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The IEEE Standard on Transitions, Pulses, and Related Waveforms, Std-181

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Abstract – The IEEE has revised the now withdrawn IEEE standards on pulse techniques and definitions. This revision includes adding and deleting definitions, clarifying existing definitions, providing examples of different waveform types, updating text to reflect electronic computation methods, and incorporating algorithms for computing waveform parameters.

I. INTRODUCTION

The Subcommittee on Pulse Techniques (SCOPT)[1] of the IEEE Technical Committee 10 (TC-10, Waveform Measurement and Analysis) has, since 1996, been in the process of writing a new standard on terms, definitions, and algorithms for describing and computing waveform parameters that is based on two withdrawn IEEE standards, IEEE STD-181-1977, Standard on Pulse Measurement and Analysis by Object Techniques[2], and IEEE-STD-194-1977, Standard Pulse Terms and Definitions[3]. These withdrawn IEEE standards were adopted in 1987 by the International Electrotechnical Commission and are the IEC 60496-2, Pulse Techniques and Apparatus, Part 2: Pulse measurement and analysis, general considerations[4], and IEC 60469-1, Pulse Techniques and Apparatus, Part 1: Pulse terms and definitions[5]. The proposed standard, the P181, has been recently unanimously approved, without change, by the voting members of the P181 balloting committee. The final step in becoming an official IEEE standard will be a vote of approval from the IEEE Standards Association Review Committee.

The purpose of the standard is to facilitate accurate and precise communication concerning parameters of transitions, pulses, and related waveforms and the techniques and procedures for measuring them. Because of the broad applicability of electrical pulse technology in the electronics industries (such as computer, telecommunication, and test instrumentation industries), the development of unambiguous definitions for pulse terms and the presentation of methods and/or algorithms for their calculation is important for communication between manufacturers and consumers within the electronics industry. The availability of standard terms, definitions, and methods for their computation helps improve the quality of products and helps the consumer better compare the performance of different products. Improvements to digital waveform recorders have facilitated the capture, sharing, and processing of waveforms. Frequently these waveform recorders have the ability to process the waveform internally and provide pulse parameters. This process is done automatically and without operator intervention. Consequently, a standard is needed to ensure that the definitions and methods of computation for pulse parameters are consistent.

The purpose of our paper is to introduce the new IEEE standard by extracting the key and most technologically important terms and presenting their definitions and associated algorithms, if available.

II. PROBLEM DEFINITION

The SCOPT is comprised of an international group of electronics engineers and physicists with representatives from national metrology laboratories, national science laboratories, the test instrumentation industry, and academia. The SCOPT meets two to three times a year to discuss terms describing waveform parameters, the definitions of theseterms and, if appropriate, algorithms for calculating values for those parameters. Interested knowledgeable parties are welcome and encouraged to participate in the balloting process (please contact the IEEE TC-10 chairman).

III. RESULTS

The new standard contains approximately 100 definitions. The defined terms appear in bold and are immediately followed by their definitions, within quotations, as taken from the P181. A description of the term follows the definition. The word "clause" used herein refers to the clause of the P181. If applicable, the algorithm for calculating the value of the parameter is given, as quoted from the P181.

Signal - "A signal is a physical phenomenon that is a function of time."

This describes what is being measured and, as will be seen, is distinguished from a waveform.

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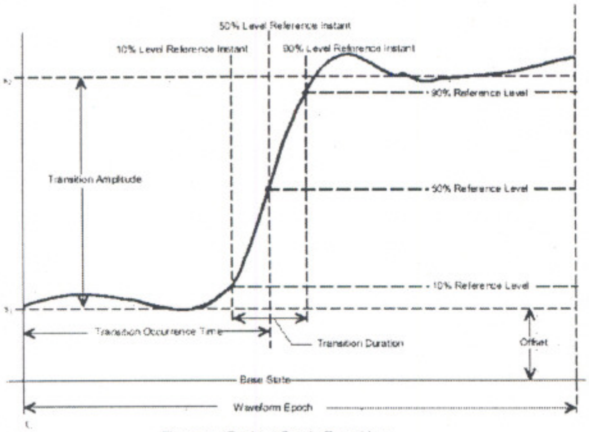

Figure 1. Positive Single Transition

Figure 1. Positive-going transition.

