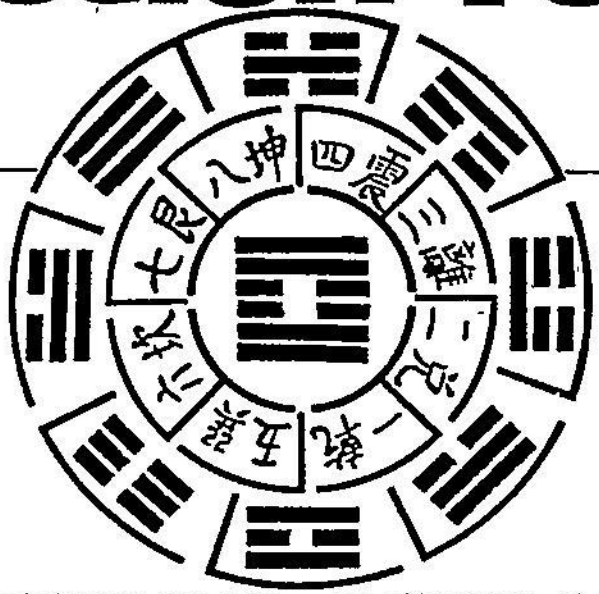
Introduction To I-Ching



The *I Ching* came out of the far East even before transistor radios. If you're planning to build our I Ching computer, you may want to know why. Danny Bakan offers enlightenment.

IN SOME CIRCLES the *I Ching* (translated it means *Book of Changes*) is a common reference text for all life situations. At least a third of the world is aware of its validity as a valuable and useful work. But most electronics and computer enthusiasts in the western world, lost in their "Dragons and Dungeons" rulebook and up to their ears in diodes, have never heard of this vital work of Chinese wisdom Not that there aren't connections between electronics, binary codes, modern physics and ancient Oriental mysticism.

In this issue of ETI you'll find an article on how to make and use the I Ching computer, basically an inovative method for randomly selecting one of the 64 hexagrams (six lined figures) of the Book Of Changes The hexagram is selected in response to a question asked of the *I Ching* Traditionally, *I Ching* has been used as an oracle and as a means of divination (foretelling the future and receiving advice). One asks a question of *the I Ching* as if the *I Ching* were a wise and informed person. Then, in a contemplative and meditative state of mind, one uses one of several methods to randomly select one or more of the 64 hexagrams. The hexagram is then examined, and the accompanying text is read and interpreted to form the answer of the question asked. The *I Ching* in this way is seen as a "living text". The book is considered as one would a person who is an avid conversationalist. The conversation can be on a cosmic scale or about trivia, about the colour of one's shoes or news of state. On all of these things the *I Ching* is considered a giver of information. The information is essentially contained within the lines of the hexagrams themselves. The commentary upon the hexagram in the form of written words is the interpretation of generations of Oriental contemplation upon the hexagrams and the lines of which they are made.

History

The *I Ching* is one of the prime examples of the genius of Oriental thought. Its antiguity dates back at least three thousand years. Confucious, who lived two thousand five hundred years ago, considered the *I Ching* even then to be an ancient text. It is told that he once said, "If additional years were added to my life I would give fifty to the study of the *I Ching*, and might then escape falling into great errors.". At a time when the Greeks, to whom Western civilization owes so much, were still living a semi-civilized nomadic lifestyle in the foothills of the Mediteranean, the Book of Changes was already established in its authority and antiguity. The text is probably the oldest we have in extant. When Emporer Chin Shih Huang Ti ordered all the ancient books destroyed in 213 B.C. he spared the *I Ching*. Since then, the Book of Changes has been used as one of the prime books of wisdom for both Confucian and Toaist thought for centuries.

The basic binary concept of the *I Ching* is said to date back to before the dawn of pre-history. It is said that the philosophies of the Book of Changes and the images of the hexagrams did not arise out of civilization, but civilization arose out of the sage's contemplation of the hexagrams. The hexagrams are made out of six lines which represent either "Yin" or "Yang". Yin is characterized as a broken line (· ·). Yang is represented as a solid line (—). These two concepts and the dialectic they form is at the very foundations of Oriental thought.

Yin and Yang can be decribed in various word pairs: male/female, heaven/earth, creative/receptive, firm/yielding, etc,.. All existance consists of a fine balance between these two basic energies. The 64 hexegrams arise out of all the possible variations of combinations of Yin and Yang within a six lined figure. In his book, *Tai Cai Ch'uan and I Ching*, Da Liu writes:

> Each of the hexagrams consists of two 3-lined figures called trigrams There are eight basic trigrams constructed from a combination of unbroken and broken lines. The trigrams, like the mathematical symbols *x* and *y*, can stand for many things. For instance, the trigram *Ch'ien* can mean heaven (the natural world), leader or king (the social realm), father (family relationship), head (part of the body), strength (quality), and other things as well. Combined in a hexagram, the symbols acquire a distinct composite meaning. Each line shows a different aspect of the situation pictured by the hexagram.
>
> The creation of the eight trigrams is attributed to Fu Shi, the legendary Chinese sage who reputedly lived during the age of

Continued from page 6

News

CMOS RF/Video switch

A new CMOS high-speed dual monolithic switch designed for RF and video system high-frequency applications is now available from Intersil Inc.

The IH5341 is unique because it precisely matches the 75-ohm impedance of video communications systems and handles signal frequencies up to 100 MHz with a loss of less than 3dB.

