The British Broadcasting Corporation Microcomputer
32016 Second Processor

# The British Broadcasting Corporation Microcomputer 32016 Second Processor

The 32016 Second Processor is an extension unit which converts a BBC Microcomputer into a 32 bit computer system suitable for the efficient development and execution of software requiring a large amount of processor power. It is of particular value to professional, scientific, engineering and educational users who require its speed, 256 Kbyte memory, numeric range and precision.

The 32016 Second Processor uses the National Semiconductor 32000 series chip set and includes the floating point chip as standard. This provides 32 bit arithmetic performance, a large uniform address space, and an architecture designed for the efficient compilation and execution of high level language programs.

The operating system PANOS supports the development and execution of high level language programs. A number of software tools are provided to assist developers in writing or porting software effectively; included are five industry-standard high level languages, BBC BASIC, C, FORTRAN 77, Cambridge LISP, Pascal.

PANOS, the operating system provided, has been especially designed and implemented for this product. The design objectives were that it should:
– provide the necessary support for professional users, applications, and software development
– in the modern style, be relatively simple but extensible
– require relatively modest configurations, but take advantage of larger ones
– integrate with BBC Microcomputer hardware and software
– provide a better user interface than possible on a BBC Microcomputer alone.

The high level languages provided have been selected to cover a wide range of application areas.

## Uses and users

The 32016 Second Processor has been designed primarily for professional users who are typically educators, scientists and engineers, rather than for those at home. However, it is expected that increasingly users will select equipment capable of use in both situations. Thus the system has been designed so that, for instance, program source files can be edited on a BBC Microcomputer at home, then compiled on a Second Processor configuration at work.

Typical uses include:
– low cost program development
– low cost scientific and engineering applications including computer aided design (CAD)
– education including computer science education and computer aided learning (CAL)
– running existing applications, in particular off-loading time-sharing systems – running new applications, eg those with computationally demanding or highly interactive loads
– extending applications currently limited by the capability of a BBC Microcomputer even fitted with a 6502 Second Processor.

## How it works

The unit connects to a BBC Microcomputer via the Tube, a high speed bi-directional interface. The resultant system thus comprises two processors operating

concurrently, one dedicated to computation, one to input and output. The configuration can accommodate a wide range of peripherals, in particular those which, either as built-in or optional components, comprise the BBC Microcomputer system. This includes floppy or Winchester disc, memory mapped text and graphics display, keyboard, printer, serial interface, IEEE interface, Econet, etc.

It is the responsibility of the operating system PANOS to manage the input and output resources. The programmer makes i/o requests through a procedural interface forming part of the library, but normally this is hidden from the high level language programmer.

PANOS itself relies on a firmware kernel (called PANDORA). Calls to PANOS are translated and routed through the kernel to the BBC Microcomputer's operating and filing systems such as the MOS, DFS etc. Direct access to the kernel is normally reserved for PANOS or stand alone language systems. This translation within PANOS never takes away functionality; it is either direct or designed to increase convenience to the programmer or user. In this way all normal BBC Microcomputer resources remain available.

Thus, programmers have in general the choice between several levels of interface with the system:
– by the use of standard language specific statements or library calls, eg WRITELN in Pascal
– by calls to the PANOS library which are interpreted by PANOS and partly executed by the MOS, filing system etc, eg BLOCKWRITE
– by calls to the PANOS library which are directly passed on to the MOS etc, eg OSBYTE.

Users normally operate the system by interacting with the PANOS command line interpreter. This has been designed for efficient use by programmers and end users alike. It permits the user to load programs from a suitable backing store/ filing system (eg floppy disc and DFS), and subsequently to execute them. PANOS is stored partly in ROM, but is otherwise loaded from the filing system, either following initialisation or on demand. The command file mechanisms permit developers to tailor applications for particular users.

Full documentation is provided in three manuals. The *32016 Second Processor User Guide* enables new users to install and explore the system without initial recourse to the other two more technical volumes, the 32016 Languages and PANOS user guides. These are published in loose leaf format and supplied with ring binders so that updates and additional sections can be easily incorporated. Note that the *Languages User Guide* assumes familiarity with the language concerned.

