A Systems Approach to a Personal Microprocessor

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Even a casual glance through the BYTE, *Radio Electronics, Popular Electronics*, etc, advertisements and articles reveals a growing proliferation of microprocessor integrated circuits and completed units. Which of these is right for you? Here are some ideas to bear in mind while making your choice.

Why do you want a processor at all? Reasons vary greatly. Many find themselves intrigued by the "computer environment" around us, and the microprocessor has become a low cost entry point into "computers."

Several amateur computer newsletters list reasons for individuals becoming interested in microprocessors. Hams see them as a working piece of equipment for their radio station. Hobbyists see them as process controllers; everything from lawn sprinkler controllers to robots. Mathematical types find them usable to run BASIC, FORTRAN, APL, etc, for problem solving.

What are your future plans with microprocessors? This may become a very open question. However, some reflection in this regard may prevent you from making an initial, very expensive, mistake. If you only have a casual curiosity, don't spend a fortune. A definite growth plan indicates a need for more careful analysis.

Investment

Microprocessor kits vary from $100 to several thousand dollars. The lowest cost units are excellent for satisfying curiosity about microprocessing in general, or will allow machine code manipulations. Several thousand dollar systems are often designed for and purchased by businessmen and professionals for applications such as payroll accounting, text editing or name file maintenance. The most frequent non business personal system investment is probably in the $500 to $1500 range.

Change

If there is one constant that is already evident in this field, it is constant change. You are about to invest (or already have invested) a significant amount of money in a microprocessor system. Unless your curiosity is easily satisfied, the chosen system should be able to easily adapt itself to

evolutionary changes being constantly invented or stressed. For instance, every six to nine months (Virginia Peschke calls it the gestation period) a major architecturally different central processor integrated circuit is announced. A system which allows upgrading without total obsolescence can be a real savings for the serious hobbyist. It can be very frustrating to be stuck with last year's wonder while everybody else has the latest microprocessor system. Several layers of change seem to be occurring. The fastest change seems to be the microprocessors themselves. The power supply and cabinet, if adequately large, can be a relatively stable portion of a hobbyist's system. The major expense in substantial processor systems is the memory components. A wise investment in memory will result in a system with a good life expectancy. The IO components are often a stable investment, sometimes an evolutionary element. A high resolution TV monitor, a mechanical hardcopy printer, or a good ASCII keyboard can outlive several generations of microprocessors. Expendable IO, such as cassette systems, analog to digital converters, and discrete IO circuits have shorter lives, but are lower cost. With proper design an evolutionary change can represent only one fourth or less of your total hardware investment instead of 75 percent.

Independency

An evolutionary system is best designed by making its various components independent of each other, and interfaced to commonly accepted levels and lines. Memory boards are relatively stable system elements in this kind of design: Speed and power consumption, besides price, are important considerations. Slower or surplus memory integrated circuits may be an expensive mistake if you want to run your latest model central processor which has become much faster. The slow memory may result in unnecessary central processor wait states. IO is generally processor independent, but IO interfaces can be susceptible to obsolescence when they depend on a specific central processor design. If you want to switch processors, they may require considerable redesign. A system which consists

of easily plugable boards can represent a major cost savings if they represent independency at the board level.

Quality

Of course everybody has it. Don't you read the advertisements? However, look beyond the surface for key items, or your long run investment will make you wish that you had. Here are some mechanical and electrical considerations of packaging:

- PC Boards – Double sided epoxy, plated, with plated through holes.
- Connectors – Gold plated fingers.
- ICs – Factory Prime, not temperature fallouts, etc.
- Conservative access speeds. Every IC socketed.
- Small Parts – Close tolerances where needed.
- Power Supplies – Conservatively rated, overcurrent, overtemperature, and overvoltage protected.

System Architectural Variations

There are a number of approaches to small system microprocessor design. Each is satisfactory for certain people, certain applications.

- *Toggle Switches and Bit Lamps:* The first hobbyist oriented microprocessor designs, and many present systems, are based on switches and lamps. If the system is limited to this, programs are small; or it takes long periods to enter longer programs, and are very susceptible to entry error. The user is forced to think at the micro level, bit by bit. If the intention of the user is to gain intimate logic knowledge of the microprocessor only, this system design is very cost effective.
- *Numeric Keyboard and 7 Segment Readout:* The ease of entry of this type of system allows a substantial gain in programming system complexity. However, the user is still at the logical data operation level. In addition, the programmer is restricted to viewing only a single byte at a time, making operator effort for analysis proportionally high.
- *Teletype or Similar Hardcopy Devices:* These systems represent the next level of improvement, offering some significant advantages. They usually have some form of monitor in a ROM which allows the operator to type in code and helps isolate him from errors. The total program may be listed or printed on hardcopy. In addition, paper tape is usually available to provide an economical media for program storage and exchange.

  There are some trade-offs, however. New hardcopy machines cost $1,000 up. Being mechanical devices, they require significant precision maintenance. The input/output speed is usually about ten characters per second; a dump of 1 K takes about two minutes, and creates a great deal of irritating noise. In addition, paper tape is a damage prone and bulky medium.

  Several integrated circuit manufacturers offer Teletype-oriented "evaluation boards." If only required for evaluation, ok; but they offer almost zero chance for either updating or extending. Both memory and IO are typically very CPU dependent, and if memory buffering is not used, supplemental memory and IO may be unusable.
- *Video and Cassette:* The latest stress has been the movement to using a TV set as an output display, a full alphanumeric keyboard for input, and an audio cassette for program storage and exchange. Video-based systems provide full user to system interaction at minimal cost. A *complete* video display and cassette based system will cost less than a hardcopy device alone. The speed of system response is practically instantaneous. Operations may be performed in almost complete silence (a major advantage to the hausfrau)! Reliability is enhanced as electromechanical mechanisms are limited to the keyboard and cassette recorder. Data media storage density is much higher; you can store the data from almost a mile of paper tape on a single C-90 audio cassette.

Conclusion

Serious hobbyists should carefully consider design alternatives and growth plans before ordering or building a microprocessor. Ease of operation, reasonable cost, and relative freedom from total obsolescence should be prime considerations.

In the following months, a detailed series of Digital Group hardware designs will be presented for your use. Next month will feature the low cost Digital Group cassette interface circuit which design provides data rates as high as 1100 baud, and may also be used as a ham RTTY terminal unit or as a telephone modem.■