VOL. 1 No. 6 October 1984

COMPUTER DIGEST

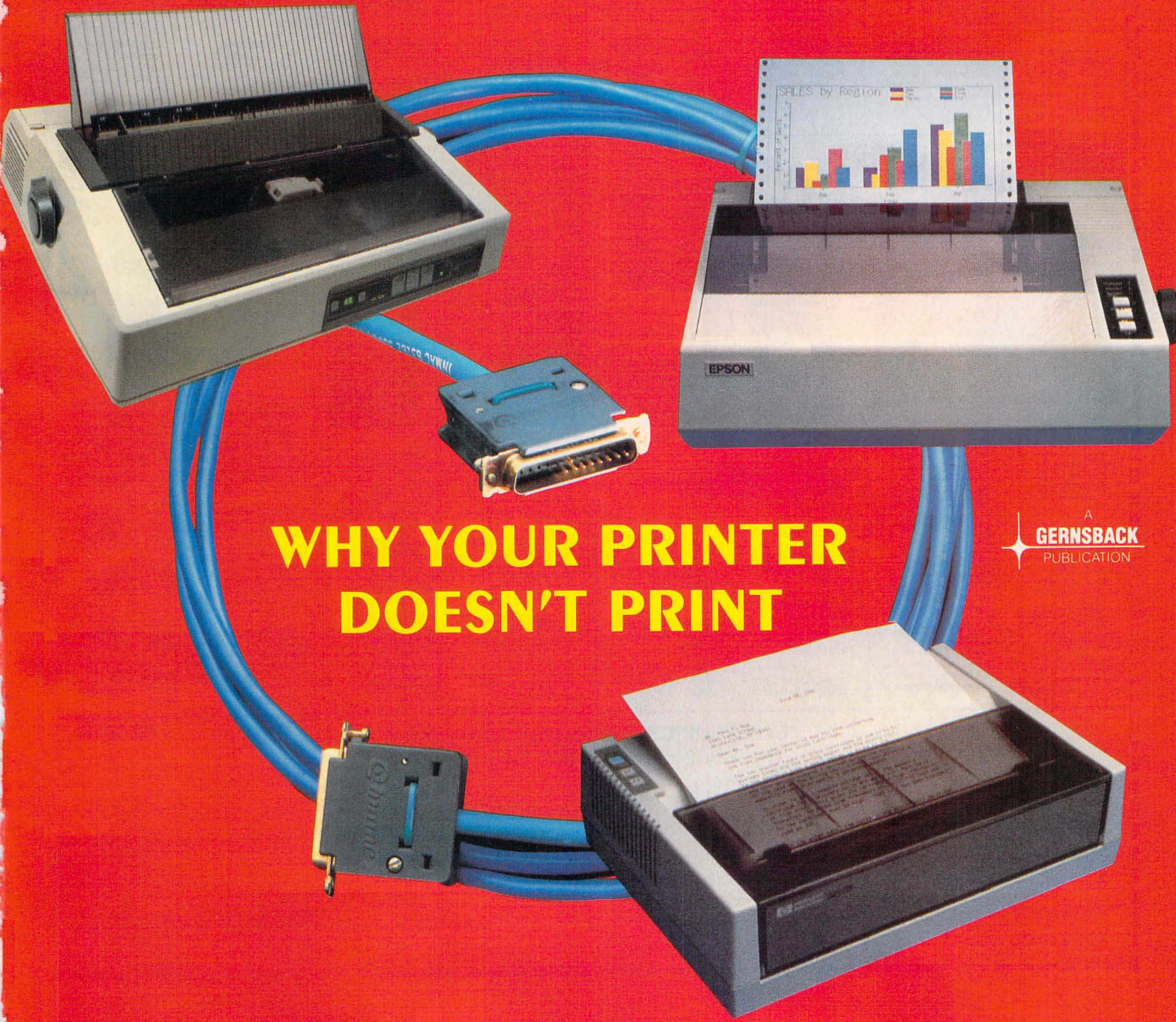
NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

OP-AMP DESIGN...

You can use your computer to save yourself a lot of time and work in designing Operational Amplifiers.

COMMODORE CASSETTE INTERFACE...

How to build a simple circuit that lets you use ANY small audio tape recorder with your Commodore computer.



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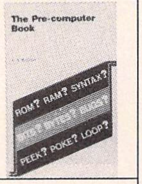

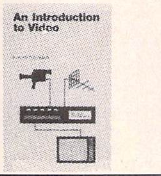

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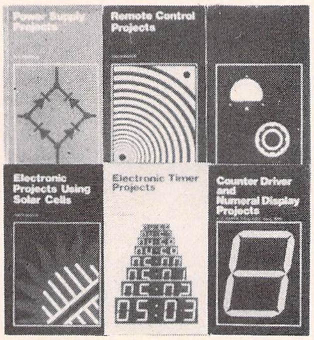

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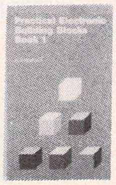

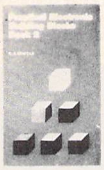

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☐ **CB PROJECTS. $5.00.** A number of useful and interesting designs for CB accessories. Speech processor, interference filter & more.

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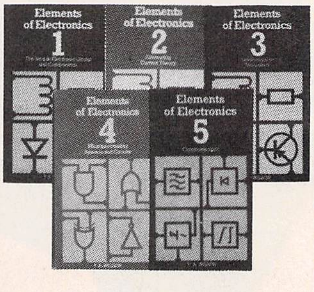

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EDITORIAL

The future is here today!

This century has been a highly innovative one. If you stop to think that at the beginning of the 20th Century, man was still bound to Earth and hadn't learned to fly, that medical science was almost barbaric as compared to today, and that electronics was but a fantastic-fiction dream, you pause and wonder at our accomplishments.

If you look at our progress in this past 100 years and try to look ahead to the next 100, it's sufficient to boggle the mind. The very computer on which this editorial is now being written could not have existed those scant few years ago.

Let's try a small exercise—an experiment, if you will. We're going to "brainstorm" or "blue-sky" the coming of the future.

Our readers are, for the most part, intelligent, scientific types. Let's concentrate on the future of computer technology. Where will we be in another century, as far as computers are concerned? What will computers be doing, how will they be doing it, and what will *we* be doing with them? And please, nothing off-the-wall.

Give us those things with sound, scientific basis, following normal developmental processes. Send your ideas to **ComputerDigest**, 200 Park Avenue South, New York, NY 10003. Got any artistic skills? Send along sketches too.

This will make an interesting project for our readers; and, of course, when all the results are tabulated, we'll put an article together that should make some fantastic reading. All entries will become the property of Gernsback Publications, Inc., and no submissions can be returned.

So put your thinking caps on, and get to work. We'll be anxious to see what you come up with!

Byron G. Wels

Byron G. Wels
Editor

ComputerDigest is published monthly as an insert in Radio-Electronics magazine by Gernsback Publications, Inc., 200 Park Avenue South, New York, NY 10003. Second-Class Postage Paid at New York, N.Y. and additional mailing offices.

COMPUTER DIGEST

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Gernsback Publications, Inc.
200 Park Ave. South
New York, NY 10003
Chairman of the Board: M. Harvey Gernsback
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ADVERTISING SALES 212-777-6400
Larry Steckler
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EAST/SOUTHEAST
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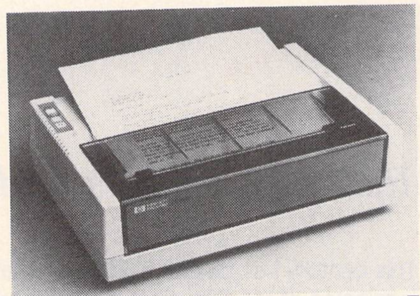

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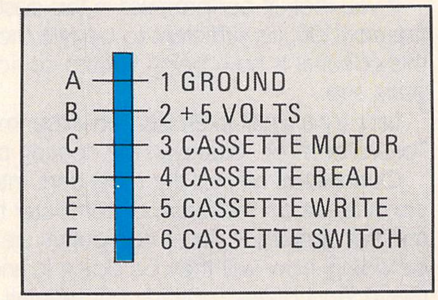

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ON THE COVER

Looking up at you from the middle of our cover, is an RS232 connector. And clockwise, starting at the other end of the cable, is the NEC printer, followed by the Epson and at the lower right, Hewlett Packard's entry. See page 7.

LETTERS

Wants portables

I'd like to see an applications-oriented article on portable computers. I'm sure that a lot of other readers would be just as interested.—Sam Bennett, Fresno, CA.

Sounds like a great idea Sam. We'll get one of our experts busy on that one right away!

No games?

