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978-0-521-46280-8 - Interfacing the IBM-PC to Medical Equipment: The Art of Serial Communication
R. W. D. Nickalls and R. Ramasubramanian
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As computerisation in the medical environment has increased, so the advantages of storage and computer analysis of data from various monitoring and measuring equipment have become well recognised. Most medical monitoring and measuring equipment now supports an RS-232 serial interface and therefore allows data to be accessed directly by computer as well as enabling the computer to have control in its turn over the monitoring equipment. This book describes the techniques used for interfacing a PC to a range of medical equipment used internationally in the areas of anaesthesia, intensive care, surgery, respiratory medicine and physiology.

Part I addresses the serial interface, including the RS-232 Standard, transmission of data, and an introduction to serial-interface programming using Microsoft QuickBASIC. Part II looks at electrical safety, the use of Kermit and data analysis. Part III considers the practical aspects of interfacing a PC to a wide range of medical equipment and includes example programs.

This essential practical information constitutes a valuable resource for a very broad audience of PC and measurement equipment users in the medical field.

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INTERFACING THE IBM-PC TO MEDICAL EQUIPMENT:

the art of serial communication

R. W. D. NICKALLS
R. RAMASUBRAMANIAN

With invited contributions by

R. J. HALL
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Preface

Most of the monitoring equipment used in hospital medicine has a serial interface, and data can therefore be accessed directly by a PC, processed, and stored on disk. Conversely, many items of medical equipment can also be controlled directly by a PC via the serial interface.

The range of such equipment is growing each year, and currently includes pulse oximeters, non-invasive blood pressure machines, syringe drivers, infusion pumps, spirometers, intravascular oxygen monitors, ventilators, and the comprehensive anaesthesia monitors.

Although most of these devices are extensively used in the fields of anaesthesia, intensive care, and respiratory medicine, there is an increasing use of many of them in other fields. For example, pulse oximeters are now widely used to monitor patients on both medical and surgical wards; they are also beginning to appear in dental clinics. In addition, non-invasive blood pressure monitors and spirometers are appearing increasingly in general practitioner clinics.

However, serial interfacing to such equipment tends to be little used and poorly documented. Furthermore, information regarding the serial interface is widely dispersed throughout a myriad texts and articles.

This book therefore represents an attempt to bring together both the details of serial communication as they relate to an IBM-compatible PC, and the problems associated with interfacing specific items of equipment. Part I addresses the serial interface, including the RS-232 Standard, transmission of data, and an introduction to serial-interface programming using Microsoft QuickBASIC™. Part II addresses a number of related topics, namely electrical safety, analysis of data, and the use of Kermit. Part III considers the practical aspects of interfacing an IBM-compatible PC to a range of equipment found principally in the domains of medicine and physiology, and includes example programs for collecting data and,

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in some cases, for controlling the equipment directly. The Appendices include a glossary, as well as sections on binary and hexadecimal notation, the ASCII code, pin-outs of serial connectors, programming information, key codes, the null modem, and a note on using the freeware package GNUPLOT.

The programs

All programming examples have been written in QuickBASIC 4.5 since not only is it the most popular compiled BASIC, but it is also particularly well suited for measurement and control applications involving the serial interface. In addition, since QuickBASIC is very similar to the interpreted QBASIC which comes as standard with MS-DOS 5.0 or greater, most of the example programs will also run using QBASIC. Furthermore, a QuickBASIC program can be easily modified for use with Visual Basic.

Although an elementary grounding in BASIC programming will be an advantage when reading this book, prior experience with QuickBASIC or QBASIC is not strictly necessary. However, newcomers to programming will need to have a QuickBASIC manual to hand.

All the example programs have been written with the beginner in mind and are fairly simple; they are not meant to be comprehensive '*all singing, all dancing*' programs. They are simply meant to illustrate one way of either accessing data, or controlling a device, and the reader is expected to modify and expand the programs as necessary to suit his/her particular requirement. For example, while an item of equipment may output several groups of data, the example program may well only demonstrate how to access one particular group of data. Each of the example programs is preceded by a series of 'program points' which we hope are useful.

ASCII font for TeX *and* LaTeX

The manuscript was typeset on a 386-PC using Eberhard Mattes' EmTeX implementation of LaTeX. However, since we were unable to find a TeX font which contained all the symbols commonly used to represent the ASCII control characters (☺ ♫ ↨ etc.; see Appendix 1), we were therefore driven to make our own font.

