A GUIDE TO THE

Use and Calibration
of Detector Array
Equipment
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of Detector Array

Equipment

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INTRODUCTION

The original version of this user guide appeared in March 2000 and resulted from a program of work sponsored by the National Measurement System Policy Unit (NMSPU) of the U.K. Department of Trade and Industry (DTI). The aim was to benefit industry by identifying the factors influencing the accuracy of measurements obtained with detector array equipment, by developing calibration techniques, and by establishing best practice procedures. It was written primarily for users of instrumentation rather than for detector specialists, and produced as a booklet mainly for small-scale distribution within the U.K. Hopefully, however, the guide has enough detail that even these “experts” will find it useful.

The reception to the original version was extremely favorable and we were therefore encouraged to make it more widely available. In revising the guide for a more worldwide readership, we have tried to leave the majority of the text intact, but to remove those parts that were felt to be overly U.K.-centric.

We also took the opportunity to bring the guide up to date by adding brief sections on electron multiplying (EM) CCDs for low-light-level imaging and on lag effects in CMOS active pixel sensors (APS). The list of references has also been revised and significantly extended. The original guide contained many references to information available via the Web. These have been checked and updated where necessary, and it is hoped that the book will carry on being an up-to-date reference guide for users of detector array instrumentation for a considerable time to come.

Solid state imaging arrays have many advantages as sensors of optical radiation compared with discrete, single-element detectors. For example, the large number of elements gives fine spatial sampling when imaging and a reduction in the measurement time when performing spectrometry. On the other hand, the large number of pixels and the complexity of array structures lead to special issues for measurement and calibration; issues which, until now, have not been addressed in any systematic way. These can arise both for the developer of array-based instrumentation (who wishes to specify, measure, and predict detector performance for his application and to provide an adequate calibration) and for the user (who may wish to assess and maintain the accuracy of his overall system).

At the start of the original study a survey was made, by questionnaire and selected interviews, of U.K. users and manufacturers/developers. This was undertaken with the help of Atkins Management Consultants, with the objective of determining equipment usage and calibration requirements and obtaining views on the preferred content and format of the user guide. Key parameters and calibration methods were then assessed in detail and measurements on typical systems performed. This work culminated in the preparation of this guide, which contains both a review of the existing literature and a large amount of new experimental data (obtained during the course of the work). The main emphasis has been on UV, visible, and near-infrared systems that use silicon detector technology, but an attempt has also been made to address the issues arising in thermal imaging with infrared detector arrays.
An outline of the guide is presented in the table on the following page. In understanding requirements for instrument calibration, it is important to realize that the detector array is not simply a black box that translates optical to electrical signals, but is a complex assemblage in which a variety of physical processes are taking place (for example, optical absorption, charge transport, and noise/dark current generation). Even in detectors for the visible region there are several detector forms, each with its own characteristics; and in the infrared the variety of array technologies multiplies rapidly. Hence, the guide starts (in Chapter 1) with an overview of detector technologies and key performance parameters. It is hoped that Sec. 1.2, which deals with the detailed definition and measurement of detector parameters will be of interest, not only to detector manufacturers and instrument developers, but also to users—first, because many of the techniques described can be used at instrument level (although more detailed guidance for users of array based systems can be found in Chapter 4); and second, since some insight is provided into the dependence of the results on measurement conditions. Chapter 1 also discusses measurement units, which are often a considerable source of confusion.

Chapter 2 gives a brief introduction to the various types of instrumentation that use detector arrays and the requirements for calibration. Chapter 3 discusses in some detail the influence of operating conditions on detector performance. It is these changes in performance which often result in the need for instrument calibration.

Further information on calibration techniques is given in Chapter 4, where there is a special emphasis on the calibration of instruments for spectrometry. Chapter 5 reviews the use of common items of calibration equipment, such as light sources, filters, and ceramic tiles, and gives guidance on the selection of components. Chapter 6 briefly reports on international efforts to harmonize measurement standards.

Each chapter is provided with a list of literature references, which the reader is encouraged to consult for further information. Sources of information of more general interest are included in Appendix A. Throughout the guide, references are made to information available on the Web. Though these resources are somewhat ephemeral (websites and their content may change), the wealth of easily accessible information considerably eases the task of assessing technology trends and sharing standards information. Appendix A also includes a list of abbreviations, and a glossary of terms can be found in Appendix B. Appendix C summarizes the recommended practices for spectrometer and imager calibration in a Quick Guide.

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Teresa Goodman
Stuart Prince
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