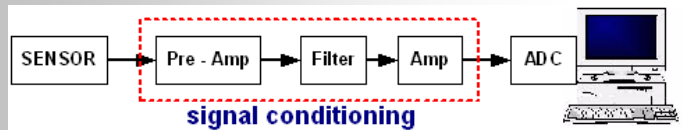
Bab 6 : Interfacing dan Pengkondisi SInyal

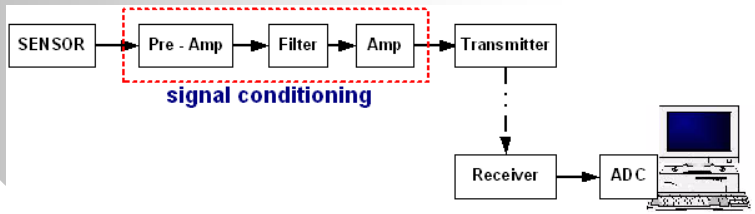
Dr. Ir. Yeffry Handoko Putra, M.T

Sistem Interfacing Instrumentasi

Sistem dengan display digital

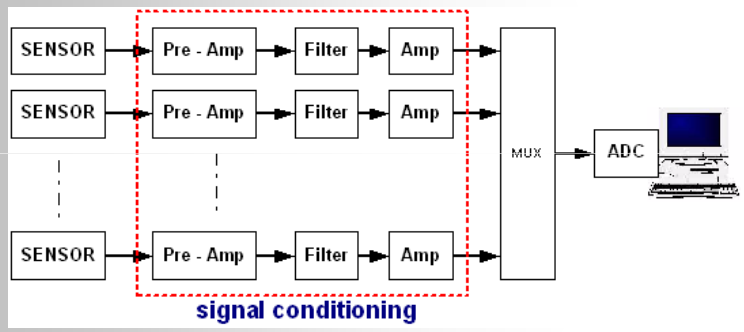


Sistem dengan transmisi data & display digital



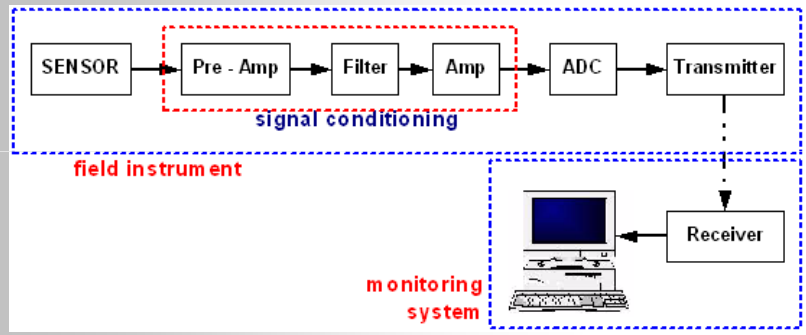
Sistem Instrumentasi

Sistem multisensor dengan display digital

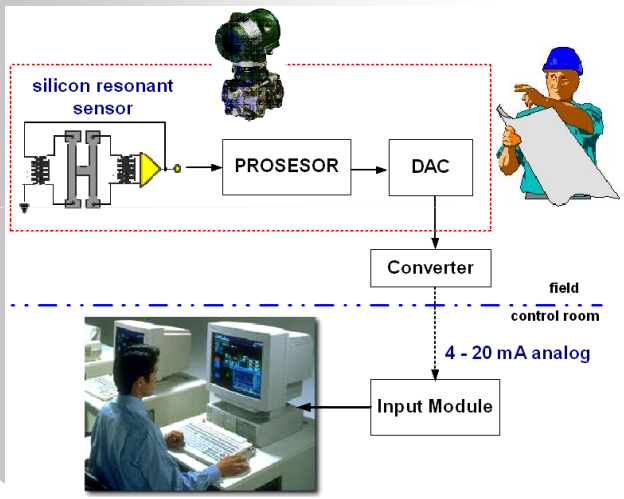


Sistem Instrumentasi

Sistem digital dengan transmisi data



Contoh : Sistem Akuisisi Data *tekanan* di industri

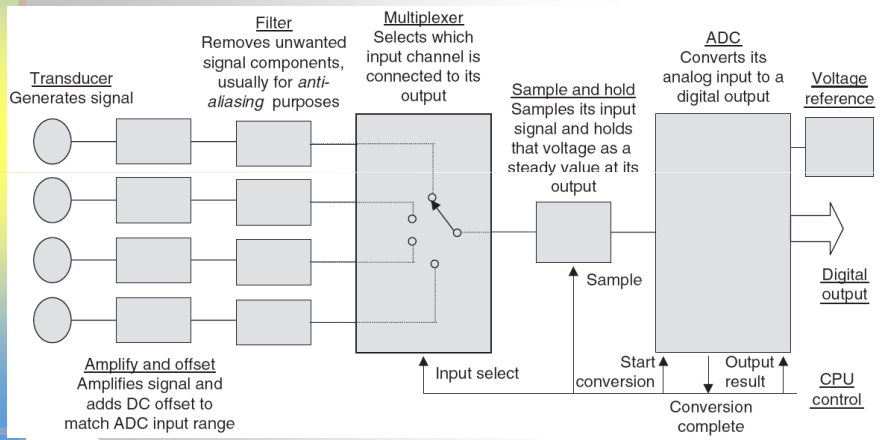


ELEMEN SISTEM INSTRUMENTASI

Elemen Sistem Instrumentasi dengan Pengkondisi Sinyal

- Sensor
- Signal Conditioning (pengkondisi sinyal)
  - Amplifier
  - Filter
- Signal Processing (pemroses sinyal)
  - Multiplexing
  - Analog – Digital Converter
  - Digital – Analog Converter
- Data Presentation (display)

Elements of a data acquisition system



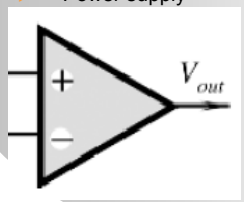