Features of the Intersil dual, single-pole, single-throw switch include:

- "Off" isolation rejection ratio of 60dB minimum at 10MHz
- Cross-coupling isolation rejection of 60dB minimum at 10 MHz.
- Switching speeds (typical) of 150 ns "on" and 80 ns "off".
- Guaranteed break-before-make switching
- Power supply current of less than 1mA.
- Power supply range of ±5V to ±15V.

For further information, call Roger Hatfield (408) 996-5249.

Connectors

The Belden Corp. Electronic Division has introduced a line of Mag-Master™ connectors as an interface for flat cable and discrete wires.

The Mag-Master06TM connector is available in 10 to 60 pins. It has a temperature range of -55°C to +105°C; a current rating of 3A DC; a contact resistance of 20 M maximum at 6V DC, 0 3A; and an insulation resistance of 1000 M minimum at 500V DC. It has a dielectric withstanding voltage of 500V AC for one minute and a UL voltage of 30V DC. The 0.64 mm (.025") contacts are selectively gold-plated.

For additional information, contact White Radio Limited, 940 Gateway Drive, Burlington, Ontario L7L 5K7. Telephone (416) 632-6894.

Touch-sensitive Display

A simple-to-use touch-sensitive display which interfaces operators to a computer is available in Canada from Allan Crawford Associates Ltd.

The new model 1780 Infotouch display incorporates a transparent switch overlay providing 60 distinct sensing areas. The operator simply reads the message displayed on the Infotouch low profile 7.6 cm x 19 cm CRT screen, then touches the screen at the appropriate location.

A standard ASCII character set is resident in PROM, while an alternate mode allows for an additional 117 characters. Even highly pictorial character sets such as Kata-Kana Japanese, are relatively simple to incorporate with the Infotouch Display. Any combination of character highlighting including blinking, reverse video, and underlining is available by software control.

Please forward reader inquiries to Miss Sindy Van Wieren, Allan Crawford Associates Ltd, 6503 Northam Drive, Mississauga, Ontario L4V 1J2 (416) 678-1500.

8085 Micro Trainer

Etronix has announced the 8085AMT Micro Trainer. The 8085AMT includes a fully tested and assembled 8085 Microcomputer with 1K RAM, 1K PROM, 2K EPROM, programmable I/O, power supply, and case.

The 8085AMT software includes step-by-step instruction manual, a complete user's manual with programs included, and a sub-routines manual describing many of the sub-routines used with a listing.

The single unit introductory price for the 8085AMT is $199.95. For additional information contact C. Larsen, Etronix, 14803 N.E. 40th, Redmond, Wa. 98052.

64K Dynamic RAM

Motorola MOS Integrated Circuits Group announces availability of the second generation 64K dynamic RAM with pin one refresh, the MCM6664A.

As with the MCM6665A, the MCM6665A can do either RAS/CAS or RAS-only refresh cycles, yet also has two additional refresh methods available to the user. These special functions are incorporated on pin 1 of the device.

They are the auto refresh and self refresh modes. The auto refresh mode is accomplished by simply making pin 1 active (V_{IL}) during the time interval when a refresh cycle is desired. The refresh address is generated internally and is automatically incremented for the next refresh cycle.

The second refresh method is intended primarily for battery backup applications where pin 1 will be active longer than two microseconds. This self refresh mode generates internal refresh pulses in addition to the internal refresh addresses.

For further information contact your local Motorola sales office or distributor.

Home TVRO Package

Winegard Company has announced the introduction of a new TVRO earth station system for consumer installations.

The SC-5014 includes a 9-foot-square fiberglass dish, a home satellite 24-channel video receiver, 120° LNA, single-base polar mount, rotating feed horn, cable, and hardware.

Winegard's one-piece 9-foot square fiberglass dish has the efficiency of a 13-foot parabolic. By eliminating the edges of a round 13-foot parabolic, engineering has created a low-cost yet highly efficient antenna. The unique design of the feed provides a sturdy mount for the LNA and behind-the-dish mounting of the rotor.

The SC-5014 complete home TVRO earth station lists for $3995 00.

For more information contact Gil. S. Cunningham, (319) 753-0121.

Robot Conference

"Robot Research, Developments and Applications in Canada" is the title of conference jointly sponsored by the Central Ontario Chapter of Robotics International of Society of Manufacturing Engineers and National Research Council of Canada.

This conference will be held at Delta Inn, Mississauga (Toronto), Ont. on September 20, 21, 1982.

A variety of technical papers and presentations will include topics on robot research and developments, applications, controllers, programming languages, sensory feedback, education and training.

Further details of the conference can be obtained from RI—SME Conference Secretariat, 6535 Mississauge Road, Mississauga, Ont. Canada L5N 1A6.

Image Intensifier Tubes

The Light Sensing and Emitting Division of Varian Associates today announced a third generation of 18mm image intensifier tube products. The new generation gives an approximate threefold increase in white light sensitivity over the second generation tubes, significantly increasing the capabilities of the night vision devices in which they are used.

The second generation intensifiers required the light of a quarter moon, whereas the third generation can be used in overcast, starlight conditions. The initial starting sensitivity of the new device combined with an improved, hermetically sealed microchannel plate result in a longer lifespan for third generation tubes.

All three generation products are currently available, with 90 days lead time. For further information, contact: Varian Associates, LSE Division, 611 Hansen Way, Palo Alto, CA 94303, telephone (415) 493-4000.

