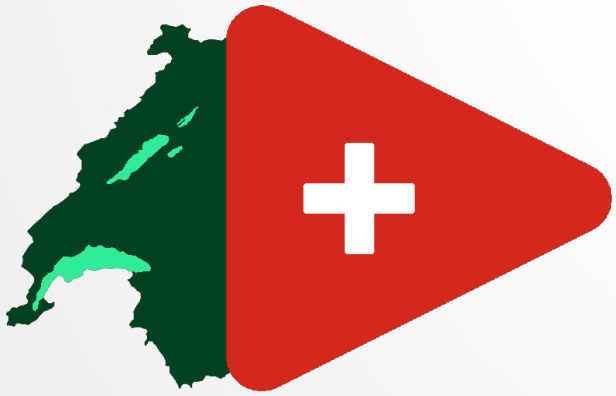
Sci-Consulting

presents

Get the most out of your measurement with NI hardware



Vincent Berseth

Romandie LabVIEW User Group Meeting
July 9, 2024

Who are we ?

Sci-Consulting

Partner
SYSTEM INTEGRATION

Training Partner

Custom development services & solutions for 30 years

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Content

- Use of COTS HW is generally optimal for prototyping, NI products are great for this
- Sometimes cost of HW already becomes an issue for medium scale deployments
- There are ways to address this and deploy NI-based systems with optimized costs without compromising performance, versatility and ease of prototyping
- Here we present a small selection of them

Analog inputs

Multifunction devices

NI USB-6341

USB X Series

PXI X Series

NI PXIe-6341

Most often ±10V analog inputs, with gains

Analog inputs

C Series include signal conditioning :

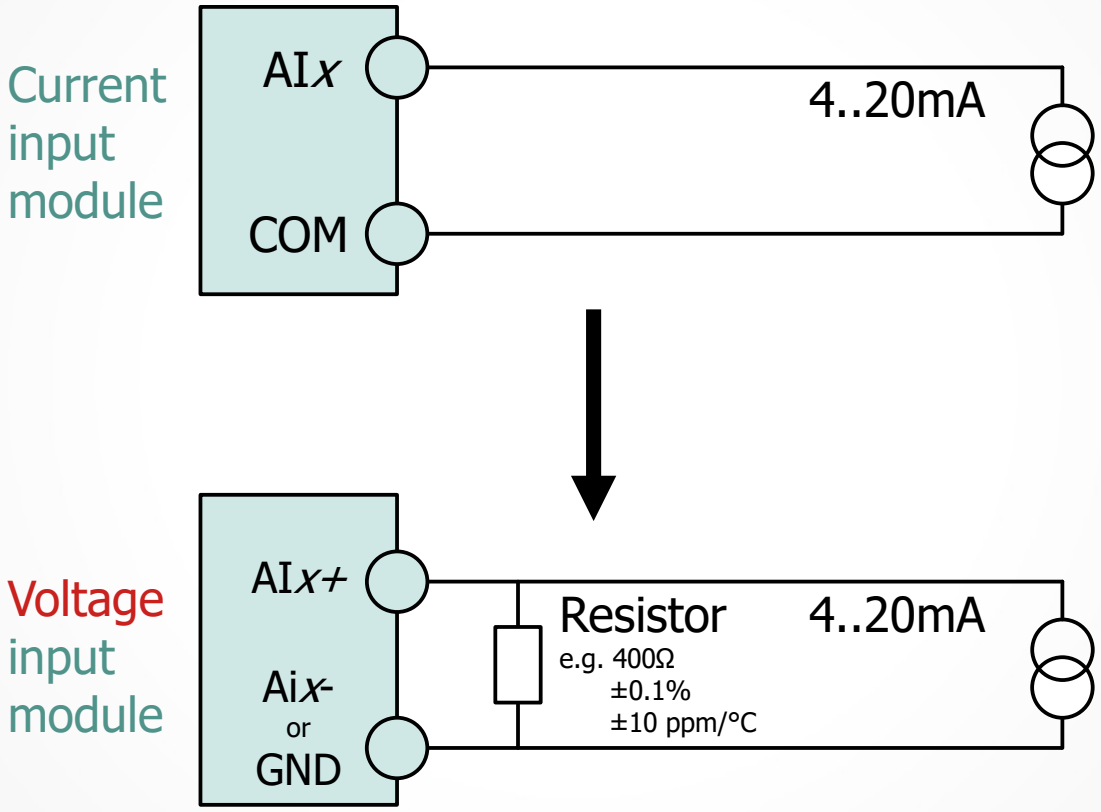
- ±10V Voltage
- Current ±20mA
- Thermocouple
- RTD
- Strain gauge

  … and more

Channel counts “granularity” : 4, 8, 16...

Converting signal conditioning

From 4..20mA sensor to voltage module



Real world example

2x thermocouples and 1x ambient probe

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Which analog input devices to use?

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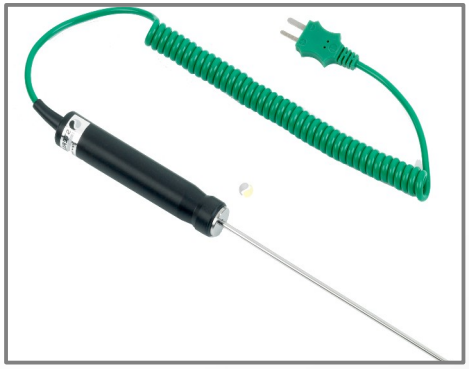
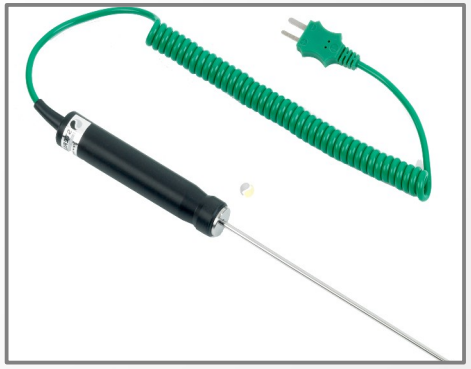
1x Ambient probe: temperature and relative humidity (2x 0..1V)





2x T-type thermocouples

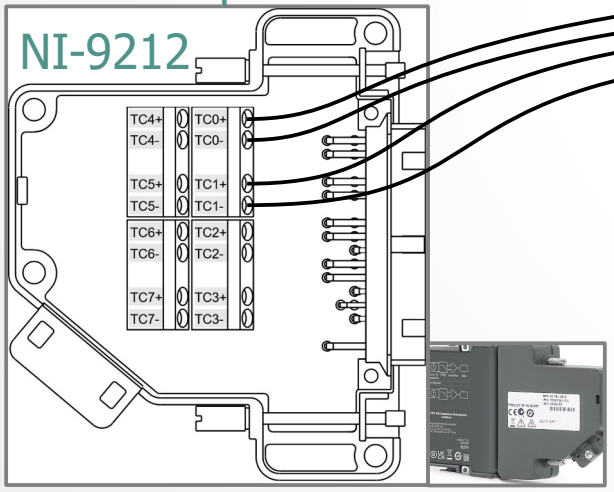
Real world example

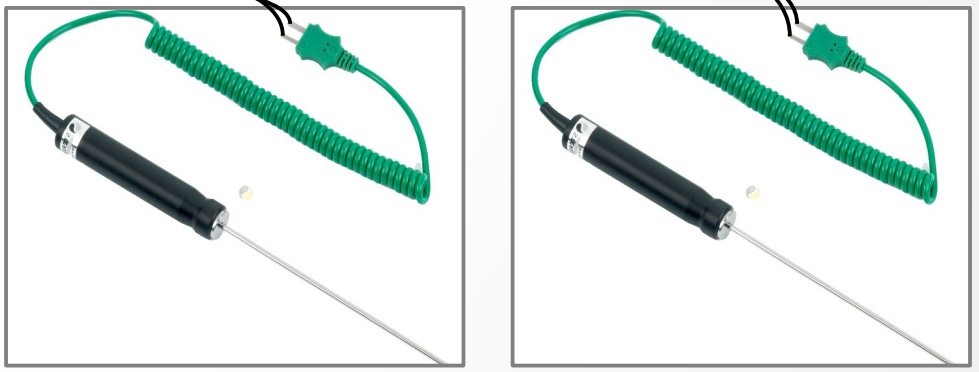
2x thermocouples and 1x ambient probe

Voltage module

1x Ambient probe: temperature and relative humidity (2x 0..1V)

