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Krystyn PAWLUK

TIME-RELATED QUANTITIES – CONCEPTS, TERMS AND DEFINITIONS

SUMMARY *A consistent system of concepts pertaining to time--related quantities to be used in electrical technology is nowadays under consideration by the Committee no 1: "Terminology" (TC1) of the International Electrotechnical Commission (IEC). The set of fifteen concepts has been elaborated and it is presented for primary voting and comments of the IEC National Committees. The author would be grateful to the readers for getting detailed observations on the matter.*

1. INTRODUCTION

An ordered system of concepts formed by terms and definitions constitutes, evidently, the main frames for physical and technical sciences. The quantities related to time are widely used but some inconsistency is observed. This is caused by the fact that the concept *time* can be hardly defined and, moreover, many time-related terms existing in common language are not used univocally

Prof. Krystyn PAWLUK
Department of Fundamental Research in Electrotechnics
Electrotechnical Institute

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involving difficulties to apply them into language in science. The activity of international institutions is directed to establish the commonly accepted systems of the concepts that could attain a widespread use in the language of science and technology. In the paper, the new system of time-related concepts recently proposed by the International Electrotechnical Commission (IEC) is presented.

2. IEC STANDARD: 60050-111 PHYSICS AND CHEMISTRY

The International Electrotechnical Commission is an organisation devoted to establish international standards in electrical technology, electronics and telecommunication. Such activity is performed by technical committees (TC). TC1 is this one of them the task of which is to formulate terminological systems for the mentioned branches of technology. The Working Group 100 (WG100) is a group of experts nominated by the National Committees to work inside the TC1 in order to maintain of the five fundamental IEC Standards [1]-[5], to revise and develop them permanently, to follow a progress in science and technology etc.

The considered time-related concepts form part of Standard [2], section 13, items 01-06. The actual Standard has been elaborated in the early part of the last decade. It has been approved by all national committees of IEC voting in favour on the final draft. Only six time-related concepts are given in [2]. Let us present here the five of them; the sixth one is *time constant* and we will not discuss it in this paper. The following concepts, for which we give below the terms in English, French, German and Polish, are considered:

1: time scale, échelle de temps, Zeitskala, skala czasu
System of unambiguous ordering of events in time.

2: instant, instant, Zeitpunkt, chwila
Single point an a *time scale*[1)].

3: date, date, Datum, data
Quantitative expression of an *instant* on a specified *time scale.*
Note – By convention, the date may be expressed in years, months, days, hours, minutes, seconds and fractions thereof.

[1)] Words typed in italics are the terms defined in the previous items.

4: time interval, intervalle de temps, Zeitintervall, przedział czasu
Part of a *time scale* between, and described by, two given *instants.*

5: duration, durée, Dauer, czas trwania
Difference between the extremes *dates* of a time *interval.*

The above concepts have been formally accepted, however recently requests were raised to reconsider them. The German scientists and engineers consolidated in the Joint Working Group on Fundamental Concepts of DKE K 111 formulated detailed conception; their common view and suggestions have been recently submitted to the IEC experts. The German colleagues would like to have the concepts *events* and *time scale* precisely defined and they observe, too, that there should be clearly mentioned that *time interval*, not being in fact a physical quantity, should have an appropriate definition.

The TC1/WG100 considered the problem at the meeting in Bologna (in April 2000). New proposals were prepared in form of a draft of an amendment to the standard [2] substituting the above five concepts by the nine ones and to complete them by the ample notes explaining the issue of the proposed terms and definitions.

3. BOLOGNA'S ATTEMPT

The first idea was that the main concept *time* is an ordinary word and therefore it would not be defined what was expressed in the relevant Note. The Bologna's attempt introduced four new concepts: *momentary event, process, time axis, duration*, moreover, some changes were introduced in the previous definitions of the five concepts defined in [2], and finally, the logical sequence of the concepts has been chosen. The new definitions were completed with notes giving additional explanations and examples.

The entire Bologna's proposal is presented bellow; the concepts not occurring in the actual standard [2] are marked here as "new" (just after item numbers); the previous concept numbers, if any, appear in parenthesis:

1: (new) **event, événement, Ereignis, zdarzenie**
Something that happens in time.

2: (new) **momentary event, événement momentané, Momentanereignis, zdarzenie chwilowe**
Event that is considered as having no temporal extension.

