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Case study

Energy Meter Instrument



Capacity Building Workshop On Understanding Conformity
Requirements For Software Controlled Weight And Measuring
Instruments For Sustainable Trade 2022

APEC

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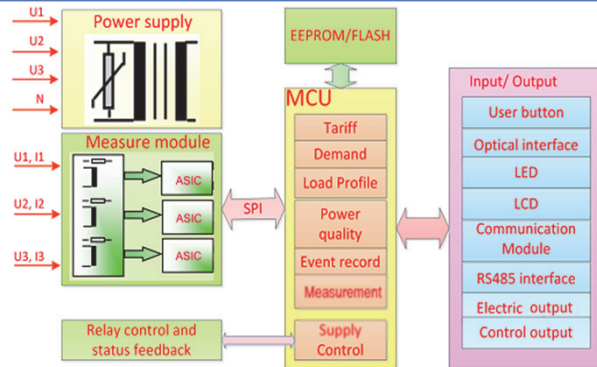
1. An overview of software-controlled energy meter

1.1 Typical construction of software-controlled energy meter

The meter is designed to measure electrical energy continuously by integrating power with respect to time and to store the result.



Photograph of the meter



Block diagram of the meter

1. An overview of software-controlled energy meter

1.2 Functions related to software

Almost all functions of the meter are inseparable from software. The software is responsible to manage and control the meter in normal operation.

- ✓ Measurement
 - ✓ Store and display
 - ✓ Control input and output
 - ✓ Control load relay by commands
 - ✓ etc.
- It manages all tasks of the meter.

Software and hardware are equally important for maintaining metrological characteristics of the meter. Software examination is required in type evaluation to validate it comply with the requirements of R46.



1. An overview of software-controlled energy meter

1.3 The content structure of R46

- Part 1: Metrological and Technical requirements
All requirements are for energy meter products, it is not divided into hardware or software requirements. Clause 3.6 Protection of metrological properties mainly involve requirements related to software.
- Part 2: Metrological controls and Performance test
The performance tests of the meter cover all the metrological properties of the meter. There is no additional metrological functions testing for software. Only validation procedures are given in clause 4.3.
- ◆ Mainly software-related contents are covered in:
 - Clause 3.6 Protection of metrological properties
 - Clause 4.1 Documentation
 - Clause 4.3 Validation procedures



1. An overview of software-controlled energy meter

1.4 Software validation methods: AD+VFTSw

- The software-related requirements focus on protection of metrological properties in R46.
 - AD: Analysis of the documentation and validation of the design.
 - VFTSw: Validation by functional testing of software functions.
- Examination level is level A (normal examination level). So all methods which need to use tools to analyze source code are not applied. such as:
 - DFA: Metrological dataflow analysis
 - CIWT: Code inspection and walk through
 - SMT: Software module testing
- The performance tests described in R46 cover all the metrological properties of the meter. There is no additional metrological functions testing for software.
 - VFTM: Verification by functional testing of the metrological functions

2. Software validation procedure and case study

2.1 Validation procedures for specified requirements

No	Requirement	Clause	Validation procedure
1	Software identification	OIML R46-1/-2:2012 3.6.2	AD + VFTSw
2	Software protection	OIML R46-1/-2:2012 3.6.3	AD + VFTSw
3	Parameter protection	OIML R46-1/-2:2012 3.6.4	AD + VFTSw
4	Separation of electronic devices and sub-assemblies	OIML R46-1/-2:2012 3.6.5	AD
5	Separation of software parts	OIML R46-1/-2:2012 3.6.6	AD
6	Storage of data, transmission via communication systems	OIML R46-1/-2:2012 3.6.7	AD + VFTSw
7	Maintenance and re-configuration	OIML R46-1/-2:2012 3.6.8	AD

2. Software validation procedure and case study

2.2 Software identification (AD+VFTSw)

- Requirements
- ✓ Specify software identification and means of identification
- ✓ Validate the presentation or display of the software identification
- ✓ Validate that the software identification is inextricably linked to the software exist, visible, linked

2. Software validation procedure and case study

2.2 Software identification (AD+VFTSw)

Cases study :

exist, visible, linked

Case 1: The software is identified with the software version. The software and hardware version only is imprinted on the PCB board.

Case 2: The software is identified with the software version. A post-build scripts inserts the version to the hex file of software. The software version is displayed on LCD or other remote device.

