DESIGN OF DATA ACQUISITION SYSTEM

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DATA ACQUISITION

- Data acquisition is the process of converting a real-life physical occurrence or phenomenon into computer-understandable data
- Data acquisition involves measuring signals (from a real-world physical system) from different sensors, and digitizing the signals for storage, analysis and presentation.
  - Analog input channels can vary in number from one to several hundred or even thousands

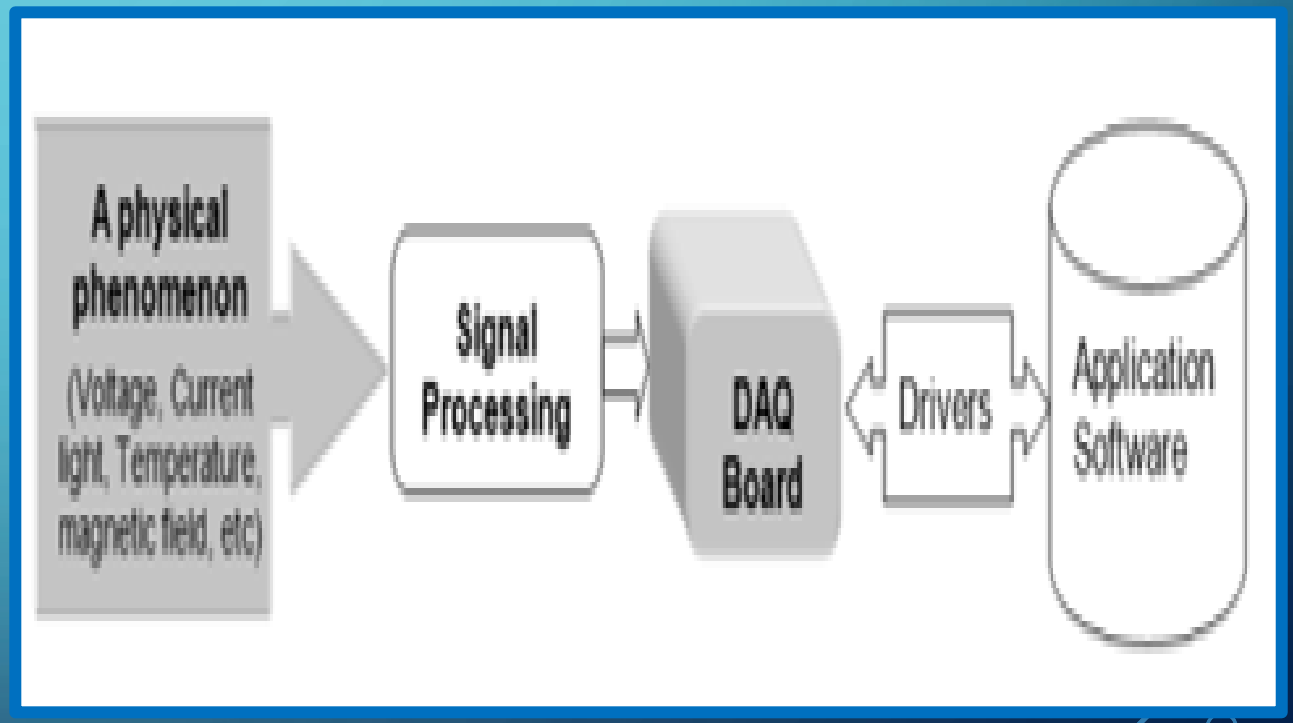
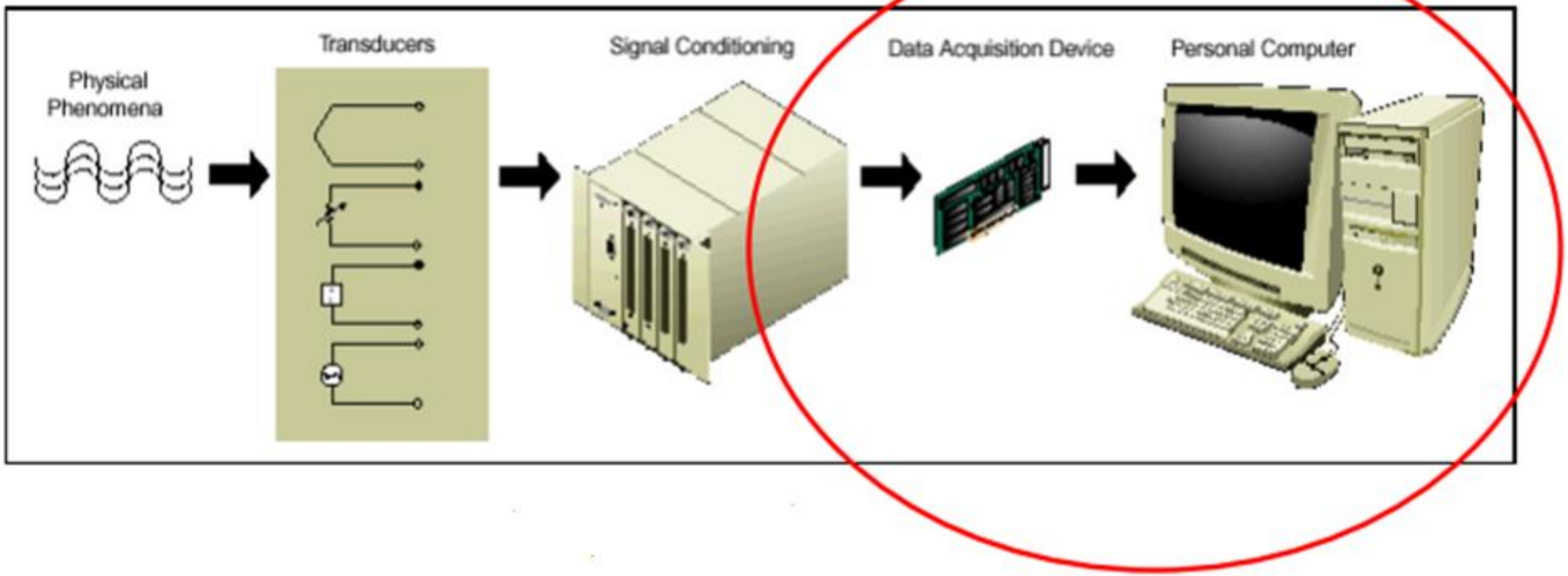


