LabVIEW-Based SRS Data Acquisition System

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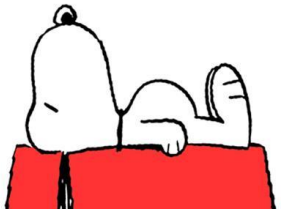
Certified Professional Instructor
National Instruments
Austin (TX)

Lecture Map



Short Lesson 1	Laboratory 1
Overview of a DAQ System	The LV DAQ-SRS under the magnifying glass
Short Lesson 2	Laboratory 2
LabVIEW as a complete DAQ tool	Taking data with LV DAQ-SRS

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Lesson 1
Overview of a Data Acquisition System

TOPICS

A. DAQ System Overview
B. Sensors
C. Signals
D. DAQ Hardware
E. Signal Conditioning
F. DAQ Software

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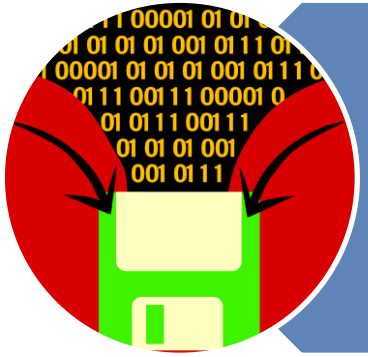
A. DAQ System Overview



Data Acquisition (DAQ)–the automatic collection of data from sensors, instruments, and devices in a factory, laboratory, or in the field.

Purpose

To measure an electrical or physical phenomenon such as voltage, current, temperature, pressure, or sound

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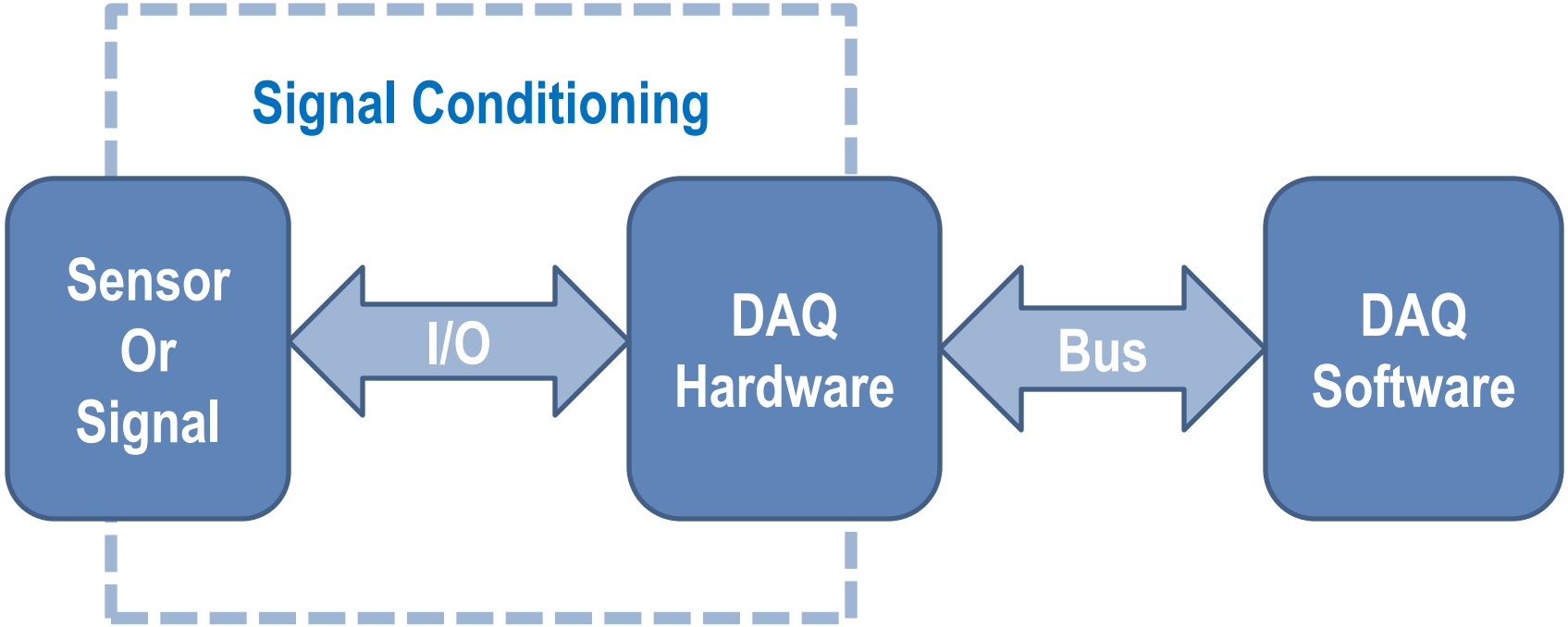
DAQ System Overview



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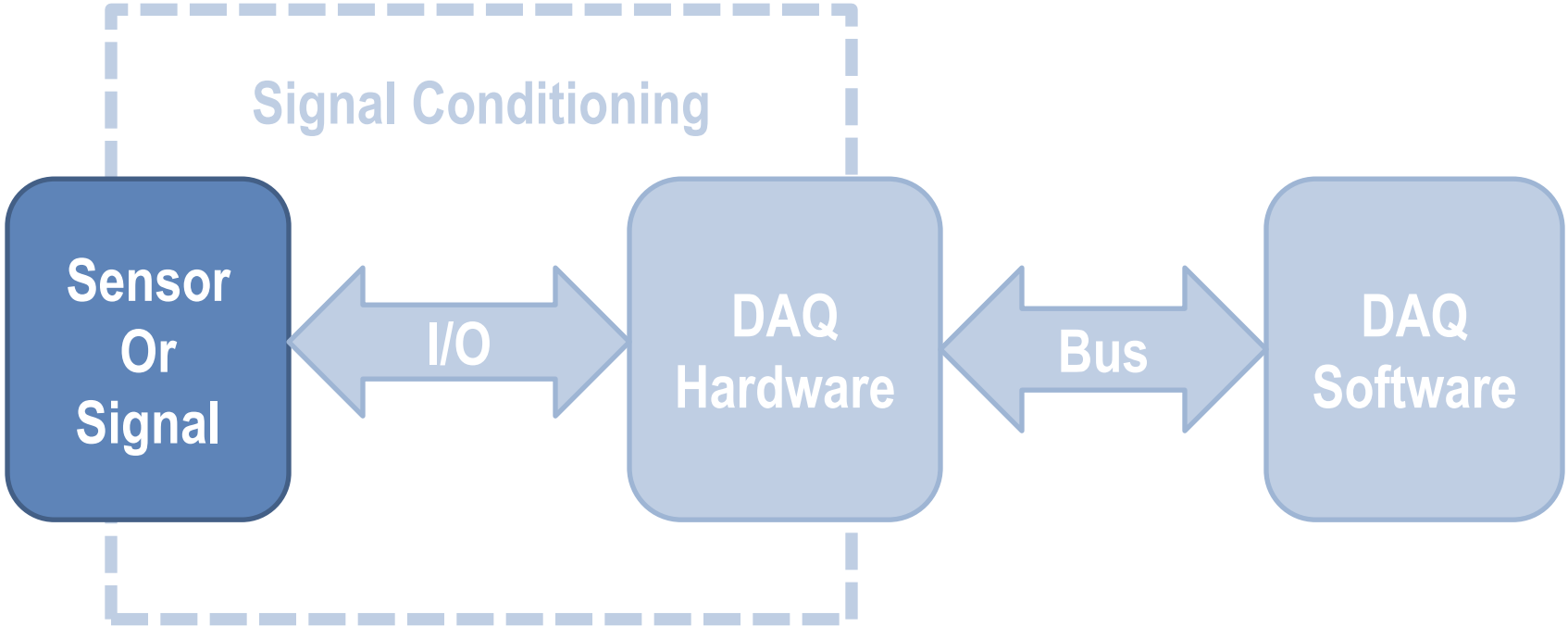
B. Sensor Overview

- What is a sensor?
- Types of sensors



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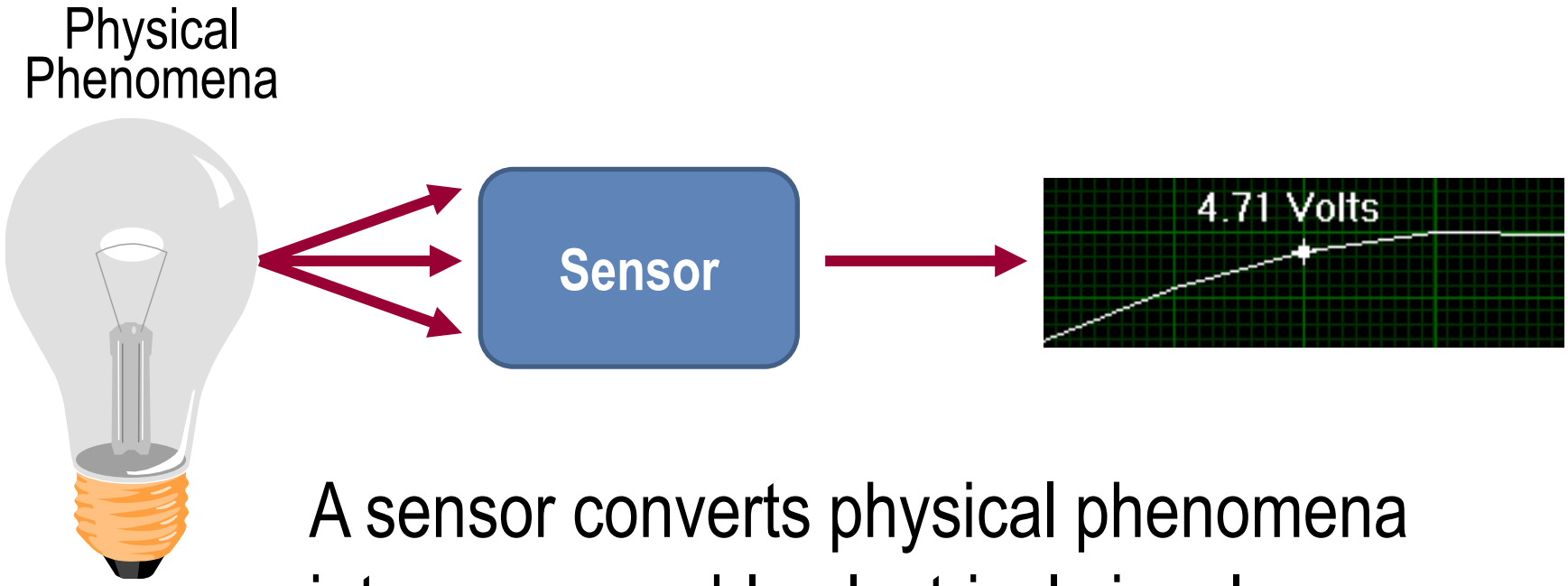
What is a Sensor?



