Measurement Concepts

This section contains basic concepts, generally adapted from the ISO/IEC, *International Vocabulary for Metrology – Basic and General Concepts and Associated Terms* (VIM), 3rd edition, ISO/IEC Guide 99:2007.

1 Basic Quantity Concepts

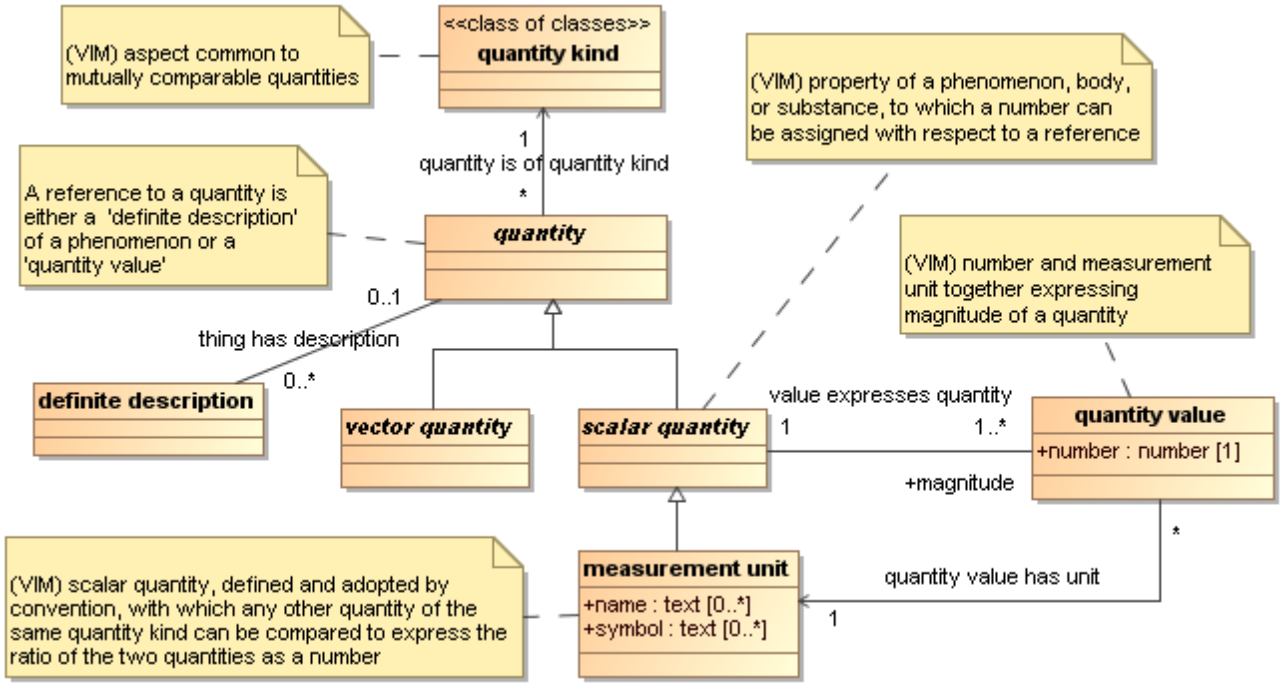

Figure 1: Quantities

quantity

Definition: a scalar quantity or a vector quantity

scalar quantity

Definition: property of a phenomenon, body, or substance, to which a number can be assigned with respect to a reference
Source: VIM [1.1, 'quantity']

vector quantity

Definition: a vector whose components are scalar quantities
Source: VIM [1.1, Note under 'quantity']

quantity kind

Definition: aspect common to mutually comparable quantities
Source: VIM [1.1, 'kind of quantity']
Concept Type: class of classes

Note: Each quantity kind is a subclass of quantity, with the property that all instances of that subclass are mutually comparable, and the further property that instances of any other quantity kind are not comparable to them.

