A Profile for Integrating Function Blocks into the Unified Modeling Language

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Specification and Validation of UML Models for Real Time Embedded Systems, SVERTS‘03

Overview

- Introduction and Motivation
  - Drilling Example
- Function block oriented languages
  - Matlab/Simulink
  - IEC 61131-3
  - IEC 61499
- Integration of function blocks into UML
  - Comparison of FBs and Classes
  - Profile “Functionblockadapters”
- Summary and Outlook

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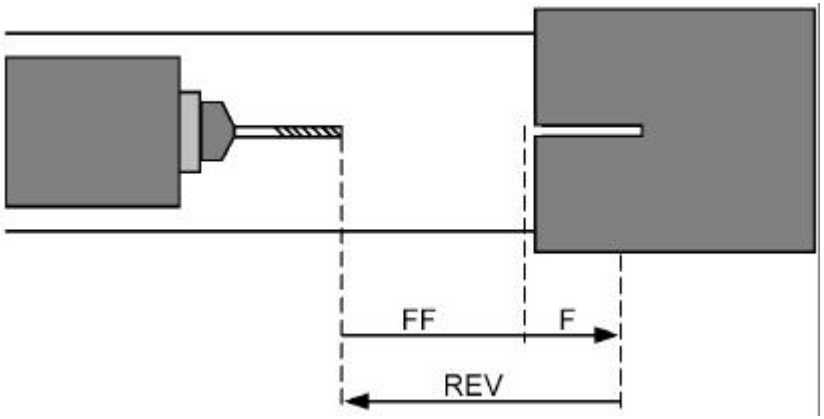
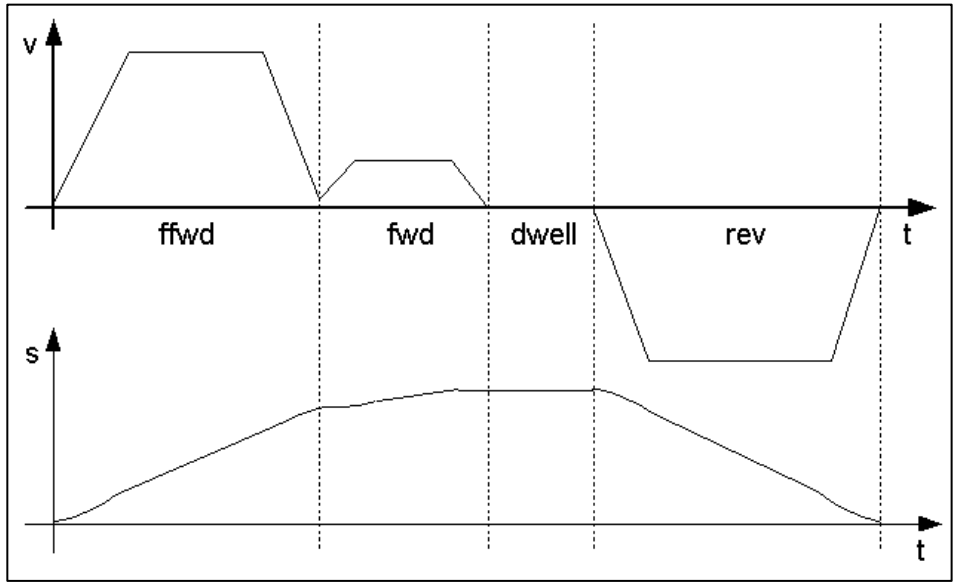
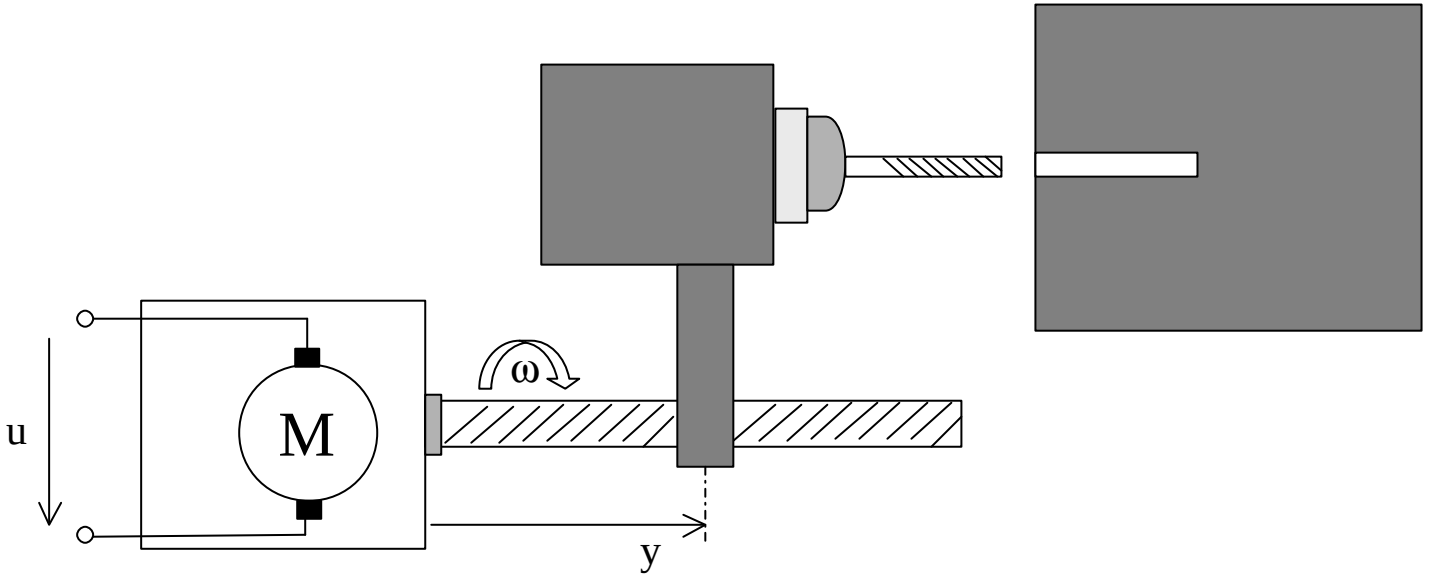
Drilling Example

