ELEKTOR ELECTRONICS USA

THE INTERNATIONAL JOURNAL FOR RECREATIONAL ELECTRONICS
NOVEMBER 1992
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FINAL ISSUE

See page 11

DIGITAL AUDIO-VISUAL SYSTEM

Output amplifier for ribbon loudspeakers

Wheatstone bridge

Printer sharing unit

Differential thermometer

Spiral T/R HF antenna

ELEKTOR ELECTRONICS USA

November 1992
Volume 2
Number 12

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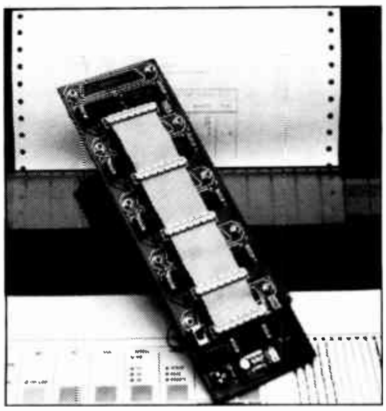
Front cover
This month we start a project for a slide control system based on a Centronics-driven dissolve unit for four slide projectors. The system allows up to 16 projectors to be controlled automatically or by hand. Music or comment to accompany the slides can be synchronized with the aid of an advanced pulse or time-code registration unit. The time-code option enables you to record all control actions in a complete slide show, whereby all relevant data are safely stored, along with the parallel sound track.



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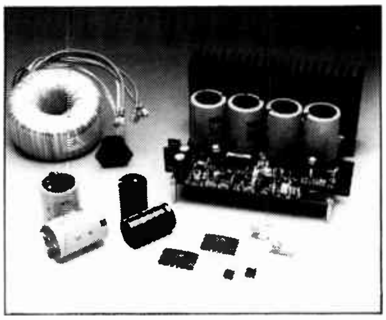

Output Amplifier For Ribbon Loudspeakers-p. 22

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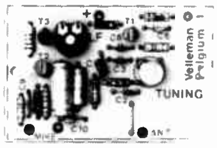
POSTMASTER: Send address changes to **Elektor Electronics USA**, Caller Box 876, Peterborough NH 03458-0876.

TAPTO ELECTRONIC KITS

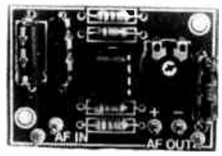
Our high quality kits will provide you with educational projects. After you complete your kit, you will have a high-tech product that will provide years of reliable operation. Assembly instruction in English, French, Dutch and German. Over 100 kits available. Call of write for a full-line catalogue.

K1771 FM Oscillator $16.95



Mini FM transmitter with good frequency stability (100-108MHZ). Built-in pre-amp (5mV Sensitivity). Interfaces to all microphones. Requires 9-12 VDC.

K1803 Universal Mono Pre-Amplifier $8.95



Ideally suited as a microphone amplifier, signal matching of tuner or tape outputs.• Supply voltage: 10-30 VDC (stabilized)• Gain: typ. 40 dB• Adjustable output level• Frequency range: 20 Hz to 20 KHZ (+/- 3 db)• Maximum input voltage: 40 mV.

K2622 AM-FM Antenna Amplifier $17.95

Do away with noisy signals! The K2622 gives you 22 dB gain where it's needed. DC supply direct or via the coax cable (50-75 Ohm impedance), metal box included.

K2637 2.5 Watt Mini Audio $13.95

This small kit comes with a pre and power amplifier. No adjustments required. Short circuit protected. Power supply: 4,5 to 15 VDC• Input sensitivity: power-Amp: 150 mV (12V)• Pre-Amp: 20 mV (12V)• Max output 2.5W (4 Ohm, 12V)• Size: 42 x 32 x 27 mm.

K2666 Precision Stereo Vu-Meter $79.95

Extremely precise VU-meter• 2 x 30 LED's "flying dot" readout• dB-linear scale from +6 to -6 dB (0.75dB per LED)• Steadily increasing scale partitions under -6dB• Peak measurements• No adjustments• Maximum error 0.5dB.

K2032 Digital Panel Meter $39.95

A compact kit that can be incorporated into many housings or into existing equipment• Power supply: 5VDC, 250 mA (regulated)• Read out: -999 mV to +99 mV, 1 mV resolution• Overload indication (positive and negative)• Linearity 0.1%• Input impedance: 100 Mohm.

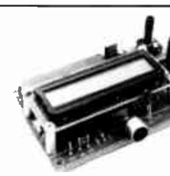
K2653 Digital Voice Record/Playback $61.95

Record your voice message on a IC and play it back! Short messages (10-12 seconds) can be repeated to welcome your guests in your home or store. Use your imagination. Tech data: Loudspeaker output: 2W at 4 Ohm• 9VDC regulated.

K2645 Geiger-Muller Counter $139.95

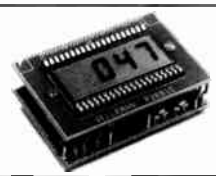
Reliable acoustic indication of radiation level. Excellent sensitivity to Gamma rays and high energy Beta rays. Battery operated (9V). Battery life exceeds 2 months in continual use and in normal natural radiation surroundings. Very compact: 99 x 54 x 25 mm. Light weight; assembled pcb weighs only 55 gr.

K2659 Morse decoder w/LC-display $109.95



Decode Morse messages on your shortwave receiver. This decoder keeps up with the quickest signallers or automatic stations, and "notes" message on LCD. Alphanumeric LCD• 1 line of 16 characters• decodes Morse at almost any speed.

K2651 Digital Volt Meter $39.95



This kit provides an easy-to-read display. Because of the simple power supply requirement and compact size of the kit, it can easily be incorporated into a variety of applications. Technical specs: Selectable - to + 200 mV or - to + 2V• Power supply: 8 to 15 VDC of 9V battery.

K4300 Audio Spectrum Analyzer $109.95

Provides visual composition of an audio signal. Kit consists of two boards and attractive front panel with 10 frequency bands. Technical specs: 10 bands: 32, 64, 125, 500, 1K, 2K, 4K, 8K and 16 KHZ• Range: 20 dB (10 LED's, 2dB per LED)• Line input: adjustable from 100 mV to 2 V rms, impedance 100K• Power supply 2 x 9v transformer: 12-15VDC• Current consumption 0.75ADC max, 70mA in stand-by.

ORDER INFORMATION

Call for a catalogue!

Call: (303) 480-7544
Fax: (303) 480-7553

1-800-758-2786

Mail: Tapto Corporation
2650 West 18th St.
Denver, CO 80211

PAYMENT METHODS

- VISA
- MASTERCARD
- CHECK

$5 Shipping charge per order

RECOMMENDED SOURCES FOR ELEKTOR ELECTRONICS USA EUROPEAN PARTS

Borbely Audio
Erno Borbely
Melchior Fanger Strasse 34A
8031 Neu-Gilching
Germany
Tel 49-8105-5291
FAX 49-8105-24605 (24H)

Bull Electrical
250 Portland Road
Hove
Sussex BN3 5QT
United Kingdom
Tel 44-0273-203500
FAX 44-0273-23077

DIL Elektronika
Jan Ligthartstraat 59-61
3083 AL Rotterdam
The Netherlands
FAX 31-10-4841150

EasyTech, Inc.
2917 Bayview Dr.
Fremont, CA 94538
Tel (800) 582-4044
FAX (800) 582-1255

ELV France
BP 40
F-57480 Sierck-les-Bains
France
Tel 33-82-83-72-13
FAX 33-82-83-81-80

Meek It Electronics
Rob Planken
Paveljoensgracht 35A
2515 BL Den Haag
The Netherlands
Tel 31-70-3600357
Tel 31-70-391-4381
FAX 31-70-397-9707

Technomatic
Technohouse
486 Church Lane
London NW9 8UF
United Kingdom
Tel 44-081-205-9558
FAX 44-081-205-0190

WorldRadioHistory

A LAST LETTER TO YOU

After two years plus one final issue, we must, with deepest regret, suspend publication of *Elektor Electronics USA*.

Doubtless the recession has been a major factor in the need for our decision. But other causes, as well. Advertisers were reluctant to use a new, untried medium, and apparently we did not always find the vendors to whom you were interested responding. Advertisers' phones did not ring, orders did not pour into advertisers' mailboxes. And no magazine of this size and quality can survive on an annual circulation price of $28 per year without advertising support and reader response to them.

The larger picture in the US is a theme I have expounded upon to readers and other friends ad nauseam. But Americans are rapidly losing their ability to make things with their hands. The number of helpless, hapless individuals grows steadily with each new generation. Most people consider this unimportant. The advertising moguls love it. The end user is being offered less and less in the way of handcraft projects which are seriously challenging. But a do-it-yourself revival is, I believe, underway, fueled largely by necessity in bad economic times.

A new company formed last month to assist Americans in learning to use their computers, or to get them running again, is named "Rent-a-Nerd." Thus, the ability to make something, repair it, or even understand it, makes you some kind of weird aberration, somehow comic and subnormal. Whether this has anything to do with the United States continuing to be the world's most innovative and productive industrial nation, given our attitudes, is not a question I think we can answer positively with any real hope.

On page eleven I am pleased to offer you a rather rich menu of alternative publications. We naturally begin with our own three which specialize in do-it-yourself audio design and construction. Details of how those may be chosen to fulfill your unexpired subscription are stated there.

May I request, as strongly as I can, that you help us by FAXing or mailing your choices of alternative periodicals as promptly as you can. Also, I am sure you can understand that if you call about your subscription, you are likely to get a busy signal. We will process your choice as quickly as possible—but we have only three phone lines servicing subscriptions, and they cannot be useful if everyone on the list calls. Our FAX is open 24 hours, 7 days a week.

The cooperating magazines, other than our three, will require some time to enter your request and for the schedule to deliver your first copy. Most of the larger periodicals have a six-week to two-month time lag on "new" subs. Since your name is on our integrated subscriber list already, a choice of one of our periodicals could be quicker, but keep in mind they are all bimonthly or quarterly in schedule.

Lastly, I thank you all for your response to *Elektor Electronics USA*. I have been proud to publish it. I remain convinced that it is the best electronics design periodical available—and sorry that it will no longer be available here in the USA.—E.T.D.

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Telephone: 603-924-9464 *(National)*
or +1 (603) 924-9464 *(International)*
FAX: (603) 924-9467 *(National)*
or +1 (603) 924-9467 *(International)*
Advertising: Maureen E. McHugh
Telephone: (603) 358-3756
FAX: (603) 358-0157
Subscriptions: Katharine Gadwah
Elektor Electronics USA
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Uitgeversmaatschappij Elektuur b.v
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6190 AB BEEK
The Netherlands
Telephone: +31 46 38 94 44
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Elektuur BV
Postbus 75
6190 AB BEEK
The Netherlands
Telephone: 011 31 4638 9444
Telex: 56617 (elekt nl)
FAX: 011 31 4637 0161
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Editors: D.R.S. Meyer
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Editor: E.J.A. Krempelsauer

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Editor: E. Xanthoulis

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Elektor Elektronikai folyoirat
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Batthyany U. 13
Editor: Lakatos Andras

INDIA
Elektor Electronics PVT Ltd
Chhotani Building
52C, Proctor Road, Grant Road (E)
BOMBAY 400 007
Editor: Surendra Iyer

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Publisher: M. Avraham

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Peter Treckpoelstraat 2-4
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Editor: P.E.L. Kersemakers

PAKISTAN
Electro-shop
35 Naseem Plaza
Lasbella Chawk
KARACHI 5
Editor: Zain Ahmed

PORTUGAL
Ferreira & Bento Lda
R.D. Estef-83-ni, 32-1°
1000 LISBOA
Editor: Jeremias Sequeira

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Resistor Electronica Aplicada
Calle Maudes 15 Entlo C.
28003 MADRID
Editor: Agustin Gonzales Buelta

SWEDEN
Electronic Press AB
Box 5505
14105 HUDDINGE
Editor: Bill Cedrum

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ELECTRONICS SCENE

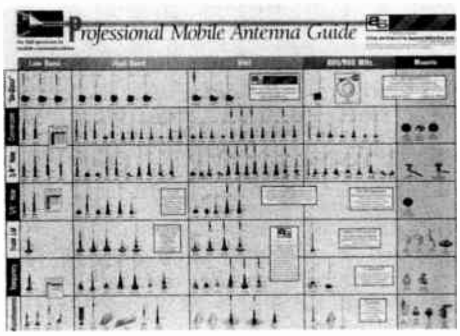
WOMEN'S TECHNET ON-LINE

Women's Technet, an organization dedicated to improving opportunities for women in pro audio, video, broadcast, recording and related industries, is now on-line. Both men and women are encouraged to become a part of this organization in its quest to promote, educate, and support women in these technical industries.

Technet has established two private conferences on a non-profit telecommunications network, the Institute for Global Communications (IGC), which provides all the typical services at extremely competitive prices, including electronic mail, FAX and telex using computer and modem. You can participate in hundreds of public conferences worldwide, and send electronic mail to dozens of popular computer networks.

The cost of an IGC subscription is $10/month, with an initial sign-up fee of $15, which includes one hour of off-peak connect time to the network each month. Technet solicits the participation of people with expertise, knowledge, information, and a desire to contribute to the advancement of women in these technical careers.

For more information send a self-addressed, stamped envelope (with postage for two ounces) to Women's Technet, PO Box 966, Ukiah, CA 95482.

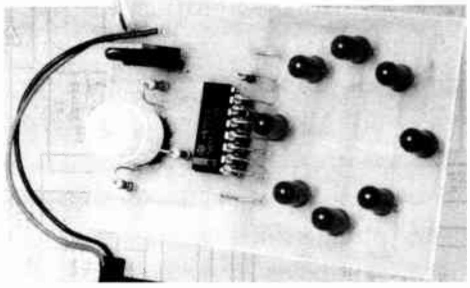


ANTENNA GUIDE

Antenna Specialists has produced a Professional Mobile Antenna Guide, a full-color illustrated wall chart depicting 150 mobile antenna models grouped by frequency range from low-band through 800–900MHz, and cross-referenced to various mounting schemes.

The chart, which measures 54″ × 38″, also presents antenna solutions for special applications such as transit, motorcycle, and railroad. Each antenna is illustrated, and its components identified by part number.

For more information, contact the Marketing Department, Antenna Specialists Co., 30500 Bruce Industrial Parkway, Cleveland, OH 44139-3996, (216) 349-8400, FAX (216) 349-8407.



SPEAKER DESIGNER, 2.0

Stuart Bonney is now offering an enhanced version of **Speaker Designer**, a program for loudspeaker system design and modeling. Release 2.0 accommodates closed or vented system designs and is based on Thiele/Small parameters. It models both small- and large-signal performance over the frequency range of 10–300Hz.

Enhancements include user-designed input files which you can save to or retrieve from disk; input error trapping and correction functions; new sample input files for less experienced users that include closed, vented, single driver, and dual-driver designs; and an on-disk user's guide with revisions, expansions, and instructions for modeling multiple-driver systems.

Other features include English/metric conversion, ASCII format, menu-driven selections, and speed. Speaker Designer runs on any IBM PC or compatibles, MS-DOS version 2.0 or higher, and comprises 38K-bytes.

Speaker Designer, 2.0 (#SOF-SPD1B5, $27.50 plus $2 S/H) is available from Old Colony Sound Lab, PO Box 243, Peterborough, NH 03458, (603) 924-6371, FAX (603) 924-9467.

POWER OUTLET

MFJ Enterprises announces the new MFJ-1116 Deluxe DC Power Outlet strip with built-in voltmeter, master switch, 15A fuse, and eight terminals for connecting rigs and keyers, TNCs, and tuners. Each of the outlets uses heavy-duty five-way binding posts, with standard spacing for dual banana jacks.

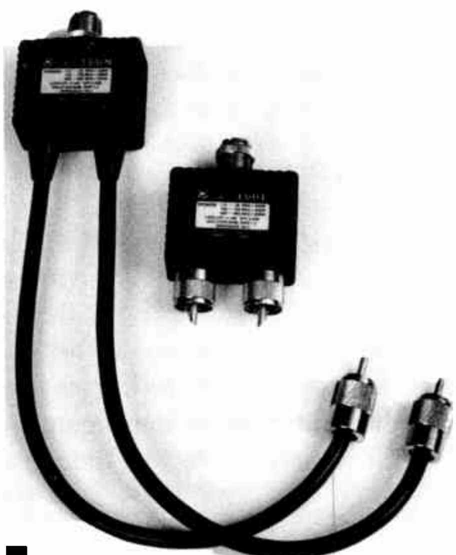
Order through any MFJ dealer, or MFJ Enterprises, Inc., PO Box 494, Mississippi State, MS 39762, (601) 323-5869, (800) 647-1800, FAX/Telex (601) 323-6551.

REMOTE SOFTWARE

Remote-Console announces the release of Version 4.0 system software, which adds CGA, EGA, and VGA graphics capability. The new version also reduces memory overhead to 18K-bytes when running text-mode applications. All programs fit on a single 360K floppy disk, and password data is placed on removable media for system security. Remote-Console® works with DOS 3.0 and higher, DR-DOS, Windows 3.0, VM/386, and OS/2, among others.

The software is a remote access and control system, and is designed to link two personal computers via modem or direct cable. It can be used to run any program on an unattended host computer from a remote location, and runs on all IBM PCs. Host and remote sides, a full-screen text editor, a calendar program, and diagnostic software are included for $119. Version 4.0 is available on both 5.25″ and 3.5″ disks.

Contact Louis Wheeler at Remote-Console, PO Box 888, Oceano, CA 93445, (805) 481-5687.



NEW DAIWAS

The PS50T is the latest in Daiwa's series of power supplies, which are available from **Electronic Distributors Corp.** This 5A low-capacity power supply has a cigarette lighter plug (meter not provided). The multipurpose 12V DC power source can be used with hand-held scanners and transceivers, and mobile scanners. List price is $49.95.

Daiwa's DX10 series duplexers cover 1.6–150MHz and 400–460MHz. Insertion loss is less than 0.1dB. The DX10D ($27.95) comes with two PL259 connectors; the DX10M ($36.95) is supplied with cable and two connectors; the DX10N ($37.95) comes with cable, one PL259 and one N connector.

For a dealer near you, contact Electronic Distributors Corp., 325 Mill St., Vienna, VA 22180, (703) 938-8105, FAX (703) 938-6911.

Continued on page 12

A MENU OF MAGAZINE CHOICES

This November, 1992 issue of *Elektor Electronics USA* is the last to be published by Audio Amateur Publications, Inc. We deeply regret this but the economic times were a factor we could not have anticipated in laying our plans three and one half years ago. Below we list a menu of alternative periodical choices for your consideration. Each title is followed by a description and the number of copies the publisher will send you to fulfill unexpired issues of *Elektor Electronics USA*.

We ask your cooperation and patience in this transition period. You will help us greatly and expedite this changeover by doing the following:

1. Please fill in the postcard you will find between pages 4 and 5 indicating your choice of alternative magazine. Next, peel the label from the front of the magazine and place it on the card.This tells us how many issues are due you and your customer number. Please remember that your EEUSA subscription was for 11 issues per year. Make a copy of your customer number and expiration date for your records.

2. Mail or FAX this card as quickly as you can. MAIL: Elektor, PO Box 876, Peterborough NH 03458. FAX (603) 924-9467.

3. If you are already a subscriber to the magazine you choose, your subscription to it will be **extended** by the number of issues **at the fulfillment ratio** remaining in your 11-issue per year EEUSA subscription.

4. Please do not telephone our circulation department since we have only two circulation clerks on duty and any significant use of the phones will clog the lines. If you wish to leave messages about problems, our answering machines are open at 4:15pm EST, M-F and are on all night until 8:00am. They are also open 24-hrs on weekends.

MAGAZINES — Fulfillment Ratio

COMPUTERCRAFT (MONTHLY) — 2 *CC* for 1 *EEUSA*

The practical magazine for "hands-on" users of IBM/compatibles, microcontrollers and single-board computers. How-to articles cover upgrades, enhancements, and construction projects enabling readers to get more out of their machines. Electronics projects that relate to computer technology are also presented, such as adding video or musical instrument digital interface (MIDI) capabilities. Also included are incisive technical articles, product reviews and new products. (Formerly: *Modern Electronics)*

ELECTRONIC SERVICING & TECHNOLOGY (13 ISSUES/YEAR) — 1 *ES&T* for 1 *EEUSA*

For professional servicers of consumer electronics and computers, it will also appeal to anyone who enjoys working on such products. Detailed servicing articles, troubleshooting tips, and frequently-encountered diagnostic problems are offered for TVs, VCRs, audio/video equipment, personal computers, microwaves, and more. Each issue includes a schematic on a popular consumer product, and a special 13th issue is devoted to numerous schematics and component sourcing.

COMMUNICATIONS QUARTERLY (QUARTERLY) — 1 *CQQ* for 4 *EEUSA*

Technically-oriented amateur radio magazine gives in-depth coverage to the science of communications. Each issue, over 100 pages of purely technical material examines state-of-the-art subjects like direct digital synthesis, digital signal processing, station control by microprocessor, clover technology, and computer-aided antenna design. Authors and editorial review board are drawn from amateur radio's most knowledgeable and experienced operators.

CQ AMATEUR RADIO (MONTHLY) — 1 *CQ* for 1 *EEUSA*

The largest independently published amateur radio magazine, it covers a wide variety of amateur radio's most popular aspects. Contesting, DX'ing, construction projects, radio fundamentals, equipment updates, and more, are all presented in a friendly, entertaining format. Technical information and product reviews are practical and easy to understand. World-renowned contributors include Bill Orr, W6SAI; Buck Rogers, K4ABT; Dave Ingram, K4TWJ; and Lew McCoy, W1ICP.

POPULAR COMMUNICATIONS (MONTHLY) — 1 *PC* for 1 *EEUSA*

For scanner monitors and world band shortwave radio listeners and enthusiasts. Regular columns cover new stations and schedules, car phones, CB radio, satellites, pirate broadcasters, FCC activities, beginning ham radio, old-time radio and much more. A non-technical magazine, it is written and edited to help the average enthusiast get more out of this hobby.

ELEKTOR ELECTRONICS (UK) (11 iss/yr) — 1 *EEUK* for 2 *EEUSA*

Identical editorial content to US edition, British advertising, reader support services for circuit cards, panels, firmware,books, and software will continue to be available through Old Colony. ELEKTOR UK offers one for two because of the heavy postage costs. Readers choosing this alternative will be offered a reduced rate of US $48./yr. at renewal time rather than the regular $56 rate.

BACK ISSUES OF *EEUSA* ARE ON SALE AT 10% OFF UNTIL JANUARY 31, 1993. *See pp. 52-3 for order card.*

PLEASE TURN TO PAGE FOUR, FILL IN THE BIND-IN CARD AND RETURN IT. THANKS.

Continued from page 10

ELECTRONICS SCENE

RELOCATION

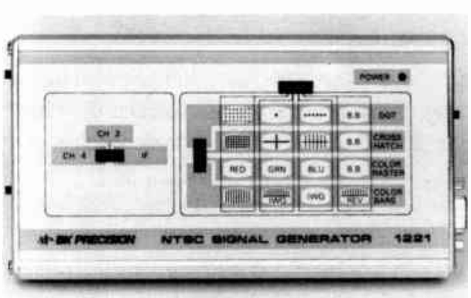
Circuit Works, manufacturer of printed circuit boards, has relocated to a new facility for production of microwave circuits, as well as single- and double-sided boards. All camera work and step-and-repeat process is done in-house; prototypes and small runs are usually one-week delivery.

Circuit Works' is located at 85 W. Sylvania Ave., Neptune City, NJ 07753, (908) 774-1811.

COLOR GENERATOR

The Model 1221 from **B + K Precision** is a portable television/video signal generator which generates 14 patterns of stable video signals for testing, servicing, and adjustment of television and video equipment. Applications include color or monochrome video monitors, CGA computer monitors, video cassette recorders, television receivers, closed-circuit television systems and components, and cable TV systems.

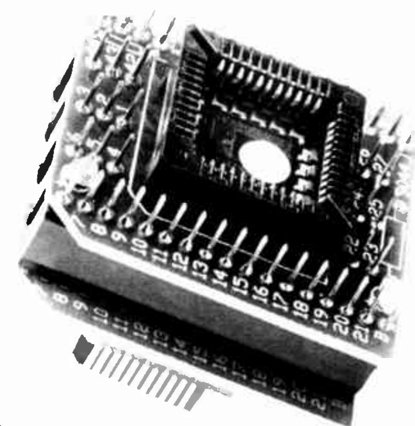
Powered by an AC adapter (provided) or an external 12–18V DC source, it comes complete with output cable and manual for $369. For immediate delivery or complete specifications, contact your local distributor or B + K Precision, Division of Maxtec International Corp., 6470 W. Cortland St., Chicago, IL 60635, (312) 889-1448, FAX (312) 794-9740.



DATA CONTROLLER

Now available from **Advanced Electronic Applications**, the DSP-1232 Multi-Mode Data Controller featuring digital signal processing. The single-port version ($799) features packet, AMTOR, Baudot, ASCII, Morse Code, NAVTEK, WEFAX, all satellite digital modes, automatic identification of most digital signals, software switchable radio port selection, and complete 18K-byte personal mailbox.

For a product data sheet and list of authorized dealers, contact Advanced Electronic Applications, Inc., PO Box C2160, 2006 196th St. SW, Lynnwood, WA 98036, (800) 432-8873, (206) 774-5554.



TEST ADAPTER

Antona Corp.'s Model ANC-4044 is designed to monitor and test socketed 44-pin plastic-leaded chip carrier (PLCC) or pin grid array (PGA) type components.

Oscilloscope and logic-analyzer test leads can be attached to any of the component leads by means of numbered test points. Two LED status circuits visually indicate user-selected signals. The user's manual includes a template sheet of the adapter, which designers can use as a signal-to-pin designation guide.

The unit sells for $122. For additional details, contact Bob Mikkelson at the Antona Corp., 1643½ Westwood Blvd., West Los Angeles, CA 90024, (310) 473-8995, FAX (310) 473-7112.

SIGNAL PROCESSOR

Digital Interactive's DSP-120 connects to the printer port of any IBM PC compatible, and to the audio output of your receiver. Real-time digital signal processing frequency and time-domain techniques are brought to the computer, which is used to store previously defined filter responses for rapid recall, calculation of filter coefficients, sound recording and playback, fast high-resolution graphic display in both the frequency and time domain, and control adaptive DSP algorithms.

Enhance weak voice or music signals with the mouse or cursor, or draw a tight band-pass filter around the signal to eliminate as much as 95% of the noise bandwidth in the audio frequencies. The hardware supports future software application extensions for easy upgrading.

For more information, contact Digital Interactive, Signal Corp., 2317 NE 168th Ave., Vancouver, WA 98684, (206) 256-8654.

LINE TESTER

The Model 485T Tester from **B&B Electronics** can be used to check signal conditions at any node on an RS-422 or RS-485 network, to determine if the maximum permissible negative or positive voltages are being exceeded. The tester also checks for the existence of minimum required differential voltages, and uses the data that is transmitted on the line to check the voltage value.

The unit runs on either a 9V battery, or from an external 12V power supply. Also included are an instruction manual, and an RS-232 output that can be used to monitor the network data. The tester is priced at $139.95, and the external power supply costs $14.95.

Contact B&B Electronics, 4000 Baker Rd., PO Box 1040, Ottawa, IL 61350, (815) 434-0846, FAX (815) 434-7094.

TEMPERATURE HEAD

Fieldpiece Instruments has introduced the model ATH3 Dual Temperature Head, which converts the signals from two K-type thermocouples to display them as temperature on a digital multimeter, and can be calibrated in the field to an accuracy of ±1°F. It converts the Fieldpiece HS20 "Stick" series meter to a one-piece temperature meter, but works well with any digital multimeter with "Fluke style" jacks and input impedance of 9–10MΩ.

Inputs from two thermocouples are accepted simultaneously, with a conversion ratio of 1.0mV DC output per 1.0°F input. The converter is powered by a 9V battery, and automatically goes off after 45 minutes. The list price of $89 includes two K-type thermocouples; test leads cost $12.95.

For more information, contact Fieldpiece Instruments, Inc., 8322B Artesia Blvd., Buena Park, CA 90621, phone/FAX (714) 992-1239.

ELECTRONICS SCENE

MINI PC

The Saelig Co. now offers GCAT from DSP Design, the first commercially available credit-card-sized PC compatible, measuring 3.4" × 2.6". The 14MHz F8680 PC/chip processor has built-in graphics hardware, and will drive a CGA LCD screen or CRT without additional boards. The serial port is fully COM1-hardware compatible, and the board has 1M byte of DRAM and a 512K-byte ROM disk capability as standard features. With DOS and BIOS installed, about 400K-byte of application space remains for diskless applications.

Under normal conditions, the board consumes 73mA from a single 5V rail. In suspend mode, consumption drops below 600μA (300μA with 3V supply). Expansion to I/O is via PCbus, and a GCAT Development System is available.

For further details, contact Carol Goldsmith, The Saelig Co., 1193 Moseley Rd., Victor, NY 14564, (716) 425-3753, FAX (716) 425-3835.

HAND-HELD INTERCEPTOR

Optoelectronics has developed the pager-sized Model R20 AM Communications Interceptor ($119), a modern version of the crystal detector radio with microwave diodes and transistors. A ten-LED bargraph provides a relative signal level display using 3dB steps, for all RF signals that are detected. The frequency range covered is from 0.5MHz to over 2.5GHz. The detected audio output is amplified and processed using automatic level circuitry.

Contact Optoelectronics, Inc., 5821 NE 14th Ave., Fort Lauderdale, FL 33334, (800) 327-5912, (305) 771-2050, FAX (305) 771-2052.

PHONO JACKS

A Hex Base has been added to **Mouser Electronics'** panel mount phono jack, allowing a 9mm nut driver to secure the jack from the front of the panel, and preventing it from turning while it is being tightened from the back. The nut driver minimizes damage to delicate panel finishes. The new phono jack mounts in a single ¼" hole.

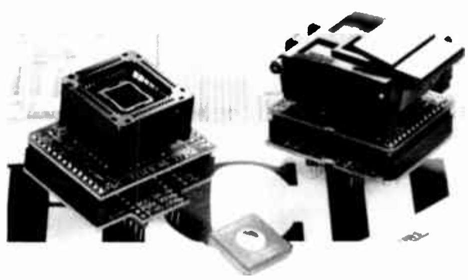
Contact Mouser Electronics, 2401 Hwy. 287 North, Mansfield, TX 76063, (800) 346-6873.

PROGRAM MOTOROLA

The 8-bit Motorola 68HC711E9 ('E9) is now programmable using the 27C256 footprint and programming algorithm available from **Logical Systems**. Adapters make the proper connections between the EPROM programmer's 28-pin socket and Motorola's 52-pin 'E9, making it usable in products requiring device serialization, small volume production, or one-time calibration. Just set the programmer for 27C256, and plug in the adapter.

The PA711E9 ($145) and PA711E9B ($145) adapters feature a 52-pin Auto-Eject PLCC test socket. The PA711E9-ZIF ($165) and PA711E9B-ZIF ($165) feature a lidded 52-pin PLCC ZIF test socket. The test sockets can be serviced without replacing the adapter.

