Checking the relationship of burden load and power loss

The rated load of the transformer must be 1.5 to 2 times greater than the power loss in the connection circuit to ensure that the transformer is not overloaded and that the electrical current limitation is ensured during a short-circuit.

At a maximum secondary current of 4 A, the power loss in the connection circuit is calculated according to the following formula for a connection cable (outgoing and incoming line) with a length of 10 m, a cross-section of 1.0 mm², and an Energy meter load resistance R_{Burden} of 25 mΩ:

$$P_{Connection\ circuit} = (R_{Connection\ cable} + R_{Burden}) \times I^2_{Max.\ secondary}$$

$$P_{Connection\ circuit} = (178.6\ m\Omega + 25\ m\Omega) \times 4^2\ A^2 = 3.26\ W$$

The ratio of rated load and power loss in the connection circuit is:

$$\frac{Z_{N\ Rated\ load}}{P_{Connection\ circuit}} = \frac{5\ VA}{3.26\ W} = 1.54$$

The required ratio of the electrical current transformer's rated load and power loss in the connection circuit is within the required range (between 1.5 and 2). The example electrical current transformer has the correct electrical characteristics for this application.

连接电路中电流互感器额定负载与功率损耗的要求比在要求范围内(1.5 ~ 2)。

Configure I/O address space

4

4.1 TIA Portal project overview

Introduction

To configure the SM 1238 Energy Meter 480VAC after connecting it, you use the TIA portal device configuration software. In addition, you can change some parameters in RUN mode, with the user program.

Configuring

You configure the SM 1238 Energy Meter 480VAC with STEP 7 (TIA Portal) V13 SP1 with Update 8 or higher and HSP 0151. The HSP or Hardware Service Pack adds the Energy meter to the TIA Portal hardware catalog.

The following steps show the basic procedure for configuring the S7-1200 CPU and SM 1238 Energy Meter 480VAC.

1. Find the S7-1200 CPU that you are using in the hardware catalog insert the CPU in your project's Device view window.
2. Find the SM 1238 Energy Meter 480VAC in the hardware catalog under the AI (Analog Input) folder and insert the module into your device view window, on the CPU's right-side. You can use any right-side position.
3. Click on the SM 1238 Energy Meter 480VAC module image in the device view to see the module's configuration parameters on the Properties tab.
4. Set the parameters of the SM 1238 Energy Meter 480VAC for your requirements.

Once the configuration has been compiled without errors, you can download the configuration to the CPU and begin S7-1200 and SM 1238 Energy Meter 480VAC operations with your user program.

For configuration parameter details, see Configuration with the TIA Portal (Page 70).

4.2 Choosing a module version

4.2.1 Module version options

Introduction

When you configure the SM 1238 Energy Meter 480VAC, you use the parameter "Module version" to select the size of the PLC user data program interface and whether the measurement data group is fixed or if changing the Process data variant with your program logic is allowed.

Each module version supplies quality information via the input user data.

With the exception of the module version "2 I / 2 Q", you can read the measured values as user data cyclically from the PLC process image. You also have the option to read measured value records from the SM 1238 Energy Meter 480VAC acyclically by using the RDREC instruction.

Influence of the module version on the address space

Note

Influence of the SM 1238 Energy Meter 480 VAC on I/O address allocation in the S7-1200 PLC

The available address space of a S7-1200 CPU is influenced by the following factors:

- S7-1200 CPU model
- Other I/O modules that may be plugged into the S7-1200 CPU

The maximum I/O address space required by the SM 1238 Energy Meter 480VAC is determined by the size of the user data provided to your control program.

The configuration parameters "Module version" and "Process data variant" (when enabled) set the maximum size of the user data.