A sensor converts physical phenomena into measureable electrical signals

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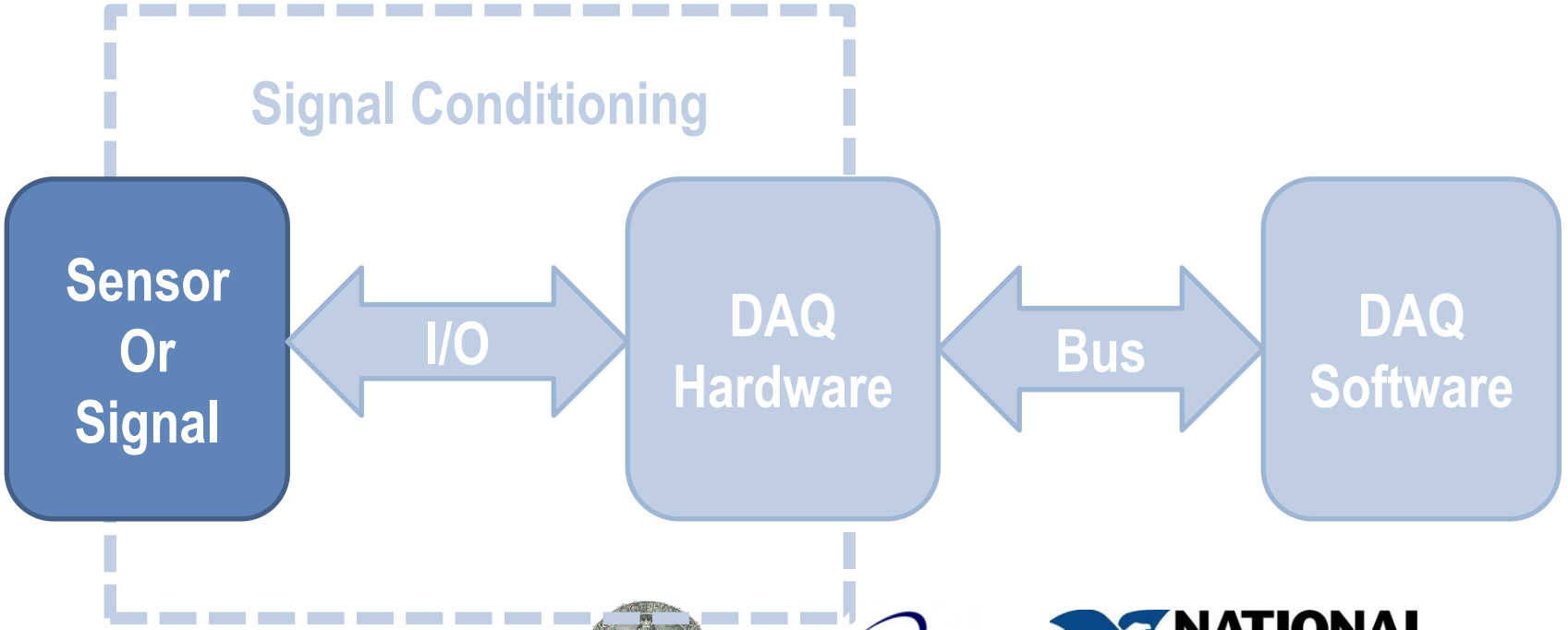
Types of Sensors

Phenomena	Sensors
Temperature	Thermocouples, Resistive Temperature Devices (RTDs), Thermistors
Strain and Pressure	Strain gages, Piezoelectric transducers
Sound	Microphone
Vibration	Accelerometer
Position and Displacement	Potentiometers, Linear voltage differential transformer, Optical encoder
Fluid	Head meters, Rotational flowmeters
pH	pH electrodes
Light	Vacuum tube, Photo sensors
Particles and Radiation detection in general	Ionization-proportional-Geiger chambers, Scintillators, Silicon detectors,…

C. Signal Overview

- Signal classification
- Signal information



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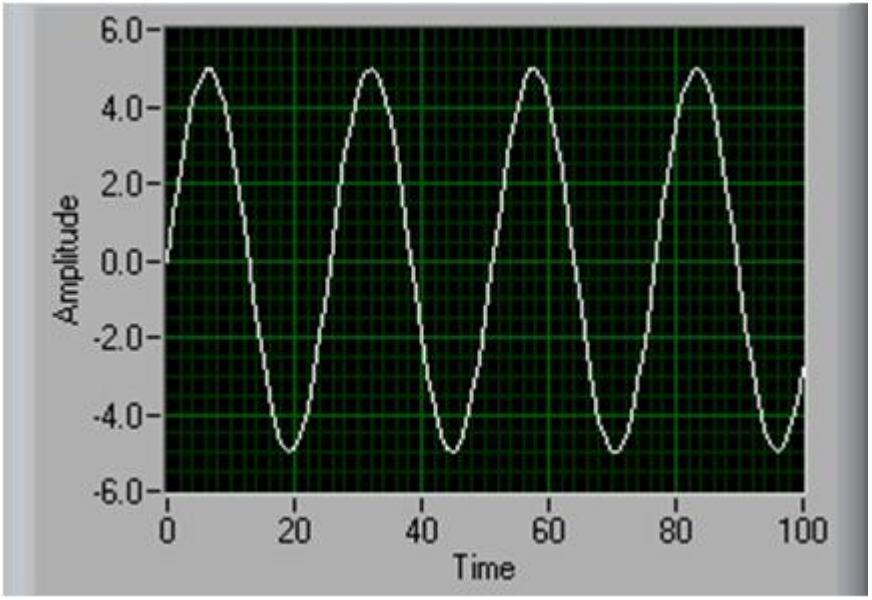
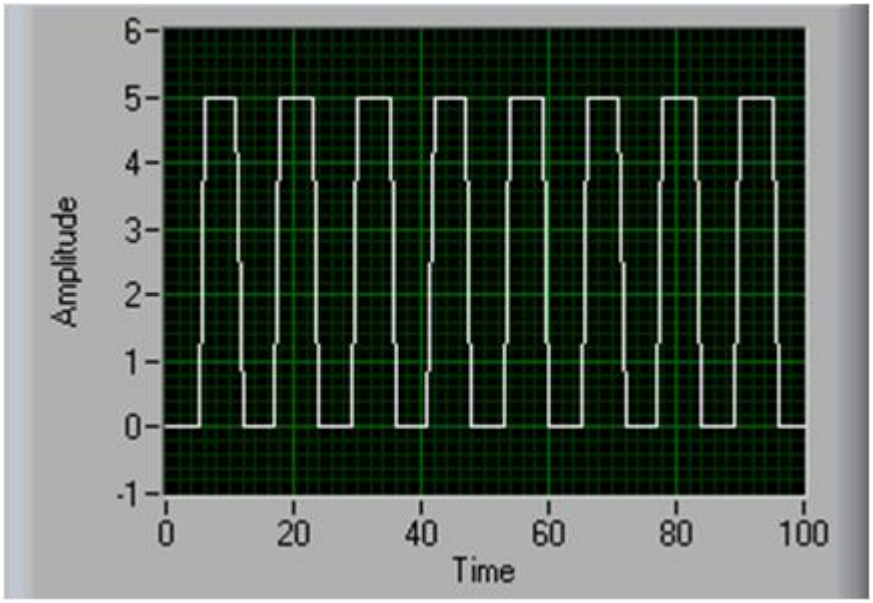
Signal Classification

Analog



Digital



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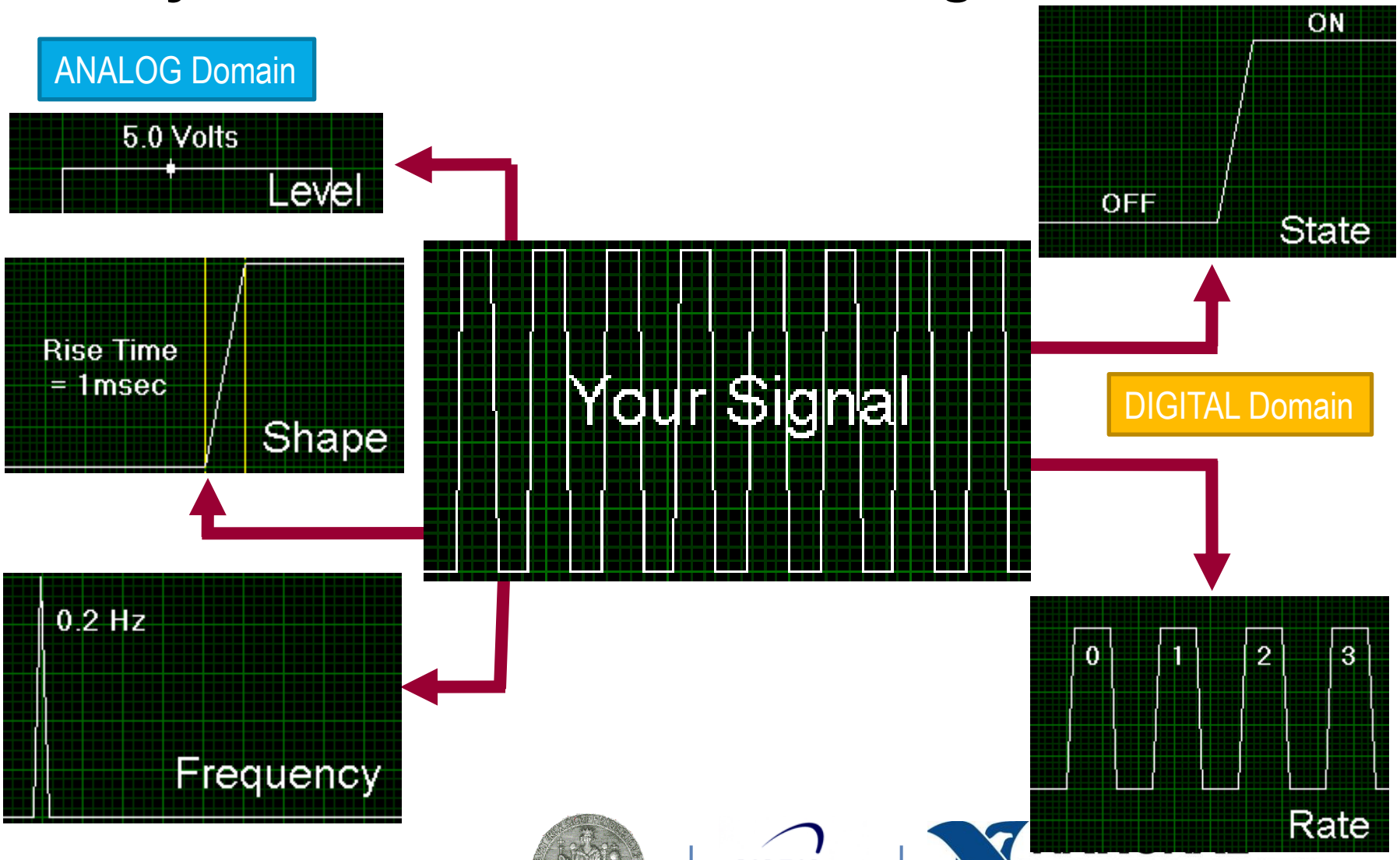
5 Ways to Measure the Same Signal



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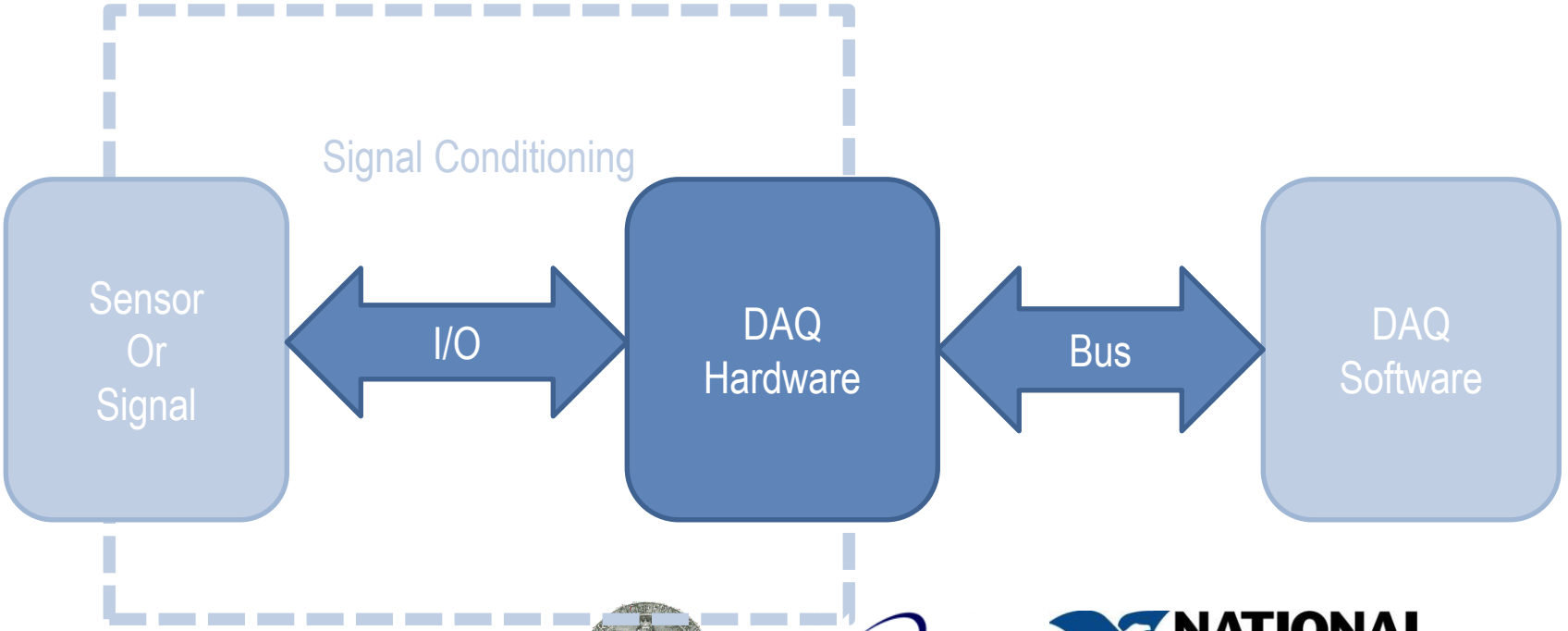
D. DAQ Hardware Overview