- Four steps
  - Moving to drilling position
  - Drilling
  - Cleaning the hole
  - Moving back

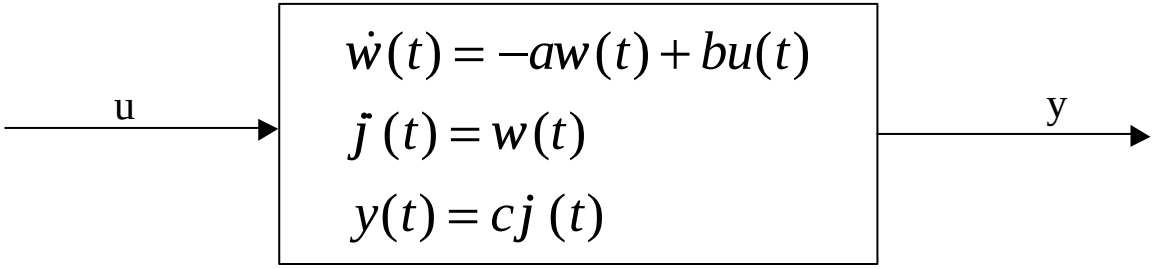




Mathematical Modeling of the Plant

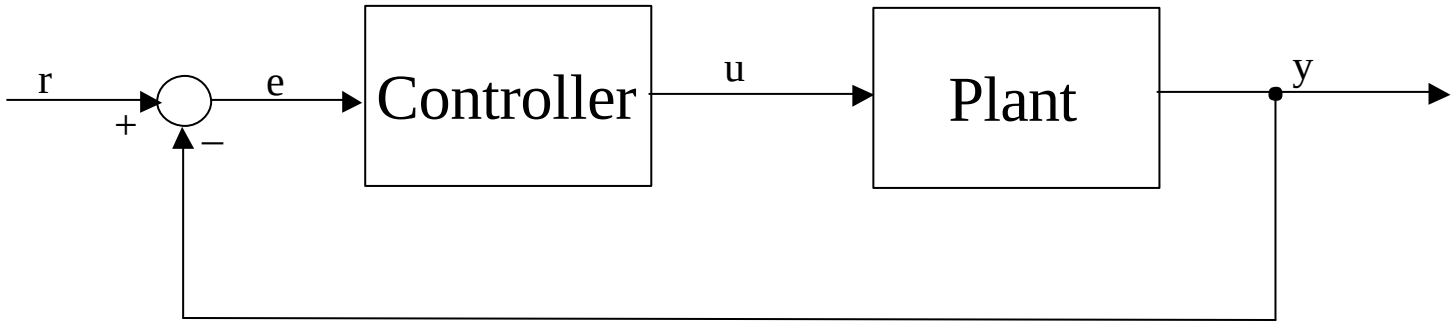


System Modeling



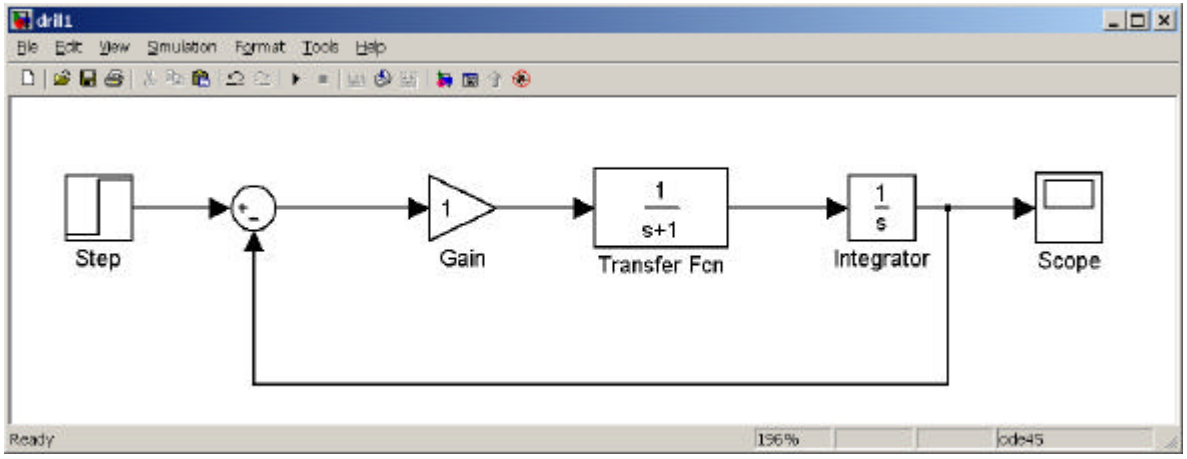
Control Loop Design

- Common structure of feedback control loops
- Controller is real-time software