Figure: Components of DAS

DATA ACQUISITION (DAQ)

Computer-based DAQ system:



INTRODUCTION TO THE DESIGN OF DAS

- Computer-based system used in many applications are composed of simple stand-alone personal computer with board connected or microprocessor-based systems to realize a complete network of minicomputers.
- Such systems are used in many real time applications including process control and monitoring.
- Design process of data acquisition systems (DASs) is an obscure process.
- It is possible to consider system design in two principal phases: functional design and final design.

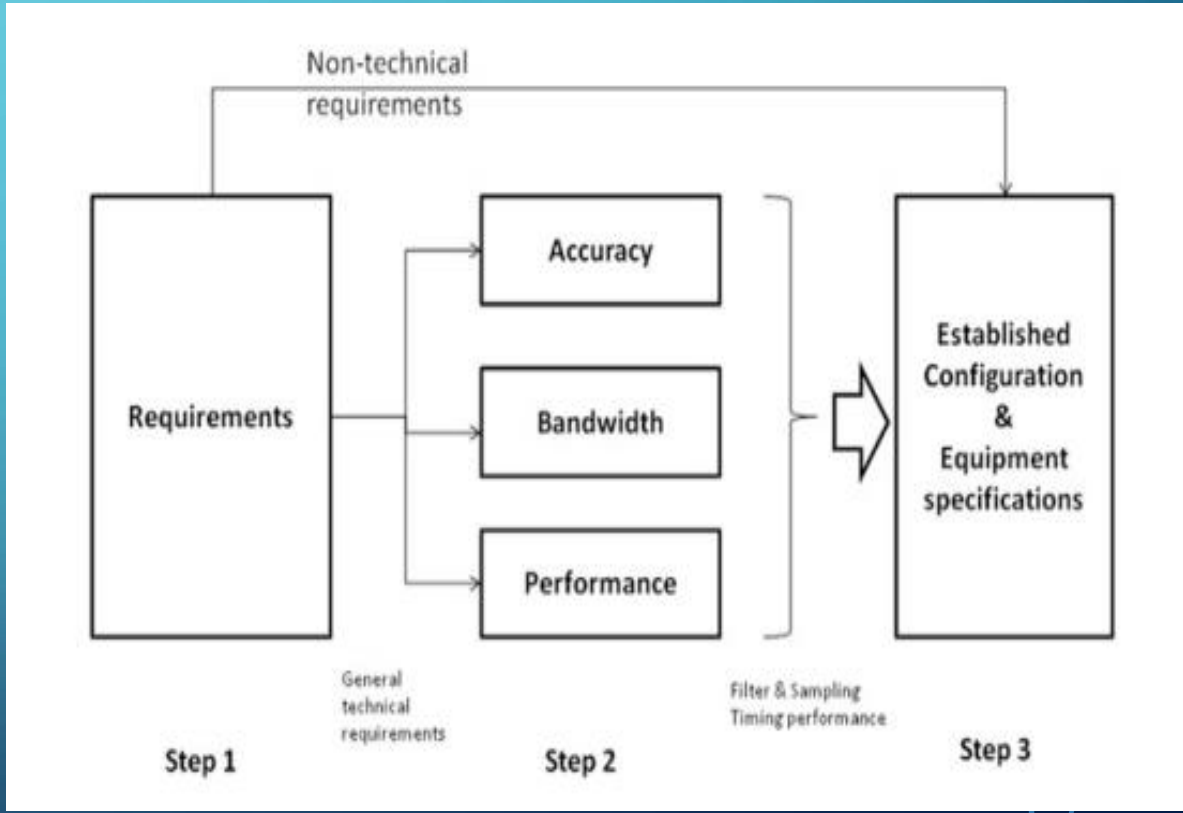


Figure: Design steps of DAS

REQUIREMENTS OF DAS

