostrophes will retrieve the current viscosity including all added compensations from the system.
  - Entering **“bts USER_AVR_CHOICE 5;”** without the apostrophes will set the moving average to 64 samples.
- For Mac computers using BlueTooth low energy the Adafruit Bluefruit LE Connect terminal program can be downloaded from the App Store. It requires OSC 10.10 or later.
- For other operating systems check out proof of concept versions here: https://github.com/adafruit/adafruit-bluefruit-le-desktop


Tapping in the single line next to the send button opens the keypad and a command can be entered.




The response from Bluetooth module after sending the entered command “btg USER_VISCOSITY;”


Entering the command “bts BTPRINT 1;” creates a continuous ASCII dump to the screen.


The ASCII dump after sending the command “bts BTPRINT 1;”.


Using a command without any header, the Plotter function can be utilized. Entering “bts BTPLOT 6;” creates a continuous ASCII dump of of the MV value plus four averages (16, 32, 64, 128) to the screen as seen on the right.


The ASCII dump after sending the command “bts BTPLOT 6;”. This shows how to compare the averages for best suitability.

Once the ASCII dump has started, returning to Modules and choosing Plotter the ASCII dump can be shown as a chart.

## User accessible commands (USB and Bluetooth)

| Command | Select | Type | Command | Description |
|---|---|---|---|---|
| **Commands for retrieving only** | | | | |
| The commands below can be in initiated to retrieve measurement information via the USB or Bluetooth connection.<br><br>**get xxxx** to retrieve parameters or measurements.<br><br>Use the commands below as follows: **get USER_VISCOSITY;** will retrieve the viscosity value, capitalization is not required.<br><br>The same commands can also be in initiated to retrieve measurement information via the optional Bluetooth connection, however “btg” instead of “get” has to to be used.<br><br>**btg xxxx** to retrieve parameters or measurements.<br><br>Use the commands below as follows: **btg USER_VISCOSITY;** will retrieve the viscosity value, capitalization is not required.<br><br>The viscosities are created in order from raw_viscosity to user_viscosity. If any compensation method is not chosen it will be skipped. | | | | |
| RAW_VISCOSITY | | | | Raw viscosity (dimension mPa.s x gr/cm3 or Pa.s x gr/cm3) using the zero setting from the factory calibration. |
| ZEROED_VISCOSITY | | | | Zeroed viscosity (dimension mPa.s x gr/cm3 or Pa.s x gr/cm3) - if customer zero procedure has not been performed raw_user_viscosity will be displayed. |
| DYN_VISCOSITY | | | | Density compensated viscosity (dimension mPa.s or Pa.s) - if din_viscosity has not been applied, zeroed_viscosity will be displayed. |
| KIN_VISCOSITY | | | | Viscosity compensated by the density squared (dimension mPa.s / gr/cm3 (cSt) or Pa.s / gr/cm3) - if kin_viscosity has not been applied, dyn_viscosity will be displayed. |
| TEMP_COMP_VISCOSITY | | | | Temperature compensated viscosity (dimension as selected above) - if temperature compensation has not been applied kin_viscosity will be displayed. |
| PRESS_COMP_VISCOSITY | | | | Pressure compensated viscosity (dimension as selected) - if pressure compensation has not been applied, temp_comp_viscosity will be displayed. |
| USER_VISCOSITY | | | | User viscosity. This is the viscosity shown on the VT-IRFT display using all the selections above. |
| PT100_PDO | | | | Process temperature in user selected units. Note: All parameters are calculated in degrees C, degrees F is only used for display. |
| PT100_PTC | | | | Process temperature in degrees C. |
| PT100_PTF | | | | Process temperature in degrees F, note: All parameters are calculated in degrees C, degrees F is only used for display. |
| PT100_PTK | | | | Process temperature in degrees K, note: All parameters are calculated in degrees C, degrees K is only used for display. |

| Command | Select | Type | Command | Description |
|---|---|---|---|---|
| PT100_HDO | | | | Housing temperature in user selected units. Note: All parameters are calculated in degrees C, degrees F is only used for display. |
| PT100_HTC | | | | Housing temperature in degrees C. |
| PT100_HTF | | | | Housing temperature in degrees F, note: All parameters are calculated in degrees C, degrees F is only used for display. |
| PT100_HTK | | | | Housing temperature in degrees K, note: All parameters are calculated in degrees C, degrees K is only used for display. |
| DENSITY | | | | Density used for viscosity compensation to dynamic or kinematic viscosity. |
| PRESSURE | | | | Process pressure if provided via analog input |
| RESONANCE | | | | Sensor resonance. |

| Command | Select | Type | Command | Description |
|---|---|---|---|---|

## Commands for retrieving and setting

The commands below can be initiated for setting or retrieving parameters via the USB or optional BlueTooth connection.

