|  |  |  |
| --- | --- | --- |
| **Title:** | **Software Subsystem Design Description <MVM Subsystem>** | |
| **Distribution** | Development, Project Leader | |
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| **Review** | See Review Section | See Review Section |
| **Approved** |  |  |
| **Remarks** | | |

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# Context

This document is a representation of analysis, planning, implementation and designing for the VT5 MVMeasurement subsystem. One of its major goals is to support reuse of the described subsystem.

## Overview

This document describes the functional design specification for the MVMeasurement subsystem of VT5. The main functionality of the MVMeasurement is to calculate standard volume flow, Mass flow, and Energy flow for liquid, steam and gas. If the flow is out of alarm limits, it will also raise alarms.

## Use Case Diagram

The following Use Case diagram illustrates the major functionality requirements listed in the MVMeasurement Subsystem Requirements Specification [1].



Figure 1: Use Case Diagram for SVM Subsystem

## Subsystem Definitions

|  |  |
| --- | --- |
| Diagnostic Subsystem | Subsystem handles error conditions and warnings. Also provides General Alarm data for the DO subsystem and CO Subsystem. |
| HART Subsystem | Subsystem for interfacing to HART (Highway Addressable Remote Transducer) protocol communications. |
| HMI Subsystem | Subsystem providing Human Machine Interface for local user access via display and key input. |
| NV Subsystem | Subsystem responsible for read / write access and maintenance of non-volatile memories (in transmitter and sensor). |
| MVMeasurement Subsystem | Subsystem responsible for multi- Variable Measurement |
| SVMeasurement Subsystem | Subsystem responsible for Single- Variable Measurement |
| Mapper Subsystem | Subsystem for mapping the device variable to HART dynamic variable |
| ElectronicService Subsystem | Subsystem for providing RAM/ROM check, temperature/ push button check. |
| Coordinator Subsystem | Subsystem for coordinating tasks. |

## Acronyms and Abbreviations

|  |  |
| --- | --- |
| Term | Definition |
| MVM | MVMeasurement |
| N/A | Not Applicable |
| NV | Non-volatile |
| TBD | To Be Determined |
| DO | Digital Output |
| CO | Curent Output |
|  | The Upper range value of energy flow |
|  | The Upper range value of volume flow |
|  | The Upper range value of standard volume flow |
|  | The Upper range value of mass flow |
|  | The Upper range value of biogas volume flow |
|  | The Upper range value of biogas volume flow |

# Data Sheet

This chapter gives an overview about all important facts of the subsystem. It can be used by a developer who would like to reuse this subsystem.

|  |  |  |
| --- | --- | --- |
| *Category* | *Item* | *Description* |
| Development | Version / Status | Release |
| Known Bugs | Not known ―― None |
| Planned Improvements | None |
| HW-Platform | Type | M16C63 R5F363AM |
| Clock | Oscillation clocking 3,6864MHz  *CPU clocking 1,8432MHz* |
| SW-Development Environment | Compiler | IAR M16C 3.40 |
| Operating System | Segger embOS for M16C version 3.28g |
| Case / Code-Generation Tool | Entry Tool 1.1.3 |
| Required Resources | Operating System | OS\_EnterRegion  OS\_LeaveRegion |
| HW | None |
| RAM | 3kbytes |
| NVRAM (Plant) | 200bytes |
| ROM | 70kbytes |
| Execution Time | NA |
| Subsystems | 1. Coordinator Subsystem 2. MVM Subsystem 3. Electronic Service Subsystem 4. Diagnosis Subsystem 5. HMI Subystem |
| Data Objects | ACTION  CONST\_U8  DEV\_RNGFLT  DNY\_FLOAT  FLOAT  INT16  RANGEFLT  SIMPLE\_FLOAT  SIMPLE\_U16  SIMPLE\_U8  T\_DIAGNOSIS\_ALARM  TABENUM8  UOM\_PF |
| Safety | Safety Related. |
| Standards | Other | None |
| Requirements / Use Cases | Please refer to [*USE CASE*](#_Use_Case_Diagram) |
| Documentation | Public Interface Description | *Please refer to* [API for Other Subsystem](#_API_for_Other) |
| Test Specification | See [TP021] |

# Detailed Description

## Static Modelling



Figure 2: Class Diagram for MVM Subsystem

## Dynamic Modelling

This collaboration diagram represents the collaboration between MVM and other subsystem



Figure 3: Collaborate diagram for MVM Calculation

## Detailed Design

### Measure flow of liquid

#### Calculate Normal Volume flow of liquid

is the normal flow rate of the medium, which can be calculated based on , reference temperature, real temperature and expansion coefficient.