Printer

HI-G Incorporated has announced a new addition to its line of high-quality, affordable dot matrix printers. Designated "9/80PSF," the new 80-column model has been specifically designed for the requirements of forms printing.

Featuring a reversable tractor paper feed system and demand printing function, the HI-G 9/80PSF performs reliably and accurately with no forms waste or special forms required, reducing overall costs. With its graphics capability, it can accomplish oversized character presentations without a second pass or added programming.

Major performance characteristics include: 150 cps, bidirectional, logic seeking, 9 x 9 matrix, Centronics-compatible parallel, RS232C serial or current loop interfaces and a 9-wire ballistic-type printhead rated at 600 million characters.

For complete information write HI-G Co. Inc., Printer Products, 580 Spring Street, Windsor Locks, CT 06096.

High Current Power Supply

A new, double slot power supply is being offered which provides a choice of two switch-selectable DC voltages: 5 ± 1½V and 13V ± 1½V. It has a current capability up to 7.5 amperes at each voltage.

The WP-709 has two 3 digit LED displays for continuous monitoring of both voltage and current during application. A single knob permits fine adjustment of the voltages over the adjustable ± 1½V range.

The output is laboratory quality, ripple being less than 10mV peak to peak. Line and load regulation is better than 0.1%. Each output has adjustable current limiting up to 7.5A with instant pushbutton reset.

For more information, contact H.W. Cowan Canada Ltd., Box 268, Richmond Hill, Ontario L4C 4Y2, telephone (416) 773-4331.

hunting and fishing around 5,000 years ago By studying and observing heaven, earth, animal tracks and his own body, he devised the broken and unbroken line as symbols of the fundamental nature of the universe. From these, he constructed eight trigrams, each of which stood for an aspect of nature, society, and the individual.

(Tai Chi Ch'uan and I Ching, Da Liu, Perennial Library, Harper & Row.

Yin and Yang do not represent good and bad in the way Western morals and philosophy tends to view the duality. Yin and Yang are equal energies. The Tai Chi diagram (Fig. 1) is the symbolic representation of Yin and Yang. As one can see, Yin and Yang are *of* each other. The black and the white define and create the other.

Originally, before the establishment of the hexagrams, when one consulted the *I Ching* the answer was in terms of a yes or a no as defined by either a solid or broken line. This was later expanded into four possible line pairs:

The lines of these pairs further differentiated the *I Ching*. The Yin or Yang line could now be defined as either "young" or "old". The young line is in transition to an old line; the old line is in transition to a young line of the opposite polarity. All lines are in a constant state of flux. All Yin lines are in transition to Yang lines, and all Yang lines change back into Yin lines. All the line pairs are constantly changing yet they are connected by an underlying pattern. The pattern represents eternal change. Like the phases of the moon, there is consistancy in the changes.

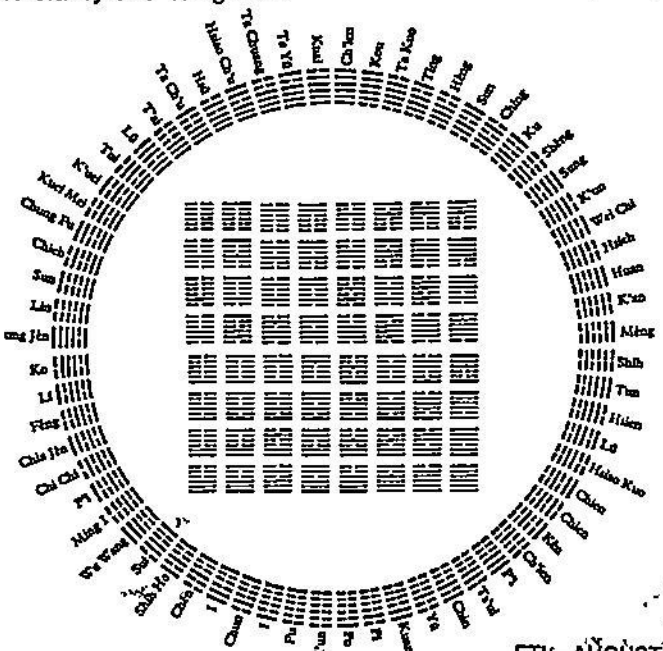
Out of this early development arose the concept of change, from which comes the title, "Book of Changes" All things and energies are in a constant state of eternal transition as represented by the hexagrams. Any or all lines in any given hexagram may be young or old lines. Since all lines are in transition to their opposite, each hexagram is in transition to another. According to the *I Ching*, this is one of the most fundamental truths in life; all things change. Change is one of the few things we can rely on. The text of the Book of Changes helps one to perceive where one stands in the cycle of change. Various hexagrams represent times of increase or decrease, preponderance of the small or the great, or whether it is a time for creative movement or receptive stillness. The *Superior Man* is the term the text gives to the one who is able to work with the changes of existance so as to bring prosperity and supreme success The *Superior Man* is concerned for the well being of all things and energies in creation He maintains his humbleness and his inner strength. The text of the *I Ching* points one to follow in his steps.

Questions

When one makes an enquiry of the *I Ching*, using either traditional methods such as the throw of three coins or the use of fifty yarrow sticks, or "updated" methods such as the I Ching Computer, the information required is contained within the lines of the hexagram (or hexagrams, in the case of moving lines) itself. The balance of Yin/Yang energies in each hexagram gives rise to a unique symbolic meaning. The text of the Book of Changes is to clarify and bring forth the meaning of the hexagram itself. It is then for the reader to interpret the text for the specific situation, although many have found the response to the question asked to be awesome in its clarity Although its validity as an oracle may be doubted by some, the powerful imagery and complex symbolism of this ancient text cannot be denied.