How come you don't report on new computer games the way some computer magazines do? —Fred Morrison, Madison, WI.

Fred, take a look at our front cover. It says "A New Kind of Magazine For Electronics Professionals." We want all the readers we can get, but no magazine can be all things to all people.

Settle an argument

A friend says that a good computer "hacker" can break into almost any computer system, regardless of the security. I am wondering if that statement is really true? —Gene Lyons, Atlanta, GA.

Gene, while nothing is ever 100%, the odds are against it, despite what the movies show! Cracking the most basic system would take more patience than most people have, and a system, where codes are periodically changed, would be all but foolproof.

More kudos!

I would like to see *ComputerDigest* continue to present concise summaries of current events in the computer field, and am relieved to have discovered a computer magazine which is not just a sales pitch! —P. D. Broadhurst, Channel Islands.

Thank you too, Mr. Broadhurst. More and more, our readers are beginning to learn what we're all about! It's very gratifying indeed.

More hardware

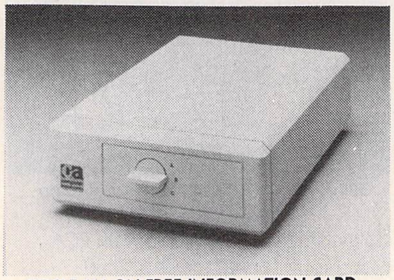
I'm so tired of software-only articles that I could write some myself, just from the ones I read! Yours is the last magazine that contains useable information on projects and hardware. And printing my comments is not expected. —Irving E. Shivar, Jr., Camden, SC.

Surprise, Mr. Shivar! Thanks for understanding (and appreciating) what we're trying to do. Keeping a wide variety of readers happy is our goal.

COMPUTER PRODUCTS

For more details use the free information card inside the back cover

PORT EXPANDERS/SWITCHERS, *Data Director* models *Q23, Q24, Q25, Q13, Q14,* and model *Q15* are a series of "port traffic cops"—port expanders with A/B/C switch routing—that can switch one port to any of three devices, or one device to any of three ports.



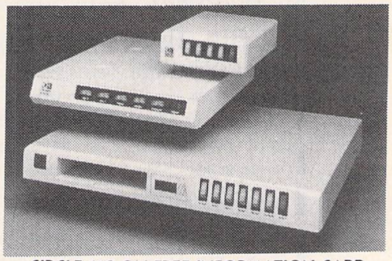
CIRCLE 111 ON FREE INFORMATION CARD

Model *Q23*, model *Q24*, and model *Q25* are in stand-alone cabinets, while model *Q13*, model *Q14*, and model *Q15* are designed to fit inside Computer Accessories' model *P12* Power Director (line-conditioning power-control accessory) cabinet.

The three models in each series meet specific connector needs for a given port or system. For standard RS-232 serial ports, Data Director offers model *DB25* female (models *Q13/Q23*) or male (models *Q14/Q24*) connectors. For standard parallel (printer) ports, Data Director (models *Q15/Q25*) offers 36-pin Centronics-style connectors.

Models *Q23, Q24,* and *Q25* are priced at $199.00 each; models *Q13, Q14,* and *Q15* are priced at $189.00 each.—**CA Computer Accessories,** 7696 Formula Place, San Diego, CA 92121.

POWER OUTLET EXPANDER/FILTER, the *Power Director* model *P22*, model *P2*, and model *P12* are designed to filter radio-frequency noise, spikes, glitches, and surges that imperil sensitive electronics equipment.

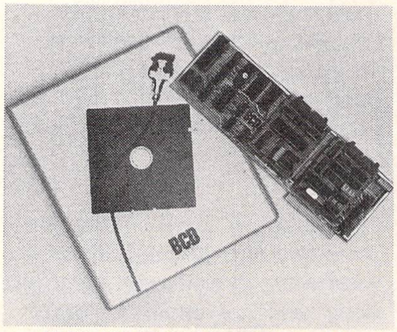


CIRCLE 112 ON FREE INFORMATION CARD

These are desktop-design devices and individual and collective (master) outlet control are part of the design. Each outlet is monitored with a power pilot light (amber for the individual outlets, red for the master) a circuit breaker adds overload protection. While the pilot lights are located on the front panel, the actual outlets are out of sight on the back panel.

The stand-alone model *P22* (sized to stack with such items as disk drives and modems) offers four outlets and is available for $99.00. The monitor-base model *P2* (sized to fit under a CRT or video monitor) offers five outlets and is available for $129.00. The model *P12* (sized to fit atop the IBM PC system unit, for example) offers six outlets, plus a digital clock and stowaway storage areas for diskettes, quick-reference cards, or small manuals, is priced at $199.00.—**Computer Accessories Corporation,** 7696 Formula Place, San Diego, CA 92121.

VIDEO TAPE/DISC CONTROLLER, model *VIPc*, is a plug-in board that lets an IBM *PC* (or similar computer) control industrial-type videotape



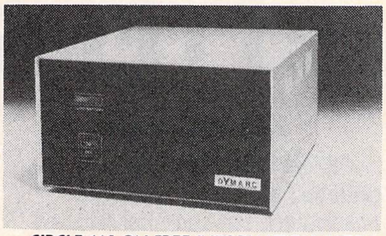
CIRCLE 113 ON FREE INFORMATION CARD

recorders with frame-accurate precision. It can also control videodisc players. The internal microprocessor, and up to 32K of RAM/ROM, translates simple user commands into complex videotape-recorder and/or videodisc player operations. The model *VIPc*'s motherboard plugs into the computer and may host one or two "video modules" to control tape, disc, or one of each.

The model *VIPc* with tape or disc video module is priced at $1195.00; with tape and disc video modules, it costs $1695.00.—**BCD Associates, Inc.,** 5809 S.W. 5th Street, Oklahoma City, OK 73128

UNINTERRUPTABLE POWER SUPPLY, model *1350*, provides 10 minutes of backup electric power for computers during a power failure. It weighs 32 pounds and fits in a compact, ½ cubic-foot space.

The model *1350* provides 120 volts at 350 volt-amps—sufficient power for a computer, disk-drive, printer, and monitor. The unit has a transfer time of 12 milliseconds, typical, and a single-phase 60-Hz supply (±0.5%). It also contains a patented clipper circuit to

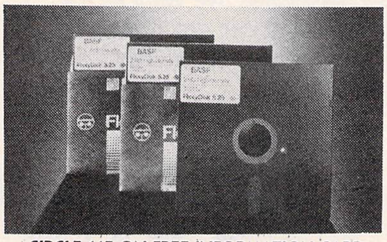


CIRCLE 114 ON FREE INFORMATION CARD

provide on-line surge protection from both normal and common-mode transients. RFI suppression is handled by Sprague filters.

The model *1350* has a suggested retail price of $750.00 and comes complete with a maintenance-free battery.—**Dymarc Industries,** 21 Governor's Ct., Baltimore, MD 21207.

HIGH-DENSITY DISKETTE, model *2HD*, features a new coating technology that allows the 5.25-inch diskette to store up to 1.6 megabytes, or 60% more than the conventional 5.25-inch 96 TPI floppy. The improved storage value helps to close the gap between the 5.25-inch rigid and the



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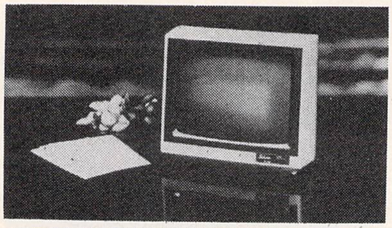
5.25-inch floppy. It is priced at $9.25 per disk.—**BASF Systems Corporation,** Crosby Drive, Bedford, MA 01730.

AMBER MONITOR, model *SA-1000*, has a 12-inch CRT and a non-glare, high contrast faceplate. Among its features are composite video-input signal, a resolution of 900 dots center and 800



CIRCLE 116 ON FREE INFORMATION CARD

dots corner. It also includes an RCA-type input connector, and 2000 character display format (5 × 7 dots, 80 characters × 25 lines).

The amber monitor model *SA-1000* is priced at $159.00.—**Sakata USA Corporation,** 651 Bonnie Lane, Elk Grove Village, IL 60007.

WHY YOUR PRINTER DOESN'T *PRINT...*

It's standards that make parallel printers work. It's the lack of standards that gives us trouble.