  - implemented in microcontrollers, PLCs, ...
- Plant is real world, but for simulation and testing it is also software



Simulation of Continuous Time Controllers

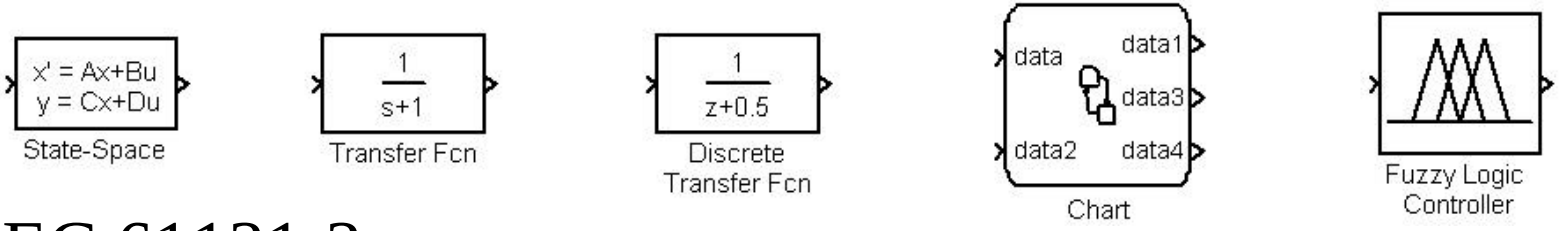
- For example using Matlab/Simulink™:



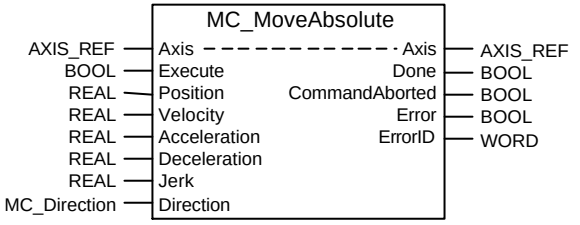
- Behavior of such blocks can also be described using
  - z-transfer functions,
  - statecharts,
  - ...