Where:

* = Operating temperature of the medium (℃).
* = Reference temperature at normal state (℃).
*  = Coefficient of volumetric expansion.
* = Actual volume flow rate of medium (m3/h).
* = Normal volume flow rate at normal state (m3/h).

#### Calculate Mass flow of liquid

The mass flow of liquid is calculated based on volume flow and density or normal flow and reference density. The calculation method depends on the selection of liquid correction.

#### Density Correction

In case of setting “liquid Mass Corr” as “Density Corr”, the formula calculated mass flow is,



Where:

* = Operating temperature of the medium (℃).
* = Reference temperature at normal state (℃).
* = Coefficient of density expansion (1/℃).
*  = Actual volume flow rate of medium (m3/h).
*  = Reference density at normal state (kg/m3).
*  = Mass flow rate (kg/h).

.

#### Volume Correction

In case of setting “liquid Mass Corr” as “Volume Corr”, the formula calculated mass flow is,



Where,

* = Operating temperature of the medium (℃).
* = Reference temperature at normal state(℃).
* = Coefficient of volumetric expansion (1/℃).
*  = Actual volume flow rate of medium (m3/h).
*  = Reference density at normal state (kg/m3).
*  = Mass flow rate (kg/h).

#### No Correction

In case of setting” liquid Mass Corr “as “No Corr”, the formula calculated the mass flow is:



Where,

*  = Mass flow rate (kg/h).
* = Actual volume flow rate of medium (m3/h).
*  = Operating density of the medium (kg/m3).

#### Calculate Power flow of liquid

The energy flow rate of the liquid is calculated based on mass flow rate and heat capacity.



Where,

* = Energy flow rate of medium (KJ/h).
*  = Mass flow rate (kg/h).
*  = Heat capacity (KJ/(Kg\*K)).
*  = Medium temperature at inlet (from SwirlMaster itself) (Kelvin).
*  = Medium temperature at outlet (from other temperature transmitter) (Kelvin).

### Measure flow of gas

#### Calculate standard Volume flow of Gas

There are four standard states can be selected .The “Gas Ref conditions” are as follows:

* 14.7 PSI, 60 ℉ (15.4℃) (UK),
* 14.7 PSI, 70 ℉ (21.6℃) (US),
* 1013.25 mbar, at 0℃,
* 1013.25 mbar, at 20℃.

The formula is

For ideal gas at standard state

or

 for Natural Gas as As select Gas Std. Mode” as one of “AGA8” or “GERG88

Where,

* = Standard volume flow rate (m3/h).
*  = Actual volume flow rate (m3/h).
*  = Operating pressure (kPa).
*  = Reference pressure at standard state (kPa), see “Gas Ref conditions”.
* = Operating temperature (℃).
*  = Reference temperature at standard state (℃), see “Gas Ref conditions”.
*  = Reference compress factor at standard state.
*  = Operating compress factor.

When we take the gas as “Ideal Gas”, the compress factor will be reset to 1.0.

If we select Gas Std. Mode” as one of “AGA8” or “GERG88”, a master (compute station) need to use DTM software to calculate compress factors, and configure compress factors on SwirlMaster .

#### Calculate Mass flow of Gas

If prefer “Ref. density”, then the formula for the gas mass flow is:



Where,

*  = Mass flow rate (kg/h).
* = Standard volume flow rate at standard state (m3/h).
*  = Reference density at standard state (kg/m3).

If select actual density. The formula for the gas mass flow is:



Where,

* = Actual volume flow rate (m3/h).
*  = Operating density (kg/m3).

#### Calculate Power flow of Gas

Gas power flow rate is calculated as follows:



Where,

* = Power flow rate (KJ/h).
* = Normal volume flow rate (m3/h).
*  = Energy Density (MJ/m3).

#### Biogas Actual Volume

Biogas actual volume flow rate is calculated as follows:



Where,

* = Actual volume flow rate of biogas (m3/h).
* = Actual volume flow rate of gas (m3/h).
*  = Biogas percentage (%).

#### Biogas Standard Volume

Biogas standard volume flow rate is calculated as follows:



Where,

* = Standard volume flow rate of biogas at standard state (m3/h).
* = Standard volume flow rate of gas at standard state (m3/h).
*  = Biogas content (%).