- *Analog Input Channels*: the system is designed to store 64 channels of analog data.
- The analog signals have a maximum differential voltage range of 10 V.
- Some transducers will be used to convert the signal in electrical form.
- *Analog Output Channels*: the system is designed for a parallel transmission of eight analog signals reconstructed from digital form stored in memory board.
- All output analog signals (maximum voltage range 10 V–10 kΩ) are in singled-ended mode.

DESIGN PARAMETERS

- *Accuracy:* the mean squared error between an analog signal and its reconstruction in output can be defined by the following equation

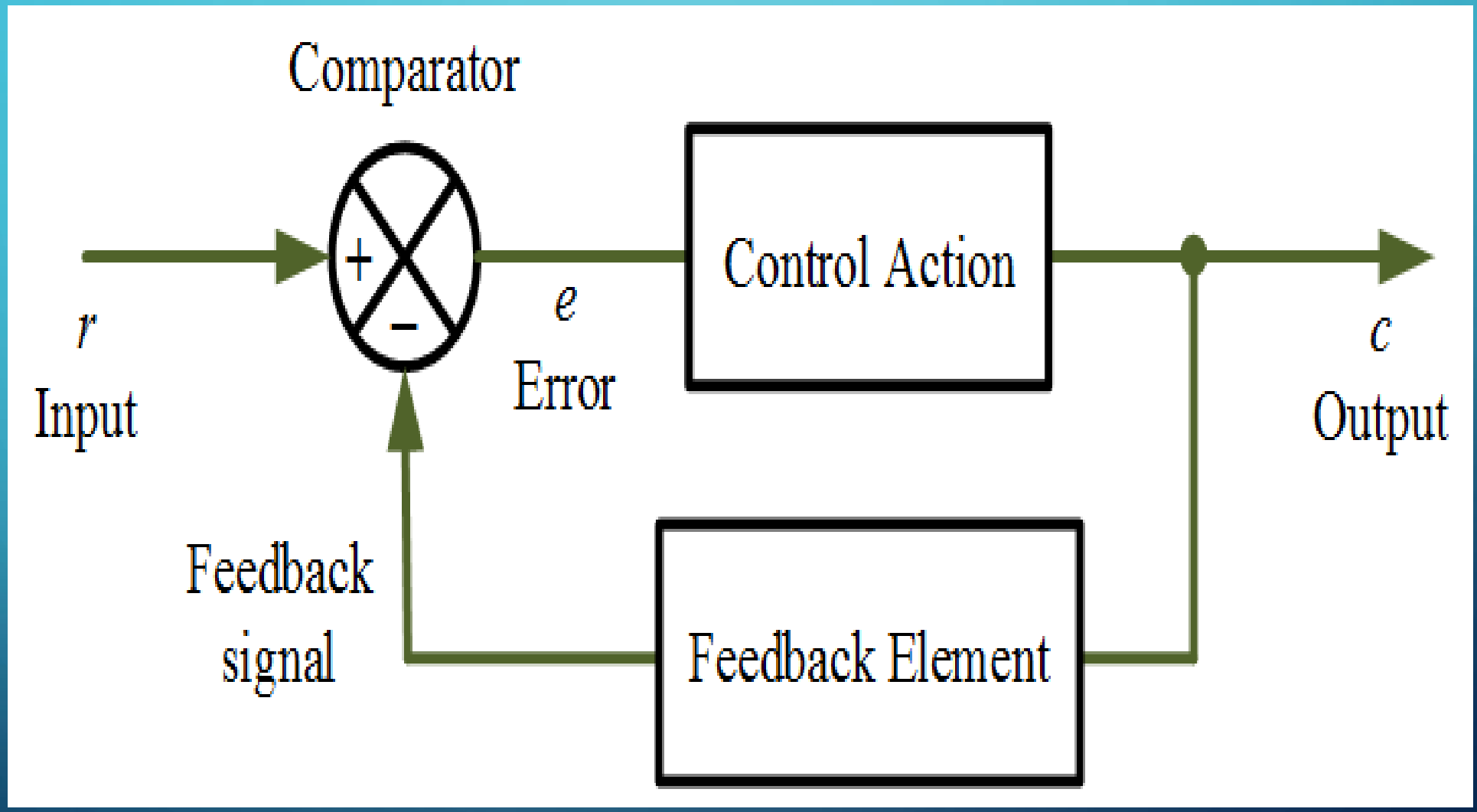
$$\frac{\int_{T_1}^{T_2}[y(t)-x(t)]^2 dt}{\int_{T_1}^{T_2}[y(t)]^2 dt}$$