PENGKONDISI SINYAL - Amplifier

Amplifier

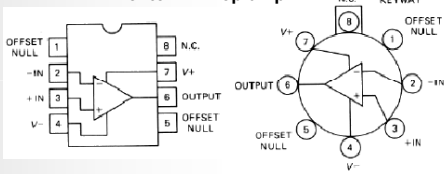
- Operational Amplifier
- Instrument Amplifier

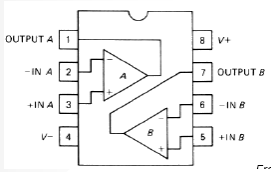
OPERATIONAL AMPLIFIER

- Primary op-amp terminal
  - Inverting input
  - Non-inverting input
  - Output
  - Power supply



Contoh : IC op-amp 741



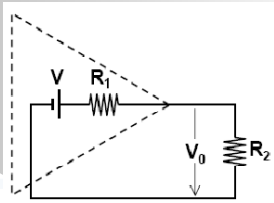


Dual op-amp 1458

Amplifier : Op - Amp

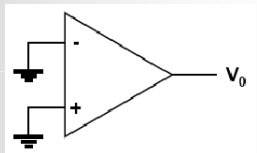
Karakteristik Op-Amp Ideal

- Infinite open loop voltage gain
  - *Open loop gain* adalah *gain* op-amp tanpa umpan balik
  - Ideal open loop gain : tidak terhingga
- Infinite input impedance
  - Arus input adalah NOL
  - Beberapa *low grade op-amp* memiliki arus input dalam orde mA
- Zero output impedance
  - Beberapa op-amp memiliki *output impedance* sekiat 100 – 200 Ω



Amplifier : Op - Amp

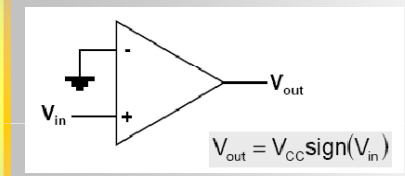
- Zero noise contribution
- Zero DC output offset
  - *Output offset* merupakan tegangan output pada saat kedua input di-ground (nol)