Thermocouple module



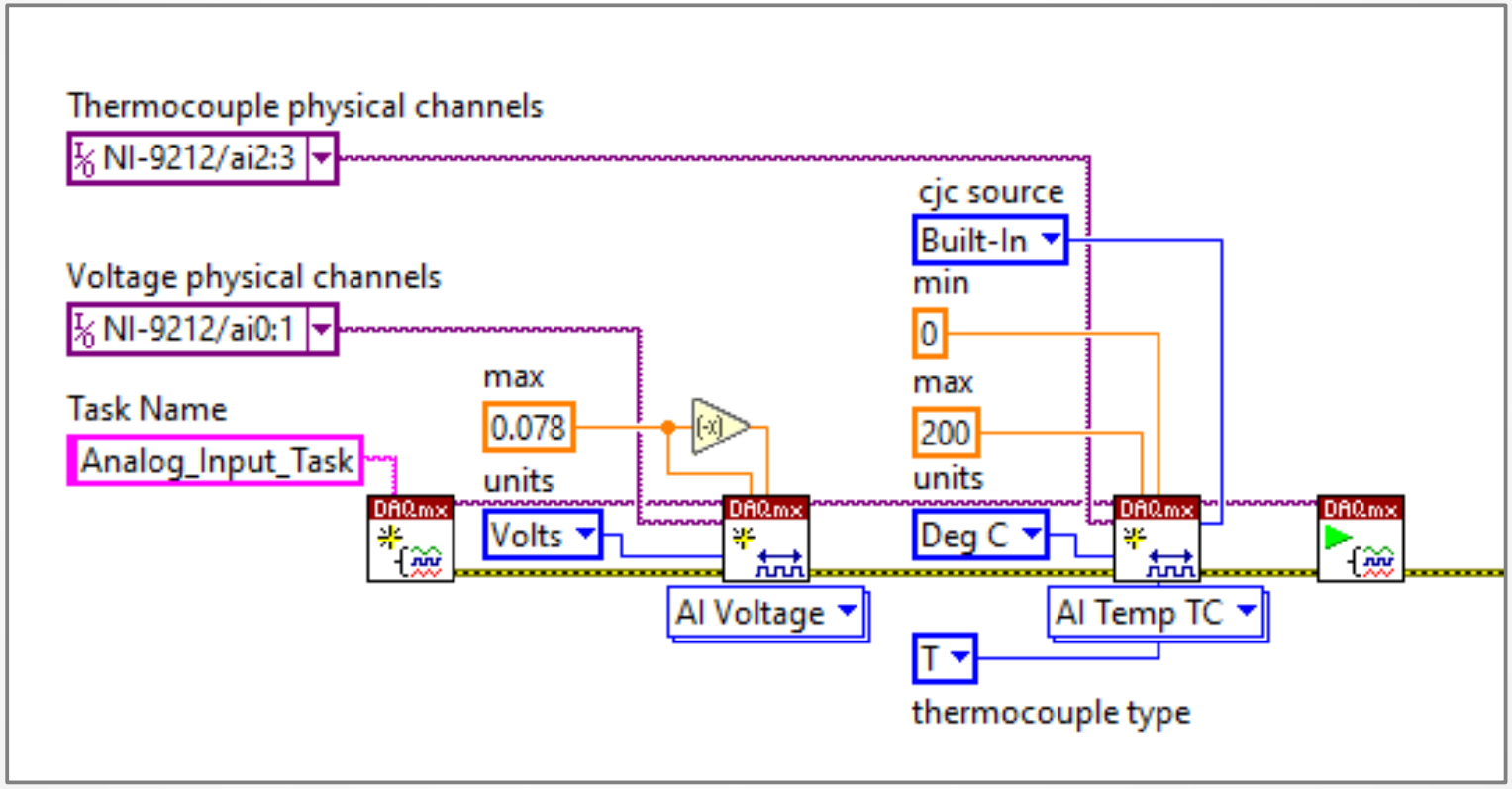


2x T-type thermocouples

Real world example

Thermocouple modules can also measure raw voltage

With DAQmx driver, simply configure as separate channels of different types in same task

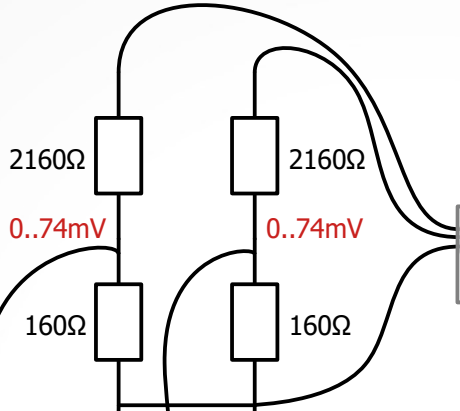


Real world example

2x thermocouples and 1x ambient probe

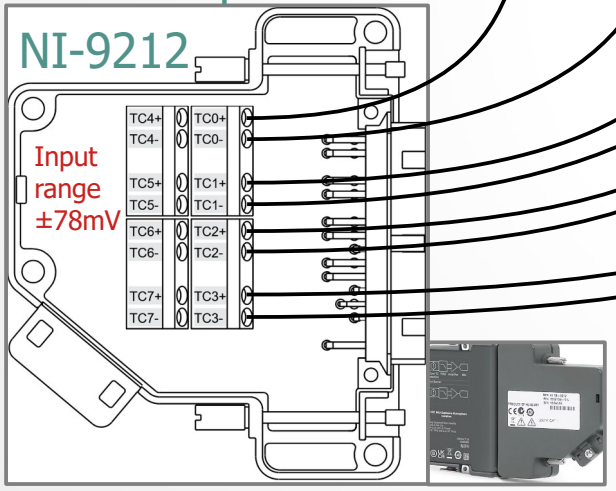
Voltage module

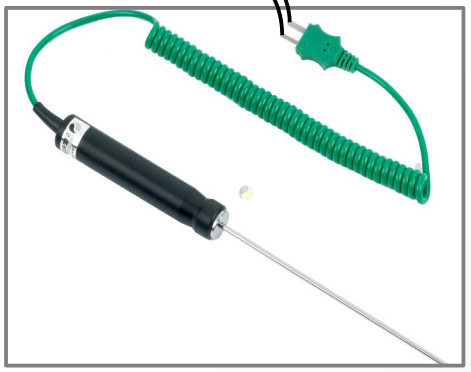
Resistive divider

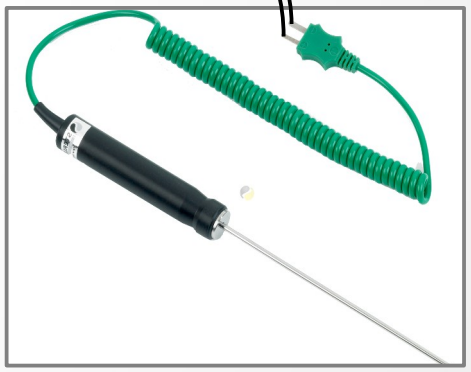


1x Ambient probe: temperature and relative humidity (2x 0..1V)

