BUILD A DIGITAL AUTO/MARINE TACHOMETER

Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

JUNE 1975/75c

HOW TO DESIGN YOUR OWN POWER SUPPLIES

- Getting Started With Op Amps
- Filter Sharpens CW Reception
- Electronic Music Timbre Circuits

TEST REPORTS:

Burwen 1201 Dynamic Noise Filter

Sony TC-645 Open-Reel Tape Deck

Telephonics 4-Channel Headphones

Pace 2300 AM CB Mobile Transceiver

Danameter Liquid-Crystal DVOM

New Modules Simplify Building Stereo Power Amp

"TITAN" HIGH-POWER-OUTPUT KIT

A ZIFF-DAVIS PUBLICATION

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potential can and often do exist between two points of a grounding system if any current flows in the system.

The sketch illustrates the phantom wire resistance that forms the common signal point. Note that any instrument plugged into the three-wire outlet is essentially coupled to all other outlets via an interlocking set of phantom resistors.

If you connect a couple of line-powered test instruments as shown in sketch B, a ground loop can occur. The metal chassis of both instruments are grounded via the third (green) wire of the receptacle. In some cases, there may be some real capacitors between the ac line and chassis. In all cases, there is the phantom capacitance across the power transformer. Hence, if any current is flowing within the building's power-line "ground," this signal will be "felt" by the measuring system, which will introduce a false signal into the measurement loop.

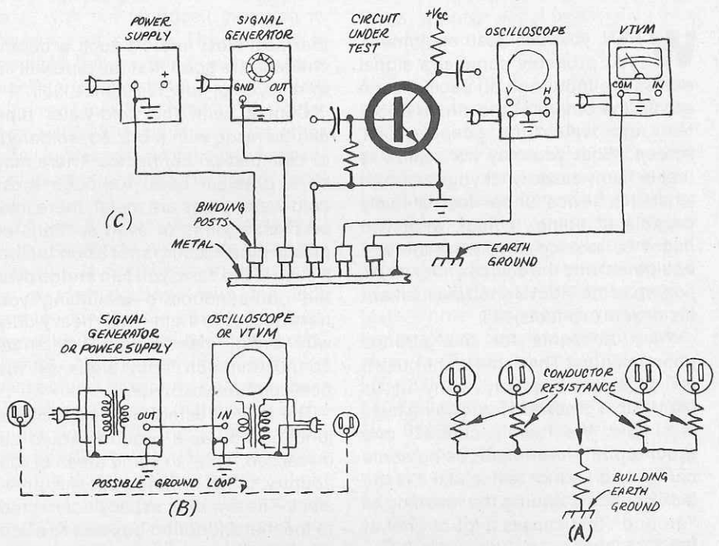
To break the ground loop and remove false signals, the third wire at one of the instrument power plugs must be broken. (Use a three-wire to two-wire adapter.) As a result, the system is grounded at only one point and, since the ground loop is now broken, false signals produced by ground currents are eliminated.

In using the ungrounded adapter, there is a potential danger if the "hot" power line within the instrument touches the metal chassis. So, before using this approach, make certain that all internal wiring is sound.

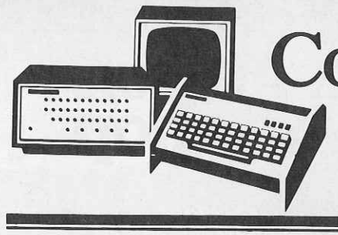
In multi-instrument setups, there may be more than one ground connection, creating more than one ground loop. Any one of these loops can introduce a problem. Since shielded cables are often used to interconnect a system, especially in audio, all shields should be connected together and then tied to ground at the same point used by the measurement system.

A typical bench setup is shown in sketch C, where two-wire power plugs are used to eliminate the possibility of ground loops. In general, if more than one point in a system must be connected to ground, the ground connections must be made only at the same point where the input is grounded.