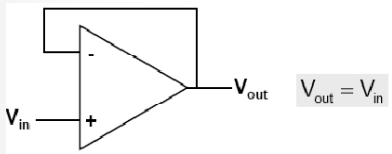
- Infinite bandwidth
- Differential inputs that stick together

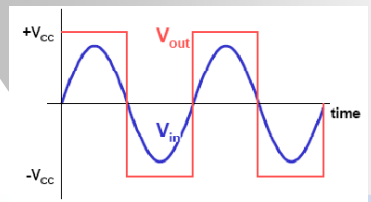
Amplifier : Rangkaian Op - Amp

- **Voltage comparator**



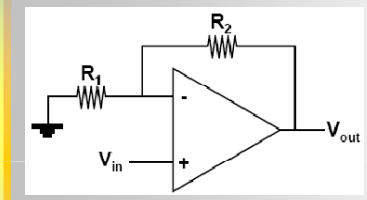
- **Voltage follower**





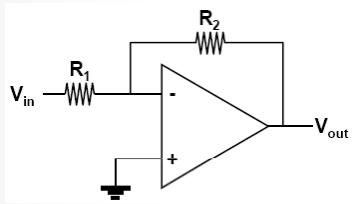
Amplifier : Rangkaian Op - Amp

- Non-inverting amplifier



$$V_{out} = \left(1 + \frac{R_2}{R_1}\right) V_{in}$$

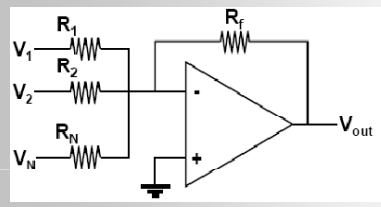
- Inverting amplifier



$$V_{out} = -\frac{R_2}{R_1} V_{in}$$

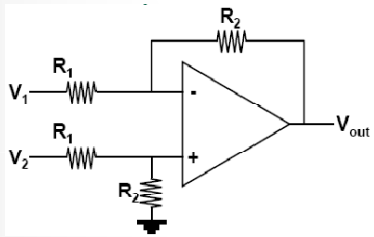
Amplifier : Rangkaian Op - Amp

- Summing amplifier



$$V_{out} = -\left(V_1 \frac{R_f}{R_1} + V_2 \frac{R_f}{R_2} + \cdots + V_N \frac{R_f}{R_N}\right)$$