HERB FRIEDMAN

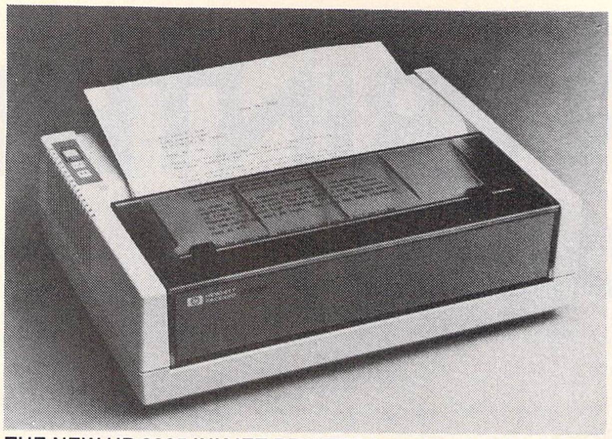
■*Standards* are what keeps the world working. They insure that an 8-32 screw from Outer Mongolia will fit an 8-32 nut manufactured in Lower Sandusky, Ohio: that your telephone will access any other telephone in North America, possibly the world: that the portable TV you purchased in New York—which was manufactured in Osaka—will not blow up when you plug it in to a power outlet in Yellowknife.

Unfortunately, manufacturers of many kinds of consumer equipment are prone to utilizing only part of a standard, prefering—for whatever the reason—to make their own proprietary modifications to the standard for what often appears to be be no rational reason. In actual fact, many times an actual standard or a *de facto* standard is modified to intentionally prevent a device from being used with any other equipment supposedly using the *standard*. Printers intended for use with personal computers are an excellent example of modified standards, which is often the reason you can't get your old and faithful printer to work with the new computer, or why your new computer won't work with someone else's printer. For example, we all know the IBM graphics printer is an Epson. Right? Only partially right. Use your old Epson and you'll print the standard ASCII characters, but not the IBM graphics.

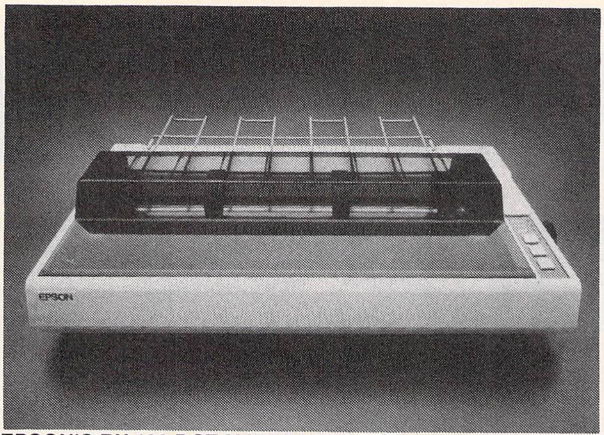
And while we're talking about IBM, we all know the Epson printer, or a Smith Corona L-1000 daisy wheel, or any of a hundred printers have *standard* Centronics-type connections. So does the IBM. So how come you can't plug a Centronics type printer into an IBM-compatible personal computer? Because while the connections are standard, the connector isn't. IBM-compatible computers employ a a DB-25 connector for their parallel printer output, but the DB-25 is the standard for RS-232/O, it in no shape, form or manner is the equivalent of the truly standard Centronics-type Delta connector. To use a Centronics-type printer with an IBM-compatible computer the user must purchase a special, and somewhat expensive, adapter cable having a DB-25 on one end and a Centronics connector on the other end. But don't blame only IBM for not using a *standard*. How about Diablo and Xerox (same printer, different brand name)? Their daisy printers—considered the very finest by most users—have what is supposedly a standard RS-232 serial I/O. True enough, it's standard, only the connections aren't the ones used by most of the computer manufacturers. Take your printer home, plug it in, and it's an odds-on bet it won't work properly, if at all.

Get it working.

The best way to start interfacing a printer is to just get it working. If it can at least print the full ASCII alphanumeric character set and feed paper you're on your way. We'll start with parallel printer connections because they are the least troublesome. Parallel printer connections are called Centronics-type because they are the connections for the earliest printers—manufactured by Centronics—that were used with personal computers. To their credit, the Centronics connections were well thought out and have never required upgrading or a retrofit. The only time they give trouble is when a manufacturer goes out of their way to muck things up, as did Apple with non-sequential wiring of their parallel printer card; IBM and IBM-compatible computers with their use of a DB-25 connector for the parallel output; and Radio Shack with their card edge-connectors having non-sequential numbering and a forced automatic line feed after carriage return. Fortunately, the Centronics interfacing was so well thought out that most users can easily get around any problems created by the computer manufacturer. The Centronics printer connections are shown in Table 1. While there are many individual circuit connections because Centronics provided for every possible kind of parallel handshaking and fault indication, every connection isn't necessarily used by every printer. For example, a printer that uses the BUSY for handshaking (stopping and starting the computer's output) won't use the ACK, and vice versa.



THE NEW HP 2225 INKJET PRINTER from Hewlett Packard is fully portable, may be used with portable or desktop computers, operates below 50 dB.



EPSON'S RX-100 DOT MATRIX PRINTER operates at a speed of 100 characters per second on a 136-column carriage.

But be careful! Sometimes you can make a false assumption and get yourself into really-big trouble. The safest bet is that anything that can go wrong, will go wrong.

Unfortunately, some manufacturers modify the wiring of the signal pair returns—which are grounded—or put +5 volts on one of the normally-unused pins. If in doubt, the safest thing to do is wire only those connections which are absolutely required for parallel operation, the ones indicated with an asterisk (*), for no manufacturer will meddle with them (so far); they are safe to use because a computer or printer will automatically reject their use if not needed. The connections marked with a "pound" (#) symbol are normally unused and they are the ones manufacturers often employ to provide external voltages for external accessories—or they tie them together and connect them to +5 volts—which can prove a disaster. Do not use these wires unless you are absolutely certain you need them. Try running the printer without them. Be especially careful of terminal #18, which is often, but not always used to provide +5 volts from the printer or the computer for powering ancillary devices, such as a serial-to-parallel converter. Some manufacturers put the full rail voltage on the connection, others provide the 5 volts through a resistor. If in doubt, leave this connection open because 5 volts on #18 is not part of the standard wiring. Depending on the equipment, the wrong hook-up can cause a lot of damage. Same thing for terminals 33-36. They aren't used for standard connections. Some manufacturers use them for providing power to ancillary hardware or tie them to +5 volts. If in doubt, leave the connections open. Terminals 16 (GND) and 17 (CHASSIS) are "ground." Terminals 19 thru 30 are return lines for the signal and handskaking circuits, "return" being a fancy word for "common" or "ground" connection.

Depending on the particular printer and the computer being used, your equipment might work if all terminals 19 thru 30 aren't connected; then again, the equipment might not work. Your equipment will always work if the wires are individually brought through from one connector to the other, but if you're making up a multi-wire cable and are short on connecting wires, you can connect terminals 19 thru 30 to terminal 16; and if in doubt, also connect 17 to 16. Be extremely careful of terminal 35; do not use it unless you know what you're doing. While not used in the Centronics standard, one very popular computer uses it for a redundant ground while an equally popular printer uses it for +5 volts.

In your anxiety to get things going, you tend to look for shortcuts. This can result in dire consequences. While it may seem expedient to take advantage of "unused" terminals, they aren't always as available as they might seem.

The potential for a catastrophic failure is obvious, so don't use terminals 33 through 36 unless you have schematics for everything. Do not eliminate any standard connections thinking they aren't needed.

Some connections accommodate several different fault indicators which your computer might require for operation. For example, while the BUSY signal normally tells the computer the printer isn't ready for data because it's printing, some printers use the BUSY to also stop the computer when the ribbon runs out, the cover is open, the power is off, the paper has run out, etc. Other printers put the out of paper indicator, cover open, ribbon out, etc. on the FAULT line. The safest bet is to always use all the standard connections. Normally, Centronics-type connectors can be wired straight across, that is, the wire connected to terminal #1 on one side connects to terminal #1 on the opposite side.

To their credit, even when using different connectors (ie., card edge-connectors) Radio Shack has always arranged the circuits in the Centronics order so the wiring is always correct when connectors are squeezed on ribbon cable. Unfortunately, this isn't the case with other computers. The IBM-compatibles use a DB-25 for the parallel output, and the terminal numbers simply don't match. Also, you can mistake the IBM parallel printer output for an RS-232 connection, and it is possible to blow out something in the computer, so be extremely careful when making parallel printer connections to a DB-25 connector. Also, a commonly used computer (the Osborne 1) and at least one printer buffer (the Angel) don't have standard parallel Centronics connectors, so again take extreme care if you make up your own cables because the connections aren't in the Centronics order.

TABLE 1
Standard Centronics-Type configurations for Scotch "Delta" 36-pin connectors.