- Purpose of DAQ hardware
  - Transfer data between your sensor/signal and your software



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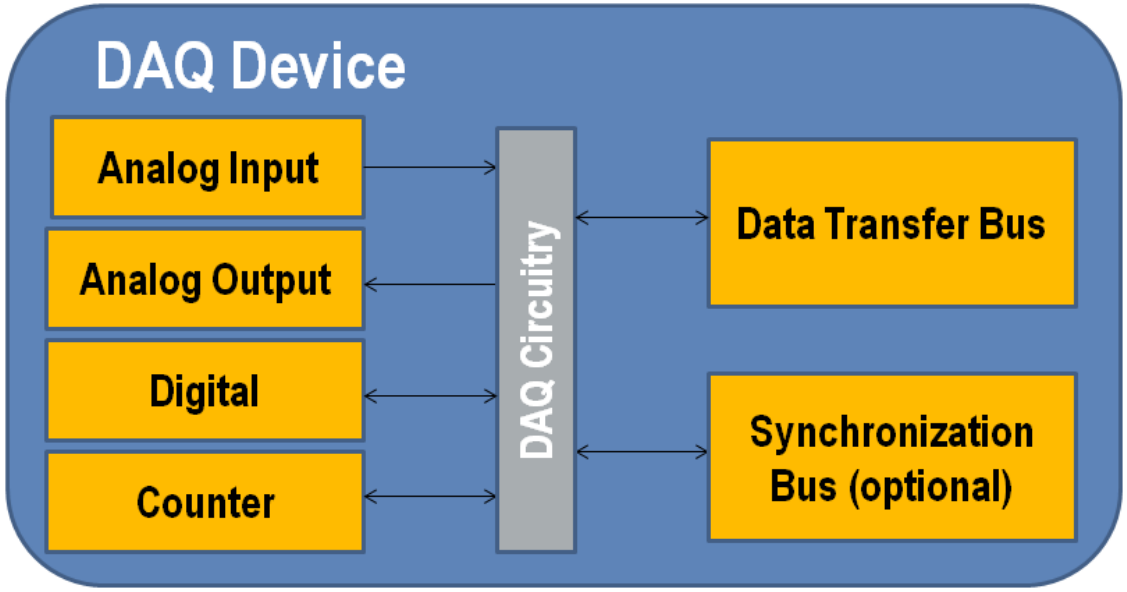
Typical General Purpose DAQ Device Architecture

Features
- Analog Input
- Analog Output
- Digital I/O
- Counter

DAQ Circuitry
  - Clock&Timing, FIFO,…

Data Transfer Bus
  - USB, PCI, PCI Express, PXI, PXI Express



Synchronization Bus
- Used to synchronize multiple DAQ devices
- Allows sharing of timing and trigger signals between devices

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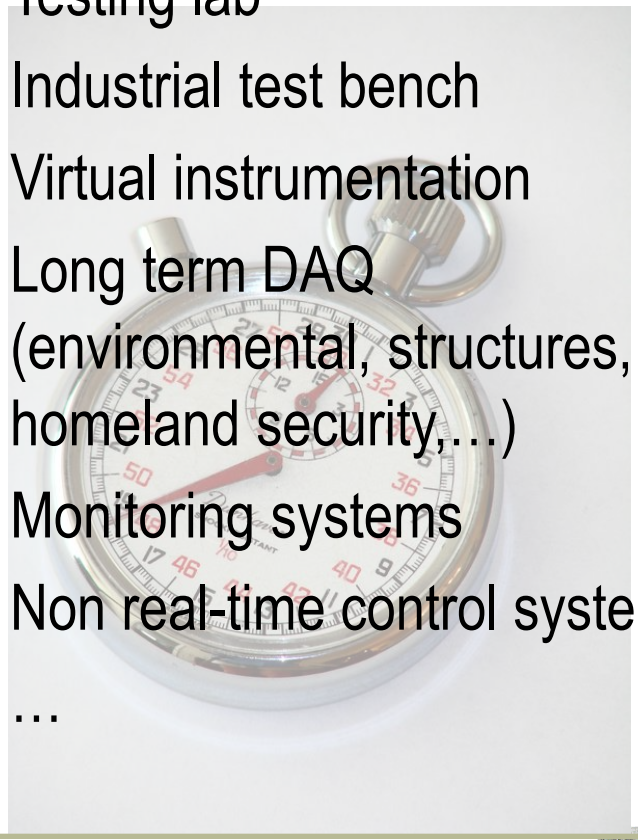
General DAQ Devices vs Specialised ones

General DAQ Devices are suitable for DAQ in «simple» situations

- Testing lab
- Industrial test bench
- Virtual instrumentation
- Long term DAQ (environmental, structures, homeland security,…)
- Monitoring systems
- Non real-time control systems
- …



Easy or standard signal conditioning needed

Physics presents different challenges

- Weak and fast signals
  - Bad as both voltage or current sources !!! → need very special signal conditioning
    - Charge integration amplification
    - Low noise techniques
    - Wide frequency band with the risk of EMI &/or auto oscillations
- Signal timing
  - Fast signals, short rise and fall time
  - Triggering techniques needed

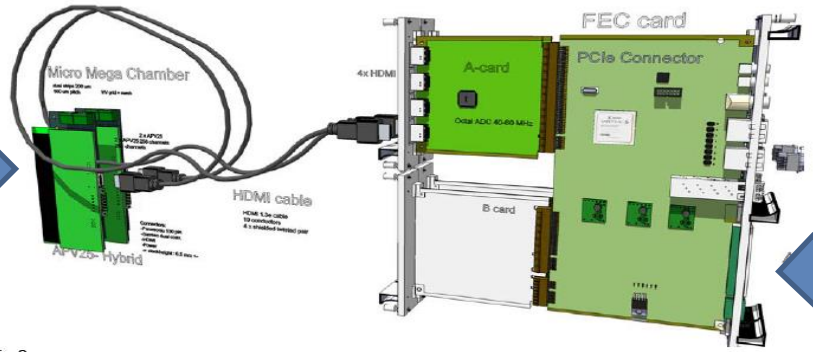
NON-standard signal conditioning!

- Custom front-end electronics
- Very specialized custom or industry-made DAQ electronics

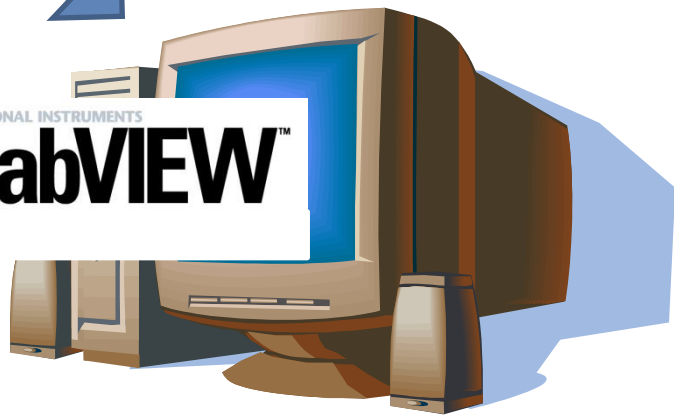
The LabVIEW DAQ-SRS

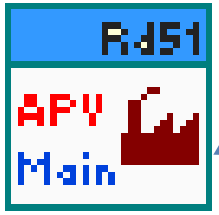
Chambers → ON Board Electronics (signalconditioning) →
DAQ System → Bus connection → PC running LV (≥ 2012)