The only true way to experience the *I Ching* is through direct contact. It contains much wisdom and complicated subtlety. The most widely recognized English translation is the Richard Wilhelm /Cary F. Baynes version. This also contains the famous forward by psychologist Carl Jung. But the best teacher for the student of the Book of Changes is the *I Ching* itself

> The Changes is a book
> From which one may not hold all of .
> Alteration, movement without rest,
> Flowing through the six empty places,
> Rising and sinking without fixed law,
> Firm and yielding transform each other.
> They cannot be confined within a rule;
> It is only change that is at work here .
>
> They also show care and sorrow and their causes
> though you have no teacher,
> Approach them as you would your parents
>
> From Book Two of the *I Ching* "The Great Treatise" pg. 348-9 Wilhelm/Baynes translation
> Princeton University Press
> copyright 1950 by Bollingen Foundation Inc., N.Y



I-Ching Computer

The I Ching is older still than even Pierre Trudeau's last rational thought (and probably as hard to understand). For a more complete explanation of the background for this project, consult page 22.

DUE TO THE mathematical and essentially binary nature of the I Ching, the medium of digital electronics is ideal for generating the random hexagram patterns with the authentic probability structure of the yarrow stalks. Also, by using solid state indicators, a visual display taking the form of the original Chinese hexagram can be produced.

Each line of the hexagram can be in one of four states (as described above), a moving (old) yin, a moving (old) yang, a young yang or a young yin. In terms of their probabilities, all six lines can be considered as totally independent of each other.

A moving yin has a probability of occurrence of 1/16, a moving yang 3/16, a young yang 5/16, and a young yin 7/16. Adding these probabilities in different ways we find a probability of ½ that a line will be yang (ie there is a 50-50 chance between yin and yang), and a probability of a ¼ that any line will be moving.

On the I Ching generator the hexagram is displayed on an array of red rectangular LEDs; an additional column of green LEDs indicates any moving lines that are present. There is a push-button which must be pressed six times to create the hexagram; each press randomly throws up one line, with the probabilities described above being derived from a fast binary counter and logic decoding gates.

The lines remain invisible until the last one is complete; the display then illuminates the entire hexagram pattern. A 'clear' button is provided for removing the hexagram, enabling further hexagrams to be created, but it is not considered advisable to cast doubt on the oracle's answers by re-questioning. A frivolous attitude to the I Ching will result in meaningless answers to your questions. The hexagram that is cast can be found in the Book of Changes, and the text that accompanies it should be carefully studied before interpretation. There are further descriptions for each line that may be moving, these should be studied also. Finally, if moving lines are present, the 'change' switch should be operated and any lines that are moving will change into their opposite, thus forming a new hexagram. This hexagram should also be looked up to complete the prediction.

Construction

By using two separate PCBs the machine can be made quite compact, most of the room being taken up by the battery. A smaller battery cannot be used as the current consumption with all the LEDs on is about 40 mA. As these PCBs are not double-sided there are quite a few links which must be soldered in first: 11 on the logic board and six on the display board.

When soldering in the LEDs on the display board take a very careful look at the internal photo and the overlay diagram. This display produces the actual form of the hexagram, the LEDs should all rise to exactly the same height (1.5 cm from the board surface to the top of the LED). Observe also their polarity; all the cathodes should be on the right.

The rest of the display board is straighforward, but it is worthwhile double-checking the transistor pinouts before soldering them all in circuit (perhaps you should build an ETI component tester). A length of ribbon cable can then be wired to the nine lead-out points as marked on the overlay.

When assembling the logic board don't forget to use IC sockets; there is adequate room on the board for these. One problem area may be the zener diode, ZD1. The holes for this diode are very close to the socket for IC7. On our board the end of the socket was filed off. Make sure that both the socket and the diode will fit before soldering them in.

Twisted pairs of wires for connecting the switches should be

TABLE 1

The Eight Trigrams with their commonly accepted equivalents

Chinese name	Chinese meaning	Natural element	Corresponding direction	Moral or Mental quality
Ch'ien	heaven	heaven	NW	strength
K'un	earth	earth	NE	weakness
chen	activity	thunder	E	being active
sun	bending	wind	SE	flexibility
K'an	pit	water	N	being in danger
li	brightness	fire	S	elegance
kên	to stop	mountain	SW	firmness
Tui	pleasure	collection of water	W	joyfulness

Table 1. the commonly accepted equivalents and cardinal points according to King Wen.

soldered as indicated on the overlay diagram. The switches PB1, PB2 and SW1 should be temporarily connected up for testing purposes when assembly is complete. The leads of the ribbon cable from the display board should now be wired to the corresponding points marked on the logic PCB.

