Testing Solutions for Siemens PLC programs based on PLCSIM Advanced

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PLC program testing

Traditional PLC program testing

Traditional PLC program testing is often difficult, because:

. **physical hardware** is needed for the test execution,
. it requires **manual effort** to feed inputs and evaluate outputs,
. it is **imprecise** due to the lack of of proper **synchronisation**.

Testing through simulators

Testing through a simulator offers several benefits:

. tests may be run on a **virtual PLC**: no need for physical hardware,
. **may be automated** through an API,
. precise **time**- and **cycle**-based **synchronisation** options.

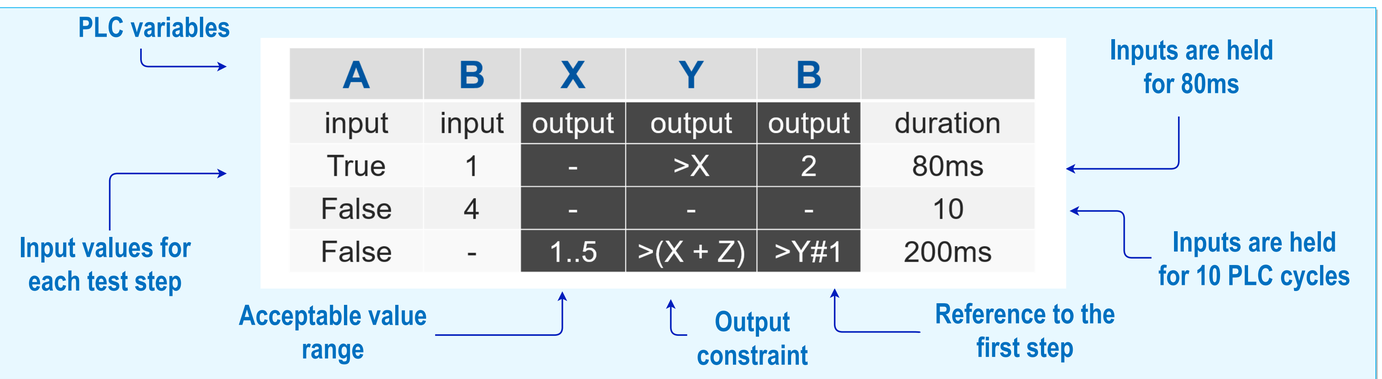
For Siemens PLCs: PLCSIM Advanced

Testing workflow built on PLCSIM Advanced

Test definition

We use an **intuitive**, but **powerful** test **table** format with support for

- access by **tag names** and **memory locations**,
- complex **expressions**,
- **cycle-based** and **time-based** duration requirements,
- **references** between test steps.



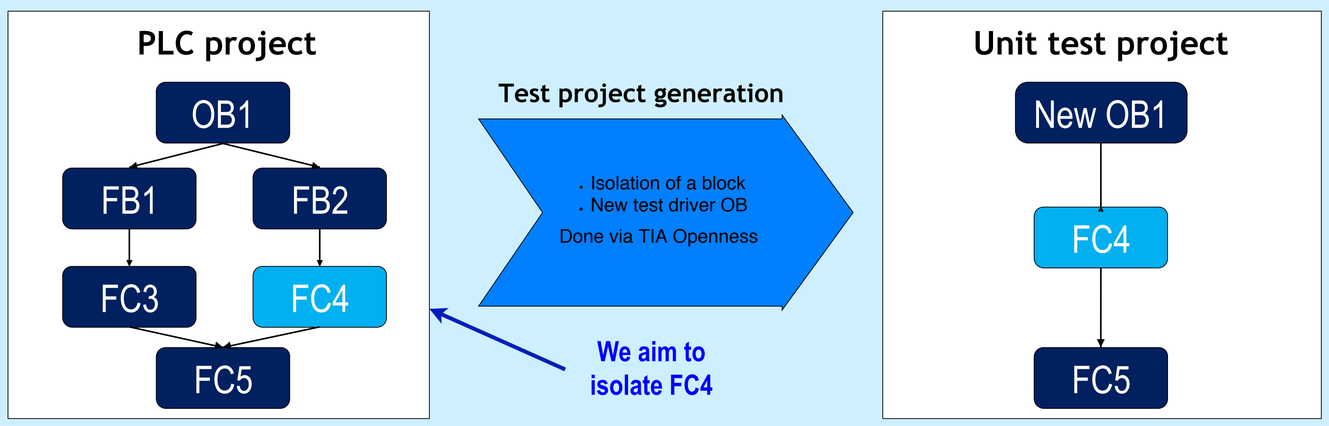
A	B	X	Y	B	
input	input	output	output	output	duration
True	1	-	>X	2	80ms
False	4	-	-	-	10
False	-	1..5	>(X + Z)	>Y#1	200ms

Test project generation

Certain levels and types of testing (unit, integration, etc.) cannot be carried out on a PLC project without some modifications.