Function Block Oriented Languages

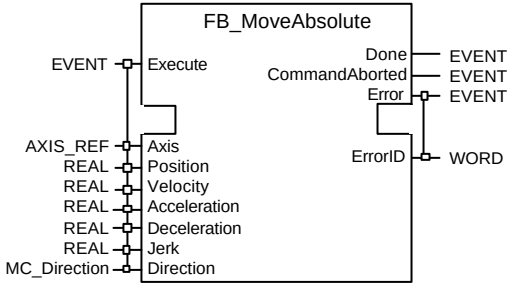
- Matlab/Simulink



- IEC 61131-3 (Languages for programmable controllers)
  - 5 languages

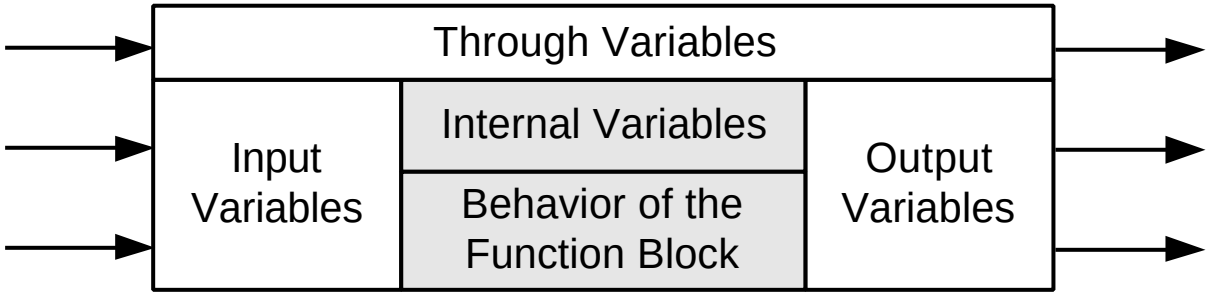


- IEC 61499 (Function Blocks for Industrial-Process Measurement and Control Systems)
  - Execution Control Chart (ECC)
  - action language from 61131-3



A General Function Block Model

- Our working model for the integration of existing FB-languages into UML
  - interface: input, output, through variables (all static)
  - internal: static data structures + behavior
  - type (class) and instance



Example for Protocols of Function Blocks

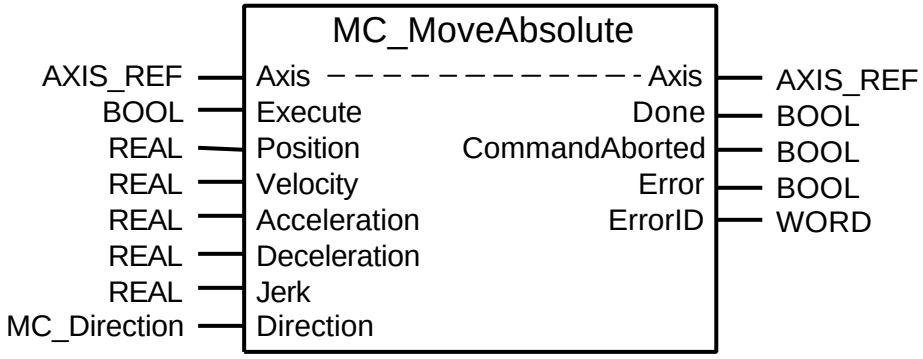
PLCopen

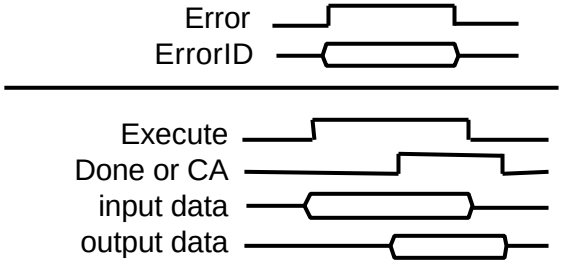
Standardization in Industrial Control Programming