There are two excellent books that deal with the subject of grounding when working with test equipment. One is *Basic Electronic Instrument Handbook* by Clyde F. Coombs, Jr. (McGraw-Hill) and the other is *Guide to Electronic Measurements and Laboratory Practice* by Stanley Wolf (Prentice-Hall). ◈



How grounding problems originate. (A) shows how differences in wire resistances create potential differences. (B) shows ground loop in building power line which introduces a false signal. At (C) is a typical test-bench setup with 2-wire plugs to eliminate loops.



Computer Bits

By Jerry Ogdin

A NEW BREED OF HOBBYISTS

FOR many years, the thought of having one's own digital computer was only a dream because they could cost anywhere from $100,000 to several million.

But in the late 1960's, Digital Equipment Corp. announced its $24,000 PDP-8, raising hopes of forward thinkers for that elusive home computer. With the 1970 introduction of the microprocessor IC (CPU-on-a-chip), representing the "heart" of a full-blown digital computer in a single IC package, they knew it was just a matter of time before prices dropped.

Not content to wait, amateur computer users banded together during the early '70s to share ideas and equipment. In fact, many of the successful applications of microprocessors on the market today owe their origination to these hardy souls, who experimented with building personal computers.

The breakthrough in low-cost microprocessors occurred just before Christmas 1974, when the January 1975 issue of POPULAR ELECTRONICS reached readers with the first relatively inexpensive unit—about $400 in kit form—that competed in performance with much costlier commercial units. The aftermath is heartwarming to electronics hobbyists—CPU prices are plummeting, and at least one major manufacturer drastically cut the price of its microprocessor.

People interested in computers fall into three major groups: (1) Strong background in "hardware," the physical electronics equipment; weak in "software," the instruction programs needed to make the computer perform some useful task. (2) Strong background in "software," weak in "hardware." (3) Interested amateurs who have no experience in either sector, but find the world of computers an exciting challenge they'd like to tackle.

So it's not surprising to learn that small hobbyist groups are springing up all over the country, where competent and enthusiastic programmers who cannot read a wiring or logic diagram share ideas with electronic engineers and technicians who work with computers daily, but still find the mysteries of software virtually a black art. For example, a recent letter addressed to POPULAR ELECTRONICS from Hal Singer (hardware editor) and Steve Diamond (software editor), Cabrillo Computer Center, 4350 Constellation Road, Lompoc, CA 93436, stated that they represent a user group of 300 hobbyists actively constructing microcomputers, and would like to encourage participation in their group by persons planning to build the *Altair 8800* computer that debuted in POPULAR ELECTRONICS' January 1975 issue. The group published four newsletters, which can be received by sending a self-addressed manila envelope with 50¢ stamp to the address above.

What's a Computer? A computer is a deceptively simple kind of device if you look at it from a "black box" viewpoint, not trying to understand all the electronic "innards."

All computers are fundamentally alike from the largest to the smallest. And the humblest of computers can perform the same work as a huge computer can, except that it takes more time to do it! With a suitable program (software) in its memory, a computer can be a game player, a home accounting machine, or an environmental controller; and in many cases, it can be all of these things at the same time.

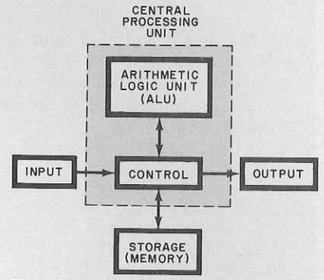
No matter how large or small, a computer must have five basic elements, as illustrated.

1. The Arithmetic Logic Unit (ALU) performs additions, subtractions, and all the other arithmetic and logical operations on the input data (something on the order of a super calculator). It is the features of the ALU that determine the ultimate potential power of the computer.

2. The Control portion orchestrates the movement of data and instructions from one part of the computer to another by taking the operational instructions that were inserted (programmed) into the memory and using these to perform some function to change the input data to output data.