with $x(t)$ is the analog input signal, $y(t)$ is the analog output signal, and $(T_2 - T_{1)}$ is the analysis interval. This value must not exceed 0.2 % .

The following conditions must be taken care when designing DAS Output signal are reconstructed from digital data stored in memory board.

- All input signals are considered of low pass type.
- The accuracy will be applied to each input and output signals at a data rate up to maximum frequency.
- System gain is unitary.

- *Analog Data Sampling Frequency:* It is important to have an high accurate reproduction of the signals for each input corresponded to the bandwidth.
- The sampling frequency can be selected manually or via computer.
- The system will permit the simultaneous collection of 64 channels with bandwidth DC-5 kHz.


Comparator
+
–
r
Input
e
Error
Control Action
c
Output
Feedback
signal
Feedback Element

CONTD..

- *Anti-Aliasing Filters*: Each analog input will be provided with an anti-aliasing filter; it will be managed manually or via computer.
- *Minimum and Maximum Analysis Times*: the system will be capable to store 64 analog channels with time interval from 10 ms to 1 s according to the sampling frequency. Accuracy of time interval should be of about ±25µs.
- *Analysis Bandwidth*: The data bandwidth of any input or output channel will be operated from a minimum of DC-2.5 kHz to the maximum of DC-25 kHz in conformity with the sampling frequency.
- *System Calibration Program*: A program is designed to verify that the DAS is operated following the requirements. The program will locate which element is not in work.

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- *Data Collection Program*: A program that starts and stops the recording of 64 analog channels. In particular the program is designed to have the following operations: set the number of data input, select the bandwidth, the data interval, the sampling rate, and the gain of input channel signal conditioner.
- *Transducer Calibration Program*: A program is designed to make the test and calibration of the transducers. All calibration data are stored in memory board or exported in other mass storage devices.
- *Temperature*: The system is designed to operate in a temperature range of, for example, -10◦–+70◦ without damage. Normally, the system will be operated at a temperature of 20◦.
- *Shock and Vibration*: The system is designed to resist from the repeated shock and/or vibration. Vibrations of, for example, 15.24mm double amplitude at frequency from 5 to 60 Hz.

ANALYSIS OF STATIC ACCURACY

Let $x(t)$ is the analog input signal,
$y(t)$ is the analog output signal,
$(T_2 - T_1)$ is the analysis interval.

$$\frac{\int_{T_1}^{T_2}[y(t)-x(t)]^2 dt}{\int_{T_1}^{T_2}[y(t)]^2 dt}$$

$$\frac{\int_{T_1}^{T_2}[y(t)-x(t)]^2 dt}{\int_{T_1}^{T_2}[y(t)]^2 dt} \leq \frac{0.2}{100}$$

$$E = y(t) - x(t)$$

$$x(t) = C$$

$$\frac{\int_{T_1}^{T_2}[E]^2 dt}{\int_{T_1}^{T_2}[C]^2 dt} \leq 0.002$$

$$\frac{E^2(T_2 - T_1)}{C^2(T_2 - T_1)} \leq 0.002$$

$$E \leq (0.044)C$$

The static accuracy requirement is interpreted to be 0.044 times of input C will be 0.45 V

ANALYSIS OF DYNAMIC ACCURACY

- *Filter Pass-Band Ripple*: We consider specifications of 0.1 dB for pass-band ripple. For full scale (10 V), this value is corresponded to an error of

$$0.1\ \text{dB} = 20\log(e_0/e_1), e_1 = 10\,\text{V}$$
$$e_0 = 9.885$$

- *Aperture and Input Filter Consideration*: Aperture time is the width of the sampling window. The value of aperture time can be estimated assuming a sinusoidal input and calculating by the time required for input to change less than the resolution.