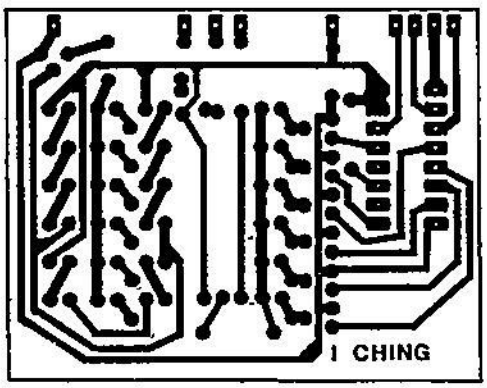
Test Patterns

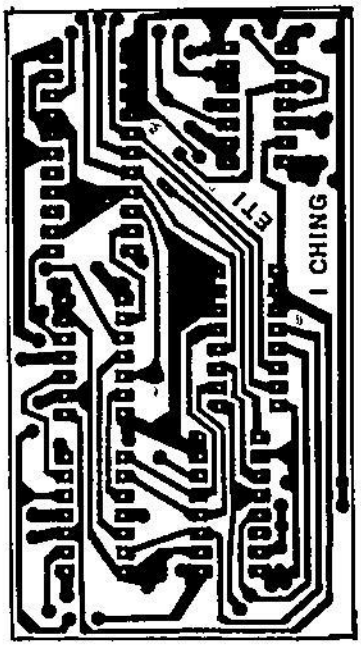
The circuit is now ready for testing, and this is easier if it is done before mounting the boards in the case.

Connect a 9V battery to the supply leads and operate the 'clear' switch PB2. The display should be completely blank. Now press the 'lines' switch PB1 six times; on the sixth press the display should illuminate in a random pattern. The two outside columns of red LEDs should be fully illuminated, and the centre column will consist of any combination of on or off LEDs. Some of the green LEDs might be on; if so, then operating the 'change' switch will change the state of the centre red LED in the corresponding row (from on to off or vice versa). Pressing the clear switch again should blank the display ready for another pattern.

When testing the prototype machine it was discovered that the switching threshold of the Schmitt trigger gates (IC1) can vary considerably from one pack to another This affects the frequency of the main clock built round IC1d, and the frequency of this clock will affect the brightness of the outside columns of red LEDs. Our clock had a frequency of 6 kHz with the first chip we tried, giving a well-lit display, but only 800 Hz with a different chip, causing rather dim LEDs. If the brightness of the outside LEDs does not match the centre column LEDs, then alter the value of C6 until they are of uniform brightness.

If all is well the circuit boards can now be assembled into the case.





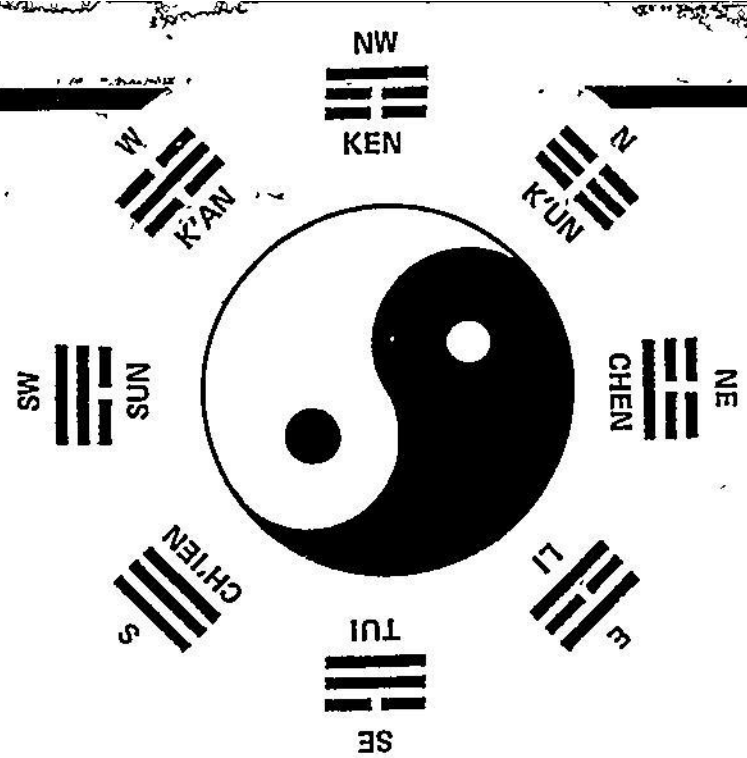


Fig. 1 The arrangement of the eight trigrams according to the legendary emperor Fu Hsi. The diagram is not upside down; south is traditionally shown at the top.

PARTS LIST

Resistors (all ¼W, 5%)	
R1	100k
R2,3	10k
R4,6	47k
R5	68k
R7,8,12,13	4k7
R9	270R
R10,11	220R
R14	1M0

Capacitors	
C1	22n ceramic
C2,3,6	1n0 ceramic
C4	2n2 ceramic
R5	10n ceramic
C7	100n ceramic
C8	100u 10V tantalum

Semiconductors	
IC1	4093B
IC2	4520B
IC3	4011B
IC4	4053B
IC5	4070B
IC6	4051B
IC7	5101
Q1-6,9	MPS6523
Q7,8	MPS6515
ZD1	6V2 400 mW zener
LED1-6, 13-24	rectangular red LED
LED7-12	rectangular green LED

Miscellaneous	
PB1,2	push-to-make switch
SW1,2	miniature slide switch
PCBs; battery and clip.	

HOW IT WORKS:

The overall circuit operates in two distinct modes. Initially, the user presses the 'lines' button PB1 six times and during this time two random binary bits are written into six sequential address spaces of a memory. On the sixth press, after recording the last two bits, the circuit switches to its other mode of operation. Here, a binary counter is clocked continuously and its outputs are used to scan the addresses to the memory. The previously recorded data is read out to a multiplexed LED display scanned by these same address lines. Essentially the two modes are; build up the hexagram pattern, then display it.