Thermocouple module





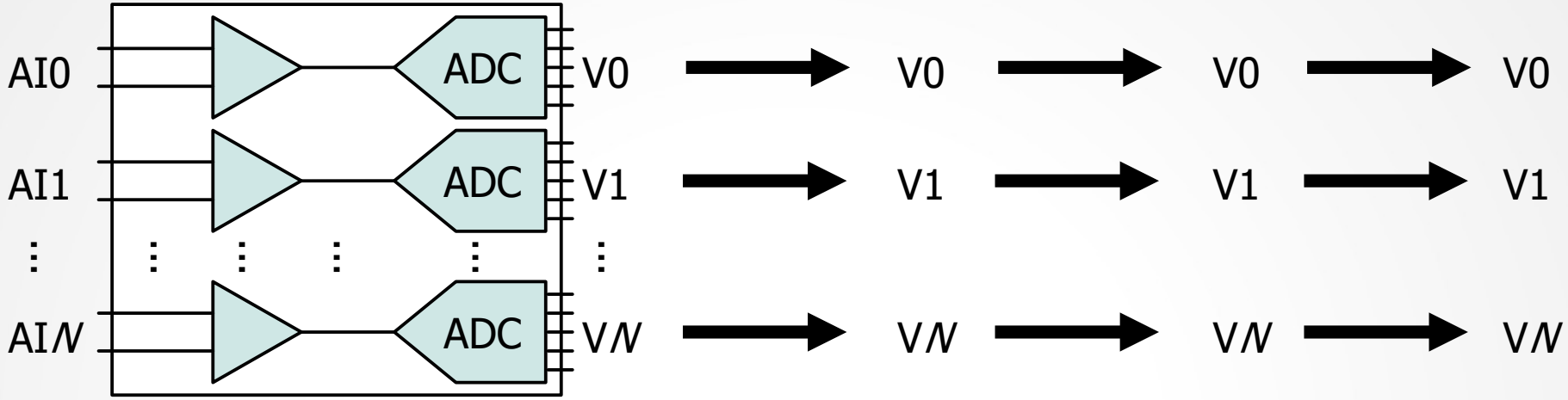


2x T-type thermocouples

Simultaneous vs scanned

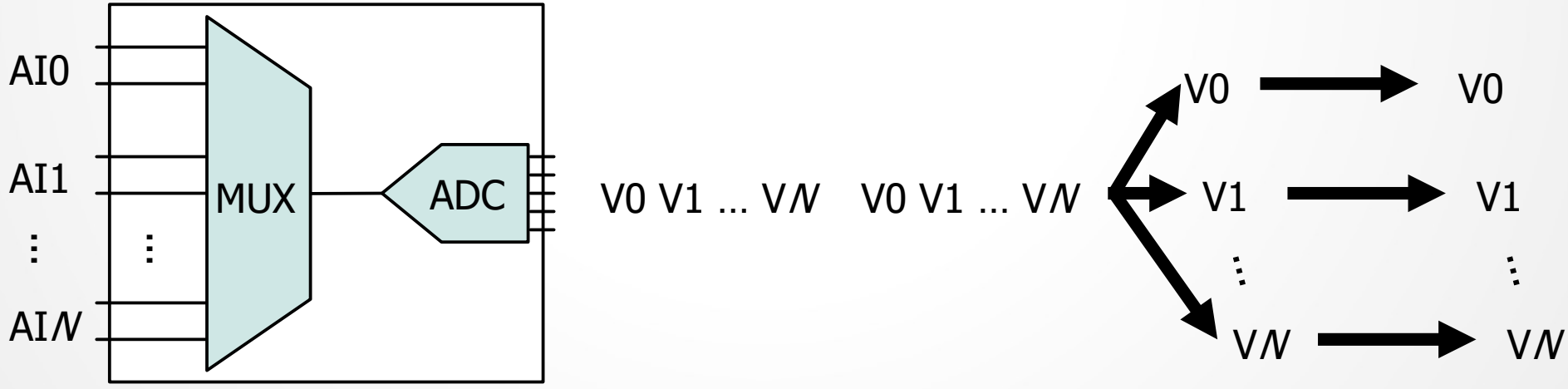
Simultaneous : one ADC per channel

Samples/s/ch



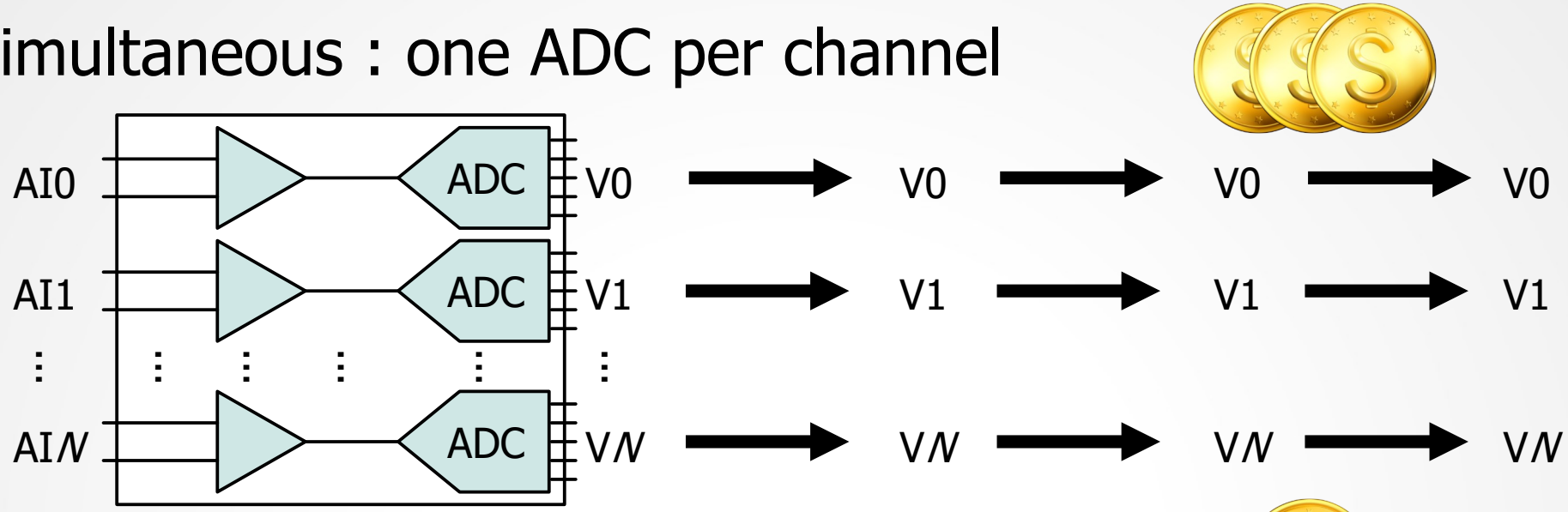
Scanned : only one ADC, with multiplexer

Samples/s aggregate



Simultaneous vs scanned

Simultaneous : one ADC per channel



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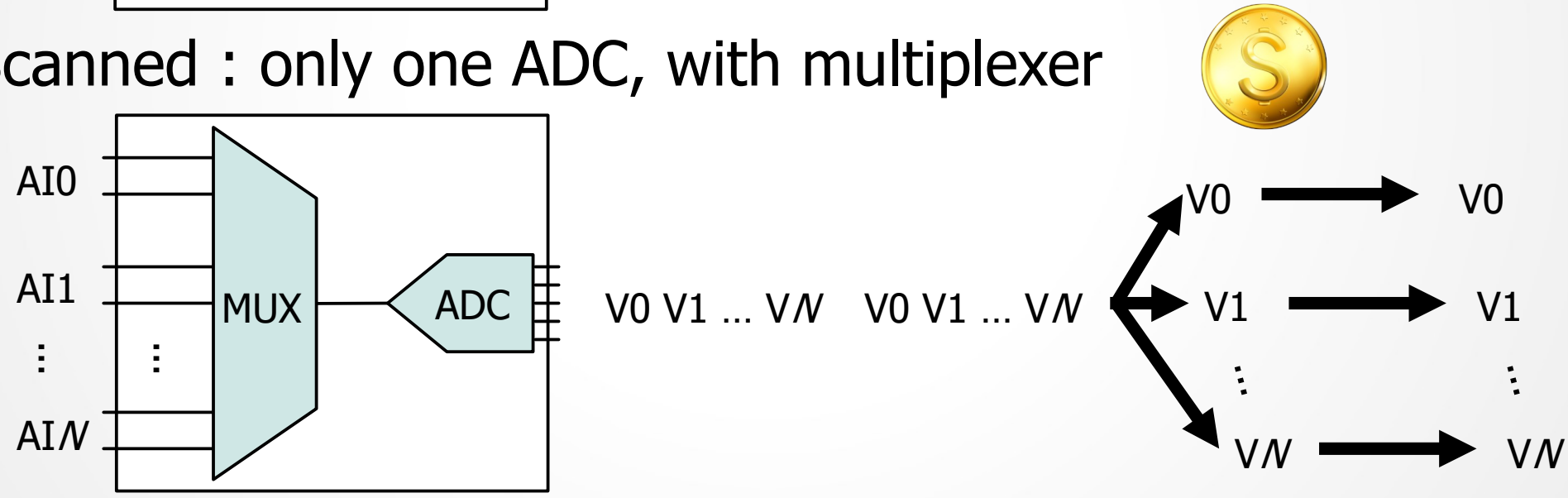
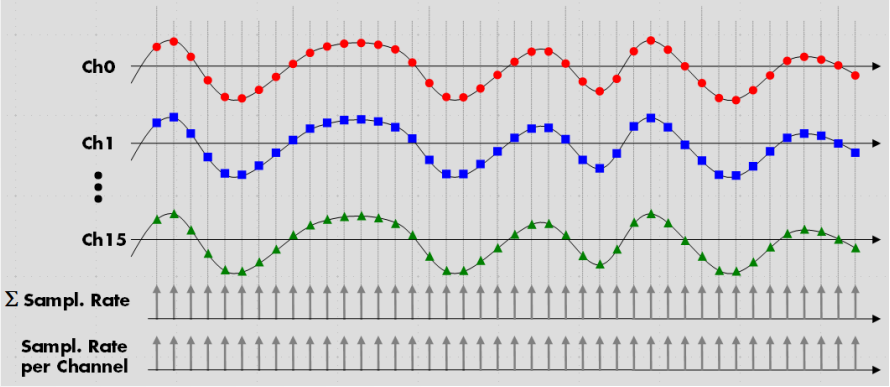
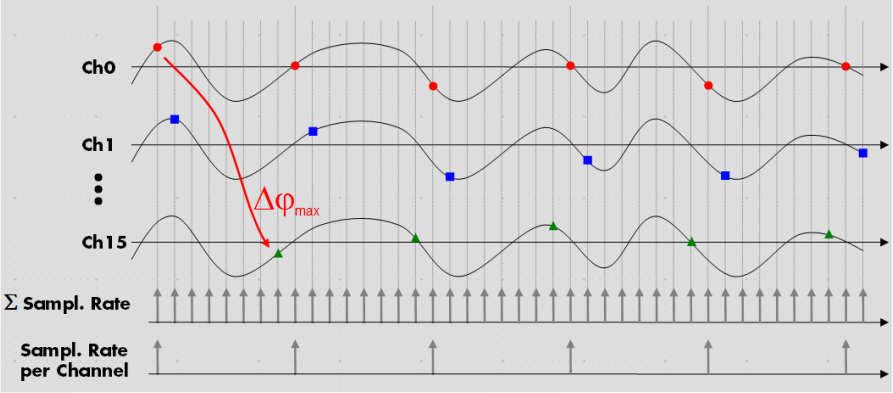