KEY	PIN	FUNCTION
*	1	DATA STROBE
*	2	DATA 1
*	3	DATA 2
*	4	DATA 3
*	5	DATA 4
*	6	DATA 5
*	7	DATA 6
*	8	DATA 7
*	9	DATA 8
*	10	ACK
*	11	BUSY
#	12	PAPER EMPTY (PE)
#	13	SELECT PRINTER
*!	14	SIGNAL GROUND
*	15	NC
*	16	GND
*!	17	CHASSIS GND
#	18	(CAUTION + +5VDC)
*!	19	PAIR GROUND
*!	20	PAIR GROUND
*!	21	PAIR GROUND
*!	22	PAIR GROUND
*!	23	PAIR GROUND
*!	24	PAIR GROUND
*!	25	PAIR GROUND
*!	26	PAIR GROUND
*!	27	PAIR GROUND
*!	28	PAIR GROUND
*!	29	PAIR GROUND
*!	30	GROUND (GND)
#	31	INPUT PRIME
*	32	FAULT
#	33	NC
#	34	NC
#	35	NC
#	36	NC

There is not necessarily any correlation between printers as far as codes are concerned. Again, the lack of actual standards is plainly evident. Ask any manufacturer of printers about this, and you'll probably be told that they do indeed cleave to rigorous standards—their own! The confusion is borne out when you get down to the hard wiring. To see precisely what can happen, take a look at Table 2.

The printer codes.

Regardless of whether the printer is serial or parallel input and the actual order of the connections, the most frustrating difficulties you're likely to face when installing your printer are the *printer codes*, for which there is essentially no standard other than for the ASCII characters. With virtually no exception, every modern printer can do something more than just print the 96 ASCII characters. Depending on the particular model and type of printer, it's possible to underline characters; boldface through multi-striking and carriage shift; print letters larger, smaller or in itallics (matrix printers); print trade marks, smiling or happy faces; or foreign characters or Greek or electrical symbols. You name it and there's a printer out there that can do it. Your only problem is to tell the printer what you want to do, and that's where printer codes come in. All printers uses standard ASCII codes for the character set and control codes. The ASCII code is numbered from 0 through 127 in decimal, which corresponds to hex 0 through hex 7F. (Printer codes can be either decimal or hex, depending on the particular printer and/or software.The codes from 0 to 31 are non-printing *Control Codes*, meaning they can be used to "trigger" specific computer or printer functions. Decimal code 32 (hex 20) is the *space*. The ASCII codes from 33 (hex21) to 126 (hex 7E) produce the *ASCII character set*: the alphanumerics which can be printed by a printer capable of printing the full 96 character set.

Code 127 (hex 7F) is the old teletype *delete*: The modern printer either doesn't respond to code 127 or prints a "block." Normally, every printer responds to ASCII codes 32 to 126. For example, if the computer sends a 32 (hex 20) to the printer every printer made will space. If the computer sends a 65 (hex 41) to the printer every English-language printer made for use with personal computers will print the letter A. The first problem with printer standards you're likely to run across are the ASCII codes below 32. (See Table 2.) Some are truly standard, for example, 13 (hex OD) is always used for CR (carriage return) while 10 (hex OA) is always used for LF (line feed), and 27 (hex 1B) is always ESC (escape). And that's about where the standards really end. For example, while an 8 (hex 08) will cause most printers to backspace, your printer might not recognize 8 as the backspace control code, hence, any software you have that backspaces with an ASCII 8 for strikeover or underline won't budge your printer; it might require some other code, or use a special code for underscoring. For example, send a 25 (hex 19) to a Smith-Corona TP-1 daisywheel printer and every character will underline. Send a second 25 and the underline will stop. But if you have a Smith-Corona TP-2 printer the second Hex 19 won't do a thing because it requires a 31 (hex 1F) to stop the underline. Tricky? You bet! Unless your software can be modified, or can send user-programmed control codes from within the program, there's no way you're going to get the underline straightened out. And if you think Smith-Corona underline is tricky, try the Epson with Graftrax.

Underscore *on* is ESC-1 (hex 1B 5F 31); underline *off* is ESC-0 (hex 1B 5F 30). (Someone must have been asleep at the design board because one of the most popular personal computers cannot output a control code zero (0) from its word processor.)

Everyone for themselves.

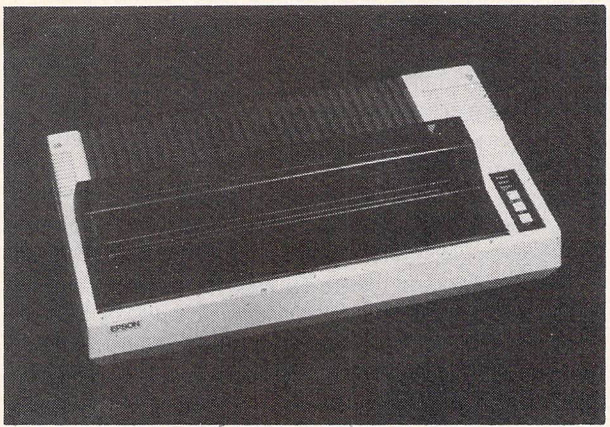
From ASCII 128 and higher it's every manufacturer for themselves. For example, the famed budget-priced Smith-Corona daisy printers do not respond to codes above 127. On the other hand, the Radio Shack model DWP-210 daisy wheel printer has a few additional characters accessed by printer codes higher than 127.

For example, a 169 (hex A9) will produce the single character imprint TM (for Trade Mark), while a 171 will produce the circled-C (©) used to indicate copyright. Similarly, a 222 will produce the ¢, which is not on the standard ASCII keyboard (it is a typewriter character).

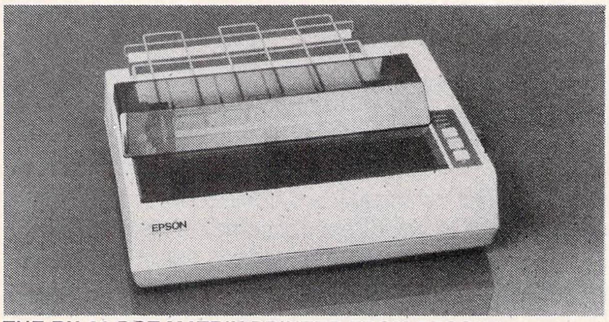
While daisy printers might respond to a few specific printer codes above 127, it's the matrix-type printers

TABLE 2

ASCII	CODE	PRINTER #1	PRINTER #2
0	NUL	NULL	NO RESPONSE
1	SOH	SET LINE SPACING	NO RESPONSE
2	STX	DEFAULT LINE SPACING	NO RESPONSE
3	ETX	NO RESPONSE	NO RESPONSE
4	EO	NO RESPONSE	END OF TEXT
5	EN	NO RESPONSE	NO RESPONSE
6	AC	NO RESPONSE	AKNOWLEDGE
7	BE	SOUNDS BELL	NO RESPONSE
8	BS	NO RESPONSE	BACKSPACE
9	HT	NO RESPONSE	TAB
10	LF	LINE FEED	LINE FEED
11	VT	VERTICAL TAB	NO RESPONSE
12	FF	FORM FEED	FORM FEED
13	CR	CARRIAGE RETURN	CARRIAGE RETURN
14	SO	EXPANDED CHARACTERS	NO RESPONSE
15	SI	COMPRESSED CHARACTERS	NO RESPONSE
16	DLE	NO RESPONSE	NO RESPONSE
17	DC1	ACCEPT DATA (X-ON)	ACCEPT DATA (X-ON)
18	DC2	COMPRESSED OFF	TAB SET
19	DC3	DESELECT (X-OFF)	DESELECT (X-OFF)
20	DC4	EXPANDED OFF	TAB CLEAR
21	NAK	NO RESPONSE	NO RESPONSE
22	SYN	NO RESPONSE	NO RESPONSE
23	ETB	NO RESPONSE	NO RESPONSE
24	CAN	NORMAL CHARACTERS	MARGIN RELEASE
25	EM	NO RESPONSE	UNDERSCORE ALL
26	SUB	NO RESPONSE	NO RESPONSE
27	ESC	NO RESPONSE	NO RESPONSE
28	FS	NO RESPONSE	LEFT MARGIN SET
29	GS	NO RESPONSE	NO RESPONSE
30	RS	NO RESPONSE	UNDERSCORE WORD
31	US	NO RESPONSE	END UNDERSCORE



THE NEW FX-100 PRINTER FROM EPSON operates at 160 characters per second, carries a suggested retail price of $895.00.