Contact Logical Systems Corp., PO Box 6184, Syracuse, NY 13217-6184, (315) 478-0722, FAX (315) 475-8460.



REMOTE CONTROL

Dubbed electronic panning, **Bellcore**'s experimental camera system—together with a high-speed communications network—will allow an unlimited number of people in separate locations to view a scene from an infinite number of directions. The system allows users to customize their views by selecting and controlling what they would most like to see—without affecting the view seen by the other participants.

For example, during a football game on television, one person could watch the action on the field, another person could watch the band practice in the end zone, while a third could look around the stands.

The electronic panning camera incorporates Bellcore-created technology that allows users to visually scan a remote scene while the camera and lens remain stationary.

According to Bellcore, an electronic panning system could span 280° or even 360° so that, fully realized, this technology would permit one to check on rush hour traffic or the children at school without leaving home.

Bellcore (Bell Communication Research) is located at 290 West Mt. Pleasant Ave., Livingston, NJ 07039-2729.

PAGING ENCODER

The PE-15 from **Communications Specialists** is a miniature sub-assembly capable of sending codes in the POCSAG format. Intended for operators of local "in-house" radio systems wanting to signal tone-only pagers, it has 15 available codes which may be used to activate up to four distinct alert tones on each pager, 15 individual pagers, or any combination of these.

The PE-15 ($99.95) is factory programmed to your specific address codes, or may be field programmed by means of an available keypad. For more information, contact Communications Specialists, Inc., 426 W. Taft Ave., Orange, CA 92665-4296, (800) 854-0547, (714) 998-3021, FAX (714) 974-3420.

HIGH TECH RADIOS

Lowe receivers are now available in the US and Canada through **Electronic Equipment Bank**. HF150 is the most recent addition, converting 30kHz-30MHz, AM, SSB, and Synchro detection. Equipped with 2.5 and 7kHz filters, 60 memories, and a large LCD readout, it accepts three antennas, balanced wire, whip and 50Ω, and weighs less than 3 lbs.

For more details, contact Electronic Equipment Bank, 323 Mill St. NE, Vienna, VA 22180, (800) 368-3270, FAX (703) 938-6911.

JUST THE FAX

Allied Electronic Services announces the addition of the Tempo Fax Line Eliminator, which answers incoming calls on the first ring and routes the call to the appropriate device, thus eliminating the need for dedicated phone lines.

Three models are available, with prices ranging from $225 to $750. For further details, contact Allied Electronic Services, Stonybrook Rd., Lebanon, NH 03766, (603) 448-3572.

A COMPACT SPIRAL T/R HF ANTENNA

This is a short, efficient, horizontal indoor spiral transmitting/receiving antenna, using 139 feet (approx. 42 m), that can be compacted into a length of about 15 feet (approx. 3 m). It is based on a pair of Slinkys. And, quite reasonably, you may ask "and what on earth is a Slinky?"

By Richard Q. Marris, G2BZQ

SLINKY was first met, by courtesy of the two sons of a colleague, while the author lived and worked in the U.S.A. for several years during the 1970's. Slinky is manufactured in the U.S.A. by James Industries Inc., Hollidaysburg, PA 16648. It consists of 90×2¾ in (90×7 cm) diameter turns of spring made of 67 ft (approx. 20 m) of flat bright steel wire. Each Slinky weighs about ½ lb (approx. 0.45 kg), and can be extracted to about 15 ft (4.5 m). However, it comes compressed into a 2¼-in (5.7-cm) length in a robust red carton on which we read that Slinky is 'a walking spring toy' for 'ages 6 and up!'. It was demonstrated to the author as a fascinating toy which would, among other things, walk down stairs!

Design background

It so happens that as a Slinky is expanded, it resonates as a ¼λ between 7 and 8 MHz. In fact, the retailers (Antenna West) offer suggestions, and kits of parts, for using it as a 7-MHz or 14-MHz delta matched dipole. Each dipole can be resonated by expanding or contracting the spring coil. It is estimated that the bandwidth would be comparatively narrow. Each kit comes with a Slinky, a transparent messenger line, transparent coil positioning tabs, ceiling hooks with hardware, transparent suction caps and white coaxial feedline.

Antenna description

The requirement was for a short efficient indoor multiband T/R antenna, which can be slung diagonally across a room, and used on most of the H.F. amateur bands.

As the primary, and lowest, frequency was for the 80-m (3.5-MHz) band, two Slinky coils (without accessories) were obtained, and electrically secured end-to-end. The long double Slinky was hung diagonally across a room, and end-fed with a short single feedline plugged into a suitable ATU (antenna tuning unit) which would resonate it on all amateur bands between 10 m (28 MHz) and 80 m (3.5 MHz). It was anticipated that the voltage and current distribution would be relatively uniform over the whole length, and that a sizeable section of each band could be used without retuning the ATU. As two coils weigh about 1 lb (approx. 0.9 kg), the whole spring was supported by thin nylon cord, enabling the antenna to be length adjusted, and compressed into a few inches when not in use. Also, it could be discreetly hidden in a corner of the room.

The final operating arrangement is shown in Fig. 1a, and the non-operational arrangement, in Fig. 1b. The 5-ft long feedline drops down from the room corner end, located over the equipment, the ATU. Various ATU types were tried, but the simple 'T' type shown in Fig. 2 proved to be the most effective. The earth connection was taken with about 15 ft (4.5 m) of stout

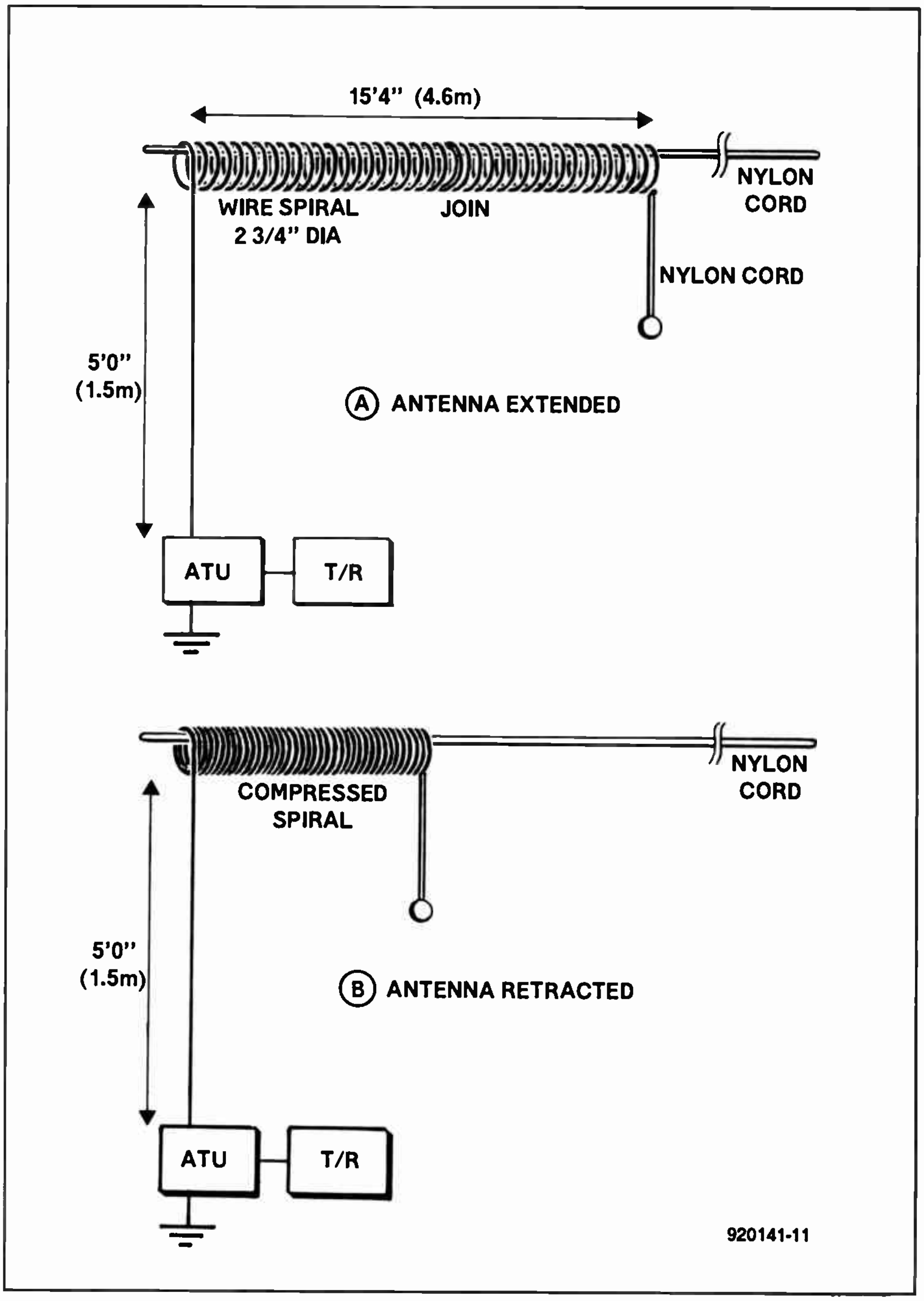


Fig. 1. The spiral loop hangs on a nylon cord attached to the apartment ceiling. Note: length difference between extended and retracted antenna is not to scale.

flex to a convenient water pipe. Though the final antenna is only 15'4" long (approx. 4.6 m), plus the 5-ft (1.5-m) drop-down feeder, there is actually a total of 139 ft (41.7 m) of wire, i.e., 2×67 ft plus 5 ft. The diagonal space across the room was 18 ft (5.4 m). The drop-down feedline is part of the antenna.

Antenna construction

A length of 1/16-in (1.6-mm) diameter white nylon cord is now suspended diagonally across the room, at least 9 ft (2.7 m) away from the ceiling, and carefully avoiding electric light fittings. Here, the length from corner to corner is 18 ft (5.4 m). The wire coil is now slipped over one end of the nylon cord, before it is securely fixed at one end. A stout 5-ft (1.5-m) long single-core flex feeder lead is soldered to one end of the coil, and dropped down to the ATU, as shown in Figs. 1a and 1b. A piece of nylon cord is tied to the other end of the coil, and terminated with a plastic ring or knob. By using this short nylon cord as a tow line, the coil can be expanded to a length of 15'4" (approx. 4.6 m), and a few turns of nylon cord wound and knotted at this point form an 'anchoring stop' for quickly expanding the antenna coil when in use. The last turn of the coil is slipped over this 'stop'.

When not in use, the coil can be pulled back to a discreet compressed coil at one end (see Fig. 1b). The horizontal length of nylon cord is nearly invisible against a white ceiling.

ATU construction

Possibly the reader has a suitable existing ATU, and this can be tried. Several ATU configurations were tried with the 'T' type, shown in Fig. 2, which was also the final design adopted. The inductor, L, is a length of B&W coil stock (see Components List), and C1 and C2 are both 250-pF good quality air-spaced variable capacitors. The whole is built into a convenient metal box, the maximum size of which will depend mainly on the type and size of the variable capacitor used. At least one diameter clearance should be left around L.

The spindles of C1 and C2 must be isolated from all metalwork. A convenient way of doing this is to mount C1, C2 and L on a sheet of perspex, or non-metallized fibre-glass board, which is mounted on four short pillars, just behind the metal front panel. Large clearance holes will be required in the metal box panel, so that the spindles of C1 and C2 do not touch the metalwork. Sockets Skt1 and Skt2 are coaxial types of convenient type to the user.

Taps should be made on L, for each band to be used. The ATU will match the antenna to the transmitter/receiver on the 80-m (3.5-MHz), 40-m (7-MHz), 20-m (14-MHz), 15-m (21-MHz) and 10-m (28-MHz) amateur radio bands. The author uses tapping clips, but some of you may prefer a ceramic wafer rotary switch. The method of locating the taps is described below.

Setting up, testing and operating

With the antenna extracted to 15'4" (4.6 m), and plugged into Skt1, and Skt2 connected to the transceiver with a short length of coaxial feedline, an earthing/grounding connection should be made to the ATU. Here, about 15 ft (4.5 m) of stout wire flex is firmly connected to a convenient metal water pipe. Other convenient grounding arrangements may be used depending on individual circumstances.

Do not connect the ATU to plastic water pipes, metal gas pipes, or metal electric wiring conduit. Do not connect it to the AC mains earthing pin either. Even though the mains earth will, no doubt, be connected to the transceiver, it must not be used as an RF earth connection to the ATU.

Tune the receiver to a convenient spot on the 80-m (3.5-MHz) amateur radio band. Set C1 and C2 to 50% capacity, and move the tap along the coil, L, for maximum signal. Adjust C2 for maximum signal — this will match the ATU to the receiver's input impedance. Next, repeat the adjustment of C1 for best antenna matching. Switch on the transmitter, and carefully re-adjust C1 and C2 for best loading and lowest SWR. Once you are satisfied with the results, secure the 80-m tapping point by either solder, switch or clip connection, depending on what has been decided. An SWR of 1:1 is obtainable with care. Repeat the process for the other bands selected.

It is also possible to match the ATU/antenna combination to Top Band (1.8 MHz), but it is presumed that performance would be suitable for the shorter range operation. It has not been tried.

As an example, the author has used this spiral antenna quite extensively, in the early morning, on the 80-m band, using a 14 watts input CW transmitter. An SWR of 1:1 has been achieved; no harmonics radiation or TVI detected, and the CW section of the band between 3.5 MHz and 3.6 MHz can be used without retuning C1 and C2. The antenna appears to be omnidirectional, with near uniform current/voltage distribution along the whole spiral coil. Tests on other bands have been similar. The results with the antenna diagonally across the room, in a first floor room, have been very satisfactory. For anyone who has not the full required length available, it is suggested that part of the far end of the spiral be dropped down, or taken off at an angle.

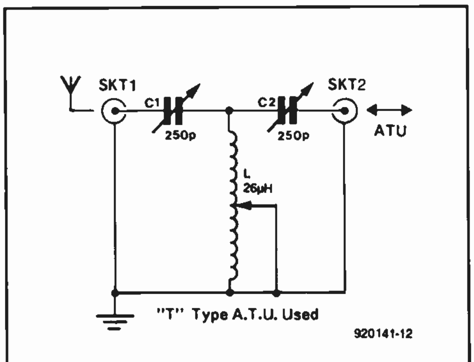


Fig. 2. Type 'T' ATU used.

COMPONENTS LIST

Antenna:
White nylon cord, approx. 1 mm diameter. DIY Stores (trade name in UK: Winchester).
Qty. 2 Slinky 2¾" diameter coils. Antenna West, 1500 North 150 West, Provo, UT 84604, U.S.A.

Note: at the time of writing, a Slinky coil (2¾" dia.) costs $10 each, plus $10 air mail (total $30). VISA and Mastercard accepted.

ATU:
L = 26µH indutance. B&W no. 3059 (available in the UK from RF Engineering, Main Street, Coln-St. Aldwyns, Cirencester, Glos GL7 5AN.
C1 and C2 = good quality 250-pF single-gang variable capacitor, with knob.
SKt1, Skt2 = see text.
Perspex or fibre glass board (see text).

Final considerations

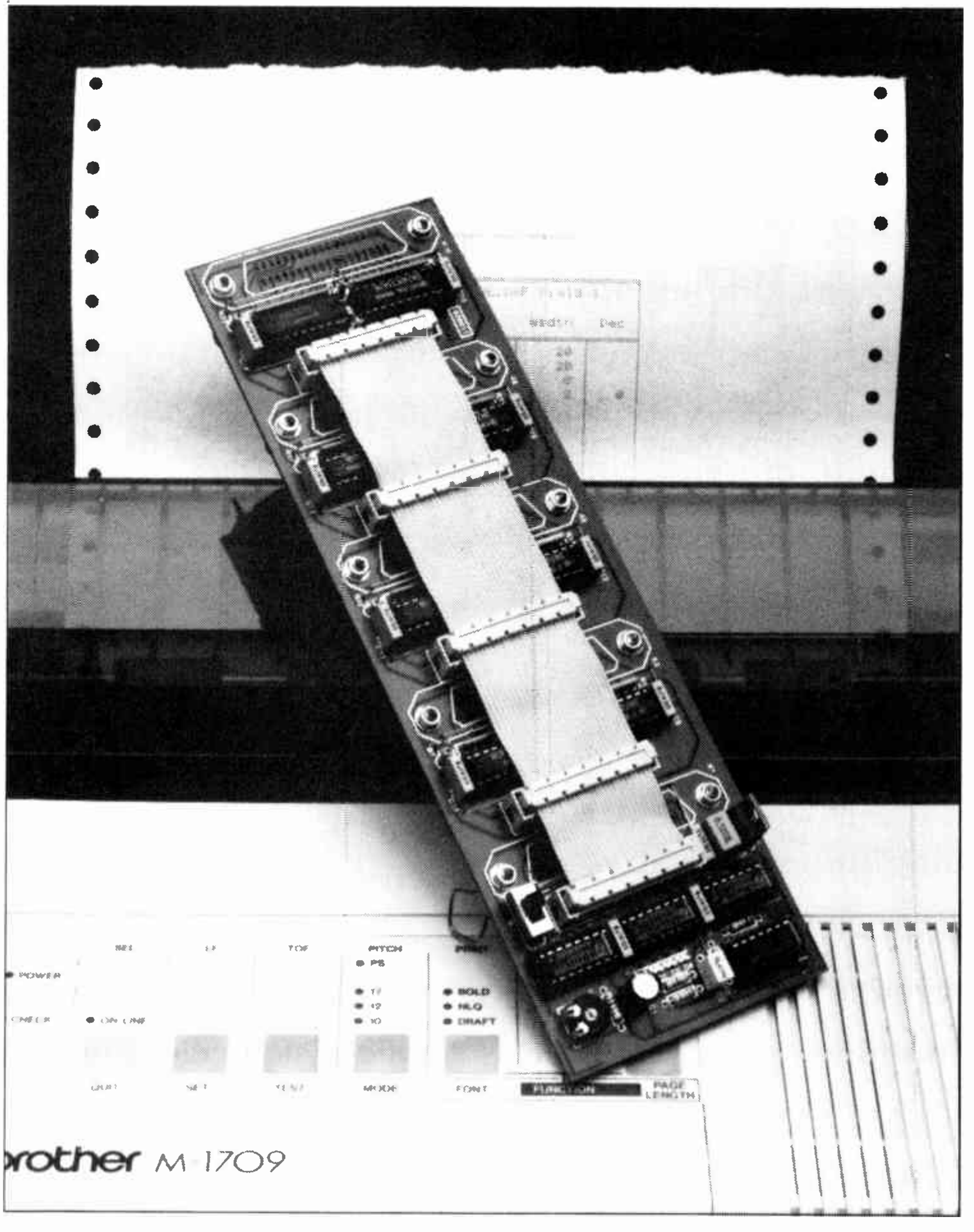
The spiral antenna has been designed for use indoors. It could, of course, be used outside, but being made of bright steel, would quickly corrode. This problem could probably be eliminated by any reader who has facilities to degrease and marine varnish each turn, inside and outside, and between turns. At least two coats of varnish would be necessary for protection. An expensive, and, alas, somewhat specialized, alternative would be to chromium-plate the whole spiral coil.

Assuming that this antenna will be used indoors (as designed and intended), in the interest of safety, only low transmitting power should be used. Good quality air-spaced receiver-type variable capacitors for C1 and C2 should be satisfactory with transmitter output levels of up to 25 watts. ■

Useful reading

Antennas — 2nd edition, 1988, by John. D. Kraus (McGraw-Hill Book Company).
Antenna Book — 16th edition, 1991 (American Radio Relay League).
W1FB's Antenna Notebook — by Doug De Maw, 1987 (American Radio Relay League).

PRINTER SHARING UNIT



A printer is an essential peripheral device for nearly every one using a PC. However, since a printer will rarely be used all the time, it is not necessary to have one with every PC within a range of, say, 10 m. The circuit described here is an automatically operating switching unit that allows up to four PCs to make use of a single printer.

Design by A. Rietjens

IN particular with fairly expensive printers it is common practice to set up some kind of sharing arrangement where there are several PCs. Not surprisingly, printer switching units are found in many small offices these days.

The basic operation of the printer sharing unit is illustrated by the block diagram given in Fig. 1. There are up to four Centronics inputs, each of which is connected to a bus that conveys the signals to the printer connected to K1. The block marked 'select' connects each of the four inputs to the output, at a repeat rate of ⅓ second. If a computer connected to a particular input does not send data at that time, the circuit switches to the next input. If the computer does send data during the time it is connected to the printer, this responds by making the BUSY line high. This event triggers a monostable multivibrator (MMV) which immediately disables the oscillator and the select block. As long as BUSY remains high, or goes high again within the MMV's monotime, the printer will remain connected to the computer that sends data. However, as soon as the computer is found waiting longer than the set monotime, the circuit starts to scan its inputs again for activity, i.e., another computer that may have data ready for the printer.

Some of you may wonder at this point why the BUSY line of the printer is used rather than the strobe pulse of the computer to detect if data is being conveyed. At first glance, using the strobe pulse would appear much more logical since that signal is supplied by the source of the data, i.e., the computer. There is, however, a snag: some computers may block the printer switch when they are switched off, because the strobe output then forms a low level (remember, the strobe pulse is active low). By contrast, a 'true' Centronics strobe output is an open collector driver without a pull-up resistor, and does not cause problems in this respect because it 'floats' when the PC is switched off. Unfortunately, not all printer card manufacturers abide by the Centronics standards, so that it is very well possible that the strobe line forms a 'low' level when the PC is switched off. Obviously, this causes problems on the printer sharing unit since in that case an active Centronics port is detected.

The above problems are prevented by using the printer's BUSY line. This allows the circuit to respond to the fact that data have already arrived at the printer, and this data can only originate from a computer that is switched on.

Still, the printer switch is not quite perfect. As far as we have been able to ascertain, there are two cases in which things can go wrong. This has to do with the structure of the software that runs on the computer.

In the first case, we refer to programs that check beforehand if a printer is available. In most cases, this check lasts long enough to allow the printer sharing unit to finish its input scanning cycle until it reaches the computer that wants to print at that time. By contrast, there are also programs that insist on finding a printer right at the first check. If the computer that runs such a program happens to be not selected during the check, the program will refuse to print (on some computers this occurs, for instance, with the 'print screen' routine). Fortunately, this can be solved manually: the scan rate of the printer switch inputs is indicated by LEDs, and slow enough for you to launch the print job at the right instant. The only proviso for this little trick is that you can see the printer sharing unit from your workplace.

The second problem arises when a program interrupts its printer output routine to calculate the next data to be printed. If this calculation lasts longer than the set MMV time on the printer sharing box, another computer may 'throw in' its data. If you are using such software, there is no option but to ask your fellow printer users not to send data before your PC is finished.

How it works

The circuit diagram, Fig. 2, shows five sub-circuits. The bus that connects these sub-circuits is a length of flatcable with five IDC sockets inserted into the even numbered headers. The use of the flatcable bus will be reverted to when we talk about the printed circuit board.

Four of the five sub-circuits are identical. They represent the four PC input connectors (K3, K5, K7 and K9) with the associated electronic switches. Here, the switches are formed by buffers with three-state outputs (IC6-IC13). When a particular input circuit is not selected, its buffer outputs are switched to high impedance, which means that all signals from the computer to the bus and the printer, and from the bus to the computer, are disconnected. Also, the bus-to-computer lines are then pulled to a logic level that tells the computer that the printer is not ready to receive data. This is achieved with the aid of pull-up and pull-down resistors. A normal Centronics link between computer and printer exists only on the selected input, since there the buffer outputs are switched to their active state.

The most interesting section of the circuit is the fifth sub-circuit. Electrically, this sits between printer connector K1 and bus connector K2. This is the central control of the printer sharing unit. Assuming the printer is not busy, and none of the PCs offers any data, the printer's BUSY line (pin 11 on K1) is logic low, and monostable IC4a is not triggered. In this condition, the pulse generator built around IC2d is enabled, and produces a short pulse every 0.33 s. The trailing edge of the oscillator pulse clocks two J-K bistables, IC5a and IC5b, which function as a counter. The counter continually cycles through states 0, 1, 2 and 3. The counter state is sent to four individual lines by decoders IC3a and IC3b. The four outputs of IC3a are used to select the buffers in the input circuits. This selection runs at a rate of 0.33 s. Decoder IC3b functions similarly to IC3a, but it controls LEDs instead of input buffers. These LEDs indicate the currently selected input. IC3a also controls LEDs fitted with each input connector. The purpose of these LEDs will become evident when the construction of the unit is discussed.

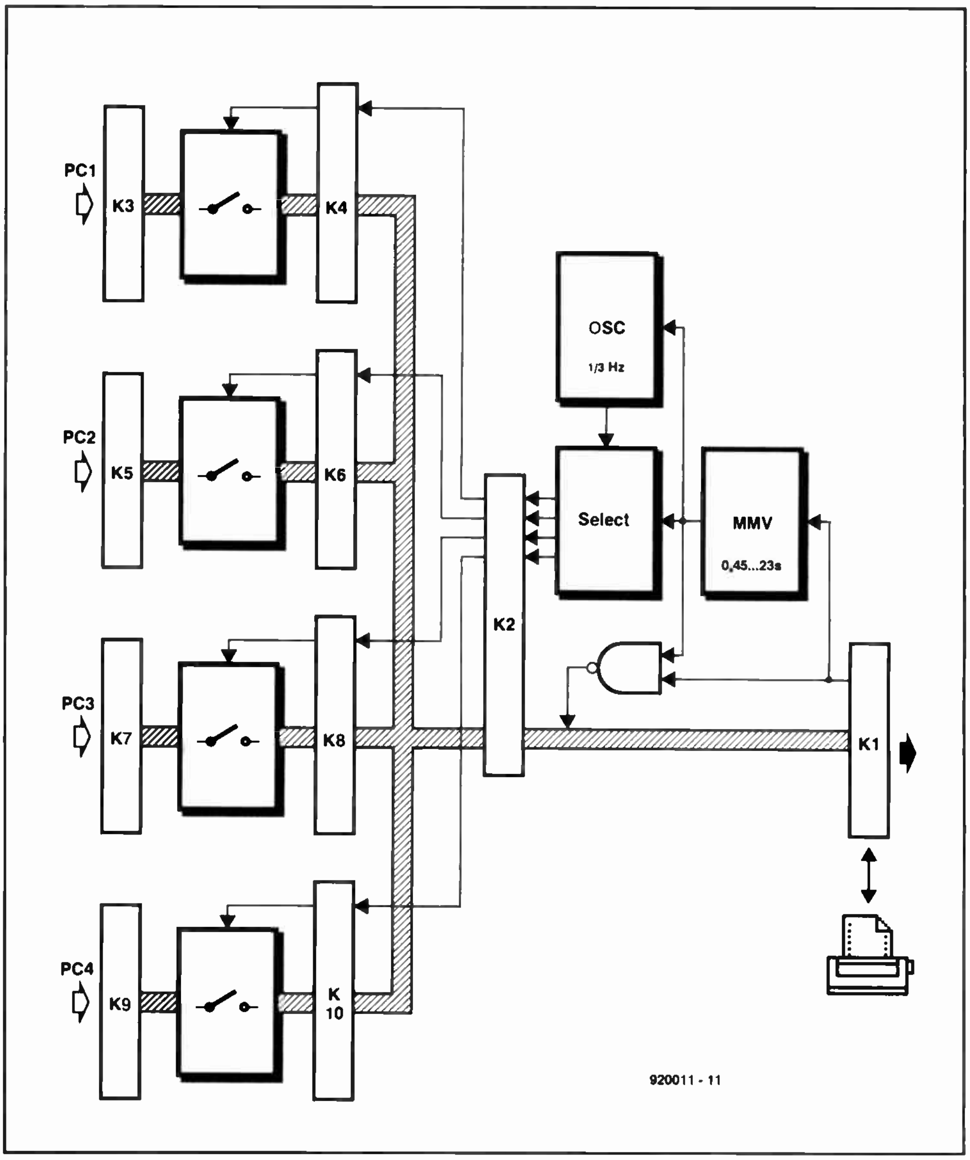


Fig. 1. Block diagram of the printer sharing unit. Four inputs are continuously monitored for the presence of printer data.

Gates IC2a, IC2b and IC2c are essential to prevent timing problems. Their logic function is

$$BUSY_{(out)} = BUSY_{(in)} + CLK \bullet Q\backslash$$

which means that the BUSY signal supplied by the printer ($BUSY_{(in)}$) is always conveyed directly to the connected computer ($BUSY_{(out)}$). However, it is also readily seen that the circuit, when it is not active (Q\ at '1') supplies a 'BUSY' signal to the computer when the clock pulse is high. From that moment on, the selected computer can not send data any more. But what happens if the computer has just before sent its first byte, and the printer has not responded to it by pulling the BUSY line high? Fortunately, the clock pulse is long enough to ensure that this first BUSY signal arrives before the end of the clock pulse. In that case, the circuit will keep the active computer 'hanging on'. i.e., selected. If no BUSY signal arrives from the printer in the mean time, the circuit can safely switch to the next computer input, which happens on the trailing edge of the clock pulse. After this edge, the selected computer is immediately supplied with a low (inactive) BUSY signal (neither the printer nor the circuit was busy). This is taken to indicate that new data may be sent. Since this data will not be ready for at least 0.5 µs, input switching can safely take place.