Case 3: The software identification contains version and signature. The software signature is computed after software build, using CRC32 algorithm. The software identification is displayed on LCD. In addition, it's possible to read it via remote or local communication.



2. Software validation procedure and case study

2.3 Software protection (AD+VFTSw)

Prevention misuse

The meter should be constructed that possibilities for unintentional, accidental misuse are minimal.

The examiner should:

✓ Validate that possibilities of misuse are minimal

The user accesses the software through the user interface

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2. Software validation procedure and case study

2.3 Software protection (AD+VFTSw)

- Fraud protection
 - ✓ Validate that legally relevant software is secured against modification, loading or changes
 - ✓ Validate that only clearly documented functions can be activated by the user interface which shall be realized in such a way that it does not facilitate fraudulent use.
 - ✓ Validate protection/sealing that makes unauthorized access impossible or evident

secured means

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2. Software validation procedure and case study

2.3 Software protection (AD+VFTSw)

- Cases study :
 - Case1: The software is constructed that there is no way to modify the parameters and legally relevant configuration but via a permission switch. This switch is mechanically sealed in the inactive position.

Physical protection using seal and switch

2. Software validation procedure and case study

2.3 Software protection (AD+VFTSw)

Cases study :

Case2: The software is constructed that there is no way to access the parameters and legally relevant configuration but by authorized persons. If a person wants to enter the parameter menu item he has to insert his smart card containing a PIN as part of a cryptographic certificate. The software of the meter is able to verify the authenticity of the PIN by the certificate and allows the parameter menu item to be entered. The access is recorded in an audit trail including the identity of the person (or at least of the smart card used).

Authorized mechanism protection

2. Software validation procedure and case study

2.4 Parameter protection (AD+VFTSw)

Legally relevant parameters:

Parameters that fix the legally relevant characteristics of the energy meter .

Type-specific parameters:

They are identical values for all specimens of a type and fixed at type approval.
 such as :meter model, meter type (electromechanical/static) , hardware and software version, accuracy class, nominal voltage, nominal frequency, etc.

Device-specific parameters:

Legally relevant parameter with a value that depends on the individual instrument.
 such as : The total energy, gain and phase compensation value for metering, tariff rate period schedule, RTC, etc.

2. Software validation procedure and case study

2.4 Parameter protection (AD+VFTSw)

The examiner should:

- ✓ Validate that legally relevant characteristics are secured against unauthorized modification.
- ✓ Validate the checking facility event record when modifying a (legally relevant) device-specific parameter .
- ✓ Validate that the meter stops registering energy when modifying a (legally relevant) device-specific parameter

Note :


- Zeroing or changing the register for total energy , Zeroing or changing the event record of a checking facility should be considered as modifications to (legally relevant) device-specific parameters.
- An event counter is not a technically acceptable solution.

2. Software validation procedure and case study

2.4 Parameter protection (AD+VFTSw)

Cases study

Case : The meter provides a hardware real time clock (RTC) and manages the calendar to switch the correct tariff rate, generate billing records, record important events, etc. Setting the RTC is possible via remote communication. It is protected by DLMS security mechanism and will generate a time modification event record. During Setting the RTC , the meter doesn't stop registering energy.

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2. Software validation procedure and case study

2.5 Separation of electronic devices and sub-assemblies (AD)

- The examiner should:
- Validate metrological critical parts of an electricity meter – whether software or hardware parts – shall not be inadmissibly influenced by other parts of the meter.

The performance tests in R46 cover all the metrological properties of the meter.

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2. Software validation procedure and case study

2.5 Separation of electronic devices and sub-assemblies (AD)

- Cases study :


Case: The meter is equipped with optical interface for reading out measurement values .The meter stores all the relevant quantities and keeps for a sufficient time span. In this system the communication interface is part of the non-legally relevant software. The protective interface prevents any inadmissible commands.

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2. Software validation procedure and case study

2.6 Separation of software (AD)

- The examiner should:
 - ✓ Validate legally relevant software
 - ✓ Validate the interface between legally relevant software and other software parts
 - ✓ Validate documented interface commands and statement of completeness

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2. Software validation procedure and case study

2.6 Separation of software (AD)

- Cases study:

case : Software separation is implemented in a single MCU. The two software parts are physically separated. They are stored in separate areas of internal Flash. they communicate with each other via the software interface. The software interface bases on shared RAM buffer in a single MCU. They are identified and protected with their own version and signature.

