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METROLOGY AND CALIBRATION
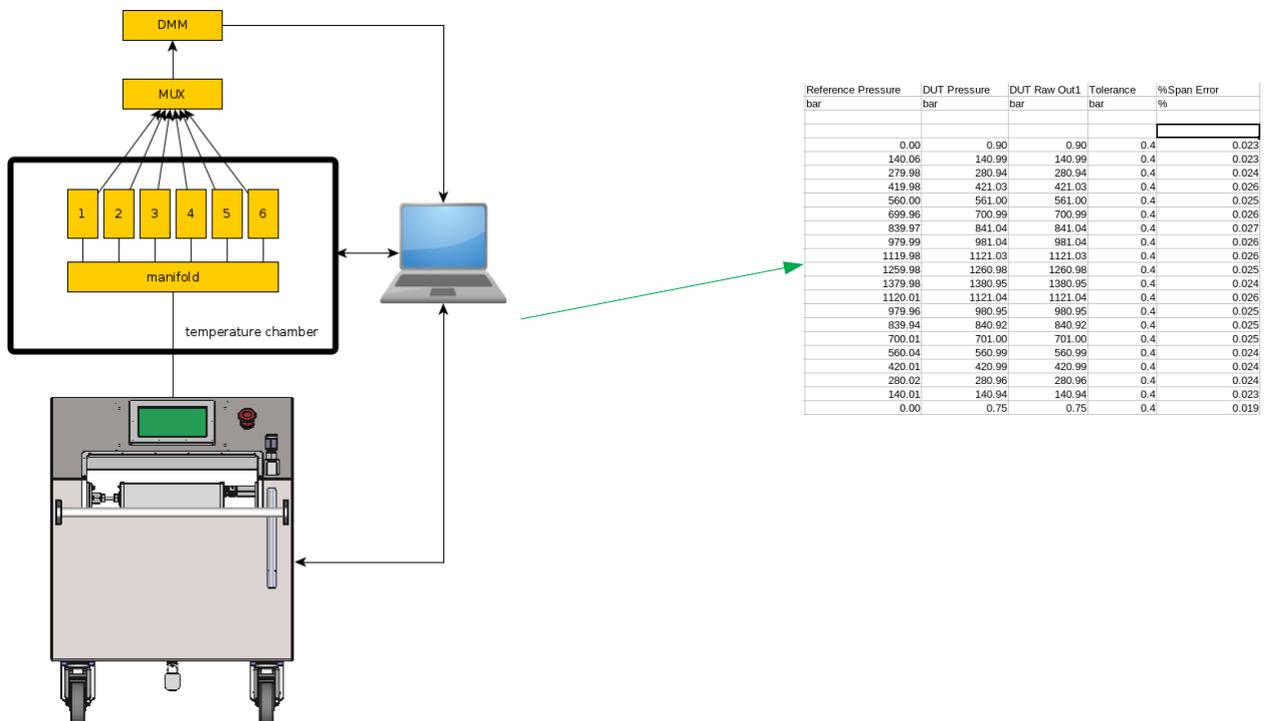
Ensuring carefree traceability

The MNR-800-HPC400 high pressure controller (HPC) is a hydraulic pressure controller intended to generate and precisely control pressure in an attached volume as needed to calibrate and test pressure measuring instruments in a wide variety of applications.

The HPC has a local user interface from which all functions needed to perform a calibration can be conducted, but it is more likely that the user would like to automate the calibration process and use calibration software to set and measure pressure.