The moment the printer responds to the data with a BUSY signal, monostable multivibrator IC4a is triggered. The setting of the monostable determines how long the circuit waits for new data after the printer has stopped printing. Because IC4a is triggered, Q\ goes low. During the monotime, the clock generator and the counter are disabled, and gates IC2a, IC2b and IC2c simply convey the printer's BUSY signal. As long as the BUSY line remains high, or goes high again within the monotime, the MMV is triggered again. The monotime can be set to between 0.45 s and 23 s with the aid of preset P1. If the monotime passes without a BUSY signal arriving, Q\ reverts to high, and the counter and oscillator are enabled again. The circuit is then back in its stand-by state, scanning the

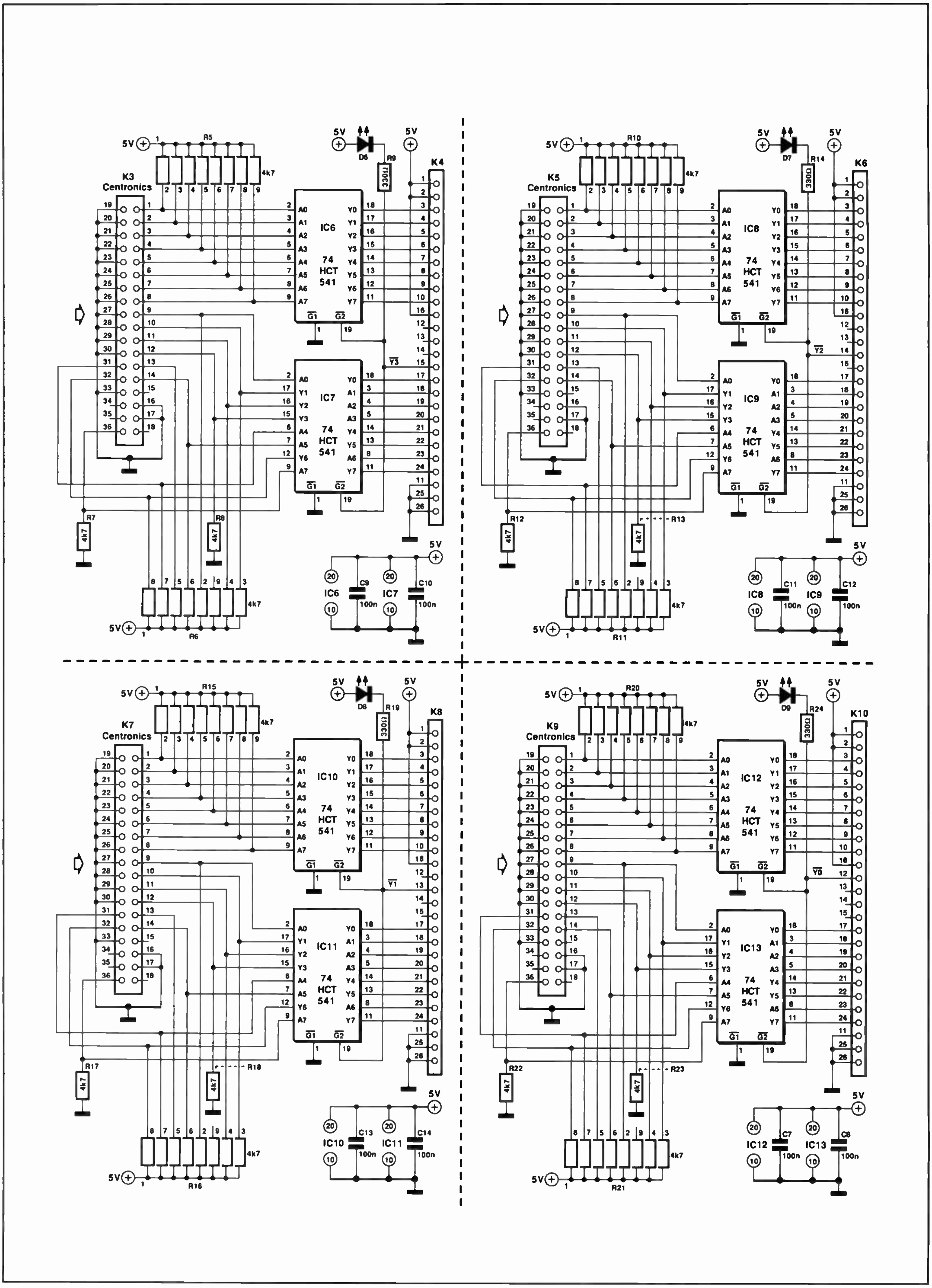
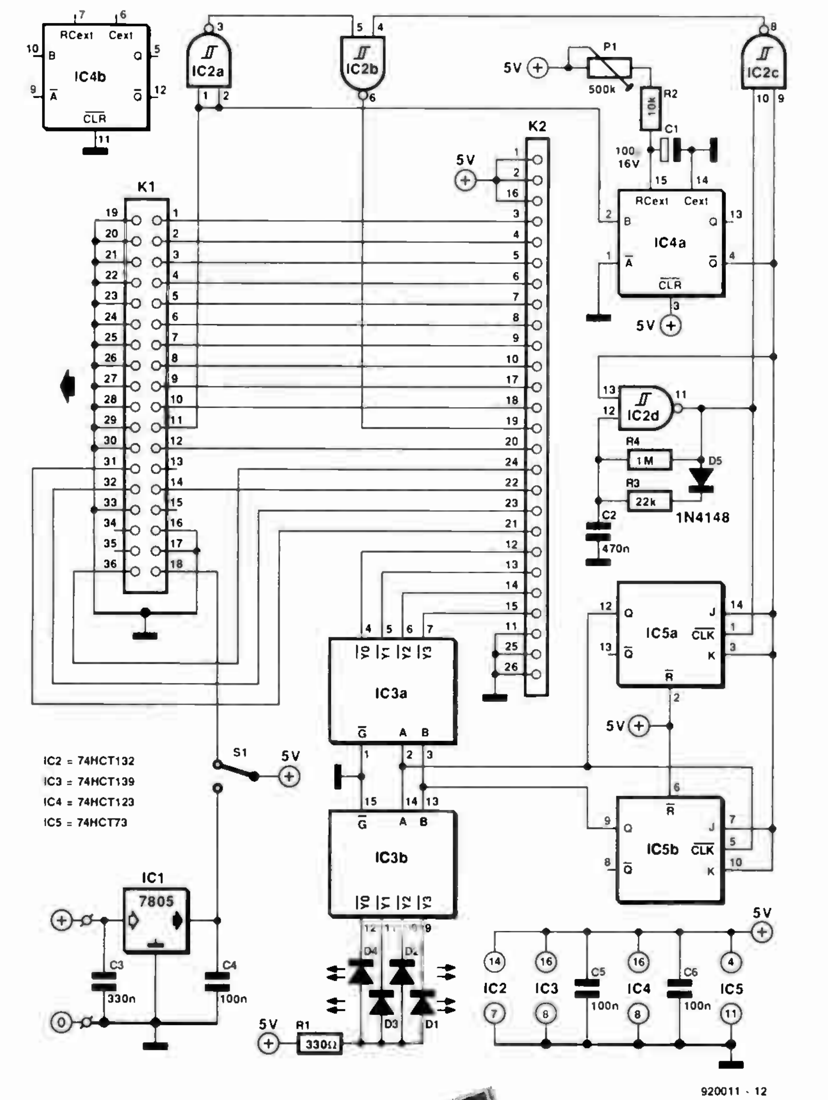
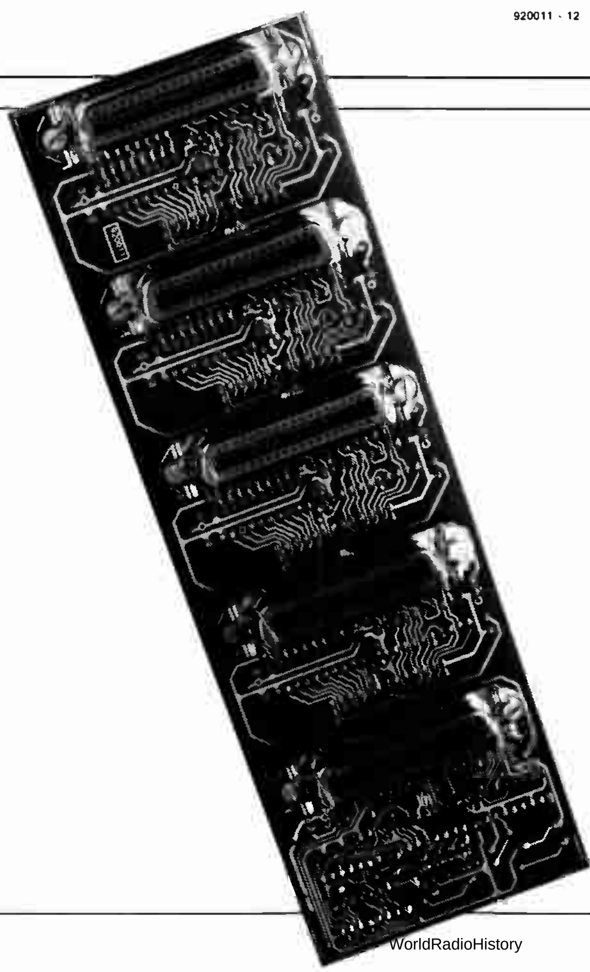


Fig. 2. The circuit diagram consists of five blocks: four identical input circuits, and a control/output circuit.





four inputs for data.

The power supply for the printer sharing units may be realized in two ways. With switch S1 set to the position shown in the circuit diagram, the supply voltage is obtained from the printer. Unfortunately, not every printer furnishes a suitable supply voltage, whence the external power supply option. Any external power supply may be used that supplies an unstabilized direct voltage between 8 V and 20 V. Regulator IC1 reduces this unstabilized voltage to a stabilized 5-V rail for the circuit. Incidentally, do not be surprised if you find that the circuit works perfectly with no power supply connected at all — in some cases, it can draw enough current from the computer outputs to build up its own supply voltage. Convenient as it may be, this situation does not guarantee reliable operation!

A large circuit board

The printed circuit board designed for the printer sharing unit consists of five smaller boards, which are interconnected via a flatcable (the previously mentioned bus). In spite of the 'modular' layout of the large PCB, it is by no means necessary to separate the sub-boards from another. Even when they are left together, they form a compact printer switch. However, if you wish to separate them, this is no problem at all — all that has to be done is to adapt the length of the flatcable as required.

A number of options are available for the LEDs that indicate the currently active input. An LED may be fitted next to each input connector. Alternatively, LEDs may be fitted next to the output connector. The decision on fitting or not fitting a certain LED depends on the way the printer switch is built into a case. For instance, you may fit a LED next to each connector on the rear panel (particularly useful for faultfinding purposes), and the other four LEDs on the front panel, for all users to see.

Apart from the flatcable, the Centronics connectors and the LEDs next to the input connectors, construction of the unit is all plain sailing. As always, fit the wire links first so that these are not forgotten later. Pins 1 to 18 of the connector are at the side of the associated LED. Before you start soldering the connector pins, fit the connectors on two 7.5-mm (0.3 in.) high pillars. Alternatively, if you can not find Centronics sockets for PCB mounting, you may use connectors with solder pins, fit these at the required height, and connect them to the PCB via short wires.

Assuming that you have not cut the PCB into modules, the next step is to make the flatcable. This is precision work, since the spacing of the IDC sockets on the cable is critical. If you fit them too close together, you will be unable to plug them on to the headers on the board. Likewise, if

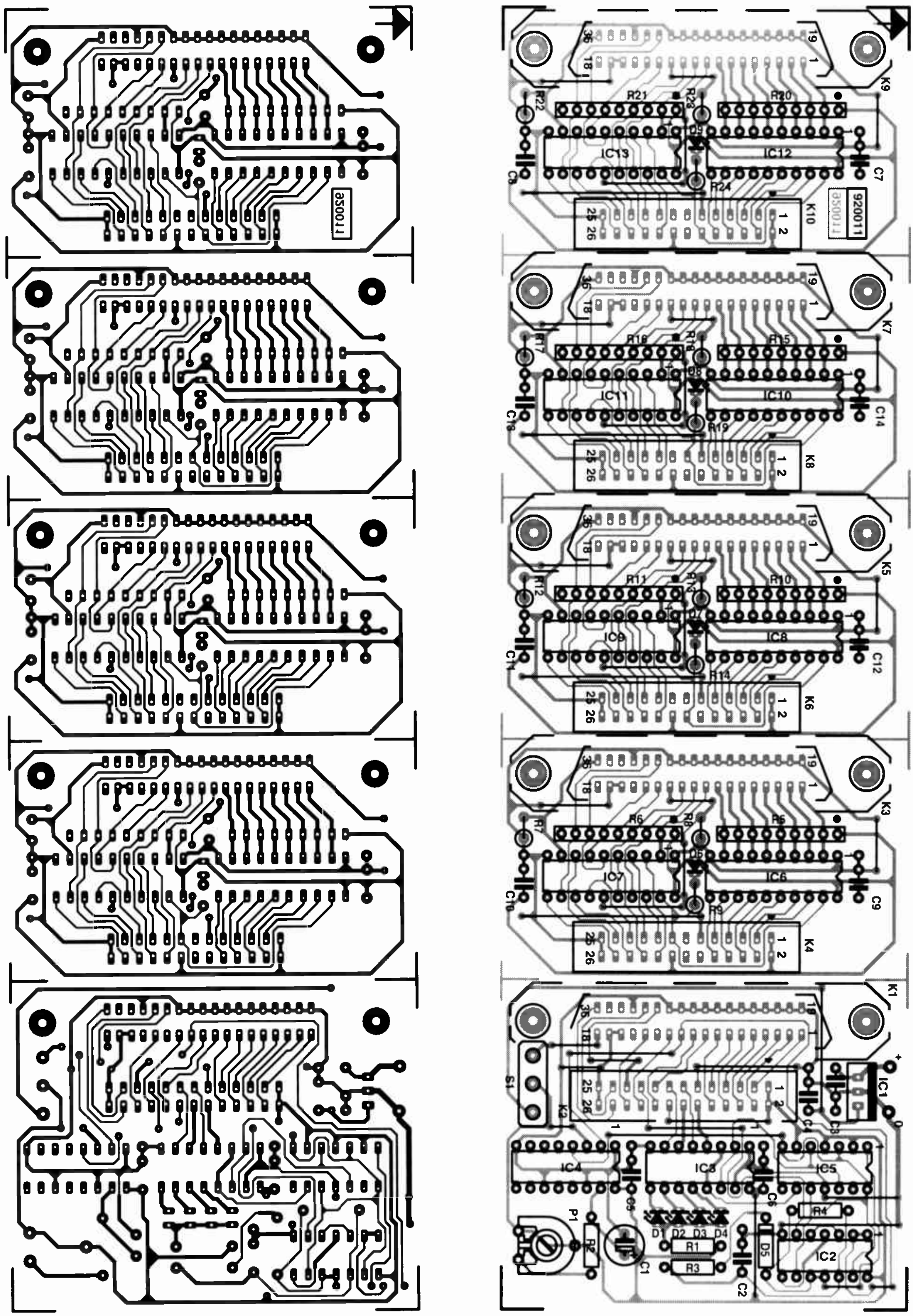


Fig. 3. The printed circuit board may be cut into five separate parts.

COMPONENTS LIST

Resistors:

5	330Ω	R1;R9;R14; R19;R24
9	4kΩ7	R7;R8;R12; R13;R17;R18; R22;R23
1	10kΩ	R2
1	22kΩ	R3
1	1MΩ	R4
8	4kΩ7 8-way SIL	R5;R6;R10; R11;R15;R16; R20;R21
1	500kΩ preset H	P1

Capacitors:

1	100µF 16V radial	C1
1	470nF	C2
1	330nF	C3
11	100nF	C4-C14

Semiconductors:

8	LED	D1-D4;D6-D9
1	1N4148	D5
1	7805	IC1
1	74HCT132	IC2
1	74HCT139	IC3
1	74HCT123	IC4
1	74HCT73	IC5
8	74HCT541	IC6-IC13

Miscellaneous:

1	SPST switch for PCB mounting (raster: 7.5 mm)	S1
5	36-way PCB-mount Centronics socket, straight pins	K1;K3;K5;K7; K9
5	26-way box header, straight pins	K2;K4;K6;K8; K10
5	26-way IDC flatcable socket	
	17cm 26-way flatcable	
1	Printed circuit board 920011	

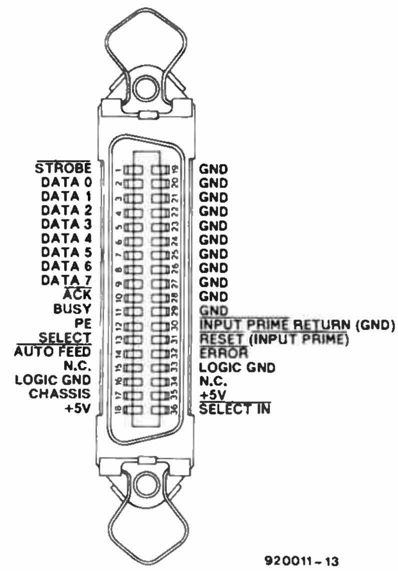


Fig. 4. Centronics connector pinning.

you fit them too far apart, the cable will bulge. That is not a problem in itself, however it does not look very good.

When the completed PCB is to be fitted behind a front or rear panel, this will have to be done from the inside. Note that the Centronics sockets used here are not really suitable for panel mounting, but it can be done. First, drill the holes for the fixing screws. Next, cut and file a rectangular clearance that is long and wide enough to pass the connector and the clamp springs (approx. 58×15 mm). The locations of the holes are easily pencilled out on the panel by making use of the (empty) printed circuit board, or a photocopy of the component layout.

The circuit has only one adjustment: preset P1. This has to be adjusted such that the printer sharing unit is capable of 'bridging' the longest time your software needs for calculations before it sends new printer data. In case you are not sure about what sort of times to expect, simply set P1 to maximum resistance (wiper towards IC4). ■

WorldRadioHistory

OUTPUT AMPLIFIER FOR RIBBON LOUDSPEAKERS PART 1

Design by T. Giesberts

This article describes an out-of-the-ordinary amplifier for driving very-low-impedance transducers such as ribbon loudspeakers. The amplifier is able to deliver 20 A_{rms} (with peaks up to 30 A) into a load of 0.4 Ω with low distortion.

The modern ribbon loudspeaker is among the most efficient transducers available. Its construction is very simple: the diaphragm consists of an aluminium foil ribbon suspended between the poles of a magnet—see Fig. 1. The nominal flux density in the gap is about 1.0 Tesla. A practical ribbon is 5–7 mm long, 8–12 mm wide, 3 μm thick and has a mass of 3–4 mg. Its resistance is 0.2–0.5 Ω. Such a unit is eminently suitable for use as a tweeter. However, over the past few years wide-range ribbon loudspeakers using much longer ribbons have become available, such as those of Strathearn (50 cm or 2 in) or, among others, Gold Ribbon and Speakerlab that measure a metre or more.

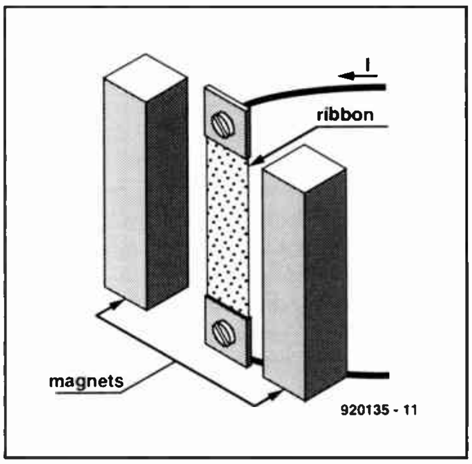


Fig. 1. Principle of ribbon loudspeaker.

Low impedance

Unfortunately, ribbon loudspeakers have such a low impedance that they are normally connected to the output stage via a suitable impedance transformer. This is, however, not beneficial for the reproduction of the higher audio frequencies.

The present amplifier enables direct driving of a ribbon loudspeaker: it can deliver up to 160 W into 0.4 Ω. The larger part of the transfer resistances in the connections are compensated by two separate sense lines. Although it is designed primarily for the Strathearn speaker, it is equally suitable for other transducers that have an impedance of 0.2–1 Ω (higher is possible, but the available power may then be insufficient owing to the low supply voltage used).

The concept

A current of 20 A_{rms}, corresponding to a power of 140 W into 0.4 Ω, was deemed sufficient for most applications. The output transistors are Sanken types which offer a combination of high current amplification, good bandwidth, and a high peak collector current.

To nullify the transfer resistances of the output connections (a cable resistance of 0.05 Ω is not negligible if the load impedance is only 0.4 Ω), the feedback point is as close to the loudspeaker as possible: a sort of sense input. The result is that the amplifier compensates for virtually all resistance between its output and the loudspeaker.

Problems also arose in the choice of the power-on delay that obviates the clicks resulting from switching the amplifier on. For a number of reasons, relays were discounted from the onset. Of the various electronic means, an optocoupler-triac solution was found to be the most efficient and satisfactory.

Block diagram

The block diagram of the amplifier given in Fig. 2 clearly shows the symmetrical design. Differential amplifiers T_1 and T_3, each giving an amplification of about ×100, form the input stage. They are followed by differential amplifiers T_2 and T_4 respectively, each of which has an amplification of ×20.

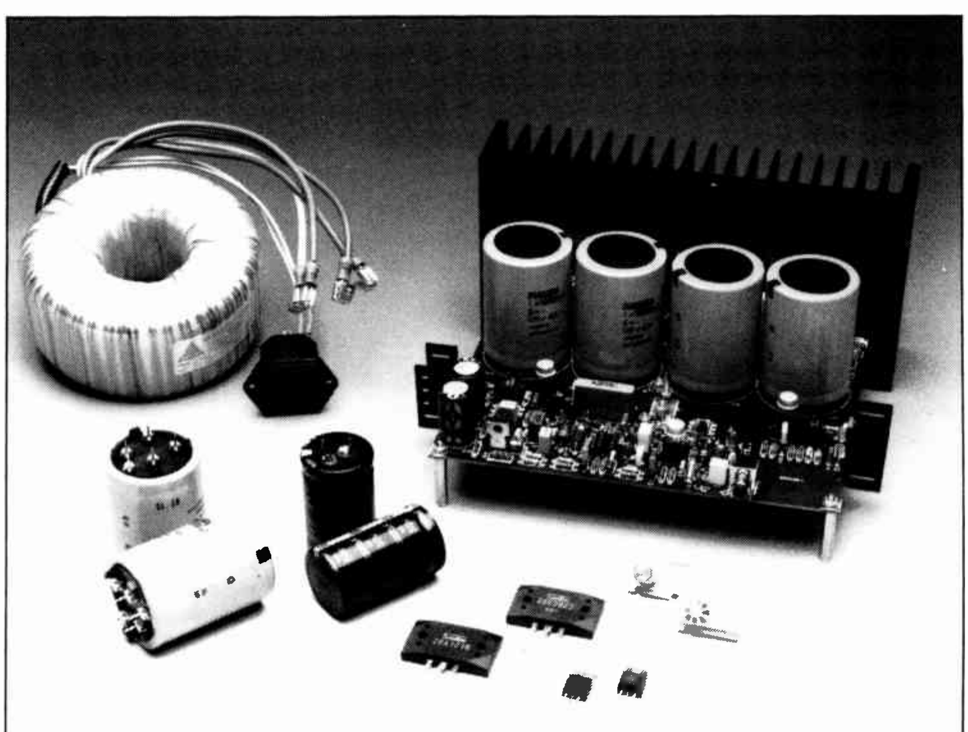
The optocouplers in the collector circuits of T_2 and T_4 serve to suppress clicks resulting from switching the amplifier on or off. The power-on delay ensures that the LEDs in the optocouplers light up slowly. Intially, therefore, impedance matching transistors T_{12} and T_{13}, and thus drivers T_{16} and T_{17}, are off so that no current flows in the output stage. Since in this way the opto-transistors are driven into conduction slowly, power to the output stages rises gradually. This arrangement effectively suppresses switching-on clicks.

Since the impedance matching transistors are current-driven by the differential amplifiers, any non-linear behaviour of the opto-transistors has no effect on the reproduction quality.

Transistor zener T_{14}-T_{15} between impedance matching transistors T_{12} and T_{13} arranges the quiescent current through the output stages.

Each of the output stages consists of a driver, T_{16} and T_{17} respectively, which drives two parallel-connected output transistors, T_{18}-T_{19} and T_{20}-T_{21} respectively.

The current through the output transistors is monitored by the current limiting stage; if it rises above 30 A (dependent on the base-emitter voltage of T_{22}) and the mains fuse



does not blow, the optocouplers are switched off instantly and the fuses in the power supply lines blow because the protection circuit switches on two heavy-duty triacs between those lines and earth. The protection circuit is also actuated if a direct voltage should appear at the amplifier output.

The loudspeaker is connected to the output stages by four wires: two heavy-duty ones through which the high currents flow, and two sense lines that carry the feedback signals.

Circuit description

The input signal, normally provided by a preamplifier or active cross-over network, is applied to C_1. This capacitor and R_1 form a high-pass filter with a cut-off frequency of 9 Hz (this frequency may be lowered by giving C_1 a higher value). This is followed by a high-pass filter, R_2-C_2, with a cut-off frequency of 280 kHz, to prevent transient intermodulation distortion (TID).

The signal is then fed to differential amplifiers T_1 and T_3. Since the thermal stability of these amplifiers depends on the coupling between the two transistors, the types shown are ideal because the two transistors are housed on one chip. Unfortunately, there is a dearth of double transistors, so that the choice here is very limited.

Frequency compensation for these amplifiers is provided by R_5-C_3 and R_{10}-C_4 respectively. The values of the emitter and collector resistors shown give an amplification of around ×100.

The constant-current sources for the amplifiers are formed by T_5 and T_6, which use LEDs (D_1 and D_2) as reference. The current throught these diodes is held constant by ancillary current source T_9-R_{15}.

Since the amplification of T_1 differs from that of T_2, it is important that the offset voltage of the amplifier is kept is small as feasible. To this end, the base currents of these transistors are compensated by a negative voltage derived from regulator IC_4 via R_{55} and R_{74}. This negative voltage holds the base voltage at virtually 0 V. Any other drift, such as caused by temperature variations, is nullified by an integrator based on IC_3. This stage readjusts the base voltages of T_1 and T_3 if required. The supply lines of IC_3 are additionally buffered by C_{18} and C_{19}, which ensure that the stage remains operative for a short while after the amplifier has been switched off.

Then follow differential amplifiers T_2 and T_4 ($\alpha \approx 20$), whose frequency compensation is provided by C_9 and C_{10}. Transistors T_7 and T_8, together with diodes D_3 and D_4, form the constant-current sources for the amplifiers. The current through the LEDs is held stable by ancillary current sources T_{10}-R_{17} and T_{11}-R_{18}.

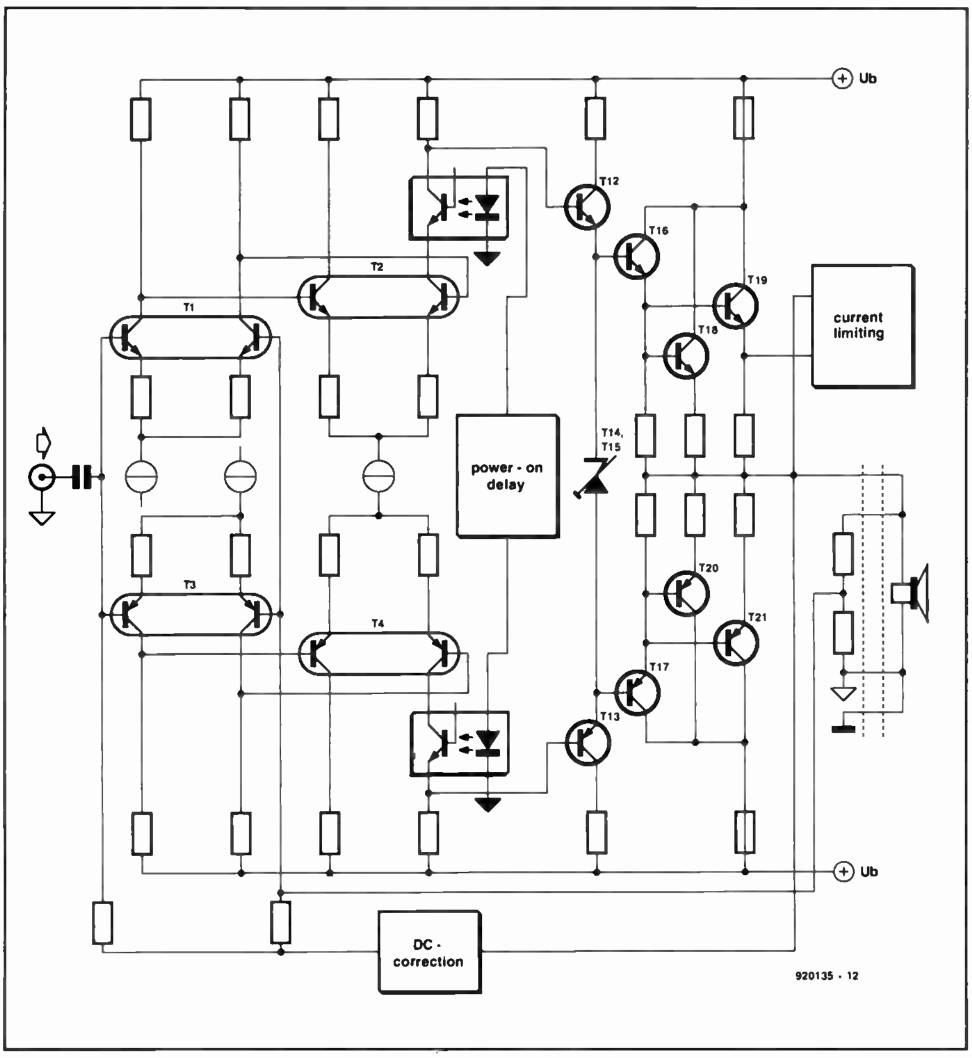


Fig. 2. Block diagram of the output amplifier.

Because of the arrangement of the ancillary current sources, it is essential that diodes D_1–D_4 have a forward voltage of 1.55–1.65 V.

The signal is then applied via the transistors in the (power-on delay) optocouplers to impedance matching transistors T_{12} and T_{13} that drive current amplifiers T_{16} and T_{17}. The collectors of T_{12} and T_{13} are linked by transistor-zener T_{14}-T_{15}. The voltage across this zener, and consequently the direct current through power transistors T_{18}-T_{19} and T_{20}-T_{21}, is preset with P_1.

The emitter resistances of the power transistors consist of parallel combinations of resistors. This is not because of dissipation, but rather to divide the large currents over a number of soldering points. Moreover, the arrangement lowers the spurious inductance, which is important with low-impedance loads.

Transistor T_{22} is switched on when the peak emitter current of T_{19} or T_{21} exceeds 30 A, whereupon the protection circuit is actuated.

Although fuses F_1 and F_2 are rated at 7.5 A, they can withstand currents of up to 30 A, since they carry only one-half of the output signal. The + and – terminals in series with them are connected to the protection circuit. If one of the fuses blows, the LED in parallel with it lights.

Resistor R_{47} and C_{12} form a Boucherot network. Inductor L_1 is for use only with traditional loudspeakers; if only ribbon types are used, it may be omitted.

The sense lines are connected to potential divider R_{48}–R_{50}, of which R_{49} and R_{50} determine the feedback factor, while R_{48} and R_{51} ensure that the feedback remains functional if the sense lines are not connected. The feedback signal is taken from junction R_{49}-R_{50} to the bases of T_{1b} and T_{3b}. Network R_{75}-R_{76}-C_{23}-C_{24} serves to equalize the impedance at the bases of T_{1b} and T_{3b} with that at the inputs of T_{1a} and T_{3a}. This arrangement improves the common-mode behaviour of the amplifier. The network does not affect the feedback.

Protection circuit

The diagram of the protection circuit is shown in Fig. 4. When the power is switched on, capacitor C_5 is charged slowly via R_4. It takes, therefore, a few seconds before darlington T_7-T_8 is switched on, whereupon the LEDs in the optocouplers (connected to B1 and B2) begin to light. When the potential across C_5 has risen to 1.7–1.8 V, the LEDs light at maximum brightness. The darlington then operates as a constant-current source, since D_5 holds the voltage across R_{13} and that across the base-emitter junction of T_7 and T_8 stable.

Since T_1 is connected to the secondary of the mains transformer via diodes D_1 and D_2, it is switched on every half period as long as the mains voltage is on. Transistor T_2, and consequently T_3, is then off. When there is no voltage across the secondary, for instance, when the power is switched off, T_2, and, consequently T_3, is switched on after half a period. This results in Schmitt trigger T_4–T_6–D_4 changing state, whereupon T_7 and T_8, and thus the optocouplers, are switched off. This is indicated by the lighting of D_{11}.

