Simulation for Automation &
Virtual Commissioning

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siemens.com/virtual-commissioning
“..digital twins are slowly entering mainstream use”

“The results — especially when compared with past surveys — show that digital twins are slowly entering mainstream use,” said Benoit Lheureux, research vice president at Gartner.

Gartner, Survey on Digital Twins, 2019

In context of digitalization the competitive advantage of OEMs will shift from „Competence in steel and iron to competence in software and data analysis.“ Digital twins – the virtual copy of the value chain on three level product, production and performance – will become more and more important or even a must-have in numerous areas of OEM industry.

IG Metall, Digital Transformation in OEM industry, 2018

„13% of organizations implementing IoT projects already use digital twins, while 62% are either in the process of establishing digital twin use or plan to do so…“

Gartner, Survey on Digital Twins, 2019
Simulation & virtual commissioning
Different challenges through the lifecycle

Machine level

Virtual commissioning for production machines
- Requirements
- Preliminary design
- Detailed design
- Commissioning
- Operation
- Retrofit

Virtual commissioning for production lines
- PLCSIM Adv. – Simcenter Amesim
- PLCSIM Adv. – Process Simulate
- PLCSIM Adv. – Plant Simulation

Line level

Virtual commissioning for material handling and Warehousing

Increase in operation performance of machines

Requirements
Preliminary design
Detailed design
Commissioning
Operation
Retrofit

PLCSIM Adv. – SIMIT – NX MCD
PLCSIM Adv. – Process Simulate
PLCSIM Adv. – Plant Simulation
Simulation & virtual commissioning leads to faster time-to-market, reduced error costs and risks

<table>
<thead>
<tr>
<th>Pain point of machine &amp; line builder</th>
<th>Advantages of simulation &amp; virtual commissioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed</td>
<td>• Reduced time-to-market thanks to parallelization of mechanical and automation engineering</td>
</tr>
<tr>
<td>Cost</td>
<td>• Test earlier and avoid mistakes during engineering phases</td>
</tr>
<tr>
<td>Risk</td>
<td>• Secure design, reduce risk and time from the concept to real commissioning</td>
</tr>
<tr>
<td>Flexibility</td>
<td>• Validate changes on the production machine or line during operation</td>
</tr>
</tbody>
</table>

Increasing complexity leads to longer time from the product idea to the industrial production.

Damages to the machine during commissioning are expensive, as well as improving the design after prototyping (time- and moneywise).

Starting a new production machine or line includes uncertainties concerning the schedule and the performances.

Access to real machine for retrofit and optimization is limited as machine downtimes have to be avoided.

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The virtual environment is dependent upon the respective issue under investigation

- Logic of PLC and HMI control components
- Interaction between mechanical and automation system
- Interaction of multiple components in a cell, plant or line
The Siemens portfolio offers solution scenarios for virtual commissioning for all analysis stages.
The Siemens portfolio covers application scenarios for virtual commissioning for all analysis stages

- Validation of control logic, as well as visualization
  - Approx. 95% of all TIA Portal programmers

- Validation of automation logic and component behavior of a machine
  - Basic solution for S7-1500 applications (Software-in-the-loop)
  - Advanced solution for broad market (Hardware-in-the-loop & software-in-the-loop)

Workflow level

- VC for controllers and HMI
- VC for machine builders
- VC for production cells, line or factory

Validation of interaction between various components within a line, plant or cell
- Line builder, end user, SI

Complexity and planning reliability

Digitization readiness
The virtual machine model is a combination of different simulation models

Virtual machine model

Automation model

Logic of the PLC program and visualization

Electrical model and behavior pattern

Active components (e.g. drives, valves) and behavior of peripherals

Physical and kinematic model

Mechanical components

Siemens offers

- Scalable VC solutions depending on the customers targets and skills
- One integrated software landscape
- Implemented interfaces to PLCSIM Advanced for simulation software for physical/kinematic model (in NX Mechatronics Concept Designer) and behavior model (in SIMIT)
- Pre-Sales and consulting support
PLCSIM vs PLCSIM Advanced
Functional Differences