The line labelled 'control line' on the circuit diagram is used to switch the operating mode. This line is taken from the output of IC3a, a NAND gate whose inputs are wired to the B and C outputs of the slow binary counter IC2a. Thus the line is normally logic high and will go low when IC2a reaches a count of six. This control line is used to switch the address lines of the memory (IC7) and display decoder (IC6) from the slow counter IC2a to the fast counter IC2b. This is achieved with IC4 (a triple one-of-two CMOS switch) whose switch-select lines on pins 9, 10 and 11 are wired to the control line.

When power is first applied to the circuit, the slow counter IC2a is reset to all zeroes by the C4/R4 network. PB1 is the 'lines input' button. When pressed, it takes the input of IC1a (pin 12) high; this input is normally held low by R1, with C1 providing switch debouncing. The pin 13 input of IC1a will be held high by the control line, thus the output on pin 11 will go low while the input switch is pressed. This signal must initiate the following actions: first the random bit generator must be stopped, allowing the data to become stable, then this data must be written to the memory, and finally IC2a must be clocked to its next count position.

The random bit generator is implemented by driving the binary counter IC2b from a 6 kHz clock and decoding the four bit output with the logic gates IC3b, IC3c and IC5a. This provides two bits with the correct interdependent probabilities of occurrence; the truth table for these gates (Table 2) shows how these probabilities are derived. For example, when the counter is stopped, the D output has a 50-50 chance of being either high or low; this is the yin-yang indicator. The output of IC3c on pin 11 determines whether the line is moving or not; a logic low signifies a moving line. The counter is stopped by disabling the clock oscillator built around Schmitt trigger IC1d, C5 and R5. The pin 9 input to IC1d is wired to the push-button signal on pin 11 is high and disabled when low (i.e., when PB1 is pressed).

The two random bits which are selected when the clock is stopped are fed directly to two data inputs of the memory IC7 (a CMOS 5101). The data will be stored when the write line is wired to the output of IC1c where a 10 uS negative-going pulse arrives 10 uS after the clock has been stopped.

This pulse is again derived from the logic low push-button signal, the delay is provided by R2, C2, and Schmitt inverter IC1b, and the short negative-going pulse by C3, R3, and inverter IC1c. After the data has been stored, the positive-going edge of this same pulse is used to clock the slow counter IC2a which sets the next address for writing to memory.

This circuit action takes place on each operation of the switch, the memory location being incremented when the button is depressed and the free running clock generating random bits when it is released. On the sixth press of the button, when the last line of the hexagram is written to memory, IC2a then clocks to count 6, thus switching the control line from high to low.

The control line puts a low on the pin 13 input of IC1a, so inhibiting further operation of PB1, and allowing the fast clock to oscillate continuously. The control line also enables NAND gate IC3d via inverter IC5b; and by placing a logic low on the inhibit pin of IC6, the diplay decoder is also enabled. These controls allow the display to illuminate.

The address lines for the memory and display are now switched to the A, B and C outputs of the binary counter IC2d. For each three bit binary address that is routed through switch IC4 from the counter IC2b, one sequential output of the decoder IC6 is selected in conjunction with the corresponding memory word. (The 5101 chip is a 256 word by four bit memory, but in our application only six words of two bits are used; it's still the cheapest and simplest method though!)

The 1-of-8 line analogue decoder IC6 connects the base of the corresponding PNP transistor (Q1-6) via R8 to ground; this switches on the transistor which in turn takes the anode of the associated red and green LEDs to the positive supply rail.

The two bit memory word selected by the address lines A5, 6 and 7 of IC7 is available on the data output pins 10 and 12.

The moving line information from pin 12 is fed via inverter IC5d and R13 to the base of NPN transistor Q8. The collector of Q8 is connected via R11 to all the cathodes of the green LEDs (LEDs 7-12). Thus when a moving line is present the output of IC5d will be high, turning on Q8 and providing a ground return for the selected LED.

A yang line is represented by a logic low on the data output pin 10; this provides one input to an EXOR gate IC5c. The other input is normally held high via R14, which makes the gate act as an inverter, thus driving Q8 and the red LEDs in the same manner as the moving line indicators. Since the address lines are driven by a continuous binary count, each line of the hexagram is repeatedly displayed in turn, giving the effect of a complete display. The outside columns of red LEDs must also be on continuously to complete the hexagram pattern. They are driven by a pulse waveform derived from the main clock using C6, R6 and IC3d to produce a train of negative-

Inside the I Ching computer. Everything fits in neatly if the recommended case, battery and PCBs are used.

going pulses. These pulses turn on Q9 for a short period in each clock cycle, allowing a current burst to illuminate the series-parallel combination of LEDs (LEDs 13-24). Driving the LEDs in this way reduces the current consumption required for the same brightness.

SW1 is the 'Change' switch; when closed it has the effect of turning any moving lines into their opposite state; yin for yang and vice versa. The 'moving line' data output on pin 12 of IC7 will be conected to one input of EXOR gate IC5c, which then acts as a logic-level-controlled inverter, to produce the desired effect

To create another hexagram the 'RESET' switch PB2 can be pressed. This resets the counter IC2a back to zero, which is turn switches the control line high again, blanking the display and returning the circuit to its first operating mode. The 'Lines' push-button now becomes operational again, allowing new hexagrams to be determined.