Current monitoring transistor T_{22} is connected to terminal A. When the load current gets too large, T_{22} begins to conduct, so that T_3 is switched on and the optocouplers are switched off. Darlington T_{11} switches on triacs Tri_1 and Tri_2 via D_8, whereupon the supply lines are short-circuited to ground. If this option is not required, that is, the switching off of the optocouplers is deemed sufficient, D_8 may be omitted.

Protection against high temperatures is provided by T_{12} (connected as diode) and IC_{1a}. Through the transistor, which is mounted on the common heat sink for the power transistors, flows a direct current via R_{18} and R_{19}. The voltage across T_{12} is applied to the inverting (–) input of IC_{1a}, which operates as a comparator with hysteresis (provided by

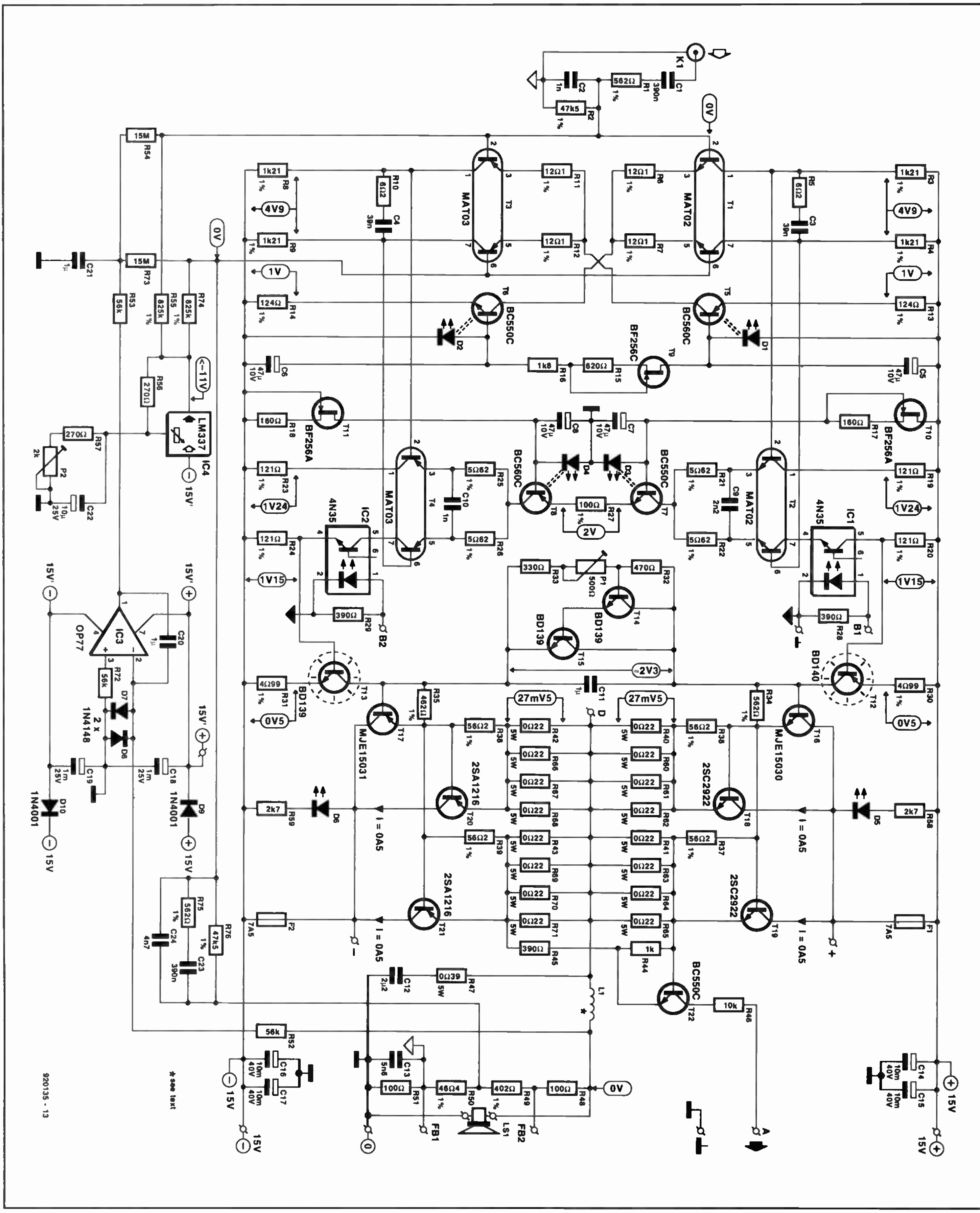


Fig. 3. Circuit diagram of the amplifier.

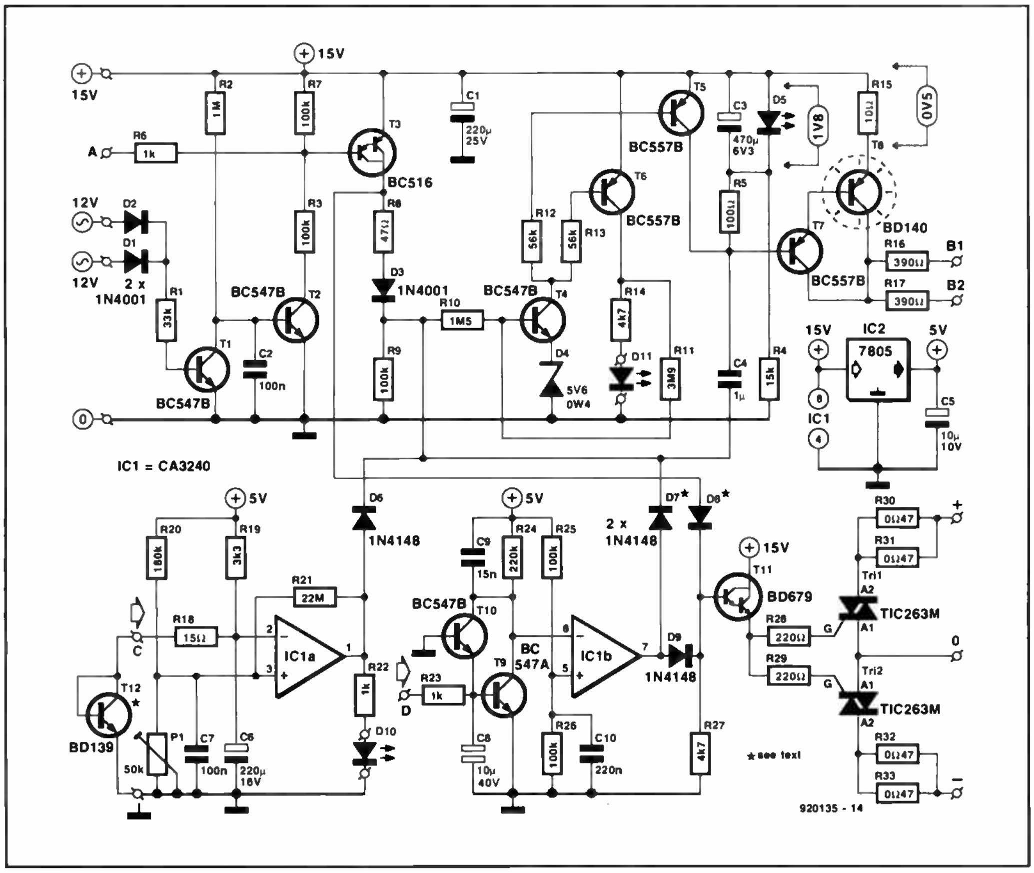


Fig. 4. Diagram of the protection circuit.

R_{21}). That voltage is compared with a reference potential provided by R_{20}-P_1. If it drops below the reference potential, the output of IC_{1a} changes state, whereupon the optocouplers are switched off via D_6. After the temperature has dropped some degrees, the amplifier is switched on again. The temperature at which the protection circuit becomes active is set with P_1.

Any direct voltage at the output of the amplifier is detected by low-pass filter R_{23}-C_8. If the direct voltage exceeds ±0.6 V, transistor T_9 (positive) or T_{10} (negative) is switched on. The inverting input of IC_{1b} goes low and its output goes high, whereupon triacs Tri_1 and Tri_2 are switched on via D_9 and T_{11}. At the same instant, the optocouplers are switched off via D_7. Options here are to omit D_9, so that only the optocouplers are switched off, or to fit D_9, but omit D_7, so that only the supply lines are short-circuited. ■

The construction of the amplifier will be described in next month's instalment.

DIFFERENTIAL THERMOMETER

Design by J. Ruiters

Temperature is a physical property of a body that determines the direction of heat flow when the body is brought into contact with another. Heat always flows from a region of higher temperature to one of lower temperature. A standard thermometer measures the temperature of a body with respect to an arbitrary point—usually 0 °C (or, in the USA, 32 °F) which is the temperature at which pure water freezes, or 0 K, that is, absolute zero or –273.15 °C. It is, however, not always convenient to measure the temperature with respect to these arbitrary points; many measurements are required to indicate the difference in temperature between two regions or bodies. This may be done with a differential thermometer such as the one described here.

Basically, the differential thermometer consists of two sensors that convert temperature into potential, a differential amplifier that magnifies the difference between the two sensor output voltages, a display which indicates that difference, and two switching outputs that may actuate a circuit or circuits if the difference exceeds a predetermined level.

Differential amplifier

The simplest differential amplifier is one designed around one opamp and a number of resistors. This is often expanded by two buffer opamps to obtain a higher input impedance, resulting in the familiar three-opamp differential amplifier. However, the present design is based on a two-opamp differential amplifier—see Fig. 1.

The input signals are applied to the non-inverting (–) inputs of the opamps to ensure a high circuit input impedance. The potential at the inverting (+) input of the first opamp is $U_{cm}-U_d/2$, while that at the inverting input of the second opamp is $U_{cm}+U_d/2$, where U_{cm} is the common-mode voltage and U_d is the difference between the two sensor output voltages. The output voltage, U_o, is calculated from:

$$U_o=\frac{R_4}{R_3}\left[1+\frac{1}{2}\left(\frac{R_2}{R_1}+\frac{R_3}{R_4}\right)+\frac{R_2+R_3}{R_0}\right]U_d$$

$$+\frac{R_4}{R_3}\left(\frac{R_3}{R_4}-\frac{R_2}{R_1}\right)U_{cm}$$

From this it is evident that suppression of the common mode signal is an optimum if $R_2/R_1=R_3/R_4$. Anu deviations are amplified by a factor R_4/R_3. To obviate this, R_1 may consist of a fixed and a variable resistor so that the common mode rejection can be set to maximum. However, if matters such as the dynamic range of the amplifier and the temperature coefficient of the resistors are taken into account, it is better to make resistors R_1–R_4 equal. The term R_4/R_3 is then 1 and, since all resistors change equally with temperature, the balance between R_2/R_1 and R_3/R_4 is retained.

The amplification of the difference signal may be adjusted with the value of R_0. It is clear from the foregoing formula that R_0 affects only the difference signal and not the common mode signal. This makes adjusting the amplification, if needed, simpler.

An incidental advantage of making the values of the resistors equal is that the formula for U_o simplifies to

$$U_o=2(1+R_n/R_0)U_d,$$

where $R_n=R_1=R_2=R_3=R_4$.

A drawback of this type of differential amplifier, in contrast to the one-opamp and three-opamp types, is that the first opamp magnifies not only the signal, but also the common-mode voltage. Assuming thet R_1–R_4 are equal, the common-mode signal in the output, U_1, of the first opamp is amplified by a factor of ×2. The level of U_1 is given by

$$U_1=-(1+R_n/R_0)U_d+2U_{cm}.$$

The maximum drive to the second opamp must, of course, also be borne in mind. Suppose that the differential amplifier has an amplification of ×10 for a maximum differential voltage of ±1 V. The ratio R_n/R_0 is then 4 and the maximum output voltage is ±10 V. Potential U_1 is ±5 V+$2U_{cm}$. If the maximum output voltage is equal to the maximum drive level (that is, ≈ supply voltage), the level of the common-mode voltage must not exceed ±2.5 V to prevent the first opamp being overdriven.

Supply/reference voltages

The power supply for the thermometer, shown in Fig. 2, is fairly unusual in that the reference voltage regulator is integrated in the display driver, although for clarity's sake it is shown separate.

The unregulated 8–15 V supply voltage is stabilized by the reference voltage source, which is preset with the aid of R_{18} and R_{19} to give an output of 6.3 V. Since the differential amplifier requires a symmetrical supply, an articificial 'earth' is concocted with the aid of opamp IC_{2a} and resistors R_{15}–R_{17}, R_{20} and R_{21}. This does not, of course, result in a true

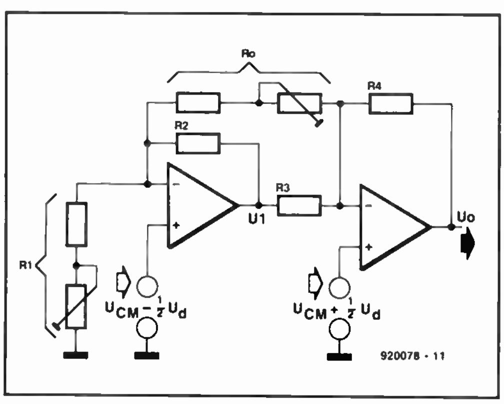


Fig. 1. Basic two-opamp differential amplifier.

TECHNICAL PARAMETERS

Sensors	Silicon diodes (e.g., 1N4148) with maximum junction temperature of 200 °C.
Switching outputs	Open-collector type (BC517: I_c max. 400 mA; T_j max 150 °C; P_{tot} max 6.25 mW; $R_{th\text{j-a}}$ 200 K/W
Supply voltage	8–15 V, unregulated
Display	LED bar (10 LEDs)
Sensitivity	Preset (standard 0.25 °C per LED)

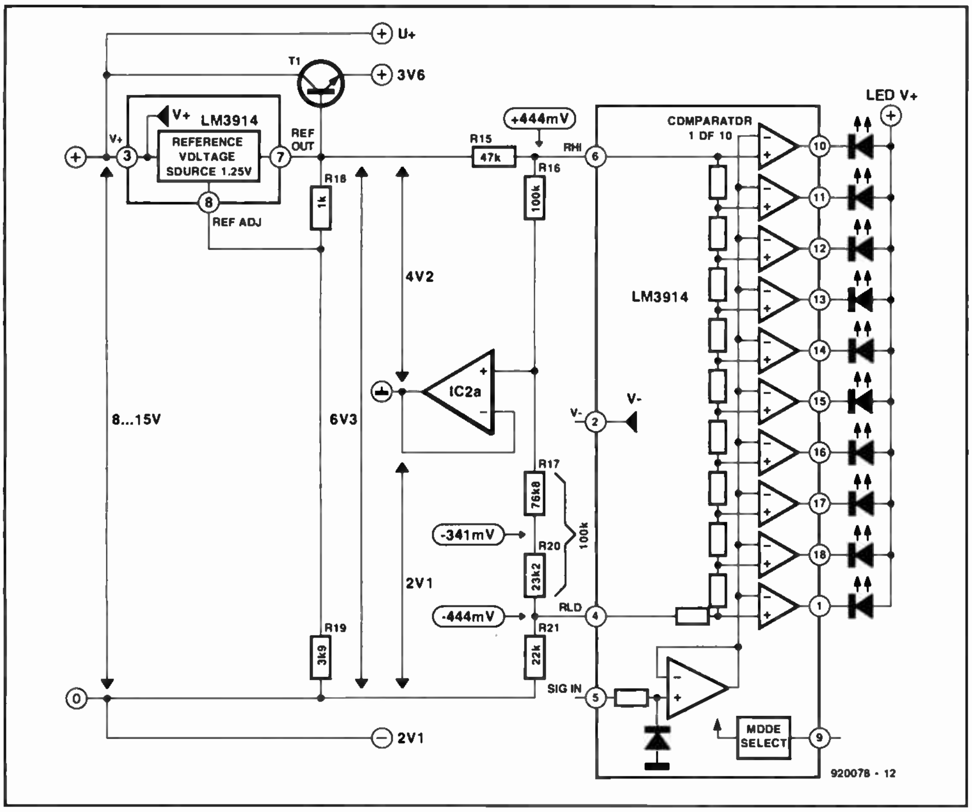


Fig. 2. The internal voltage regulator of the display driver is the source of all required supply voltages.

symmetrical supply: the 'earth' potential is 2.1 V above true earth and 4.2 V below the output level of the regulator. Raising the level of the positive voltage more than that of the negative voltage with respect to true earth increases the drive capability of the differential amplifier.

The supply voltage so created still cannot be used, however. This is because the output current of the regulator determines the current through the display LEDs. Since the current through each LED is about ten times as large as the output current of the regulator, the latter must not be too large and, moreover, must not vary much. For this reason, the regulator action is 'enhanced' by transistor T_1. However, since the output voltage of the regulator is also used as reference for the display, T_1 is not in the feedback circuit. The transistor, therefore, cannot influence the quality of the regulator. It means, however, that the positive supply voltage for the differential amplifier is 3.6 V instead of 4.2 V it is no longer so well regulated, but this is of no consequence here.

The reference voltage for the regulator is derived from potential divider R_{18}–R_{19}. To ensure that the display indicates the same magntitude irrespective of whether the temperature difference is positive or negative, the voltage across the resistive divider in the display driver (about 12 kΩ) must be symmetrical with respect to earth. This is arranged by using 100 kΩ resistors, R_{16} and R_{17}–R_{20} respectively, between earth and reference inputs R_{HI} and R_{LO} of the display driver (note that the +input of IC_{2a} is at ground potential). The reason for using two resistors, R_{17} and R_{20} instead of a single 100 kΩ will be discussed later on.

Circuit description

The temperature sensors in the prototype are Type 1N4148 diodes, D_1 and D_2 in Fig. 3. Silicon diodes are used because their threshold voltage has a temperature coefficient of about 2 mV K^{-1}. The diodes are connected in a bridge circuit that, when their temperature is the same, is balanced by P_1.

The signals from the sensors are applied to differential amplifiers IC_{3a} and IC_{3b} via low-pass filters R_3–C_4 and R_{14}–C_6 respectively.

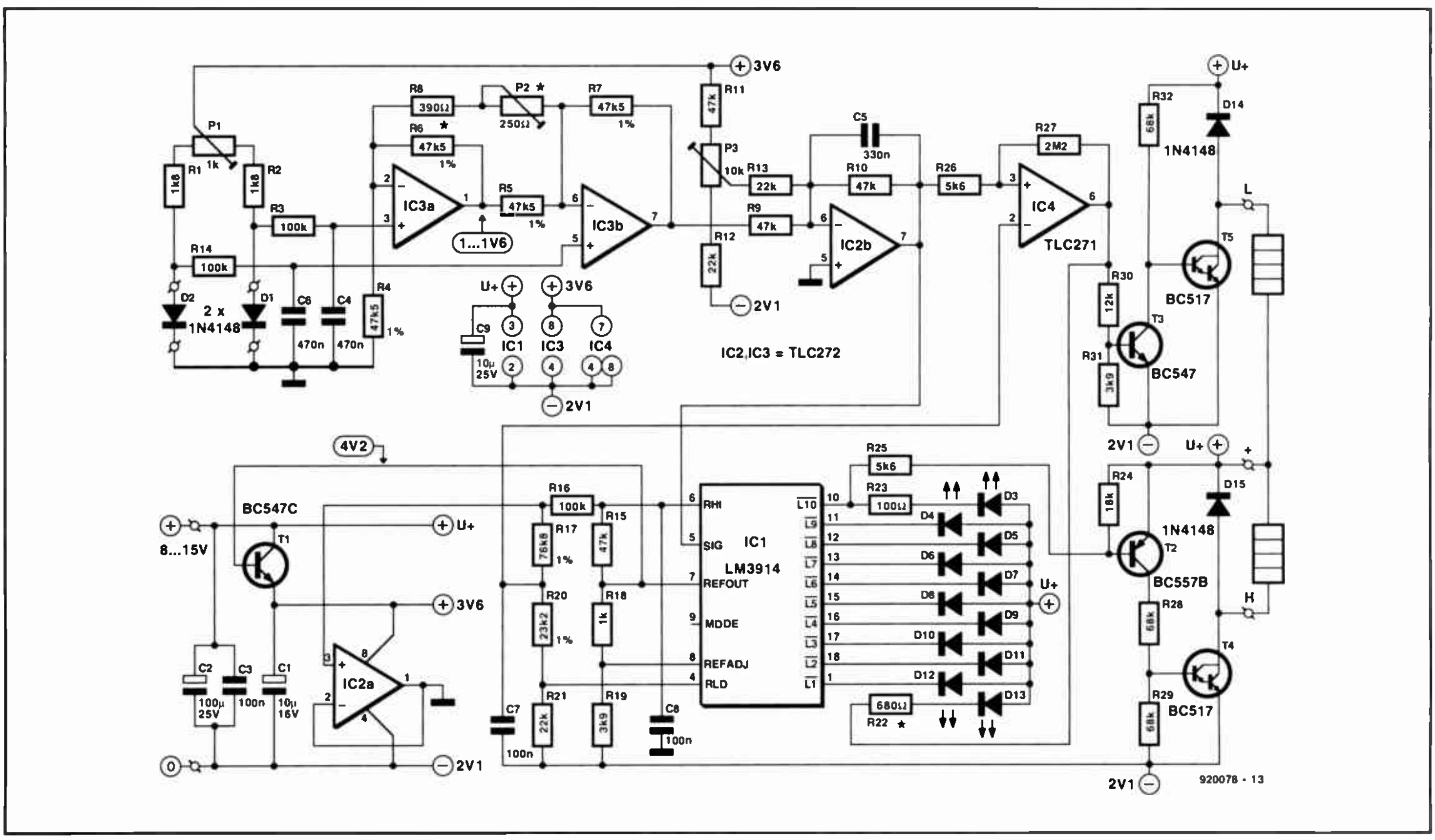


Fig. 3. Circuit diagram of the differential thermometer.

The output of the amplifier is fed to IC_{2b} which, with the aid of P_3, corrects the offset of the amplifier. The signal at the output of IC_{2b} is then suitable as input for display driver IC_1.

The driver has two switching outputs, of which one operates when the positive peak is reached, and the other when the negative maximum is about to be exceeded.

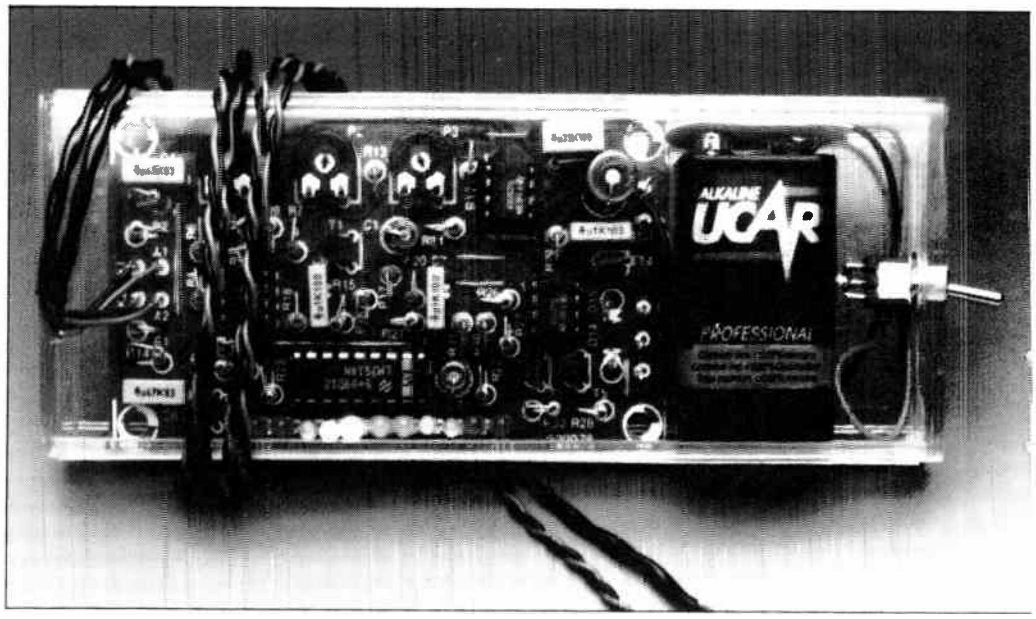
In the case of positive levels, as soon as D_3 has been switched on by the driver, T_2 will also be on. This transistor in turn switches on T_4, resulting in the load (relay) being switched on. In the case of negative levels, the input voltage to IC_1 is compared with the potential at junction R_{17}–R_{20} at which D_{12} just goes out. When the measured temperature is sufficiently negative, the output of IC_4 goes low, whereupon D_{13} lights, T_3 is switched off, and T_5 is switched on, so that the associated load (relay)is switched on.

The relays are shunted by free-wheeling diodes D_{14} and D_{15}. If relays are not required, terminals L and H may be interlinked to form a wired-OR connection.

The circuit without relays draws a current of about 30 mA from an 8–15 V supply; when either of the relays is switched on, the current increases to well over 400 mA. If the thermometer is not used constantly, a 9 V PP3 battery may be used as supply.

Construction and calibration

The thermometer is best constructed on the printed-circuit board shown in Fig. 4. Sensors D_1 and D_2 may be linked to it via a cable up to 1 m (3 ft) long. The diodes may be replaced by transistors, for instance, Types BC107 and BC547, whose base and collector are linked together: the base–emitter diode serves as the sensor.



The brightness of D_{13} may be somewhat less than that of the other LEDs; this may be rectified by varying the value of R_{22} by trial and error.

Before the circuit can be calibrated, both sensors must be at the same temperature and all potentiometers set to the centre of their travel.

Connect a high-impedance voltmeter between the anodes of D_1 and D_2, and adjust P_1 for zero reading (no LED lights). Next, adjust P_3 until the centre LED (D_8) just lights. The magnification of the differential amplifier is then ×185 (gain=45 dB). Assuming a temperature coefficient of 2 mV °C^{-1} and an input sensitivity of the display of 88.8 mV per LED, the overall sensitivity is about 0.25 °C per LED (88.8/2×185).

If greater precision or a different scale is required, the two sensors should be kept at the desired temperature difference and P_2 adjusted until D_{13} just lights. Another method is to multiply the maximum temperature difference by 2 and take the result as a voltage in mV. With a voltmeter between the anodes of D_1 and D_2, adjust P_1 until the meter indicates that voltage. Next, adjust P_2 until D_{13} just lights and readjust P_1 for zero reading of the meter. ■

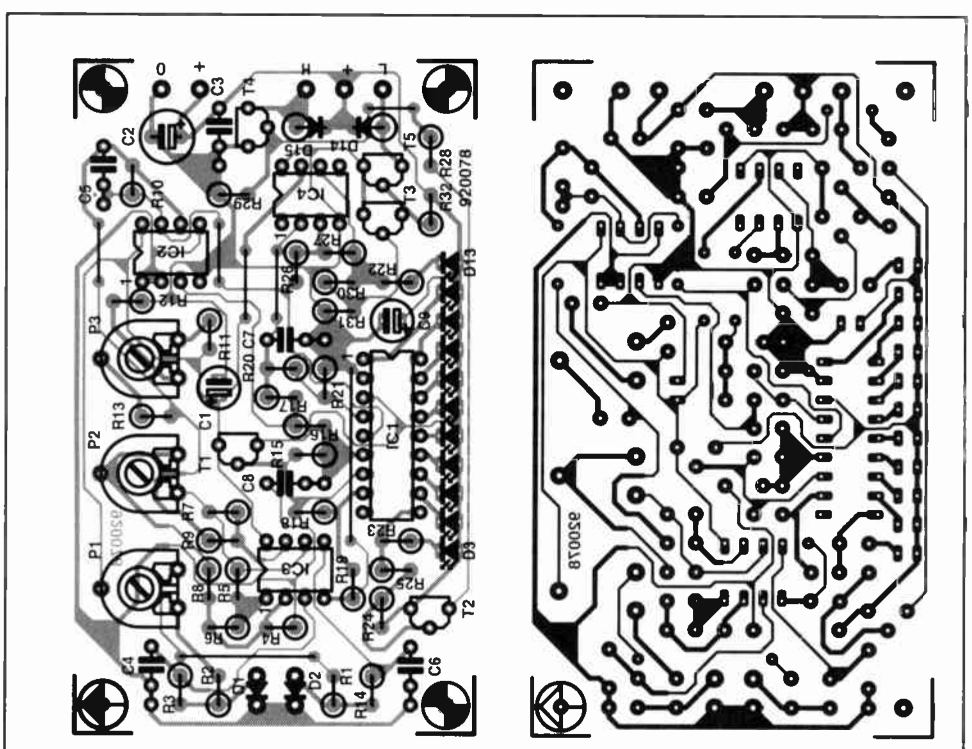


Fig. 4. Printed circuit board for the differential thermometer.

PARTS LIST

Resistors:
R1, R2 = 1.8 kΩ
R3, R14, R16 = 100 kΩ
R4–R7 = 47.5 kΩ
R8 = 390 Ω
R9–R11, R15 = 47 kΩ
R12, R13, R21 = 22 kΩ
R17 = 76.8 kΩ
R18 = 1 kΩ
R19, R31 = 3.9 kΩ
R20 = 23.2 kΩ
R22 = 680 Ω
R23 = 100 Ω
R24 = 18 kΩ
R25, R26 = 5.6 kΩ
R27 = 2.2 MΩ
R28, R29, R32 = 68 kΩ
R30 = 12 kΩ
P1 = 1 kΩ preset, horizontal
P2 = 250 Ω preset, horizontal
P3 = 10 kΩ preset, horizontal

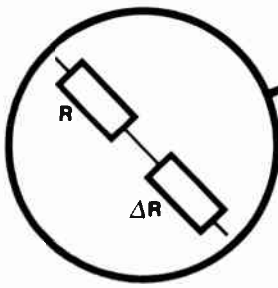
Capacitors:
C1 = 10 µF, 16 V, radial
C2 = 100 µF, 16 V, radial
C3, C7, C8 = 100 nF
C4, C6 = 470 nF
C5 = 330 nF
C9 = 10 µF, 25 V, radial

Semiconductors:
D1, D2, D14, D15 = 1N4148
D3, D4, D12, D13 = LED, 3 mm, red
D5, D6, D10, D11 = LED, 3 mm, yellow
D7–D9 = LED, 3 mm, green
T1, T3 = BC547C
T2 = BC557B
T4, T5 = BC517
IC1 = LM3914
IC2, IC3 = TLC272
IC4 = TLC271

Miscellaneous:
Enclosure 57×142×23.5 mm (2¼×5⁹⁄₁₆×¹⁵⁄₁₆ in)
PCB Type 920078 (see page 70)

THE WHEATSTONE BRIDGE

Any time a device produces a resistance (or resistance change) as the transducible property for a measurement, we can use the Wheatstone bridge to make the measurement easier. The bridge is probably the most common form of resistive sensor circuit.