### Measure flow of Steam/Hot-Water

#### Calculate Mass flow of Steam

Steam mass flow rate is calculated as follows:



Where,

* = Actual volume flow rate (m3/h).
*  = Operating density (kg/m3).

#### Calculate Power flow of Steam/Hot-Water

Steam Power flow rate is calculated as follows when user select the net energy:



If user select to calculate the gross energy. It calculate thru the follow equation.



Where,

* = Power flow rate (KJ/h).
* = Mass flow (kg/h).
*  = Enthalpy of steam at inlet (kJ/kg).
*  = Enthalpy of steam at outlet (kJ/kg).

The enthalpy  is calculated based on steam pressure and steam temperature at inlet. The enthalpy  is calculated based on steam pressure and steam temperature at outlet. The details refer to IAPWS-IF97 standards.

### API for Other Subsystem

#### Calculate MaxDN for Normal Liquid Volume

Funciton Name:

Void UpdateLiquidQnMaxDN\_MVM(void)

Funciton Description:

is the physical measurable ability of normal flow liquid medium, which can be calculated based on , preset temperature, real temperature and expansion coefficient.



Where:

* = Operating temperature of the medium (℃).
* = preset actual temperature (℃).
*  = Coefficient of volumetric expansion.
*  = physical measurable ability of actual volume flow (m3/h).
* = physical measurable ability of normal flow liquid medium at normal state (m3/h).

#### Calculate MaxDN for BiogasQv

Funciton Name:

Void UpdateBiagasQvMaxDN\_MVM(void)

Funciton Description:

This function is use to calculate the physical measurable ability of value of Biogas Volume flow.



Where,

* = Physical measurable ability of Biogas Volume flow (m3/h).
* = Physical measurable ability of Volume flow (m3/h).
*  = Percentage of Biogas (%).

#### Calculate MaxDN for GasQn and BiogasQn

Funciton Name:

Void UpdateGasQnMaxDN\_MVM(void)

Funciton Description:

The formula calculated the physical measurable ability of normal volume flow value is



Where,

* = physical measurable ability of standard volume flow (m3/h).
*  = physical measurable ability of actual volume flow (m3/h).
*  = Operating pressure (KPa).
*  = Preset actual pressure (KPa).
* = Operating temperature (℃).
*  = Preset actual temperature.
*  = Compress factor at preset temperature and preset pressure.
*  = Operating compress factor.

When the internal gas temperature and pressure, compress factor matrix table are not configured with DTM. The compress factor will be reset to 1.0.

The formula to calculate the physical measurable ability of BiogasQn is:



Where,

* = physical measurable ability of Biogas standard volume flow (m3/h).
* = physical measurable ability of standard volume flow (m3/h).
*  = Percentage of Biogas (%).

**Flow Chart:**



Figure 4 flow char of UpdateGasQnMaxDN\_MVM

#### Calculate MaxDN for Mass Flow

Function Name:

Void UpdateQmMaxDN\_MVM(void)

Function Description:

We get the physical measurable ability of mass flow directly from QMaxDN and preset density.



Where,

*  = physical measurable ability of mass flow (kg/h).
* = Physical measurable ability of Volume flow (m3/h).
*  = preset actual density (kg/m3).

#### Calculate MaxDN for Liquid Power

Function Name:

Void UpdateLiquidPowerMaxDN\_MVM(void)

Function Description:

The physical measurable ability of liquid energy flow is deprived from mass flow rate and heat capacity. We consume that the max temperature depress is 80.0 Kelvin.



Where,

* = physical measurable ability of energy flow (KJ/h).
*  = physical measurable ability of mass flow (kg/h).
*  = Heat capacity (KJ/(Kg\*K))

#### Calculate MaxDN for Gas Power

Function Name:

Void UpdateGasPowerMaxDN\_MVM(void)

Function Description:

The physical measurable ability of gas energy flow is deprived from volume flow and Energy Density.



Where,

* = physical measurable ability of energy flow (KJ/h).
* = Physical measurable ability of Volume flow (m3/h).
*  = Energy Density (MJ/m3).

#### Calculate MaxDN for Steam Power

**Funciton Name:**

Void UpdateSteamPowerMaxDN\_MVM(void)

**Funciton Description:**

Steam mass flow rate is calculated as follows:



Where,

* = physical measurable ability of energy flow (KJ/h).
*  = physical measurable ability of mass flow (kg/h).
*  = Enthalpy of steam at inlet (kJ/kg).
*  = Enthalpy of steam at outlet (kJ/kg).