3: (new) **process, processus, Prozess, przebieg**
Sequence in time of interrelated *events.*
Note – This definition presents a time-related concept of process. A function-related definition is given in [7].

4: (new) **time axis, axe de temps, Zeitaxe, oś czasu**
Mathematical representation of the succession of *momentary events* in time, permitting an unambiguous ordering of them.
Note – This representation is applicable to classical non-relativistic physics.

5: (2) **instant, instant, Zeitpunkt, chwila**
Single point on a *time axis*.
Note – A momentary event occurs at a specific instant.

6: (4) **time interval, intervalle de temps, Zeitintervall, przedział czasu**
Part of a *time axis* extended from an initial to a final i*nstant.*
Note – A time interval comprises all instants between the two limiting instants.

7: (new) **time scale, échelle de temps, Zeitskala, skala czasu**
Range of values for the quantitative ordering of *momentary events* that are represented on a *time axis.*
Note 1 – A time scale may be chosen as discrete or continuous. An example for a continuous time scale is the universal time co-ordinated UTC, see [8]. Examples for discrete time scales are usual calendars.
Note 2 – A time scale for physical and technical calculations is based on an initial instant together with a unit of measurement.

8: (3) **date, date, Datum, data**
Quantitative expression marking an *instant* on a specified *time scale.*
Note 1 – By convention, the date may be expressed in years, months, days, hours, minutes, seconds, and fractions thereof with respect to the origin of the time scale.
Note 2 – On a discrete time scale two distinct instants may be expressed by the same date.
Note 3 – In practice the term “time” is often used instead of “date”. Examples: function of time, time derivative.

9: (5) **duration, durée, Dauer, czas trwania**
Physical quantity equal to the difference between the *dates* of the final and the initial *instants* of a *time interval.*
Note 1 – The duration is a non-negative quantity.
Note 2 – The period of a time-dependent periodic quantity is a duration that is independent of the choice of the initial instant.

Note 3 – Instead of the term “duration” the terms “time” or “time interval” are often used, but the first one is not recommended and the second one is deprecated because the concept “time interval” has been above defined not as a quantity but as a pair of points on the time axis.

The above presented nine concepts were put for observation of the IEC National Committees. The German, French and Polish NCs sent their own comments that have been considered by TC1/WG100 meeting in Fribourg (in September 2001).

4. FRIBOURG'S DRAFT FOR VOTE

A very important change in relation to the Bologna's attempt is a decision taken in favour of the definition of the concept "time" itself, for which two consecutive definitions have been proposed, see items 1 and 2 below.

The entire Fribourg's draft is presented below[2)]; The concepts not existing in the Bologna's draft are marked here as "new" (just after item numbers); the previous concept numbers appear in parenthesis, if any.

1: (new) **time (1), temps (1), Zeit (1), czas (1)**
Fundamental concept used together with three-dimensional space as a frame to describe the Universe.

2: (new) **time (2), temps (2), Zeit (2), czas (2)**
symb: *t*
Continuous one-dimensional quantity used to express *time (1)* quantitatively.
Note 1. – Time is one of the base quantities in the SI.
Note 2. – In some cases, the term “time” is used instead of some related concepts, e.g. duration, date, etc. Example: “time between failures”, see [6].
Note 3. – Together with a qualifier, "time" is sometimes used for "time interval". Example: “maintenance time”, see [6].

3: (1) **event, événement, Ereignis, zdarzenie**
Something that happens in *time (1)*

4: (new) **instantaneous, instantané, momentan, chwilowy**
Pertaining to an *event* that is considered as having no temporal extension.

[2)] The Polish terms are chosen as terms of the first attempt.

5: (3) **process, processus, Prozess, przebieg**
Sequence in *time (1)* of interrelated *events.*

6: (4) **time axis**
In non-relativistic physics, mathematical representation of the temporal succession of *instantaneous events* along a unique axis.

7: (5) **instant, instant, Zeitpunkt, chwila**
Point on the *time axis.*

8: (new) **simultaneous, simultané, simultan, jednoczesny**
Pertaining to two or more *events* having the same initial *instant* and the same final *instant.*
Note: An instantaneous event may be marked by a specific instant.

