

CONCEPT AND BASE PLAN
FOR
HEATH / ZENITH HOME COMPUTER

May 15, 1980

Z MACHINE HARDWARE

STANDARD EQUIPMENT

MICROPROCESSOR

There are a large number of microprocessors that are used in the current crop of personal computers. TI uses their 9900, Atari and Apple use the 6502, Mattel uses two processors ... a GI chip in the game portion of their machine and a 6800 in the keyboard portion. Radio Shack will use the 6809 in their new machine, APF uses the 6800 and Bally uses the Z 80. With the exception of Mattel and Radio Shack; the processors are common 8 bit micros.

It is my belief that the processor selection for the Z Machine should be based on two primary factors. First, will the processor efficiently control the other hardware functions in the machine? Second, which processor provides for the most productive development and continued benefit from software?

Nearly all of the current 8 and 16 bit microprocessors will easily satisfy the first requirement. They will all effortlessly handle the control elements at sophistication levels we envision being part of the Z Machine. Therefore, the CPU selection is influenced mostly by software issues.

If we agree that most of the 8 bit processors have near equal performance, then we would opt for the Z 80 based on our experience and availability of software and hardware support tools. However, none -of the current 8 bit processors have the internal architecture that efficiently supports development of software in higher level languages. Of the three new 16 bit processors 68000 Z8000, and 8086 - only the 8086 has a little brother, the 8088, that has a combination of 16 bit internal architecture and 8 bit external interface. The 8088 processor with its internal 16 bit architecture, will allow efficient development of software in higher level languages and is externally as simple as most 8 bit processors.

I see the selection boiling down to a race between the Z 80 and the 8088.

Z 80 strengths:

1. More software available today that runs in 8080/Z 80 machine language.
2. The Z 80 at \$5.00 versus the 8088 at \$15.00 to \$20.00 will cost less going in.
3. We as a company have had more hardware and software design experience with the Z 80.
4. With H8's and H89's in abundance, we have more design tools.

8088 Strengths:

- 1 Supports efficient compilation of software developed in higher level languages. Higher level language software development is easier, quicker, less error prone, and will live on after new generations of processors are available. It is my opinion that this one major strength could be the basis for the processor selection.
2. The 8088, while having a 16 bit internal architecture, is no more complex externally than the Z 80. Low cost Z 80 and 6800 family peripheral chips can be directly interfaced to the 8088.
3. It is likely that sometime during the life of the Z Machine, the price difference between the Z 80 and the 8088 will erode away to nothing.
4. It may be possible to translate existing software for some 8 bit processors to run on the 8088. The 8088 has the speed and power to equal some 8 bit processors while running in an emulation mode.

Decision

Approach the early portion of the hardware design with intent to use the 8088 microprocessor. However, provisions will be made to quickly convert to the Z 80 if software issues dictate it. The design could progress well along without a change of course having major negative impact.

At prototype time two boards - Z80 first for easier debugging followed by an 8088 board.

CPU board will include:

- CPU chip (Z80 or 8088)
- Clock Generator (12.288 Mhz)
- Ready (wait) logic
- Address latches & buffers
- Data bus bidirectional buffers
- Control bus buffer
- 8 priority interrupt (NB type)
- Boot ROM 24 pin Textool socket (I 2716)
(ROM disable on Z80 version)
- Clock ÷ 10 (1.2288 Mhz) clock for floppy

MEMORY

Since a large portion of the bill of material cost in the Z Machine will come from memory cost careful attention must be given. I have received conflicting reports as to when the price for the new 64K dynamic RAMS will erode down to or below equivalent prices for 16K dynamic RAMS. Some reports from TI indicate as early as mid 1981; therefore directly impacting on the first production of Z Machines. Other reports from Mostek and Intel suggest the prices for 64K's will stay higher until 1982 or even 1983. There does, however, seem to be a correlation between the report sources and the corresponding state of development of their 64K part. The manufacturers now sampling parts are the ones with the earliest predicted price reduction dates.

It is both possible and prudent to design the Z Machine so as to support both sizes of RAMS. It will be some time from now before we are forced to freeze a PC board layout. Also, half-good 32K versions of the 64K parts may be a desirable tack for us to follow since the half good parts cost substantially less than half the price of a completely good part.