The enthalpy  is calculated based on preset pressure and preset temperature. The enthalpy  is calculated based on preset pressure and preset external temperature at outlet. The details refer to IAPWS-IF97 standards.

**Flow Chart :**



Figure 5: flow chart of UpdateSteamPowerMaxDN\_MVM

#### Calculate gas compress factor

Funciton Name:

Void CalcCompressFactor\_MVM(void)

Funciton Description:

If gas is configured by DTM tool successful with ‘gasConfFlag’ set as MVM\_GONFIGED. Then this function will calculate the compress factors for three statuses:

* Real Work status
* Selected Refer Standard status
* Preset status.

#### Calculate steam density

Funciton Name:

Void CalcSteamDensityEXE\_MVM (TFLOAT inTReal, TFLOAT inPReal)

Funciton Description:

Calculate steam density at given temperature and pressure.

#### Calculate steam enthelpy

Funciton Name:

Void CalcSteamHEXE \_MVM (TFLOAT inPReal, TFLOAT inT1Real, TFLOAT inT2Real)

Funciton Description:

Calculate steam enthalpy at given temperatures and pressure. And also monitor the status of steam.

Paremete1:

Steam Pressure.

Paremete2:

Steam temperature sampled at inlet.

Paremete3:

Steam temperature sampled at outlet.

#### Calculate biogas Volume flow

Function Name:

Void CalculateGasQvPartialEXE\_MVM(TFLOAT inVF, TFLOAT biogasPerc)

Function Description:

Calculate steam enthalpy at given temperatures and pressure. And also monitor the status of steam.

Paremete1:

Input volume flow.

Paremete2:

Input biogas percentage.

#### Calculate gas standard volume flow

Function Name:

Void CalculateGasQnEXE\_MVM(TFLOAT volumeFlow, TFLOAT tReal, TFLOAT pReal)

Function Description:

Calculate gas standard volume flow

Paremete1:

Input volume flow in m3/h

Paremete2:

Input the real Temperature in Celsius

Paremete3:

Input the real Pressure in base unit (kPa).

#### Calculate biogas standard volume flow

Funciton Name:

Void CalculateGasQnPartialEXE\_MVM(TFLOAT inNVF, TFLOAT biogasPerc)

Function Description:

Calculate biogas standard volume flow.

Paremete1:

Input gas standard volume flow in base unit (m3/h).

Paremete2:

Input biogas percentage.

#### Calculate gas mass flow

Function Name:

Void CalculateGasQmEXE\_MVM (TFLOAT inVF, TFLOAT inNVF, TFLOAT densityReal)

Function Description:

Calculate gas mass flow.

Paremete1:

Input gas volume flow in base unit (m3/h).

Paremete1:

Input gas standard volume flow in base unit (m3/h).

Paremete2:

Input density of gas in base unit (Kg/m3).

#### Calculate gas energy flow

Funciton Name:

Void CalculateGasQpEXE\_MVM(TFLOAT inVF)

Funciton Description:

Calculate gas enegery flow.

Paremete1:

Input gas volume flow in base unit (m3/h).

#### Get percentage flow of QmMAX

Funciton Name:

Void GetQmPercentageSRV\_MVM (void)

Funciton Description:

Get Percentage flow of. It’s available in the liquid mass operating mode, gas mass operation mode, steam mass operation mode, liquid power operation mode and steam power operation mode.

#### Get percentage flow of QnMAX

Function Name:

Void GetQnPercentageSRV\_MVM (void)

Function Description:

Get Percentage flow of. It’s available in the liquid normal volume operating mode, gas standard volume operation mode, biogas standard volume operation mode and gas mass operation mode.

#### Get percentage flow of QpMax

Funciton Name:

Void GetQpPercentageSRV\_MVM (void)

Funciton Description:

Get Percentage flow of. It’s only available in liquid power operation mode, gas power operation mode and steam power operation mode.

#### Get percentage flow of Biogas QMaxbiogas

Function Name:

Void GetQvPartialPercentageSRV \_MVM (void)

Function Description:

Get Percentage flow of. It’s only available in biogas volume operation mode.

#### Get percentage flow of biogas QnMaxbiogas

Function Name:

Void GetQnPartialPercentageSRV\_MVM (void)

Function Description:

Get Percentage flow of. It’s only available in biogas standard volume operation mode.

#### Check data CRC

Funciton Name:

Void CheckDataCrcSRV\_MVM(void).

