Painting microprocessors in broad strokes

No one likely would argue the microprocessor's place on our roster of Milestones That Mattered. Surely, there'd be heated discussion over who invented the processor. But the benefits of the invention are clear. Productivity has benefited hugely from the processor-based PC. And thousands of processors surround us in our everyday lives, with vendors adding more daily.

One of the themes of our 50th anniversary issue, due this September, will be "softwarerization." We know it's not a word. But the movement of functions to software has been an unmistakable and enduring trend, which the microprocessor, at least in the broadest set of applications, has enabled. Designers can implement anything from simple hardware circuits, such as UARTs, to complex data-coding functions, such as MPEG, in software.

But let's get back to history. Intel claims to have developed the first commercial microprocessor with the launch of the 4004 in 1971. The company built the first design for customer Busicom of Japan and targeted calculators, although Intel later reacquired the rights to the 4004. Ted Hoff and Federico Faggin of Intel get the credit, although Intel tried at one point to erase Faggin's contribution from history after he defected to Zilog.

Some historians, however, believe that Four Phase Systems was shipping the AL1 processor a year before Intel delivered the 4004. Lee Boysel designed the AL1, but history largely buried the achievement because Motorola acquired the company, which most people forgot about. Texas Instruments also lays claim to early processor development.

What's undeniable is that Intel was most successful in commercializing the technology that would underwrite decades of innovation. You can read the complete original *EDN* account of the 4004 with the online version of this article at www.edn.com/060720mtm. That early processor sold for $100 in low volumes.EDN

01.15.72

FROM THE VAULT

"Announcing a new era of integrated electronics."

This introduction for a new IC may seem immodest, but Intel Corp. might just be correct. The IC is a single-chip CPU designed for low-speed microprogrammable applications, such as terminals, peripherals, test systems, and process control. The one-chip CPU was described at the *EDN*/EEE seminars in August.

The CPU, Type 4004, is designed to work with other members of Intel's MC5-4 microcomputer set. The other ICs in this kit of standard building blocks are the 4001 ROM, 4002 RAM, and the 4003 shift register (SR).

The minimum system configuration consists of one CPU an one 256×8-bit ROM. For one-of-a-kind applications, an electrically programmable ROM can be used in place of the mask-programmable 4001. The MCS-4 microcomputer is fabricated with silicon-gate, low-threshold MOS technology.

Packaged in a 16-pin ceramic DIP, the CPU chip consists of a 4-bit adder, a 64-bit (16×4) index register, a 48-bit (4×12) program counter and stack, an address incrementer, an 8-bit instruction register and decoder, and control logic. Forty-five instructions are included in the 4004's repertoire. All timing, control, and arithmetic operations are implemented internally.

Information flows between the 4004 and the other chips through a four-line data bus. A system built with the MCS-4 set can have up to 4k×8-bit ROM words, 1280×4-bit RAM characters, and 128 I/O lines without requiring any interface logic. With the use of external gates, the computer size can be increased even further. The MCS-4 uses a 10.8-μsec instruction cycle. The basic instruction execution requires eight or 16 cycles of a 750-kHz clock. Addition of two 8-digit numbers requires 850 μsec.

Custom systems using this 4004 chip are implemented by microprograms stored in a ROM. The idea of microprogramming a process to implement a special controller is not new. IBM's system 360 computer and HP's 2100A desk calculator are two examples of both large and small systems that have exploited the inherent design and production advantages of microprogramming. In desktop calculators, about 35% of the logic is associated with doing arithmetic. The other tasks are keyboard encoding, printing results, displaying status and general control. These functions can be done by microprogramming rather than by additional random logic. Microprogramming can even be used for keyboard switch debouncing and for converting 4-bit BCD code to seven-segment lamp code. Many features may be added to systems using this chip by providing additional ROMs.

This approach provides a flexible and modular technique for system design in which memory devices are used instead of logic devices. The major limitation to its application is speed. While an IC logic can make a decision in about 5 nsec, and combinatorial networks allow many decisions to take place in parallel, this computer chip performs decisions sequentially at 10.8 μsec per instruction.

—*EDN*, Jan 15, 1972