9: (6) **time interval, intervalle de temps, Zeitintervall, przedział czasu**
Part of the *time axis* limited by two *instants.*

10: (7) **time scale, échelle de temps, Zeitskala, skala czasu**
Quantitatively ordered set of values which can be attributed to *instants* on the *time axis.*
Note 1 – A time scale may be chosen as continuous, discontinuous or discrete. An example for a continuous time scale is the universal time coordinated UTC, see [8]. Examples for discontinuous time scales are usual calendars. Discrete time scales are used for finite automata describing some digital devices.
Note 2 – For physical and technical applications, a time scale is based on a chosen initial instant together with a unit of measurement.

11: (8) **date, date, Datum, data**
Quantitative expression marking an *instant* by means of a specified *time scale.*
Note 1 – By convention, the date may be expressed in years, months, days, hours, minutes, seconds, and fractions thereof with respect to the chosen origin of the time scale.
Note 2 – On a discontinuous time scale two distinct instants may be expressed by the same date.
Note 3 – For a continuous time scale, the date is the value of the time (2).

12: (new) **calendar date, date de calendrier, Kalendardatum, data kalendarzowa**
Date on a *time scale* consisting of an origin and a succession of days, where consecutive days are grouped together in various periods.
Note 1 – In a usual calendar, each day extends from one midnight to the next midnight for the standard time at a given location.

Note 2 – In a usual calendar, a calendar date is expressed by a triple numbers consisting of the number of the year, of the number of the month within this year and on the number of the day within this month.

13: (new) **clock time, temps d'horloge, Uhrzeit, czas zegarowy**
Quantitative expression marking an *instant* within a day by duration elapsed after midnight in standard *time* at a given location.
Note – Usually, clock time is represented by the number of hours elapsed after midnight, the number of minutes elapsed after the last full hour, the number of seconds elapsed after the last minute, with decimal parts of a second if necessary.

14: (9) **duration, durée, Dauer, czas trwania**
symb: *t*
Non-negative physical quantity attributed to a *time interval*, with the value equal to the difference between the *dates* of the final and the initial *instants* of the *time interval.*
Note 1 – Different time intervals may have the same duration, e.g. the period of a time-dependent periodic quantity is a duration that is independent of the choice of the initial instant.
Note 2 – Instead of the term "duration" the terms "time" or "time interval" are often used, but the term "time" is not recommended, and the term "time interval" is deprecated to avoid confusion with concept of time interval.

15: (new) **accululated time, total duration, addierte Zeit, czas sumaryczny**
Sum of the *durations* of time *intervals* characterized by specified conditions over a given *time interval.*
Note – The time intervals related to the different durations may overlap each other or not. Example for non-overlapping time intervals: accumulated down time, see [6]. Example for overlapping time intervals: maintenance man-hours, see [6].

5. FUTURE STANDARDIZATION PROCEDURE

A Fribourg's draft of the time-related concepts presented in the paper should be, very soon, submitted for vote of the IEC National Committees. In the case of majority of positive votes for the Fribourg's draft, the IEC will prepare the final draft of an international standard and, after getting final positive voting,

the special Amendment to [2] will be issued. There is the duty of the (Polish) Commission for Standardisation Nr 8 *Terminology* to express the adequate observations on the matter: to vote in favour of the draft or not.

The author would be delighted to get detailed opinions from various scientist and engineer circles on the merits of the presented time-related concepts, on their terms and definitions. It should be decided, whether the draft may be accepted at all and the given concepts are sufficient for phenomenological description of the base events in the field of electrical technology, electronics and telecommunication.

6. FINAL REMARCS

More then hundred IEC terminological standards form an assembly under common title *International Electrotechnical Vocabulary* (IEV). The time-related concepts proposed by the Fribourg's draft should be included into the IEC Standard [2]. The Standards [1-5] form a group of the five basic IEC terminological standards of the IEV. "Basic" means that the concepts of this group are widely used in electrical technology, electronics and telecommunication. It is not a general idea to transfer a totality of time-related concepts used in physics into the Standard [2]

A concept *standard time* used in the definition of item 13 *clock time* in the Fribourg's draft is a local mean solar time depending upon longitude. Until 1928 the standard time of the zero meridian was called *Greenwich Mean Time (GMT).* In the time being, the term *Universal Time (UT)* adopted by the International Astronomical Union (IAU) is in use. The concept *standard time* should be probably included into the second draft of the time-related quantities.