Funciton Description:

If the calculation data is updated, then it will recalculate the CRC all calculation data, if data is not updated, it will check the CRC of the all data, if not the same as the saved value before, then enters break mode; If the same it will do nothing.

This function for executing check calculation data valid and is used to be called by Electronic Services in a cyclic manner.

#### Update Alarm information

Function name:

Void UpdateDiagnosisEXE\_MVM(void)

Description:

It combines the alarm of simulation of MVM and the real Alarm. And put the combined value to diagnosis subsystem.

## Design Decisions and Limitations

The MVM Subsystem is designed base on ABB BUI Common Framework. Use entry tool to generate all the public objects and methods.

## Hardware Dependencies

## Data Object Description

Provide a detailed description of all Data Objects.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Object name** | **T\_DATA\_OBJ** | **Data Class** | **Storage** | **Description** |
| Qn | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| QnSimEnable | TABENUM8 | Protected | RAM |  |
| QnSim | DNY\_FLOAT | Protected | RAM |  |
| QnDamped | SIMPLE\_FLOAT | DynamicDuplicated | RAM | volume flow after damped |
| QnUnitCode | TABENUM8 | STATIC\_RARE | NON\_VOLATILE | Volume flow unit. the default is m3/h |
| QnUnitType | CONST\_U8 | CONSTANT | ROM |  |
| QnObj | UOM\_PF |  |  | An object to combine volume flow and the unit. |
| QnDampedObj | UOM\_PF |  |  |  |
| QnSimObj | UOM\_PF |  |  |  |
| QnRange | DEV\_RNGFLT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| QnSimUnitCode | TABENUM8 | Protected | RAM | Range unit code. of volume flow rate |
| QnRangeObj | UOM\_PF |  |  | Object to combine the Volume flow rate upper range with the Range unit. |
| QnMaxDN | SIMPLE\_FLOAT | Protected | RAM | The max permission volume flow rate. It always marks on the nameplate. |
| QMinDN | SIMPLE\_FLOAT | Unprotected | RAM |  |
| QnMaxDNObj | UOM\_PF |  |  |  |
| QnPerSim | FLOAT | Protected | RAM |  |
| QnPercentage | SIMPLE\_FLOAT | DynamicDuplicated | RAM | The volume flow rate percentage of the deviceVariable2ax. |
| QnClassification | SIMPLE\_U8 | Protected | READONLY\_RAM |  |
| QnStatus | SIMPLE\_U8 | Protected | RAM |  |
| QnDampingTime | FLOAT | STATIC\_RARE | NON\_VOLATILE |  |
| Qm | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| QmSimEnable | TABENUM8 | Protected | RAM |  |
| QmSim | DNY\_FLOAT | Protected | RAM |  |
| QmDamped | SIMPLE\_FLOAT | DynamicDuplicated | RAM | volume flow after damped |
| QmUnitCode | TABENUM8 | STATIC\_RARE | NON\_VOLATILE | Volume flow unit. the default is m3/h |
| QmUnitType | CONST\_U8 | CONSTANT | ROM |  |
| QmObj | UOM\_PF |  |  | An object to combine volume flow and the unit. |
| QmDampedObj | UOM\_PF |  |  |  |
| QmSimObj | UOM\_PF |  |  |  |
| QmRange | DEV\_RNGFLT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| QmAlmRange | RANGEFLT | STATIC\_RARE | NON\_VOLATILE |  |
| QmSimUnitCode | TABENUM8 | Protected | RAM | Range unit code. of volume flow rate |
| QmRangeObj | UOM\_PF |  |  | Object to combine the Volume flow rate upper range with the Range unit. |
| QmMaxDN | SIMPLE\_FLOAT | Protected | RAM | the max permission volume flow rate. it always mark on the nameplate. |
| QmMaxDNObj | UOM\_PF |  |  |  |
| QmPerSim | FLOAT | Protected | RAM |  |
| QmPercentage | SIMPLE\_FLOAT | DynamicDuplicated | RAM | The volume flow percentage of the deviceVariable2ax. |
| QmClassification | SIMPLE\_U8 | Protected | READONLY\_RAM |  |
| QmStatus | SIMPLE\_U8 | Protected | RAM |  |
| QmDampingTime | FLOAT | STATIC\_RARE | NON\_VOLATILE |  |
| Qp | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| QpSimEnable | TABENUM8 | Protected | RAM |  |
| QpSim | DNY\_FLOAT | Protected | RAM |  |
| QpDamped | SIMPLE\_FLOAT | DynamicDuplicated | RAM | volume flow after damped |
| QpUnitCode | TABENUM8 | STATIC\_RARE | NON\_VOLATILE | Volume flow unit. the default is m3/h |
| QpUnitType | CONST\_U8 | CONSTANT | ROM |  |
| QpObj | UOM\_PF |  |  | an object to combine volume flow and the unit. |
| QpDampedObj | UOM\_PF |  |  |  |
| QpSimObj | UOM\_PF |  |  |  |
| QpRange | DEV\_RNGFLT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| QpSimUnitCode | TABENUM8 | Protected | RAM | Range unit code. of volume flow rate |
| QpRangeObj | UOM\_PF |  |  | Object to combine the Volume flow rate upper range with the Range unit. |
| QpMaxDN | SIMPLE\_FLOAT | Protected | RAM | the max permission volume flow rate. it always mark on the nameplate. |
| QpMaxDNObj | UOM\_PF |  |  |  |
| QpPerSim | FLOAT | Protected | RAM |  |
| QpPercentage | SIMPLE\_FLOAT | DynamicDuplicated | RAM | The volume flow rate percentage of the deviceVariable2ax. |