THE RX-80 DOT MATRIX PRINTER FROM EPSON has tractor and friction feed, prints 100 characters per second, offers two full 96- character ASCII sets plus nine international sets including 128 type styles.

that really get mileage from 127 and higher—and they cause the most standardization problems. For example, connect your old reliable printer to your new IBM-compatible computer and program for a few of the IBM graphic characters. Depending on the particular model printer you might wind up with unusual graphic symbols, or even italic characters, but you won't get the graphic characters that match those in the computer's documentation. The reason, of course, is because only codes 32 to 127 are standard. The Epson printers sold under the IBM label have internal ROMS with a completely different set of graphics than any other model for the codes above 127. To obtain the IBM graphics, whatever matrix printer you use must be specifically programmed from ASCII 128 up to produce the IBM graphics. (That's why IBM can charge so much for a printer you could otherwise purchase for several hundred dollars less.) Similarly, if you try to use an older Radio Shack printer with a new Radio Shack computer something's not going to work when your software attempts to produce graphics, because the late model computers are intended for printers with a different "graphic set" than the earlier printers.

Essentially, if you're into using computer hardware and software from several manufacturers you've got to triplecheck that the graphic ASCII codes are all compatible, else you will wind up with "garbage" or just empty blank spaces on the paper. In Part 2 we'll untangle the serial priners and the parallel-to-serial and serial-to-parallel converters.

COMPUTERIZED OP-AMP CALCULATOR

KIRK VISTAIN

Find all the circuit values for three important op-amp configurations in an instant with this spreadsheet template.

■What electronics hobbyist wouldn't love to be able to calculate all the resistor and capacitor values for a differential op-amp circuit in less than a minute? Better yet, imagine being able to do it for inverting, non-inverting, and differential configurations simultaneously. You can eliminate arithmetic errors, change designs in mid-stream, or perform "what-if" analyses to your heart's content.

Well, the op-amp "calculator" we'll describe in this article helps you do it. It's an op-amp design template written for use with the popular and powerful *Supercalc*, an electronic spreadsheet from Sorcim Corporation. It was developed on a Xerox *820*, with an 80 column display, operating under CP/M, but it should work on any computer running *Supercalc*. Note that you'll need to use horizontal scrolling on a 40-column display.

To use the template, simply load in an installed *Supercalc* program, then load the template, which we've named OPAMPC. Figure 1 shows the screen after loading. At the upper left is the *user choice* selection. The number (no alphabetical prefixes or suffixes, please) of the desired op-amp is typed in, and the gain-bandwidth product (GBP) is automatically returned to the right. (That selection is customized by the user).

Next, the desired input resistance (INPUT R), voltage gain (A_V), low-frequency cutoff (LOW F_C), and high-frequency cutoff (HIGH F_C) are entered. The rest of the operation is automatic.

Resistor and capacitor values are simultaneously calculated for three basic configurations, and automatically rounded to the nearest EIA standard values. Circuit parameters are then recalculated using those values, and displayed in the ACTUAL column. Percent deviation from desired performance is returned in the next column to the right. In most cases, those errors are kept to less than 10%.

Why use *Supercalc*? There are a number of reasons. First, *Supercalc* is a versatile piece of software that can be adapted to many different purposes. For that reason, it is among the first programs a new computer owner buys. Secondly, because of its many logical and arithmetic commands, much of a programmer's work is already done, so designing and entering a template is quicker than writing a program in say, Pascal or BASIC. We could have used *Visicalc*, another electronic spreadsheet, but doing so would have forced us to sacrifice the automatic rounding-to-EIA-standards that makes OPAMPC so convenient. No doubt, some enterprising programmers will come up with ways to adapt this template to their particular spreadsheet program.

Three types of error messages are included, summarized at the upper right of the worksheet. Each amplifier configuration is represented separately, listed under INDEX. If the actual or desired *Gain-Bandwidth Product* (GBP) is greater than the rated GBP of the selected op-amp, a 1 appears. If not, 0 is returned. A similar function is provided to test whether R2

```
=======================================================================
      USER CHOICES
-----------------------------------------------------------------------
     DEVICE:      1458  RATED GBP: 5e5      ------ERROR FLAGS------
    INPUT R:       1e5        INDEX         GBP R2
  GAIN (Av):         5      A12. Invert.     Ø   Ø   1 = TOO HIGH
     LOW Fc:        25      A24. Non         Ø   Ø   Ø = OK
    HIGH Fc:       2e4      A36. Diff        Ø   Ø

    >> Ø Indicates Selected R or C Out of Range <<<

DIFFERENTIAL AMP MODE
                                       ACTUAL              %ERROR
           R1      1e5                GAIN: 5eØ              2.ØØ
           R2    5.1e5             LOW Fc:  23              -6.38
           R3      1e5                 GBP: 1e5
           R4    5.1e5              Rin +: 6e5
           C1  6.8e-2mF             Rdiff: 7e5
           C2    1e-2mF
-----------------------------------------------------------------------
```

FIG. 1—VIDEO DISPLAY (80 column) as it looks during a sample differential amp calculation using OPAMPC.

(negative feedback resistor) is less than 1 megohm, a necessity for proper DC stability in common bipolar op-amps. If you're using BiFET's, you can change the flag point to account for their lower current requirements. Refer to the device manufacturer's data.

An R2 error will also occur if calculations result in a value out of the lookup table's range. That will be corroborated in the individual amplifier sections.

Structure of OPAMPC

OPAMPC is functionally divided into three sections. In USER CHOICES, device number and desired circuit parameters are entered. GBP and R2 error flags are included, along with an index of the calculation section.

The CALCULATION area of the spreadsheet contains the formulas necessary to determine component values from the user's choices. Inverting, non-inverting, and differential configurations are treated separately. Spacing between the subsections aids readability and quick access when using the window mode.

The LOOKUP TABLES are the key to the rounding function. That section is automatically searched by the CALCULATION area to find the standard resistor or capacitor value closest to the calculated one. Don't be intimidated by its 151-line length! It's quickly built, using *Supercalc*'s automatic functions.

Theory of operation

Figure 2 shows three common amplifier designs, and the formulas used to determine component values. The OPAMPC template is based on an AC model, and was specifically written for audio applications. Power supply connections are not shown, nor are compensation or offset circuits. Many devices use internal compensation, and offset is usually not a big problem. If in doubt, consult one of the many op-amp design books available.

Most of the formulas shown in Fig. 2 were simply converted into *Supercalc* format and entered onto the worksheet (more on that later).

Inverting amp

OPAMPC ignores the negative component of the inverter's output, a common convention. Remember, though, that the output signal will actually be 180° out of phase with the input.

The 1E6 factor in the calculation for C1 produces an answer in microfarads, instead of farads. That applies to the other configurations as well. 1E6 is *Supercalc* shorthand for 1×10^6. Using the optional resistor R3 will minimize input offset, although, commonly, the non-inverting input is simply tied to ground.

Non-inverting amp

In the non-inverting amp, for minimum offset, R3 = R1||R2 (the symbol || means "in parallel with"). The value of R3 is equal to the input resistance, so whatever value you select in the USER section appears opposite R3. We know that the gain of a non-inverting op-amp is 1 + (R2/R1), but how do we use that formula without selecting a fixed value for R2 and R1? Remember that whatever combination of resistors we pick must have a parallel value equal to R3.

The trick is trying to get R1 and R2 solved for two different equations simultaneously in a way *Supercalc* could handle. After trying many of the normal methods for that, unsuccessfully, we hit upon the idea of simply defining R1 + R2 = 1 megohm. That automatically kept the feedback resistor below our design limit of 1 megohm, eliminating an annoying and clumsy term in the calculations to boot.

You may have noticed that an undefined condition will exist if the user selects a gain less than or equal to 1, because $(A_V - 1)$ will then equal 0, by which you can't divide, or a negative number, whose square root is not a real number.

The low-frequency rolloff points of the inverting and non-inverting inputs respectively are $-f_C$ and $+f_C$. The value of $+f_C$ is user-selected and equal to LOW F_C. The value of $-f_C$ is arbitrarily set for five times $+f_C$ in order to minimize low-frequency noise gain.

Differential amp

The calculations for the differential configuration are virtually identical to those for the inverting mode, except that they apply to both inputs. Best CMRR (Common Mode Rejection Ratio) requires $+f_C = -f_C$, where $+f_C$ is the cutoff frequency of the non-inverting input, and $-f_C$ is the cutoff frequency of the inverting input. For simplicity, we let R1 = R3 and R2 = R4. That results in differing input resistances for the inverting and non-inverting inputs.

User-selected INPUT R becomes the resistance of the inverting input, with the non-inverting input R being calculated and returned opposite $r_{in}+$. It will always be higher than the user-selected figure, but that is not generally a problem in signal circuits. The differential input resistance, R_{DIFF}, appears in cell F42, and is the sum of $R_{IN}+$ and $R_{IN}-$.

Lookup table

Seldom do calculations yield precise, convenient, standard values for resistors and capacitors. If we intend to translate our design to the real world, however, that is necessary.