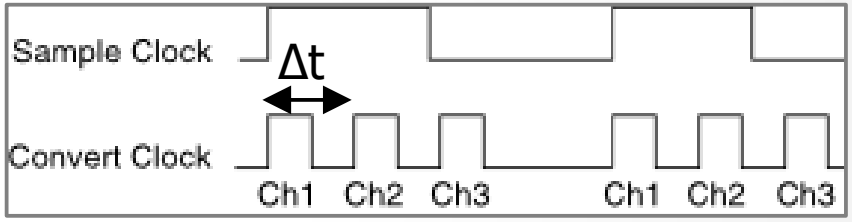
Simultaneous vs scanned

Simultaneous : channels sampled at same time

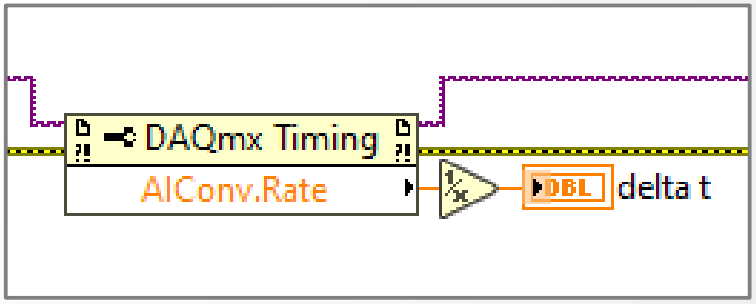


Scanned : channels not sampled at same time





but Δt is deterministic and known :



NI 9205 : 250 kS/s, Δt = 4 µs usually OK

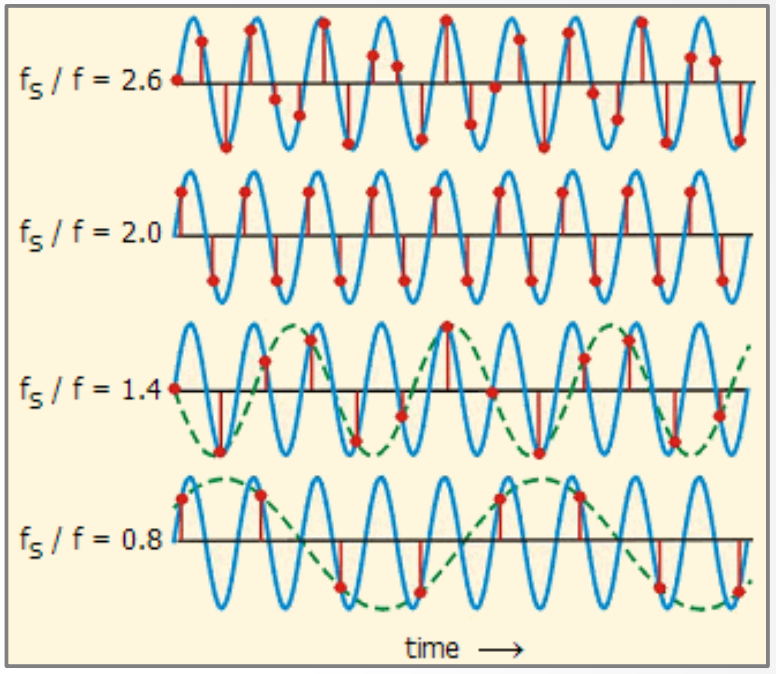
Nyquist–Shannon sampling theorem

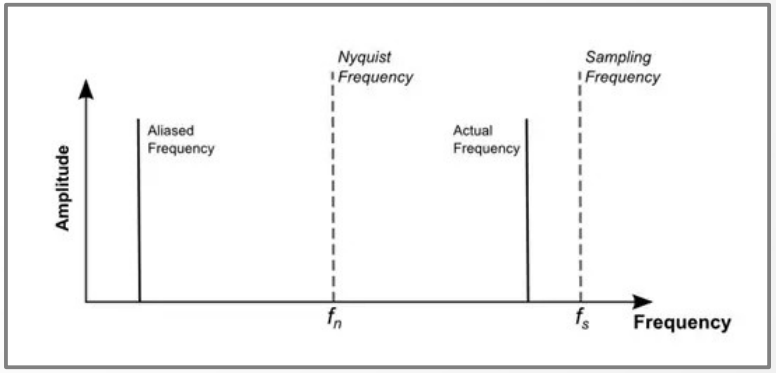
We cannot analyze frequencies larger than $f_{sample}/2$, due to aliasing

NI 9205 250 kS/s 32 channels max

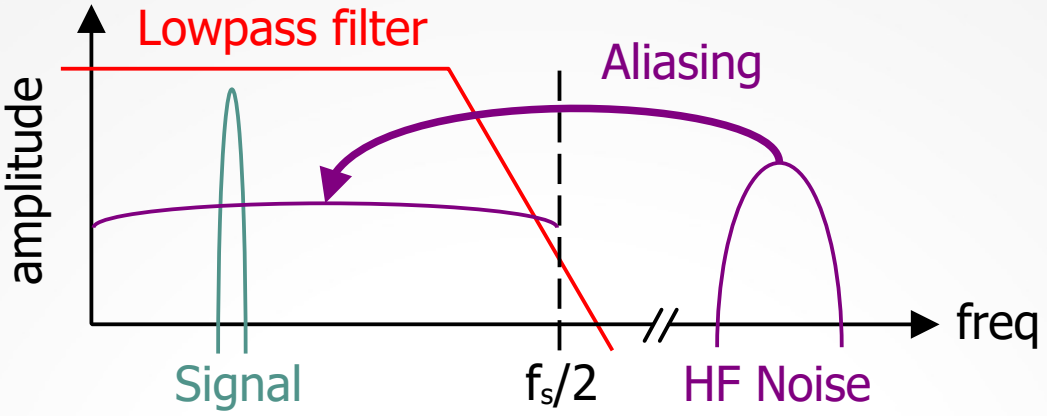
- 1 ch : FFT up to 125 kHz
- 12 ch : FFT limited to 10.4 kHz
  sampling 20.8 kS/s/ch