Acorn has a policy of strict quality control for both hardware and software. 32016 Second Processor hardware is designed and manufactured to a high standard of reliability and to comply with the appropriate British standards for safety.

32016 Second Processor compilers and operating systems are subjected to a rigorous test programme consisting of some or all internal acceptance tests, certification by international standards bodies, independent audits and extensive field trials. High level languages have been extensively used for implementation of the compilers and operating system.

# A 32 bit high level language architecture

The NS32016 is a full 32 bit architecture in a 16 bit external data bus, 24 bit address bus implementation; it is object code compatible with other processors in the family.

The 32000 series chip set is designed primarily for the execution of high level languages. There is architectural support for integers, floating point, Boolean, bit field and BCD data types; for arrays, records, strings and stacks; and for procedures and modules. This support is achieved through a carefully designed choice of instruction set, addressing modes, registers and dedicated tables. There is a symmetric architecture and a linear address space.

Instructions are of variable length with up to two general operands. Efficient encoding of instructions and displacements results in very compact code. Full 32 bit fixed point arithmetic is possible, ie two 32 bit operands can be operated upon to yield a 32 bit result (a 64 bit result is possible for multiply). The floating point hardware supports either 32 bit or 64 bit operands and results. With minimal software, it is capable of working to IEEE floating point standard.

The designers of the 32000 were not constrained by the need to retain upwards compatibility with existing, much more primitive microprocessor designs. Instead the best ideas were adopted from those of 32 bit super minicomputers and realised in an advanced VLSI implementation.

## A high level language development environment

The software provided with the 32016 Second Processor enables developers to write or port software effectively using a number of industry standard high level languages.

Included with PANOS are a number of modern software tools. The editor is of the full screen type and supports multiple windows. Thus, for example, error messages may be viewed in one window, and source text edited in another. A procedural model of program execution is followed, thus, given sufficient memory, programs may be initiated from the editor and output viewed in another window.

The PANOS library provides developers with a set of common procedures for input and output, for exception handling and so on. Most high level languages through their run time systems rely on this library. Apart from BBC BASIC and Cambridge LISP, which are self contained, all generate a common object code format, AOF (Acorn Object Format), and may be linked together. A cross calling standard permits procedures in one language, including library procedures, to be called from another.

The PANOS command line interpreter supports command files with parameter substitution. The PANOS filing system model extends the normal BBC Microcomputer approach so that a filename may be extended with a filing system name. Filename extensions which provide type information and time/date stamping are both provided. All filing systems are treated uniformly.

All compilers together with the linker are written to take advantage of 32000 architecture, eg the module and link mechanisms. All high level language compilers generate code that makes use of the FPU.

To retain compatibility with the BBC Microcomputer, the 32016 BBC BASIC interpreter operates as a stand alone system rather than under PANOS. Thus, wherever possible, OSWORDs, OSCLIs etc still operate normally. Floating point operations are carried out in software with the same range and precision as BBC Microcomputer BASIC.

Both the C and FORTRAN 77 compilers have been designed to assist programmers to port existing software effectively and execute code efficiently. The designer of the Pascal compiler has paid particular attention to the needs of student programmers.

# Technical data

## Equipment
32016 Second Processor 256 Kbyte UK version.

## Sales order code
NC05.

## Prerequisites
A BBC Microcomputer Model B (with MOS version 1.2 or later) is required along with a suitable file store plus a monitor. Software development requires at least a dual 80 track double sided disc drive.
32016 software is distributed on 80 track double sided DFS format floppy discs, but the operating system supports most relevant Acorn filing systems including DFS and NFS.

## Construction
The electronic components are mounted on a four layer printed circuit board which is powered from 15W, 3A, 5V two rail power supply with overvoltage and short circuit protection. No fan is required.