Technical Specification
PLCopen - Technical Committee 2 – Task Force

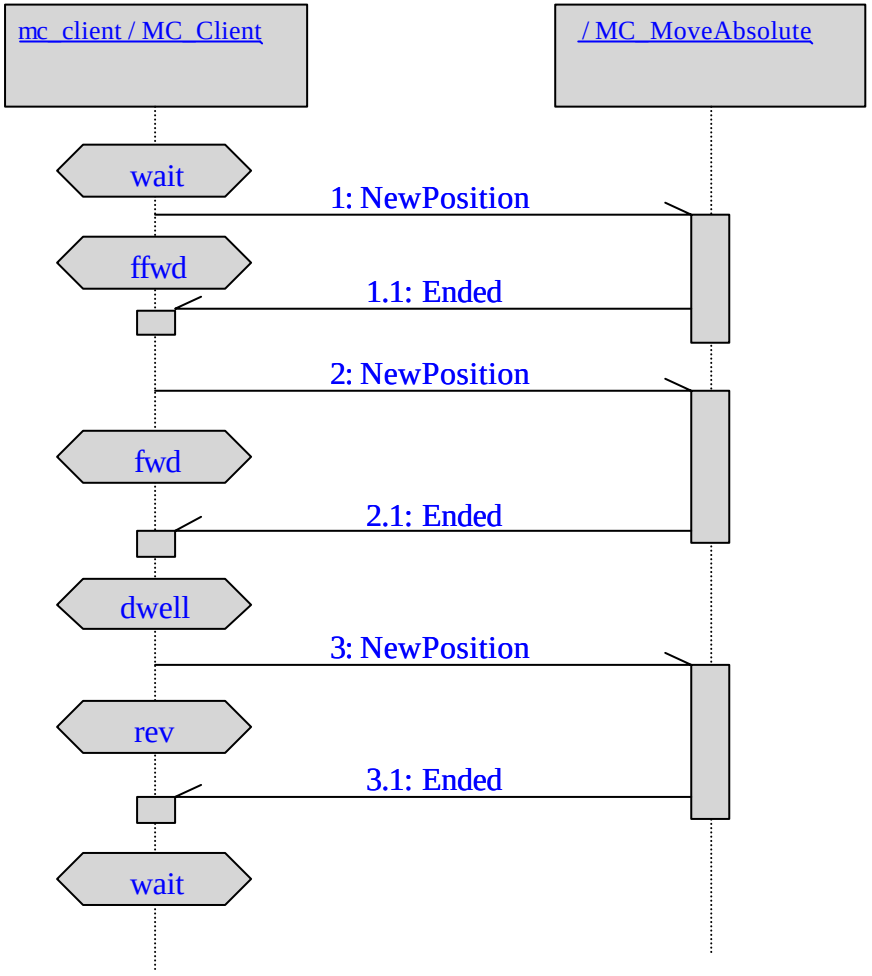
Function blocks for motion control

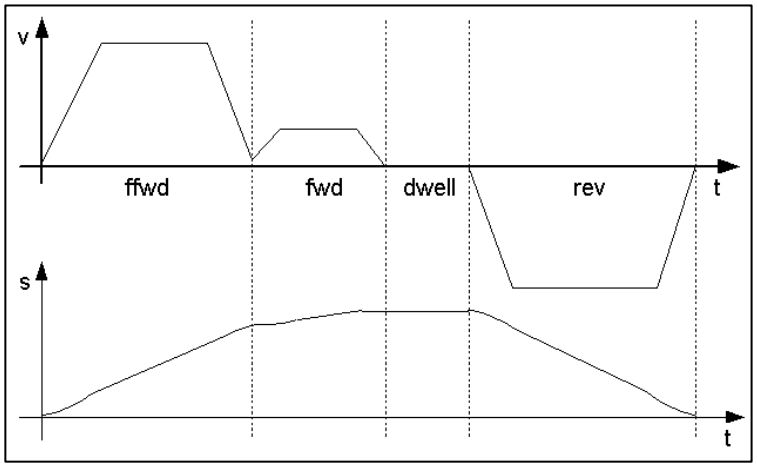
Version 1.0

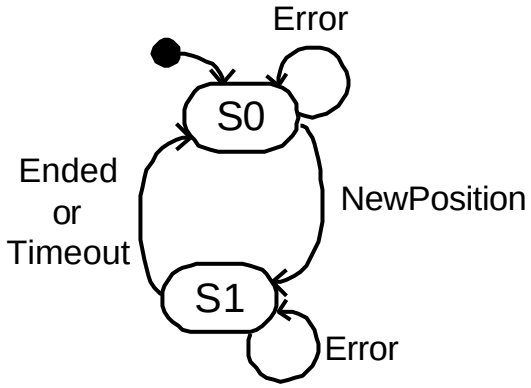




Example for UML Protocols

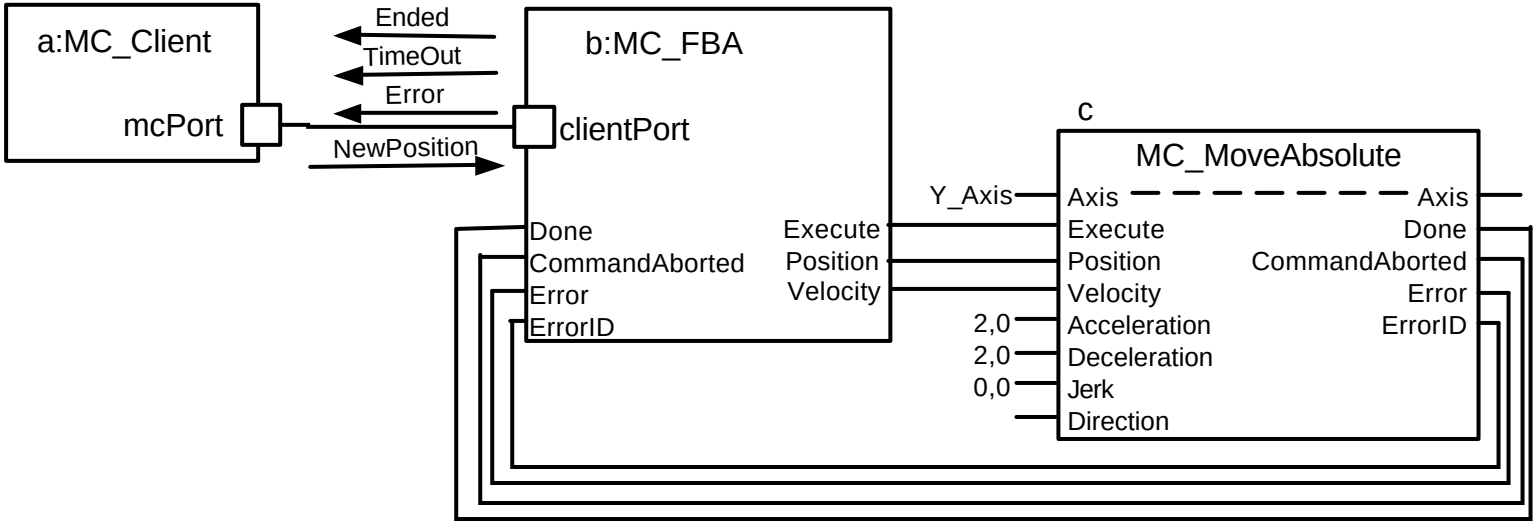






Function Block Adapters

- Work as programmable protocol adapters between UML protocols and function block protocols
- Platform independent
- Provided as a UML profile



Summary and Outlook

- High importance of function block oriented languages in industrial control modeling and programming
- Combination of UML and function blocks is promising
- Function block adapters provide a framework and design patterns for integrating UML and function blocks
- Previous work was based on IEC 61131-3
- Current work:
  - profile *Functionblockadapters*
  - extension to function block oriented languages
- Outlook: functionblocks.org

Comparison of Function Blocks and Classes

- Function Blocks
  - type
  - instance
  - internal variables
  - internal behavior

  - interface variables

- UML
  - class
  - instance
  - attributes
  - one operation/statechart
  - no direct match
    - this is discussed in the next slide

Discussion of Interface Variables

- Comparison to parameters
  - both have a direction kind (in, inout, out)
  - but: should be independent of behavior execution
- Comparison to attributes
  - both are independent of internal behavior execution
  - but: direction kind is missing
- Comparison to pins of activities
  - both are connectable and have a direction kind
  - but: should be independent of activity execution
- Comparison to ports
  - ports are mightier than interface variables 

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Using Ports as Interface to Function Blocks