Simultaneous sampling devices do not "derate" with channel count



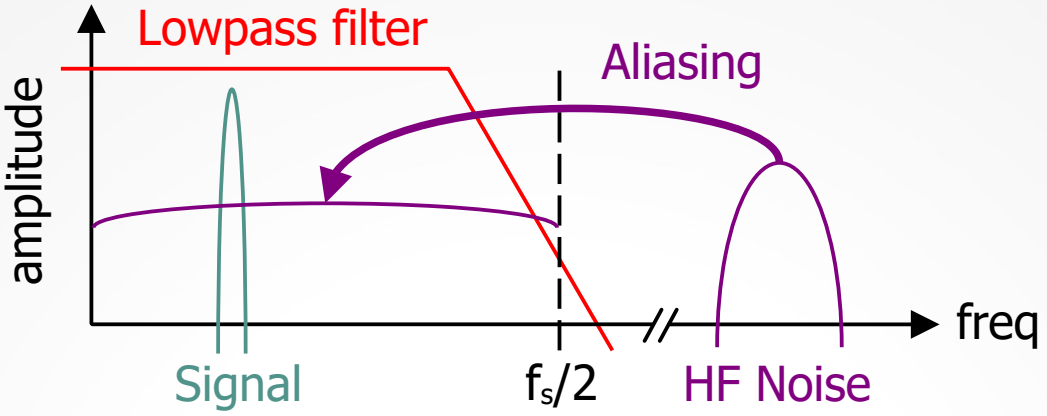


Nyquist–Shannon sampling theorem



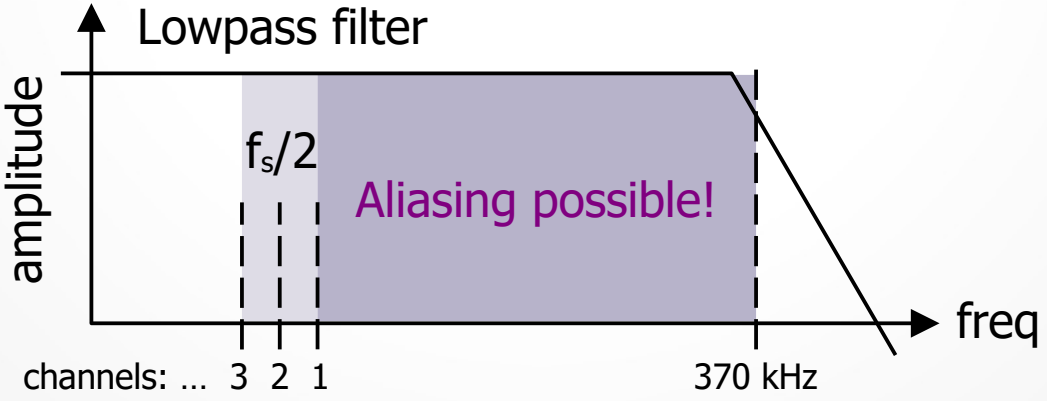
Need to lowpass filter everything above $f_s/2$ Anti-aliasing filter

Nyquist–Shannon sampling theorem



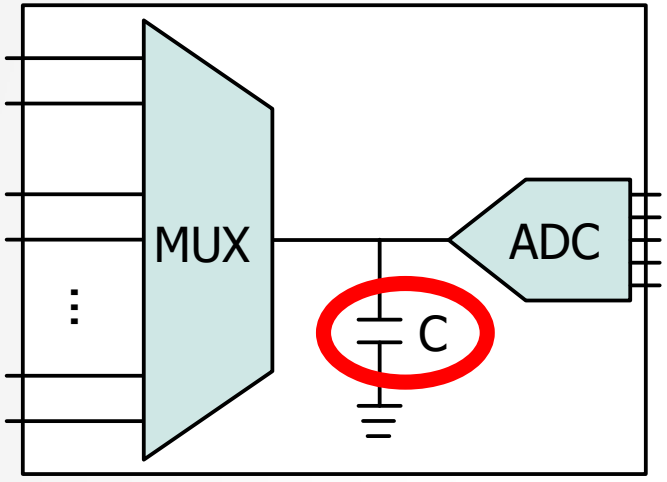
Need to lowpass filter everything above $f_s/2$ Anti-aliasing filter

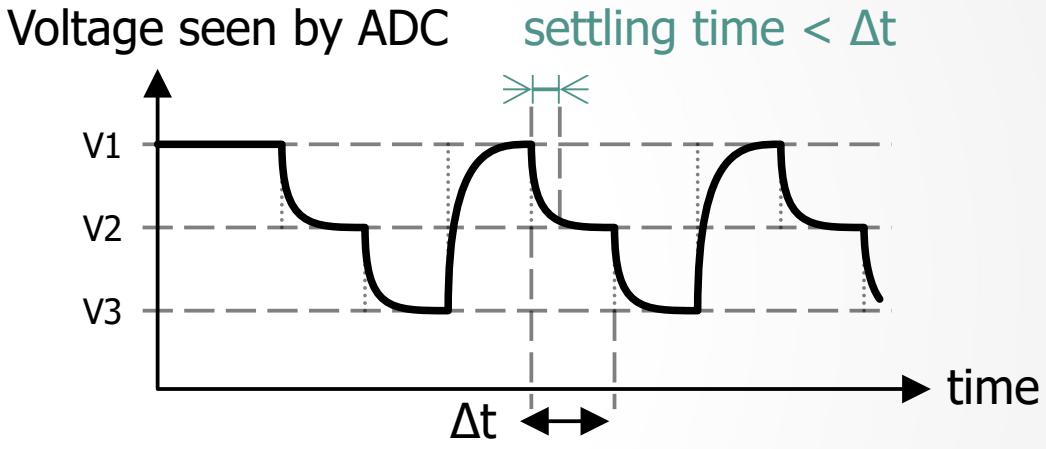
NI 9205 sampling max 250 kS/s, $f_s/2$ = 125 kHz
But from specifications: input bandwidth 370 kHz



Anti-aliasing filtering

Signal needs to settle fast enough at ADC despite parasitic capacitance C



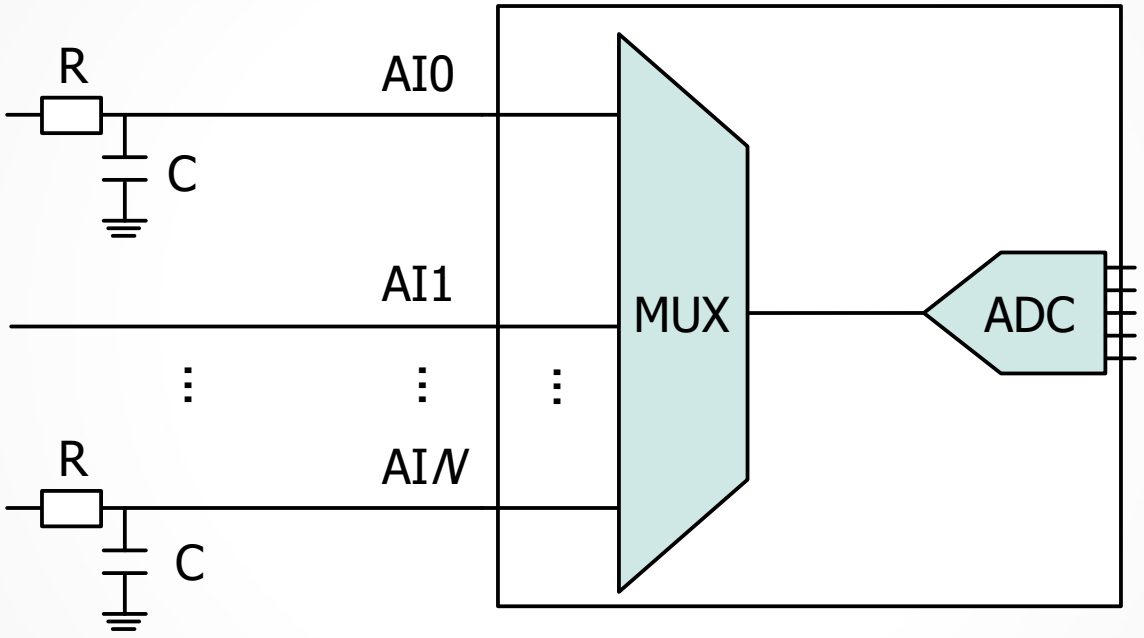


Embedded anti-aliasing filter :

- Simultaneous
- Scanned

Anti-aliasing filtering

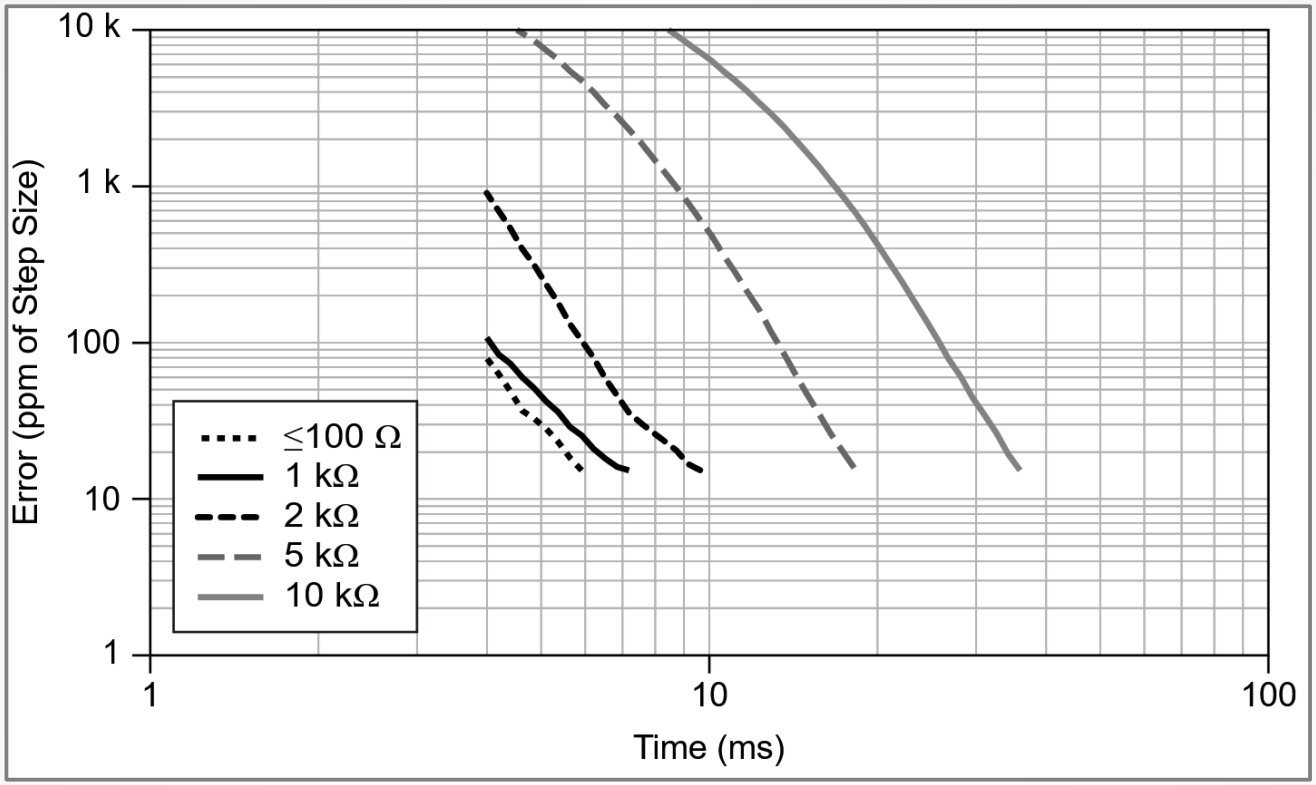
Let’s place a simple external RC lowpass filter when needed !



