# D-NA5.1 Holistic Test Specification – Handout

## Terminology

- **Holistic testing** *is the process and methodology for the evaluation of a concrete function, system or component (object under investigation) within its relevant operational context (system under test), corresponding to the purpose of investigation*

- **Test objective:** The purpose for carrying out the test. These can be divided into three categories:
  - Characterization test: a measure is given without specific requirements for passing the test. *Examples*: characterizing performance of a system; developing a simulation model.
  - Validation test: functional requirements and abstract measures are provided, but are subject to interpretation; qualitative test criteria. *Example*: is a controller ready for deployment?
  - Verification test: Tests where requirements are formulated as quantitative measures and thresholds of acceptable values are quantified. *Example*: Testing if a component conforms to a standard.
- *Remark:* Test objectives can be characterized by the *context provided by development process in* of a given Test object (e.g. development vs. certification)
- A **test case** provides a *set of conditions* under which a test can determine whether or how well a system, component or one of its aspects is working given its expected function.
- A **test specification** defines the test system (i.e. how the object under investigation is to be embedded in a *specific system under test*), which parameters of the system will be varied and observed for the evaluation of the test objective, and in what manner the test is to be carried out (test design).
- The **experiment specification** defines by what exact means a given test specification is to be realized in a given laboratory infrastructure.

- **Use case:** Specification of a set of actions performed by a system, which yields an observable result that is, typically, of value for one or more actors or other stakeholders of the system.

- **Component:** constituent part of a system which cannot be divided into smaller parts without losing its particular function for the purpose of investigation.
  - Remark: In a system configuration, components cannot further be divided; connections are established between components.
- **System (generic):** Set of interrelated elements considered in a defined context as a whole and separated from their environment.
  - Remark: In a system configuration, a system represents a grouping of components, which may be divided into sub-systems; interfaces between systems are called connections.
- **Domain:** An area of knowledge or activity in the context of smart grids characterized by a set of concepts and terminology understood by practitioners in that area.
  - Remark: In a system configuration, domains represent a categorization of the connections between systems; a domain can be divided into sub-domains; domains interface with other domains via components.
- **System(s) configuration:** an assembly of (sub-)systems, components, connections, domains, and attributes relevant to a particular test case.

# Step-by-Step Guideline for Holistic Test Case Template

The definition of a holistic test case entails the following steps:

**1. Motivation and context of Test case: Set scope and goal:**

a. Formulate the narrative in one sentence or paragraph:
   i. Test case or test objective?
   ii. To what use case does it apply? in context of what system configuration?
   iii. Define a unique test case identifier (if relevant)
b. Identify related Generic System Configuration (GSC) and Use Cases (UC).
c. Revisit the test objective to ensure it is stated in relation to the GSC and UC elements.

**2. Identify Holistic test components:**

a. Identify the System under Test (SuT) within the Generic System configuration
   i. If not explicitly identified here, any component of the SuT may become OuI in the following specification steps
   ii. The domains identified in the SuT are all possible Domains under Investigation, unless the DuIs are identified further here.

b. List the functions:
   i. FuT: functions required to be operational in the SuT
   ii. FuI: functions for which test criteria have to be defined.

c. Purpose of Investigation (PoI):
   i. Reformulate test objective into a numbered list (PoIs) so that at least one objective is specified per expected test.
   ii. Ensure that each PoI is formulated wrt. A specific OuI and/or FuI
   iii. Ensure that each PoI is qualified as either characterization, validation or verification.
   iv. Reflect on the relationship between PoI and SuT: are all aspects reflected in the system configuration?

**3. Specify *Test criteria* for each PoI (reference PoI list items)**

a. Formulate the *target metric* as a quantity to be derived from SuT and DuI related variable types.

b. Identify *variability attributes* qualitatively as ranges of relevant test parameters in terms of acceptable uncertainty and required variability (also) for non-OuI components of the SuT.

c. Define the quality attributes, for assessing an acceptable test result. In case of a *characterization* PoI, here the remaining model uncertainty is stated; for *verification* PoI, the acceptance threshold (worst case for passing the test) is stated; for *validation* PoI another criterion for ending the test execution can be chosen.