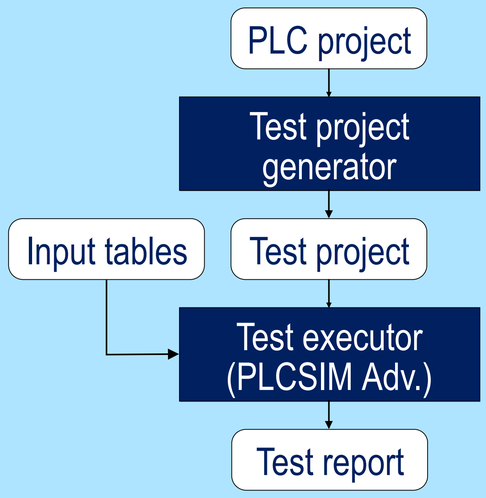
- They **require isolation**, which may mean **intrusive modifications of the** PLC **program**.
- They need a **test driver,** that must be inferred from the list of program blocks.

Our solution: **automated** generation of a **new project** for unit testing



Test execution

- The generated test project is executed on a virtual PLC.
- PLCSIM Advanced supports multiple execution modes, such as continuous, cycle-by-cycle, and time-synchonised.
- Creation of a simulator instance, PLC program download and execution are all automated through the PLCSIM C# API and
- TIA Portal Openness.
- The captured outputs are evaluated against the constraints in the test definition.



Continuous integration

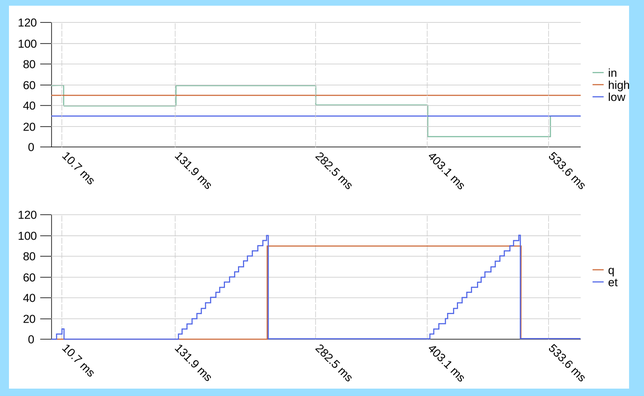
Through a **command line** interface, the test workflow can be executed in a CI pipeline (such as Jenkins or Gitlab CI).

- **Automated execution** on each commit.
- **Checks** before merge.
- Execution on a **remote machine** – no need to install the simulator on every developer workstation.

Test report and visualisation

- The tool produces test **reports is various formats**, such as plaintext, HTML, timing diagrams, waveform diagrams.
- The behaviour of the system can be **recorded** in **every cycle**, enabling the display of detailed **timing diagrams** for each test case execution.

Mode	Command	Interlock	Test Duration	ManReg01	POnOff.ParReg	AuOnR	AuOffR	TStopI	OutOnOV	OutOffOV	MMoSt	AuMoSt
Auto (Default)			1	0	0	True	False	False	-	False	False	True
			500ms	0	0	True	False	False	True	False	False	True
		TS	1	0	0	True	False	True	-	-	False	True
		TS	500ms	0	0	True	False	True	False	False	False	True
			500ms	0	0	True	False	False	True	False	False	True
Manual			1	2	0	True	False	False	-	False	True	False
	Off		500ms	32	0	True	False	False	-	False	True	False
			2000ms	0	0	True	False	False	False	False	True	False
	On		500ms	16	0	True	False	False	-	False	True	False
			2000ms	0	0	True	False	False	True	False	True	False
	Off		500ms	32	0	True	False	False	-	False	True	False
			2000ms	0	0	True	False	False	False	False	True	False
Auto			1	1	0	True	False	False	-	False	False	True
			500ms	0	0	True	False	False	True	False	False	True
			500ms	0	0	False	False	False	True	False	False	True
			500ms	0	0	False	True	False	False	False	False	True
			500ms	0	0	False	False	False	False	False	False	True
			500ms	0	0	True	False	False	True	False	False	True



Use cases

Our testing workflow has demonstrated its usability in acceptance, integration and unit testing scenarios.

- Proof-of-concept CI testing workflow for the baseline objects included in the UNICOS framework.
- Automatically reproducing counterexamples obtained from our formal verification workflow (PLCverif) for the CERN SPS accelerator personnel protection system.