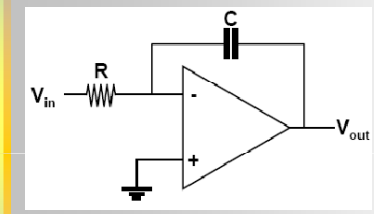
- Differential amplifier



$$V_{out} = \frac{R_2}{R_1}(V_2 - V_1)$$

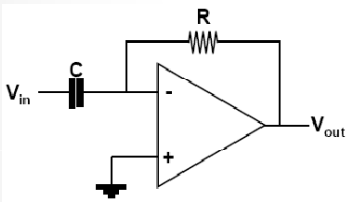
Amplifier : Rangkaian Op - Amp

- Integrating amplifier



$$V_{out} = -\frac{1}{j\omega CR} V_{in} = -\frac{1}{RC} \int V_{in} dt$$

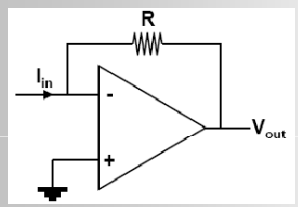
- Differentiating amplifier



$$V_{out} = -\frac{R}{\frac{1}{j\omega C}} V_{in} = -RC \frac{dV_{in}}{dt}$$

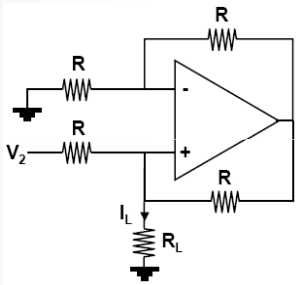
Amplifier : Rangkaian Op - Amp

- Current to Voltage converter



$$V_{out} = -I_{in} R$$

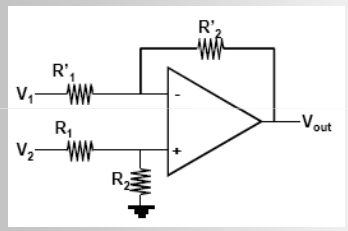
- Voltage to Current converter

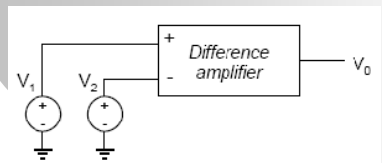


$$I_L = \frac{V_{in}}{R}$$

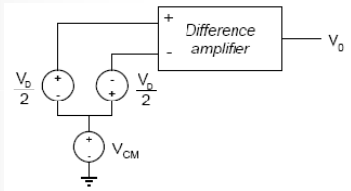
Amplifier : Instrumentation Amplifier

- Differential Amplifier





- Tegangan COMMON MODE & DIFFERENCE MODE



$$V_{CM} = \frac{V_2 + V_1}{2}$$

$$V_D = V_2 - V_1$$

Amplifier : Instrumentation Amplifier

- Jika R input 1 & 2 tidak identik, maka gain pada kedua input tidak sama

$$V_0 = G(V_2 - V_1) \overset{R_k' \neq R_k}{=} G_2 V_2 - G_1 V_1 = G_2\left(-\frac{V_D}{2} + V_{CM}\right) - G_1\left(\frac{V_D}{2} + V_{CM}\right) =$$

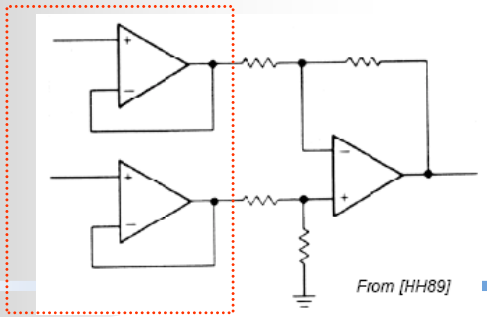
$$= -V_D\left(\frac{G_2 + G_1}{2}\right) + V_{CM}(G_2 - G_1) = -V_D G_D + V_{Cm} G_{CM}$$

- Didefinisikan Common Mode Rejection Ratio (CMRR)
  - **CMRR** merupakan fungsi frekuensi dan besarannya menurun dengan kenaikkan frekuensi

$$CMRR = 20\log_{10}\left(\frac{G_D}{G_{CM}}\right) = 20\log_{10}\left(\frac{G_2 + G_1}{2(G_2 - G_1)}\right)$$

Amplifier : Instrumentation Amplifier

- Terminologi INSTRUMENTATION AMPLIFIER digunakan untuk Differential Amplifier dengan
  - High Gain
  - Single ended Output
  - High input impedance
    - Dapat dilakukan dengan *buffering*
  - High CMRR



From [HH89]

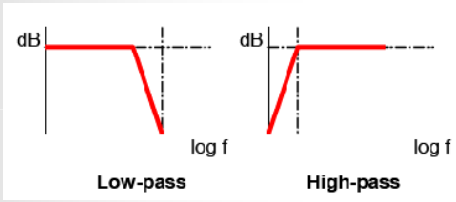
Filter

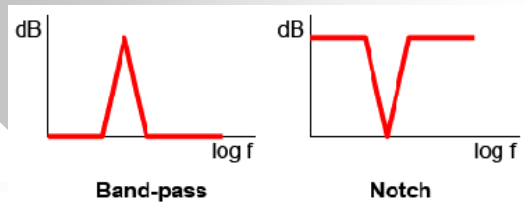
- Filter digunakan untuk membuang sinyal dengan frekuensi yang tidak diinginkan
- Klasifikasi filter berdasarkan implementasi
  - **Filter aktif** (termasuk rangkaian RC dan op-amp)
  - **Filter pasif**
    - Terdiri atas rangkain RLC
  - **Filter digital**