μMGas,
GEM,…
chambers



UDP connection

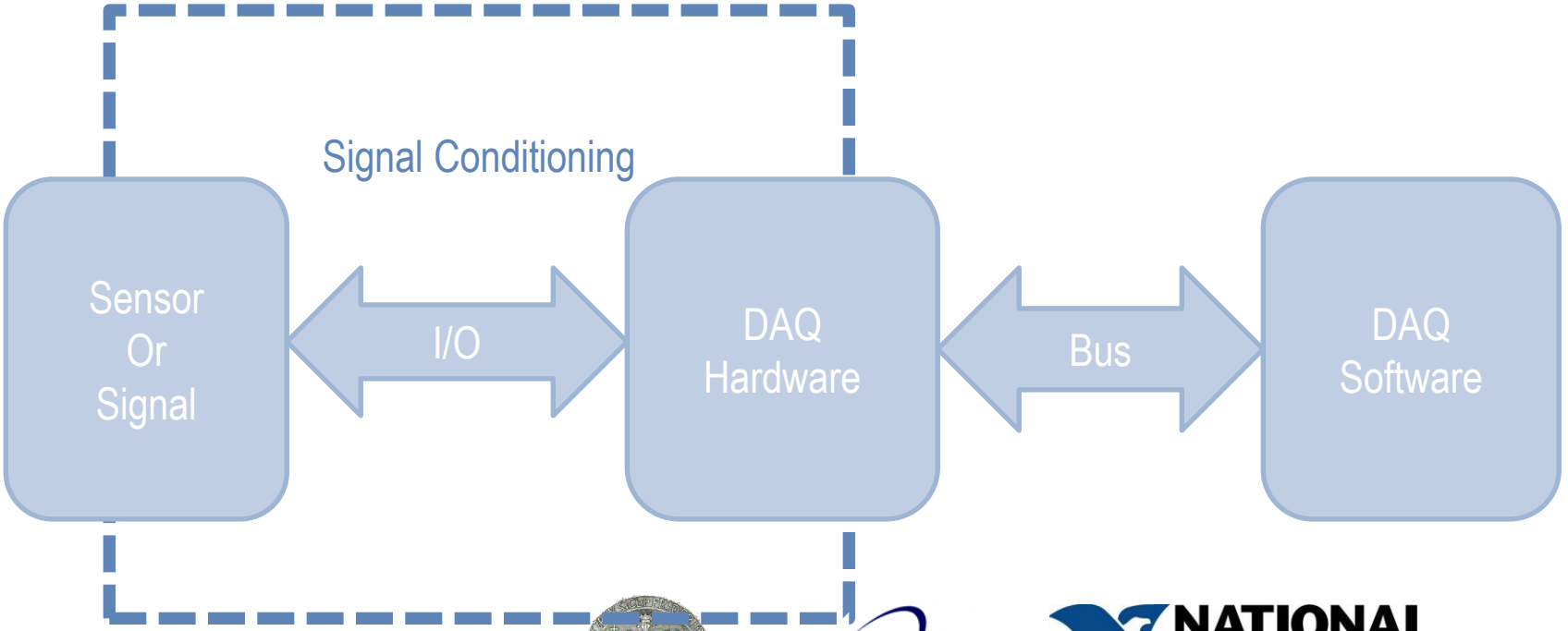




"RD51-srs"
LabVIEW Project

E. Signal Conditioning

- Purpose of signal conditioning
- Signal conditioning tasks and examples



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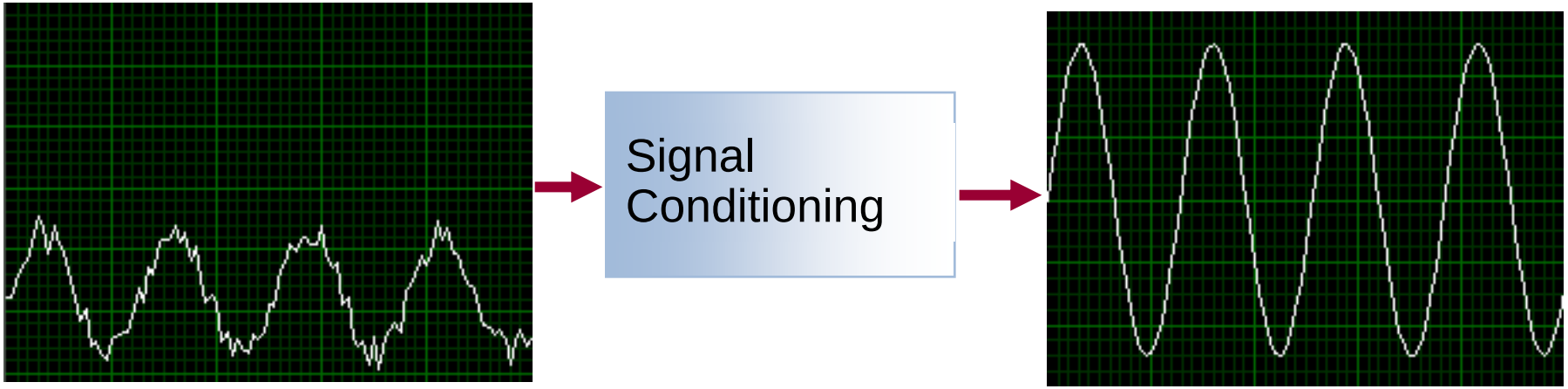
Purpose of Signal Conditioning

- Signal conditioning takes a signal that is difficult for your DAQ device to measure and makes it easier to measure
- Signal conditioning is not always required
  - Depends on the sensor or signal being measured



Noisy, Low-Level Signal

Filtered, Amplified Signal

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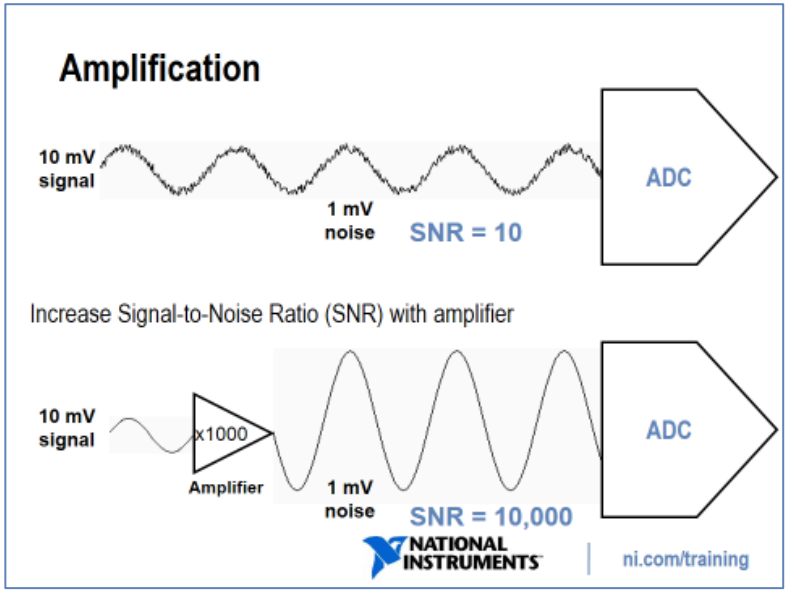
Signal Conditioning Tasks

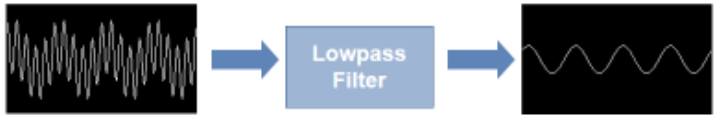
They depend on the type of signal, but in principle

Analogue domain:

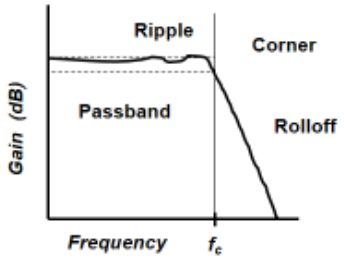
- Voltage measurement
  - Amplification
  - Attenuation
  - Isolation
  - Filtering



Filtering



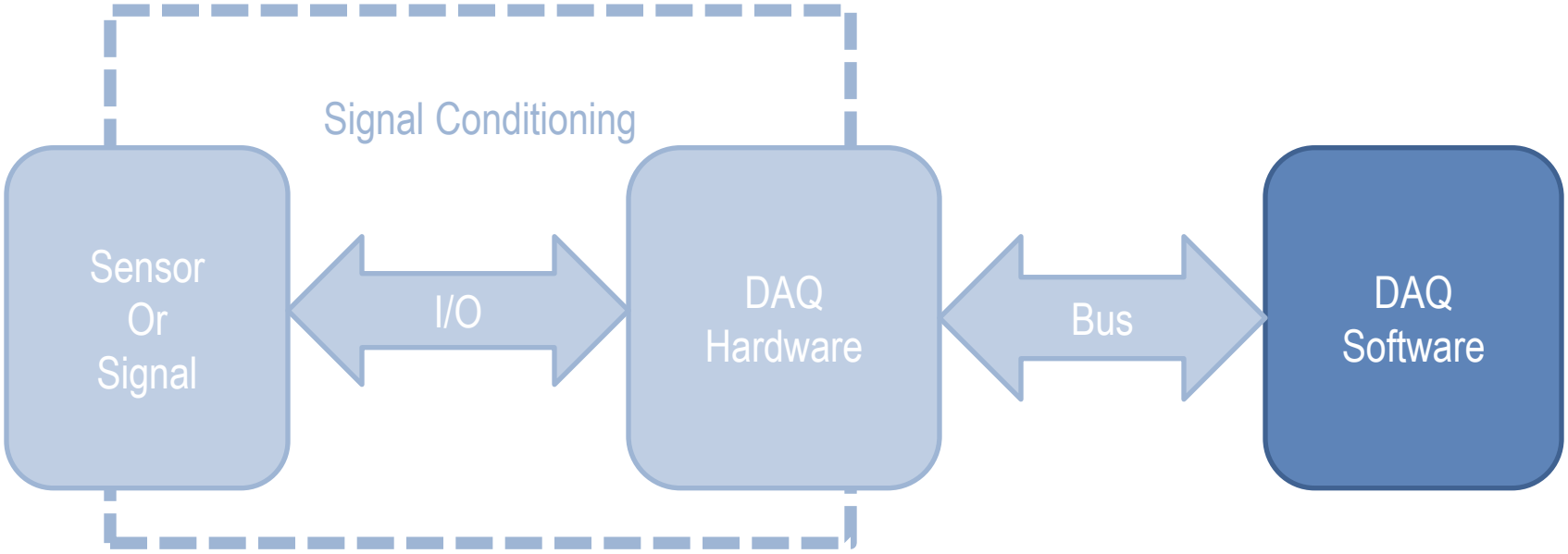
Bode Plot



- Passband – frequencies the filter lets pass
- Ripple - filter's effect on the signal's amplitude
- Corner – frequency where the filter begins blocking the signal
- Rolloff – how sharply the filter cuts off unwanted frequencies

F. DAQ Software Overview

- After acquiring data, you usually still need to do more
  - Signal processing, generate a report, interact with data, etc.



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Lesson 2
LabVIEW as a complete DAQ tool

TOPICS

A. What is LabVIEW
B. Learning LabVIEW
C. LV Design Patterns
D. Event programming
E. LabVIEW SRS DAQ program structure

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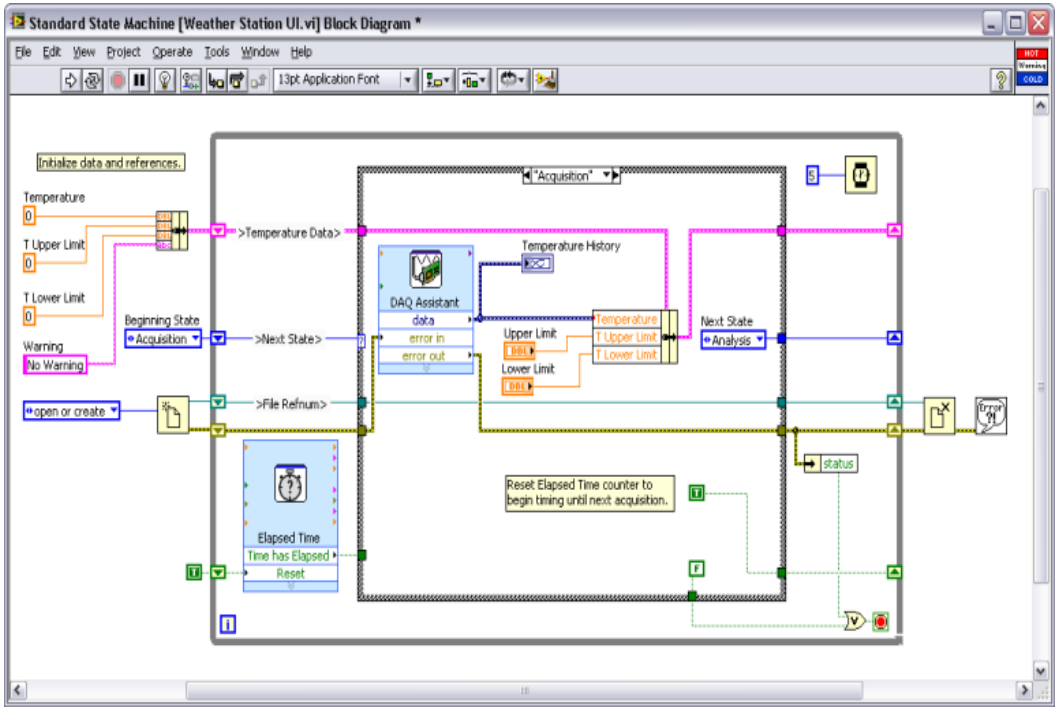
A. What Is LabVIEW?

— A graphical programming environment used to develop sophisticated measurement, test, and control systems.