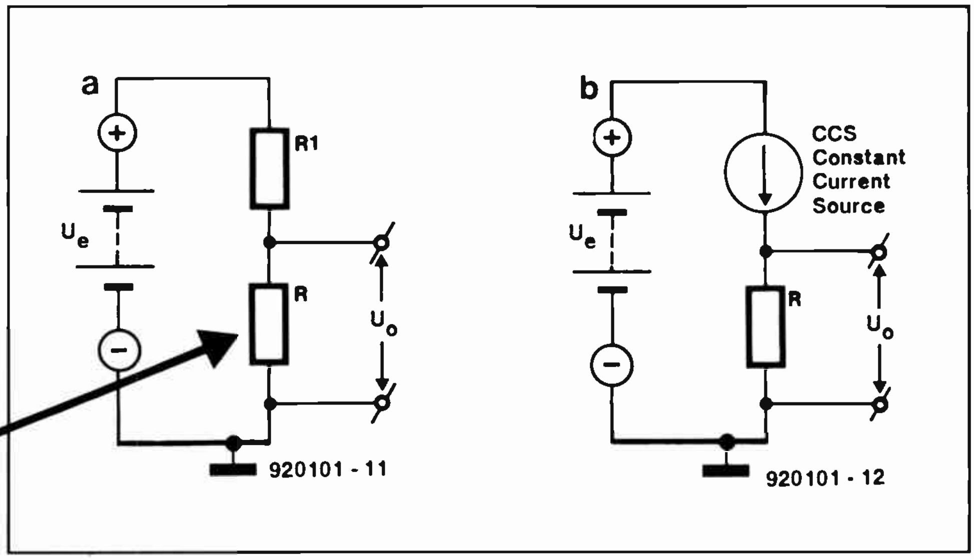


Fig. 1. (a) Basic half-bridge circuit; (b) half-bridge circuit based on a constant current source (CCS).

By Joseph J. Carr

MANY sensors used in electronic instruments use electrical resistance as the transducible property. For example, a thermistor produces a resistance that is a function of the applied temperature. Strain gauges are wire or semiconductor elements that change resistance when deformed in either tension or compression; this phenomenon is called piezoresistivity, and forms the basis for a wide range of pressure sensors and other instruments. Photoresistors produce a resistance that is inversely proportional to the applied light level. All these resistive sensors can be accurately measured with the aid of the Wheatstone bridge.

Bridge circuits

Before any resistive sensor can be useful, it must be connected into a circuit that will convert its resistance changes into a current or voltage output; most applications are voltage output circuits. Figure 1 shows several popular forms of circuit. The circuit in Fig. 1a is both the simplest and least useful (although not useless); it is sometimes called the 'half-bridge' circuit, or 'voltage divider' circuit. The sensor element of resistance R is placed in series with a fixed resistor, R1, across a stable d.c. voltage, U_e. The output voltage, U_o is found from the standard voltage divider equation:

$$U_o = \frac{U_e R}{R + \mathrm{R1}} \qquad (1)$$

Equation (1) describes the output voltage U_o when the sensor is at rest (i.e., nothing is stimulating the resistive element). When the element is stimulated, however, its resistance changes a small amount, ΔR. The output voltage in that case is:

$$U_o = \frac{U_e (R \pm \Delta R)}{(R \pm \Delta R) + \mathrm{R1}} \qquad (2)$$

Another form of half-bridge circuit is shown in Fig. 1b, but in this case the sensor element is connected in series with a constant current source (CCS), which will maintain current I at a constant level regardless of changes in the strain gauge resistance. In this case, $U_o = I(R \pm \Delta R)$. The LM334 device is an example of a commercial CCS.

Both of the half-bridge circuits suffer from a serious defect: output voltage U_o will always be present regardless of the value of the force applied to the sensor. Ideally in any sensor system, the output voltage should be zero when the applied stimulus is zero. For example, when a gas pressure sensor is open to atmosphere, the gauge pressure is zero so the output voltage should also be zero. Secondly, the output voltage should be proportional to the value of the stimulus when the stimulus is not zero. A *Wheatstone bridge* circuit has these properties. We can use resistive sensors for all of the elements of the Wheatstone bridge, or just one.

Figure 2a shows the basic circuit for the Wheatstone bridge: the circuits to follow are but variations on this theme. The bridge consists of four resistive arms (R1 through R4), and an *excitation voltage* source, U_e. As can be seen in the redrawn circuit of Fig. 2b, the Wheatstone bridge is basically two resistor voltage dividers in parallel with each other. Voltage divider R1/R2 produces an output voltage U_1:

$$U_1 = \frac{U_e \mathrm{R2}}{\mathrm{R1} + \mathrm{R2}} \quad , \qquad (3)$$

while voltage divider R3/R4 produces voltage U_2:

$$U_2 = \frac{U_e \mathrm{R4}}{\mathrm{R3} + \mathrm{R4}} \quad . \qquad (4)$$

Each of these voltages is single-ended, i.e., it is unbalanced with respect to common or ground. Output voltage U_o is *balanced* with respect to common, and is the difference between each half-bridge voltage:

$$U_o = U_1 - U_2 = U_e \left(\frac{\mathrm{R2}}{\mathrm{R1} + \mathrm{R2}} - \frac{\mathrm{R4}}{\mathrm{R3} + \mathrm{R4}} \right). \qquad (5)$$

When $U_1 = U_2$, and $U_o = 0$, the bridge is balanced, and is said to be in the *null condition*. This state occurs when:

$$\frac{\mathrm{R1}}{\mathrm{R2}} = \frac{\mathrm{R3}}{\mathrm{R4}} \quad . \qquad (6)$$

Please note that the resistances need not be equal, only the *ratio* of the resistances in the two arms need be equal to establish the null condition.

One also might notice that knowledge of three resistance values (say, R1, R2 and R3) implies knowledge of the fourth by calculation when the null condition is present. It is common practice to use fixed precision resistors for two elements (e.g., R1 and R3), and a calibrated variable resistor for the third resistor (e.g., R2), and then an unknown for the four-resistance branch. Such a system for measuring unknown resistances is shown in Fig. 2c.

If R2 is adjusted for $U_o = 0$, with unknown Rx connected in place of R4, the value of Rx is inferred from:

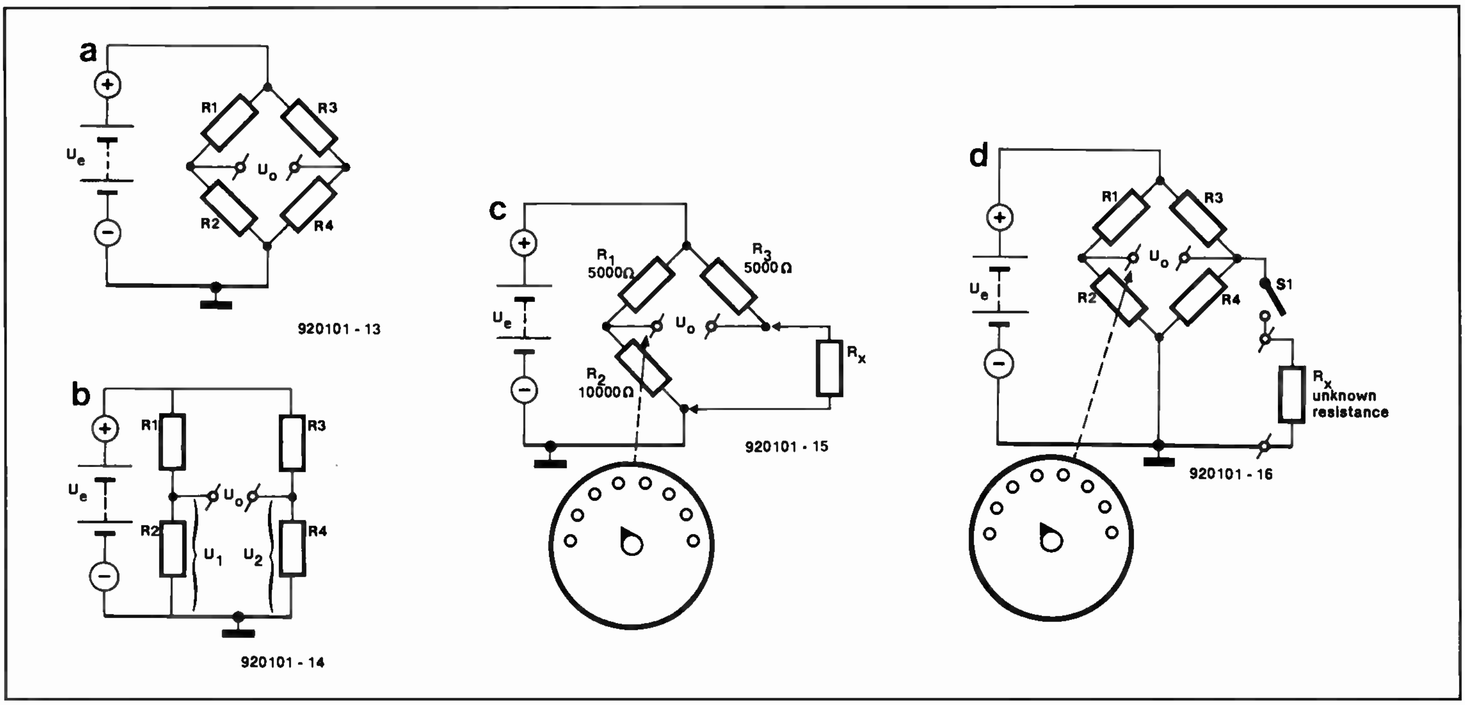


Fig. 2. (a) Standard Wheatstone bridge circuit; (b) circuit redrawn to show the two voltage dividers more clearly; (c) circuit for using a Wheatstone bridge to measure an unknown resistance; (d) alternate circuit for measuring unknown resistances.

$$R_x = \frac{R_2 R_3}{R_1} \qquad (7)$$

or, where R1 = R3 (not a necessary condition, but certainly convenient), Rx = R2.

Another operating condition is shown in Fig. 2d. This method uses a *departure from null* to indicate Rx. With switch S1 open, resistor R2 is adjusted to null (i.e., $U_o = 0$). Switch S1 is then closed, causing Rx to shunt R4 to produce a new (lower) resistance for this arm of the bridge, and forcing $U_o \neq 0$. The value of U_o is an indication of unknown Rx.

Alternatively, switch S1 can be an SPDT type that replaces R4 with Rx, rather than simply shunting (R4 ∥ Rx). This 'departure from null' is the basis for many sensor based instruments.

Figure 3a shows a Wheatstone bridge circuit in which two resistive sensors (SG1 and SG2) are used in two arms of the bridge, with fixed resistors R1 and R2 forming the alternate arms of the bridge. It is usually the case that SG1 and SG2 are configured so that their actions oppose each other; that is, under stimulus, SG1 will have resistance R+ΔR, and SG2 will have resistance R–ΔR, or vice versa.

One of the most linear forms of sensor bridge is the circuit of Fig. 3b in which all four bridge arms contain resistive elements. In most such sensors, all four strain gauge elements have the same resistance (*R*), which will usually be a value between 50 Ω and 1000 Ω.

The output from a Wheatstone bridge is the difference between the voltages across the two half-bridges. We can calculate the output voltage for any of the standard configurations from the equations given below (assuming all four bridges have nominally the same resistance, *R*.

One active element:

$$U_o = \frac{U_e \Delta R}{4R} \qquad (8)$$

(accurate to ±5% if $h < 0.1$)

Two active elements:

$$U_o = \frac{U_e \Delta R}{2R} \qquad (9)$$

Four active elements:

$$U_o = \frac{U_e \Delta R}{R} \qquad (10)$$

Where:
U_o is the output potential in volts (V);
U_e is the excitation potential in volts (V);
R is the resistance of all bridge arms;
ΔR is the change in resistance in response to the applied stimulus.

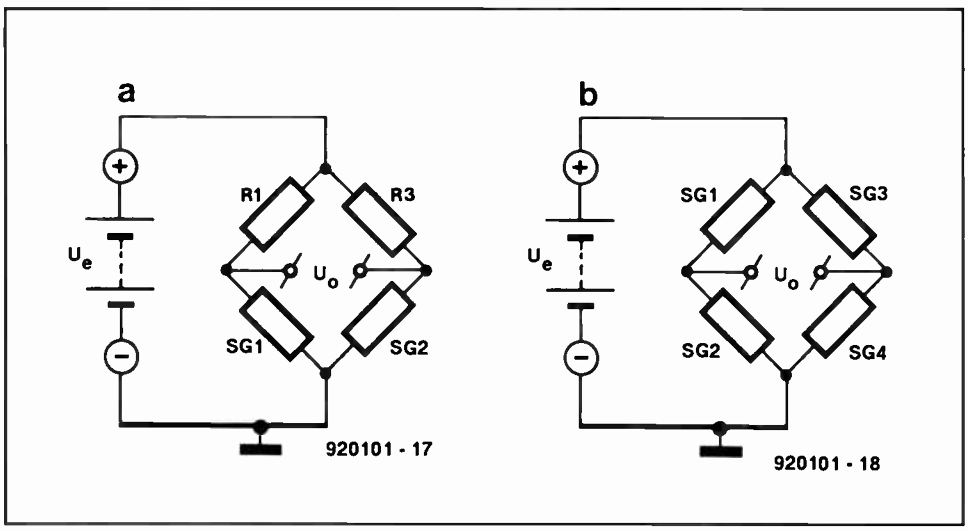


Fig. 3. (a) Two-sensor bridge circuit; (b) four-sensor bridge circuit.

Sensor sensitivity

The sensitivity factor (Φ) of a Wheatstone bridge sensor circuit relates the output voltage (U_o) to the applied stimulus value (Q) and excitation voltage. In most cases, the sensor maker will specify a number of microvolts (or millivolts) *output potential per volt of excitation potential per unit of applied stimulus*:

$$\Phi = U_o / U_e / Q_0 \qquad (11)$$

or, written another way:

$$\Phi = \frac{U_o}{U_e Q_0} \qquad (12)$$

Where:
Φ is the sensor sensitivity ($\mu V/U_e/Q$);
U_o is the output potential (V);
U_e is the excitation potential (V);
Q is one unit of applied stimulus.

If we know the sensitivity factor, we can calculate the output potential as follows:

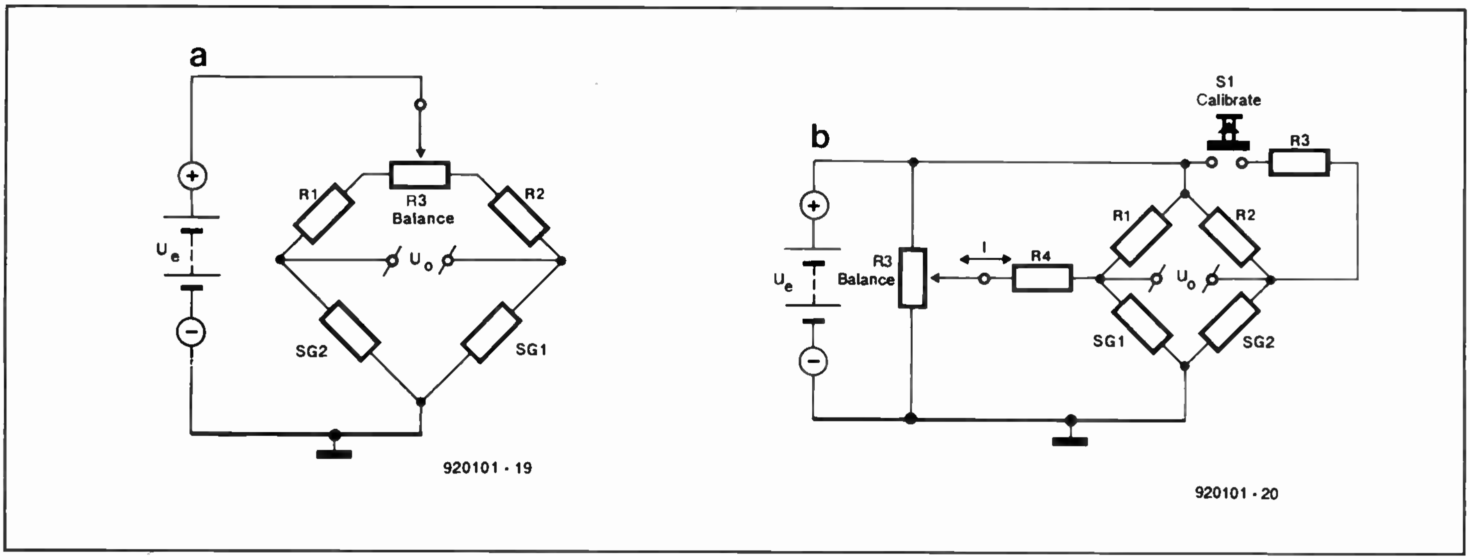


Fig. 4. (a) Bridge balance potentiometer (R3) to compensate for circuit tolerances; (b) injection current method for balancing the bridge.

$$U_o = \Phi U_e Q_0 \qquad (13)$$

Equation (13) is the one that is most often used in circuit design.

Example

A certain fluid pressure sensor has a sensitivity (P) of 5 $\mu V/U_e/T$, which means that 5 microvolts output potential is generated per volt of excitation potential per Torr of pressure[1]. Find the output potential when the excitation potential (U_e) is +7.5 V, and the applied pressure is 400 Torr.

$$U_o = \Phi U_e Q$$

$$U_o = \left(\frac{5\mu V}{U_e T}\right) \times 7.5V \times 400Torr$$

$$U_o = (5 \times 7.5 \times 400)\mu V = 15{,}000\mu V$$

(which is 0.015 V, or 15 mV).

Balancing and calibrating a bridge sensor

Few, if any, Wheatstone bridge sensors meet the ideal condition in which all four bridge arms have exactly equal resistances at rest. In fact, the bridge resistance specified by the manufacturer is only a nominal value, and the actual value may vary quite a bit from the specified value. There will inevitably be an offset voltage (i.e., U_o is not zero when Q is zero). Figure 4 shows two circuits that will balance the bridge when the stimulus is zero.

In Fig. 4a the balancing potentiometer is placed between the excitation potential and one of the excitation nodes. The resistance balance of the potentiometer is varied between the two legs of the bridge, nullifying any differences between them. The potentiometer is usually a precision type with five to fifteen turns to cover the entire range.

The purpose of the potentiometer in Fig. 4b is to inject a balancing current (I) into the bridge circuit at one of its nodes. R1 is adjusted, with the stimulus at zero, for zero output voltage.

Another application for this type of circuit is injecting an intentional offset potential. For example, on an electronic scale, one that uses a strain gauge to measure weight, such a circuit is used to adjust for the 'tare weight' of the scale, which is the sum of the platform and all other weights acting on the sensor when nobody is standing on the scale. This is also sometimes called 'empty weight compensation'.

Calibration of a bridge sensor

Calibration can be accomplished either the hard way, or the easy (and less accurate) way. The hard way is to set the sensor up in a system and apply the stimulus. The stimulus is measured and the result is compared with the sensor output. For example, if you are testing a pressure sensor, connect a manometer (pressure measuring device containing a column of mercury), pressurize the system, and then measure the pressure directly. The result is compared with the sensor output. Similarly, temperature sensors can be exposed to a known temperature, and the bridge output noted. All sensors should be tested in this manner initially when placed in service and then periodically thereafter.

The easy (and less accurate) way is to connect a calibrating resistor in parallel with one leg of the bridge (R3 in Fig. 4b) to create an offset that is equal to some standard stimulus. A 'CAL' switch (S1) will insert the resistor in the circuit, unbalancing the bridge an amount R, whenever a quick calibration or test is needed.

Output display devices

The output of the Wheatstone bridge is a differential voltage, U_o, that is proportional to the unbalance of the bridge. This

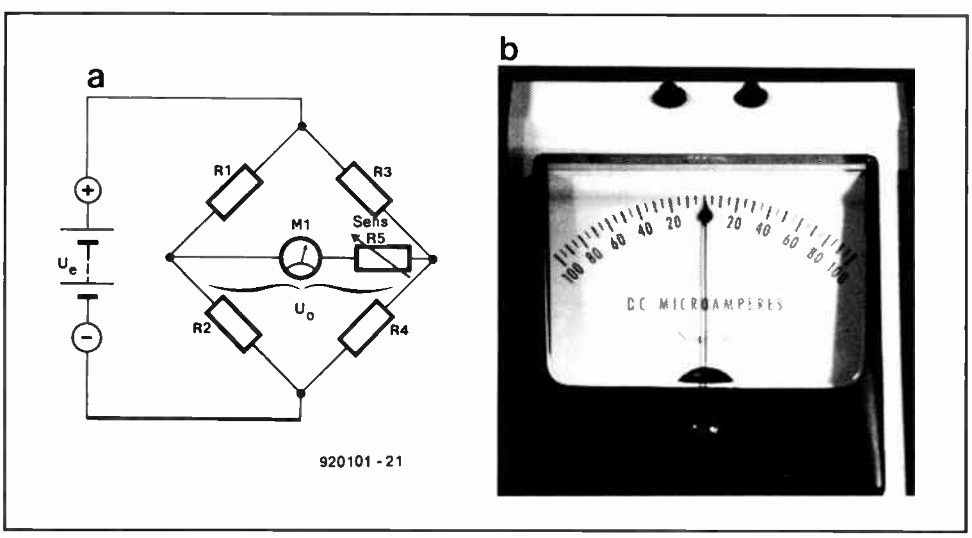


Fig. 5. (a) Analog current meter movement used as a bridge circuit display device; (b) zero-center meter suitable for use in a bridge circuit such as Fig. 5a.

[1] **torr.** A unit of pressure used in vacuum technology. One Torr equals 1/760 standard atmosphere pressure (very closely, 1 mm Hg or 133.322 newtons per square metre).

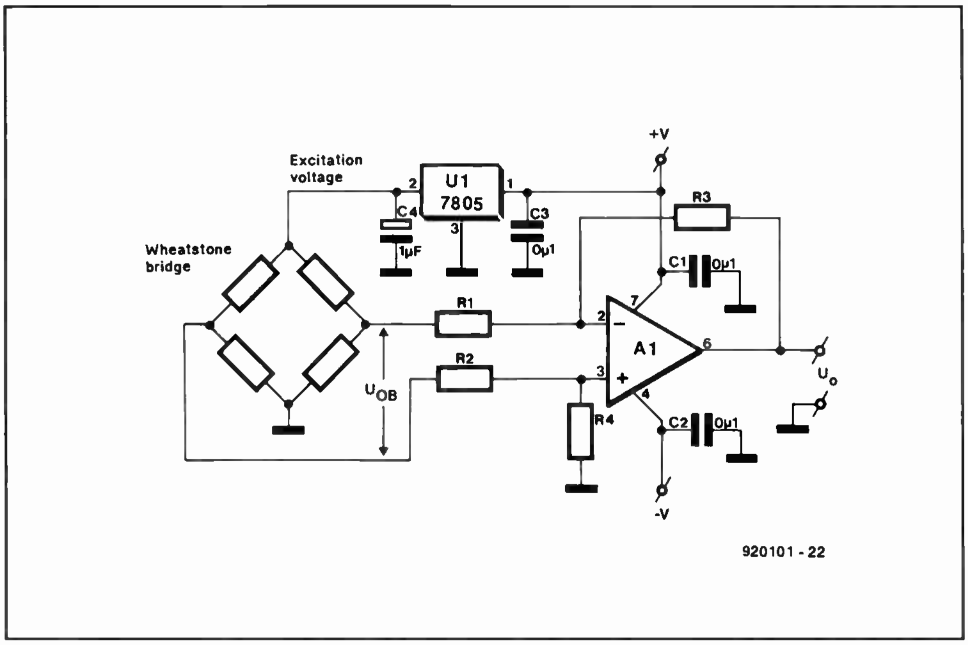


Fig. 6. DC differential bridge amplifier circuit.

voltage can be either positive or negative, depending on the direction of unbalance. In many cases, the output of the bridge will be displayed on an analogue or digital voltmeter, an oscilloscope or a strip-chart recorder.

It is also possible to use a current meter for the output display, as shown in Fig. 5a. The meter, M1, is connected between the output nodes across which U_o appears. This meter is usually a milliammeter or microammeter (Fig. 5b), depending on the best sensitivity required.

It is not strictly necessary to insert the sensitivity control (R5) in series with the meter, but it is highly recommended if the unbalance is large and the meter has a low current range. Large displacements of the bridge could generate sufficient current to damage the meter. It is common practice to initially set R5 to maximum, or near maximum, resistance, and then reduce its resistance as the bridge nears the null condition. A few commercial resistance measuring bridges place a switch in shunt with R5 in order to remove it from the circuit when the bridge is close to null.

Bridge amplifier circuit

The output potential of most bridges (U_{ob} in Fig. 6a) is a very small voltage that, for many applications, must be amplified for practical use. The Wheatstone bridge is a balanced device, so a differential amplifier is needed to amplify U_o. The amplifier circuit uses an operational amplifier (A1) in the d.c. differential amplifier configuration. In this type of circuit, R1 = R2 and R3 = R4, in order to maintain balance, and the voltage gain is:

$$A_v = \frac{R3}{R1} \qquad (14)$$

The input resistors, R1 and R2, should be at least ten times the source resistance of the bridge. If all arms of the bridge are equal, then the source resistance is the value of any one arm of the bridge.

The excitation voltage in Fig. 6a is supplied by an IC voltage regulator. Separate regulation is needed because variations in the power supply voltage are transmitted to the bridge, and reflected as changes in the output voltage. In the case shown, the voltage for the bridge is +5 V, so a 7805 regulator is used. In general, the excitation voltage for typical bridges is low in order to prevent self-heating of the sensors, so a 7805 is a reasonable general selection.

In many cases, the output of the bridge is so small that it is difficult to transmit for any length in a wire or cable. In those cases, it is sometimes prudent to install a preamplifier on the body of the sensor. I constructed such a preamp for the user of a Grass Type FT-3 gram-force transducer, which is based on the Wheatstone bridge circuit that uses strain gauge elements as the arms. The output signal tends to be 100 μV, or so, at full scale. In order to overcome interfering hum from the 60 Hz power mains, I built a gain-of-100 d.c. differential amplifier (making the output voltage 10 mV rather than 100 μV) inside a small metal box that interfaced with the mating connector.

Applications of bridges: circuits that you can build

The Wheatstone bridge can be used in a wide variety of applications circuits, only a few of which can be covered here. The purpose of the circuits below is to stimulate thinking into these and other applications for which the same principles hold.

Differential Thermometer

A differential thermometer produces an output voltage that is proportional to the *difference* between two temperatures. Uses for such thermometers include investigations of thermal insulation effectiveness; control of heating/cooling equipment based on temperature differences; simple curiosity as you gaze through an iced window pane; and so forth. Figure 7 shows the circuit for such a thermometer based on thermistor sensors.

The thermistor is a device that produces a resistance value that is a function

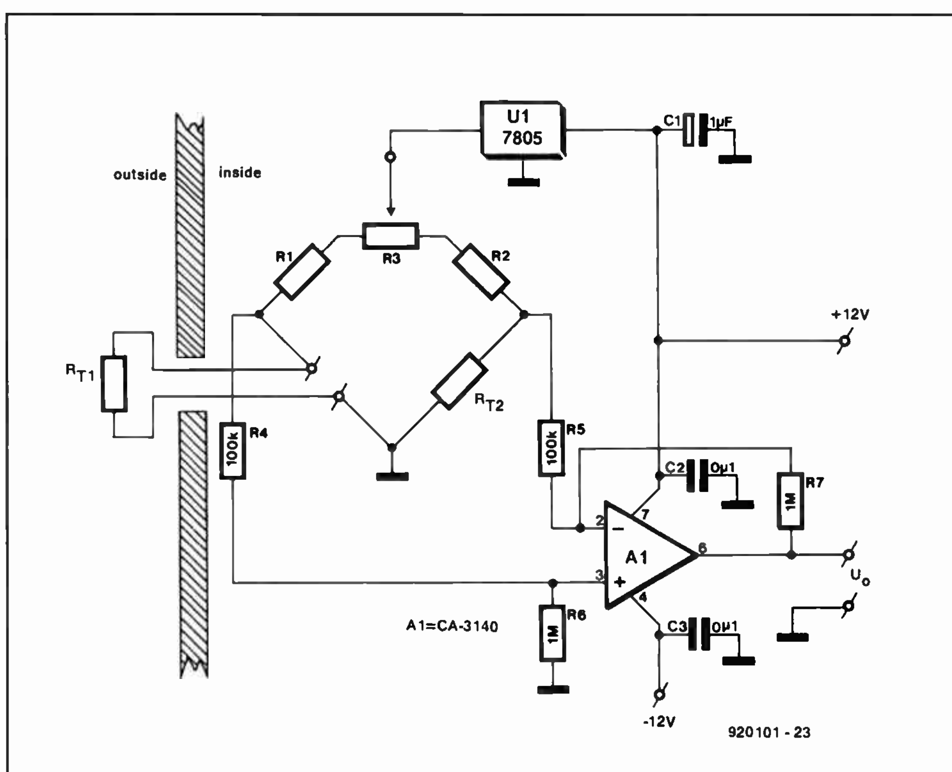


Fig. 7. Differential thermometer circuit.

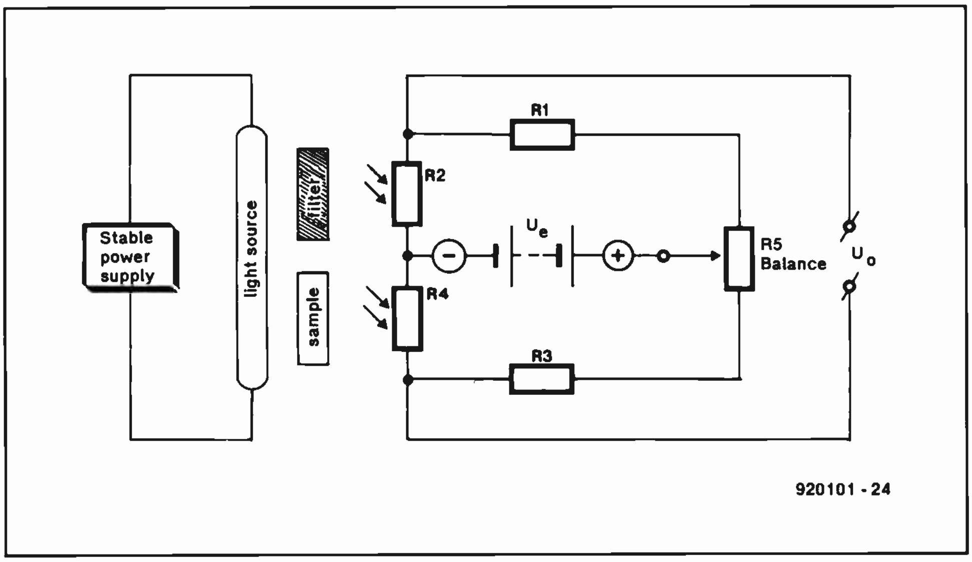


Fig. 8. Photocolorimeter circuit.

of temperature. Devices RT1 and RT2 in Fig. 7 are identical thermistors, and are used in two opposing arms of a Wheatstone bridge circuit. Resistors R1 and R2 form the other two arms of the bridge. The values for R1 and R2 are not given because the convenient values depend on the specific thermistors being used. A rule-of-thumb is to make R1 and R2 equal to each other, with a value approximately the value of RT1 and RT2 at a mid-range temperature. Balancing potentiometer R3 should have a value of 10 to 20 percent of the value of R1 and R2.