3. The Memory (more properly called Storage, but the two words are used interchangeably) is used to hold operational instructions for the computer, and store intermediate results, commonly used tables, and other pertinent data.

4. The Input Circuit allows the computer to accept data from the outside world. The actual input can come from a single sensor, a two-wire system, or a complex network of things to be monitored. Anything that can be converted into computer-acceptable data can be used as the input.



Five basic parts of any computer.

5. The Output Circuit delivers the data generated by the computer to some form of device that does the appropriate work. Without output capabilities, the computer serves no useful purpose.

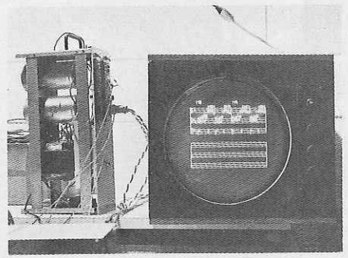
The ALU and Control circuits are often combined and called a Central Processing Unit (CPU). Years ago, the CPU was awesome—a few feet high, a couple of feet deep, and several feet long. With the advent of large-scale integration (LSI), a complex CPU can now be contained within a single integrated circuit having 40 or less pins. Interestingly, there are now over 25 microprocessors to choose from, if you elect to build your own computer.

All of the current microprocessors have been described in a publication called "The New Logic Notebook," issued monthly. Its premier issue included a "Microprocessor Scorecard" that summarizes the major features of all known CPU's (since publi-

cation, General Instrument introduced its CP1600, a 16-bit address chip). To obtain a free copy of the scorecard, write directly to Microcomputer Technique, Inc., 11227 Handlebar Road, Reston, VA 22091, enclosing a 9″ × 12″ self-addressed, stamped (10¢) envelope.

The Biggest Problem. It is not overly difficult nor expensive to build your own computer. The major problem that plagues hobbyists (and the computer industry as well), is an inexpensive and useful input/output device such as a terminal.

The first reaction is usually to suggest using a teletypewriter such as Teletype Corp.'s 33ASR. However, this means connecting a $1200 device to a $400 computer—hardly a desirable match from the point of view of cost. There are, to be sure, some inexpensive teleprinters on the surplus market, and many hobbyists have adapted them to computer use. However, there is still a major problem—this equipment is bulky, noisy, and slow.

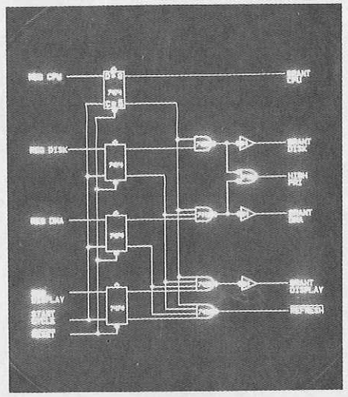


Graphics terminal (above left), designed by Hal Chamberlain, can draw pictures of music scores or logic diagrams, as at right.

The second reaction to the problem is almost always to consider using a TV set as the output display device and an inexpensive keyboard as the input medium. Connecting a keyboard to a computer is easy, of course, but driving a TV set with the output is a difficult task. At present, estimates run to a few hundred dollars to make this type of TV data display. (A couple of low-cost "computer terminals" are currently being advertised, but we have no experience with them to date.)

One solution to this problem has been the design of a graphics terminal by Hal Chamberlain, writing in "The Computer Hobbyist,' Box 295, Cary, NC 27511. This terminal is controlled from an Intel 8008 microprocessor with as little as 1024 (eight bit) bytes of memory. In addition to alphanumerics, it is also capable of drawing pictures (for example: chessboards, music manuscripts and logic diagrams). When combined with a low-cost keyboard for the input device, this display can serve as the primary output device for a small computer.

Sharing. The sharing of hardware and software ideas depends upon common agreement as to symbols and media. Electronic circuits all conform to standardized schematic symbol rules. However, computer programs are usually too complicated to be so simply described. It is common, therefore, for programmers to share and exchange programs.