The choice of Module version and Process data variant is influenced by the following factors:

- Planned application
- Available address space

在run模式更改

The following table shows the different Module version options and the required I/O address space:

Module version name	Process data variant options	Number of input I bytes used	Number of output Q bytes used	Comment	Changing Process data variant in RUN possible
2 bytes I / 2 bytes O	No Process data variants available	2	2	Contains quality information only.	No
32 bytes I/ 12 bytes O	All Process data variants possible, except EE@Industry measurement data profile e3	32	12		Yes
112 bytes I/ 12 bytes O	All Process data variants possible	112	12		Yes
EE@Industry measurement data profiles e0 / e1 / e2 / e3	No Process data variants available	e0: 12 e1: 4 e2: 12 e3: 104	12	Content depends on the data profile choice. Contains no quality information.	No

When you select the "32 bytes I /12 bytes O" **or** the "112 bytes I /12 bytes O" module version, you **must** also select a "Process data variant" pre-defined measurement group from the following table. 当您选择“32字节I /12字节O”或“112字节I /12字节O”模块版本时，还必须从下表中选择预定义的“Process data variant”度量组。

Process data variant options and hexadecimal identifier codes	Number of input I bytes used	Number of output Q bytes used
Total power L1, L2, L3 (FE_H)	32	12
Active power L1, L2, L3 (FD_H)	32	12
Reactive power L1, L2, L3 (FC_H)	32	12
Apparent power L1, L2, L3 (FB_H)	32	12
Basic measurement values (FA_H)	32	12
Total energy L1, L2, L3 ($F9_H$)	32	12
Energy L1 ($F8_H$)	32	12
Quality values 3-phase measurement ($F0_H$)	32	12
Energy meter (periodical) overage meter (EF_H)	32	12
[1]EE@Industry Measurement Data Profile e3 ($E3_H$)	112	12
EE@Industry Measurement Data Profile e2 ($E2_H$)	32	12
EE@Industry Measurement Data Profile e1 ($E1_H$)	32	12
EE@Industry Measurement Data Profile e0 ($E0_H$)	32	12
Basic values Single Phase Measurement L1 ($9F_H$)	32	12
Basic values Single Phase Measurement L1a ($9E_H$)	32	12
Basic values Single Phase Measurement L2 ($9D_H$)	32	12
Basic values Single Phase Measurement L2a ($9C_H$)	32	12
Basic values Single Phase Measurement L3 ($9B_H$)	32	12
Basic values Single Phase Measurement L3a ($9A_H$)	32	12

[1] EE@Industry Measurement Data Profile e3 ($E3_H$) is only available with the "112 bytes I /12 bytes O" module version.

Module version features

The following table shows which module version is suitable for a given purpose.

Module version	Application	Note
2 bytes I /2 bytes O	• Use of several SM 1238 Energy Meter 480VAC in an S7-1200 CPU or where a small address space is available • Reading quality information for measured values • Counting of operating hours and energy • Acyclic acquisition of measured values (optional) • Consistent measured values (optional)	Read the measured values via the RDREC instruction from a measured value data record
32 bytes I/ 12 bytes O 112 bytes I/ 12 bytes O	• Cyclic measurement per phase • Counting of operating hours and energy • Flexibility by switching predefined Process data variants during RUN mode.	Available measured values depend on the active Process data variant.
EE@Industry measurement data profile e0 / e1 / e2 / e3	• Cyclic measurement per phase • Counting of operating hours and energy	Available measured values depend on the configured measurement data profile.

4.2.2 STEP 7 project planning and module versions

Module versions with fixed Process data

Module version	User data	Address space	Comment
2 bytes I / 2 bytes O	No cyclic process data. Access to measured values through RDREC read data record instruction.	2-byte inputs / 2-byte outputs	Information about the structure of the 2 bytes I /2 bytes O module version is available in the appendix Module version "2 bytes I /2 bytes O" (Page 110)
EE@Industry E0	Process data in accordance with EE@Industry measurement data profiles	12 byte inputs / 12 byte outputs	Information about the structure of the EE@Industry measured data profiles is available in the appendix Module version "EE@Industry measurement data profile E0 / E1 / E2 / E3" (Page 122).
EE@Industry E1		4 byte inputs / 12 byte outputs	
EE@Industry E2		12 byte inputs / 12 byte outputs	
EE@Industry E3		104 byte inputs / 12 byte outputs	

Module versions with selectable Process data variants

Module version	User data	Address space	Comment
32 bytes I / 12 bytes O	Selectable Process data variants	32 byte inputs / 12 byte outputs	You can change the Process data variant during operation. Information about the structure of the 32 bytes I /12 bytes O module version is available in the appendix Module version "32 bytes I /12 bytes O" (Page 113). Information about the structure of the 112 bytes I /12 bytes O module version is available in the appendix Module version "112 bytes I /12 bytes O" (Page 117). Information about the Process data variants is available in the appendix "Overview of Process data variant options" (Page 126)Hotspot-Text.
112 bytes I/ 12 bytes O		112 byte inputs / 12 byte outputs	