As in the previous case, the bridge excitation source is a 7805 IC voltage regulator, which produces a regulated +5 V from the +12 V power supply.

The input resistors to A1, the differential amplifier, should be at least ten times the 'looking back' resistance of the bridge. Examination of thermistor catalogues reveals that 10 kΩ at 30 °C is a common value, so I set these resistors at ten times that value, or 100 kΩ. The gain of ten was set for convenience, and requires 1 MΩ resistors for R6 and R7. Depending on the thermistors used, and the output voltage required, it may be necessary to increase the gain of the amplifier (remember, R1 = R2, R6 = R7, and A_v = R7/R5 = R6/R4).

Photocolorimetry

One of the most basic forms of instrument circuit is also both the oldest and most commonly used: *photocolorimeters*. These devices are used for such applications as measuring the oxygen content in blood, CO_2 content of air, water vapour content in a gas, blood electrolyte (Na and K) levels, and a host of other similar measurements.

Photocolorimetry is basically a comparison measurement technique in which light (or IR and UV depending on the purpose of the instrument) transmission over two paths is compared. Figure 8 shows the basic circuit of the most elementary form of colorimeter. Although the circuit is very basic, this is the actual circuit used in a once widely-used medical blood oxygen meter.

The basic circuit is the Wheatstone bridge, and it uses a pair of photoresistor cells (R2 and R4) as the light sensors. Potentiometer R5 in Fig. 8 is used as a bridge balance control, and it is adjusted for zero output (U_0 = 0) when the same light shines on both photoresistors. The output voltage from the bridge (U_0) will be zero when the two legs of the bridge are balanced. In other words, U_0 is zero when R1/R2 = R3/R4. It is not necessary for the resistor elements to be equal (although that is often the case), only that their resistance ratios be equal. Thus, a 500 kΩ/50 kΩ ratio for R1/R2 will produce zero output voltage when R3/R4 = 100 kΩ/10 kΩ.

The photoresistors are arranged such that light from a calibrated source illuminates both equally and fully, except when an intervening filter or sample is present in one or both pathways. Thus, the bridge can be nulled to zero using potentiometer R5 under this zero condition. In most instruments that are based on this principle, a translucent sample is placed between the light source and one of the photocells. The amount of transmission to light allowed by the sample is a measure of its optical density, and is thus a transducible property. Let us look at a couple of different types of instrument to see how this principle is applied.

(1). Blood O_2 Level. A once widely used method for measuring blood oxygen level is based on the basic colorimeter of Fig. 8. It works because the 'redness' of human blood is a measure of its oxygenation. This instrument is nulled with neither standard filter cell nor blood in the light path; i.e., when white or red light shines on both cells. A standard colour 800 nanometer[2] filter is introduced between the light source and R2, and a blood sample is placed in a standardized tube between the light source and R4. The degree of blood O_2 saturation in the sample is thus reflected by the difference in the bridge reading between the sample path and filter path. On one model oxygen meter, a separate resistor across the R1/R2 arm is used to bring the bridge back into null condition, and the dial for that resistor is calibrated in percent-O_2. More modern instruments based on digital computer techniques provide the measurement in a more automatic manner.

(2). Respiratory CO_2 Level. The exhaled air from humans is roughly 2 to 5 percent carbon dioxide (CO_2), while the percentage of CO_2 in normal room air is negligible. A popular form of 'End Tidal CO_2 Meter' is based on the fact that CO_2 absorbs infrared (IR) waves at three discrete wavelengths. The 'light source' in that type of photocolorimeter is actually either an IR LED or a Cal-Rod device (identical to the one that heats an electric coffee pot!); the photocells are selected for good IR response. In this type of instrument, room air is passed through a glass cuvette placed between R2 and the heat source, while patient expiratory air is passed through the same type of cuvette placed between the heat source and R4. The difference in IR transmission across the two paths is a function of the percentage of CO_2 in the sample circuit.

The associated electronics (not shown) will allow zero and maximum span (i.e., gain) adjustment. The zero point is adjusted with room air in both cuvettes, while the maximum scale (usually 5% CO_2) is adjusted with the sample cuvette purged of room air and replaced with a calibration gas (usually 5% CO_2, 95% nitrogen). This calibration gas must be obtained from a local supplier, and be specified as a calibration gas. Otherwise, the quantities may be only approximate. Also, be sure of the type of measurement: calibration gases are available by either weight or volume.

The uses of colorimeters do not end with the medical laboratory. The clue to looking for a transducible event is detection of either a density change, or an absorption differential to one or two wavelengths, that is a transducible function of the parameter being measured; for example, IR is absorbed by CO_2, and a certain O_2 saturation level passes light at 800 nm wavelength.

Conclusion

The Wheatstone bridge is simple to understand, simple to build, well behaved, and can form the basis for a very large variety of simple physical instruments that you can build. ■

[2] 800 nm is the *isobestic* point wavelength at which oxygenated arterial blood and deoxygenated veinous blood have the same transmittivity.

DIGITAL AUDIO-VISUAL SYSTEM

PART 1 (OF 4): SYSTEM OUTLINE AND DISSOLVE UNIT

This is the first instalment of an article that describes a high-end slide control system based on a Centronics-driven dissolve unit for four slide projectors. The system allows up to 16 projectors to be controlled automatically or by hand. Music or comment to accompany the slides can be synchronized with the aid of an advanced pulse or timecode registration unit. The timecode option enables you to record all control actions in a complete slide show, whereby all relevant data are safely stored, along with the parallel sound track.

FRONT COVER PROJECT

Design by A. Rietjens

ABOUT four years ago we published a computer-controlled slide fader for four projectors (Ref. 1). Together with a Centronics interface published a little later (Ref. 2), this fader allowed photography enthusiasts to put a computer in control of up to 16 slide projectors. The software written for this system was an MSX BASIC program with limited features. The designer of the slide fader, Albert Rietjens, a keen photographer and slide maker himself, has used the intervening years since this 'early' publication to elaborate the basic system into what is presented here. The result is, we feel, definitely up to scratch: a DiAV (for Digital Audio-Visual) system that competes on all fronts with far more expensive commercial equipment (which appears to be few and far between). In fact, the DiAV will cost you only about one fifth of any commercially available product with an equal set of features.

The DiAV system

The drawing in Fig. 1 presents an overview of the complete system to be described. The central block is formed by the DiAV main unit, which is based on the multi-purpose Z80 card (Ref. 3). The main unit is capable of controlling up to four dissolve units (slide control units, each suitable for controlling up to four projectors). This is achieved by connecting the individual units in series.

A tape recorder may be connected up into this system to add a music channel to the slide series. The tape recorder used for this purpose must have the possibility to record pulses that, on being played back, are converted into control signals for the projectors. This is the simple option. The more advanced is the timecode interface (Ref. 4), which is capable of reading from, and writing to, tape either one of two formats: a timecode signal or a 'special code' called Special Data Language, SDL. The SDL is recorded 'in parallel' with the sound track (music channel) to ensure absolute synchronicity. In addition to information about the course of the slide series, the SDL also contains all information on the current positions of the slide carriers in the projectors. This synchronization works so well that the system is capable of moving the carriers in all projectors to the desired positions (i.e., slide) when the tape is started at any point in the series. Once running, the whole system is perfectly synchronized, and the slides appear in the programmed order from the new start point onwards.

The main unit puts the user in general control over all sub-systems, and has a large number of options for its control. Those of you who have followed the articles on the multi-purpose Z80 card know that this sports interfaces for a liquid crystal display (LCD), a PC-XT keyboard and an infra-red (IR) remote control receiver module. The keyboard and the IR link are the primary control elements of the main unit. The remote control is particularly useful for 'quick and dirty' control of the main unit, i.e., if you want to show a couple of slides without bothering too much about special effects. Although the IR remote control can be used to enter all data, the PC-XT keyboard will be preferred whenever a 'real' series is to be programmed.

Owners of an IBM PC or compatible may also control the main unit via the RS232 serial interface, or convey control programs written with a word processor from the PC to the DiAV, and vice versa.

The main unit has a 32-kByte RAM disk (with battery backup) to hold the program that describes the slide series. This program can also be read back for editing on the PC. The RAM allows up to 32 series to be stored, or fewer if the series are relatively large (the average series will comprise something like 100 slides, and consume a RAM space of about 1 kByte).

For emergency cases, the main unit has a small keyboard that allows you to select those basic functions that 'save' you when you have forgotten the remote control, or when the batteries are flat.

The electronics

The complete DiAV is a combination of a number of building blocks published earlier in *Elektor Electronics* (see references). However, since the original slide control unit goes back four years, we thought it fit to design a new interface for it, taking into account everything we have learned in the mean time about its practical use. Fortunately, this does not mean that constructors of the 'old' interface have another piece of equipment to forfeit. The 'new' interface is compatible with the 'old' one, provided the latter is controlled via the Centronics interface developed for it. Those of you who have a fully-fledged slide control plus Centronics interface may, therefore, skip the following sections on function and construction. Note, however, that the 'new' interface has a number of extras and improvements. Also, its 'package' is stylish, neat and attractive looking — see the introductory photograph.

The dissolve unit

The block diagram of the new dissolve unit is given in Fig. 2. The most conspicuous feature of this unit is that it is controlled by a microprocessor rather than by discrete electronics. Here, using a microcontroller allows us to cut down drastically on external components. The circuit may be controlled via a Centronics interface, which is available on most, if not all, PCs. Note, however, that the computer is required only if you do not use the Z80 main unit, or if you wish to write your own system software.

The control signals supplied by the PC are passed to another dissolve unit (if used) via a Centronics connector. In addition to a Centronics input, the interface also has an I²C connection. This is reserved for future applications, and not implemented in the current control software.

To enable the processor to control the brightness of the projector lamps directly, it must know when the zero crossing of the mains voltage occurs. This information is supplied by a zero-crossing detector incorporated in the power supply. The zero-crossing detector is common to all projector lamps, which means that the dissolve unit and all projectors must be powered from the same mains outlet (via an approved distribution block). Note that this is not essential in the UK because in a ring circuit all outlets have the zero crossing simultaneously. The processor uses the zero-crossing information and the commands received via the inputs to arrange the brightness of the individual projector lamps, and the changing between projectors. It can do so via the 'projector control' blocks shown in Fig. 2.

In principle, the functions described so far would suffice for the target system, because they allow us to do all we want: control lamp brightness, and change slides on any of the connected projectors. The processor, however, also allows us to control a display that indicates the slide positions in the carriers, the lamp brightness, and the 'slide change' function. These functions are controlled via the count display block and the lamp indicator block, respectively.

About the projectors

Before discussing the electrical schematic, we have a look inside a typical slide projector. The crucial part is shown in Fig. 3. Broadly speaking, projectors can be divided into two classes: types with one-button control, and types with two-button

DiAV: a slide control system with professional features

Dissolve unit
- Microcontroller-driven
- No special ICs except microcontroller
- Interface compatible with slide controller (earlier publication)
- Transistor drivers for carrier solenoids
- No modifications inside projectors
- Simple to connect; only connecting cable depends on projector
- Also usable as a stand-alone unit (with limited functions)

Main unit
- Controlled by multi-purpose Z80 card
- Stand-alone system; independent of computer type
- Operated via infra-red remote control or via PX-XT keyboard
- Battery back-up
- Memory for up to 32 slide series
- RS232 interface for PC control and program exchange
- Direct synchronization by pulse control (connects straight to ITT recorder for slide control)

Main unit in combination with timecode interface
- Full tape synchronization possible
- Uses timecode for synchronization
- Slide series program editing using timecode
- Perfectly timed slide changes (accuracy: 10 ms)

Overall performance comparable to £1250+ systems.

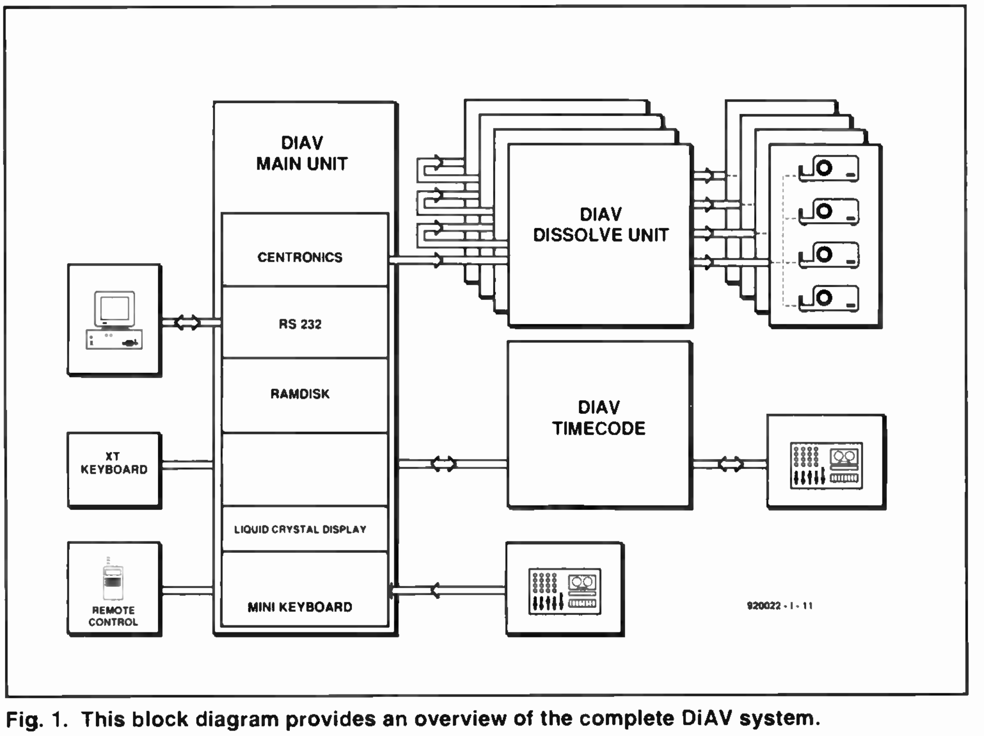
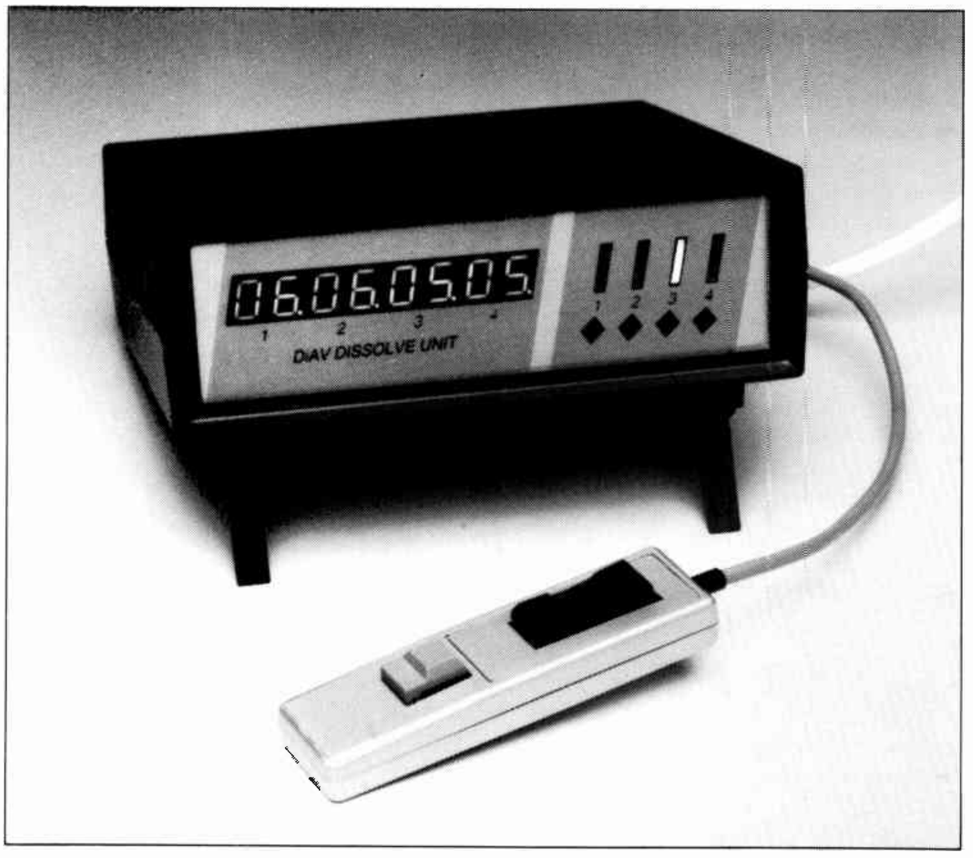


Fig. 1. This block diagram provides an overview of the complete DiAV system.



control. With one-button projectors, the forward of reverse direction of the slide carrier is determined by the time the button is pressed. By contrast, the two-button type has one button for each direction. The buttons cause electromagnets (solenoids) to be energized that, in turn, cause the slide carrier to move forward or reverse (or turn accordingly in the case of a carousel carrier). The electromagnets are powered by a direct voltage which is derived from the secondary of the mains transformer fitted in the projector.

The electromagnets are usually shunted by back-e.m.f. suppressor diodes. In some older projectors, these diodes are not present, and must be retro-fitted to enable the proposed projector control to function properly.

Figure 3 also shows the triac as it is wired in projectors with a straight slide carrier. By contrast, the triac is connected externally to most professional 'carousel carrier' projectors we have seen so far.

Dissolve unit electronics

The central parts in the circuit diagram of the dissolve unit (Fig. 4) are a microcontroller (IC3), an address latch (IC4) and an EPROM (IC5) that contains the necessary software. The microcontroller is a 16-MHz 80C32. Apart from the EPROM, the controller addresses a number of buffers with specific functions: IC7 to read the Centronics input; IC8 to set the slide carrier control; and IC9-IC10 to control the display functions. All these ICs are addressed via IC15a.

The Centronics input is formed by connector K1, which is 'looped through' to the Centronics output, K2, via IC12 and IC6. This means that all series-connected units receive the same data. Each new databyte is latched in IC6 at the end of the strobe pulse, whereupon it can be read via IC7. At the same time, bistable IC13a is set, which produces a high signal on the BUSY line of K1. IC12d passes the busy signal(s) from any further unit(s). This enables all units to evaluate the received data. The Q\ output of IC13a (pin 6) triggers the INT1 interrupt input of the processor, so that the received data can be processed immediately. Switches 1 and 2 of S1 determine which bank of four projectors is controlled (see Table 1).

As already mentioned, the I²C interface is not supported by the current software version. It is, however, used for a simple manual control that allows two, three or four projectors to be controlled, with a variable overflow time between 0 s and 10 s, in steps of 1 s (see also Table 1).

Power supply

The circuit is powered from an alternating voltage source to enable the zero-crossings of the mains voltage to be detected (this is necessary for the lamp dimmers). Figure 5 shows the timing relevant to the triac gate triggering. The signal numbers refer to the test points in the circuit diagram of the dissolve unit, Fig. 4.

The alternating voltage applied to J1 is rectified by D5-D8. The smoothing, however, does not take place until 'behind' D9. The anode of D9 carries signal '1', which enables components R26, R28, D34, T13 and IC12a to detect the zero-crossings (signal '2'). When the voltage drops below the threshold voltage of D34 plus the voltage across the base-emitter diode of T13, this transistor will stop conducting, so that the collector voltage swings high. This high level is fed to the processor via buffer

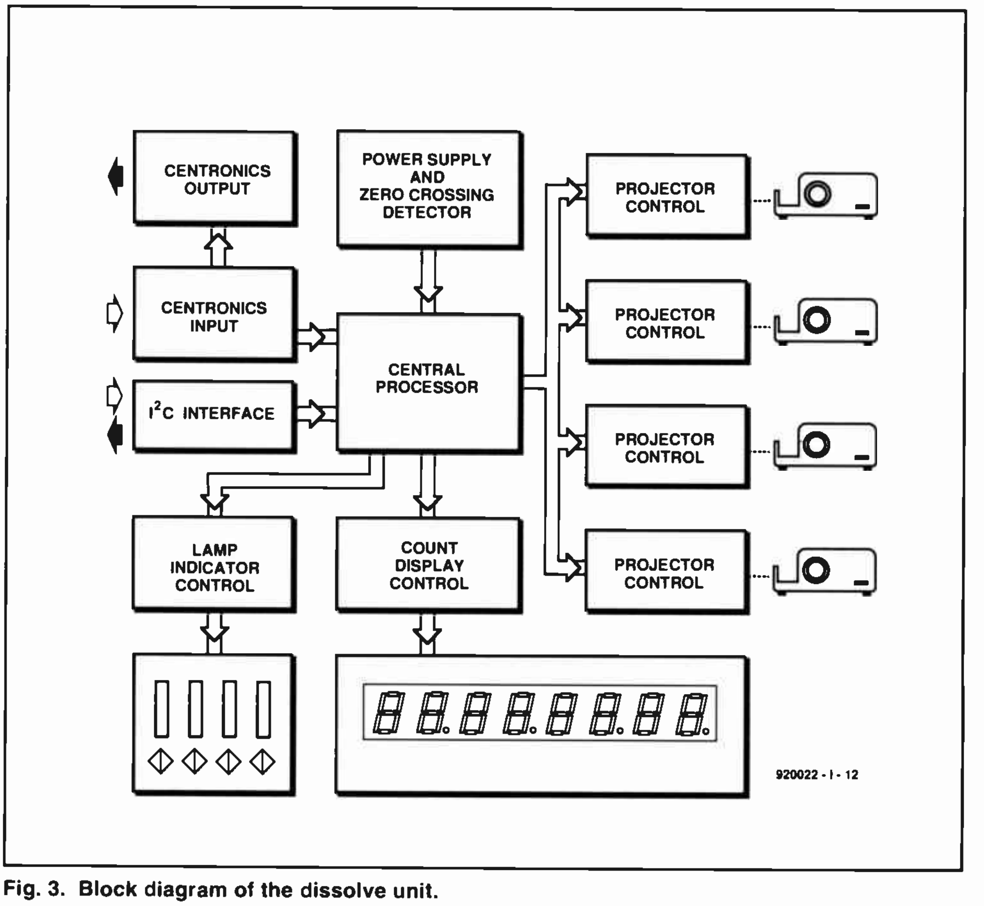


Fig. 3. Block diagram of the dissolve unit.

IC12a. To enable a minimum brightness level to be set, this signal is also applied to IC11b, a monostable multivibrator (MMV). The negative (falling) edge at pin 9 triggers the MMV, which responds by generating a pulse that starts at the end of the zero-crossing, and lasts until just before the next zero-crossing. A preset, P1, determines how far the end of the pulse is removed from the new zero-crossing. The processor will fire the triac from the end of the pulse to the next zero-crossing, which sets up a minimum brightness level (signal 4a). This setting ensures that the lamp filament can never go 'cold' between two successive overflow actions. This enables the lamp to light up quickly from 'off' to the desired brightness. Signals 4b and 4c in Fig. 5 show the gate control with a partly dimmed lamp, and one that lights at full intensity, respectively.

Next, let us have a look at the four identical projector control circuits. The functions of the previously mentioned push-buttons on the projector controls are taken over by combinations of an optocoupler and a transistor. The operation of this interface can be explained by reverting for a moment to the internal diagram of the projector. The common connection of the forward/reverse buttons is connected to the highest direct voltage in the projector. When, for instance, R1 is connected to ground, optocoupler IC1a sends base current into T1, and so causes the relevant electromagnet in the projector to be energized. The need for a suppressor diode across the electromagnet coil is evident: without it, the back-e.m.f. produced when a coil is switched off would very likely destroy the relevant driver transistor.

If jumper JP1 is closed (fitted) at power-on, the interface will control the projectors as if they were 'one-button' types, and control the relevant transistor connected to pin 2 of K9-K12 such that the slide carrier moves in the desired direction. This setting may be changed, via the control, while the unit is in use.

The second function to be controlled in each projector is the lamp intensity, or, in other words, the triac. This is achieved with the aid of T3 (T6, T9 and T12 have identical functions). When the circuit is connected to the projectors, the anode terminal, A1, of the triac is connected to ground, while resistor R5 is connected to the gate terminal. By making T3 conduct, a gate current is established for the triac, which fires. When the gate current is interrupted, the triac stops conducting. In this way, the lamp brightness is controlled by means of the phase angle, as already illustrated in Fig. 5. The gate driver transistors are controlled directly by the microprocessor. This is achieved by resetting an internal counter at the end of every zero-crossing, and then enabling the counter again. Next, the contents are compared with a predetermined value, which depends on the desired brightness. When

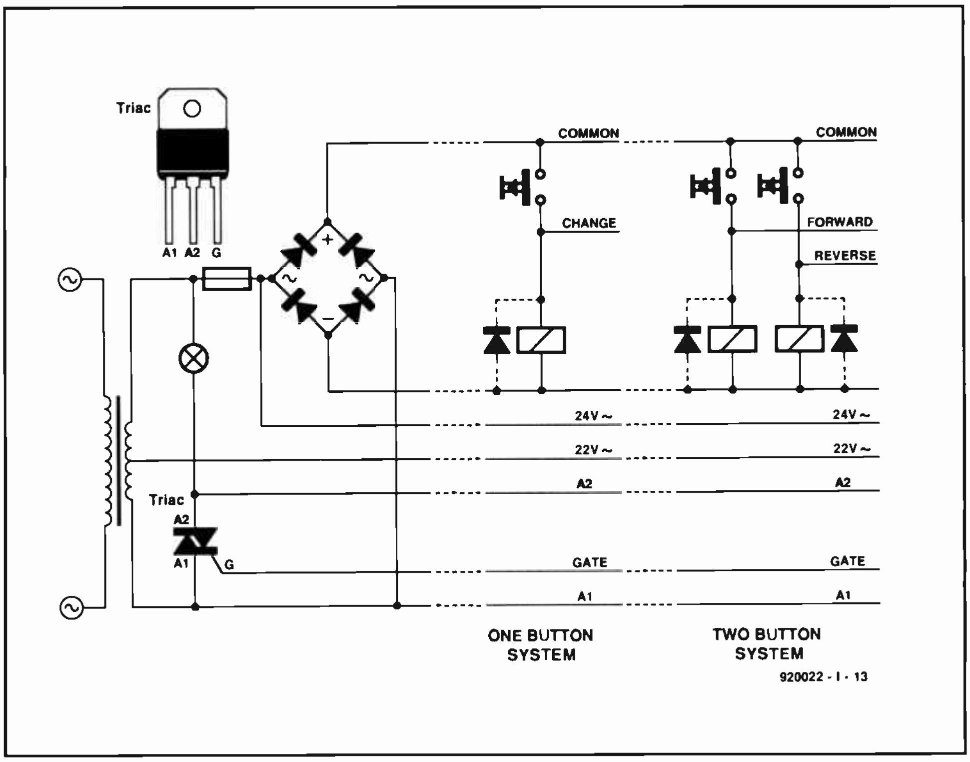


Fig. 3. Typical lamp/solenoid circuit in one-button and two-button slide projectors. Mind you: the triac is not fitted in all projectors!

S1-1	S1-2	S1-3	S1-4	Function
on	on	X	X	Bank 1: projector 1-4
off	on	X	X	Bank 2: projector 5-8
off	off	X	X	Bank 3: projector 9-12
on	off	X	X	Bank 4: projector 13-16
X	X	on	on	2 projectors in manual mode
X	X	off	on	2 projectors in manual mode
X	X	on	off	3 projectors in manual mode
X	X	off	off	4 projectors in manual mode

Table 1. Switches S1-1 and S1-2 set the dissolve unit bank selection, while switches S1-3 and S1-4 set the number of projectors when manual control is used.

the counter state exceeds the preset value, a pulse train is sent to the triac gate. This train lasts until the next zero-crossing occurs. A simple filter, R3-C1, is fitted to prevent excessive 'pollution' of the dissolve unit power supply voltage. The projector connections of all four projectors are gathered on K7, from where a length of flatcable takes them to K13. This connector, in turn, is wired to DIN connectors for the four individual projectors.

The display

The display consists of two parts: a counter display (eight 7-segment displays) and the lamp display (24 LEDs). Both displays are multiplexed in a simple way by software that varies the data applied to IC9 and IC10. In both cases, the addressed display section is determined by a part of the latched dataword (the two highest bits on IC9, and bits D4, D5 and D6 on IC10). A decoder IC is used to produce numbers on the display. The decoder converts a 4-bit number into a 7-segment code. The remaining bit, D7, is used to drive the decimal point.

LEDs D15, D21, D27 and D33 indicate the slide changing operations, while the remaining LEDs indicate the set lamp brightness.

A switch, S3, on the main board allows the display to be switched to a lower intensity in case the light it emits is distracting (in the dark, during a slide show).