  ADC Resolution- According to magnitude of the error, we can estimate the resolution of ADC considering that all aliases must be attenuated by at least 80 dB, thus implying that the system's dynamic range is at least 80 dB: So it requires ADC of 14 bit. $\text{db} = 20\log(\text{ADC} - \text{resolution}) = 0.0001$

- *Bandwidth* -The bandwidth is calculated to be 5 kHz expandable to 25 kHz for some channels conveniently selected, with all aliases attenuated by at least 80 dB.

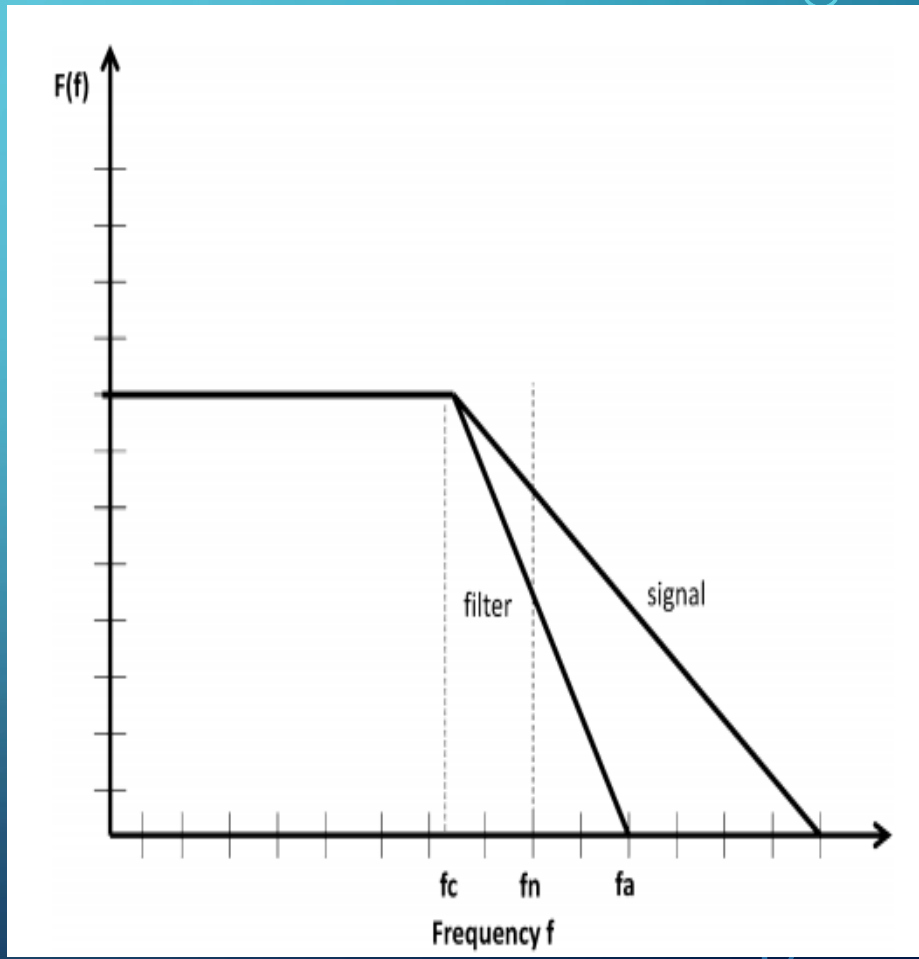

Figure: Frequency response of filter

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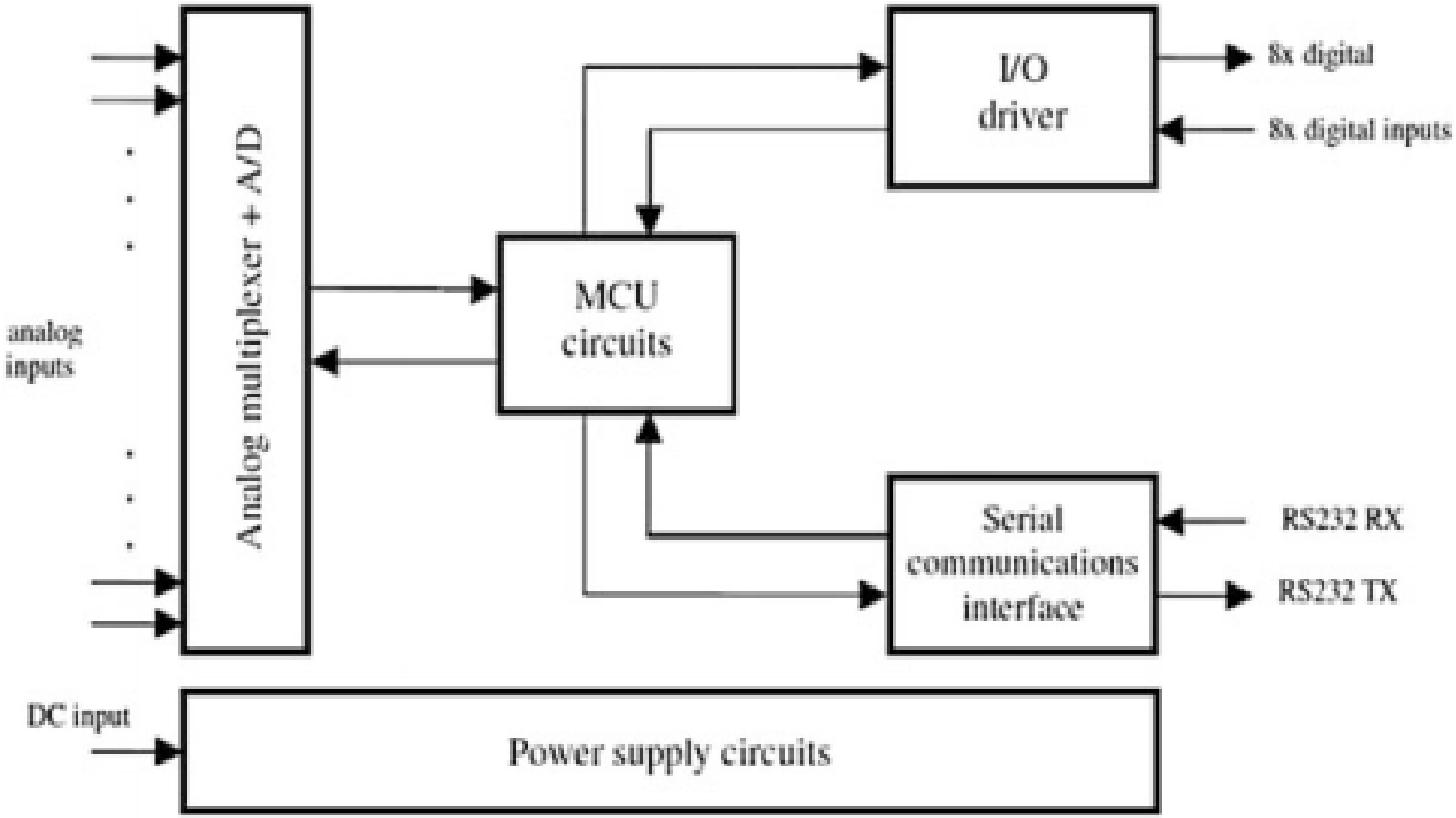
analog inputs
Analog multiplexer + A/D
MCU circuits
I/O driver
8x digital
8x digital inputs
Serial communications interface
RS232 RX
RS232 TX
DC input
Power supply circuits

DESIGN OF PORTABLE DAS

- The hardware and software design of a portable measurement system is more complicated than just choosing the right IC to meet the required electrical performance. There are many tradeoffs to be considered.
- For example: size respect to the board, total cost, life cycle, and so on.
- At one extreme is a discrete design using readily available standard components and at the other extreme is a custom design using a single mixed-signal chip.