| QpClassification | SIMPLE\_U8 | Protected | READONLY\_RAM |  |
| QpStatus | SIMPLE\_U8 | Protected | RAM |  |
| QpDampingTime | FLOAT | STATIC\_RARE | NON\_VOLATILE |  |
| QnPartial | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| QnPartialSimEnable | TABENUM8 | Protected | RAM |  |
| QnPartialSim | DNY\_FLOAT | Protected | RAM |  |
| QnPartialDamped | SIMPLE\_FLOAT | DynamicDuplicated | RAM | volume flow after damped |
| QnPartialObj | UOM\_PF |  |  | An object to combine volume flow and the unit. |
| QnPartialDampedObj | UOM\_PF |  |  |  |
| QnPartialSimObj | UOM\_PF |  |  |  |
| QnPartialRange | DEV\_RNGFLT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| QnPartialRangeObj | UOM\_PF |  |  | Object to combine the Volume flow rate upper range with the Range unit. |
| QnPartialMaxDN | SIMPLE\_FLOAT | Protected | RAM | The max permission volume flow rate. It always marks on the nameplate. |
| QnPartialMaxDNObj | UOM\_PF |  |  |  |
| QnPartialPerSim | FLOAT | Protected | RAM |  |
| QnPartialPercentage | SIMPLE\_FLOAT | DynamicDuplicated | RAM | The volume flow rate percentage of the deviceVariable2ax. |
| QnPartialClassification | SIMPLE\_U8 | Protected | RAM |  |
| QnPartialStatus | SIMPLE\_U8 | Protected | RAM |  |
| QnPartialDampingTime | FLOAT | STATIC\_RARE | NON\_VOLATILE |  |
| QvPartial | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| QvPartialSimEnable | TABENUM8 | Protected | RAM |  |
| QvPartialSim | DNY\_FLOAT | Protected | RAM |  |
| QvPartialDamped | SIMPLE\_FLOAT | DynamicDuplicated | RAM | volume flow after damped |
| QvPartialObj | UOM\_PF |  |  | An object to combine volume flow and the unit. |
| QvPartialDampedObj | UOM\_PF |  |  |  |
| QvPartialSimObj | UOM\_PF |  |  |  |
| QvPartialRange | DEV\_RNGFLT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| QvPartialRangeObj | UOM\_PF |  |  | Object to combine the volume flowrate upper range with the Range unit. |
| QvPartialMaxDN | SIMPLE\_FLOAT | Protected | RAM | the max permission volume flow rate. it always mark on the nameplate. |
| QvPartialMaxDNObj | UOM\_PF |  |  |  |
| QvPartialPerSim | FLOAT | Protected | RAM |  |
| QvPartialPercentage | SIMPLE\_FLOAT | DynamicDuplicated | RAM | The volume flow rate percentage of the deviceVariable2ax. |
| QvPartialClassification | SIMPLE\_U8 | Protected | RAM |  |
| QvPartialStatus | SIMPLE\_U8 | Protected | RAM |  |
| QvPartialDampingTime | FLOAT | STATIC\_RARE | NON\_VOLATILE |  |
| steamStatus | TABENUM8 | Unprotected | RAM | Steam Satus. |
| steamType | TABENUM8 | REPLACE\_STATIC\_RARE | NON\_VOLATILE | To store the steam type. It must be one of the saturated steam and Overheat steam |
| liquidCorrection | TABENUM8 | REPLACE\_STATIC\_RARE | NON\_VOLATILE | Correction for the liquid. Could be no correction. Volume correction or density correction. |
| heatCapacity | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE | Heat Capacity. To calculate the power for liquid. |
| densityRef | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| densigyRefObj | UOM\_PF |  |  |  |
| densityS | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| densityExpandBeta2 | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| volumeExpandBeta1 | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| gasRef | TABENUM8 | REPLACE\_STATIC\_RARE | NON\_VOLATILE | Standard Gas condition selection. |
| gasComputeType | TABENUM8 | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| gasDensitySelection | TABENUM8 | REPLACE\_STATIC\_RARE | NON\_VOLATILE | Gas Density Selection |
| calorificEnergy | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE | Calorific Value |
| gasConfFlag | TABENUM8 | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| molFractions | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE | MolFractions[0]=Methane CH4 MolFractions[1]=Ethane --C2H6 MolFractions[2]=Propane --C3H8 MolFractions[3]=ISO\_Butane --C4H10 MolFractions[4]=n\_Butane --C4H10 MolFractions[5]=ISO\_Petane --C5H12 MolFractions[6]=n\_Petane --C5H12 MolFractions[7]=n-Hexane --C6H14 MolFractions[8]=n-Heptane --C7H16 MolFractions[9]=n-Octane --C8H18 MolFractions[10]=n-Nonane --C9H20 MolFractions[11]=n-Decane --C10H22 MolFractions[12]=Carbon-Dioxide --CO2 MolFractions[13]=Nitrogen --N2 MolFractions[14]=Hydrogen Sulfide --HS MolFractions[15]=Helium --He MolFractions[16]=Water --H2O MolFractions[17]=Oxygen --O2 MolFractions[18]=Argon --Ar MolFractions[19]=Hydrogen --H2 MolFractions[20]]=Carbon Monoxide --CO |
| compressFactorArray |  |  |  | 9\*7 [0...6] |