Many particular time-related concepts are used in the field of a wide-world coordination of time and time measuring as well as to assure a faultless telecommunication at long-distance, first of all the satellite telecommunication. Some of them are defined in particular parts of IEV (group 700), other ones were standardized by specialized international or regional organizations. For instance, the concept of *Universal Time Coordinated (UTC)* mentioned in Note 1 to item No 10 of the Fribourg's draft is defined in the Standard [8] as a particular time scale.

Let us remember here the definition established by the *Conférence Générale des Poids et Mesures (CGPM)* of the SI unit of time *second* that is equal to the duration of 9 192 631 770 periods of the radiation corresponding to the

transition between the two hyperfine levels of the ground state of the caesium-133 atom – see [2]. Nowadays, the time scale *International Atomic Time (TAI)* is based on about six caesium standards that operate continuously or periodically on this caesium frequency.

In last decade, the *Global Positioning System (GPU)* that is the system of satellite navigation has been introduced. It makes possible to coordinate and measure time with extremely high accuracy of a few nanoseconds for the inter-continental distance. There is established the *GPS time* as a continuous time scale related to the UTC.

In relativistic physics and in exploration of the cosmos the time-related concepts need special consideration. The concepts *simultaneous* or *time axis* have relative meaning. In modern time coordination the relativistic contribution should be also taken into account. For instance, a clock that displays the international atomic scale on Earth reveals periodic, relativistic deviations from dynamical scale *Barycentric Dynamical Time (BDT)* – see [9].

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WIELKOŚCI ZALEŻNE OD CZASU – POJĘCIA, TERMINY I DEFINICJE

K. PAWLUK

STRESZCZENIE *Komitet Nr 1: Terminologia (TC1) Międzynarodowej Komisji Elektrotechnicznej (IEC) zajmuje się obecnie opracowaniem logicznego i pełnego systemu terminologicznego obejmującego pojęcia związane z wielkością fizyczną "czas". Podany tutaj zbiór piętnastu pojęć został opracowany w formie projektu i zostaje skierowany do pierwszego głosowania i zaopiniowania przez Komitety Krajowe IEC. Autor byłby bardzo zobowiązany za otrzymanie od czytelników szczegółowych uwag dotyczących zaproponowanego zbioru pojęć.*

Prof. Krystyn Pawluk was born in 1926; he received the M.Sc. and El. Eng. degree (1951), and later the Ph.D. degree (1959) from the University of Mining and Metallurgy in Cracow. He became habilitation from the Electrotechnical Institute in Warsaw (1974) and the title of professor in 1979.

In 1951...1961 – assistant-professor at the Department of Electric Machines in the University of Mining and Metallurgy in Cracow, in 1961...1980 – research-engineer at the Department of Electric Machines in the Electrotechnical Institute in Warsaw 1981...1983 – assistant-professor at the Intitut Agronomique et Vétérinaire de l'Université de Mohammed V in Rabat, Morocco, since 1983 – professor at the Department of Fundamental Research in Electrotechnics in the Electrotechnical Institute in Warsaw; at present, he takes a post of substitute of head of the Department. Since 1985, prof. Pawluk has been nominated an expert of the Polish Committee of Standardisation at the International Electrotechnical Commission and he takes continuously part in works of the IEC committees and working groups: No1 – Terminology, No 25 – Quantities and Units. He is also a president of the national commission of standardisation for terminology and units in electrical engineering. Prof. Pawluk is a member of steering committees of the internatinal conferences:

- International Symposium of Electromagnetic Fields in Electrical Engineering, bi-annual meetings in various countries of Europe,
- International Seminar on Fundamentals of Electrotechnics and Circuit Theory, annual meetings in Poland.

Prof. Pawluk develops large research activity: project leaderships, heading of laboratories, he is the author of numerous scientific works (about 150 bibliographic items), conference reports, reviewing of scientific works, opponent of doctor thesis, etc. His main research field is the following:

- electric machines, in particular synchronous machines: measurement of transient quantities, dynamic behaviour and design of turbo-generators and motors,
- electric and magnetic fields in objects of electrical technology; boundary element method, inverse problems, stationary and quasi-stationary fields,
- terminology and units in electrical technology.