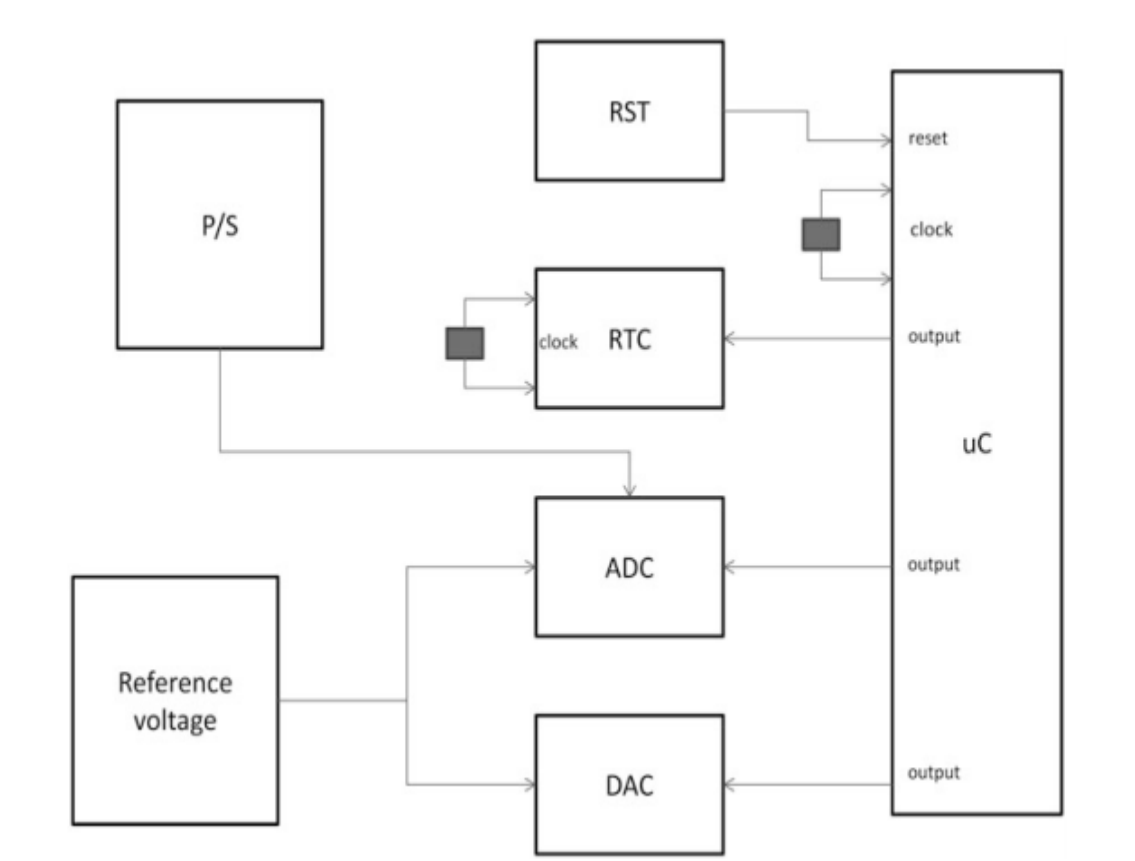

Figure: PORTABLE DAS

SOFTWARE FOR DATA ACQUISITION SYSTEMS

- The design of data acquisition (DAQ) and control software must have the capacity to recover gracefully from instrument component failures and power outages without losing data.
- Data Acquisition software must be easily reconfigurable and provides a high level language for algorithm design.
- Moreover, it is required a data archiving method that can verify the integrity of the data acquired application software normally does such tasks as
- Real-time monitoring
- Data analysis
- Data logging
- Control algorithms
- Human machine interface (HMI)

