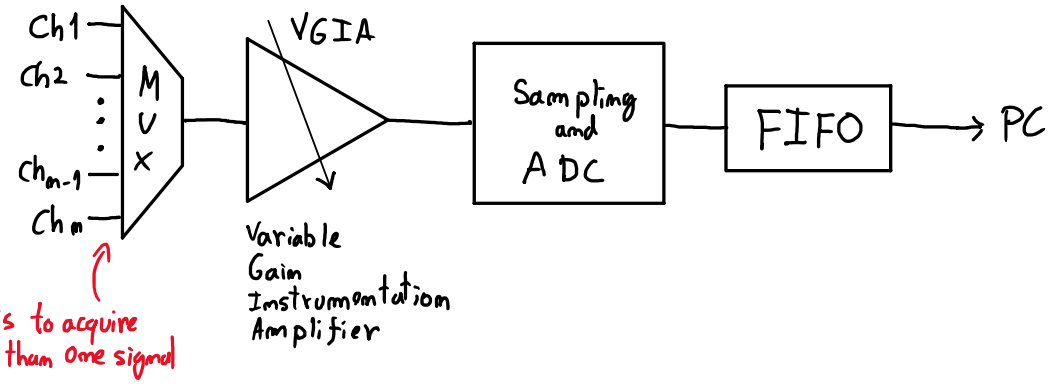
1a) Draw the circuit diagram of a data acquisition card (DAQ), which is the component that allows you to acquire more than one signal, with a single ADC? Does the acquisition of multiple signals occur simultaneously? Justify your answers.



Allows to acquire more than one signal

Those are not acquired simultaneosly, but squentialy controled by a clock

1b) Indicate what minimum characteristics (input mode, ADC frequency, single channel gain, number of bits) a DAQ must have, inside which there is an amplifier with gains G_i = 0.5, 1, 10, 100 and an A/D converter with dynamics ±3 V, to be able to simultaneously acquire the following signals:

V_1 Analog signal with a maximum bandwidth of 20 kHz, maximum amplitude 100 mV peak-to-peak, with zero average value, of which you want to appreciate details with a resolution better than 0.1 mV.

V_2 Analog square wave with levels 0 V and 3 V, at a frequency of 500 Hz, of which at least 50 samples per period must be acquired.

V_3 Temperature signal from a thermocouple, with sensitivity of 50 µV/K, used to measure a temperature of an oven around 500 °C, with a resolution of at least 0.35 °C.

V_4 Signal from an absolute pressure sensor, with sensitivity of 15 mV/kPa placed 10 meters below sea level (1 atm = 101.325 kPa) that measures the pressure with resolution Δ V_4 = 1 mV.

V_1: f_s = 40kHz
G = 10
m = 13

V_2: f_s = 25 kHz
G = 1
m = –

V_3: f_s = –
G = 100
m = 12
Differential!

V_4: f_s = –
G = 1
m = 13

$G_i = 0{,}5;\ 1;\ 10;\ 100 \quad D = \pm 3\ V$

V_1:

$B_W = 20\,kHz \Rightarrow f_s = 40\,kHz$

$D = \pm 50\,mV \quad DC = 0$

↳ $G = 10 \Rightarrow D = \pm 0.5\,V$

$\Delta V = 0.1\,mV$

↳ $2^m \geq \log_2\left(\frac{G}{\Delta V \cdot G}\right) \Rightarrow m = 13$

V_2:

$D = +3\ V \Rightarrow G = 1$

$f = 500\,Hz$ with 50 S/period

↳ $f_s = 25\,KHz$

8 channels in differential mode

13 bits and f_s = 160 kHz

V_3: Thermocouple ⇒ Differential

$S = 50\,\mu V/K$

$T = 500 \Rightarrow V = S \cdot (T - T_{AMB}) = 23.75\,mV$

↳ $G = 100$

$\Delta T = 0.35C^\circ$

↳ $2^m \geq \log_2\left(\frac{G}{G \cdot \Delta T \cdot S}\right) \Rightarrow m = 12$

V_4: $S = 15\,mV/kPa \quad 1\,atm = 101.3\,kPa$

$h = 10\,m$

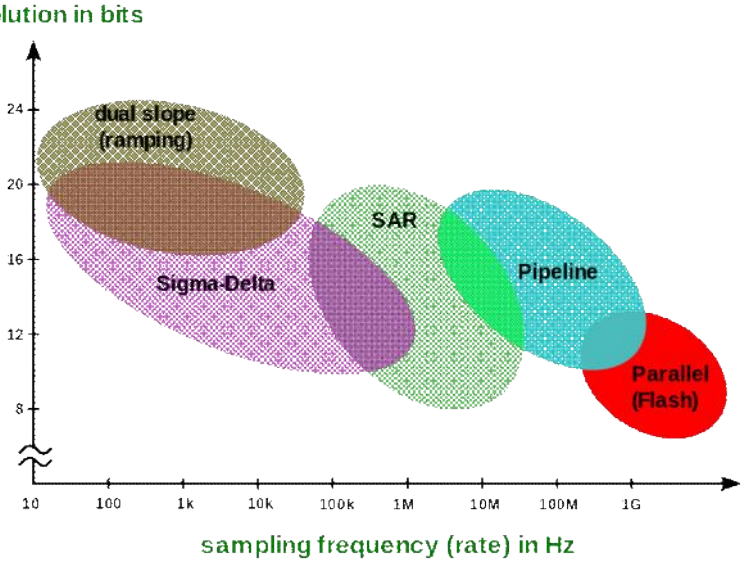
$\Delta V_4 = 1\,mV$

$P = \rho h g + 1\,atm = (98 + 101.3)\,kPa = 199.3\,kPa$

$V = P \cdot S = 2.99 \Rightarrow G = 1$

$2^m \geq \log_2\left(\frac{G}{\Delta V_4 \cdot G}\right) \Rightarrow m = 13$

1c) Which type of analog-to-digital converter is probably used in the DAQ, as it is suitable for this measurement? If it were necessary to acquire an additional V5 signal with 10 MHz analog bandwidth and amplitude that varies between ±2 V, which type of converter (indicate the architecture among those known) would be necessary to use inside a new acquisition card, which simultaneously acquires all five signals?



13 bit and 160 KHz

↳ Can either be a sigma delta or a SAR

$V_5 \Rightarrow f_s = 20\,MHz$

Total $f_s = 100\,MHz \Rightarrow$ Pipeline