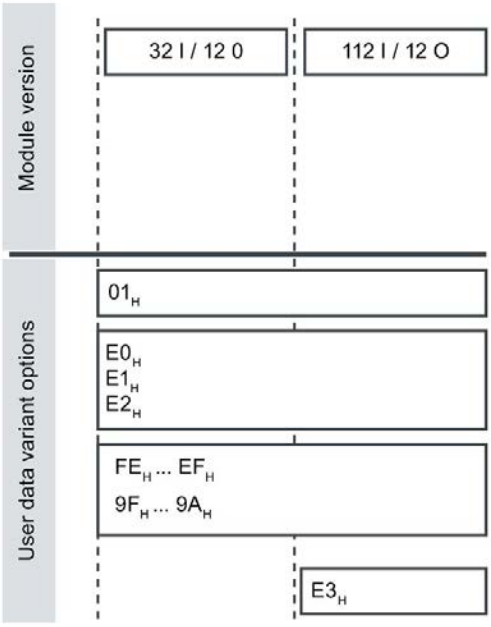
4.2.3 Changing the Process data variant in RUN mode

Introduction

Your program can change the Process data variant by writing Q byte 0 (in the current Process data variant) with the ID value of a different Process data variant.

The following figure shows that the EE@Industry measured data profile e3 ($E3_H$) is only possible for the "112 bytes I/ 12 bytes O" module version.

下图显示，EE@Industry measured data profile e3 (E3H)仅适用于“ 112 bytes I/ 12 bytes O ”模块版本。



Requirement

- User program has been created.
- SM 1238 Energy Meter 480VAC is configured as module version "32 bytes I/ 12 bytes Q" or "112 bytes I/ 12 bytes Q".
- Start address of the output Q address in the process image of the CPU is known.

Procedure

步骤

1. Create one constant with the data type BYTE per Process data variant.
2. Enter the Process data variant ID as a value in each case.
3. Write the constant to the start address of the module in the process image output.

Result

The Process data variant is switched on the next cycle. 进程数据变量在下一个循环中切换。

Note

Information about Process data variant changeover

The Process data variant change fails and defaults to the parameterized Process data variant (stored in DS 128), in the following cases: 以下情况会导致切换失败

- A "0" is written in byte 0 in the output data of a Process data variant.
- Byte 0 in the output data of a Process data variant contains an invalid value:
  - Code for the Process data variant not available

    or
  - Available address space is not sufficient for the Process data variant.

4.2.4 Recommendations on the choice of a module version 关于模块版本选择的建议

The following table shows which module version is suitable for a given purpose.

Module version	Application	Note 仅通过RDREC指令从测量值数据记录中读取测量值。
2 bytes I / 2 bytes O	• Using a maximum of 8 SM 1238 Energy Meter 480VAC modules with one S7-1200 PLC or where there is limited address space available	• Read the measured values solely via the RDREC instruction from a measured value data record. • Quality information about the measured values is always available. 可用的测量值取决于配置的测量数据概要。
EE@Industry measurement data profile E0 / E1 / E2 / E3	• Cyclic measurement per phase • Supply measured values in accordance with the EE@Industry measured data profile	• Available measured values depend on the configured measurement data profile. • The process data are fixed and cannot be changed dynamically. Alternatively, you can read the measured values asynchronously from a measured value data record via the RDREC instruction. 流程数据是固定的，不能动态更改。或者，您可以通过RDREC指令从测量值数据记录异步读取测量值 • No quality information
32 bytes I /12 bytes O 112 bytes I /12 bytes O	• Cyclic measurement per phase • Flexibility by switching pre-defined Process data variants during RUN mode	• Quality information about the measured values is always available. • Depending on the active Process data variant, you must convert the measured values in the CPU to physical values using the supplied scaling factor. • One cycle elapses for each Process data variant changeover. Measured values from the next Process data variant are thus supplied with a slight time offset. 对于每个流程数据变体的转换，都有一个周期。因此，来自下一个过程数据变体的测量值具有轻微的时间偏移 Alternatively, read the measured values asynchronously from a measured value data record via the RDREC instruction. Consistent measured values of a measuring cycle are supplied. 或者，通过RDREC指令。提供了测量周期的一致测量值。

Quick start 5

5.1 Getting measured values quickly

Introduction

This section shows you how to read and view your first measured values from the SM 1238 Energy Meter 480VAC.