Consequently, OPAMPC contains lookup tables, which effectively round calculated values to EIA standards. We use *Supercalc*'s built-in LOOKUP function and some long lists to do this.

Building the worksheet

To ease entry, we've divided OPAMPC into two files, called OPCALC.CAL, which contains amplifier formulas and the user choice section, and LOOKVAL.CAL, the resistor, capacitor, and op-amp lookup tables. Once we've built and saved those two files, we'll combine them into a single template called OPAMPC.CAL. (.CAL signifies a file of *Supercalc* type. The file type is understood and need not be stated when working within the *Supercalc* program.)

Good practice calls for frequent saves and backing up all files on a separate disk.

To build the lookup tables, first enter the headings as shown in Fig. 3. The column widths were selected only so

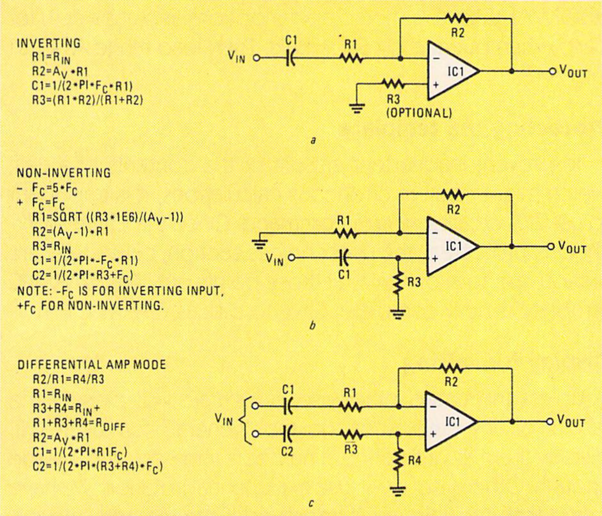


FIG. 2—THREE OP-AMP CONFIGURATIONS. An inverting amp is shown in *a*, a non-inverting amp in *b*, and a differential amp in *c*.

the headings would fit. Once the tables are integrated on the OPAMPC worksheet, column width will be irrelevant.

Next, starting at cell D3, enter the following series of numbers in column D:

1E−5	2.2E−5	4.7E−5
1.11−5	2.7E−5	5.6E−5
1.5E−5	3.3E−5	6.8E−5
1.8E−5	3.9E−5	8.2E−5

Put a 0 in C2 and D2 and enter the formula D3 + C*.9 in cell C3. Replicate it in the range C4:C100. Now, enter the formula D3 + C*10 at cell D15 and replicate it from D16:D100. Enter 0's at the bottom of the capacitor list in cells C101 and D101.

The resistor table is built similarly. Zeros go into cells F2 and G2. The following list is entered into column G, starting at G3:

1	1.8	3.3	5.6
1.1	2	3.6	6.2
1.2	2.2	3.9	6.8
1.3	2.4	4.3	7.5
1.5	2.7	4.7	8.2
1.6	3	5.1	9.1

The formula G3 + C*.95 goes into cell F3 and is replicated from F4 to F150. Similarly, cell G27 gets G3 + C*10, which is replicated in the range G25:G150. Zeros are then entered at F151 and G151.

The op-amp list should be customized for whatever devices you favor. We've shown a few popular ones as an example in Fig. 3. The list can be as short or long as you want, but remember to put a 0 at the beginning and end to avoid ERROR or N/A messages. You will also need to modify the expression in E5 to match the list's range.

You'll notice the resistor list is longer than that used for capacitors. For accuracy's sake, the complete USA Standard C83.2 (formerly EIA GEN 102), Series 10, sequence is used for resistors. That way, no matter what the result of a calculation (assuming it is not out of range) a standard value within ±5% of it can be found. We selected Series 20 values (±10%) for the capacitor list, because "in-between" capacitors are scarce.

```
WIDTH:   12         8       8         12        4       10        5
  :      A      ::  B   ::  C    ::   D     :: E::     F      :: G :
 1: OP AMP LIST MAX GBP CAPACITOR LOOKUP            RESISTOR LOOKUP
 2:           Ø Ø        Ø         Ø               Ø          Ø
 3:         324 .2E6     D3*.9     1E-5       mF   G3*.95     1
 4:         741 .2E6     D4*.9     1.2E-5     mF   G4*.95     1.1
 5:        1458 .5E6     D5*.9     1.5E-5     mF   G5*.95     1.2
 6:        1458 5E5      D6*.9     1.8E-5     mF   G6*.95     1.3
 7:           Ø Ø        D7*.9     2.2E-5     mF   G7*.95     1.5
 8:                      D8*.9     2.7E-5     mF   G8*.95     1.6
 9: R and C values       D9*.9     3.3E-5     mF   G9*.95     1.8
1Ø: are USA Standard     D1Ø*.9    3.9E-5     mF   G1Ø*.95    2
11: C83.2.               D11*.9    4.7E-5     mF   G11*.95    2.2
12:                      D12*.9    5.6E-5     mF   G12*.95    2.4
13: Res. use series 1Ø   D13*.9    6.8E-5     mF   G13*.95    2.7
14: Caps. use series 2Ø  D14*.9    8.2E-5     mF   G14*.95    3
15:                      D15*.9    D3*1Ø      mF   G15*.95    3.3
16:                      D16*.9    D4*1Ø      mF   G16*.95    3.6
17:                      D17*.9    D5*1Ø      mF   G17*.95    3.9
18:                      D18*.9    D6*1Ø      mF   G18*.95    4.3
19:                      D19*.9    D7*1Ø      mF   G19*.95    4.7
2Ø:                      D2Ø*.9    D8*1Ø      mF   G2Ø*.95    5.1
21:                      D21*.9    D9*1Ø      mF   G21*.95    5.6
22:                      D22*.9    D1Ø*1Ø     mF   G22*.95    6.2
23:                      D23*.9    D11*1Ø     mF   G23*.95    6.8
24:                      D24*.9    D12*1Ø     mF   G24*.95    7.5
25:                      D25*.9    D13*1Ø     mF   G25*.95    8.2
26:                      D26*.9    D14*1Ø     mF   G26*.95    9.1
27:                      D27*.9    D15*1Ø     mF   G27*.95    G3*1Ø
                            ...To  row  1Ø1...      ...To  row 151...
```

FIG. 3—LOOKUP TABLE HEADINGS and general layout, in formula display. The column widths shown were selected only so the column headings would fit. Once the tables are integrated with the OPAMPC worksheet, column width will be irrelevant.

After we've built the lookup table on the worksheet, we'll save it on disk as LOOKUP.CAL. Making another backup copy is an excellent idea. The tired hand or mind, not to mention a faltering powerline, could trash a screen or disk, obliterating many hours of work. If you don't have a backup copy of a file on another disk, you don't have the file.

In order to reduce calculation time when using the worksheet, it is advisable to use only the lookup-table values, not the formulas. Otherwise, every time we hit <!>, the "force calculation" command, the lookup table will recalculate, greatly reducing the speed of the worksheet. So, do another save of the lookup table, but this time with values only. Name the file LOOKVAL.CAL.

```
  :     A      ::    C   ::      D      ::     E   :: F:: G ::     H   :
 1:                             OPAMPC
 2:==============================================================
 3:      USER CHOICES
 4:--------------------------------------------------------------
 5:     DEVICE:              RATED GBP: 2e5     -----ERROR FLAGS-----
 6:    INPUT R:                    INDEX        GBP R2
 7:  GAIN (Av):                 A12, Invert.     Ø    Ø    1 = TOO HIGH
 8:     LOW Fc:                 A24, Non         Ø    Ø    Ø = OK
 9:    HIGH Fc:                 A36, Diff        Ø    Ø
1Ø:
11:    >>> Ø Indicates Selected R or C Out of Range <<<
12: INVERT MODE
13:             STANDARD                   ACTUAL               %ERROR
14:                R1                       GAIN:
15:                R2                     LOW Fc:
16:                C1        mF               GBP
17:                R3
18:--------------------------------------------------------------
19:
2Ø:
21:
22:
23:
24:NON-INVERT MODE
25:                                        ACTUAL               %ERROR
26:              - Fc                       GAIN:
27:              + Fc                     LOW Fc:
28:                R1                         GBP
29:                R2
3Ø:                R3
31:                C1        mF
32:                C2        mF
33:--------------------------------------------------------------
34:
35:
36:DIFFERENTIAL AMP MODE
37:                                        ACTUAL               %ERROR
38:                R1                       GAIN:
39:                R2                     LOW Fc:
4Ø:                R3                        GBP:
41:                R4                       Rin +:
42:                C1        mF            Rdiff :
43:                C2        mF
44:--------------------------------------------------------------
```

FIG. 4—OPCALC.CAL HEADINGS. The headings should be typed in exactly as shown here.