**get xxxx** to retrieve parameters or measurements using the USB connection.

**set xxxx** is used to set parameters using the USB connection.

Examples:
**get MANUAL_ZERO_CORRECTION_DIVISOR;** retrieves the current manual correction divisor used for viscosity correction to a device connected via a USB connection.

**set MANUAL_ZERO_CORRECTION_DIVISOR 1.500;** sets the manual correction divisor used for viscosity correction to 1.5 from a device connected via a USB connection.

**Set USBPRINT 12;** instructs the system to stream complete measurement information to the USB port:
Day, Time, Firmware, Serial#, FlickIts, Cycle(ms), Loop(ms), , CoilEDTime, MovAVR, RawVisco, Zeroed MovAVR, ZeroedVisco, DynVisco, KinVisco, TempCVisco, PressCVisco, UserVisco, Density, Pressure, PPT100Res, ProcTemp, UProcTemp, HPT100Res, HousTemp, UHousTemp, MeasRes, PResSum, VibrCount, VibrCountT, PeakValue, PeakNValue, PeakPValue, FFT Avr2, FFT Avr4, FFT Avr8, FFT Avr16, FFT Avr32, FFT Avr64, FFT Avr128, FFT Avr256, % MVChange
(above selection is automatically adjusted based on installed components)

The commands for BlueTooth are identical and can be used for setting or retrieving parameters via the optional BlueTooth connection. Please note that “USBPRINT” will not respond to a command from BlueTooth and “BTPRINT” will not respond to a command via the USB connection.

**btg xxxxx** to retrieve parameters or measurements via a Bluetooth connection.

**bts xxxxx** to set parameters via a Bluetooth connection.

Examples:
**btg MANUAL_ZERO_CORRECTION_DIVISOR;** retrieves the current manual correction divisor used for viscosity correction to a BlueTooth device.
**bts MANUAL_ZERO_CORRECTION_DIVISOR 1.500;** sets the manual correction divisor used for viscosity correction to 1.5 from a BlueTooth device.

**bts BTPLOT 6;** instructs BlueTooth to stream current FFT value and averages of 16, 32, 64, and 128 measurement values as shown on page 69 and 70.

The numerics accepted by the system are Integers and Floating Points. The type is identified in the third column of this table. The second column lists the maximums or minimums, which can be used:

| | | |
|---|---|---|
| I = Integer | written as 123456789 | |
| F = Floating Point | written as 1.23456789 | or -1.23456789 |

| Command | Select | Type | Command | Description |
|---|---|---|---|---|
| USBINFO | 1 | I | set | Provides information about available USB commands |
| USBPRINT | 0<br>10<br>11<br>12<br>50<br>70<br>20 | I | set | Selection for an ASCII stream on the USB port:<br>0: None<br>10: Basic measurement information:<br>Day, Time, Serial#, FlickIts, Raw Viscosity, User Viscosity, User Temperature<br>11: Extended measurement information:<br>Day, Time, Firmware, Serial#, FlickIts, Cycle(ms), Loop(ms), MovAVR, RawVisco, Zeroed MovAVR, UserVisco, ProcTemp, HousTemp<br>12: Complete measurement information:<br>Day, Time, Firmware, Serial#, FlickIts, Cycle(ms), Loop(ms), , CoilEDTime, MovAVR, RawVisco, Zeroed MovAVR, ZeroedVisco, DynVisco, KinVisco, TempCVisco, PressCVisco, UserVisco, Density, Pressure, PPT100Res, ProcTemp, UProcTemp, HPT100Res, HousTemp, UHousTemp, MeasRes, PResSum, VibrCount, VibrCountT, PeakValue, PeakNValue, PeakPValue, FFT Avr2, FFT Avr4, FFT Avr8, FFT Avr16, FFT Avr32, FFT Avr64, FFT Avr128, FFT Avr256, % MVChange<br>(above selection is automatically adjusted based on installed components)<br>50: Information for every FFT analysis:<br>Cycle(ms), Analys(ms), SplCount, PrevRes, MeasRes, LowFrequ, HighFrequ, VibrCount, SmallP7, SmallP6, SmallP5, SmallP4, SmallP3, SmallP2, SmallP, SmallN, SmallN2, SmallN3, SmallN4, SmallN5, SmallN6, SmallN7, PeakV, ResPeakP, ResPeakN, ResPeakT<br>70: MovingAvr, RawVisco, ZeroedAvr, ZeroRatioVisco<br>20: System settings information |
| BTINFO | 1 | I | bts | Provides information about available Bluetooth commands |