TABLE 2

	COUNTER OUTPUTS				GATE CONNECTIONS		
	D	C	B	A	E	F	G
YANG	0	0	0	0	1	1	1
	0	0	0	1	1	1	0
	0	0	1	0	1	1	1
	0	0	1	1	1	1	0
	0	1	0	0	1	1	1
	0	1	0	1	1	1	0
	0	1	1	0	0	0	1
	0	1	1	1	0	0	1
	1	0	0	0	1	0	1
	1	0	0	1	1	0	1
YIN	1	0	1	0	1	0	1
	1	0	1	1	1	0	1
	1	1	0	0	1	0	1
	1	1	0	1	1	0	1
	1	1	1	0	0	1	0
	1	1	1	1	0	1	0

D = 0 indicates yang; D = 1 indicates yin
G = 0 indicates a moving line

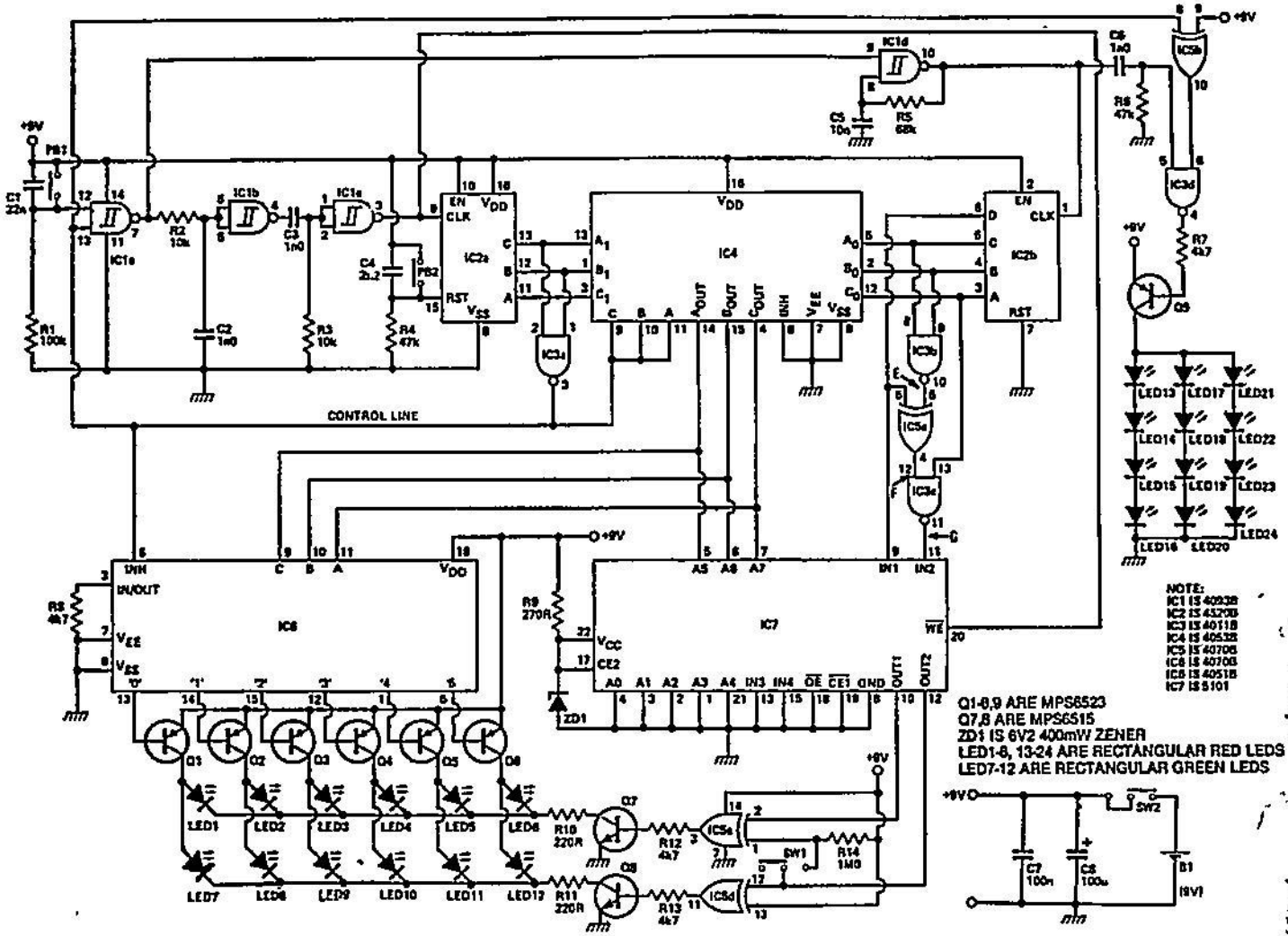


Fig. 2. (Above) Complete circuit diagram of the I Ching oracle.

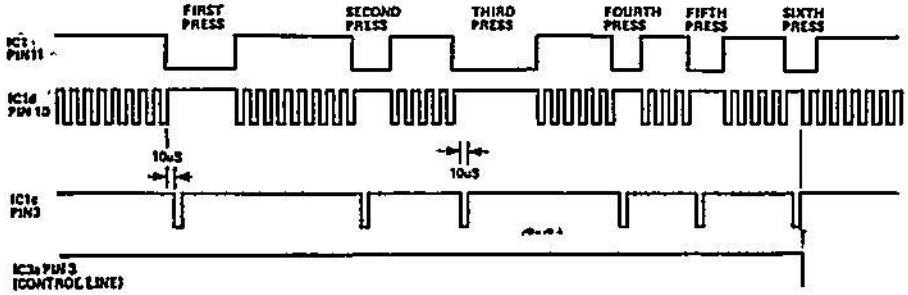


Fig. 3 (Left) Timing diagram for the logic.