Again, as with the selection of processor, the actual size need for memory will be dictated by the software. It is too early to completely understand what will come from the early software development.

In addition to RAM memory, some ROM must be available to start the machine at power up and reset time. Programs must be booted from the disk into RAM memory and control turned over then to the application program. Since ROM memory is somewhat less expensive than RAM, it may be desirable to use the ROM for storing frequently used video display service routines, disk I/O and various other utility programs.

It is my assumption that in late 1981, 4K bytes of ROM will cost no more than \$4.00, 16K, bytes of RAM will be less than \$58.00, and RAM memory implemented using 64K bit chips will be essentially the same price per bit as 16K bit chips.

Prototype to provide 64K dynamic RAM with
on board refresh.

VIDEO DISPLAY GENERATOR

All of the existing personal computers use a different technique for video generation. Also, a number of the machines use custom chips to synthesize the video information. They do share a common intent to display the video on a standard home television receiver. "Standard home television receiver" in this context is intended to mean NTSC only which excludes PAL and SECAM versions for European markets.

I would prefer to not even consider custom silicon as part of this design project. We will have enough balls in the air without taking on the development of custom integrated circuits. It may be appropriate for later product generations to reconsider. With that precondition, there are three options for video generation. First, GI - which is out for obvious reasons. Second, Motorola 6847, which while having the advantage of being second sourced, does not have the necessary performance for our need. The 6847 uses a fairly small area of the screen for active display and allows the background to be only a single static color. Third is the Texas Instrument 9918 family. This is the same part that TI uses in their 99/4. TI has several versions of this part one that generates composite video, a second that produces R-Y B-Y and Y which can be easily converted to RGB, and supposedly a version for the PAL and SECAM type receiver.

The TI 9918 et.al. gets my vote. It is supported by the major silicon house and the 99/4 proves that it is viable for this application.

9918 Features:

- * Single-chip interface to color TV (excluding RAM and RF)
- * 256 x 192 graphics resolution; 16 unique colors
- * General 8 bit bi-directional interface to processor
- * Direct connection to dynamic RAM's.
- * Automatic and transparent refresh of RAM's
- * External video input capability
- * Easy-to-use for text graphics, animation
- * Unique planar representation allows 3-D simulation
- * Standard 40 pin package

Prototype :

- 9918
- 16K of 5V only dynamic RAM
- I/O decode
- 1 volt P-P 75 Ω video output to monitor

SOUND GENERATION

Sound generation is obviously an integral part of any action game software. Phasers, tank, cannons, crowd roar, and a multitude of other sounds are desirable to enhance games. However, games are not the only application that can benefit from sound. Sound is an excellent reward for correctly completing a learning session.

Sound can be generated either by the processor, directly controlling digital to analog converters, or by sophisticated peripheral integrated circuits that generate various kinds of sounds independent of processor involvement. Again, GI is a potential vendor for this type part but will not be considered because of their quality record with Zenith. Texas Instruments is the other possible vendor, and their part will be evaluated against the processor controlled digital to analog converter approach

In that we intend to support music education as one of our applications, it may be better to pursue the digital to analog converter approach. The music sound quality will be substantially better using this approach.

During the prototype phase, both possible approaches will be investigated and a selection made. It is assumed that cost is not a strong reason for selecting either of those two approaches since neither is very expensive.

MASS STORAGE

Like the other type storage, RAM, the mass storage element will have a dominant impact on bill of material cost. Although most current personal computers start with audio cassette as their mass storage device, I strongly recommend that the Z Machine use floppy disk as its only mass storage device.

Shugart, with volume manufacturing support for Matsushita, has developed a floppy disk drive that potentially could be sold for less than \$50.00 in very large quantities. This product has the personality of an 8 track audio, player, but it still has promise.

Tanden and MFI, two floppy disk manufacturers, have indicated that their standard 5 1/4" drives will be priced in the \$80.00 to \$90.00 range when purchased without electronics. The drive electronics would add only about \$20.00 to the cost of our product if we incorporate them into our circuit and PC board.