Note: Not all subtypes of quantity are quantity kinds.

quantity *is instance of* quantity kind

Necessity: Each quantity *is an instance of* exactly one quantity kind.

measurement unit

Definition: scalar quantity, defined and adopted by convention, with which any other quantity of the same quantity kind can be compared to express the ratio of the two quantities as a number

Source: VIM (1.9, 'measurement unit')

measurement unit *has name* text

Possibility: Each measurement unit may *have* zero or more *names* .

measurement unit *has symbol* text

Possibility: Each measurement unit may *have* zero or more *symbols* .

quantity value

Definition: number and measurement unit together expressing magnitude of a scalar quantity

Source: VIM [1.1, 'quantity value']

quantity value *has* number

Necessity: Each quantity value *has* exactly one number.

quantity value *has* measurement unit

Necessity: Each quantity value *has* exactly one measurement unit.

quantity value *expresses* scalar quantity

Inverse: scalar quantity *has magnitude* quantity value

Possibility: Each quantity may *have* more than one *magnitude* .

2: Systems of Quantities

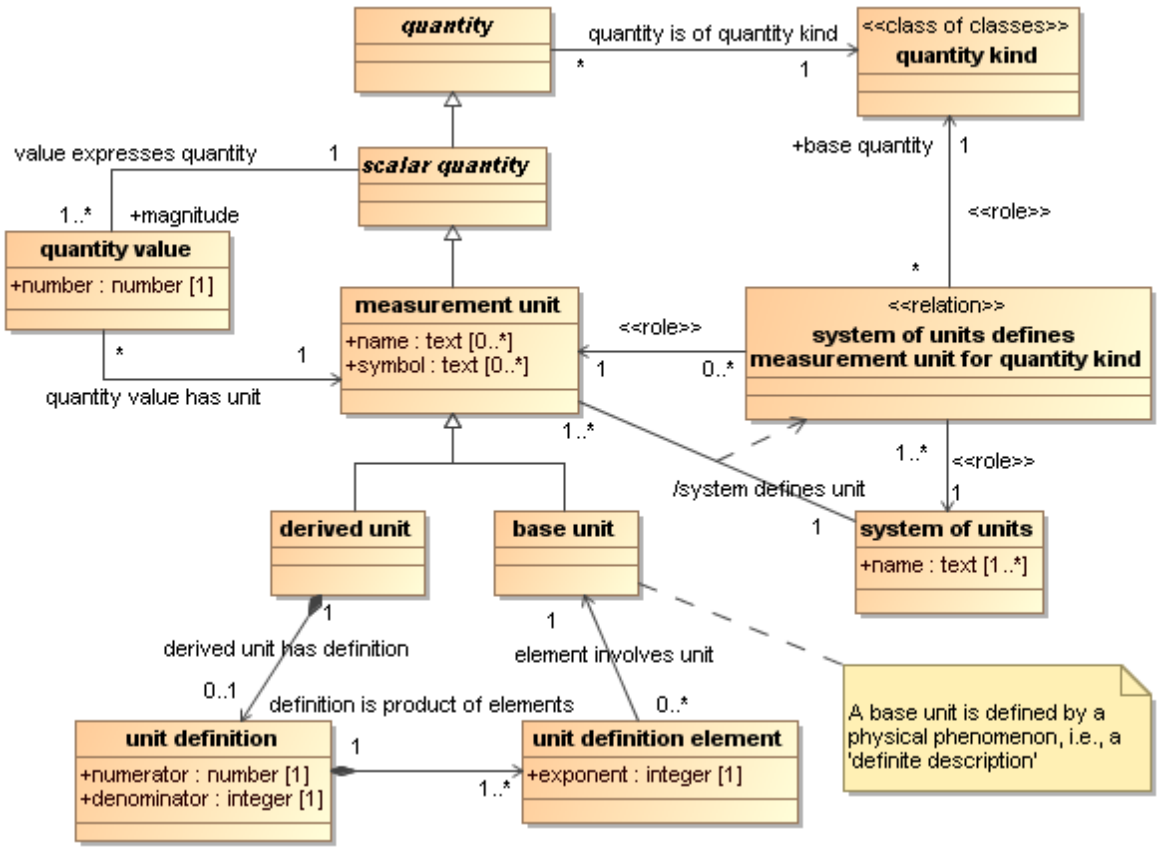

Figure 2

system of quantities

Definition: set of quantities together with a set of non-contradictory equations relating those quantities

Source: VIM (1.9, 'system of quantities')

system of quantities defines measurement unit for quantity kind

Definition: A system of quantities defines a set of "orthogonal quantity kinds" to be its base quantities. For each such base quantity, it defines a reference quantity that is the fundamental measurement unit for that quantity kind