Waveform - "A waveform is a representation of a signal (for example, a graph, plot, oscilloscope presentation, discrete time series, equations, or table of values). Note that the term waveform refers to a measured or otherwise-defined estimate of the physical phenomenon or signal."

Waveforms (see Figure 1) are the things that are actually observed, acquired, and analyzed.

Compound Waveform – "A waveform which may be completely represented by *m* states and *n* transitions where $(m + n) = 4$. Any compound waveform can be parsed into *n* two-state waveforms."

Compound waveforms are any waveforms that consist of more than two states, a high state and a low state, and more than one transition. Clause 5.5 of the Standard provides an algorithm for separating the waveform into a series of two-state waveforms from which all the defined parameters may be computed.

State - "A particular level or, when applicable, a level with an associated upper and lower state boundary. Unless otherwise specified, multiple states are ordered from the most negative level to the most positive level, and the state levels are not allowed to overlap. The most negative state is called state 1. The most positive state is called state n. The states are denoted by s_1, s_2, ..., s_n; the state levels are denoted by level(s_1), level(s_2), ..., level(s_n); the upper state boundaries are denoted by upper(s_1), upper(s_2), ..., upper(s_n); and the lower state boundaries are denoted by lower(s_1), lower(s_2), ..., lower(s_n). States, levels, and state boundaries are defined to accommodate pulse metrology and digital applications. In pulse metrology, the levels of a waveform are measured and states (with or without associated state boundaries) are then associated with those levels. In digital applications, states are defined (with state boundaries) and the waveform values are determined to either lie within a state or not."

This term is important because all level (voltage, current, etc.) related parameters, such as amplitude, overshoot and undershoot, etc., are based on the states of a waveform. In the withdrawn standards, the word "line" was used to describe the value corresponding to the nominally constant-valued regions of a waveform. Terms such as "topline" and "baseline" (or "bottom line") were used. "Line" is a graphical description and not an appropriate term for electronic computation of waveform parameters or for describing the output of a physical device. The term presented in the Standard is "state." State is also consistent with the description of constant-valued currents or voltages from the output of actual electronic devices. States are numbered starting at the most negative and ending at the most positive, and are designated by s_1, s_2, ..., s_n, where s_n is the most positive state and s_1 is the most negative state for an n-state waveform. For example, the waveform shown in Figure 1 is a two-state waveform. Each state has an associated level which describes the value (number with units) for that state. For example, the two-state waveform in Figure 1 can have s_1= 0 V and s_2= 0.25 V. Associated with a state are upper and lower boundaries, and a waveform is said to be in this state if its values are within these boundaries for a user specified duration. The difference between the upper boundary and lower boundaries can be different for each state.

The standard provides and/or identifies several methods for determining the levels associated with a state. Those methods include those based on histogram methods (three are described), the extreme waveform values, the final and initial waveform values, user-defined values (which should be based on the user's knowledge of the device under test), static levels (if the pulse source can also output dc values to the same connector from which comes the output pulse), and auxiliary waveforms (in the case where there is insufficient data in one waveform to compute all the desired waveform parameters). The histogram techniques may use different bin sizes and the user may select if the histogram modes, means, or medians will be used. The effect of different histogram implementations have been described elsewhere [7]. This study does show that only for pathological cases will there be noticeable difference between results from the different methods.

Waveform Amplitude - "The difference between the levels of two different states of a waveform."

The Standard contains two subordinate definitions, one for signed waveform amplitude and the other for unsigned waveform amplitude. The latter is the absolute value of the former. The amplitude of a waveform is the waveform parameter from which all other level parameters are computed and from which most time parameters are computed.