Requirements

- The Energy Meter is wired to your AC network with one of the connection types shown in the Wiring (Page 15) section.
- The SM 1238 Energy Meter 480VAC is available in the STEP 7 hardware catalog for your project's Device configuration.

Procedure 设定步骤

1. Configure an S7-1200 CPU.
2. Plug in an SM 1238 Energy Meter 480VAC module, on the right-side of an S7-1200 CPU, and connect to an AC power network.
3. Set the following Module parameters in the AI configuration "Measurement" group:
   - "Connection type" that you have used for the SM 1238 Energy Meter 480VAC (e.g. 3P4W 3-phase, 4-wire) 三相四线
   - "Voltage measuring range", which is the phase voltage (UL1-N) of your electrical power source (e.g. 230 V AC) UL1和N之间的电压
   - "Line frequency" of your power source (e.g. 60 Hz) 频率
4. Set the following Module parameters in the Process data "Operating mode" group: 操作模式
   - Set the "Module version" to "32 byte I/12 bytes O".
   - Set the "Process data variant" to "Total power L1, L2, L3 (W# 16# FE)".
5. Set the following module parameters in the "AI 3" > "Inputs" > Line conductor 1, 2, and 3 groups.
   - Primary and secondary current of your transformer (e.g. 100 A and 1 A)
   - Primary and secondary voltages of the used voltage transformer (e.g. 230 V and 230 V)
6. Leave all other parameters at their default settings. 其他的不用设定，保持缺省值
7. Successfully compile the configuration, switch On the S7-1200 CPU power, and download the configuration to the CPU.

用12个out字节控制模块，用32个字节或112个字节读取模块的数据

Result

Once the Energy Meter is powered On, it provides the measured values for the Process data variant with variant ID 254 (FE_H).

The following table shows which measured values are stored in the 32 bytes of output data from the module. The module output data is read by your program through 32 input I byte addresses and your program controls the module with 12 output Q byte addresses.

下表显示了哪些测量值存储在模块输出数据的32字节中。模块输出数据由程序通过32个输入I字节地址读取，程序用12个输出Q字节地址控制模块。

Each measured variable is referenced via the measured value ID. An overview of all the measured variables and IDs is provided in the section Measured variables and connection type (Page 102).

每个测量变量都通过测量值ID引用

Table 5- 1 Total power L1, L2, L3 Process data variant

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Process data variant	BYTE	-	254 (FE_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 … 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 … 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 … 65535	66009
8 ... 9	Total active power L1L2L3 总有功功率	INT	1 W	-27648 … 27648	66034
10 ... 11	Total reactive power L1L2L3 总无功功率	INT	1 var	-27648 … 27648	66035
12 ... 13	Total apparent power L1L2L3 总视在功率	INT	1 VA	-27648 … 27648	66036
14 ... 17	Total active energy L1L2L3 总有功电能	UDINT	1 Wh	0 …4294967295	225
18 ... 21	Total reactive energy L1L2L3 总无功电能	UDINT	1 varh	0 …4294967295	226
22	Reserved	BYTE	-	0	-
23	Total power factor L1L2L3 总功率因数	USINT	0.01	0 … 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling total active power L1L2L3	USINT	-	0 ... 255	-
28	Scaling total reactive power L1L2L3	USINT	-	0 ... 255	-
29	Scaling total apparent power L1L2L3	USINT	-	0 ... 255	-
30	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

Additional information

If you want more information on the evaluation and interpretation of the measured values, continue reading the section Reading and processing measured values (Page 34).

Reading and processing measured values 6

读取和处理测量值

6.1 Basics for reading measured values

Introduction

The SM 1238 Energy Meter 480VAC provides the measured values and variables through the following methods: SM 1238能源表480VAC通过以下方法提供测量值和变量:

- Cyclic: User data
- Acyclic: Measured value data records

Process data

过程数据变量提供一组西门子定义的测量值。测量值被循环写入CPU的进程映像。对于某些流程数据变体，测量值作为原始数据提供，您可以使用提供的比例因子将其转换为相应的物理值。

Process data variants provide a set of Siemens defined measured values. The measured values are cyclically written to the process image of the CPU. With some Process data variants, the measured values are supplied as raw data, which you can convert to the corresponding physical values using a supplied scaling factor.