## Physical
346 × W207 × H75mm (maximum) – to match the BBC Microcomputer profile. Weight 2.1kg. The unit is designed to be placed immediately to the right of a BBC Microcomputer.

## Power input
240V, 50Hz AC. A moulded 13 amp 3-pin plug fitted with a 3 amp fuse is provided.

## Electrical safety
Designed and manufactured to comply with BS5850, (1981).

## Installation
The Second Processor must be attached to the BBC Microcomputer. It may be necessary to install one or more ROMs in the BBC Microcomputer. These will be fitted by the supplier at no charge if required.

## Warranty
The Acorn standard conditions of warranty apply.

## Configurations
Suitable for use in a range of configurations including dual 80 track floppy disc drives, Winchester disc drive, IEEE interface, Prestel adapter, Econet.

# Performance and sizing

## Dynamic RAM
– 256 Kbyte
– 32 off 64 Kbit × 1
– Access time: 150 ns
– No wait states

## ROM (or EPROM)
– 32 Kbyte
– 2 off 128 Kbit

## Operating speed
– 6 MHz clock speed
– Bus cycle is performed in 4 clock cycles
– 8 byte prefetch queue
– Typical instruction times in microseconds at 6MHz for 32 bit (doubleword) fixed point operations:

| | | |
|---|---|---|
| Move | register to register | 0.50 |
| | memory to memory | 2.83 |
| Add | register to register | 0.67 |
| | memory to memory | 5.67 |
| Mult | register to register | 13.83 |
| | memory to memory | 18.33 |

# Processor data

## CPU
– 32 bit wide internal registers and data paths
– Integer range $-2147483648 <= \text{iri} <= +2147483647$
– 8 × general purpose registers (32 bits wide)
– 8 × special purpose registers
– Regular 8 or 16 or 32 bit fixed point arithmetic (multiply can produce a 64 bit result)
– 24 bit (16 Mbyte) uniform addressing
– 16 bit external data bus for memory access
– Over 100 basic instruction types
– 13 basic addressing modes plus scaled indexing

## FPU
– 32 and 64 bit wide internal registers
– 8 × general purpose 32 bit wide registers (or up to 4 × 64 bit registers)
– 1 × special purpose register
– 32 bit (single precision) and 64 bit (double precision) operations
– Normalised single precision representation: 1 bit sign, 8 bits exponent, 23 bits fraction approximate range of $1.2E{-}38 <= \text{iri} <= 3.4E{+}38$ precision of approximately 7 decimal digits

- Normalised double precision representation: 1 bit sign, 11 bits exponent, 52 bits fraction approximate range of 2.2E-308 <= | r | <= 1.8E+308 precision of approximately 15 decimal digits

# Software

## PANOS
- Program loading and execution
- Command line interpretation
- Command files with parameter substitution
- Event handling
- Cross language calls
- Library, with support for stream based i/o, type conversions, error message handling, argument decoding, memory allocation, plus OSWORD, OSBYTE calls
- Linker
- Full screen editor with multiple windows
- BBC Microcomputer editors conversion support
- Various other utilities
- Support for filing systems: DFS, ADFS, NFS
- Filename extensions
- Time and date stamping
- BBC Microcomputer STAR command

## BBC BASIC
- Fully compatible with BBC Microcomputer BASIC
- Full screen editor

## C
- Language as described in *The C Programming Language* by Kernighan and Ritchie, published by Prentice-Hall, 1978
- C library with support for maths and standard i/o

## FORTRAN 77
- Designed to conform to ANSI X3.9-1978
- Some FORTRAN 66 compatibility
- 32 bit or 64 bit reals

## LISP
- Cambridge LISP, largely compatible with University of Utah 'Standard Lisp'
- Multi-length arithmetic package
- Full screen editor
- Macro package and cross reference generator

## Pascal
- Designed to conform to BS6192 (ISO-Pascal Level 1)
- Extensions for modularity
- 64 bit reals

## Assembler
- Acorn 32016 assembler

For further details ask your nearest dealer or write to:
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Cherry Hinton
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Optimus Graphic Design, Cambridge

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