2. Software validation procedure and case study

2.7 Data store, transmit via communication systems (AD + VFTSw)

Apply to:

Before measurement values are used for legal purposes, they have to leave the meter and be stored or transmitted in an insecure environment.

Cases study:

Case 1: The meter with CPU card completes the metering and billing in real time on site.

Case 2: The meter measure and accumulate the energy value. The total current energy and monthly billing energy are stored in the meter. The information is transmit to AMI system. The AMI system is responsible for generating bills.



2. Software validation procedure and case study

2.7 Data store, transmit via communication systems (AD + VFTSw)

The examiner should:

- ✓ Validate storage of data is authenticity, integrity, security
- ✓ Validate sufficient memory storage for data
- ✓ Validate transmission delay and transmission interruption don't influence measurement data

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2. Software validation procedure and case study

2.8 Maintenance and re-configuration (AD)

- Verified update**
A person should be on the installation site of the electricity meter to check the effectiveness of the update.
- Traced update**
Traced update of software shall be automatic.
- Identify and validate the implementation for software updates**

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2. Software validation procedure and case study

2.8 Maintenance and re-configuration (AD)

- Cases study**
National authorities may prescribe that the software update mechanism is allowed or not in service.
In China, legally relevant software is not allowed update in service. it must be impossible to update legally relevant software without breaking the seal.

2. Software validation procedure and case study

2.9 summary

Limited by my own technical background and experience, all these cases have the same situation:


1. The energy meter mentioned in the case is described as a built-for-purpose device using an embedded system rather than a PC-based system.
2. These cases are described from the perspective of the type evaluation laboratory but not a software developer.

3. Program of pattern evaluation for energy meter in China

Before OIML R 46

In China Program of pattern evaluation JJF 1245 is used to conduct the work for energy meter type evaluation. Before the publication of OIML R46, Program of pattern evaluation were developed based on the national standards GB/T 17215 which were equivalent to adoption IEC relevant standards IEC 62052/62053.

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3. Program of pattern evaluation for energy meter in China

Before OIML R 46

Program of Pattern Evaluation	
JJF 1245.1-2010 general requirements GB/T 17215.211-2006/IEC 62052-11:2003	JJF 1245.6-2010 Functional and data security requirements GB/T 17215.301-2007
JJF 1245.2-2010 Electromechanical Meters for Active Energy GB/T 17215.311-2008/mod IEC 62053-11:2003	
JJF 1245.3-2010 Static Meters for Active Energy GB/T 17215.321-2008/IEC 62053-21:2003	
JJF 1245.4-2010 Electromechanical Meters for Reactive Energy GB/T 17215.322-2008/IEC 62053-22:2003	
JJF 1245.5-2010 Static Meters for Reactive Energy GB/T 17215.323-2008/IEC 62053-23:2003	
Metrological controls Metrological and technical requirements Performance test conditions and methods	Functional and data security requirements

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3. Program of pattern evaluation for energy meter in China

After OIML R 46

After the publication of OIML R46, Program of pattern evaluation were revised based on OIML R46 and national standards. The requirements of OIML R46 were adopted in program of pattern evaluation. And in JJF 1245.2-2019 Software requirements and applicable validation procedures are consistent with OIML R 46.

3. Program of pattern evaluation for energy meter in China

After OIML R 46

Program of Pattern Evaluation	
JJF 1245.1-2019 For active electrical energy meters JJF 1245.2-2019 Software requirement	JJF 1245.3-2019 For reactive electrical energy meters JJF 1245.4-2019 Special requirements and safety requirements JJF 1245.5-2019 Functional requirements
OIML R 46-1/-2	GB/T 17215.323-2008/IEC 62053-23:2003 GB/T 17215.324-2017/IEC 62053-24:2014 GB/T 17215.231/IEC 62052-31:2015

4. Summary of software validation

About analysis of the documentation

✓ Technical solutions are always developing, the examiner shouldn't reject any specified feasible solutions. In order to understand the solution, it's necessarily to talk with developer of the meter sometimes.

✓ Prepare a document check request form in advance and send it to the applicant. Let the developer do a pre-assessment based on the document check request form.

About validation procedure

The performance tests described in R46 cover all the metrological properties of the meter. There is no additional metrological functions testing for software. The examiner should focus on protection of metrological properties for the energy meter.



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Thank you