Measured value data record

每个测量值数据记录提供可以立即处理的物理值。可以用RDREC指令和一个PLC标签。每个测量值数据记录都需要对应的PLC标签。

Each measured value data record supplies physical values that you can process immediately. You can read the values of a measured value data record acyclically with the RDREC instruction and a PLC tag. You need a corresponding PLC tag for each measured value data record.

STEP 7 (TIA Portal) can read and display the measured values in a watch table.

Validity of the measured values 测量值的有效性

After supplying power to the module (for F-stand 1 supply voltage UL1), the first measured values are available after approximately 2 seconds.
In the input user data, the content of byte 0 is set to the selected Process data variant ID.
You can detect a change in byte 0 value as a trigger event. 在输入用户数据中，字节0的内容被设置为所选进程数据变量ID。可以将字节0值的更改检测为触发器事件。
As soon as the module has valid measured values, the value of this byte changes to a value within the Process data variant ID value range.
一旦模块具有有效的测量值，此字节的值就会更改为进程数据变量ID值范围内的值。

Initial startup of the module 模块的初始启动

在模块第一次启动或重启之后，配置参数将被传递到模块。您可以在硬件配置的参数中预置进程数据变量。在输出数据(字节0)中选择一个不同的进程数据变量之前，此变量一直有效。程序可以使用此方法控制程序可用的进程数据类型。

After the first startup or restart of the module, the configuration parameters are transferred to the module. You can preset a Process data variant in the parameters of the hardware configuration. This variant remains in effect until a different Process data variant is selected in the output data (byte 0). Your program can use this method to control the type of process data available to your program.

The Process data variant defined in parameter data record 128 is used under the following conditions:

- A "0" is written in byte 0 in the output data of a Process data variant.
- Byte 0 in the output data of a Process data variant contains an invalid value:
  - Code for the Process data variant not available

    or
  - Available address space is not sufficient for the selected Process data variant.

    See "Module version options (Page 26)".

Measured values of electrical current become "0" 电流测量值变为“0”

The electrical current and all other measured values based on it are suppressed (or set to "0") in the data records and in the process data in the following cases: 测量值变为0的原因

- Incoming current is less than the configured "Low limit electrical current measurement" parameter 输入的电流小于配置的最低电流
- Incoming secondary current at the channel is higher than 12 A 输入的二次侧电流大于12A

The following measured values and derived measured variables of the phase involved become "0":

- Effective electrical current value
- Active power
- Reactive power
- Apparent power
- Neutral conductor current
- Phase angle
- Power factor

A floating mean value is formed from the power values. These only become "0" after a time delay. The operating hours counter and the energy counter for active, reactive and apparent energy of the reset phase stops counting.

Substitute value behavior

The SM 1238 Energy Meter 480VAC provides the substitute value "0" to S7-1200 CPU inputs.

6.2 Quality information 质量信息

Introduction

The SM 1238 Energy Meter 480VAC supplies quality information about the measurements in a status word. This information can be used to evaluate:

- Currents (I_{L1}, I_{L2}, I_{L3}) and voltages (U_1, U_2, U_3) lie within the valid measuring range
- Operating voltage to electrical current phase angle quadrants for each of the 3 phases 工作电压对电流相位角的象限为每三个阶段
- Direction of rotation of a 3-phase system 三相系统的旋转方向

Quality information for 3-phase system

The module saves the quality information in the measurement value ID 65503 as a bit string in 2 bytes.

You can access the quality information via:

- Process data variant "Quality values three-phase measurement (ID 240 or $F0_H$)
- Process data (measured value ID 65503)
- Measured value data record 150

In addition, you can evaluate the quality information in byte 1 in all the Process data variants.

Quality information for individual phases

You can also evaluate the quality information for individual phases in the measured value data records DS 147, DS 148, and DS 149. You can obtain the phase-specific quality information under:

- Measured value ID 65500 for Phase 1 (Channel 0).
- Measured value ID 65501 for Phase 2 (Channel 1).
- Measured value ID 65502 for Phase 3 (Channel 2).