The control protocol

Those of you who wish to build the complete DiAV system can make use of the extensive control software developed for it. Alternatively, you may wish to have a go at producing your own control software, for which it is, of course, necessary to know the programming details of the

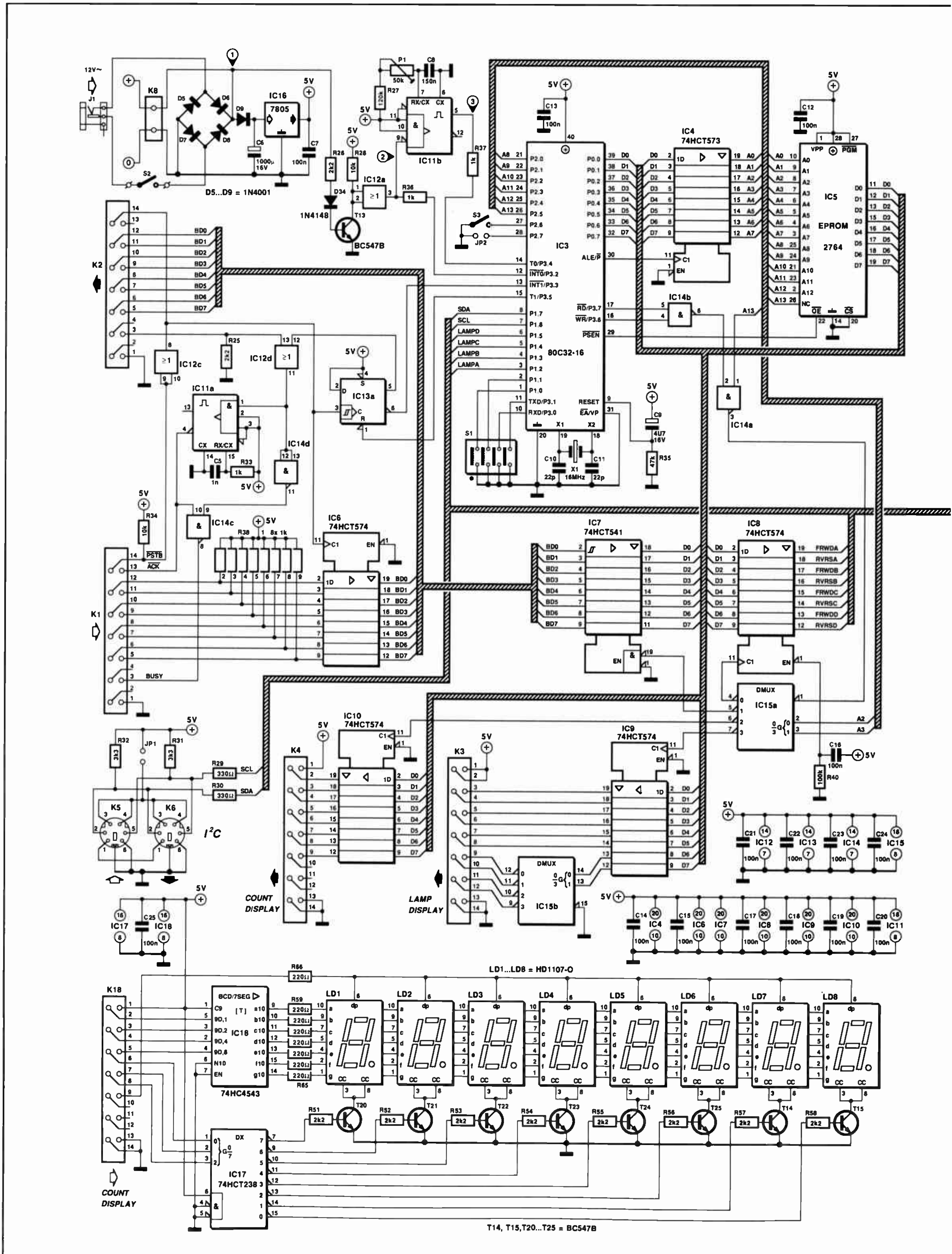
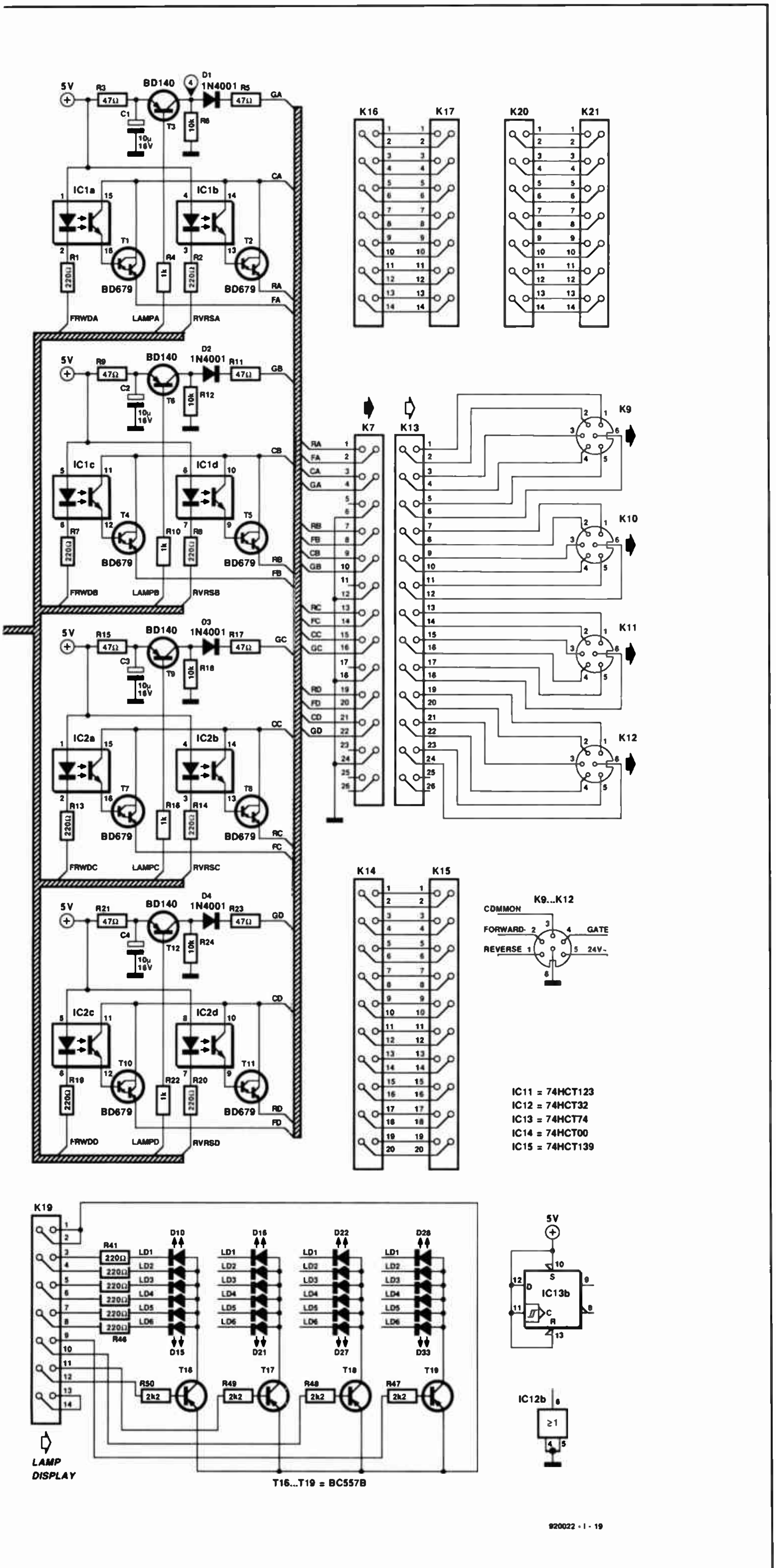


Fig. 4. Circuit diagram of the dissolve unit. At the heart of the circuit is a 16-MHz 80C32 CPU.



Centronics interface or the manual control.

As already mentioned, the present dissolve unit uses the same protocol as the Centronics interface described in Ref. 2. A control cycle consists, in principle, of two databytes sent one after another: the projector control byte and the databyte proper. The first selects the desired projectors and the associated bank of four projectors, while the databyte determines the way the selected projectors are controlled. The functions of the bits in the projector control byte and the projector databyte are given in Tables 2 and 3.

A projector control byte always has two 'ones' in the two highest bit positions. In the databyte, these positions form separate indicators for the carrier forward/reverse control. The remaining six bits in the databyte determine the lamp brightness in the selected projector. The bank selection bits in the projector control byte must match the settings of switches S1 and S2 for the selected unit to be addressed. In principle, it is possible to select all four projectors in a control byte, after which only one databyte is required to issue the same command to all four projectors. This can be done without problems when the 'old' Centronics interface is used. The present interface, however, responds differently: on receiving a 4-projector selection word (control byte 1100 00xx), it switches the dissolve unit to its set-up (initialization) mode. If the command is followed by a databyte '0', the four projectors will not only have their lamps dimmed completely, but the display is reset also. Next, a number of settings can be selected. The set-up mode is left on receipt of a carriage return (0DH) or a line feed (0AH) command. Table 4 shows an overview of the set-up options.

D7	1	control word ID
D6	1	
D5	P4	0 selects projector 4
D4	P3	0 selects projector 3
D3	P2	0 selects projector 2
D2	P1	0 selects projector 1
D1	X	bank selection
D0	X	

Table 2. Bit functions in the projector control byte.

D7	1 = change forward
D6	1 = change reverse
D0-D5	lamp intensity

Table 3. Bit functions in the projector databyte.

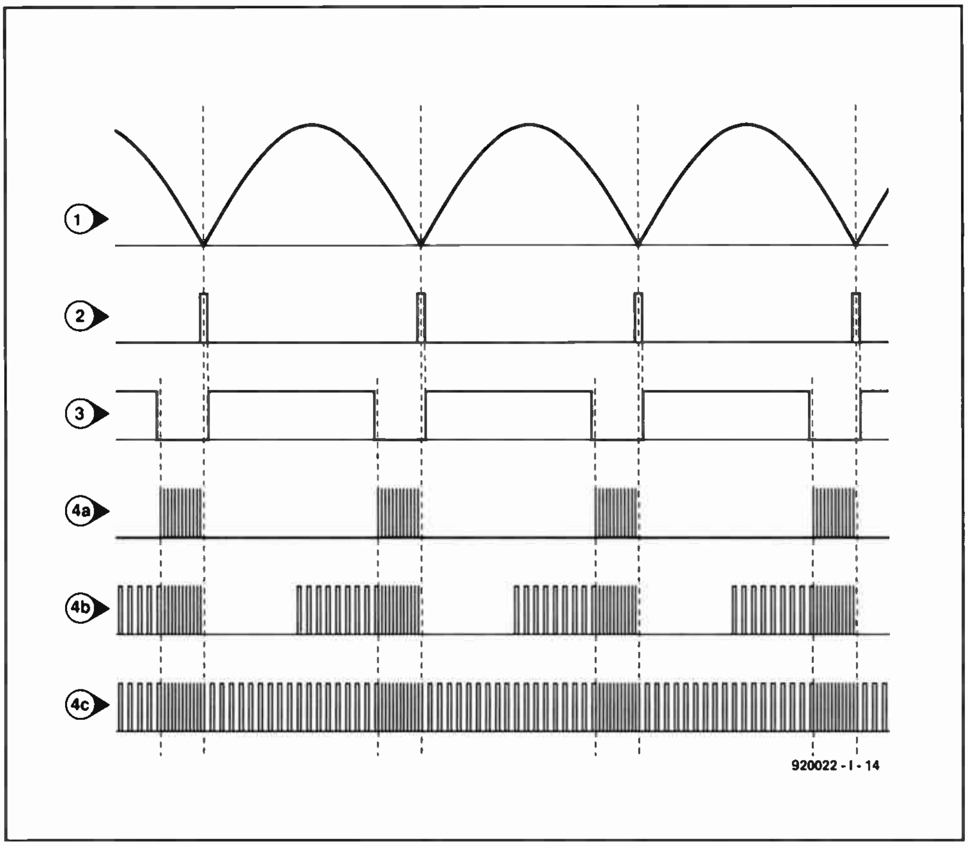


Fig. 5. Timing diagrams to illustrate the relation between the zero-crossings and the gate control signal.

The listing in Fig. 6 is an example of a simple BASIC program containing LPRINT statements to control the dissolve unit. Note the use of the semicolon (;) after each control byte. If you forget this character, the CR/LF sequence that follows it is taken to be a databyte. The semicolon is not required after databytes, because the projector selection is reset after each databyte. Just for the sake of completeness, Fig. 7 shows the wiring of the Centronics cable between the PC and the dissolve unit.

The manual control is connected to one of the I²C inputs as shown in Fig. 14. Switches S4 and S5 select between forward or reverse overflow respectively, or, after pressing S6, between lengthening or shortening the overflow time.

Connecting the projectors

It was already mentioned that some projectors have an internal triac to control the lamp brightness, while others require the triac to be connected as an external part. Those of you who feel less confident about modifying the electrics of the slide projector are best off with an 'internal triac' type of projector. In case such a projector is not available, there is no other option than to

```
10 ' Automatic dissolve program for [illegible] SLIDE CONTROLLER
20 ' A$ can be equal to '123456 @ABCDEFG'
30 ' or part of it, each defining one projector
40 CLS : LOCATE 5,10
50 A$="1234": PRINT "The projectors selected are ";A$
60 LOCATE 7,10 : PRINT " SPACE   for next projector"
70 LOCATE 8,10 : PRINT " ENTER  or  R  for previous projector"
80 LOCATE 10,10 : PRINT " F   for fast dissolve"
90 LOCATE 12,10 : PRINT " N   for normal dissolve"
100 LOCATE 13,10: PRINT " L   for long dissolve"
110 LOCATE 14,10: PRINT " Q   to exit"
120 B$=""
130 IF LEN A$ >15 OR LEN A$ =0 THEN GOTO 1040
140 '..................... Calculate the projector addresses
150 FOR I=1 TO LEN A$
160    B=ASC(MID$(A$,I,1))
170    [illegible]
180       [illegible]: GOTO 230
190       [illegible]
200       [illegible]: GOTO 230
210    [illegible]
220    B=B-[illegible]
230   B=[illegible]
240   B$=B$+CHR$(B)
250 NEXT
260 '....................... Initialize constants
270 PROJECTOR = 2 '.......... Select double button
280 CS = 3 ' ............... CS switches high low
290 DISPLAY = 6 ' .......... Display high intensity
300 BAR = 4 '............... and display as centered bar
310 '....................... The next constants have to
320 '....................... be adjusted according to your
330 '....................... system speed
340 F=160:  '............... forward changing time
350 R=320: '................ reverse changing time
360 T=400: '................ total changing time
370 W=700: '................ wait after dissolve before changing
380 S=1000: '............... basic dissolve speed
390 '....................... projectors off
400 '....................... and reset of display
410 '....................... and setup
420 LPRINT CHR$(192);CHR$(193);CHR$(194);CHR$(195);CHR$(5);
430 LPRINT CHR$(PROJECTOR);CHR$(CS);CHR$(DISPLAY);CHR$(BAR);
440 '....................... Main loop
450 X=0: Y=0: L=LEN(A$)-1: D=2*S :FIRST =1
460 C$=" rRfFnNlLqQ"+CHR$(13)
470 I$=INKEY$ : IF I$="" THEN 470
480 CHAR=0
490 FOR I=1 TO LEN(C$)
500   IF I$=MID$(C$,I,1) THEN CHAR=1
510 NEXT
520 IF CHAR <>1 THEN 470
530 IF I$=" " THEN GOSUB 630
540   IF I$=CHR$(13) OR I$="r" OR I$="R" THEN GOSUB 730: GOTO 470
550   LOCATE 11,8 : PRINT " "
560   IF I$="f" OR I$="F" THEN D=S :LOCATE 11,8: PRINT "*"
570   LOCATE 12,8 : PRINT " "
580   IF I$="n" OR I$="N" THEN D=2*S :LOCATE 12,8: PRINT "*"
590   LOCATE 13,8 :PRINT " "
600   IF I$="l" OR I$="L" THEN D=3*S :LOCATE 13,8:PRINT "*"
610   IF I$="q" OR I$="Q" THEN CLS : END
620 GOTO 470
630 '....................... Next projector
640 FIRST =0
650 Y=X
660 X=ASC(LEFT$(B$,1))
670 A$=RIGHT$(A$,L)+LEFT$(A$,1)
680 B$=RIGHT$(B$,L)+LEFT$(B$,1)
690 GOSUB 840
700 LOCATE 17,10: PRINT "Projector ";RIGHT$(A$,1);" is on"
710 DA=128: C=F: GOSUB 910
720 RETURN
730 '........................ Previous projector
740 IF FIRST =1 THEN 830
750 Y=ASC(MID$(B$,L,1))
760 DA=64: C=R: GOSUB 910
770 Y=X
780 A$=RIGHT$(A$,1)+LEFT$(A$,L)
790 B$=RIGHT$(B$,1)+LEFT$(B$,L)
800 X=ASC(RIGHT$(B$,1))
810 GOSUB 840
820 LOCATE 17,10: PRINT "Projector ";RIGHT$(A$,1);" is on"
830 RETURN
840 '........................ Dissolve
850 FOR I=0 TO 63
860 LPRINT CHR$(X); CHR$(I-1*(I=9))
870 LPRINT CHR$(Y); CHR$(63-I+(63-I=9))
880 FOR J=0 TO D: NEXT
890 NEXT
900 RETURN
910 '.......................... Change slide
920 FOR I=0 TO 100  ' ..... wait before change
930 FOR J=0 TO W : NEXT
940 NEXT
950 LPRINT CHR$(Y);CHR$(DA)
960 FOR I 0 TO 100
970 FOR J=0 TO C: NEXT: '....... changing time
980 NEXT
990 LPRINT CHR$(Y);CHR$(0)
1000 FOR I 0 TO 100
1010 FOR J 0 TO T C : NEXT
1020 NEXT: '.. Wait before next dissolve is allowed
1030 RETURN
1040 CLS: LOCATE 5,10: PRINT "Error in line 50 adjust A$"
1050 END
```

Fig. 6. A simple BASIC program to get you started with the dissolve unit. The projectors used (here: 1 to 4) are identified in line 50.

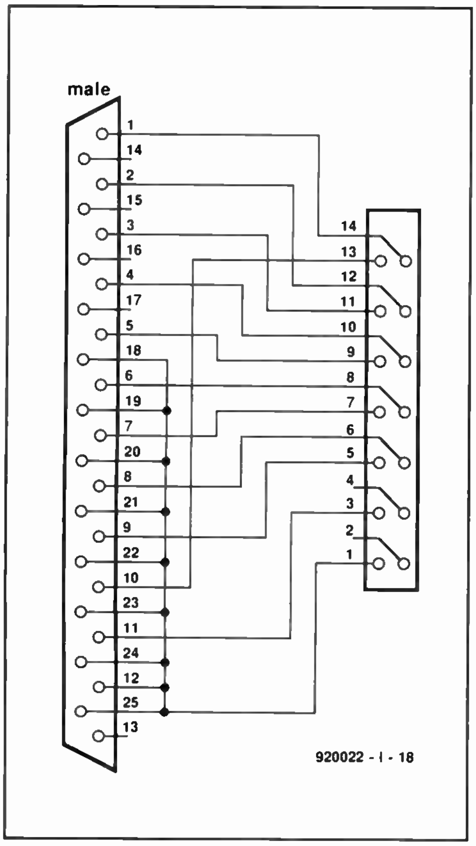


Fig. 7. Overview of connections between the PC's Centronics output and the dissolve unit.

00h	reset display and gate triggering
01h	single button projectors: change on pin 2 of K9-K11
02h	double button projectors: forward change on pin 2 of K9-K11 reverse change on pin 1 of K9-K11
03h	S3 switches display on/off
04h	S3 switches between high and low intensity
05h	set display high intensity
06h	set display low intensity
07h	lamp indicator as linear bar
08h	lamp indicator as centred bar
09h	—
0Ah	setup end
0Dh	setup end

Table 4. These setup comands can be issued to the dissolve unit after sending a setup control byte (1100 00xx).

install the triac yourself as an upgrade to the projector. Here, we show you how to do this — it is not very difficult.

Unfortunately, there is a hardware compatibility problem to begin with: manufacturers of slide projectors use different connectors for the triac control input. Figure 8 shows the three most commonly found connector types. Still other connectors and pin assignments exist, so you are well advised to consult the user manual that came with the projector. The 6-way DIN connector (Fig. 8a) is used for our system. On the projector, the overflow or AV socket is usually marked by two small triangles (see Fig. 9). Figure 10 shows the construction of the connecting cable for the 6-way DIN and the 10-way DIN versions.

Projectors with an RTG22 connector require a separate triac module to be made.

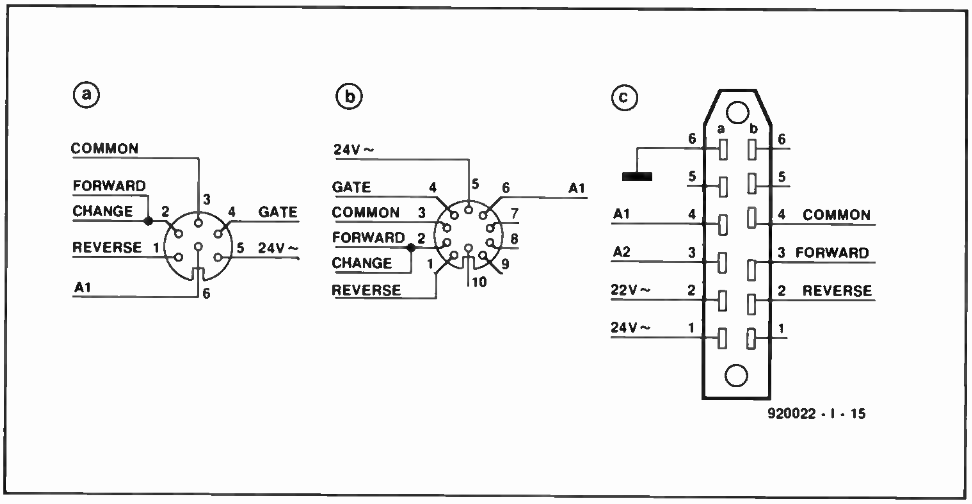


Fig. 8. Overview of the most commonly used slide projector connection systems. Figure 8a shows the 6-way version which is also used for the DiAV. In addition to this connection, you may also come across 10-way DIN (8b) and 12-way RTG22 (8c) versions (the latter nearly always on carousel type projectors).

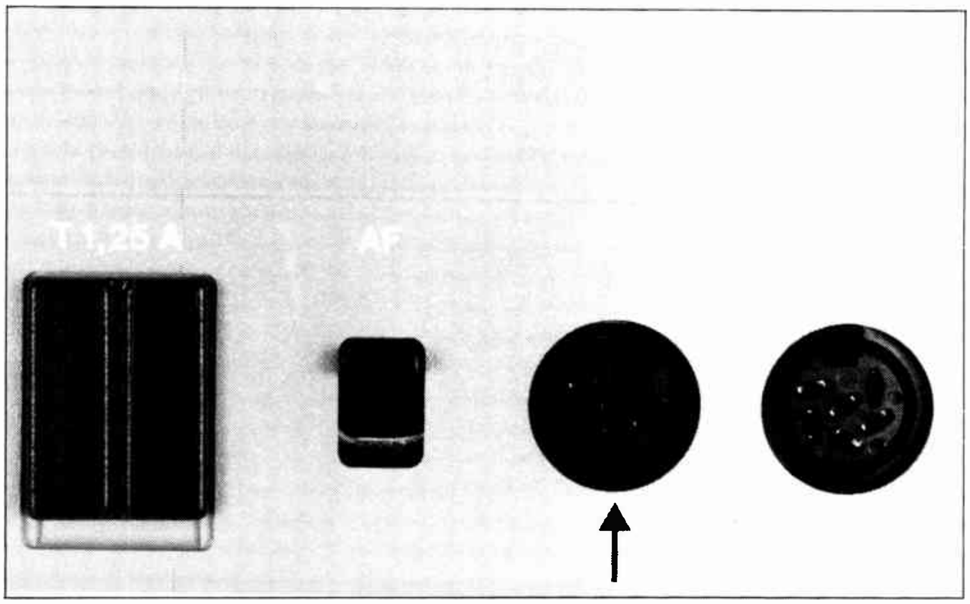


Fig. 9. Showing the AV (audio-visual) legend on projectors with an internal triac.

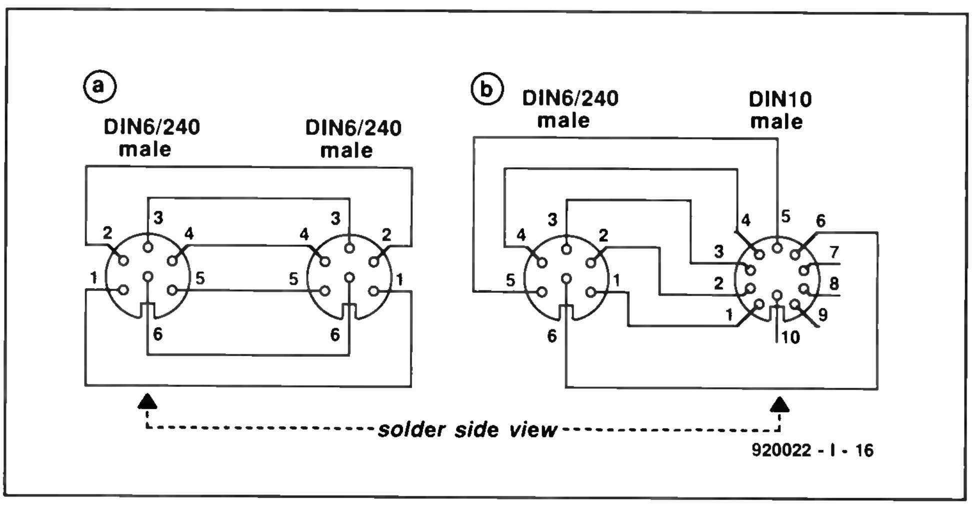


Fig. 10. Construction of the connecting cables.

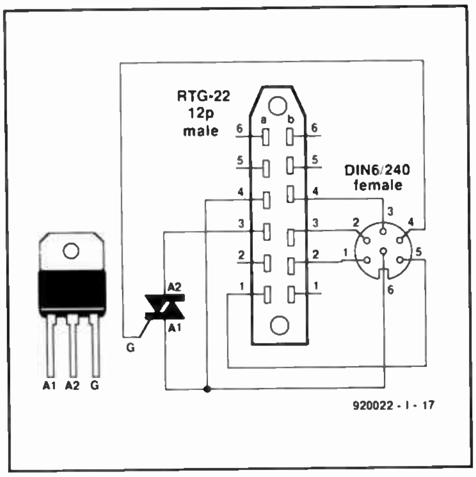


Fig. 11. Those of you who wish to make use of a carousel slide projector will have to connect the triac as an external module. The necessary parts and connections are shown here.

Fig. 14. This photograph illustrates how the triac module is constructed. Do not forget to fit the triac with a thermal insulation set.

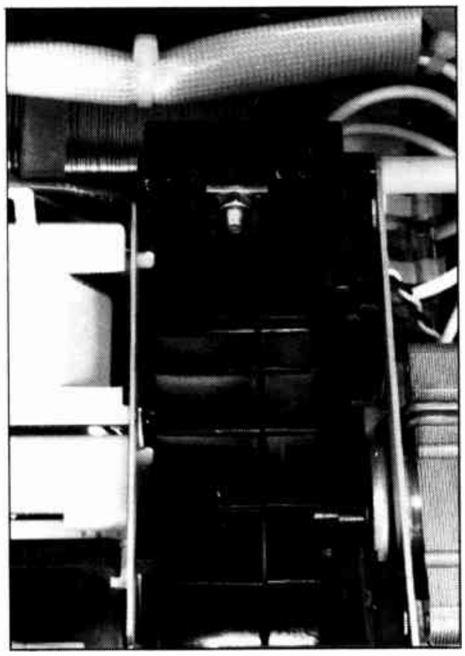


Fig. 12. Illustrating the internal triac upgrade. The triac is fitted as close as possible to the fan to ensure it is adequately cooled.

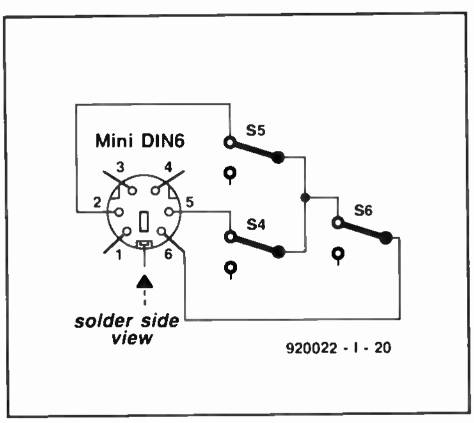


Fig. 13. Construct this simple connecting cable if you wish to use the dissolve unit as an independent control for your slide projector. This is achieved by making use of the I2C interface on the unit.

This module is connected via a 6-to-6-way cable as illustrated in Fig. 11. The module is a small diecast aluminium case drilled to accept the connectors, the triac and a heat-sink. Its construction is illustrated in Fig. 14. In view of the high currents (up to 10 A), the A1 and A2 terminals of the triac should be connected with short lengths of fairly thick wires (1.5 mm² or SWG17). Bend the anode terminals around the wire ends before soldering, so that the junction can never come loose even when very high temperatures are reached.

So far, we have assumed that the triac is contained in the projector. However, this is not usually the case with inexpensive projectors, which must be upgraded. If you do so, stick to one of the connection diagrams shown in Fig. 8, preferably 8a or 8b. The reason is obvious: compatibility! Mount the triac on a small heat-sink, close by the fan (see Fig. 12). Do not forget to use an insulating washer and mounting bush. For 150-W projectors, use a TIC236 triac, or a TIC263 for 250-W types. The triac may be tested by connecting its gate terminal to the 24-V a.c. source via a 1-kΩ resistor, whereupon the lamp should light.

To be continued...

This is the first of four instalments. The next instalment will discuss the construction and testing of the dissolve unit. Also, details will be given on the use of the multi-purpose Z80 card as the main unit in the DiAV system. For this purpose, some components on the Z80 card need to be changed with respect to the original design.

Although the DiAV is a modular system, some of you may want to built it as a self-contained, compact unit. Part 3 of this article series will, therefore, show how the timecode interface, the main unit and one dissolve unit may be fitted into a single enclosure.

The last part of the article will describe the software and the user options created in the system. ❑

References

1. 'Computer-controlled slide fader'. *Elektor Electronics* March and April 1988.
2. 'Centronics interface for slide fader'. *Elektor Electronics* December 1988.
3. 'Multi-purpose Z80 card'. *Elektor Electronics* May and June 1992.
4. 'Timecode interface for slide controller'. *Elektor Electronics* July/August and September 1991.

8051/8032 ASSEMBLER COURSE

PART 8 (FINAL): LCD AND KEYBOARD INTERFACING

By Dr. M. Ohsmann

In this last instalment of the course we first deal with an ever popular subject: how to connect a liquid crystal display (LCD) to the 80C32 single-board computer. LCD modules with one or two text lines are available at relatively low cost these days, and are simple to drive from the 80C32 SBC, as will be shown below.

LC displays

Many stand-alone microcontroller applications require an output device to display texts, numbers and measurement data. An LCD module is ideal for this purpose. For instance, it allows a sequence of user entries to be given a menu-like structure which uses only a couple of keys as the hardware.

To keep the connection of an LCD as simple as possible, a special interface is provided on the 80C32 extension board.

Connections

The electrical connections between the extension board and the LCD are established by a 14-way flatcable. It is assumed here that the LCD has a Hitachi Type HD44780 controller, or a direct equivalent. Unfortunately, the pinning of the connectors on the LCDs that can be used is not standard, so you are well advised to ask for a datasheet when purchasing a display. Suitable types include the H2570 (Hitachi), LM016L and LM1612A (Sharp), and VK2116L (Vikay). The pinning of LCD connector K1 (on the 80C32 extension board) is given in Fig. 50. This information must be used to make the cable to the connector on the LCD. The LCD enable signal is generated after a read (RD=1) or write (WR=1) operation to address 0C009H or 0C001 respectively. The level of address line IOA3 then determines whether the read/write operation concerns display data (RS=IOA3=0; address 0C009H), or a display command (RS=IOA3=0; address 0C001H). The R/W\ terminal of the LC display is connected directly to the RD output of the 80C32 SBC.

Commands and data are exchanged via the bidirectional databus. The display itself can work in 4-bit mode (bits 0-3) or 8-bit mode (bits 0-7). Since we are working with an 8-bit microcontroller, and the display is wired to the databus, it is self-evident that the LCD is programmed to operate in 8-bit transfer mode. However, if you wish to interface the LCD to, say, a PORT, it may be wiser to use 4-bit transfer mode, since this reduces the number of PORT lines used.

Voltage V0 on K1 terminal 3 serves to set the LCD contrast. The setting can be adjusted depending on the ambient light intensity and the viewing angle. Before connecting the LCD, make sure that it is properly connected — when in doubt, consult the datasheets.