A typical setup for calibrating multiple pressure transducers looks as follows :

Reference Pressure	DUT Pressure	DUT Raw Out1	Tolerance	%Span Error
bar	bar	bar	bar	%
0.00	0.90	0.90	0.4	0.023
140.06	140.99	140.99	0.4	0.023
279.98	280.94	280.94	0.4	0.024
419.98	421.03	421.03	0.4	0.026
560.00	561.00	561.00	0.4	0.025
699.96	700.99	700.99	0.4	0.026
839.97	841.04	841.04	0.4	0.027
979.99	981.04	981.04	0.4	0.026
1119.98	1121.03	1121.03	0.4	0.026
1259.98	1260.98	1260.98	0.4	0.025
1379.98	1380.95	1380.95	0.4	0.024
1120.01	1121.04	1121.04	0.4	0.026
979.96	980.95	980.95	0.4	0.025
839.94	840.92	840.92	0.4	0.025
700.01	701.00	701.00	0.4	0.025
560.04	560.99	560.99	0.4	0.024
420.01	420.99	420.99	0.4	0.024
280.02	280.96	280.96	0.4	0.024
140.01	140.94	140.94	0.4	0.023
0.00	0.75	0.75	0.4	0.019

A computer with dedicated calibration software interacts with the HPC to set and read the HPC pressure on the one hand, on the other hand it reads the output of the pressure transducers through a combination of a multiplexer and a Digital MultiMeter (DMM) or data acquisition device. The software may also control an environmental chamber or other components used in the transducer calibration.

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Translated in a flowchart a typical calibration protocol proceeds as follows :
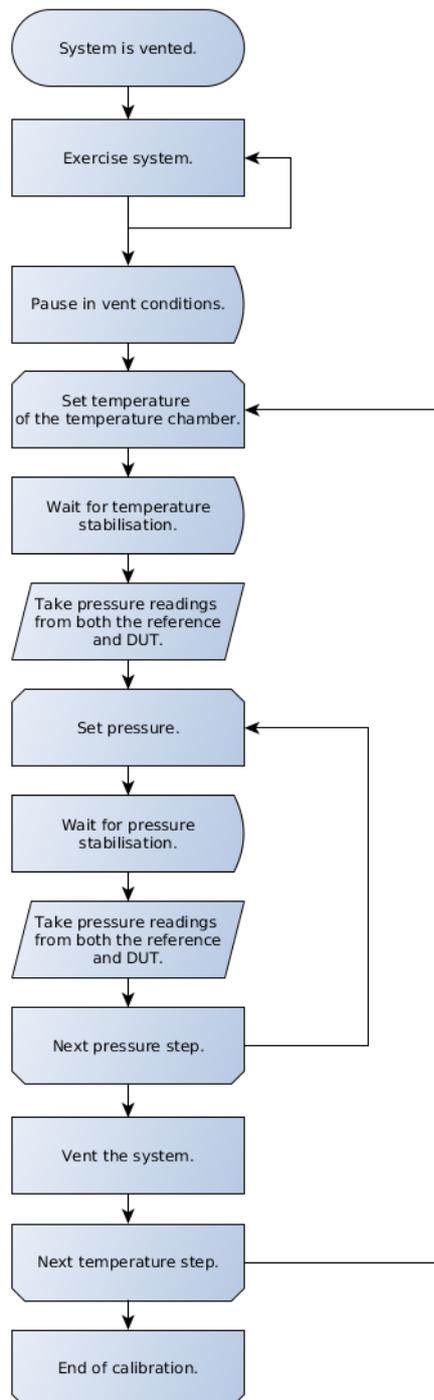
In this article we focus on the HPC commands needed to automate the calibration protocol described above.

The HPC has two ways to communicate with a computer; a USB (simulated RS232) and an Ethernet port. The simulated RS232 port does not need configuration as it will automatically detect the settings of the connected computer. The ethernet port can be configured manually or through a DHCP server on the local network.

Command structure

The HPC provides an extensive command set in SCPI format (Standard Commands for Programmable Instruments). The SCPI protocol divides commands in logical groups followed by one or more sub-commands to define the action, for example :

Group	Function	Example sub-command
MEASURE	Replies with a measured value.	:PRESSURE
SOURCE	Sets / controls to a value.	:POSITION
SYSTEM	Reads or sets system specific parameters.	:DATETIME

So what do we need to tell the HPC to run an automated calibration? The commands needed can be divided into initialisation commands which are only sent once at the beginning of the calibration process and repetitive commands used during the rest of the process.