Algorithm:

"(1) Determine s_1 and $s_2$using a method described in Clause 5.2 of the Standard.

(2) The waveform amplitude, A, is the difference between level(s_2) and level(s_1)

(2.1)For positive-going transitions, A is given by:

A= level(s_2) – level(s_1).

(2.2)For negative-going transitions, A is given by:

A= level(s_1) – level(s_2)."

Transition Occurrence Instant - "The first 50 % reference level instant (see Clause 5.3.3.1), unless otherwise specified, on the transition of a step-like waveform" (see Figure 1). These are the instants in the waveform at which the transitions are referenced. This parameter is necessary, for example, for determining pulse duration and transition duration.

Algorithm:

"(1) Calculate the reference levels as described in Clause 5.3.2.

(2) Calculate the reference level instant for $y_{x\%}$ using linear interpolation:

$$t_{x\%} = t_{x\%-} + \left(\frac{t_{x\%+} - t_{x\%-}}{y_{x\%+} - y_{x\%-}}\right)\left(y_{x\%} - y_{x\%-}\right),$$

where $t_{x\%-}$ and $t_{x\%+}$ are two consecutive sampling *instants* corresponding to data nearest in value to $y_{x\%}$ such that $y_{x\%-} \leq y_{x\%} \leq y_{x\%+}$. If there is more than one reference level instant, the reference level instant closest to the 50 % reference level instant (see Clause 5.3.3.1) is used, unless otherwise specified. " The reference levels are not necessarily the same as the state levels. For example, the 20 % reference level does not coincide with a state level whereas the 0 % reference level typically does and is the low state of the waveform.

Transition Duration [Risetime, Falltime, Leading Edge, Rising Edge, Trailing Edge, Falling Edge, Time, Transition] - "The difference between the two reference level instants of the same transition (see Figure 1). Unless otherwise specified, the two reference levels are the 10 % and 90 % reference levels. [The terms risetime, falltime, and transition time, although widely used, are deprecated because they are ambiguous and confusing. First, the use of the word time in this standard refers exclusively to an instant and not an interval. Also, if the first transition of a waveform within a waveform epoch happens to be a negative transition, some users may refer to its transition duration as its risetime, and some others may refer to its transition duration as its falltime. If the use of these deprecated terms is required, then risetime is synonymous with the transition duration of a positive-going transition, and falltime is synonymous with the transition duration of a negative-going transition. If the upper and lower state boundaries of the two states are not the user-defined reference levels (for example, the 10 % and 90 % reference levels), then the duration of a transition is not equal to the transition duration.]"

This is the most commonly quoted, referenced, and measured waveform parameter. The bandwidth of an instrument is often approximated by the equation: $BW \approx 0.35/t_d$, where BW is bandwidth and t_d is transition duration.

Algorithm:

"(1) Calculate the reference level instant, $t_{x1\%}$, for the x1% reference level in accordance with Clause 5.3.3 that is nearest to the 50 % reference level instant, unless otherwise specified.

(2) Calculate the reference level instant, $t_{x2\%}$, for the x2% reference level in accordance with Clause 5.3.3 that is nearest to the 50 % reference level instant, unless otherwise specified.

(3) Calculate the transition duration, $t_{x1\%-x2\%}$:

$$t_{x1\%-x2\%} = \left|t_{x1\%} - t_{x2\%}\right|."$$

IV. SUMMARY

The IEEE SCOPT has revised the withdrawn IEEE standards, Std-181 and Std-191, on pulse techniques and definitions. This revision includes adding and deleting definitions, clarifying existing definitions, providing examples of different waveform types, updating text to reflect electronic computation methods, and incorporating algorithms for computing waveform parameters. The draft standard has been approbed by the IEEE balloting committee. Acceptance of the draft standard as an official IEEE standard awaits approval by the IEEE Standards Board Review Committee.

REFERENCES

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