Application: Customizing the analog output

Customizing the analog output

The analog output of the XEN-5320 will give an analog output voltage of 0.5 to 2.5 V for the 0-100% range of output signal. The output signal is defined by the measurement mode. In the H2 and the HE measurement modes, it is the hydrogen resp. helium concentration. In the Custom Curve mode, it is the concentration as calculated using the Custom Curve.

By manipulating the custom curve, it is possible to create a custom analog output range. For instance, if we multiply the concentration values in the left column by the factor (100% / xx%), the 2.5 V analog output is given for xx% concentration.

In Table 1, an example is given for helium, where helium concentrations of 0% to 50% in air are mapped onto the full analog output range of 0.5 V to 2.5 V.
For the look-up table in the middle of Table 1 it holds, that the digital output will go up to 200% at 100% helium concentration, while the analog output will reach the maximum (saturation) value of 3 V at 62.5% helium concentration and higher.
In this example we can perform a set-zero with pure air, and a gain correction when supplying 50% He in 50% air (this is perceived by the XEN-5320 as a 100% concentration).

Table 1: 0-100%

He-air		output (V)
-0.05	1.0627	0.40
0.00	1.0000	0.50
0.05	0.9374	0.60
0.10	0.8790	0.70
0.15	0.8242	0.80
0.20	0.7724	0.90
0.25	0.7223	1.00
0.30	0.6757	1.10
0.35	0.6325	1.20
0.40	0.5905	1.30
0.45	0.5517	1.40
0.50	0.5143	1.50
0.55	0.4778	1.60
0.60	0.4436	1.70
0.65	0.4113	1.80
0.70	0.3805	1.90
0.75	0.3508	2.00
0.80	0.3224	2.10
0.85	0.2953	2.20
0.90	0.2691	2.30
0.95	0.2440	2.40
1.00	0.2203	2.50
1.05	0.1978	2.60

Adjusted 0-50%

He-air		output (V)
-0.10	1.0627	0.30
0.00	1.0000	0.50
0.10	0.9374	0.70
0.20	0.8790	0.90
0.30	0.8242	1.10
0.40	0.7724	1.30
0.50	0.7223	1.50
0.60	0.6757	1.70
0.70	0.6325	1.90
0.80	0.5905	2.10
0.90	0.5517	2.30
1.00	0.5143	2.50
1.10	0.4778	2.70
1.20	0.4436	2.90
1.30	0.4113	3.00
1.40	0.3805	3.00
1.50	0.3508	3.00
1.60	0.3224	3.00
1.70	0.2953	3.00
1.80	0.2691	3.00
1.90	0.2440	3.00
2.00	0.2203	3.00
2.10	0.1978	3.00

Adjusted -25% to +35%

He-air		output (V)
-0.2500	0.9986	0.000
-0.1875	0.9769	0.125
-0.1250	0.9555	0.250
-0.0625	0.9346	0.375
0.0000	0.9140	0.500
0.0625	0.8938	0.625
0.1250	0.8740	0.750
0.1875	0.8545	0.875
0.2500	0.8355	1.000
0.3125	0.8167	1.125
0.3750	0.7983	1.250
0.4375	0.7803	1.375
0.5000	0.7626	1.500
0.5625	0.7452	1.625
0.6250	0.7282	1.750
0.6875	0.7114	1.875
0.7500	0.6950	2.000
0.8125	0.6789	2.125
0.8750	0.6631	2.250
0.9375	0.6476	2.375
1.0000	0.6324	2.500
1.0625	0.6174	2.625
1.1250	0.1978	2.750

Avoiding false 0 % values
Be aware that it is advisable to let the table go all the way to the normalized transfer of 0.1978, equaling 105% helium. If the table ends at 0.5143 (for 50% helium), the output will return to 0% as soon as the helium concentration goes above 50% and the normalized transfer goes below 0.5143.

The custom curve at the right of Table 1 goes one step further, since both the 0% and the 100% output values have been changed here. This Custom Curve will return a -25% output signal, and thus 0 V analog output, at 0% He in air (transfer 0.9986 ≈ 1), while it will return a 100% output signal at 35% helium (transfer = 0.6324), and thus 2.5 V analog output voltage.
Again, at higher helium concentrations the analog output will rise up to 3 V and then saturate, assuming we have the last point of the table at a lower transfer value than the helium can generate (the green point at 0.1978).

Example of adjusted curve compilation

To give an example, if you want to optimize the analog output for 0-10% hydrogen in air, then a proper calibration at such low concentrations of hydrogen should be carried out in order to get maximum accuracy. The example below shows the analog output voltage, and also shows what a 4-20 mA output would do. In 5 steps the desired Custom Curve is generated.