Problem solved ?

Signal impedance

Well… Example from NI 6221 specifications:

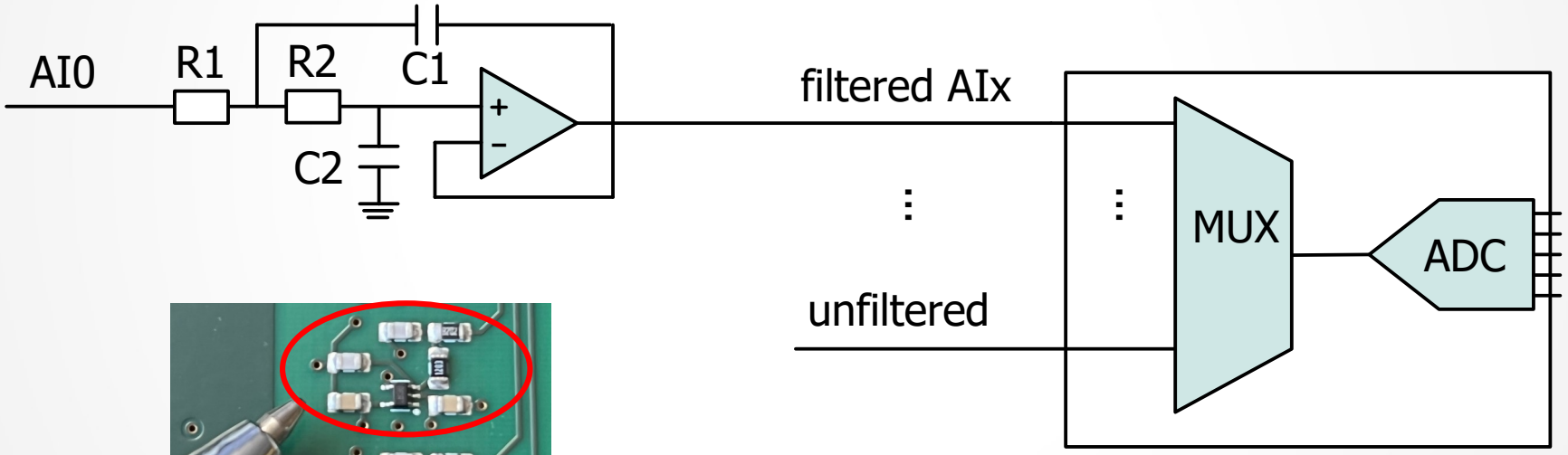


Signals with too high source impedance, such as voltage dividers and RC filters, cannot be reliably measured with scanned devices ! Symptoms : cross-talk

Anti-aliasing filtering

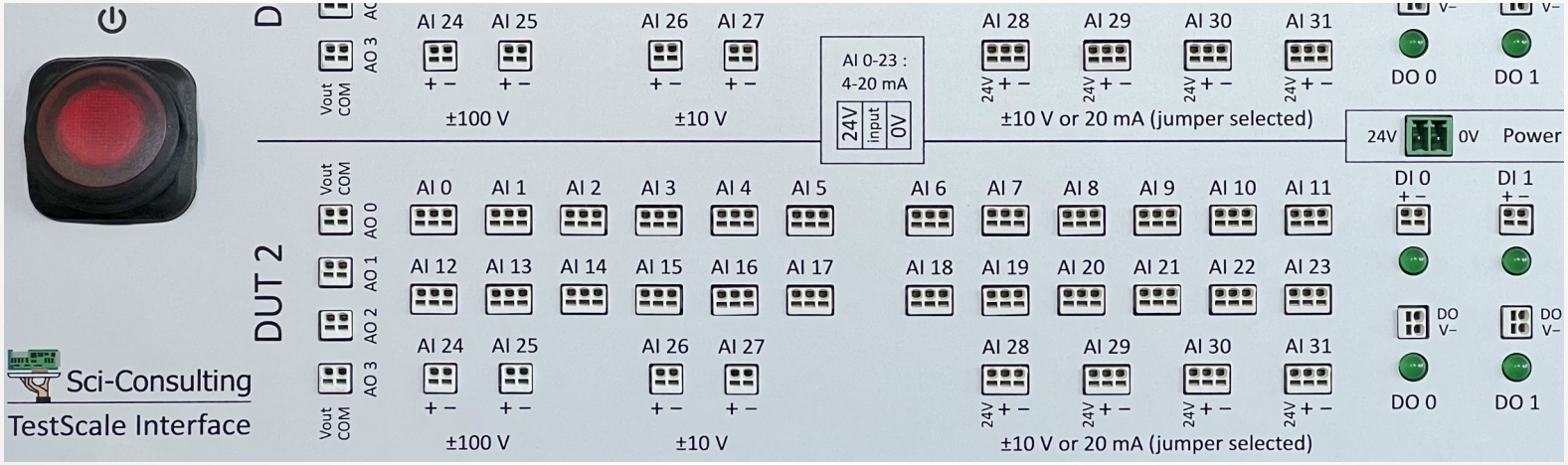
Need an external *active* lowpass filter to lower impedance

- Ex: Sallen-Key 2 poles Op-Amp to lower impedance, one per channel <u>when needed</u> (high impedance)



