Review of microprocessor architecture

Evolutionary changes have been taking place in processor architecture. **Ian Whitworth** reviews philosophies underlying microprocessor design.

The development of the microprocessor, whether as a 'computer-on-a-chip' as a set of bit-slice integrated circuits, or as a packaged microcomputer system, has been extremely rapid. In the short space of seven years, the microprocessor has grown from a set of integrated circuits intended to replace custom circuits in specialized pocket calculators, to a whole family of devices, all of which may be linked by their dependence on stored program control. Within this timescale, there have been important evolutionary changes in processor architecture, brought about by improvements in manufacturing technology, and by an increased understanding of computer users' requirements by the integrated circuit designers. It is these changes, and the philosophy underlying microprocessor design, that are the subject of the main part of this paper.

Coupled with the development of microprocessor integrated circuits, there have been changes in the projected uses to which they may be put; the original idea that a microprocessor should be just another, albeit very sophisticated, electronic component within a system, is still valid, and encompasses the volume production end of the market, where capabilities are restricted so that prices may be reduced to an absolute minimum. In addition, however, it was quickly realized that, because of their low price, microprocessor chips could be built into low-performance, but extremely cheap microcomputer systems. These emerged as minicomputer imitations, such as the Altair (originally aimed at the US personal computer market, but finding wide application in teaching and industry) and also as single-board computers and manufacturers' development cards, such as the SDK80. Whilst development of these microcomputer systems has obviously been constrained very much by the integrated circuit architecture, standards for system architecture have emerged which may allow microcomputer system design to become independent of the actual microcomputer used[2]. A final note on systems architecture completes the paper.

MICROPROCESSOR CHIP DESIGN PHILOSOPHY

All microprocessors rely on two basic concepts so far as their construction is concerned: on bidirectional bus structures (both internally and externally) and on tristate logic to implement these buses. Using such structures, which allow multiplexing of the bus lines amongst the different onchip functions, gives a smaller number of interconnections on the chip (at the metalization layer), at the expense of a slight increase in the complexity of the individual circuits connected by the bus.

External use of similar organization means that integrated circuit package pins may be easily multiplexed, leading to smaller leadframes, fewer bonding operations, and greater reliability. Making the external bus tristate (logical 0, 1, and off or high-impedance) means that the devices which communicate with the processor will not only do so in a uniform manner, constrained by the bus, but their numbers may be extended very readily, since high-impedance devices do not impose much load upon the active circuits using the bus.

The important features of microprocessor design are the choice of wordlength, of computer organization, and, because microprocessors are essentially real time devices, the way in which context switching (switching routines by subroutine calls, jumps or interrupts) is implemented. Choice of wordlength has been largely decided for the microprocessor designer by the available technology (maximum chip sizes for economic yields, minimum gate sizes, maximum leadframe sizes); in the near future, these constraints will be removed, and wordlengths will be decided by consideration of the projected application area. Computer organization is important when detailed software design is considered, especially where timing is critical; following minicomputer development of the decade 1964–1974, microprocessor architecture has been largely register-orientated (see for example the 8080 or 6800, Figures 2 and 3 respectively) using accumulators and index registers, but a relatively recent departure from this has been the appearance of at least one memory-to-memory orientated processor, the TMS9900 (following minicomputer design once again). From the simple processors of several years ago, design has progressed to a point where chip complexity allows many more sophisticated functions on a processor CPU chip. However the basic design is constrained by the desire to maintain compatibility with preceding members of the microprocessor 'family'.

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0141–9331/79/010021–08 $02.00