Concept Type: reified (ternary) relation

base quantity

Definition: quantity in a conventionally chosen subset of a given system of quantities, where no subset quantity can be expressed in terms of the others

Source: VIM (1.9, 'base quantity')

base unit

Definition: measurement unit for a base quantity in a given system of quantities

derived unit

Definition: quantity, in a system of quantities, that is defined in terms of the base units of the system
Source: VIM (1.9, 'derived quantity')
Example: In a system of quantities having the base quantities length and mass, mass density is a derived quantity defined as the quotient of mass and volume (length to the third power).

unit definition

Definition: mathematical formula that defines a given derived unit in terms of base units
Note: A unit definition involves a multiplier and technically each of the base units of the system of units to some power. The multiplier must be expressible as an exact rational number, a real number to some specified accuracy, or in certain cases, an exact irrational number (such as pi or the square root of 2).

unit definition element

Definition: a power of a base unit that serves as a "dimension" in a unit definition
Example: metres to the 3rd power (m^3) in the definition of 'stere'

derived unit *has* unit definition

Necessity: Each derived unit *has* exactly one unit definition.
Necessity: Each unit definition *is the definition of* exactly one derived unit.

unit definition *is product of* unit definition elements

Possibility: Each unit definition may *be the product of* one or more unit definition elements
Necessity: Each unit definition element *is in* exactly one unit definition.

unit definition *has numerator* number

Necessity: Each derived unit *has* exactly one *numerator*.

unit definition *has denominator* integer

Necessity: Each derived unit *has* exactly one *denominator*
Note: The denominator may well be 1. But allowing the denominator to be specified separately allows exact rational multipliers to be specified. (It also avoids the issue of whether a decimal fraction is represented exactly.)

unit definition element *involves* base unit

Necessity: Each unit definition element *involves* exactly one base unit.

unit definition element *has exponent* number

Necessity: Each unit definition element *has* exactly one *exponent*.

3 Conversions

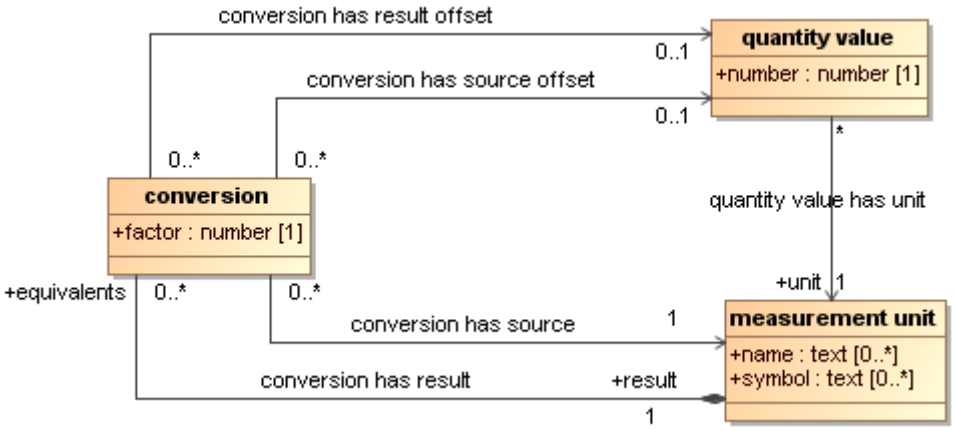

Figure 3

unit conversion

Definition: mathematical formula that relates measurement units in different systems of units

Note: A unit conversion is modeled as a linear equation of the form:

$unit_1 = factor * (unit_2 + offset_2) + offset_1$.

where factor is a real number and each offset is a quantity value in the corresponding system of units.

unit conversion *has result* measurement unit

Inverse: measurement unit *has equivalent* unit conversion

Definition: The unit conversion defines the measurement unit in terms of a measurement unit (possibly derived) in another system of measurements.

Necessity: Each unit conversion *has* exactly one *result*.

Possibility: Each measurement unit *has* zero or more *equivalents*.

unit conversion *has source* measurement unit

Necessity: Each unit conversion *has* exactly one *source*.

unit conversion *has source offset* quantity value

Necessity: Each unit conversion *has* at most one *source offset*.

unit conversion *has result offset* quantity value

Necessity: Each unit conversion *has* at most one *result offset*.