Compensated gravimetric fuel level sender

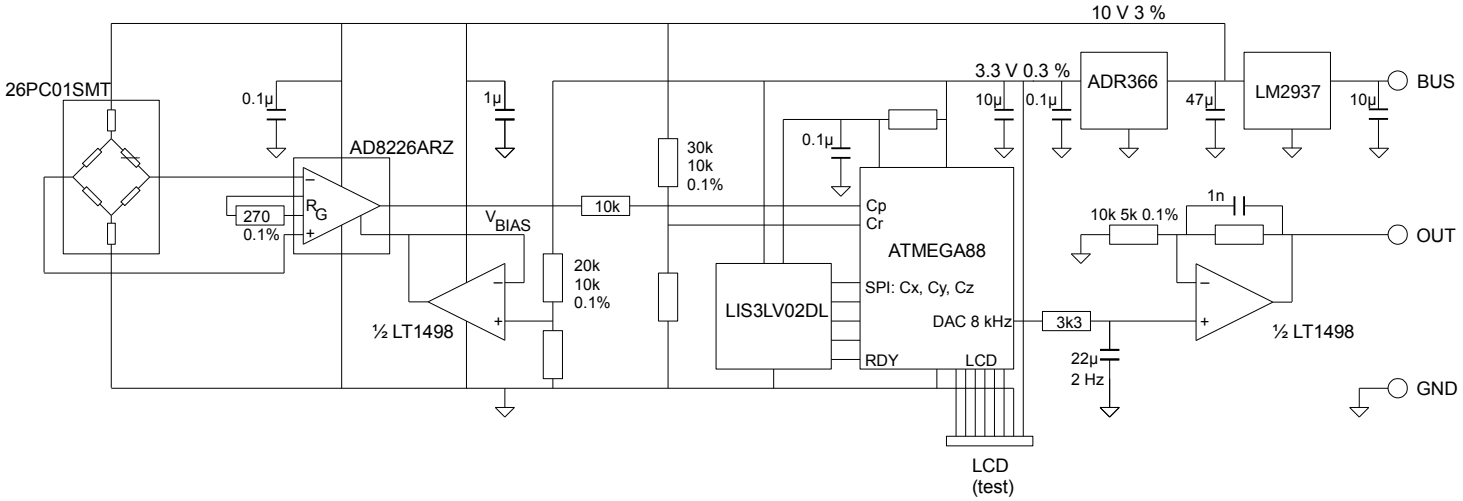
The output voltage V is a function of fuel level L in m of H2O as follows: V = 0.20 + 13.6 x L
Full scale of V = 4.96 V is set to occur at L = 0.35 m of water; the output voltage is always in the range 0 – 5 V
The value L is determined as: L = P x │G1│ / │G│, in which

P	**m H2O**	**pressure in meters of water or in units of 9.8 kPa or in units of 1.42 psi**
│G1│	**m/s²**	**absolute value of the 1 g g-force acceleration vector according to ongoing self-calibration**
│G│	**m/s²**	**absolute value of the g-force acceleration vector**

Signal conditioning from pressure sensor to output is designed to offer repeatability of ± 0.2 %
The datasheet of pressure sensor 26PC01SMT indicates the following repeatability:

- typical, at 25 °C:	**± 0.2 %**
- typical, at 0°C or 50 °C compared to at 25 °C:	**± 1.7 %**
- worst, at 0°C or 50 °C compared to at 25 °C:	**± 4.7 % ± 14.4 % of full scale**

The output voltage represents the moving average of 5 seconds of measurements (at most 10 000 samples of P, 200 samples of G)
A display instrument must be calibrated to make the translation of fuel level to fuel quantity
Save any calibration results generated and repeat the calibration after 1 year to assess long term stability



fixed amplifier output bias voltage and gain
26PC01SMT sensor sensitivity for the full scale of 35 cm H2O: 8.35 ± 1.4 mV
gain 184 (270 Ω) for an amplified range of 1536 ± 258 mV
26PC01SMT sensor maximum offset: ± 3.0 mV
the amplified maximum offset is ± 552 mV
amplifier output bias voltage: 2 x 550 mV = 1.10 V
maximum offset and sensitivity occurring together makes a full scale at 1100 + 1536 + 258 = 2894 mV
leaves 100 x (3300 – 2894) / (1536 + 258) = 22.6 % room for g-force acceleration correction – workable

measurements
amplified pressure: 10 bit ADC, full scale at 1 g single measurement count 477 ± 89
- ratiometric: P / P35 = (Cr0 / Cr) x ((Cp – Cp0)) / Cp35 – Cp0))
- Cr0, Cp0 and Cp35 calibration counts (eeprom); Cr, Cp actual counts
- > 104 µs per sample

acceleration: ± 11-bit counts for X, Y, Z acceleration (resolution 1 mg, range ± 2 g)
- G = (Cz (1 + (Cx / Cz)² / 2 + (Cy / Cz)² / 2)) / Cg1
- Cg1 ongoing calibration count; Cz, Cx, Cy actual counts
- > 25 ms per sample

1-time calibrations and references
→ test P2 – P1 = 0
note ADC count Cp = Cp0 (check 2 < Cp0 < 342), to be stored in eeprom
→ accelerometer self test
note count changes ΔCx = Cxst, ΔCy = Cyst, ΔCz = Czst, to be stored in eeprom
→ accelerometer test (0 g, 0 g, 1 g)
note counts Cx = Cx0, Cy = Cy0, Cz = Cz1, to be stored in eeprom
→ test P2 – P1 = 35 cm H2O
note ADC count Cp = Cp35 (check 387 < Cp35 – Cp0 < 4 x (1024 - Cp35)), to be stored in eeprom
note ADC count Cr = Cr0, to be stored in eeprom

ongoing 1 g g-force self calibration
the 1 g calibrated value G1 is the most frequently occurring value of G over time
histogram: ± 200 count values (± 20 %) around Cz1 (800 bytes)
every 25 minutes the winner to the queue with the last 10 winners in eeprom
the average of the 6 central values is promoted to current Cg1
the initial value of Cg1 is Cz1

g-force compensated level
L / L35 = (G1 / G) x (P / P35)
but if any count out of range then L / L35 = L / L35 unchanged

DAC
8 kHz PWM duty cycle: 0.400 + 0.960 x (L / L35)
RC 3k3 and 22µF give 2 Hz cutoff → ripple of 1 / 4000 of output range

calculations and comparisons
bits padding to limit effects on precision to < 0.01 %

X and Y errors
the monowheel sits at 6.7° from horizontal
at 9° from horizontal X and Y contribute 2 % to G
errors in X and Y vector measurements can be neglected

power-down early warning
eeprom writing needs < 4 ms per byte
Cr decrease by > 10 % indicates power loss
10 V regulator supplies < 6 mA
47 µF loses 6 V in 100 ms
3.3 V regulator supplies < 1.2 mA
10 µF loses 1.2 V in 10 ms
total time of > 50 ms while µC voltage > 2.1 V

self check errors and response
on power up:
- self test results more than 15 % different from stored Cxst, Cyst or Czst
- Cg more than 15 % different from Cz1
- G more than 4 % different from current G1

any time:
- Cp + 10 < Cp0
- current Cg1 more than 15 % different from Cz1
- new G1 more than 2 % different from current G1

there is no good check on the pressure measurement
on error the output oscillates over 100 % of the range at 0.5 Hz