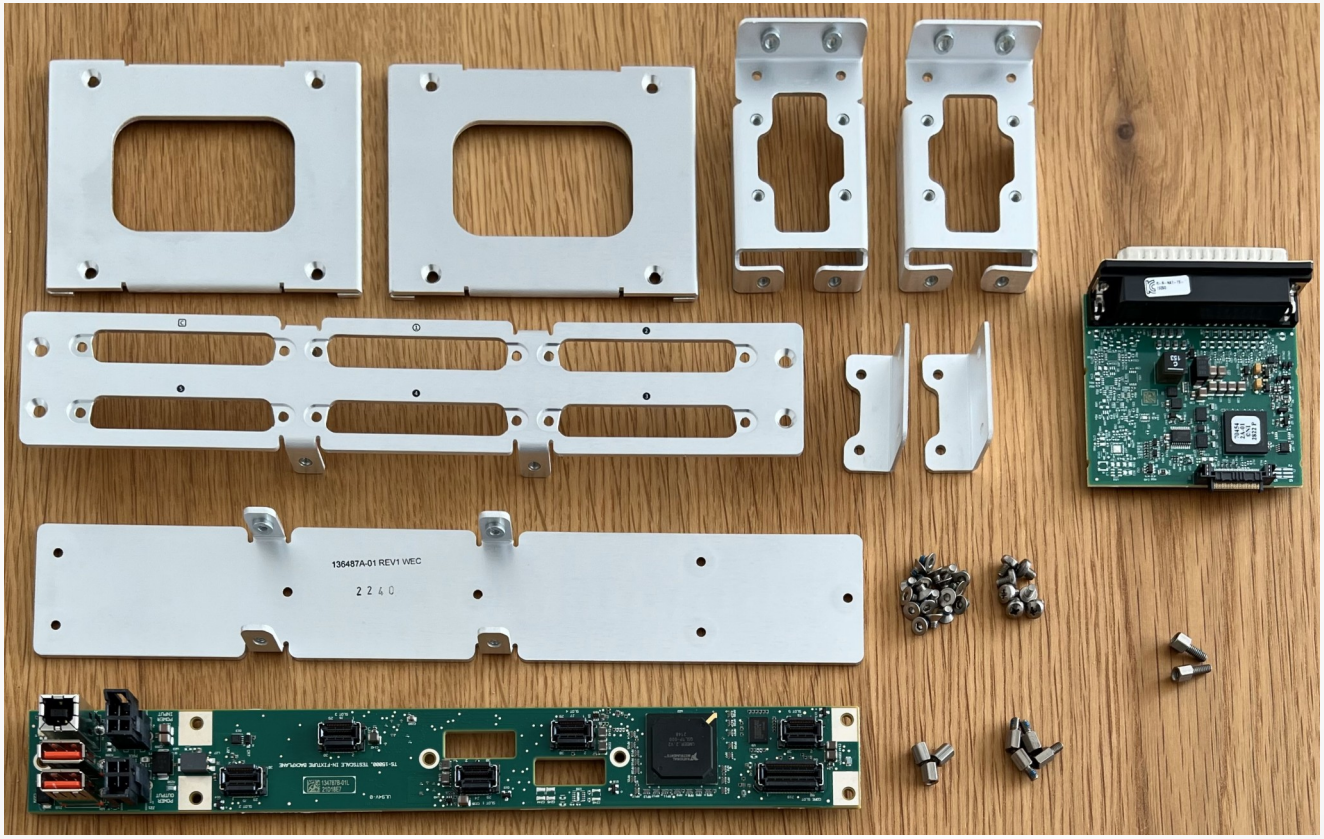
Optimization is project-specific

- Find best compromise between
  - ➔ COTS hardware
  - ➔ Tailored adaptations only when needed
- Example built around a TestScale system :



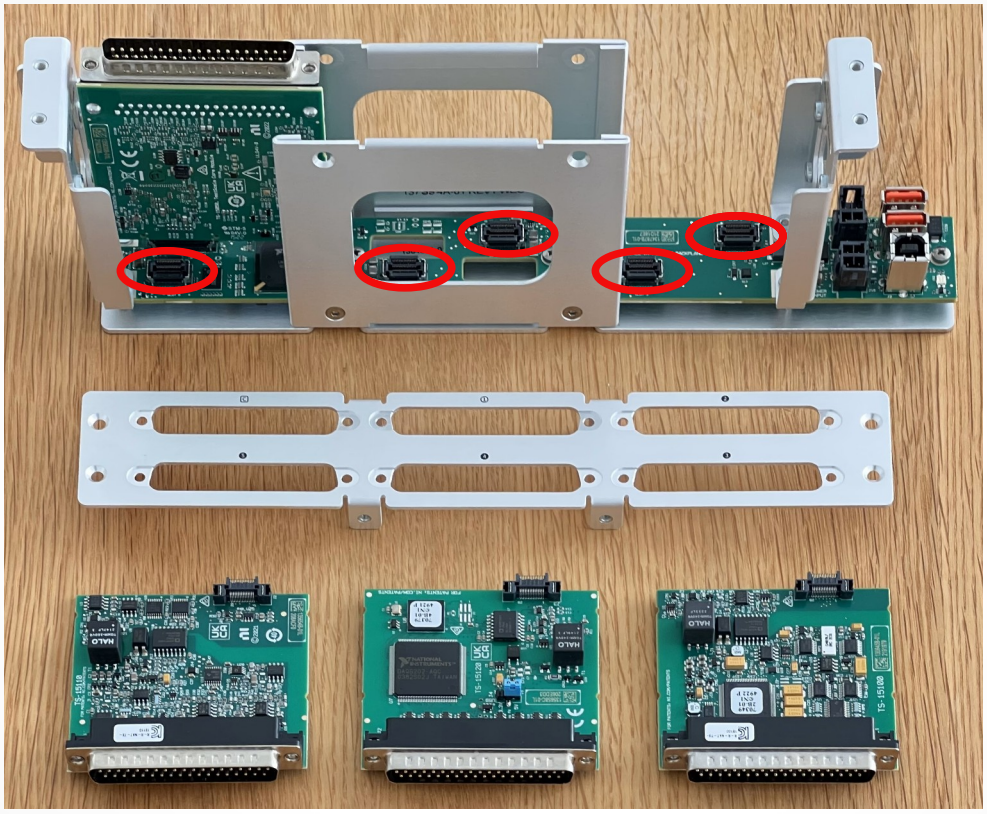
NI TestScale platform

- Base kit : frame, backplane, Core module



NI TestScale platform

- Assembled base kit, 5 slots for I/O modules



4x A Output	16x D In & 16x D Out	32x A Input
~ NI 9264	~ NI 9375	~ NI 9205

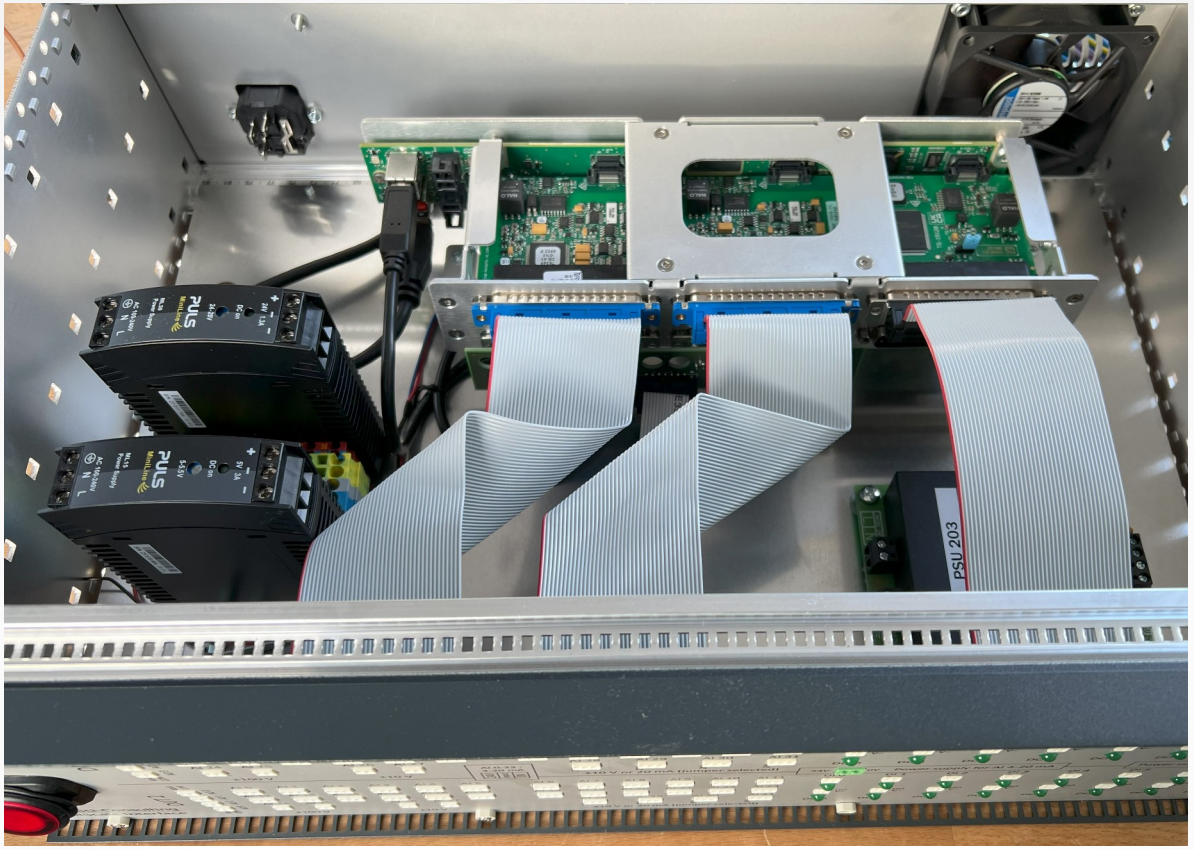
← various I/O modules

NI TestScale platform

- All modules have D-Sub 37 connectivity
- No specific signal conditioning (only ±10V analog and 5V digital)
- Backplane with USB and power in & out for daisy chaining

- System shown here : approx 2’500.- CHF
  64 analog inputs, 8 analog outputs, 16 digital inputs, 16 digital outputs, 8 PFI
- Programmed with DAQmx, same features as a cDAQ system (counters, clocks, tasks, ...)