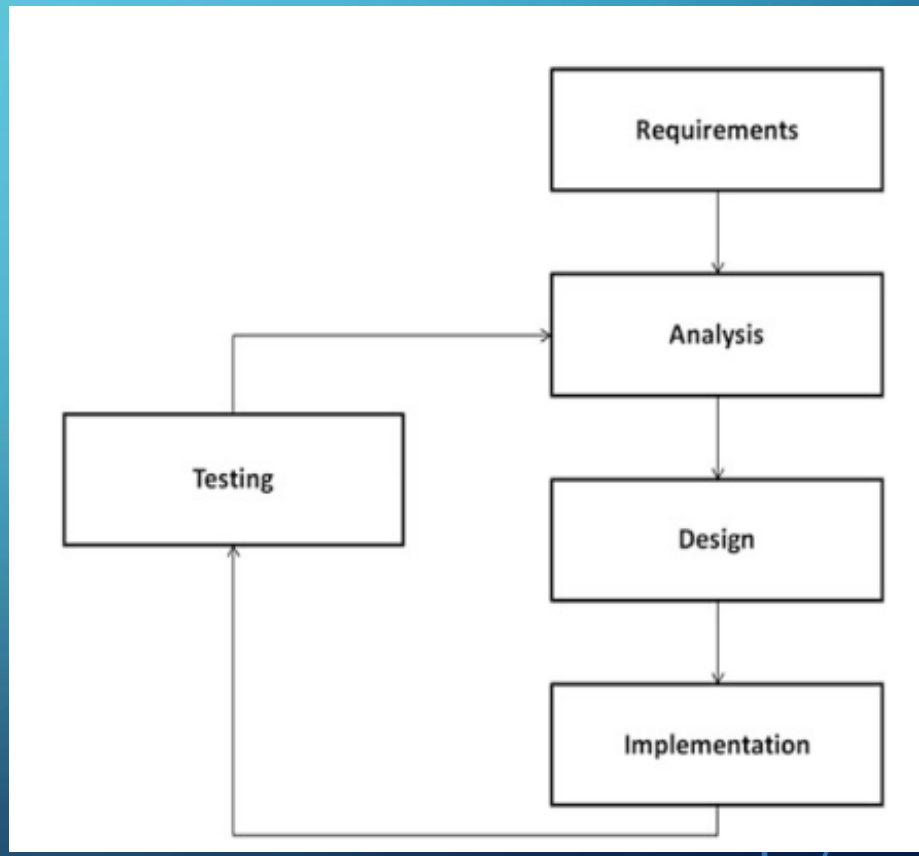

Figure: Software Process Flow

DESIGN OF FIRMWARE

- Firmware is a software program or set of instructions programmed on a hardware, installed on ROM chips (ROM, PROM, EPROM) or flash chips.
- It enables the device to render its capabilities functionally.
- Moreover, it coordinates the activities of the hardware during normal operation and contains programming constructs used to perform those operations.

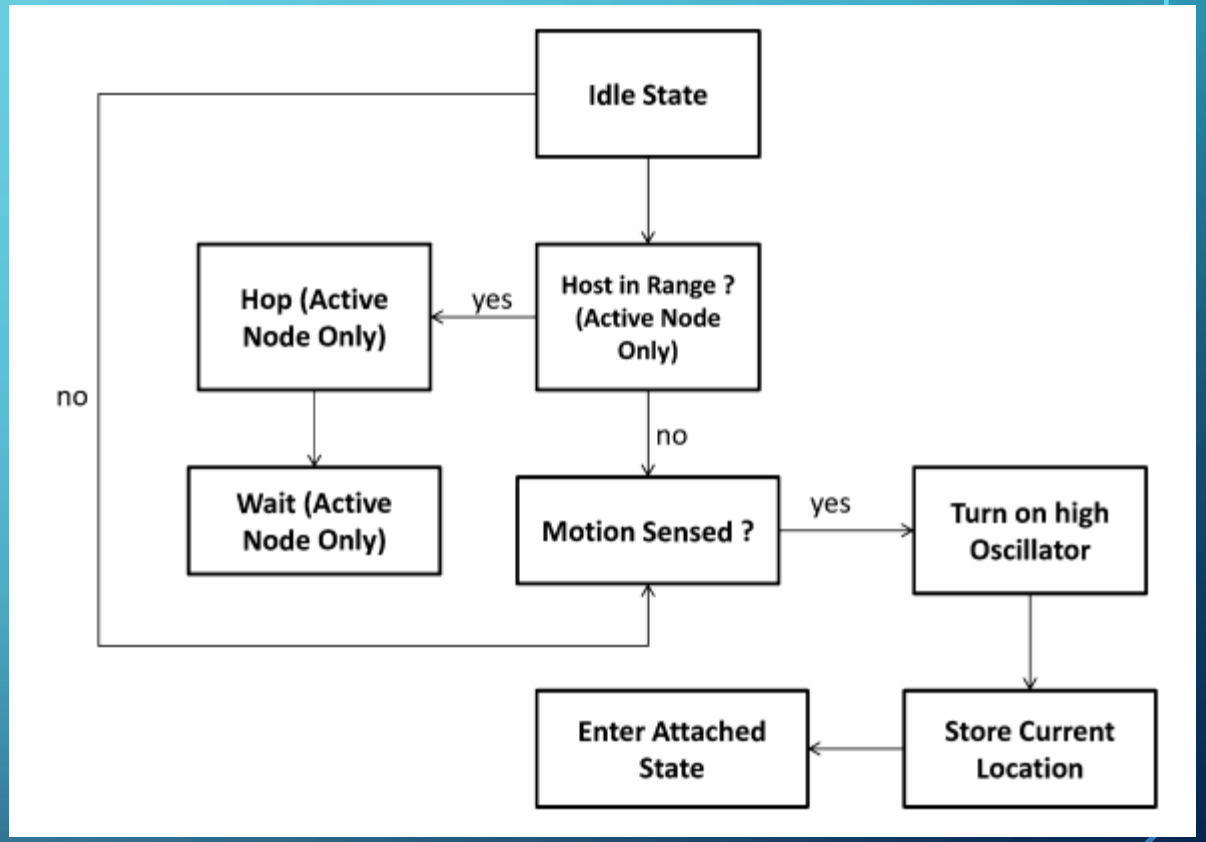

Figure: Flow diagram of Firmware

THANKS