LabVIEW:

- Interfaces with wide variety of hardware
- Scales across different targets and OSs
- Provides built-in analysis libraries

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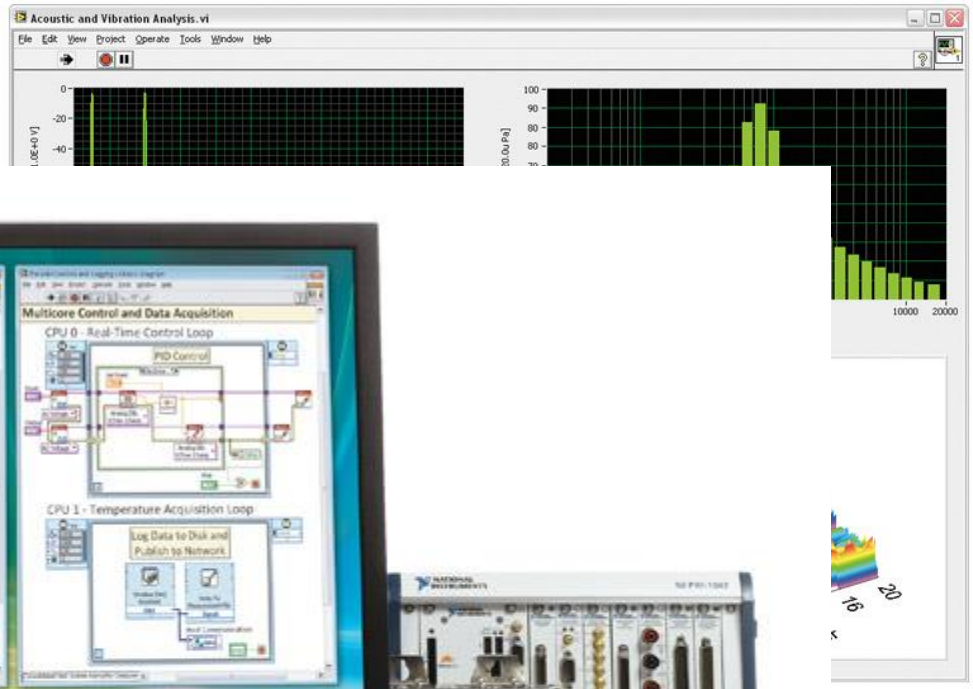
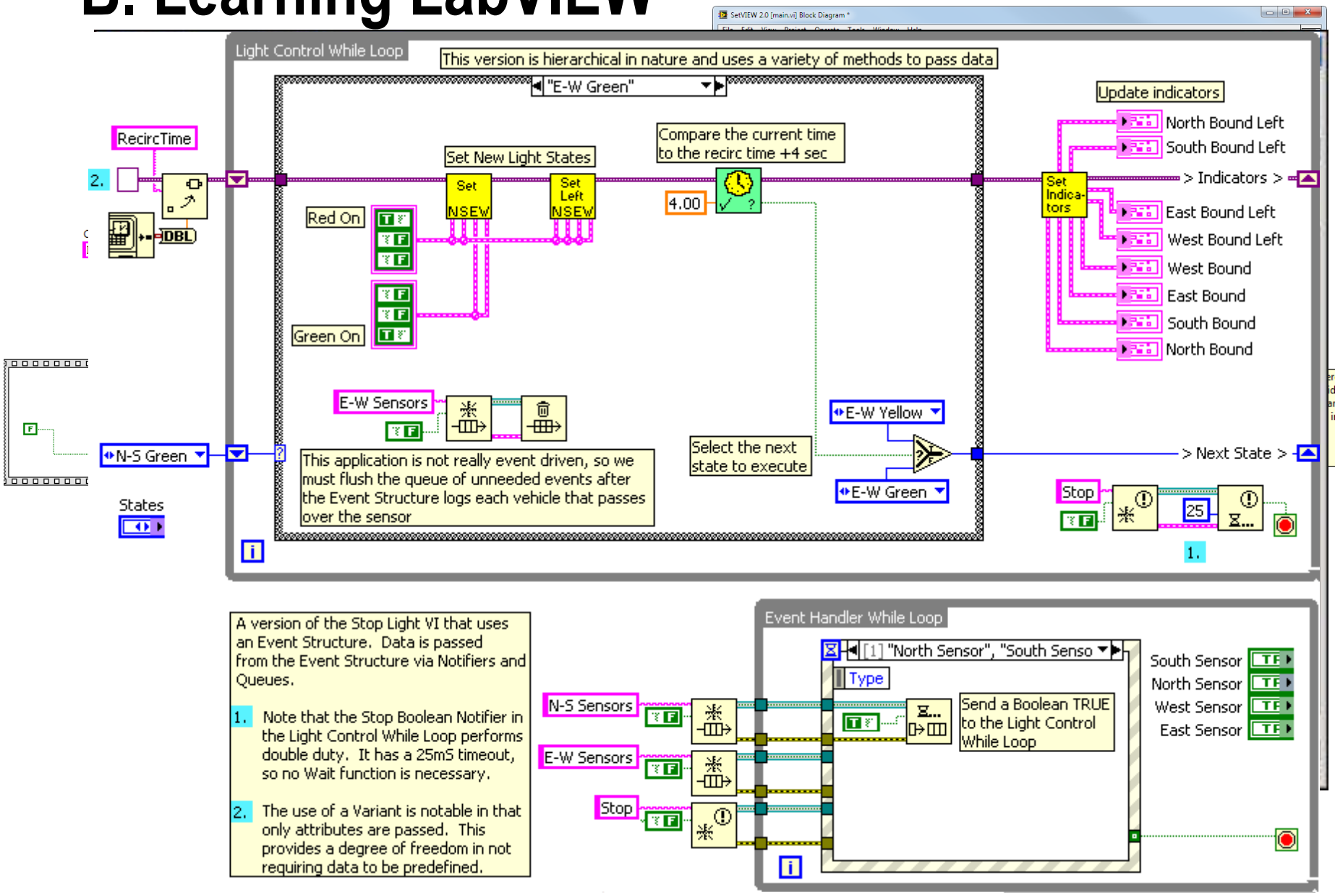
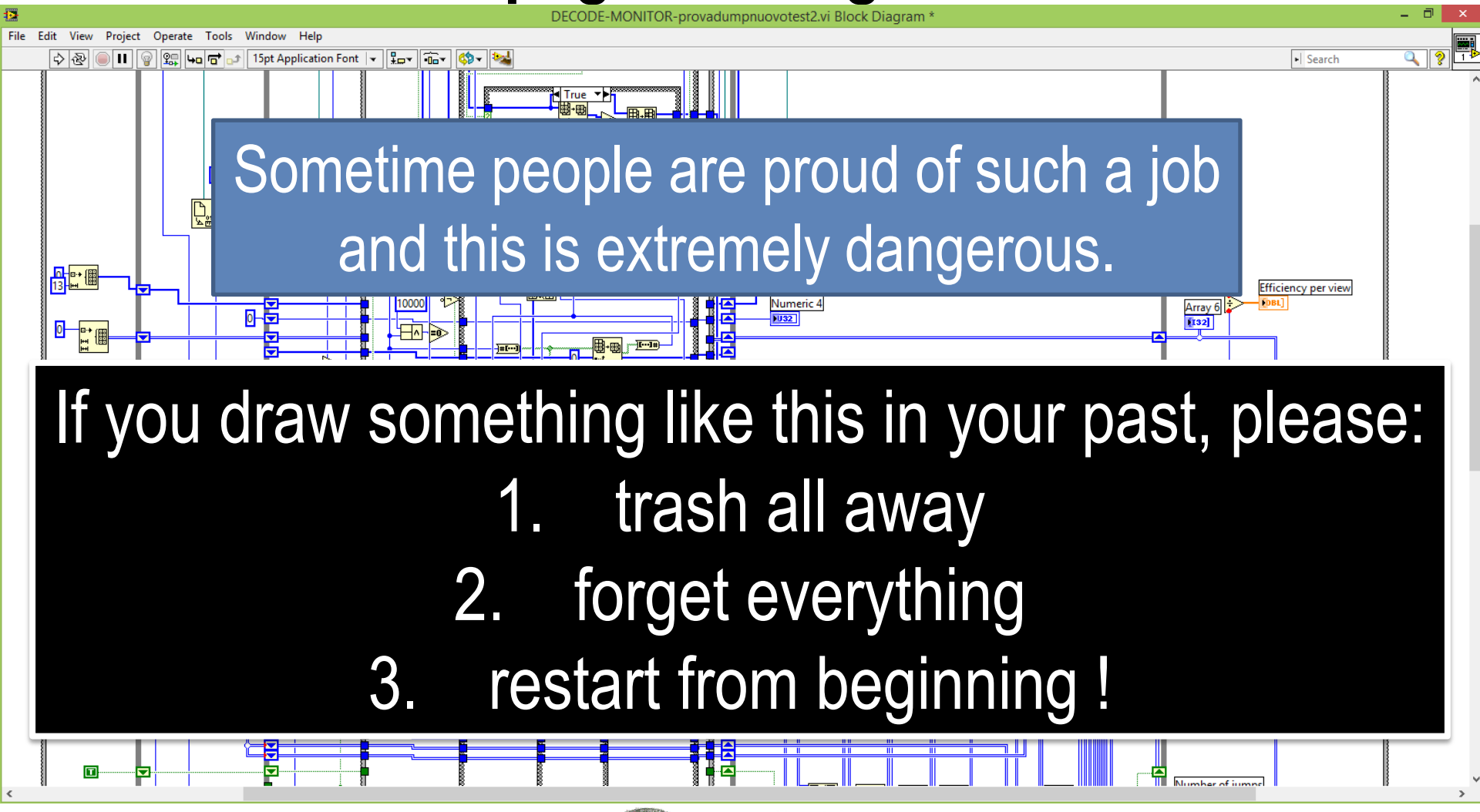
Some LabVIEW Features



B. Learning LabVIEW



Some other “spaghetti diagram”



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Available LabVIEW courses

New User | Experienced User | Advanced User

- LabVIEW Core 1
- LabVIEW Core 2
- LabVIEW Core 3
- LabVIEW Connectivity
- Object-Oriented Design and Programming in LabVIEW
- LabVIEW Performance
- Managing Software Engineering in LabVIEW
- Advanced Architectures in LabVIEW

Certifications

- Certified LV Associate Developer Exam
- Certified LabVIEW Developer Exam
- Certified LabVIEW Architect Exam

Other Courses

- LabVIEW Real-Time 1
- LabVIEW Real-Time 2
- LabVIEW Instrument Control
- LabVIEW Modular Instruments
- LabVIEW FPGA
- DAQ & Signal Conditioning

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LabVIEW Education

- Instructor Led Training
  - LabVIEW Performance
  - Object-Oriented Design and Programming in LabVIEW
  - Managing Software Engineering in LabVIEW
  - Advanced Architectures in LabVIEW
  - RealTime and FPGA
  - Data Acquisition
  - …
- Self-Paced Online: Accessible 24 hours a day, prerecorded video training modules, interactive quizzes, and challenging exercises with solutions.
- Printed Course Materials: a variety of instructional packages and tools designed to educate you at your own pace

Take time to STUDY: time spent so, acts as a credit for the future !

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C. Design Patterns

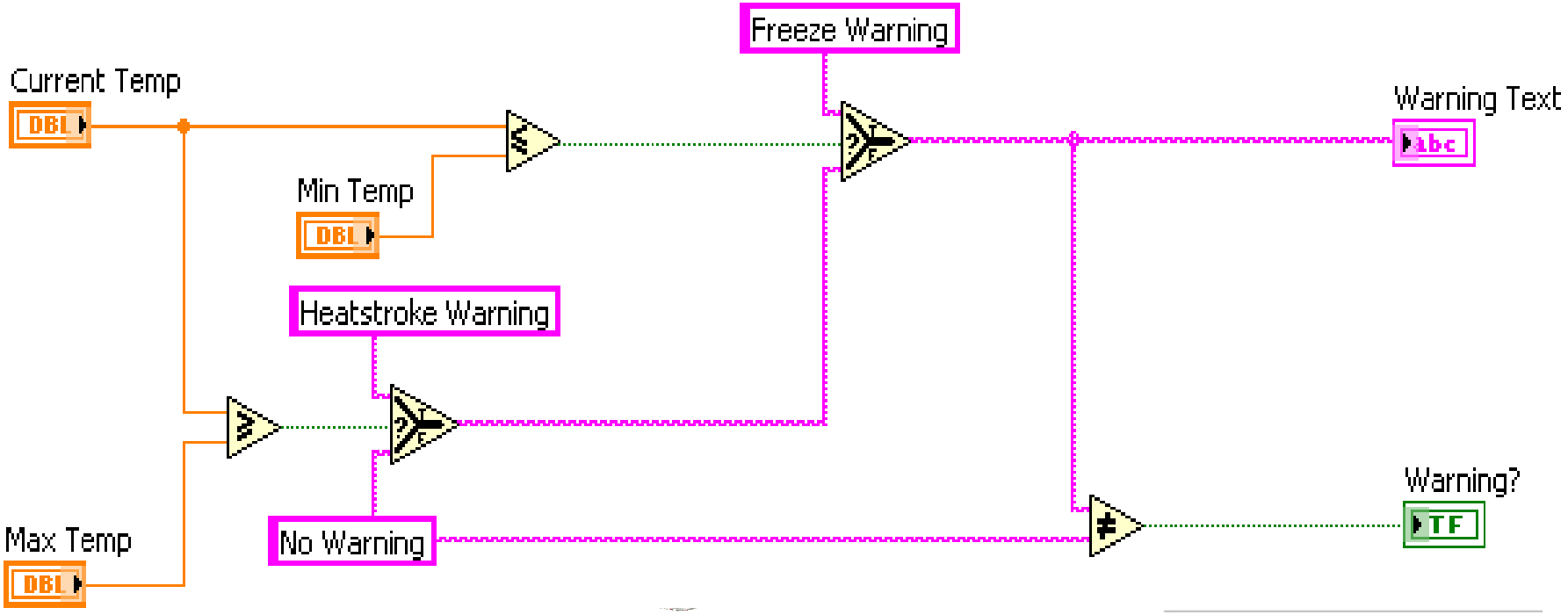
- Why use Design Patterns?
  - They have proven themselves useful for developing software.
  - You don't have to start a program from scratch.
  - They make it easier for others to read and modify your code.