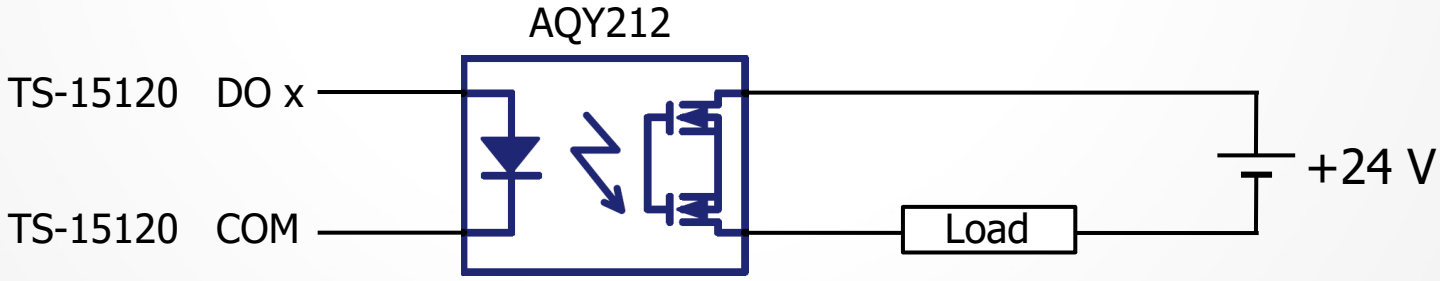
TestScale integration



- Can be cost efficient, but needs some integration effort
- Not for single system, rather for minimal volume (not necessarily large though)

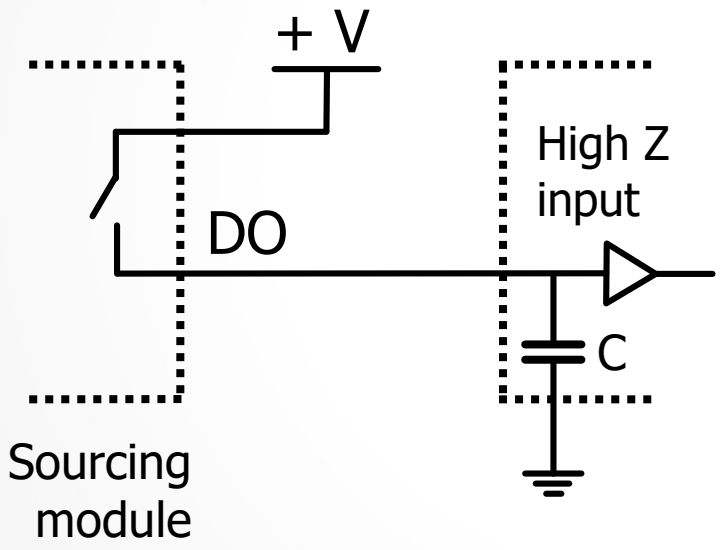
TestScale integration

- TS-15100 analog input module is like NI 9205 : scanned 250 kS/s, ±10 V with gains
- Our system uses precision 200 Ω resistors for 4..20 mA signals, anti-aliasing filters
- TS-15120 (digital IO) is 5 V only, so signals converted to / from 24 V, also with optical isolation



TestScale integration

- Digital output to high impedance “sink” : think carefully about pull-up / pull-down if output is *switching* (and not *push-pull*)



TestScale integration

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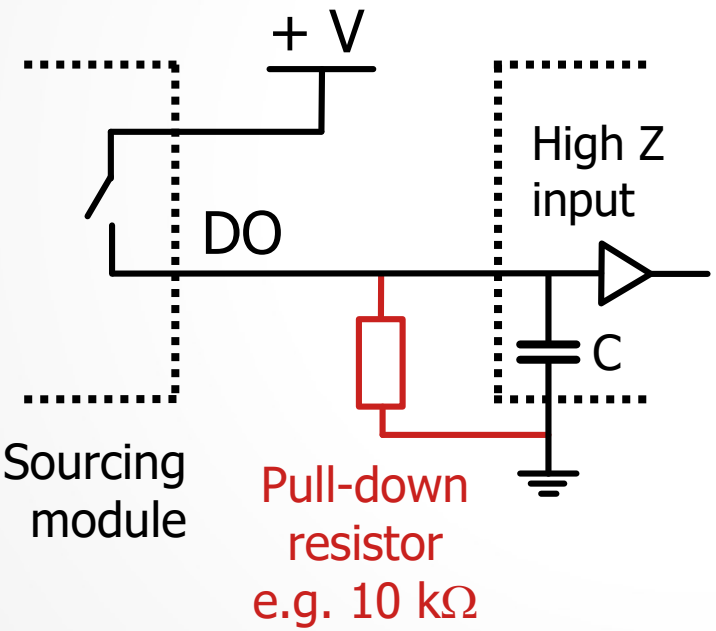
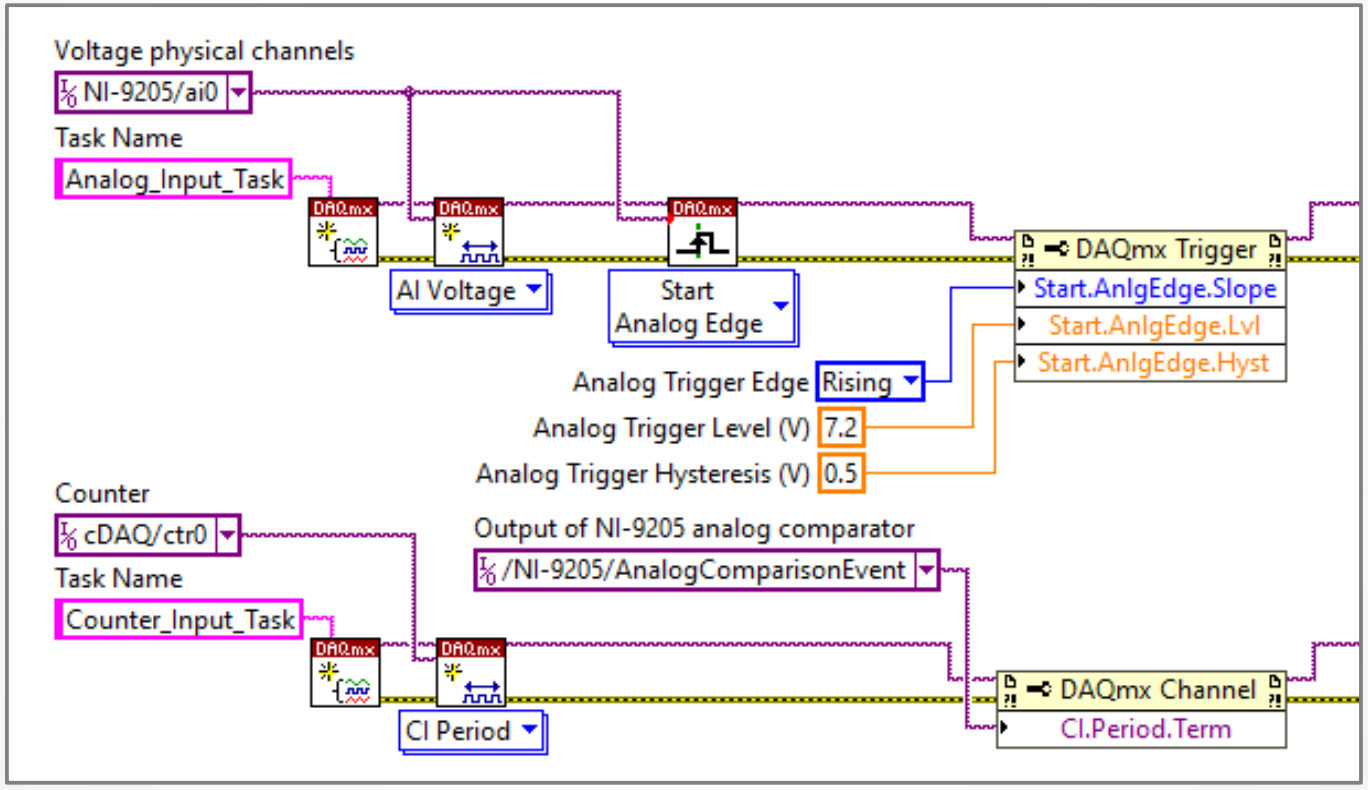
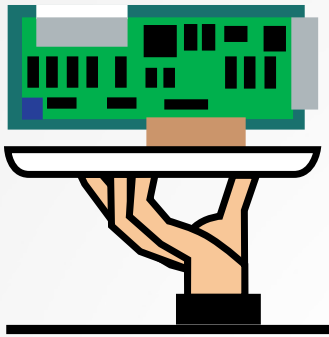


For **sinking** DO modules, use **pull-up** resistor to +V

Other topics

- Counters : Make smart use of them, very versatile !
- Counters usually work with 5V signals (PFI). But you can use this trick with APFI (X Series) or Analog comparison feature (NI 9205 or TS-15100) to use counters with analog signals (e.g. sine) with adjustable threshold just like 3rd party bench-top counters :





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Thank you for following this presentation !

Questions ?

→ info@sci-consulting.ch