# Test Case

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| **Name of the test case** | | *Name* |
| *Narrative*<br>“a storyline summarizing motivation, scope and purpose of the test case.” | | *What is the subject of the test and why is the purpose of the test?* |
| **System under Test** (*SuT*):<br>“a (specific) system configuration that includes all relevant properties, interactions and behaviours (closed loop I/O and electrical coupling), that are required for evaluating an OuI as specified by the test criteria. “<br>A list of systems, subsystems, components included in the test case or test setup. | | *What is the test system & the test system boundary? What is the system context and which interactions between your object under investigation and the surrounding system are relevant? What are the “external” interactions across the system boundary?*<br>*If possible, provide an illustration and utilize a formal (referential) system specification?* |
| | **Object under Investigation (*OuI*)**<br>"the component(s) (1..n) that are to be characterized or validated” | *Which is the actual subject of this test case? Identify the sub-system(s) or component(s) that is/are in focus for this test. It may be listed above or a part of the systems listed above.* |
| | **Domain under Investigation (*DuI*):**<br>“Identifies the relevant domains or sub-domains of test parameters and connectivity.” | *Which interactions are part of the test case? Which domains of expertise needs to be included/emulated in a potential test setup? In a multi-domain system, not all interactions need to be reflected in a test; identify the domains and/or sub-domains that are relevant for this test case.* |
| | | |
| **Functions under Test** (*FuT*)<br>“the functions relevant to the operation of the system under test, as referenced by use cases” | | *Which use cases apply to this test case or which system functions are required for an operational FuI to be investigated? List all functions required to be operational in the final test setup.* |
| | **Function(s) under Investigation (*FuI*)**<br>“the referenced specification of a function realized (operationalized) by the object under investigation” | *The function or sub-function that is operational in the OuI and subject to testing.* |
| **Purpose of Investigation** *(PoI)*<br>“a formulation of the relevant interpretations of the test purpose (e.g. in terms of Characterization, Verification, or Validation)” | | *What information will be gained by a successfully carried out test? What is the objective of this evaluation? Use keywords such as* Characterization, Verification, *or* Validation, *as well as reference to properties of the OuI or FuI.* |
| **Test criteria:** “the measures of satisfac- | | *(this field can used for explanation on how the* |

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| tion that a need to be evaluated for a given test to be considered successful." A formalization of the purpose of investigation wrt. SuT and FuT attributes. | | *PoI is broken down; or be left empty as the criteria are formalized in terms of the quantitative measures formulated below)* |
| | **target metrics** (criteria)<br>A numbered list of measures to qualify (quantify) each identified Purpose of Investigation | *Based on the PoI, formulate the central quantities which should be calculated and evaluated to determine the test outcome. What should be measured, and with what should it be compared?* |
| | **variability attributes** (test factors):<br>identification of the sets of attributes<br>(controllable or uncontrollable parameters)<br>and qualification of the required variability;<br>includes reference to purpose of investigation. | *Which system (input, state) parameters should we varied in order to disturb the OuI?*<br>*What values should these parameters assume?*<br>*What kind of faults should the system be subjected to?* |
| | **quality attributes** (thresholds): with<br>reference to purpose of investigation and/or<br>target metrics, the threshold level required<br>to pass a test or the certainty/precision level<br>(e.g. probabilistic measure) required for the<br>quality of a characterization | *How good should the target metrics be quantified in order to decide the test outcome? This field identifies the stopping criteria of a test in terms of constraints or thresholds of the target metrics (e.g. actual acceptable minimum or maximum values). In case of characterization tests, here also the required range and statistical quality of the test outcome can be specified.* |

# Test Specification

| **Title** | ***Test specification title*** |
|---|---|
| **Ref. Holistic test case** | *Reference to ID of test case* |
| **Test System** (also graphical) | *Graphical and textual description of the system under investigation and its components including interfaces between test setup and Object under investigation and type of those interfaces (e.g. electrical)* |
| **Target measures** | *Specification of the target metrics that will be derived from measured parameters in order to evaluate the test objectives. Which variables will be quantified by the test? (formula and explanation)* |
| **Input and output parameters** | *List of inputs for the system under test relevant to the object under investigation, inputs relevant to the object under investigation itself and outputs / measured parameters divided into:*<br>● *'Controllable input parameters'*<br>● *'Uncontrollable input parameters'*<br>● *'Measured parameters'* |
| **Test Design** | *The choice of mapping between required testing target and available test parameters, in terms of test sequence, decision criteria and controlled parameters. Textual or graphical description of the sequence of steps carried out during the test including parameter ranges and variation of input parameter.* |
| **Initial system state** | *Description of conditions that are prerequisites to actually run the test and initial choices of parameters.* |
| **Evolution of system state and test signals** | *Quantitative characterization of the temporal evolution of test events and evolution of the relevant test parameters, as adjustable by the input parameters (e.g. opening breakers after a certain amount of seconds); incl. variability attributes* |
| **Other parameters** | *Information of data that should be tracked apart from the input and output parameters and system state, test signals* |
| **Storage of data** | *In which format are the parameters stored?* |
| **Temporal resolution** | *Discrete or continuous simulation and (if applicable) resolution of the discrete time steps* |
| **Source of uncertainty** | *In order to evaluate the quality of the test, the possible sources of uncertainties are given in how they can be quantified.* |
| **Suspension criteria / Stopping criteria** | *Under which conditions are the test results not valid or the test is interrupted* |