Design Patterns – Code implementations and techniques that are solutions to specific problems in software design

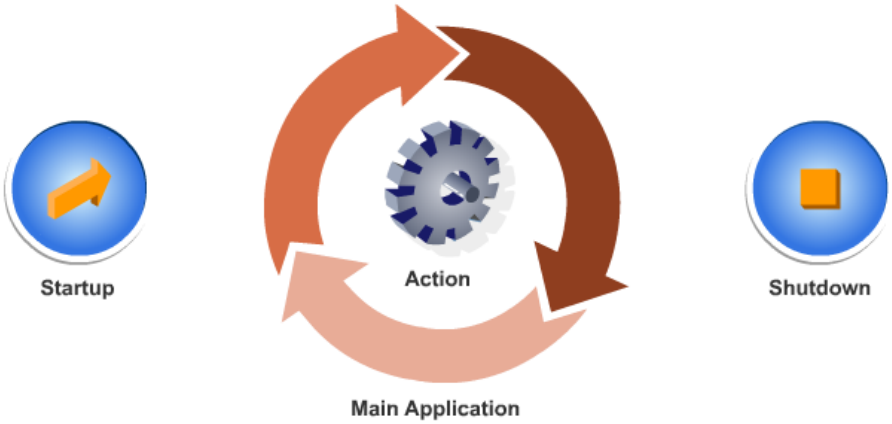
Design patterns typically evolve through the efforts of many developers and are fine-tuned for simplicity, maintainability, and readability.

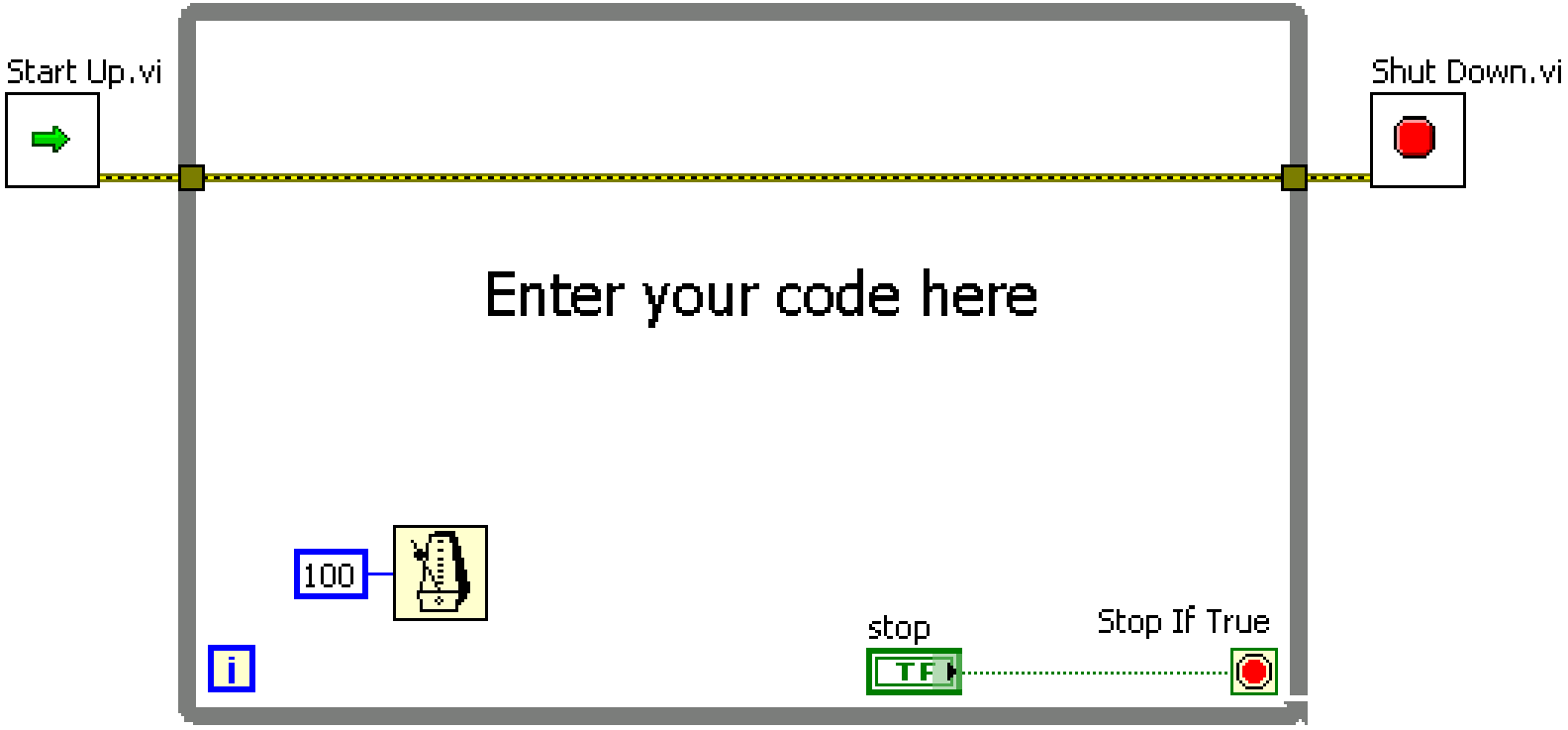
Simple VI Pattern

- Single VI that takes a measurement, performs calculations, and either displays the results or records them to disk.
- Usually does not require a specific start or stop action from the user.