Op-amp calculation area

Now we'll build a worksheet called OPCALC.CAL. It will contain all the amplifier calculations and error messages. Set the worksheet for manual calculation before starting.

Refer to Fig. 4 and format the columns to these widths:

Column A: 12	Column E: 8
Column B: 0	Column F: 6
Column C: 8	Column G: 5
Column D: 12	Column H: 8

Type in the headings exactly as they appear in Fig. 4, using *Supercalc*'s text formatting options as needed.

You'll notice that column B has a width of 0. That effectively hides the unrounded results of the amplifier calculations, so as to avoid confusion. You can still enter formulas, which will then show up on the status line. If ever the need should arise, Column B can be expanded to the standard 9 characters to show the precise results.

After checking your work for accuracy, refer to Fig. 5 for the formulas. You'll note the columns are expanded beyond their normal width for clarity. You don't have to do that on your worksheet, since any formula entered in a cell will show up in the status line, regardless of column width.

```
 :    A   ::        B         ::  C  ::   D   :: E ::    F     ::       G       ::  H  :
 1:                                         OPAMPC
 2:=============================================================================
 3:           USER CHOICES
 4:-----------------------------------------------------------------------------
 5:     DEVICE:                             RATED GBP: LOOKUP(C5,A49:A53)
 6:    INPUT R:                                 INDEX        GBP        R2
 7:  GAIN (Av):                               A12, Invert.   IF(F16>E5,1,0) OR(C15>1E6,C15=0)  1 = TOO HIGH
 8:     LOW Fc:                               A24, Non       IF(F28>E5,1,0) OR(C29>1E7,C29=0)  0 = OK
 9:    HIGH Fc:                               A36, Diff      IF(F40>E5,1,0) OR(C39>1E8,C39=0)
10:
11:   >>> 0 Indicates Selected R or C Out of Range <<<
12: INVERT MODE
13:            CALCULATED          STANDARD            ACTUAL                              %ERROR
14:         R1 C6                  LOOKUP(B14,F49:F198)   GAIN: C15/C14                     ((F14-C7)/C7)*100
15:         R2 C7*B14              LOOKUP(B15,F49:F198) LOW Fc: 1/(2*PI*C14*(C16*1E-6))     ((F15-C8)/C8)*100
16:         C1 1E6/(2*PI*C8*B14)   LOOKUP(B16,C49:C158)     GBP F14*C9
17:         R3 (B14*B15)/(B14+B15) LOOKUP(B17,F49:F198)
18:-----------------------------------------------------------------------------
19:
20:
21:
22:
23:
24:NON-INVERT MODE
25:                                                    ACTUAL                              %ERROR
26:       - Fc 5*C8                2*C8                 GAIN: (C28+C29)/C28                 ((F26-C7)/C7)*100
27:       + Fc C8                  C8                 LOW Fc: 1/(2*PI*(C31*1E-6)*C28)       ((F27-C8)/C8)*100
28:         R1 SQRT((B30*1E6)/(C7-1)) LOOKUP(B28,F49:F198)  GBP F26*C9
29:         R2 (C7-1)*B28          LOOKUP(B29,F49:F198)
30:         R3 C6                  LOOKUP(B30,F49:F198)
31:         C1 1E6/(2*PI*C8*B28)   LOOKUP(B31,C49:C158)
32:         C2 1E6/(2*PI*B30*B27)  LOOKUP(B32,C49:C158)
33:-----------------------------------------------------------------------------
34:
35:
36:DIFFERENTIAL AMP MODE
37:                                                    ACTUAL                              %ERROR
38:         R1 C6                  LOOKUP(B38,F49:F198)   GAIN: C39/C38                     ((F38-C7)/C7)*100
39:         R2 C7*B38              LOOKUP(B39,F49:F198) LOW Fc: 1E6/(2*PI*C38*C42)          ((F39-C8)/C8)*100
40:         R3 C6                  LOOKUP(B40,F49:F198)    GBP: F38*C9
41:         R4 B39                 LOOKUP(B41,F49:F198)  Rin +: C40+C41
42:         C1 1E6/(2*PI*B38*C8)   LOOKUP(B42,C49:C158) Rdiff : F41+C38
43:         C2 1E6/(2*PI*(B40+B41)*C8 LOOKUP(B43,C49:C158)
44:-----------------------------------------------------------------------------
```

FIG. 5—OPAMPC FORMULAS. Columns have been expanded and formula display has been selected in this example. During normal use, the worksheet is formatted as in Fig. 1.

Use the replicate function to simplify entering the lookup statements in column C. Be sure to select the *ask for adjust* option to prevent REPLICATE from changing the address of the lookup table. Notice that capacitor and resistor lookup tables have different addresses. When done, save the completed worksheet as OPCALC.CAL.

The union

To complete the OPAMPC template, start with a blank worksheet and load OPCALC.CAL (All) onto the screen. Ignore any error indications. Move the cursor to A48 and load LOOKVAL.CAL. You should ask for options and answer P (for part) when queried by *Supercalc*. Then load range A1:G151 into A48.

Protecting the template

To prevent inadvertent erasure of the contents of a cell, which might result in erroneous calculations, it is important to use *Supercalc*'s PROTECT command. Once the entire worksheet is protected, the user choices section, cells C5:C9 are UNPROTECTED to allow entry at those points only. The OPAMPC template is now complete. Save to disk as OPAMPC.CAL.

Display formatting

Unless instructed otherwise, *Supercalc* will present the results of any calculations in the "general" format. It will display them as ordinary real numbers if the column is wide enough. Otherwise, it will use exponential notation. We have found that intelligibility is improved if the resistors and capacitors are expressed exponentially. The same is true of the GBP.

Integer notation is preferred for the device number, gain, low f_C, and error flags. Percent of error (%error) requires the <$> (two-point decimal or "dollar sign") format.

Using op-ampc

Invoke the GLOBAL command to set the worksheet for manual calculation by columns. Position row 2 at the top of the screen. Next, use WINDOW to put a horizontal split at row 12. Make sure that both sections scroll independently. Later, when you become more familiar with OPAMPC, you can eliminate clutter on the screen by using the GLOBAL command to suppress the border.

Let's say we wish to design a differential amplifier, using a 1458 IC. Place the cursor into the upper left cell of the bottom window. Looking at the index in the upper window, you can see that the differential configuration starts at cell A36. Use <=> to jump there, then put the cursor back into the upper window and start entering your performance choices in column C. Remember to use only the device number in cell C5. No alphabetical suffixes or prefixes are allowed.

To calculate, invoke the <!> command twice. A quick glance to the right will tell you if any errors have occurred. The error flags section gives information even on configurations not currently displayed. Column C, in the lower window, displays rounded values. To the right, in column F, actual performance, recalculated using the rounded values, is shown. The percentage of deviation from the entries in the user choice section appears in column H.

Input resistance for all except the non-inverting (+) input of the differential amp will be within ±5% of that selected. The high frequency cutoff selection is included only to calculate required GBP, so no error checking is done for it.

OPAMPC is a valuable tool for the electronics hobbyist. It allows a designer to quickly calculate the three most common op-amp configurations at once. Its speed makes rapid design changes and "what if" analyses routine. Of course, it can't eliminate the "fine-tuning" necessary to produce the optimum design, but it does get you well into the ball-park.

If you have any questions about this template, feel free to contact the author on CompuServe. Address your message to Kirk Vistain, user number 72356,1355. OPAMPC is easy to enter and easy to use. Have fun with it!

COMMODORE CASSETTE INTERFACE

Use an ordinary audio cassette recorder with your Commodore 64 or VIC-20!

WALTER G. PIOTROWSKI

■When I saw the advertisement, I couldn't believe it: a computer with a real keyboard for only $84.97. Even if the *VIC-20* was not much of a computer, it had to be worth at least that much, so I bought one.

One afternoon, my son went to work on the computer and, by bedtime, had written a long program. Unfortunately, he wasn't aware at the time that we had no mass-storage device on which to save the program. The next day, we went back to the store where we bought the computer and learned that the least-expensive mass storage device for the *VIC* was a cassette recorder that was priced almost as high as the computer itself. We already had two cassette recorders that were gathering dust, so I hoped that there was some way we could use one of them instead of the relatively expensive *Datasette*.