Initialisation commands

Function	Description	Command	Reply
Lock local user interface.	It is good practice to lock the keys on the local user interface when running an unattended test.	SYSTEM:REMOTE	OK
Set pressure unit	In this example we set bar as pressure unit.	UNIT:PRESS BAR	OK
Set gauge mode	The HPC can be set in gauge or absolute mode.	SENSE:SETUP:MODE GAU	OK

Repetitive commands

Commands used during the actual calibration are commands to read and set measurands and in case of the HPC set the HPC to a certain state (vent / active control).
In this example we want to read pressure values from the HPC, set pressures and vent the system.

Function	Description	Command	Reply
Read HPC	Read reference pressure value from HPC in current pressure units.	MEAS:PRESS2:FILTERED	5.28121521E-03 bar g R
Set a pressure	When the HPC is in control mode, this command sets the desired pressure. "xx" is the desired setpoint in the active unit of measure.	SOURCE:PRESS xx	OK
Enable control	Sets the HPC in pressure control mode.	OUTP:MODE:PRESS CONT	OK
Vent HPC	Sets the HPC in vent mode in which it will ramp down a pressure and opens the vent valve.	OUTP:MODE:PRESS VENT	OK

A closer look on the measure command

It is not always the case that the software used for automating the calibration process is written by metrologists who understand the physics involved in pressure calibration. This means that the assesment of wether a measured value is acceptable or not might not be included in the software.

For this reason the HPC has built in user adjustable acceptance criteria which result in a simple ready / not ready flag. On the local user interface this ready / not ready is presented by a green or orange pressure value. Remotely the replystring from the command MEAS:PRESS2:FILTERED ends with the character "R" when it meets the acceptance criteria or "NR" if not.

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Acceptance criteria

There are two acceptance criteria when controlling a pressure :

1. **stability**
   The stability criterion is defined as the standard deviation limit measured over the rolling stability time by the active reference pressure module in percent of full scale of the pressure module.

2. **hold limit**
   A symmetrical positive and negative control limit around the setpoint within which the pressure is maintained in control mode in percent of full scale of the active reference pressure module.
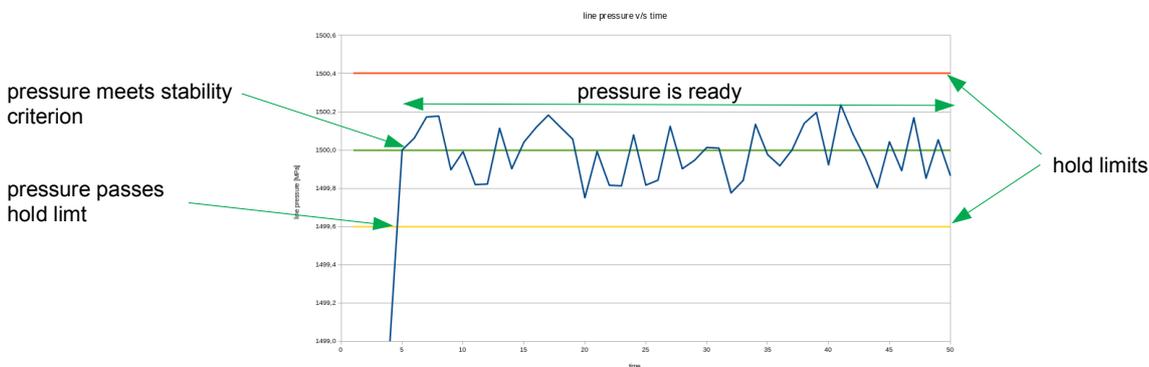
Example reply strings

Command	Reply string	Pressure		Meets criteria
MEAS:PRESS2:FILTERED	5.28121521E-03 bar g R	0.01	bar	Yes
MEAS:PRESS2:FILTERED	3.37526910E+03 bar g NR	3375.27	bar	No

In summary

With the MNR-800-HPC400 SCPI commands high pressure calibrations can be fully automated. This article shows features of a small part of all the HPC remote capabilites. For more information on how to implement the HPC in your specific system, please do not hesitate to contact us

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