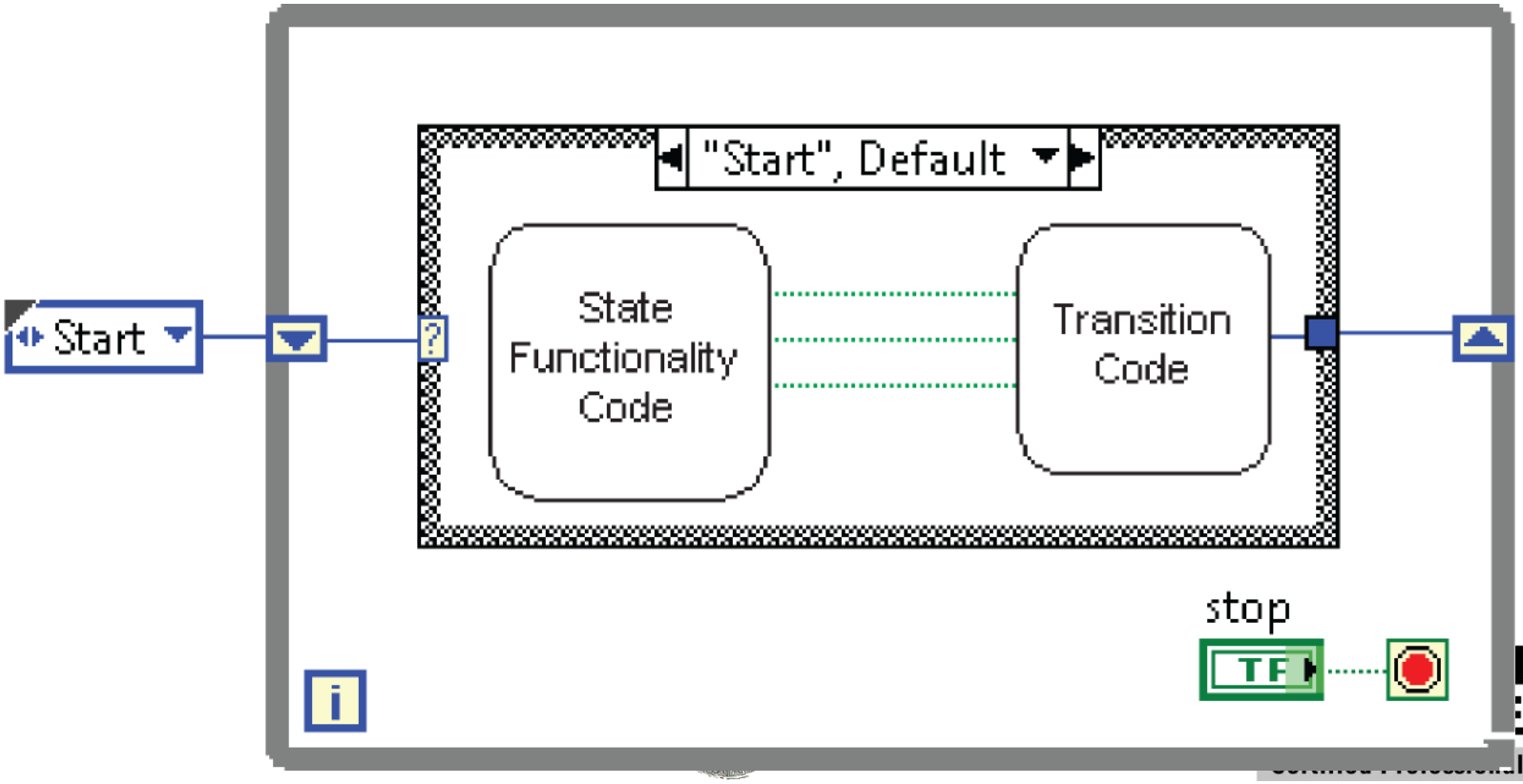


General VI Framework

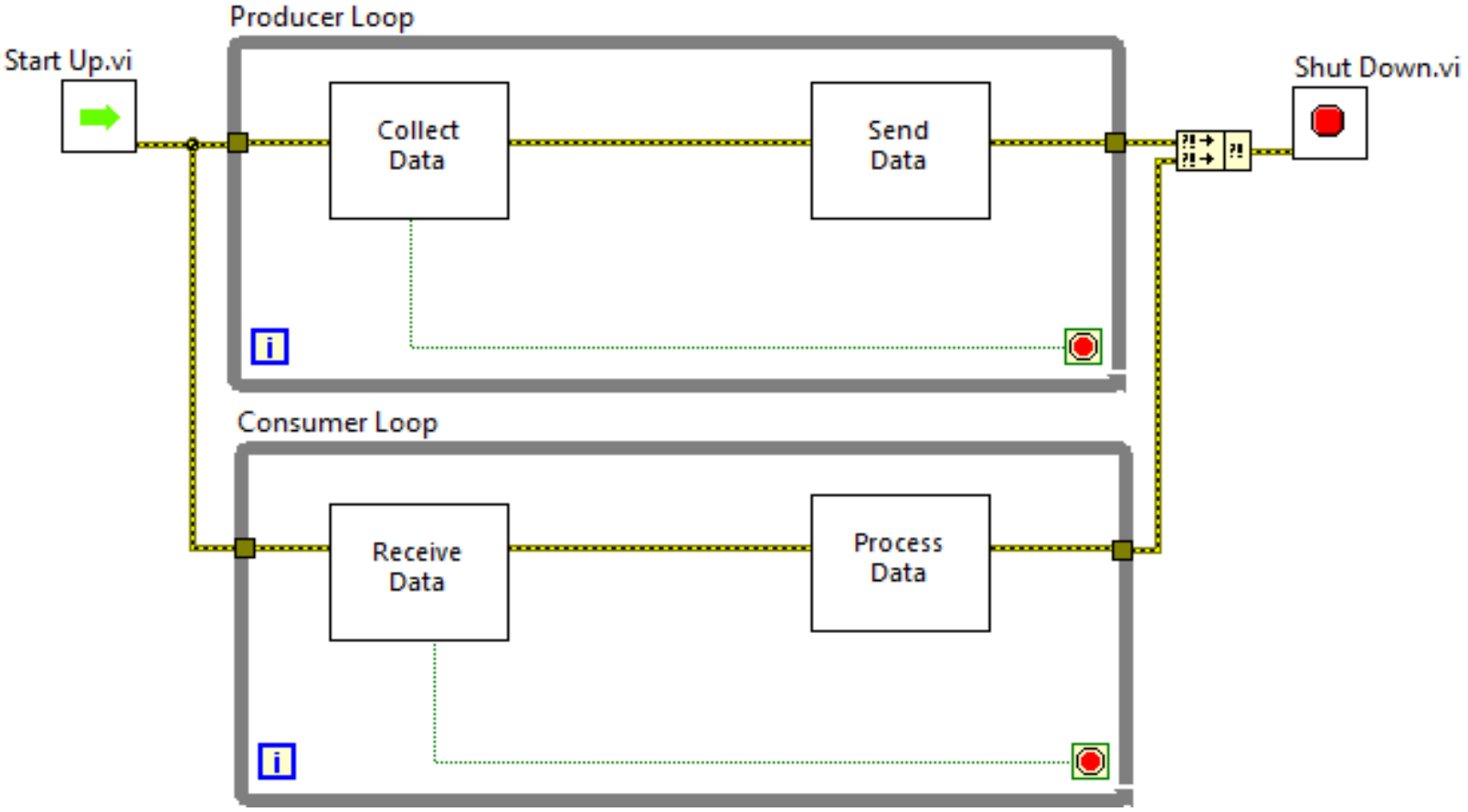




State Machine Framework



Producer/Consumer Design Patterns



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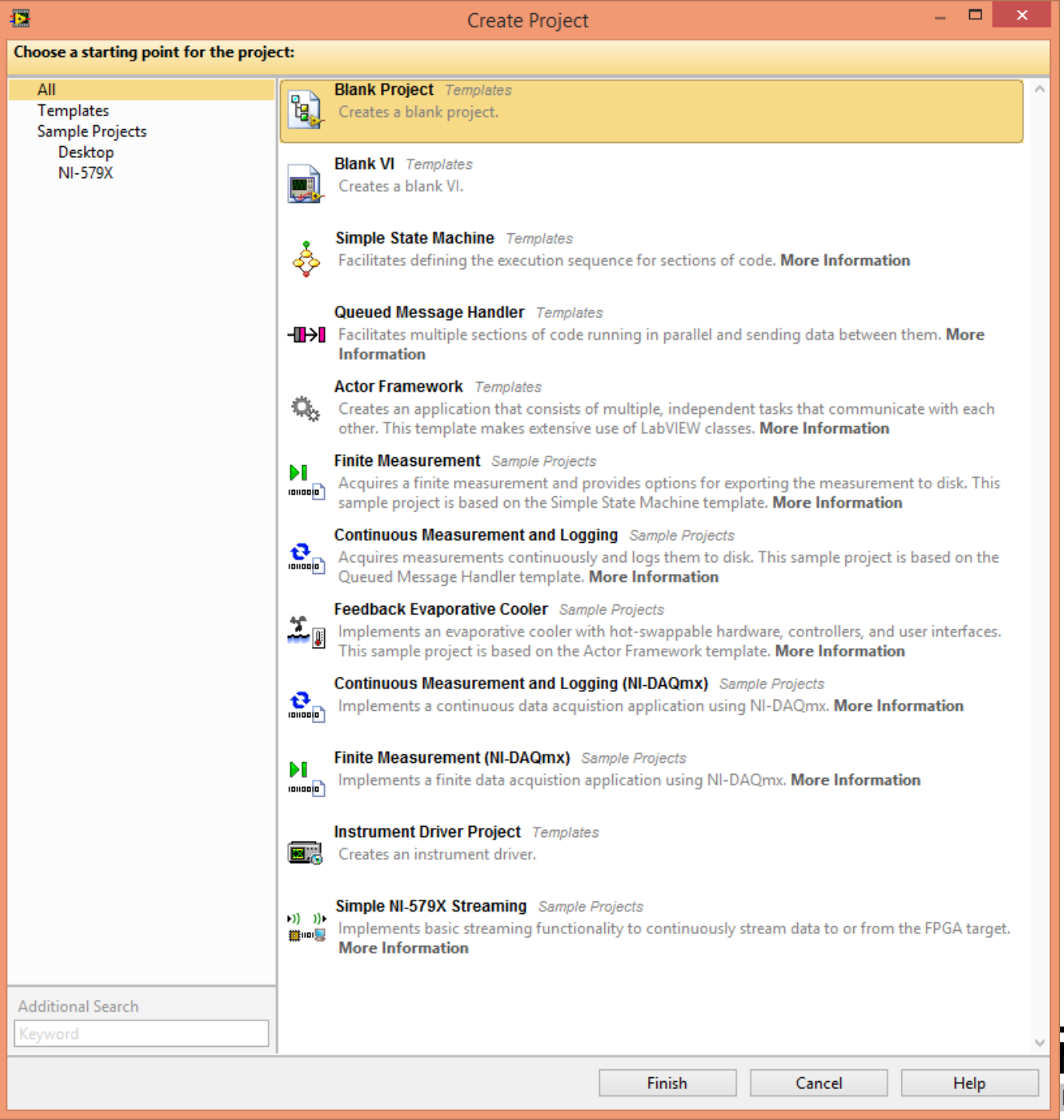
Choos

"Create



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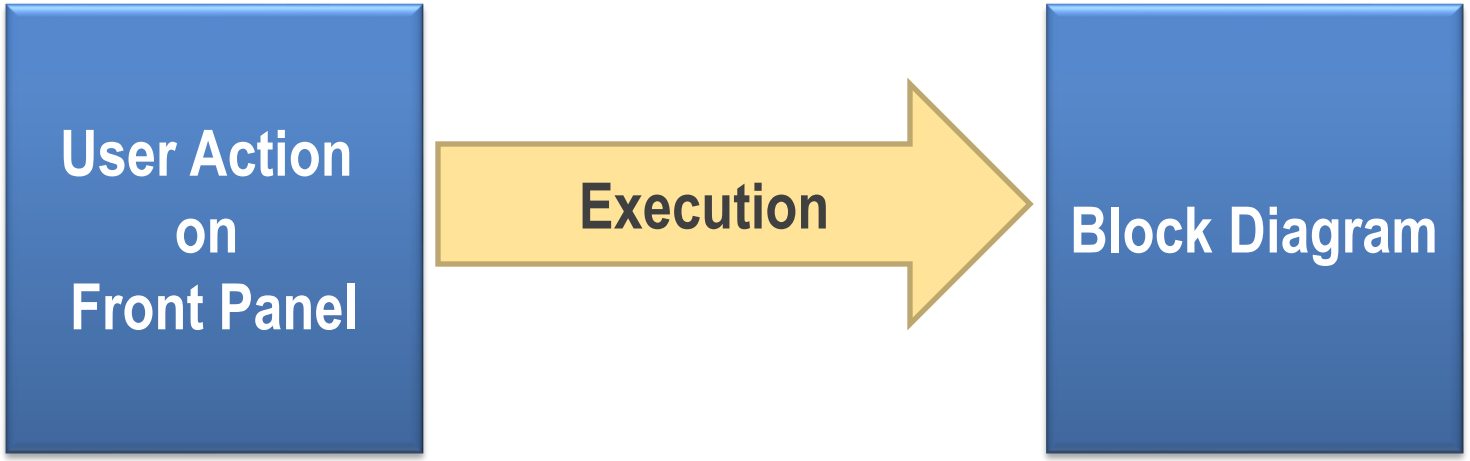
D. Event-Driven Programming

Event — An asynchronous notification that something has occurred

Event-Driven Programming — Method of programming where the program waits for an event to occur before executing one or more functions



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Polling versus Event Structures

Polling

- Method of event-based programming where a loop must continually run code to check if changes have occurred.
- Polling the front panel requires a significant amount of CPU time.
- Polling can fail to detect changes if they occur too quickly.

Event Structures

- Events in Event structures eliminate the need to poll the front panel.
- Benefits of using Event structures:
  - Reduces the CPU requirements of the program.
  - Simplifies the block diagram code.
  - Guarantees that the block diagram can respond to all interactions the user makes.

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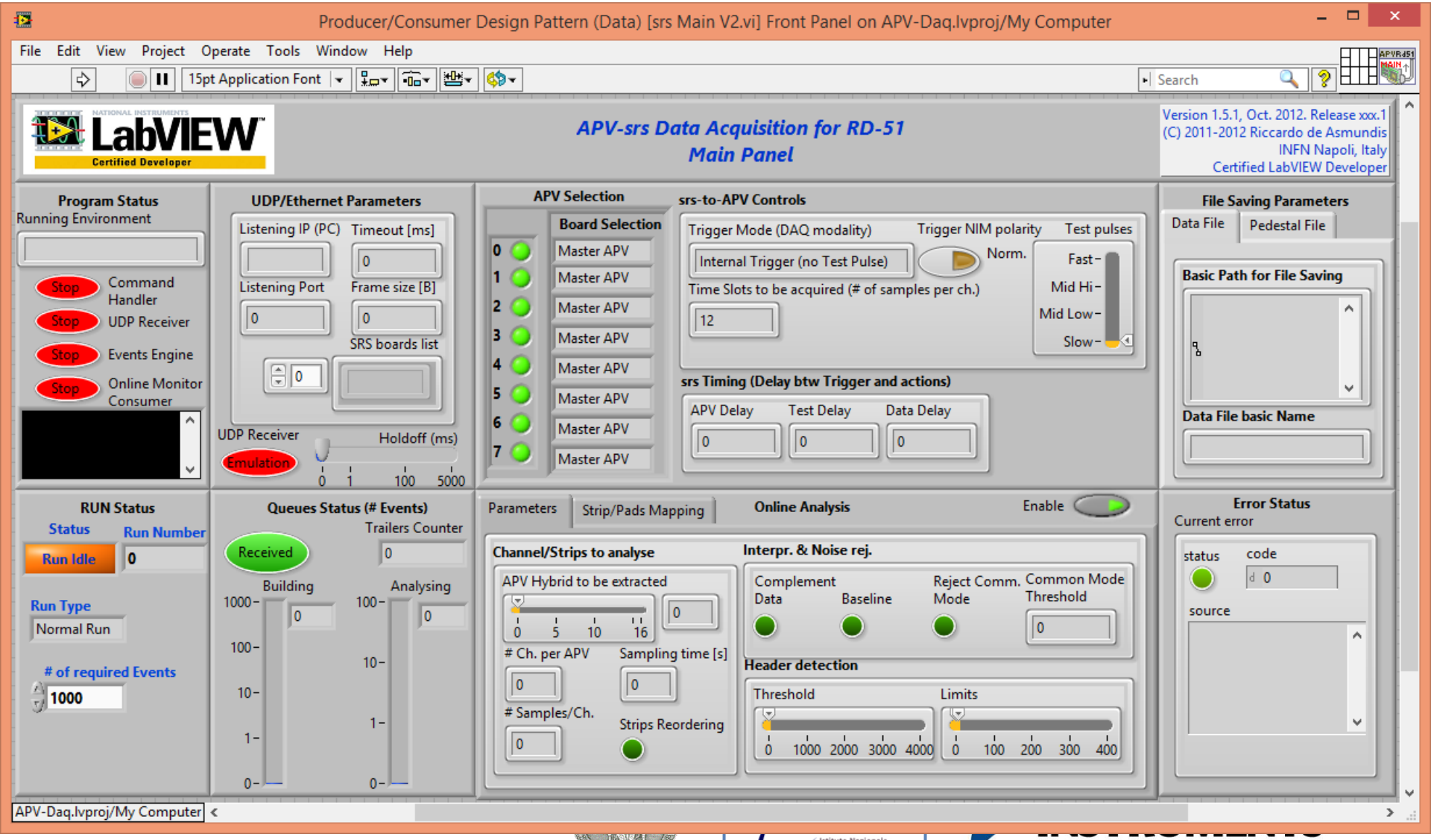
E. LabVIEW SRS DAQ Program Structure