I recommend that we pursue the standard drive, less electronics. Even though the, price is slightly higher than the Shugart product, the fact that there are multiple sources and the product is far superior technically, is more important.

Steve Ward indicates that 200K bytes of disk storage are necessary to implement the dictionary that is used in several of the MIT word games. Single-sided, single-bit density, and double-track density would provide that 200K bytes. It may be possible to purchase 96 TPI double-track density drives in mid 1981 for prices that are very little (perhaps less than 5% more than the single-track density drives. The only difference between the drives is the pitch of the head positioning mechanism, which does not have a cost factor, and the type of head used. Tanden indicates that the difference between the heads is not that great from a cost standpoint.

I propose to use the standard 1771 type single-bit density floppy disk controller chip instead of the scheme used in the H17 and H89. While the 1771 approach is slightly more expensive, the parts count is substantially less which will wash out the other cost differences.

As I indicated, I would not propose using an audio cassette for mass storage. However, it would be highly desirable to make provision for starting and stopping an audio cassette recorder to enhance educational audio/visual presentations. The cost to implement is only pennies.

Prototype:

- 1771 (Consider Motorola part)
- Inverting data buffer
- Data Separator
- I/O decode
- Separate port for DRQ
- Motor on timer

Measurement
attach to the
back.

1000
necessary to keep
probe down.
possible VCR accessory.

RF MODULATOR

The Z Machine will be designed from the outset to assume a standard TV receiver as its display monitor. An FCC approved RF modulator will be incorporated to allow direct connection to the typical home receiver through an antenna/computer switch. Zenith Engineering would be consulted to determine how the work they have done with the modulator in the STV system could be used.

In addition to providing RF output for interface to the TV receiver, both composite NTSC video and RGB will be available as outputs. The composite video would be used with a standard monitor such as the 13" model that Heath now sells. RGB would be intended to interface primarily to the coming Zenith modular component TV system.

Joe Solari and Zenith foreign marketing people will need to indicate just how viable this product might be in locations where PAL or SECAM systems are used. The video system may be much less a distraction to sales than the English language/American focus of the software. In any event, some input from the foreign marketing areas is solicited.

Prototypes

Use monitor & purchased modulator.

SPACE COMMAND

I support the Dertouzos "few button" controller. The idea of being able to move into the applications machine and perform some meaningful task, play a game, check data on your favorite stock, etc. - without having to know how to type or operate a keyboard, is desirable.

If the cost will support the idea, I would like to remote the Dertouzos "few button" controller using common TV remote control technology. One of the largest distractions of video games is the unsightly wires and cables that are necessary to attach the game to the TV and its game paddles. If we can reduce or eliminate that unsightly mess, our system will find its way into fancier rooms and offices. Obviously, rule of reason must prevail, and if the cost is excessive we have to find another alternative,

At any rate, there is potential for Zenith synergy. The possibility exists for incorporating the "few button" controller into an integrated keyboard. Inclusion of the keyboard would add perceived value to the product and substantially add to the utility of the base product.

Since a 'keyboard and associated I/O will be designed and offered anyway, the decision to integrate the keyboard or offer as an option can be delayed until we're further into the design. This will allow experimentation/determination of viable functions with the "few button" controller and human interaction to the concept during the breadboard stage. Final decision to be made prior to packaging/styling phase.

Include keyboard
with Atari-like
layout

GENERAL I/O

All other currently conceived hardware functions and modules plus those yet to be thought of will interface to the Z Machine via general purpose I/O structure. This general I/O would provide for both mechanical and electrical, inter connection of accessory element and the main unit. The electrical architecture would allow daisy chaining multiple accessories in random mechanical order while still maintaining correct logical and electrical interface.

Factors to be determined:

1. Do the accessories have their own power supplies? Large numbers of additional AC power cords are undesirable.
2. What is- the exact nature of the -mechanical daisy chain? Do the elements physically snap or clip to one another? Are slots provided in the machine?
3. What is the nature of the logical connection of the accessories as perceived by the software?
4. What is the absolute number of elements that can be attached?
5. What wild possible contrivance might we come up with in the future that might tax this I/O system?