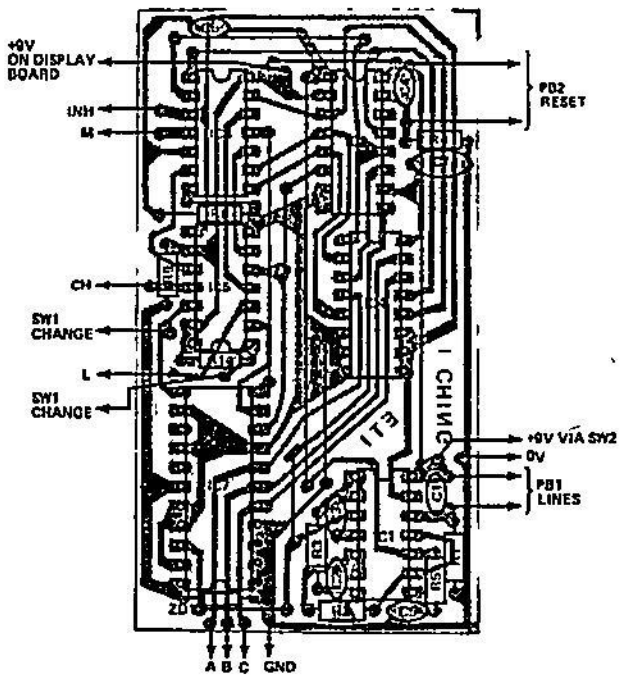


Fig. 4 (Above) Component overlay for the main board.

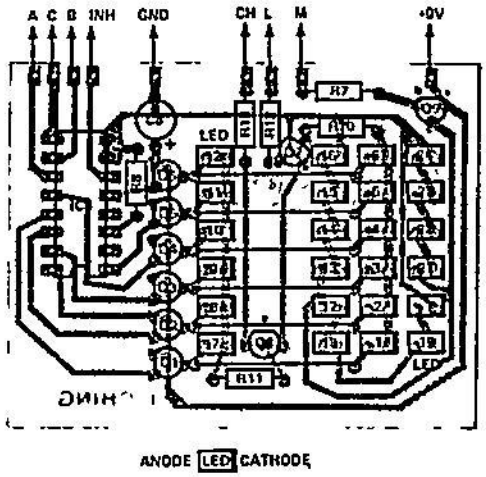


Fig. 5 Component overlay for the display board.

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current is bled out of the device through a circuit. If the light's frequency does not excite the first layer, it passes into the second layer, where it will excite that layer to produce an electrical current. This current is in turn bled out of the device through a second circuit. Thus, this device can demultiplex light of two frequencies.

When a signal reaches the end of a circuit, it has to be detected. There are a number of ways this can be done, one of the most elegant being the phototransistor.

In this device, a lightwave is absorbed by a vertically layered device consisting of Indium-Phosphide and Indium-Gallium-Arsenide. As the light is absorbed in the bottom of the device electrons are removed and bled out of the system leaving holes. These holes then produce current proportional to the light energy initially received.

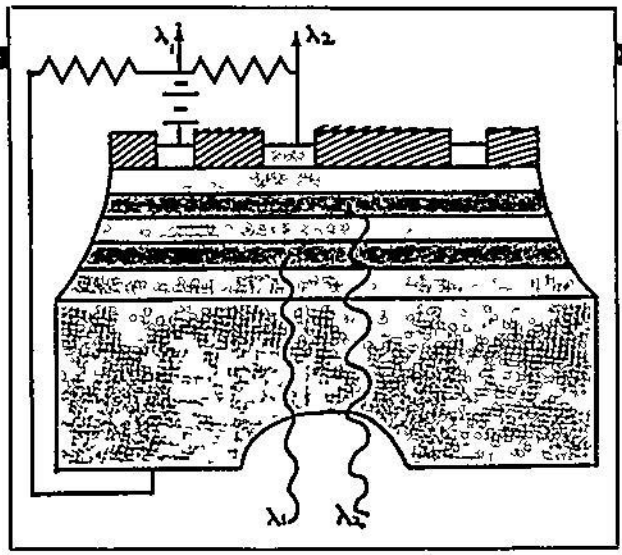

Fig. 8. Photodetector. This integrated circuit, on an Indium phosphide substrate, detects light (entering from the bottom) of two different wavelengths (X_1 + X_2) simultaneously. The circuit separates the signals and converts them into electrical form for further processing.

The Practicalities

While the foregoing is interesting in itself, it can unfortunately be considered as yet just another piece of 'gee whiz' science. The difficulty facing integrated optics researchers is that they are still in their laboratories and have as yet not turned over their devices to the commercial arms of their corporations or governments. It is all very well for Japanese researchers to talk of computers run on lightwaves, but those of us sometimes misled by scientists' predictions of the potential of various technologies may be tempted to joke about the candlepower of a computer's RAM!

While it would be misleading to suggest that integrated optics will have a comparable effect on the everyday world as the IC, one would not be wrong to suggest that the speeds to which we have become accustomed in computer technology will be substantially shortened with the large scale implementation of integrated optics.

Furthermore, because integrated optical devices (like other fiber optic devices) can operate at wide temperature and humidity extremes, and are impervious to environmental background radiation, the cost of large-scale computing devices operating on this technology will become substantially cheaper.

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