# Experiment Specification

| **Title** | ***Experiment specification title*** |
|---|---|
| **Ref. Test Spec.** | *Reference to test specification document.* |
| **Research Infrastructure** | *Specify the RI where the experiment is carried out.* |
| **Experiment Realisation** | *The setup can be realised in different ways (e.g. simulation, hardware,…): give a brief description of the realization.* |
| **Experiment Setup** (concrete lab equipment) | *Graphical and textual description of the concrete lab equipment and interconnections* |
| **Experimental Design and Justification** | *For all parameters give a reason why it has been chosen that way*<br>● *concrete values, sequences of values of "variability attributes" and*<br>● *concrete combinations of different variability attributes*<br>● *number of repetitions for each combination* |
| **Precision of equipment** | *For the components of the lab equipment the precision is given such that the experiment's uncertainty can be derived.* |
| **Uncertainty measurement** | *Based on the precision of equipment of the lab instrument and of measurement algorithms, the parameters to model the measured quantities' errors are provided it is specified how experiment's uncertainty can actually be measured.* |

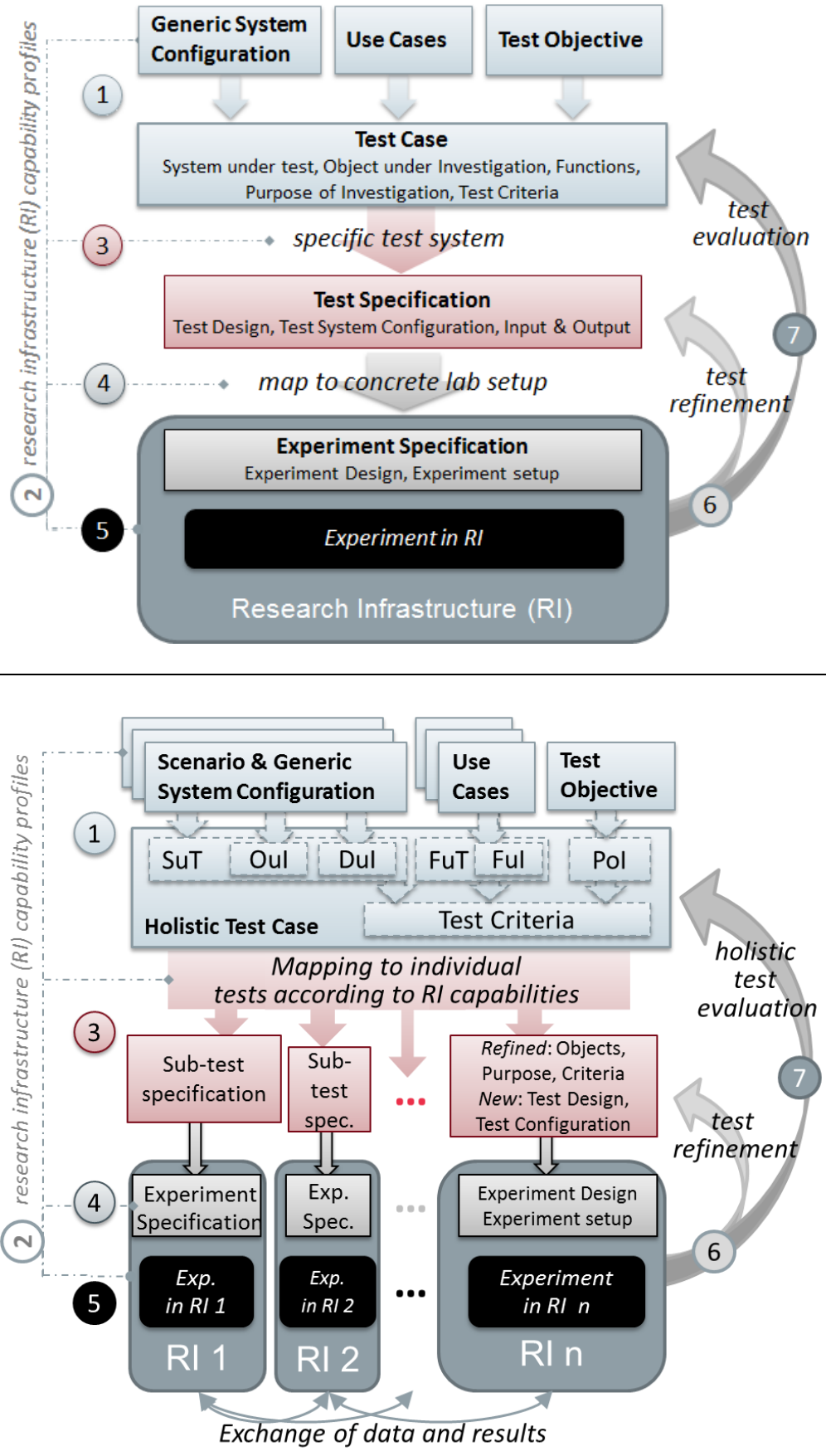


*Figure 1: Holistic testing procedure outline*

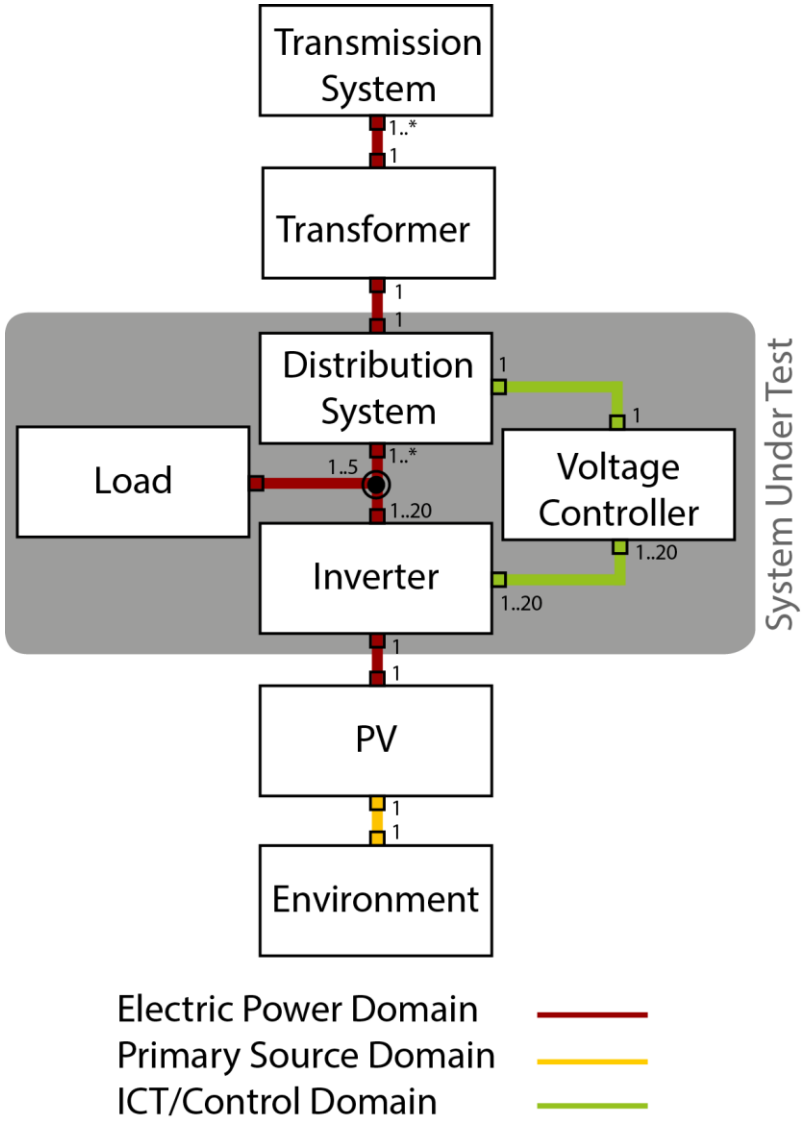


*Figure 2: Test Case - Generic System Configuration Diagram*

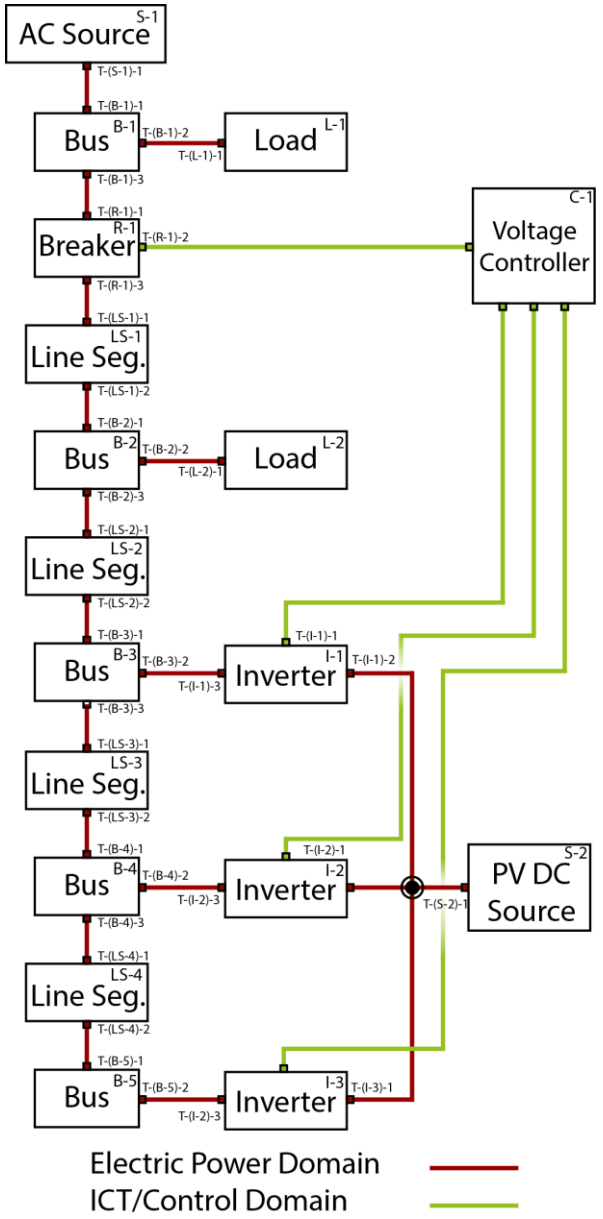


*Figure 3: Test System - Specific System Configuration Diagram*

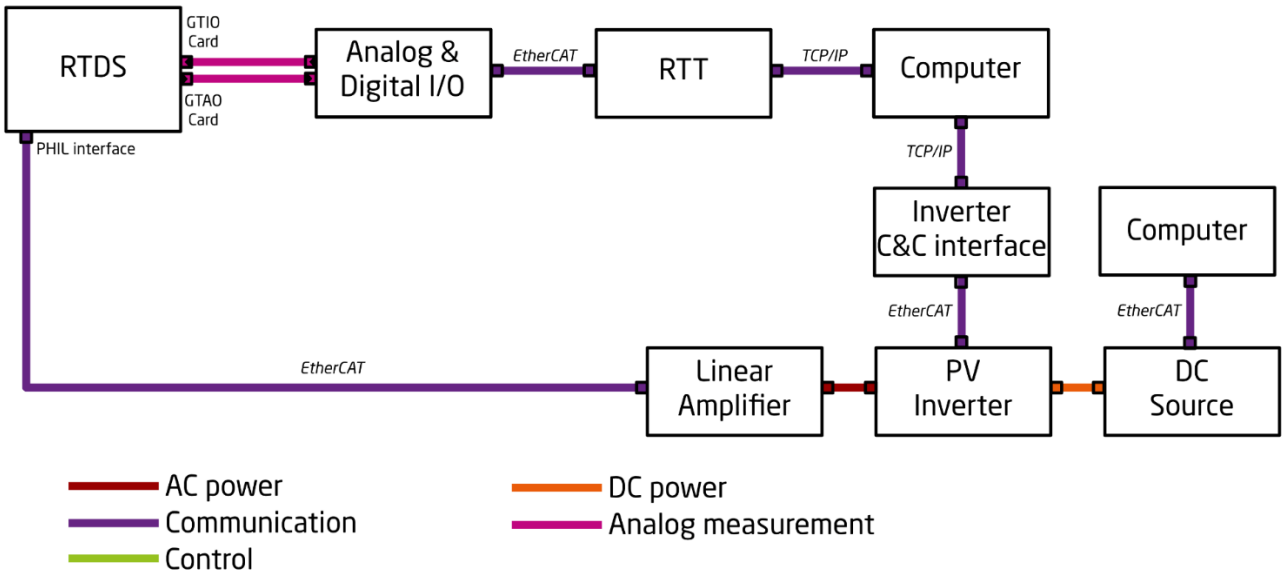


*Figure 4: Lab Setup - Specific System Configuration Diagram (L-SC)*