OPTIONAL FUNCTION MODULES

TYPEWRITER KEYBOARD

The keyboard would be designed to conform to the general I/O bus concept. A keyboard with the feel and quality of the H19 Hy-Tek is very important. The very slight additional cost is very obvious to the user. For [the more] sophisticated user the keyboard is his major interconnect to the system.

The keyboard may not quite conform to the general I/O concept in terms of mechanical connection to the main unit. There are two schools of thought regarding keyboards. Either they attach rigidly to the main unit for ease of transportation. Or they should detach for more comfortable routine usage. I propose that our keyboard do both; detach for normal use and rigidly attach for portability.

The estimated cost of the keyboard module including key switch matrix, scan and I/O electronics, and enclosure, is just over \$30.00. Development of a custom ROM one-chip microprocessor to handle scan and communication is assumed.

As mentioned earlier, the keyboard could well become a part of the base unit rather than being offered as an option.

GAME PADDLES

All of the action games, and even some of the strategy games require paddles to control elements of the game. Atari has two different paddle types; one for continuous linear control of ball paddles - for example, and a second joy stick type control for direction control as used in Space War and sports games. The Bally approach is to combine these two type controls into a single pistol shaped controller. The Bally people felt very strong about both the pistol shape and the multiple functionality of their unit.

Various manufacturers have provisions for either two or four game controllers to interface to the computer. Again, Bally was very strong on the need for four controllers that would allow up to four players to participate in most games. They indicated that their market and field test research clearly proved the need for four controllers.

The Bally style controllers will be used during the prototype phase, while some other approach may prove more appropriate later on.

DAA MODEM

I think we all agree that several of the major applications for the Z Machine will involve telecommunications. Telegames, stock market quotations, New York Times data base, and others all require interconnection of the machine with the telephone line. In order to easily communicate with other machines or data utilities, some form of a MODEM (MoDulator-DEModulator) is required. A direct connect type vs. an acoustically coupled version would be less expensive. Also, the direct connect type would allow for auto-dial and auto-answer, which is not possible with acoustic coupled versions.

While the actual MODEM should be an option, perhaps the telephone dial and answer capability should be part of the standard system. Auto dialing for normal voice conversations might be desirable, while not having an interest in telecommunications. The cost- of connection to the phone line without a MODEM is very small. This approach will be explored in the initial design phase.

BSR X-10 FRONT END

A BSR compatible transmitter would allow the Z Machine to control remote switches and dimmers. Clearly it is appropriate to use the BSR standard that exists so as to benefit from the BSR product base and standardization.

It may be appropriate to gain either distribution and/or manufacturing rights to the BSR design and sell the remote units through the Zenith distribution channels.

At some later date we should develop and market a reverse communication AC control module that would communicate back to the Z Machine from sensors in the back yard, indicating the lawn needs watering.

This same reverse communication protocol could also easily serve as the vehicle for security and fire data transmission back to the Z Machine.

MUSIC KEYBOARD

I view music and music education as a strong application area for the Z Machine. Therefore, inclusion of an electronic organ type keyboard makes a great deal of sense. Music could be composed, stored on disk, and played back. Lessons could be presented in graphical form' on the screen with the student directed to play along with the bouncing ball. When the student failed to produce coincident music, the teacher (Z Machine) would explain the error and construct appropriate lesson material to correct the particular type error.

Among the esoteric hobby set, music is a very large application for personal computers. The Z Machine would serve as something between a normal electronic organ and a Moog synthesizer.

UMTECH will be investigated as a potential source for both hardware and software.

VOICE SYNTHESIS

Three major semi conductor manufacturers are now selling voice synthesis chip sets. While the current offerings provide only limited vocabularies, disk or ROM based extension vocabularies seem possible. Also, more general systems that produce phonemes rather than actual words allow the construction of limitless vocabularies. While the speech quality is not quite as high, phonem synthesis may be a viable approach.

Clearly, speech synthesis is a strong supporter of both educational and game soft ware. Whether this option can be developed in time for the first 'production is uncertain. Perhaps this is a second generation system element.

SERIAL I/O

It would most likely be desirable to provide for normal computer peripherals like printers via a standard serial I/C port. Obviously, the greatest task here is to define the nature of the software interface to the peripheral.