Filter

Klasifikasi Filter berdasarkan respon frekuensi

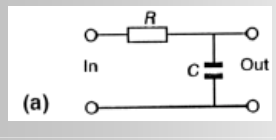
- Low pass filter
- High pass filter
- Bandpass filter
- Band Stop (notch)

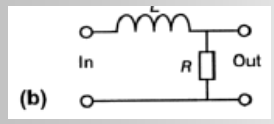


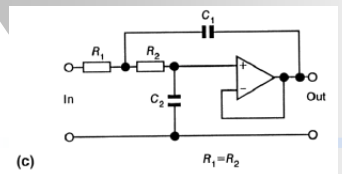


Filter

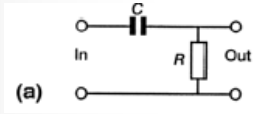
- Low pass filter

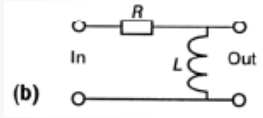


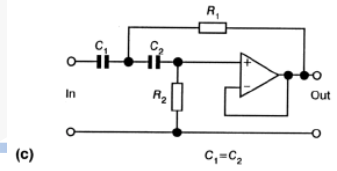




- High pass filter

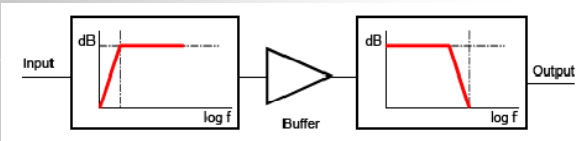




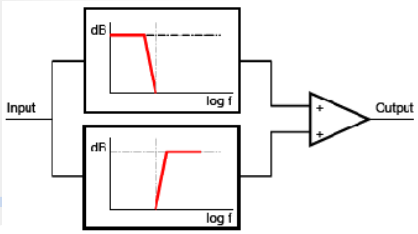


Filter

- Bandpass filer
  - Hubungan seri HPF & LPF
  - HPF harus memiliki *corner frequency* yang lebih rendah
  - Antar HPF dan LPF harus digunakan buffer

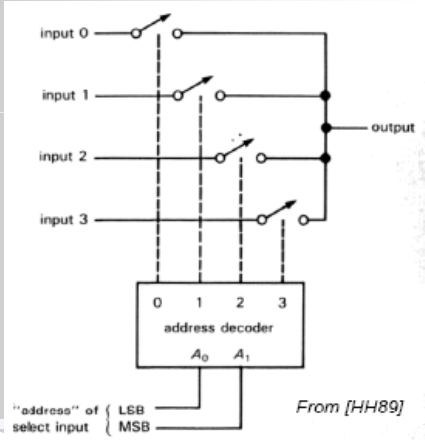


- Band stop filter (notch)
  - Hubungan paralel HPF dan LPF
  - HPF harus memiliki *corner frequency* yang lebih tinggi