The VIC cassette port

The *VIC-20's* cassette port is a card-edge connector on the machine's rear. The signals available on the card-edge fingers are shown in Fig. 1. The CASSETTE WRITE output (E-5), and the CASSETTE READ input (D-4), are both logic-level signals. A look at the *VIC's* schematic showed that both signals go to 6522 PIA's (*P*eripheral *I*nterface *A*dapters). I connected my scope to the CASSETTE WRITE output, typed SAVE, and found a five-volt, audio-rate squarewave. Unfortunately, that squarewave can't be recorded directly on audio tape. There are two reasons for that: First, the signal level must be reduced—trying to input this signal directly into the recorder's microphone jack overloads the record amplifier. The second problem is because the waveform is a squarewave. When you try to record a squarewave, the recording process attenuates the high-frequency components. The result is that you don't get a squarewave back when you play the tape. Figure 2 shows the squarewave output of the cassette port. Figure 3 shows the recorded signal—which has little resemblence to the squarewave.

Because the computer expects to see a 5-volt squarewave when it reads the tape, it will not be able to read the tape recorded on a standard cassette

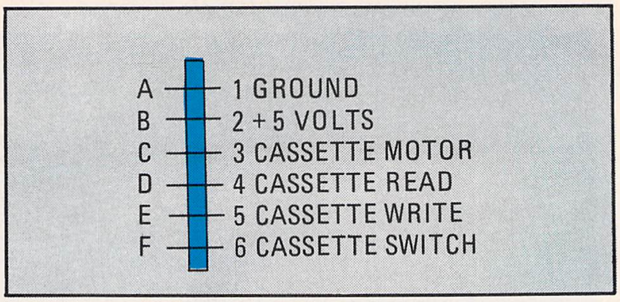


FIG.1—CASSETTE PORT SIGNALS. Note that the CASSETTE SWITCH output is called CASSETTE SENSE on the Commodore 64.

PARTS LIST

Resistors

R1—10K, ¼-watt trimmer potentiometer

R2—10K, ¼-watt, 10%

Semiconductors

IC1—74LS14 hex Schmitt trigger

Miscellaneous

Project Box (Radio Shack 270-220); 6/12 Card-Edge Connector (.156-inch centers); 14-pin IC socket; SPST toggle switch; 2 miniature phone plugs, Coaxial DC power plug (5.0mm O.D., 2.1mm I. D.), etc.

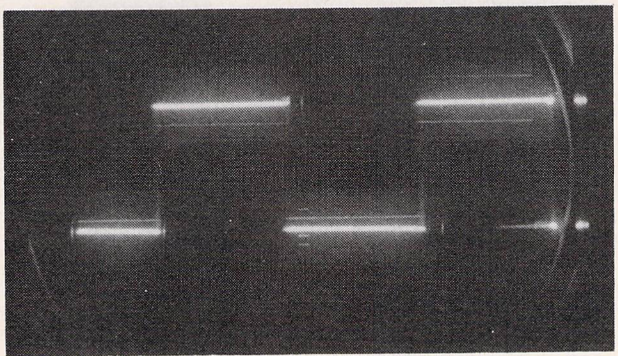


FIG.2—CASSETTE-WRITE OUTPUT WAVEFORM is part of the sync data that preceeds the actual data. When data is being transferred, the duty cycle of the waveform is varied.

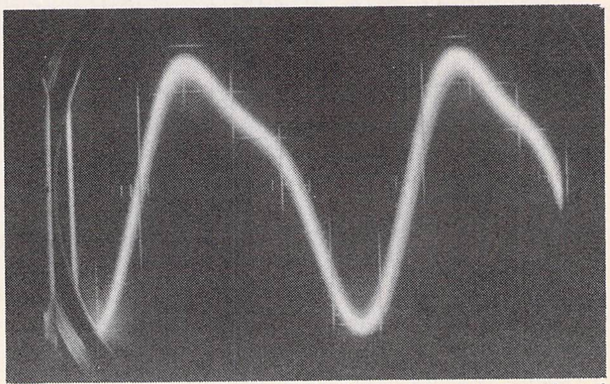


FIG.3—SQUAREWAVE AFTER RECORDING and being played back on a cassette recorder.

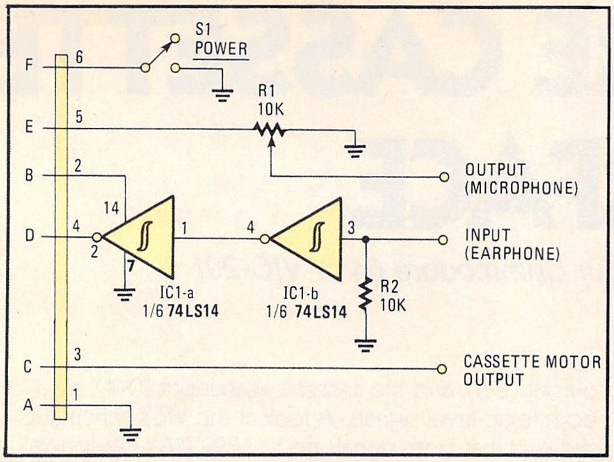


FIG.4—SCHEMATIC DIAGRAM of Commodore cassette interface.

recorder—unless you find a way to turn the recorder output back into a squarewave before the computer sees it.

Before we discuss how to get the squarewave back, let's take a look at the other cassette-port signals, the CASSETTE MOTOR output and the CASSETTE SWITCH (or CASSETTE SENSE) input.

Commodore's *Datasette* recorder doesn't have a power cord. As you might guess, it receives its operating voltage from the computer—specificcally from the CASSETTE MOTOR output on card-edge pin C-3. That output is driven by a a 2SD880 power transistor. The output voltage is 6.4 volts.

My cassette recorders, which are fairly old, have 7.5-volt input jacks, alongside the mike and headphone jacks. The recorders run perfectly on this 6.4 volt output. Most newer recorders operate on 6 volts, so you should be able to use any of them with the *VIC*.

The cassette switch input has to be pulled to ground before the VIC will turn on the cassette motor voltage. If it isn't grounded when you type a command (SAVE, LOAD or VERIFY), you will get a message on the screen that tells you to push a button on the recorder. Apparantly, the *Datasette* grounds the CASSETTE SWITCH line whenever one of its buttons is depressed (The software checks to see that a button has been pressed before trying to move the tape.)

How the adapter works.

The schematic of the circuit that allows you to use an ordinary tape recorder with your Commodore computer is shown in Figure 4. The playback line contains two Schmitt trigger inverters. The first conditions the tape's output signal back into a squarewave. Since it also inverts the signal, we need the second inverter to fix the signal's polarity.

The switch in the CASSETTE SWITCH line is not essential; things will work right if the cassette switch is always grounded. The switch does, however, provide some extra flexibility in using the recorder.

Any construction method can be used. The only caution is that when you connect the wires to the coax power connector, don't forget that the center is ground!

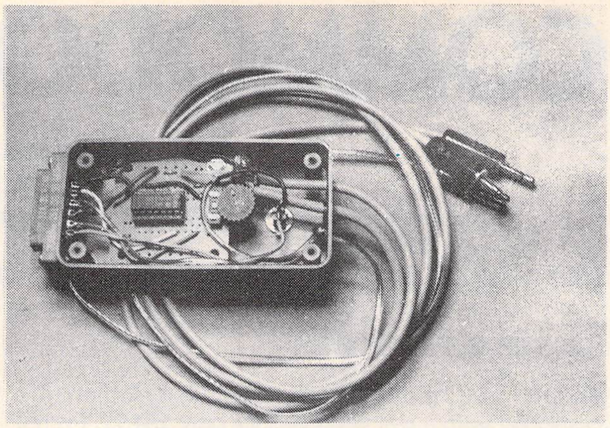


FIG.5—THE INTERFACE mounts nicely on half a standard dual-IC board and fits inside the smallest Radio Shack project case.

You'll find that without even trying very hard, you'll be able to fit everything into into the smallest Radio Shack project case. The prototype's construction is shown in Fig. 5.

Checkout and use

Setting up the adapter couldn't be easier. Simply set potentiometer R1 so that the output (when you're SAVE-ing a program) is about 0.1 volt peak-to-peak or less. (If you don't have an oscilloscope you can measure for about 50 millivolts with a DC voltmeter.) The exact voltage isn't critical, since most tape recorder inputs have automatic record-level circuits. You might have to experiment a bit with the volume and tone controls on playback. With my recorder, I get the best results with the volume control at about ⅞ full and the tone control at maximum treble. Start with those

FIG.6—HOOKED UP AND READY TO GO, the interface needs only to be checked out and then never needs to be touched again.

settings and play back a tape that you have recorded. The volume control setting is the most important, and setting it too high is better than too low. Once it is correctly set, you should not have to adjust it again. Figure 6 shows the completed unit hooked up and ready to go.

You should find that the interface works correctly with pre-recorded tapes as well as those you SAVE yourself.