Rapport BIPM-81/10

BIBLIOGRAPHY ON PULSE PILE-UP EFFECTS

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Bibliography on pulse pile-up effects

Abstract

A bibliography has been assembled of 170 references which refer to pulse pile-up effects, correction methods and related subjects. It includes publications from 1946 to 1981 in the form of a simple list of papers (with full titles) according to the year of publication and the name(s) of the author(s).

Introduction

The intercomparison of high-count-rate ^{60}Co sources (77 Smi), organized in 1975 by the National Physical Laboratory, Teddington, on behalf of the Bureau International des Poids et Mesures, Sèvres, has had the effect of drawing the attention of statisticians to the difficult problem of the counting corrections in a coincidence channel. Subsequently, the exact solution for an ideal coincidence system was found and published (77 Cox). The knowledge of this solution allowed metrologists to suggest possible explanations for the remaining discrepancies between measured and expected activities. In particular, pile-up of pulses could cause significant distortion of the timing information in certain types of equipment used in coincidence measurements. Although pile-up problems have been known for many years, they do not seem to have been considered until quite recently as an important possible cause of error in absolute actitivy measurements (81 Fur).

For this reason the BIPM Working Party "Principles of the Coincidence Method", a subgroup of Section II (Mesure des Radionucléides) of CCEMRI (Comité Consultatif pour les Etalons de Mesure des Rayonnements Ionisants), decided to assemble a bibliography of the publications dealing with pulse pile-up effects. As a first step a working document including 87 references was produced in 1978. In the present list 83 new references have been added, most of which were published in the past four years. This growing interest in pulse pile-up (sometimes also referred to as random summing) is probably due to the still increasing use of nuclear spectroscopy, in particular in radioanalytical chemistry. Numerous experiments in radioactivation analysis, Rutherford backscattering and particle-induced x-ray emission, which include more-or-less developed treatments of pile-up, have been published. In related fields we find such applications as photon counting in fluorescence-lifetime measurements and photon imaging (scintillation camera). In all these areas a common feature is the distortion of information due to events which follow each other too closely in time to be separated. This can then lead to the following effects:

1. loss in the counting of detected events,
2. distortion of the pulse amplitude,
3. distortion of the time information.

The subject most often treated refers to item 2, where we can distinguish between two quite different approaches. The first one (more important as to the number of articles) relates to instrumental improvements which include the widely used pile-up rejection circuits, whereas the second one deals with calculated corrections. The distortion of the amplitude spectrum (as measured by a multichannel analyzer), for input pulses having a constant or a Gaussian amplitude distribution, is analysed in 63 Sou, 64 Jas, and more recently in 75 Bla. The more difficult problem of correcting complex realistic amplitude spectra by using mathematical methods (convolution, least squares or successive approximations) and computer techniques is treated in 64 Ken, 65 Sou, 76 Wie and 77 Gar. Reviews of the instrumental methods used to avoid the registration of distorted pile-up pulses (68 Bla, 74 Nic) reveal that there are essentially three different methods, all of which lead to the production of a blocking signal when pile-up occurs, but accept the pulses if no pile-up is detected. These methods (which differ in the way the blocking is produced) can be summarized as follows:

- the zero-crossing time shift of bipolar pulses (66 Fus),
- coincidence between narrow direct pulses, and stretched and delayed pulses from the same detector (65 Wei),
- comparison of the shaped pulse with its second derivative (71 Sab).

The problem of the determination of the true count rate (item 1) has been treated in 77 Ros. A proposed solution is the well-known pulser method (69 And, 71 Deb, 77 Deb) and its extension to the case of a decaying source (70 Bol). A new system using a fast computer technique, allowing real-time compensation of dead-time and pile-up losses, is described in 77 Wes and 79 Wes. As for item 3, although the problem of timing distortions has been considered by several authors (66 DeL, 67 Bla, 77 Smi), the number of articles devoted to this problem remains small.

Although the number of collected references is already quite large for such a narrow subject, it is possible that important papers have escaped our attention. We would therefore appreciate receiving any suggestions for additions and corrections which could be incorporated in a possible later edition of this report.

The bibliography presented in the following pages results from a pooling of the partial lists submitted by the following members of the Working Party:

J.W. Müller, Bureau International des Poids et Mesures, Sèvres (France), coordinator of the Working Party,

J.G.V. Taylor, Atomic Energy of Canada Limited, Chalk River (Canada), and

J.-J. Gostely, Ecole Polytechnique Fédérale, Lausanne (Switzerland), editor of this report.

Apart from the contributions of the members, the editor has received a list from W. Bambynek (BCMN, Geel). The assistance of M. Furrer (EPFL, Lausanne) in collecting and evaluating the articles is gratefully acknowledged.

J.-J. Gostely

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