If you obtain a useful program from a friend, you'll often be faced with the problem of transcribing it into computer form through a keyboard. Not only is that time-consuming, but it is error-prone. As one expects, most computer centers exchange programs on magnetic tape, but the tape transports cost upwards of $5,000. Users of mini-computers tend to use punched paper tape from a Teletypewriter, but few hobbyists will have a paper tape reader.

So what is the poor computer hobbyist to do? A neat, inexpensive solution will be offered in this column next time around. ◈

Editor's Note. It is hoped that this quarterly column will serve as a clearing house for computer hobbyist groups and others with interests in the field. If you are a member of such a group, or want to be, write to Computer Bits, Popular Electronics, 1 Park Ave., New York, NY 10016.

MAC'S SERVICE SHOP

Taming Static Electricity

By John. F. Frye, W9EGV

THROUGH the open door of the service department, Mac watched Matilda typing in the outer office. She did not hear Barney, Mac's assistant, come in from the bright freezing weather outside. He quietly removed his snow boots and stealthily walked across the floor, sliding his feet on the carpet, until he was standing directly behind the absorbed girl. He slowly reached out a forefinger towards the nape of her neck, and she suddenly let out a shriek scattering the papers she was holding. Barney beat a hasty retreat to the service department with Matilda in hot pursuit.

"Let me kill him," Matilda begged, trying to dodge around Mac and get at Barney. "He stuck me with a pin."

"I did not," Barney denied, grinning down maddeningly. "I didn't even touch you."

Static Electricity Is To Blame. "He's right. I saw the whole thing," Mac said. "He gave you a shock with static electricity, and that gives me an excuse to continue a discussion of several months ago. Then we talked about the *uses* of static electricity for such things as smoke precipitation, ore separation, spray painting, and flocking. These are examples of static electricity on its good behavior —which it usually isn't! Most of the time it's causing shocks, unruly hair, clinging clothes, lightning strokes, and explosions; or it's fouling up printing and manufacturing processes or destroying IC's and transistors. Astronomy has been called the wise child of a foolish mother, astrology. In the same way, static electricity might be called the mischievous, annoying parent of a hardworking son, current electricity, which provides us with light, heat, telecommunication, and power. So now let's talk about how we can take the mischief out of static electricity."

"Amen!" Matilda said soulfully, rubbing the back of her neck.

"You both know from your high school physics or our previous discussion that, when certain substances are placed in firm contact and then separated, electrons transfer from atoms of one substance to atoms of the other. Atoms which lose electrons become positively charged ions, or cations; those gaining an electron become negatively charged ions, or anions. Both a potential difference and an electrostatic attraction develop between the separated, oppositely charged surfaces. In fact, if only one electron in 100,000 atoms of a surface is exchanged, that surface is very strongly charged. The substances vary widely, but one or both is usually a poor conductor. Some combinations are: glass and silk, wool and hard rubber, paper and a printing press roll, a fabric belt and a steel pulley, a rubber tire and the pavement, a cold dry stream of particle-bearing air and an airplane wing."

"Or the soles of a pair of size eleven clodhoppers sliding across a nylon carpet," Matilda injected tartly, glowering at Barney's feet.

"Electrostatic attraction is what makes your hair follow the comb on a snappy winter day such as this," Mac hastened to continue. "The passage of the comb leaves one type of charge on the hair and the opposite on the comb. But since the individual hairs have similar charges, they repel each other after the comb is taken away leaving you with a Phyllis Diller coiffure. Dampening the hair provides a conductive path for the charges to leak off the ends and permits you to comb it down.

"Here we have one rule for the control of static electricity problems: *provide a comparatively low resistance path for the charge to leak off as fast as it accumulates on a nonconductor or on the surface of an insulated conductor*. I say 'comparatively low resistance path' because a resistance as high as one megohm will or-