In contrast to the measured value 65503, the measured values with IDs 65500, 65501, and 65502 contain only the phase-specific information for current, voltage, and operating quadrant. The information about the other phases and the rotating field direction have the value 0. 与实测值65503相比，IDs为65500、65501和65502只包含电流、电压和工作象限的相位特定信息。其它相位和旋转场方向的信息为0。

Structure of the quality information 质量信息的结构

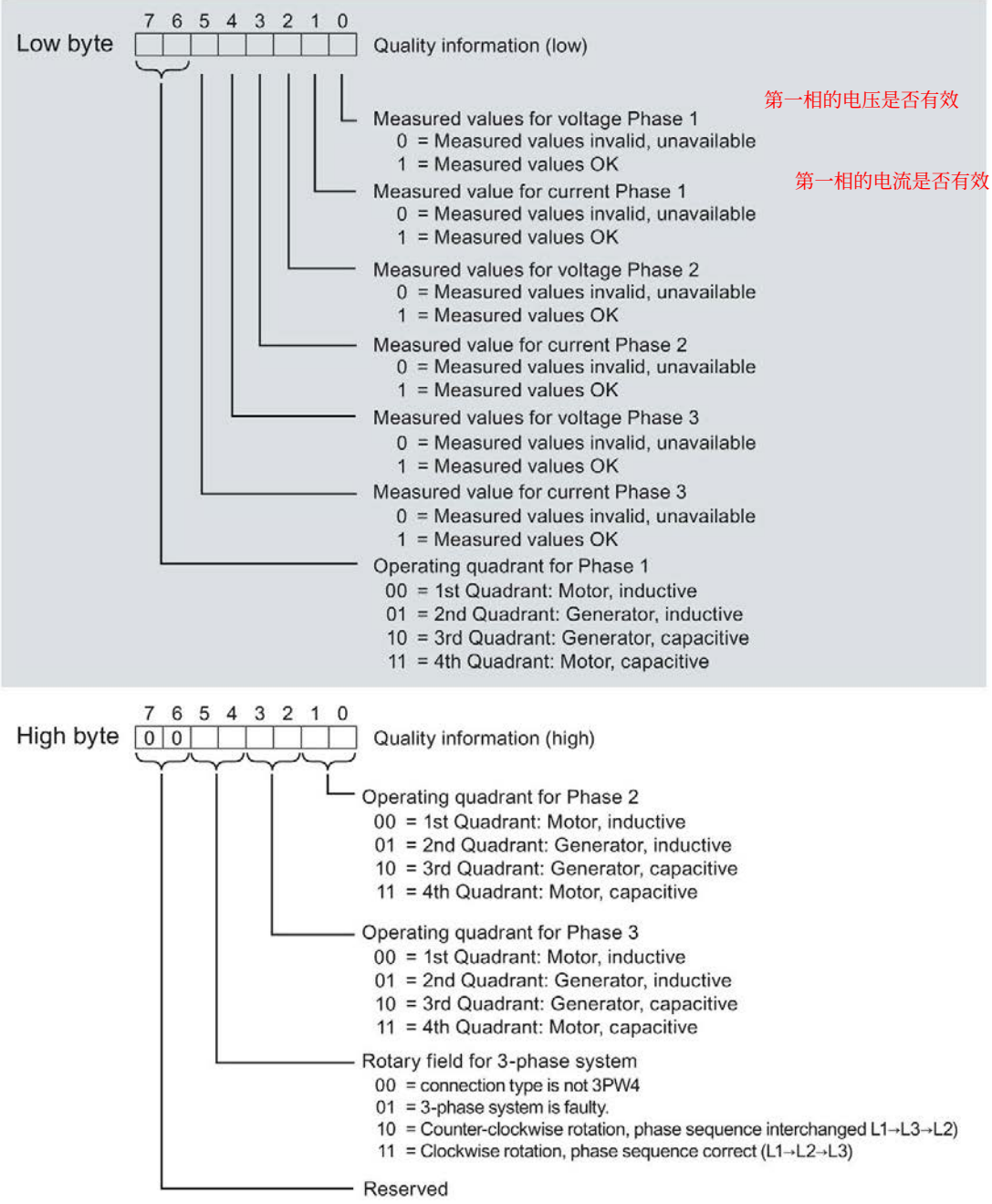


Figure 6-1 Quality data structure