| Command | Select | Type | Command | Description |
|---|---|---|---|---|
| BTPRINT | 0<br>1<br>2<br>3<br>4 | I | bts | Selection for an ASCII stream via the BlueTooth interface:<br>0: None, This command will stop streaming the ASCII dump<br>1: Basic measurement information:<br>Day, Time, Serial#, FlickIts, Viscosity, ProcTemp<br>2: Extended measurement information:<br>Day, Time, Serial#, RawViscosity, UserViscosity, ProcTemp, Resonance, Previous FFT measurement value, FFT_128 measurement value, Measurement value change, Vibration count<br>3: Information related to zeroing:<br>Day, Time, Serial#, Moving average, Raw Viscosity, Zeroed average, Ratioed zeroed viscosity<br>4: Information for every FFT analysis:<br>Serial #, Cycle time, Resonance, Measurement peak, Measurement value |
| BTPLOT | 1<br>2<br>3<br>4<br>5<br>6 | I | bts | These commands can be used to stream data for plotting with the Adafruit Bluefruit program.<br>1: User viscosity, process temperature and housing temperature.<br>2: User viscosity and process temperature.<br>3: User viscosity.<br>4: Process temperature and housing temperature.<br>5: Current FFT value and averages of 2, 4, 8 and 16 measurement values.<br>6: Current FFT value and averages of 16, 32, 64, and 128 measurement values. |
| FACT_AUTO_ZERO_CORRECTION_SUBTRACTOR | | F | get<br>set<br>btg<br>bts | Retrieve or set the subtractor generated for viscosity zero correction using the factory calibration |
| FACT_AUTO_VISCO_CORRECTION_DIVISOR | | F | get<br>set<br>btg<br>bts | Retrieve or set the divisor generated for viscosity ratio correction using the factory calibration |
| FACT_AUTO_RATIO_CORRECTED_SUBTRACTOR | | F | get<br>set<br>btg<br>bts | Retrieve or set the subtractor generated for viscosity zero correction after ratio correction using the factory calibration |
| CUST_AUTO_ZERO_CORRECTION_SUBTRACTOR | | F | get<br>set<br>btg<br>bts | Retrieve or set the subtractor generated for viscosity zero correction using the user 1 calibration |

| Command | Select | Type | Command | Description |
|---|---|---|---|---|
| CUST_AUTO_VISCO_CORRECTION_DIVISOR | | F | get set btg bts | Retrieve or set the divisor generated for viscosity ratio correction using the user 1 calibration |
| CUST_AUTO_RATIO_CORRECTED_SUBTRACTOR | | F | get set btg bts | Retrieve or set the subtractor generated for viscosity zero correction after ratio correction using the user 1 calibration |
| CUST2_AUTO_ZERO_CORRECTION_SUBTRACTOR | | F | get set btg bts | Retrieve or set the subtractor generated for viscosity zero correction using the user 2 calibration |
| CUST2_AUTO_VISCO_CORRECTION_DIVISOR | | F | get set btg bts | Retrieve or set the divisor generated for viscosity ratio correction using the user 2 calibration |
| CUST2_AUTO_RATIO_CORRECTED_SUBTRACTOR | | F | get set btg bts | Retrieve or set the subtractor generated for viscosity zero correction after ratio correction using the user 2 calibration |
| CUST3_AUTO_ZERO_CORRECTION_SUBTRACTOR | | F | get set btg bts | Retrieve or set the subtractor generated for viscosity zero correction using the user 3 calibration |
| CUST3_AUTO_VISCO_CORRECTION_DIVISOR | | F | get set btg bts | Retrieve or set the divisor generated for viscosity ratio correction using the user 3 calibration |
| CUST3_AUTO_RATIO_CORRECTED_SUBTRACTOR | | F | get set btg bts | Retrieve or set the subtractor generated for viscosity zero correction after ratio correction using the user 3 calibration |
| MANUAL_ZERO_CORRECTION_SUBTRACTOR | | F | get set btg bts | Retrieve or set the manual subtractor for viscosity zero correction of any calibration curve |
| MANUAL_VISCO_CORRECTION_DIVISOR | | F | get set btg bts | Retrieve or set the manual divisor for viscosity ratio correction of any calibration curve |