HM1

General

The air pressure sensor HM1 is used to measure air pressure differences. These differences can then be used to evaluate the altitude.

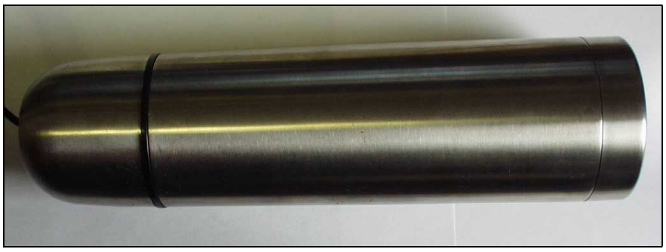


Figure 1: HM1 vacuum flask.

Output Signal

The output signal V_O is defined by

$$V_O(p) = (p_z - p) \cdot 40 \cdot k \cdot \frac{\text{V}}{\text{hPa}}$$

where k is the switch position (k = 1 or 2), p is the air pressure, and p_z is the reference pressure, which can be adjusted with a 10-turns-potentiometer. The reference pressure range begins at 1035 hPa and ends at 1085 hPa (5 hPa per potentiometer revolution ≈ 40 metres per revolution).

Pin Assignment

Output plug: The output plug is manufactured by Binder (Binder Series 719). It supplies the HM1 with voltage and puts out the pressure dependent voltages.

Pin	Assignment [Cable colour]
1	Supplying voltage (7 V to 16 V DC) [red]
2	Ground [brown]
3	Signal Output (0 V to 4.9 V) [black]
4	
5	(unused)

Specifications

Supply Voltage Range: 7 V to 16 V DC
Power Consumption (typical): 10 mA
Output Voltage Range: 0 V to 4.9 V

Mechanical Data

Vacuum flask (stainless steel):
Ø 80 mm; Height: 300 mm;
Weight: 650 g

Altitude

The international altitude formula is given by

$$p(h) = 1.013 \cdot 10^5 \,\text{Pa} \left(1 - \frac{6.5}{288000\,\text{m}} h\right)^{5.255}$$

where p is the air pressure and h is the altitude. Resolving this equation yields

$$h(p) = \frac{288000}{6.5}\text{m}\left(1 - \left(\frac{p}{1.013 \cdot 10^5\,\text{Pa}}\right)^{\frac{1}{5.255}}\right)$$

Altitude Approximation

Due to limited mathematical capabilities of data loggers and signal converters, the altitude formula can be approximated by using simple integer arithmetic: First, the air pressure p is substituted with its corresponding bit value b, and second, only the first few terms of the Taylor series at air pressure p_0 are taken into account. Thus,

$$h(b) \approx -200\text{ m} + \tfrac{1}{10}\text{m}\left(a_0 + \sum_{i=1}^{3} \frac{(a_i \cdot b)^i}{65535^{i-1}}\right)$$

TEMES Calculation Instructions

No	Operation
F1	$h_1 = \mathrm{Op}_4(Q_1 = p,\ K_1 = a_3,\ K_2 = 0)$
F2	$h_2 = \mathrm{Op}_7(Q_1 = Q_2 = h_1,\ K_1 = 65535)$
F3	$h_3 = \mathrm{Op}_7(Q_1 = h_1,\ Q_2 = h_2,\ K_1 = 65535)$
F4	$h_4 = \mathrm{Op}_4(Q_1 = p,\ K_1 = a_2,\ K_2 = 0)$
F5	$h_5 = \mathrm{Op}_7(Q_1 = Q_2 = h_4,\ K_1 = 65535)$
F6	$h_6 = \mathrm{Op}_4(Q_1 = p,\ K_1 = a_1,\ K_2 = 0)$
F7	$h_7 = \mathrm{Op}_5(Q_1 = h_6,\ Q_2 = h_5,\ K_1 = 1)$
F8	$h_8 = \mathrm{Op}_5(Q_1 = h_7,\ Q_2 = h_3,\ K_1 = 1)$
F9	$h = \mathrm{Op}_4(Q_1 = h_8,\ K_1 = 1,\ K_2 = a_0)$ Assignment: $b(h = -200\text{ m}) = 0$ bit $b(h = -199\text{ m}) = 10$ bit

Approximation for $h \le 3350$ m

Given Switch position $k = 2$

$h(p_0) = 1000$ m

Working Range: $V(p = 1060\text{ hPa}) = 0$ V

$V(p = 660\text{ hPa}) = 5$ V

Assumption: $V(0\text{ bit}) = 0$ V

$V(63937.5\text{ bit}) = 5$ V

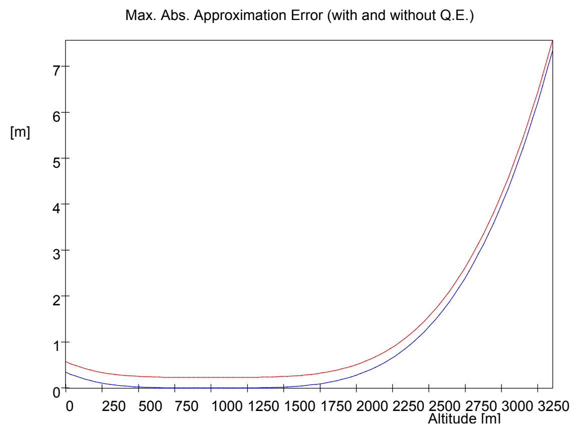
Result $a_3 = 0.3078701171$

$a_2 = 0.2674385051$

$a_1 = 0.5038948203$

$a_0 = -1853.468621$

$h \in [-200\text{m};\ 3350\text{m}]$



Q.E. = quantization error < 0.23 m

Approximation for $h \le 1350$ m

Given Switch position $k = 1$

$h(p_0) = 260$ m

Working Range: $U(p = 1060\text{ hPa}) = 0$ V

$U(p = 860\text{ hPa}) = 5$ V

Assumption: $U(0\text{ bit}) = 0$ V

$U(63937.5\text{ bit}) = 5$ V

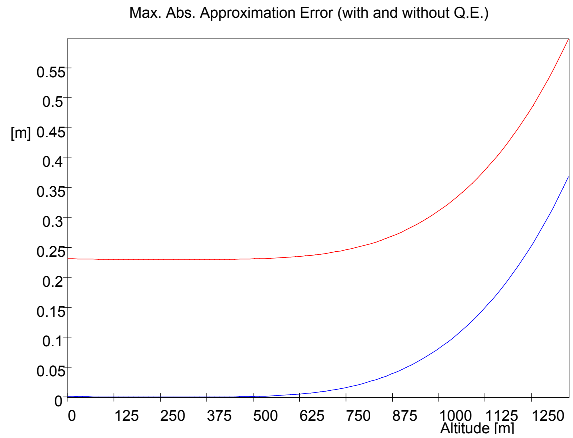
Result $a_3 = 0.1416195918$

$a_2 = 0.1390062029$

$a_1 = 0.251055528$

$a_0 = -1841.009177$

$h \in [-200\text{m};\ 1350\text{m}]$



Q.E. = quantization error < 0.26 m