In due course a font compatible with PostScript printers was eventually made, consisting of the 128 standard ASCII characters *including* the usual symbols for all the control characters. Finally, the font was

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uploaded to the TEX CTAN archive (**ftp.tex.ac.uk**) as a package called ASCII (see the directory **/pub/archive/fonts/ascii**) which includes the font in various sizes, together with a LATEX style option called ASCII.STY (Ramasubramanian, Nickalls & Reed, 1993, 1994).

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First and foremost RWDN would like to thank Elisabeth, Frances and Oliver, for their patience and support throughout the evolution of this book. Special thanks are due to Robert Hall, Faisal Jahan, and Justin McCarthy for becoming involved and contributing Chapters 7 and 16. We also thank all the staff at Cambridge University Press who were involved in the publishing process, and the many people from industry who helped with technical information.

We also thank the British Standards Institution, the American National Standards Institute, and Microsoft Corporation, for allowing us to reproduce material from their publications regarding electrical standards, ASCII, and QuickBASIC 4.5 respectively. We also thank D.J. Sapsford, I.D. Somerville and J.G. Jones for allowing us to reproduce one of their compressed spectral array graphs; Bob Winter for suggesting we include a chapter on Kermit; Novametrix Medical Systems Inc. for supplying the photograph used in Chapter 11; and the Department of Medical Photography (City Hospital, Nottingham) for supplying all the other photographs.

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Subsequent editions

It is envisaged that subsequent editions of this book will incorporate new items of equipment as they become available.

R.W.D. Nickalls June 1994
R. Ramasubramanian

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Conventions

Throughout this book the term PC is used to mean either an IBM-PC or an IBM-compatible PC.

Notation

- All numerals are decimal unless qualified by the suffix b (binary) or h (hexadecimal). Occasionally, in order to avoid confusion, a decimal number may have the suffix d.
- Tall anglebrackets ⟨ ⟩ are used to indicate either ASCII control characters or fields.

  The codes used for representing ASCII control characters are those shown in Appendix 1. For example, the Carriage Return and Start of Header control characters are represented as ⟨CR⟩ and ⟨SOH⟩ respectively.

  A field may be part of a received string of data or part of a string to be sent to a peripheral device, and may represent a number or text or an alphanumeric code. In the following example, ⟨command-code⟩ is a variable field which is included in a command string to be transmitted to a peripheral device.

  ⟨ESC⟩VT⟨command-code⟩⟨CR⟩

  Where a field consists of a specific number of *digits*, the size of the field is often indicated by the appropriate number of n's, e.g. nnnn. However, where a field consists of a specific number of *characters* (i.e. either letters or digits) then this is indicated by the appropriate number of x's, e.g. Cxx.
- Shallow anglebrackets <> are used to indicate a key to be pressed. For example, the key 'Q' is represented as <Q>.

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- Throughout this book a 'space' character which is transmitted in a string is represented by the symbol ␣. For example, a device may output a string of 3-digit data fields which are separated by a space; this would be represented as follows.

  nnn␣nnn␣nnn␣

- The symbol ^ is used for Ctrl. For example, Ctrl-Q is written as ^Q.

Programs

- All programs are written in Microsoft QuickBASIC 4.5, and are printed using a `bold face typewriter` font, with QuickBASIC 'key words' being printed in uppercase letters, as follows.

```
buffer$ = INPUT$(LOC(1), #1)
```

- Note that QuickBASIC programs consist of a 'main module' and a variable number of 'subroutines' (often known as subprograms) which are called using the `CALL` statement.
- In program listings some lines are necessarily longer than the page width, in which case they are continued on the next line. However, where this occurs it may not be immediately obvious to those readers not familiar with QuickBASIC. In view of this, the following convention is adopted throughout the book.
  Where program lines are *not* normally indented (i.e. in the main module) then line continuations are printed flush with the right margin as follows.

```
OPEN "COM1:12ØØ,E,7,2,CS,DS,CD" FOR RANDOM ACCESS
                                          READ WRITE AS #1
```

  Where program lines *are* normally indented (i.e. in subroutines) then line continuations are printed to start flush with the left margin as follows.

```
        CALL emptybuffer
        IF s$ = CHR$(6) THEN message$ = "identification
data telegram"
        IF s$ = CHR$(5) THEN message$ = "measured data
telegram"
```

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