PLCSIM

Controller simulation integrated in STEP 7 with TIA Portal

Application use case:
• Function test and validation of the STEP 7 program

<table>
<thead>
<tr>
<th>Feature</th>
<th>PLCSIM</th>
<th>PLCSIM Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td>S7-1200 (F)/ S7-1500 (F/T)</td>
<td>✔ / ✔</td>
<td>✔ / ✔</td>
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<tr>
<td>API</td>
<td>❌</td>
<td>✔</td>
</tr>
<tr>
<td>up to 2</td>
<td>❌</td>
<td>✔</td>
</tr>
<tr>
<td>Multiple instances</td>
<td>❌</td>
<td>✔</td>
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<tr>
<td>up to 16</td>
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<td></td>
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<tr>
<td>Distributed instances</td>
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<td>✔</td>
</tr>
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<td>OPC UA</td>
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<td>✔</td>
</tr>
<tr>
<td>Web server</td>
<td>❌</td>
<td>✔</td>
</tr>
<tr>
<td>Process diagnostics</td>
<td>❌</td>
<td>✔</td>
</tr>
<tr>
<td>Traces</td>
<td>(✔)</td>
<td>✔</td>
</tr>
<tr>
<td>Motion</td>
<td>(✔)</td>
<td>✔</td>
</tr>
<tr>
<td>S7 communication</td>
<td>❌</td>
<td>✔</td>
</tr>
<tr>
<td>Open User communication</td>
<td>❌</td>
<td>✔</td>
</tr>
<tr>
<td>via softbus know how protected blocks</td>
<td>(✔)</td>
<td>✔</td>
</tr>
<tr>
<td>Virtual time</td>
<td>❌</td>
<td>✔</td>
</tr>
<tr>
<td>Connection of real PLCs/HMIs</td>
<td>❌</td>
<td>✔</td>
</tr>
<tr>
<td>DNS use</td>
<td>❌</td>
<td>✔</td>
</tr>
<tr>
<td>Virtual memory card</td>
<td>❌</td>
<td>✔</td>
</tr>
</tbody>
</table>

PLCSIM Advanced

Virtual S7-1500 Controller

Application case:
• Function test of the STEP 7 program - also in the context of a plant / machine
• Operator training
• Virtual Commissioning / Factory Acceptance Test (FAT)
Simulation at every level

Production line

Robotic cell

Production machine

Component physics

Component communication

Automation

Tecnomatix
Plant Simulation

Tecnomatix
Process Simulate

NX Mechatronic
Concept Designer

Simcenter Amesim

SIMIT

PLCSIM Advanced
and WinCC
Automation validation and basic virtual commissioning

- Production line
- Robotic cell
- Production machine
- Component physics
- Component communication
- Automation

Tools:
- Tecnomatix Plant Simulation
- Tecnomatix Process Simulate
- NX Mechatronic Concept Designer
- Simcenter Amesim
- SIMIT
- PLCSIM Advanced and WinCC
Automation validation and simple virtual commissioning

Validate the automation program

How can I validate my automation program?
What is the time response of the system?
Did I configure my communication right?
How does my automation code react in case of failure?
Is my safety working?

Replacement of hardware test setup
With SIMATIC S7- PLCSIM Advanced & WinCC
- using comprehensive simulation of controller functionality
- testing via TIA Portal tools. e.g. watchtables, simulated HMI / HMI runtime etc.

Automatic program code validation
With SIMATIC S7- PLCSIM Advanced, WinCC & test application
- using data exchange over API for automatic testing of function blocks
- testing via customer specific test application
- General test application „S7UnitTest“ for basic automated tests is provided via SIOS: https://support.industry.siemens.com/cs/ww/de/view/109746405

Simulation of electrical components
With SIMIT
- testing logical response of electrical components
- using predefined catalogs including drive communication
Virtual commissioning for production machines

Production line
- Tecnomatix Plant Simulation

Robotic cell
- Tecnomatix Process Simulate

Production machine
- NX Mechatronic Concept Designer

Component physics
- Simcenter Amesim

Component communication
- SIMIT

Automation
- PLCSIM Advanced and WinCC
Virtual commissioning for production machines

Validate Machine Design and Kinematic – Optimize Engineering

How should my cam profile look?