| CFTempArray0 | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| CFTempArray1 | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| CFTempArray2 | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| CFTempArray3 | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| CFTempArray4 | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| CFTempArray5 | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| CFTempArray6 | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| CFTempArray0Obj | UOM\_PF |  |  |  |
| CFTempArray1Obj | UOM\_PF |  |  |  |
| CFTempArray2Obj | UOM\_PF |  |  |  |
| CFTempArray3Obj | UOM\_PF |  |  |  |
| CFTempArray4Obj | UOM\_PF |  |  |  |
| CFTempArray5Obj | UOM\_PF |  |  |  |
| CFTempArray6Obj | UOM\_PF |  |  |  |
| CFPressArray0 | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| CFPressArray1 | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| CFPressArray2 | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| CFPressArray3 | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| CFPressArray4 | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| CFPressArray5 | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| CFPressArray6 | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| CFPressArray7 | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| CFPressArray8 | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| CFPressArray0Obj | UOM\_PF |  |  |  |
| CFPressArray1Obj | UOM\_PF |  |  |  |
| CFPressArray2Obj | UOM\_PF |  |  |  |
| CFPressArray3Obj | UOM\_PF |  |  |  |
| CFPressArray4Obj | UOM\_PF |  |  |  |
| CFPressArray5Obj | UOM\_PF |  |  |  |
| CFPressArray6Obj | UOM\_PF |  |  |  |
| CFPressArray7Obj | UOM\_PF |  |  |  |
| CFPressArray8Obj | UOM\_PF |  |  |  |
| compressFactorR | SIMPLE\_FLOAT | DynamicDuplicated | RAM | Compress Factor at operating Status. |
| relativeDensity | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| relativeDensityRef | TABENUM8 | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| refCalorifcValue | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE | Calorific Value at ref condition |
| calorificValueRef | TABENUM8 | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| mvmAlarmSimulation | T\_DIAGNOSIS\_ALARM | DynamicDuplicated | RAM |  |
| mvmDiagnosis | SIMPLE\_U8 | DynamicDuplicated | RAM |  |
| refTemperature | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| refTemperatureObj | UOM\_PF |  |  |  |
| refPressure | FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| refPressureObj | UOM\_PF |  |  |  |
| compressFactorS | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| compressFactorPreset | SIMPLE\_FLOAT | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| matrixSize | TABENUM8 | REPLACE\_STATIC\_RARE | NON\_VOLATILE |  |
| spline2dRequest | TABENUM8 | Protected | RAM |  |
| updateCFSRequest | TABENUM8 | Protected | RAM | Request to update Compress Factor of Standard gas. |
| updateCFPresetRequest | TABENUM8 | Protected | RAM |  |
| updateMaxDNRequest | SIMPLE\_BIT8 | Protected | RAM |  |
| Hw | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| Hc | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| HwPreset | SIMPLE\_FLOAT | Unprotected | RAM |  |
| HcPreset | SIMPLE\_FLOAT | Unprotected | RAM |  |
| QnPartialDuplicated | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| QnPartialPercentageDuplicated | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| QnPartialDampedDuplicated | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| QvPartialDuplicated | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| QvPartialPercentageDuplicated | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| QvPartialDampedDuplicated | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| QnDuplicated | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| QnPercentageDuplicated | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| QnDampedDuplicated | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| QmDuplicated | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| QmPercentageDuplicated | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| QmDampedDuplicated | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| QpDuplicated | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| QpPercentageDuplicated | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| QpDampedDuplicated | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| HwDuplicated | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| HcDuplicated | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| compressFactorRDuplicated | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| compressFactorSDuplicated | SIMPLE\_FLOAT | DynamicDuplicated | RAM |  |
| mvmAlarmSimulationDuplicated | T\_DIAGNOSIS\_ALARM | DynamicDuplicated | RAM |  |
| mvmDiagnosisDuplicated | SIMPLE\_U8 | DynamicDuplicated | RAM |  |
| protectedDataCrc | SIMPLE\_U16 | Unprotected | RAM |  |
| protectedDataStatus | TABENUM8 | Protected | RAM |  |
|  |  |  |  |  |
|  |  |  |  |  |

