

**Proposed change to the draft of the ninth edition of the SI Brochure**  
**Unit of reactive power**

**Scope**

The motivation for changing the draft of the ninth edition of the SI Brochure is presented and the proposed change is justified and detailed.

**Objective**

To eliminate the dubiousness generated by the IEC adoption of two equal-footing units for the quantity reactive power.

**Introduction**

There are three distinct quantities of interest related to measurements of sinusoidal electric power: active power, apparent power and reactive power. Though all these quantities have the same unit expressed in terms of base units as  $\text{kg m}^2 \text{s}^{-3}$ , electrical engineers need to compute separately each of them when designing electric facilities. To avoid confusion, electrical engineers have historically named differently the units for each of those quantities. The active power is the average energy flow from the utility to the costumer. The unit name of active power is watt (unit symbol W). In fact, it is the actual average power supplied which is consumed in realizing work and dissipating heat. The reactive power is related with the energy that is swapped back and forth between the utility and the costumer facility. It is proportional to the average energy stored in the electric and magnetic fields. The active power does not account for such component since there is no average energy flow related to such component, or in other words, there is no average increase in the energy stored in the costumer facility. The unit name of reactive power is var (unit symbol var). The apparent power is the square root of the squared sum of the previous two power components and provides relevant information concerning the facility size and its short-circuit requirements. The unit name of apparent power is volt ampere (unit symbol V A).

Electric utilities are increasingly interested in measuring separately the active power, reactive power and apparent power. There is increasing concern in taxing separately each of these power components even for the residential costumer. This trend will continue with the advent of smart grids. The electrical instruments to be used should give clear indication on each of these power components so that the costumer knows what is being paid for. As the instrument

readings are designed to help both the utility and the consumer, the instruments provide different units for each of these power components that are widely accepted.

In addition, all National Metrology Institutes who have Calibration and Measurement Capabilities (CMC) published in Appendix C of the Mutual Recognition Arrangement (MRA) and which are capable to perform reactive power measurements publish such services in their CMCs and use the unit symbol var when declaring the related CMC entries.

### Motivation

The quantity reactive power is relevant for national commerce and economics; it is part of legal legislation in developed countries; and it is expected to continue to be used in the future.

National legislations regarding the use of units are in general based on the SI. The SI Brochure has been increasingly adopted as a reference for that purpose. The specific legislations on units are elaborated through international standards which ultimately follow the SI Brochure. The IEC Standard 80000-6 is adopted as a reference in the specific case of electrical units.

The units are arranged in IEC Standard 80000-6 in the following way:

- a) The coherent SI units (i.e. the seven base units and 22 coherent derived units) are given first;
- b) Some non-SI units are then given, being those accepted by the CIPM, or by the OIML, or by ISO or IEC, for use with the SI (such units are separated from the SI units in the item by use of a broken line between the SI units and the other units);
- c) Non-SI units currently accepted by the CIPM for use with the SI are given in small print in a specific column;
- d) Non-SI units that are not recommended are given only in Annexes with only informative character;

IEC Standard 80000-6 lists in its item 6.60 the unit of reactive power in the following way: it regards the unit volt ampere as the coherent derived unit of reactive power and the unit var as a non-SI unit accepted by IEC for use with the SI. So first the unit volt ampere (unit symbol V A) is listed and the unit var (unit symbol var) is listed below it, the two units being separated by a broken line. Note that the IEC Standard 80000-6 asseverates that 'where two or more names or two or more symbols are given for one quantity and no special distinction is made, they are on an equal footing.'

Problems have occurred in at least one country when national governments adopt in their legislation only the coherent derived units listed in SI Brochure. Electrical utilities and instrument manufacturers justifiably refuse to adopt volt ampere for the unit of reactive power. They are prompt to react or ignore any legislation on reactive power measurements based on such unit.

### **Justification**

One could think that this problem should be left for IEC to solve. IEC could perhaps eliminate the unit volt ampere as the coherent derived unit of reactive power in IEC Standard 80000-6 and leave only the non-SI unit var as the unit of reactive power. But this means to change the arrangement of units adopted by that standard and described in the previous section. That arrangement is correct and follows the SI Brochure.

It is here proposed that the draft of the ninth edition of the SI Brochure be changed to consider var as the special name of the unit of the derived quantity reactive power to be listed in its Table 4. That table lists the SI units with special names which can be constructed directly from the seven defining constants. By doing so, IEC Standard 80000-6 would list only one unit for the quantity reactive power and the current problems caused by the listing of two units would cease.

### **Detailed changes to the draft of the ninth edition of the SI Brochure**

Change Table 4 so as to include an additional entry containing the quantity reactive power in its first column as a derived unit with special name and symbol, the special name var in its second column, the expression  $\text{var} = \text{kg m}^2 \text{s}^{-3}$  in its third column and the unit V A in its fourth column. Change the caption of this table to read 'The 23 SI units with special names and symbols'.

Revise section 2.2.4 to replace the references to '22 SI units with special names' by '23 SI units with special names' and the reference to 'the set of 29 coherent SI units' by 'the set of 30 coherent SI units'.