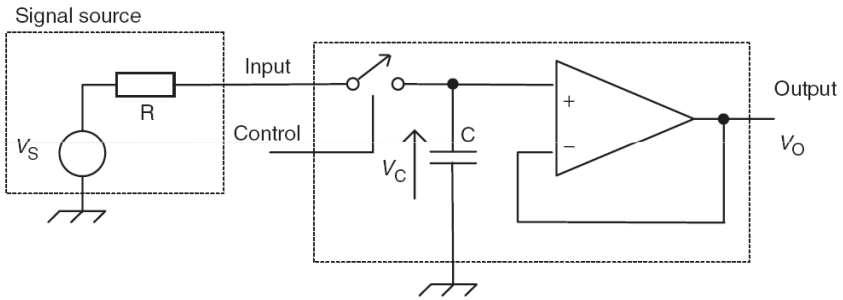


Multiplexer

- Rangkaian untuk memilih salah satu input dengan sinyal kontrol digital



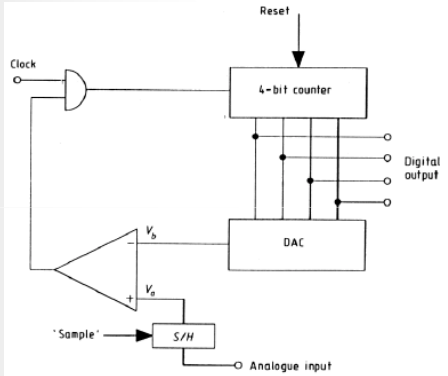
Sample and hold, and acquisition time



Analog to Digital Converter

Single Slope atau Ramp ADC

- Terdiri atas
  - Counter biner
  - DAC
  - Komparator analog
- Cara kerja
  - Reset counter
  - Input analog dicacah
  - Jika $V_A > V_B$ counter naik
  - Jika $V_A = V_B$ counter berhenti dan kode biner merupakan output
- Karakteristik
  - Relatif lambat karena waktu konversi dapat mencapai 2^N, dimana N adalah resolusi ADC

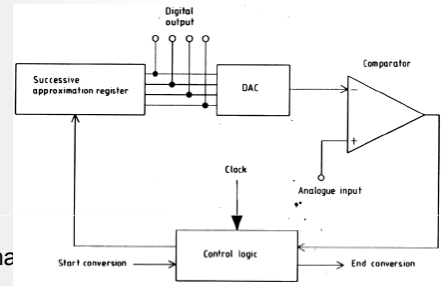


From [BW96]

Analog to Digital Converter

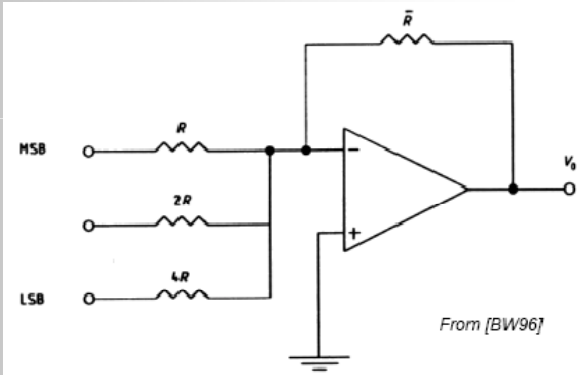
Successive approximation ADC

- Terdiri atas
  - DAC
  - Komparator analog
  - Modul logic kontrol
  - Successive Approx Register
- Cara kerja
  - Kondisi awal : semua bit sama dengan NOL kemudian dimulai dengan MSB sama dengan 1 (10000…..0)
    - Jika analog input lebih besar, maka MSB = 1 atau MSB = 0
    - Regiister melakukan operasi yang sama dari MSB ke LSB



Digital to Analog Converter

- Binary weighted ladder
  - Setiap input diberi bobot oleh masing-masing resistor pada rangkaian op-amp



From [BW96]

Data Acquisition System

- Introduction
- Components of DAS
- Methodology
- Types of Data Acquisition System
- Applications

Introduction

- **Data acquisition systems**, as the name implies, are products or processes used to collect information to document or analyze some phenomenon.
- **Data acquisition** and data acquisition systems typically involves the conversion of analog waveforms into digital values for processing by computer.

Components of DAS

- The components of data acquisition systems include:
  - Sensors that convert physical parameters to electrical signals.
  - Signal conditioning circuitry to convert sensor signals into a form that can be converted to digital values.
  - Analog-to-digital converters, which convert conditioned sensor signals to digital values.