Step 1: Measure the transfer of the XEN-5320 at various concentrations of H_2, and divide by the value at 0% H_2 to get the normalized transfer. For example, this could yield the following (fictitious) data:

% Hydrogen	Transfer in V/W	Normalize the transfer	Normalized transfer
0% H_2:	21.81	= 21.81 / 21.81	1.00000
2% H_2:	20.95	= 20.95 / 21.81	0.96070
5% H_2:	19.74	= 19.74 / 21.81	0.90498
10% H_2:	17.90	= 17.90 / 21.81	0.82070

Step 2: Place the data in an EXCEL sheet (or use another means of calculations), and make a graph of normalized transfer versus fraction H_2, see Fig. 1.

Step 3: Make a 2nd (or 3rd) order polynomial trendline in EXCEL and also display the trendline equation and R^2 value (should be close to 1), see Fig. 1.

Step 4: Interpolate and extrapolate extra data points using the trendline equation to get a 23-points Table (with a point below 0% and one above 10% to allow for offset drift), see Table 2 on the left.

Step 5: Multiply the fractions by 10 to scale the output for 0-10% H_2, see Table 2 on the right. Change the transfer of the 1.05 point to encompass the full hydrogen scale and avoid false 0 V readings. This is done in Table 2 where the green point 0.16700 represents the 105% H_2 reading. Thus, the 10% to 105% H_2 concentration is mapped onto the analog output 2.50 to 2.60 V.

Measuring with the new curve and analog output:
Make a text file of the curve, upload it into the XEN-5320 using the LabView program, and change the measurement mode to Custom Curve.

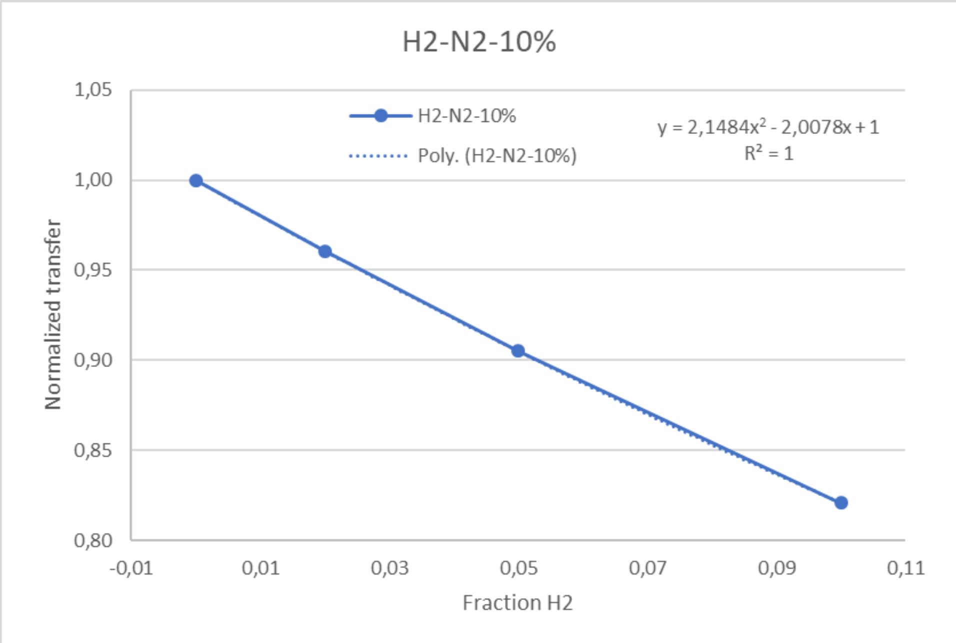


Figure 1: A plot of the calibration data between 0% and 10% H_2, with a 2nd order polynomial trendline to be used to get additional data points.

Table 2: Custom curve to get an analog output 0.5V at 0% H_2 and 2.5 V at 10% H_2. In yellow the original calibration points are highlighted. Above 10.5% H_2 the output will become 0% again, unless a transfer value (0.16700) lower than hydrogen can generate is inserted for the 1.05 point.