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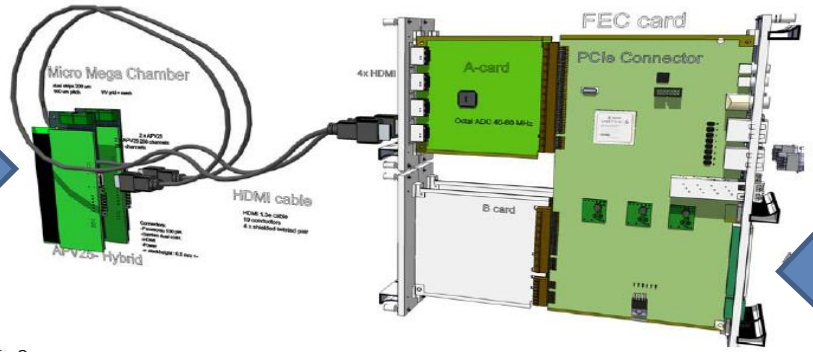
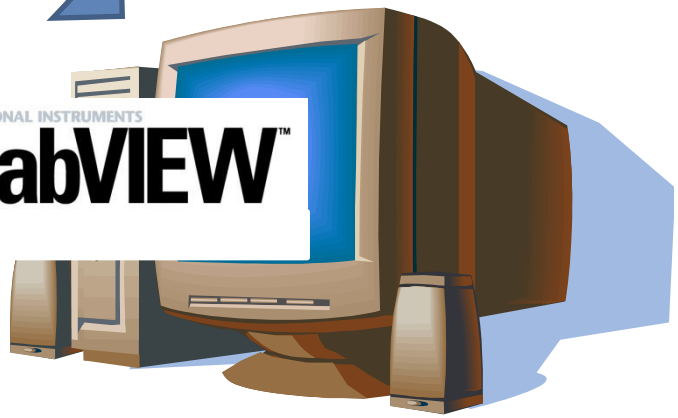
The LabVIEW DAQ-SRS

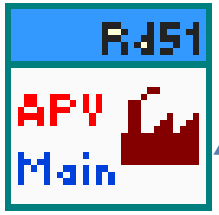
Chambers → ON Board Electronics (signalconditioning) →
DAQ System → Bus connection → PC running LV (≥ 2012)

μMGas,
GEM,…
chambers



UDP connection





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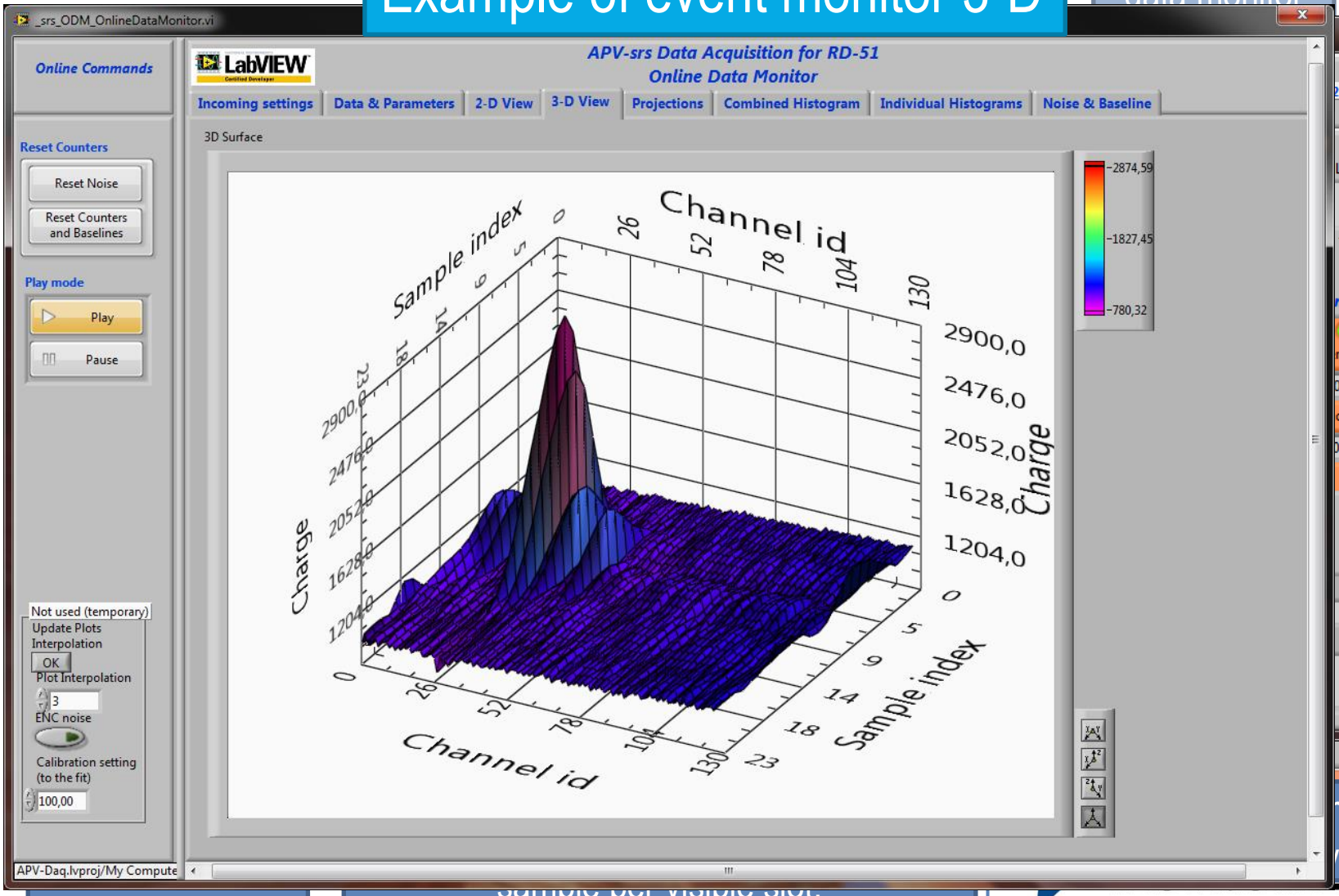
Program Features

Example of event monitor 3-D

UDP Codes data monitor



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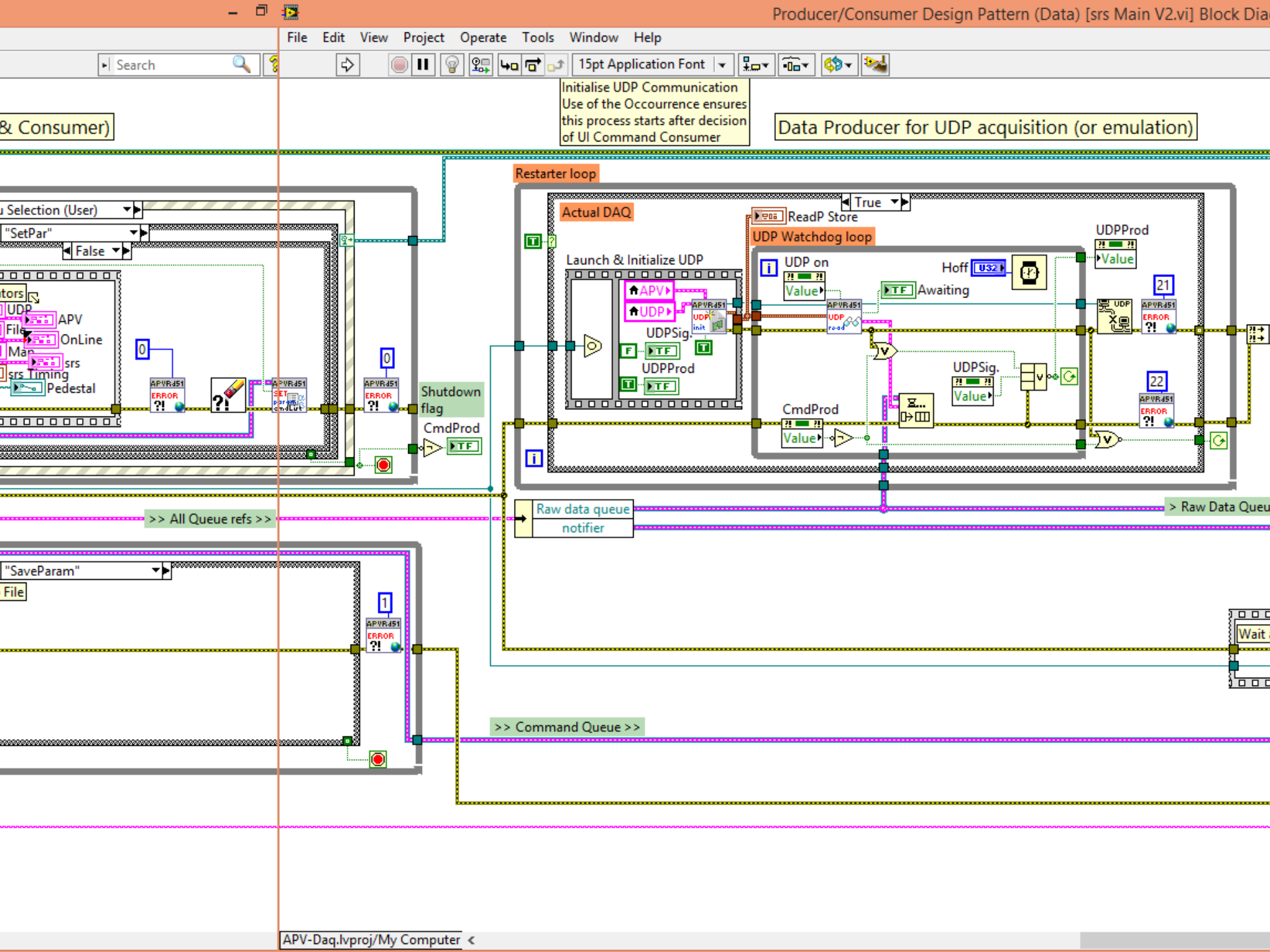
Producer/Consumer Design Pattern (Data) [srs Main V2.vi] Block Dia
File Edit View Project Operate Tools Window Help
Search
15pt Application Font
Initialise UDP Communication
Use of the Occourrence ensures
this process starts after decision
of UI Command Consumer
& Consumer)
Data Producer for UDP acquisition (or emulation)
Restarter loop
Actual DAQ
True
ReadP Store
UDP Watchdog loop
Launch & Initialize UDP
UDP on
Value
Hoff
U32
Awaiting
UDPProd
Value
21
22
APV
UDP
UDPSig.
UDPProd
CmdProd
Value
Shutdown
flag
CmdProd
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False
APV
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srs
Pedestal
>> All Queue refs >>
Raw data queue
notifier
> Raw Data Queu
"SaveParam"
File
>> Command Queue >>
Wait
APV-Daq.lvproj/My Computer

Than You

See you in the Lab this afternoon

For demonstrations