Table 1: Objects Table

# Design Review

## Review Participants

|  |  |  |  |
| --- | --- | --- | --- |
| *Place* | *Dept.* | *Name* |  |
| Shanghai | PAMP | Jax Yang, Spring Zhou | 2013-06-21 rev 0.1 |
| Shanghai | PAMP | Merrick Huang | 2014-01-08 rev 0.2 |
|  |  |  |  |

## Decision of the Review

|  |  |  |
| --- | --- | --- |
|  | *Decision* | *Next steps* |
| ■ | Inspection passed ***without restrictions*** | Phase finished |
| □ | Inspection passed ***with restrictions*** | some changes must be done |
|  | Inspection ***not*** passed | Inspection must be repeated |

**Changes are proved:** The Reviewer confirms that all changes are done:

|  |  |  |
| --- | --- | --- |
| proved Rev: | Date: | Reviewer: |
| 0.1 | 2013-06-21 | Spring Zhou |

**Changes are proved:** The Reviewer confirms that all changes are done:

|  |  |  |
| --- | --- | --- |
| proved Rev: | Date: | Reviewer: |
| 0.2 | 2014-01-08 | Merrick Huang |

**Changes are proved:** The Reviewer confirms that all changes are done:

|  |  |  |
| --- | --- | --- |
| proved Rev: | Date: | Reviewer: |
| 0.3 | 2015-06-26 | Lawrence Shi |

## Check List

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Yes | No |
| 1. | Is the software architecture distinct and documented? | **√** |  |
| 2. | Fit the modules together? | **√** |  |
| 3. | Are complex algorithms/procedures explained? | **√** |  |
| 4. | Is a strategy for error handling designated? | **√** |  |
| 5. | Is the configuration management system well prepared? | **√** |  |
| 6. | Are all open issues transferred to the defects table? | **√** |  |

## Defect

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. | Checkpoint | Description | Major defect | Done date |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

References

|  |  |
| --- | --- |
| **Ref.** | **Document** |
| [1] | [RS017]MVMeasurement Subsystem Requirements Specification |
| [2] | Properties of water and steam, W.Wagner, A.Kruse, 1998. |
|  |  |

Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| **Rev.** | **Description of Version/Changes** | **Primary Author(s)** | **Date** |
| 0.1 | Initial revision. | Zuochen Wang | 2013-05-21 |
| 0.2 | Change Gas Power calculation and Steam Power Calculation | Zuochen Wang | 2014-01-08 |
| 0.3 | Add Hot/water in steam power calculation. Change Steam power flow rate calculation selection strategy from regarding temperature input from AI or Hart bus to regarding the net energy selection of user. All changes are in chapter 3.3.3.2 | Zuochen Wang | 2015-06-26 |
|  |  |  |  |