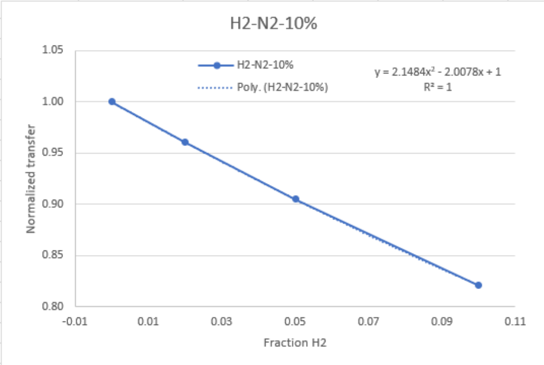
H_2 Fraction	Normalized transfer	Output voltage V	4-20 mA output	Multiply the Fraction by 10 to get a 0-10% curve	Normalized transfer	Output voltage V	4-20 mA output
0.105	0.81287	0.71	5.7	1.05	0.16700	2.60	20.8
0.100	~~0.82070~~	~~0.70~~	~~5.6~~	1.00	0.82070	2.50	20.0
0.095	0.82865	0.69	5.5	0.95	0.82865	2.40	19.2
0.090	0.83670	0.68	5.4	0.90	0.83670	2.30	18.4
0.085	0.84486	0.67	5.4	0.85	0.84486	2.20	17.6
0.080	0.85313	0.66	5.3	0.80	0.85313	2.10	16.8
0.075	0.86150	0.65	5.2	0.75	0.86150	2.00	16.0
0.070	0.86998	0.64	5.1	0.70	0.86998	1.90	15.2
0.065	0.87857	0.63	5.0	0.65	0.87857	1.80	14.4
0.060	0.88727	0.62	5.0	0.60	0.88727	1.70	13.6
0.055	0.89607	0.61	4.9	0.55	0.89607	1.60	12.8
0.050	0.90498	0.60	4.8	0.50	0.90498	1.50	12.0
0.045	0.91400	0.59	4.7	0.45	0.91400	1.40	11.2
0.040	0.92313	0.58	4.6	0.40	0.92313	1.30	10.4
0.035	0.93236	0.57	4.6	0.35	0.93236	1.20	9.6
0.030	0.94170	0.56	4.5	0.30	0.94170	1.10	8.8
0.025	0.95115	0.55	4.4	0.25	0.95115	1.00	8.0
0.020	0.96070	0.54	4.3	0.20	0.96070	0.90	7.2
0.015	0.97037	0.53	4.2	0.15	0.97037	0.80	6.4
0.010	0.98014	0.52	4.2	0.10	0.98014	0.70	5.6
0.005	0.99001	0.51	4.1	0.05	0.99001	0.60	4.8
0.000	~~1.00000~~	~~0.50~~	~~4.0~~	0.00	1.00000	0.50	4.0
-0.005	1.01009	0.49	3.9	-0.05	1.01009	0.40	3.2

H2-N2-10%	
1.05	0.81286
1.00	0.82070
0.95	0.82864
0.90	0.83670
0.85	0.84485
0.80	0.85312
0.75	0.86149
0.70	0.86998
0.65	0.87856
0.60	0.88726
0.55	0.89606
0.50	0.90498
0.45	0.91399
0.40	0.92312
0.35	0.93235
0.30	0.94170
0.25	0.95114
0.20	0.96070
0.15	0.97036
0.10	0.98014
0.05	0.99001
0.00	1.00000
-0.05	1.01009

H2 fraction	Norm Transfer
Calibration measurements	
0.00	1.00000
0.02	0.96070
0.05	0.90498
0.10	0.82070

Transfer = S

Norm = 1- 2.0078*S+2.1484*S^2



Fraction	Norm Transfer	Multiply Fraction by 10 to get 10% curve	
0.105	0.81287	1.05	0.81287
0.100	0.82070	1.00	0.82070
0.095	0.82865	0.95	0.82865
0.090	0.83670	0.90	0.83670
0.085	0.84486	0.85	0.84486
0.080	0.85313	0.80	0.85313
0.075	0.86150	0.75	0.86150
0.070	0.86998	0.70	0.86998
0.065	0.87857	0.65	0.87857
0.060	0.88727	0.60	0.88727
0.055	0.89607	0.55	0.89607
0.050	0.90498	0.50	0.90498
0.045	0.91400	0.45	0.91400
0.040	0.92313	0.40	0.92313
0.035	0.93236	0.35	0.93236
0.030	0.94170	0.30	0.94170
0.025	0.95115	0.25	0.95115
0.020	0.96070	0.20	0.96070
0.015	0.97037	0.15	0.97037
0.010	0.98014	0.10	0.98014
0.005	0.99001	0.05	0.99001
0.000	1.00000	0.00	1.00000
-0.005	1.01009	-0.05	1.01009

Figure 2: Screen shot of the EXCEL sheet with the data manipulations. The four calibration measurement points are derived from the original 0-10% curve (on the far left), and following the steps we arrive at an almost identical curve again (on the far right).