Methodology

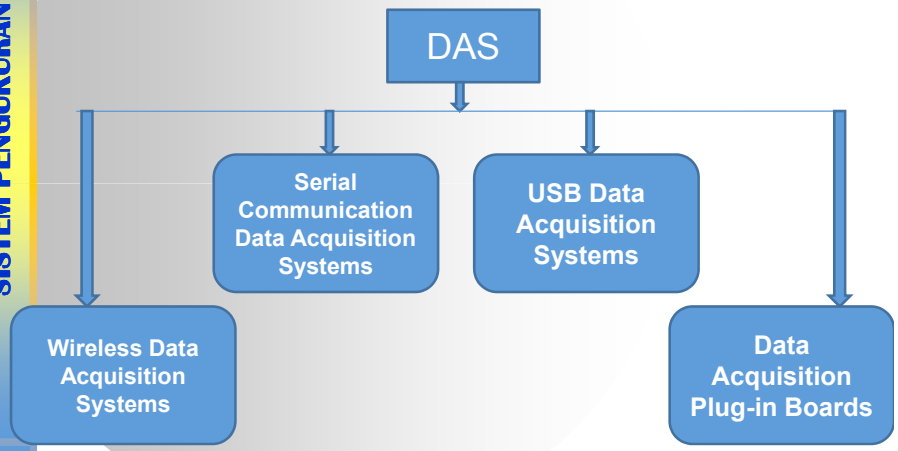
- **Source**

Data acquisition begins with the physical phenomenon to be measured. Eg. of this include temperature, light intensity, gas pressure, fluid flow, and force. The values of these quantities must first be transformed into a unified form that can be sampled by a data acquisition system. The task of performing such transformations falls on devices called *sensors*.

- **Signals**

Signals may be digital (also called **logic signals** sometimes) or analog depending on the transducer used. Signal conditioning may be necessary if the signal from the transducer is not suitable for the DAQ hardware being used. The signal may need to be amplified, filtered or demodulated.

Types of DAS



UWTC Wireless Thermocouple Connector System

iDRX Series Serial Port

OMB-DAQ-3000 Series USB Data Acquisition Modules

OME-PCI-1000 Series Data Acquisition Plug-in Boards

Applications

- Measure & Visualize
  - Quick measurements
  - Real-time data visualization
- Control
  - PC-based industrial automation
  - PID and other closed-loop control
- Test Automation
  - Design validation and verification
  - Manufacturing test automation
- Monitoring
  - Alarming and notification
  - Long-term data trending
- Prototyping
  - Functional prototypes
  - Customer proof of concepts

Data Loggers

- Introduction
- Instumentation Protocols
- Types
- Choosing a Data Logger
- Applications
- Data logging versus data acquisition

Introduction

- A **data logger** (also **data recorder**) is an electronic device that records data over time or in relation to location either with a built in or via external instruments and sensors
- Data loggers are available in various shapes and sizes.
- The range includes simple economical single channel fixed function loggers to more powerful programmable devices capable of handling hundreds of inputs.
- Simple single channel data loggers cost as little as $25. More complicated loggers may costs hundreds or thousands of dollars

Types of Data Loggers

OM-CP-TEMP100
Single Input Logger

OM-CP-QUADTEMP
Fixed Input Logger

OM-DAQPRO-5300
Portable Datalogger

OM-320
Modular Logger

Choosing a Data Logger

- Input Signal
- Number of Inputs
- Size
- Speed/Memory
- Real Time Operation

Examples

- A flight data recorder (FDR),
- An event data recorder (EDR),
- A voyage data recorder (VDR0,
- Ultra Wideband Data Recorder,
- A Depth Recorder

Applications

- Unattended weather station recording (such as wind speed / direction, temperature, relative humidity, solar radiation).
- Unattended hydrographic recording (such as water level, water depth, water flow, water pH, water conductivity).
- Unattended soil moisture level recording.
- Unattended gas pressure recording.
- Offshore buoys for recording a variety of environmental conditions.
- Road traffic counting.
- Environmental monitoring.
- Vehicle Testing
- Monitoring of relay status in railway signalling.

Data logging versus data acquisition

Data logging

- Data logger is a data acquisition system
- Typically have slower sample rates.
- Data loggers are implicitly stand-alone devices
- Data loggers used magnetic tape , punched paper tape ,directly viewable recorders Such as strip chart recorders

Data acquisition

- Data acquisition system is not necessarily a data logger.
- Typically have fast sample rates.
- Data acquisition system must remain tethered to a computer to acquire data.
- Data acquisition used Static RAM, flash memory, EEPROM.