How does the machine work? What is the sequence of operations?

Is there a risk of collisions?

Where should I place a sensor?

What should I change the mechanical design of the machine?

Simulation of production machines

With NX Mechatronic Concept Designer

- Define and validate the mechatronic concept of the machine directly with the CAD model in the early phases of development
- Enable collaboration by sharing data between mechanical, electrical and automation departments
- Define mechatronic model including kinematic, sensors, actuators, logic and signals
- Reuse standardized mechatronic components for a faster machine design
- Optimize machine design before the first prototype (sequence, traveling path, speed of motors, position of sensors…)
- Connect directly with PLC Hardware or PLC Simulation (PLCSIM Adv.)
Increase In Operation Performance for Production Machines and Machine Tools

- Production line
  - Tecnomatix Plant Simulation

- Robotic cell
  - Tecnomatix Process Simulate

- Production machine
  - NX Mechatronic Concept Designer

- Component physics
  - Simcenter Amesim

- Component communication
  - SIMIT

- Automation
  - PLCSIM Advanced and WinCC
Increase In Operation Performance for Production Machines and Machine Tools - **Optimize** the machine, cell or plant

- Is the electric motor powerful enough?
- What is the time response of the system?
- What maximum pressure can be reached?
- Is there any risk of vibration?
- How can I optimize the control parameters of my automation?

**Simulation of components and machine physics**

With Simcenter Amesim
- Optimization before machine building and during operation
- Size actuators according to performance and consumption targets
- Connect directly with PLC Hardware or PLC Simulation (PLCSIM Adv.)
- In operation simulation for additional information on the current state of the machine and additional safety loops (virtual sensors)
- In operation optimization using the simulation of future machine states
- Validate performances during retrofit phases
Virtual commissioning for production lines

**Production line**
- Tecnomatix Plant Simulation

**Robotic cell**
- Tecnomatix Process Simulate

**Production machine**
- NX Mechatronic Concept Designer

**Component physics**
- Simcenter Amesim

**Component communication**
- SIMIT

**Automation**
- PLCSIM Advanced and WinCC
Virtual commissioning for production lines
Validate Robotic - Optimize Engineering

Is the layout of my production cell valid?
Can my robot tool reach all the right positions without collisions?
What is the cycle time of my production cell?
What if a component is failing or a robot stopping?
How can I validate my robot code with my automation including safety?

Simulation of robotic cells
With Tecnomatix Process Simulate
- Design production cell layout and validate mechanical sequences
- Create robot trajectories, check collisions and reachability
- Develop and validate complete robot programs using robot controllers
- Verify PLC code together with robot programs and HMI
- Test Safety Interlocks
- Perform System Diagnostic testing
- Validate prior to cell construction
Increase In Operation Performance for Production Lines

Production line

Robotic cell

Production machine

Component physics

Component communication

Automation

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Plant Simulation

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SIMIT

PLCSIM Advanced
and WinCC

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Increase In Operation Performance for Production Lines - Optimize Material Flow and Line Performances

What are the best control parameters & strategies?
What is the throughput time of my production line?
How much stock do I need and my buffer size?
How to optimize the work in progress?
How can I plan the maintenance of different parts of my plant?

Simulation of production lines

With Tecnomatix Plant Simulation
- Validation prior to conveying or AGVs system construction
- Validate material flow and control logic
- Optimize PLC parameters, control strategy and HMI
- Verify conveying unit and head unit level
- Perform system diagnostic testing
- Perform “what-if” scenarios (Failure Modes or Maintenance Modes)
- Operator training
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