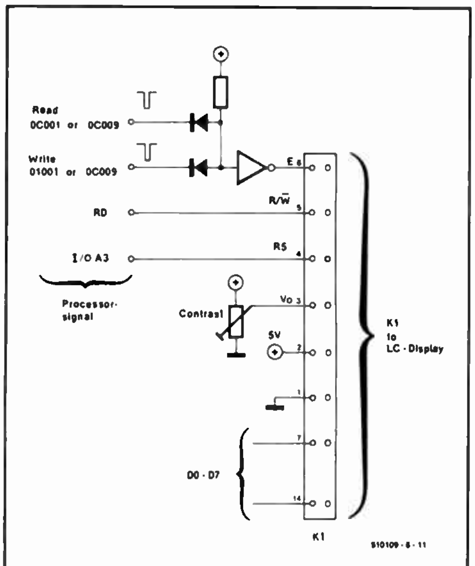


Fig. 50. Connecting the LCD to the 80C32 SBC extension card.

Instruction	RS	R/W̄	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Description	Execution Time (when f_{cp} or f_{osc} is 250KHz)
Clear Display	0	0	0	0	0	0	0	0	0	1	Clears all display and returns the cursor to the home position (Address 0)	82 μs ~ 1 64ms
Return Home	0	0	0	0	0	0	0	0	1	*	Returns the cursor to the home position (Address 0) Also returns the display being shifted to the original position DD RAM contents remain unchanged	40 μs ~ 1 6ms
Entry Mode Set	0	0	0	0	0	0	0	1	I/D	S	Sets the cursor move direction and specifies or not to shift the display These operations are performed during data write and read	40 μs
Display ON/OFF Control	0	0	0	0	0	0	1	D	C	B	Sets ON/OFF of all display (D), Cursor ON/OFF (C), and blink of cursor position character (B)	40 μs
Cursor or Display Shift	0	0	0	0	0	1	S/C	R/L	*	*	Moves the cursor and shifts the display without changing DD RM contents	40 μs
Function Set	0	0	0	0	1	DL	N	F	*	*	Sets interface data length (DL), number of display lines (L), and character font (F)	40 μs
Set CG RAM Address	0	0	0	1	A_{CG}						Sets the CG RAM address CG RAM data is sent and received after this setting	40 μs
Set DD RAM Address	0	0	1	A_{DD}							Sets the DD RAM address DD RAM data is sent and received after this setting	40 μs
Read Busy Flag & Address	0	1	BF	AC							Reads Busy flag (BF) indicating internal operation is being performed and reads address counter contents	1 μs
Write Data to CG or DD RAM	1	0	Write Data								Writes data into DD RAM or CG RAM	40 μs
Read Data to CG or DD RAM	1	1	Read Data								Reads data from DD RAM or CG RAM	40 μs
	I/D = 1 Increment; I/D = 0 Decrement S = 1 Accompanies display shift S/C = 1 Display shift; S/C = 0 Cursor move R/L = 1 Shift to the right R/L = 0 Shift to the left DL = 1 8 bits; DL = 0 4 bits N = 1 2 lines; N = 0 1 line F = 1 5 x 10 dots; F = 0 5 x 7 dots BF = 1 Internally operating BF = 0 Can accept instruction										DD RAM Display data RAM CG RAM Character generator RAM A_{CG} CG RAM address A_{DD} DD RAM address Corresponds to cursor address AC Address counter used for both of DD and CG RAM address	Execution time changes when frequency changes (Example) When f_{cp} or f_{osc} is 270 KHz $40\mu s \times \frac{250}{270} = 37\mu s$

*Don't care

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Fig. 51. LCD controller command set.

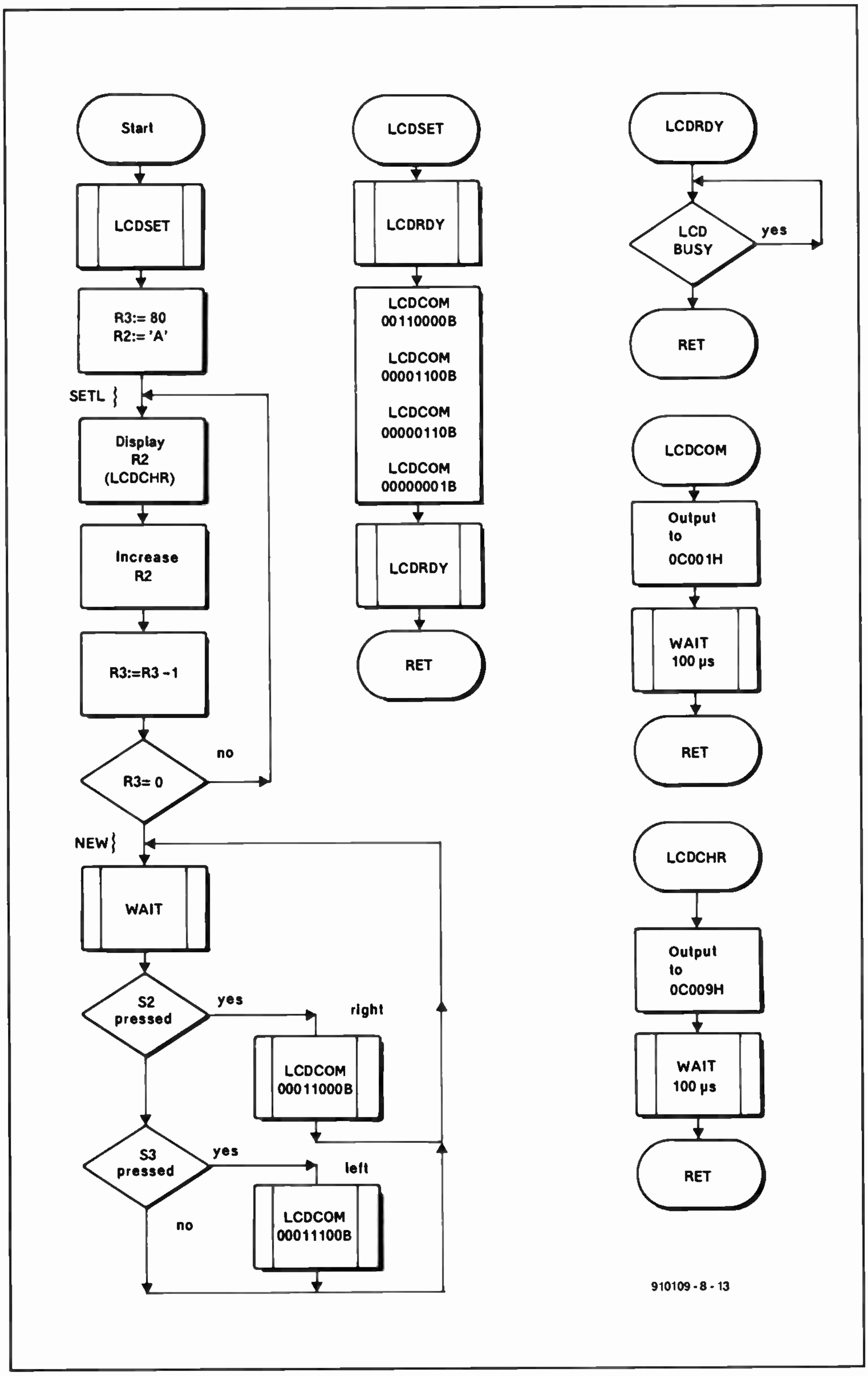

Fig. 52. Flowchart of the LCD driver program.

MCS-51 PROGRAMMING

A COURSE IN 8 INSTALMENTS

Hardware/software requirements:

- **a 8032/8052AH-BASIC single board computer as described in Elektor Electronics May 1991. The preferred CPU is a 8051 or 80C32. Alternatively, any other MCS51-based microcontroller system (but read part 1 of the course);**
- **a course diskette (IBM: order code ESS 1661; Atari: order code ESS 1681) containing programming examples, hex file conversion utilities, and an assembler;**
- **a monitor EPROM (order code ESS 6091);**
- **an IBM PC or compatible operating under MS-DOS, or an Atari ST with a monochrome display.**

Overview of publications:

Part 1: Introduction (February 1992)
Part 2: First 8051 instructions (March 1992)
Part 3: Hardware extensions for 80C32 SBC (April 1992)
Part 4: Flags, bit addressing, PSW, conditional jumps, logic operators (June 1992)
Part 5: Arithmetic instructions (July 1992)
Part 6: Analogue signal processing and stack management (September 1992)
Part 7: Serial interface programming (October 1992)
Part 8: LCD and keyboard interfacing (November 1992).

LCD commands

The Hitachi LCD controller databook devotes some 30 pages to a full description of all possibilities offered by the controller-plus-LCD combination. Hence, we are forced to limit ourselves to the most important commands, in the knowledge that more extensive information is available from the manufacturer.

Many LCDs capable of displaying the ASCII character set have the same LCD controller IC, and thus the same command set. The one listed in Fig. 51 is valid for the popular LCD modules Type H2570, LM016L and LM1612A.

To begin with, a few words about the basic operation of these displays with integrated controller. The display has an internal buffer with a capacity of 80 characters. This is the Display Data RAM, DD-RAM, at addresses 000H to 04FH. A display with one line of 16 characters displays the characters contained between 00H to 0FH, starting at the left side of the screen. In this way, a kind of window is created, which can be shifted by the Display Shift command. This works in a simple manner: while the characters remain stored at the same address in the DD-RAM, the window in the DD-RAM is given a different start address.

With a two-line display such as the LM16255, the top line displays the characters starting at 000H, and the second line displays the characters starting at 040H. This is what makes two-line LCDs a little more difficult to program than one-line types.

Then there is the cursor, which determines the position (in the DD-RAM) of the next character. This position is called the address counter in the following description. The cursor may be visible or invisible, depending on the way it is programmed. It may also flash, if desired. By appropriate programming, you can select between a display shift and a cursor movement when a character is transferred to the LCD. This enables a horizontally scrolling text to be displayed relatively easily.

Finally, the LCD has an on-board character RAM, designated CG-RAM, in which you can store the pixel outlines of ASCII codes 0 to 7. The exact organization of the CG-RAM is given in the datasheets. This RAM allows you to define your own characters.

Commands are sent to the LCD by outputting the desired code to address 0C00H (i.e., RS is low, and R/W\ also).

After this brief introduction follows a short description of the various LCD commands. The asterisk in the examples below stands for 'bit level irrelevant'.

Clear Display
0 0 0 0 0 0 0 1

This command causes all DD-RAM locations to be filled with 20H (= ASCII 'space'). The cursor is set to position 0, as is the display window, which negates the effect of any previously given Display Shift command.

Return Home
0 0 0 0 0 0 1 *

Resets the cursor to position 0, and resets any previously given Display Shift. The contents of the DD-RAM are not changed.

Entry Mode Set
0 0 0 0 0 1 I/D S

This command serves to determine what happens after a databyte has been transferred to the display. The increase/decrease (I/D) bit determines whether the internal DD-RAM is automatically increased (I/D=1) or decreased(I/D=0) when a character is read or written. The value of this address is stored in the address counter, AC.

The shift bit, S, indicates if a display shift is to occur automatically in the direction set by the I/D bit. This shift occurs when S=1, and does not occur when S=0. During the shift, the cursor retains its position inside the display window.

Display ON/OFF Control
0 0 0 0 1 D C B

This command enables us to switch the display and the cursor on and off without changing the contents of the DD-RAM. The display is switched on and off by programming D=1 and D=0 respectively. Similarly, C=1 and C=0 switch the cursor on and off, and the same goes for the 'blink' (B) bit.

Cursor or Display Shift
0 0 0 1 S/C R/L * *

This command is used to move the cursor or shift the display. It is essential if you want to program a horizontally scrolling text. The options are:

S/C	R/L	
0	0	Cursor left
0	1	Cursor right
1	0	Display left, cursor follows display
1	1	Display right, cursor follows display

Function Set
0 0 1 DL N F * *

DL=1: 8-bit interface
DL=0: 4-bit interface
N=0: one line
N=1: two lines

Only on some types:
F=0: 5×7 dot matrix
F=1: 5×10 dot matrix

This command sets the display's mode of operation after the reset at switch-on. We will be using the LCD in 8-bit mode with one line.

Set CG RAM Address
0 1 a5 a4 a3 a2 a1 a0

This command prepares the LCD for a data transfer to the character RAM by fixing the CG address for the next byte to be conveyed. Bits a0 and a5 form the address to be loaded into the address counter, AC.

Set DD RAM address
1 a6 a5 a4 a3 a2 a1 a0

This command prepares the LCD for a data transfer to the display data RAM (DD-RAM) by fixing the DD-RAM address for the next byte to be conveyed. Bits a0 to a6 form the address to be loaded into the address counter, AC.

Read Busy Flag
Read back:
BF a6 a5 a4 a3 a2 a1 a0
(where R/W\=1)

When BF=1, the display is busy processing the previous command, and can not accept a new command or data. When BF=0, the display is ready to accept a new command, or new data. At the same time, the value of the AC is read.

Write DATA to CG or DD-RAM
Data:
d7 d6 d5 d4 d3 d2 d1 d0
(where R/W\=0; RS=1)

Depending on whether a CG-RAM address or a DD-RAM address was sent, this command takes a byte into the respective memory area. The mode defined with the aid of the Entry Mode command determines whether the AC is increased or decreased after the byte has been conveyed.

Read DATA from CG or DD-RAM
Data:
d7 d6 d5 d4 d3 d2 d1 d0
(where R/W\=1; RS=1)

This command allows bytes to be read from the CG-RAM or the DD-RAM. Before this command, the address must have been conveyed by SET CG ADDRESS or SET DD ADDRESS.

Display test

The flowchart and assembly listing of a simple LCD test program are given in Figs. 52 and 53 respectively. The function of the program is simple: first, a text is written to the display. Next, the display contents can be shifted to the left or to the right by pressing a key.

The example program on your course disk (XAMPLE12.A51) contains a number of subroutines which you may use in your own programs. The operation of each of these routines will be discussed below.

LCD subroutines

Subroutine **RCOM** fetches the state of the LCD into the accumulator. This is achieved by setting Port P2 to the high byte of the display address, 0C01H. The lower address byte is loaded into register R0. Next, a MOVX instruction is used to read out the LCD's BUSY flag, which appears in accumulator bit position 7. As mentioned earlier in this course, Port P2 is used as the high address byte with indirect addressing of the external memory.

Subroutine **LCDRDY** waits until the LCD BUSY flag is at 0. RCOM is used for this function. LCDRDY is used during the relatively 'slow' LCD initialization commands, to make sure that the LCD has actually accepted the command conveyed.

Subroutine **WT1** waits 100 µs. Since most LCDs have a display command execution time shorter than 100 µs, this subroutine may be used to wait for a display command to finish.

Subroutine **LCDCOM** conveys a command (RS=0) to the display. The addressing method is the same as that used with the MOVX instruction in the RCOM subroutine. The command is followed by a 100-µs delay.

Subroutine **LCDCHR** sends a character to the character RAM (DD-RAM) of the display (RS=1), and then waits 100 µs. Before calling LCDCHR, it may be neces-

```
****** LISTING of EASM51 (XAMPLE12) ******
LINE LOC  OBJ        T          SOURCE
   1 0000                ; ****** FILE XAMPLE12.A51 ************************************
   2 0000                P2      EQU   0A0H  ; for higher address
   3 0000                ACC     EQU   0E0H
   4 0000                Addrhi  EQU   0C0H  ;  MSB of LCD address C001H or C009H
   5 0000                addrRS0 EQU   001H  ;  LCD LS byte of address with RS=0
   6 0000                addrRS1 EQU   009H  ;  LCD LS byte of address with RS=1
   7 0000                ;
   8 0000                        ORG 4100H
   9 4100 31 2F      [2] START   ACALL LCDSET        ; initialize LCD
  10 4102 7B 50      [1]         MOV   R3,#80        ; 80 characters
  11 4104 7A 41      [1]         MOV   R2,#'A'       ; starting with A
  12 4106 EA         [1] SETL    MOV   A,R2
  13 4107 31 4F      [2]         ACALL LCDCHR        ; display on LCD
  14 4109 0A         [1]         INC   R2            ; next character
  15 410A DB FA      [2]         DJNZ  R3,SETL       ; repeat
  16 410C 31 24      [2] NEW     ACALL WAIT          ; wait
  17 410E 90 C0 00   [2]         MOV   DPTR,#0C000H ; read keys
  18 4111 E0         [2]         MOVX  A,@DPTR
  19 4112 30 E7 05   [2]         JNB   ACC.7,RIGHT  ; test bits 7 and 6
  20 4115 30 E6 08   [2]         JNB   ACC.6,LEFT
  21 4118 80 F2      [2]         SJMP  NEW           ; nothing to do
  22 411A 74 18      [1] RIGHT   MOV   A,#00011000B ; shift display S/C=1 R/L=0
  23 411C 31 47      [2] OUT     ACALL LCDCOM        ; send as LCD command
  24 411E 80 EC      [2]         SJMP  NEW
  25 4120 74 1C      [1] LEFT    MOV   A,#00011100B ; shift display S/C=1 R/L=1
  26 4122 80 F8      [2]         SJMP  OUT
  27 4124                ;
  28 4124 78 FF      [1] WAIT    MOV   R0,#255       ; wait a while
  29 4126 79 FF      [1] WAIT1   MOV   R1,#255
  30 4128 00         [1] WAIT2   NOP                 ; 255*4 microsec
  31 4129 00         [1]         NOP
  32 412A D9 FC      [2]         DJNZ  R1,WAIT2
  33 412C D8 F8      [2]         DJNZ  R0,WAIT1      ; * 255
  34 412E 22         [2]         RET                 ; approx. 65500*4 microsecs
  35 412F                ;                           ; LCD driver routines
  36 412F 31 41      [2] LCDSET ACALL  LCDRDY        ; wait for last command to complete
  37 4131 74 30      [1]        MOV    A,#00110000B ; DL=1 N=0 F=0 : 8 bit , one line , 5*7 dots
  38 4133 31 47      [2]        ACALL  LCDCOM        ; as command
  39 4135 74 0C      [1]        MOV    A,#00001100B ; D=1 C=0 B=0, display on, cursor/flash off
  40 4137 31 47      [2]        ACALL  LCDCOM
  41 4139 74 06      [1]        MOV    A,#00000110B ; I/D=1 S=0 : increment w. display shift
  42 413B 31 47      [2]        ACALL  LCDCOM
  43 413D 74 01      [1]        MOV    A,#00000001B    ; reset Display
  44 413F 31 47      [2]        ACALL  LCDCOM
  45 4141 31 5A      [2] LCDRDY ACALL  RCOM              ; wait until LCD ready
  46 4143 20 E7 FB   [2]        JB     ACC.7,LCDRDY      ; bit 7 = BUSY-Flag
  47 4146 22         [2]        RET
  48 4147                ;
  49 4147 75 A0 C0   [2] LCDCOM MOV    P2,#Addrhi        ; send command to LCD
  50 414A 78 01      [1]        MOV    R0,#addrRS0       ; RS=low <=> command
  51 414C F2         [2]        MOVX   @R0,A             ; output at address P2,R0
  52 414D 80 06      [2]        SJMP   WT1               ; wait
  53 414F                ;
  54 414F                LCDCHR EQU $                    ; output character via LCD
  55 414F 75 A0 C0   [2]        MOV    P2,#Addrhi        ; MS address
  56 4152 78 09      [1]        MOV    R0,#addrRS1       ; RS=high <=> data
  57 4154 F2         [2]        MOVX   @R0,A             ; output at address P2,R0
  58 4155 78 32      [1] WT1    MOV    R0,#50            ; 100 microseconds
  59 4157 D8 FE      [2] WT2    DJNZ   R0,WT2            ; wait
  60 4159 22         [2]        RET
  61 415A                ;
  62 415A 75 A0 C0   [2] RCOM   MOV   P2,#Addrhi     ; read LCD status
  63 415D 78 01      [1]        MOV   R0,#addrRS0    ; RS=low
  64 415F E2         [2]        MOVX  A,@R0          ; fetch
  65 4160 22         [2]        RET
  66 4161                       END
********** SYMBOLTABLE (21 symbols) **********
       P2 :00A0       ACC :00E0    Addrhi :00C0   addrRS0 :0001
  addrRS1 :0009     START :4100      SETL :4106       NEW :410C
    RIGHT :411A       OUT :411C      LEFT :4120      WAIT :4124
    WAIT1 :4126     WAIT2 :4128    LCDSET :412F    LCDRDY :4141
   LCDCOM :4147    LCDCHR :414F       WT1 :4155       WT2 :4157
     RCOM :415A
```

Fig. 53. Assembly code listing of the LCD driver.

sary to set the new RAM address with the aid of SET DD-RAM ADDRESS.

Subroutine **LCDSET** arranges the basic settings of the LCD. First, it calls LCDRDY to make sure that all previous commands have been processed. Next, the LCD mode is set to: 8-bit; one line; 5×7 dots. This is done with the aid of LCDCOM. After the mode setting operation, the display and the cursor are switched off (lines 39 and 40), and the Shift mode is set (lines 41 and 42). Next, the display is cleared. Since this command may take up to 1.6 ms, it is followed by subroutine LCDRDY. Those of you who have studied the listing carefully will have noted a useful programming trick. When 'subroutine1' ends with the instruction sequence

```
LCALL subroutine2
RET
```

this can be replaced with a single line instruction

```
LJMP subroutine2
```

and so make use of the RET command of 'subroutine2' (line 52 in the listing). Although this trick saves a few lines of assembly code, it should not be used too often since it easily causes confusion. Here, it is only shown in the interest of the example.

The main program

The main LCD driver program starts by calling LCDSET to set up the display. Next, it writes 80 ASCII characters *ABCDEFG....* into the display RAM before entering an endless loop starting at NEW. In this loop the state of keys S2 and S3 is tested. When one of these is pressed, a left or right Display Shift command is sent to the LCD via LCDCOM. To make sure that the display contents scrolls slowly, subroutine WAIT is called in every loop iteration. WAIT simply idles 0.26 s (255×255×4 µs).

Assignment: road diversion

The last assignment in the course is to write a program that displays text and numbers (decimal and hexadecimal) on the LCD. To get started, have a look at the character output routine (V24 serial interface driver) in the system monitor, EMON51, and work on routeing the characters to the LCD.

Further outlook

This brings us to the end of the 8051/8032 Assembler Course, which has covered the most important programming aspects of the MCS-51 family of microcontrollers. The knowledge gathered during the course should enable you to start your own projects based on one of the processors in the family, or any of the follow-up types that are currently available.

To avoid awkward problems arising later, microcontroller-based projects should have a fairly long planning phase. Always give a good deal of thought to questions such as: which part of the project is realized by software, and which by hardware? How are the necessary hardware extensions connected (ports or bus)? Is battery backup required? Does the processor used have enough speed and computing power to handle the desired task? Are interrupts required to deal with 'fast' events? What are the sub-problems into which the overall program and project can be divided?

Answering the above questions requires quite some experience, which, as we all know, can only be acquired 'the hard way', i.e., by practice. In not a few cases, an apparently simple task may prove quite tangled when looked back upon, or will eventually appear to be over your head. In general, a good start can be made with simple hardware projects that can be built from a couple of TTL ICs: a die, a digital clock, a morse code generator, and so on. The functions of such devices lend themselves very well to software implementations that yield a lot of practical experience.

Keyboard interfaces

Most hardware projects you may come up with will require some kind of data input device. To offer you some insight into the problems that may crop up, we will briefly discuss six ways of interrogating the state of a keyswitch, i.e., determine whether it is pressed or not. As will become evident, the proposed circuits differ in regard of hardware as well as software.

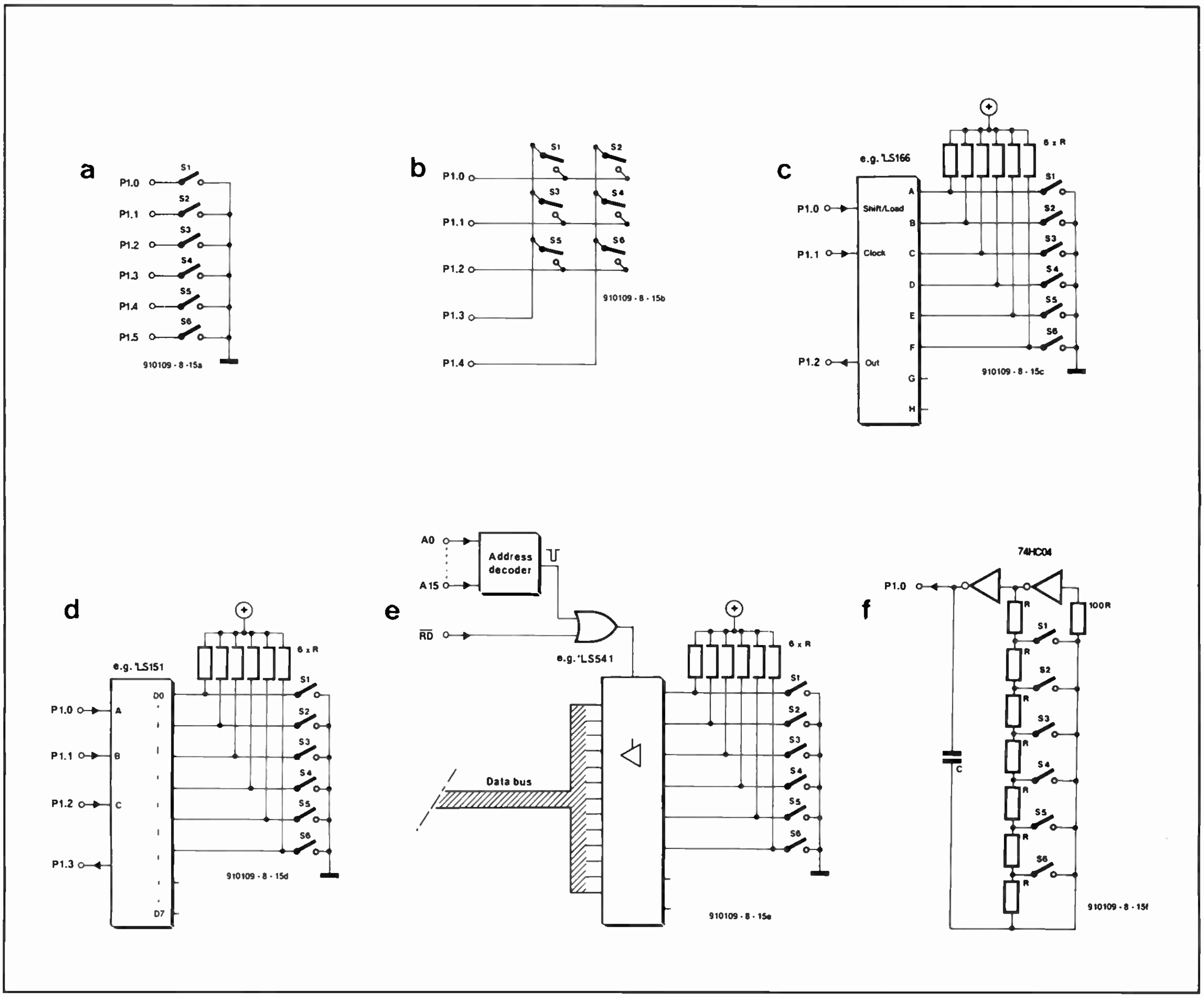

Fig. 54. Six possible ways of connecting switches or a keyboard to the 80C32 single-board computer.

Also, each circuit has its own advantages and disadvantages.

a. Direct port connection
The connection shown in Fig. 54a is the simplest of all: each key pressed takes a port line to ground. Current limiting is not even required because the 8051 contains pull-up resistors. The software is simple, too: each switch can be interrogated by a bit test instruction (JB or JNB). The disadvantage of this circuit lies in the number of port lines used. This makes it difficult to implement, say, an ASCII keyboard interface, since there some 60 keys (= port lines) are involved.

b. Matrix port connection
In this circuit (Fig. 54b), the keys are arranged in rows and columns that form a matrix. The state of any individual key in the matrix can be interrogated by putting a 'wandering low' on to the row lines. The position of the pressed key is then easily found by scanning the rows. The advantage of the matrix circuit is that a large number of keys can be read using relatively few lines: only 16 to read 64 keys. There is also a disadvantage: keys may not be pressed simultaneously. However, this may be overcome by fitting decoupling diodes at the matrix crosspoints. Unfortunately, the software for the matrix keyboard is fairly complex.

c. Shift register connection
The circuit option given in Fig. 54c requires remarkably few lines. A load pulse is used to copy the switch state into the shift register. Next, the switch state is shifted into the 8051 by eight clock pulses sent via port line P1.2. Note that only three port lines are required, and that the control software is fairly simple. Where more keys need to be read, shift registers may simply be cascaded (connected in series). Note, however, that this results in a longer 'read' time.

d. Multiplexed connection
The switch circuit in Fig. 5d requires four port lines, of which P1.0, P1.1 and P1.2 select one of keys S1-S6 via an 8-to-1 multiplexer. The state of the selected switch is fed back to the controller via port line P1.3. This circuit can make do with simple control software, and is simple to turn into a cascade to allow more keys to be connected.

e. BUS connection
The circuit drawn in Fig. 5e uses the processor bus to convey switch states. It is particularly useful when there is no free port line available. The keyboard address is selected via an address decoder, and the read signal is used to transfer the state of the keys on to the databus via a three-state buffer. Although the software for this option is relatively simple, the hardware is a bit on the complex side, particularly because we need to connect both the address bus and the databus.

f. Multivibrator interface
The last keyboard input circuit to be discussed here, Fig. 5f, works with only one port line. An oscillator based on two in-

verters operates at a frequency which changes when one of the keys is pressed. The 'key identity' is then established by the software, which measures the frequency of the rectangular signal on P1.0. Although this circuit requires the fewest port lines of all variants (except, of course, the bus connection), its suffers from two disadvantages: first, it requires fairly complex software and, second, it is not so easy to extend the number of keys since the frequency differences then become too small to be resolved reliably by the processor.

The way ahead

To be able to make the best possible use of the experience gathered from simple programs and projects, teach yourself to write program sections in such a way that they can be used later for other applications. In the course of time, this method of working will yield a collection of items that can be used over and over again to build larger programs. Also, the better your documentation on each subroutine, the easier it becomes to fit one into a larger program.

Contrary to common belief, assembly language programming is not all juggling and applying one trick after another. In the author's opinion, assembly language does allow structured programming just like any other higher language, since the program structure is mainly the result of the programmers's thinking. In this context, it is perhaps useful to advise beginners to read as much as possible about assembly language programming.

In spite of the different sources available for learning purposes, assembly language programming is never easy, and is quite demanding in regard of discipline. Fortunately, life is made a little easier by a number of programming tools, which will be discussed briefly below.

Macro-assembler

During this course we have used a simple assembler which is, none the less, perfectly adequate for the beginner. The professional user with a large budget will, of course, want to use more powerful tools. Well, these are available: a number of commercially available assemblers have 'extra' features such as the ability to handle macros. A macro is a 'shorthand' identifier for a long, frequently used, sequence of instructions or other texts. The assembler recognizes the macro identification, and automatically translates it into the text it represents.

Apart from this possibility, many assemblers allow the separate assembly of chunks of assembly code, which can be 'stitched together' later, along with items from a subroutine library. This is achieved with the aid of a linker. Although working with 'bits and pieces' is most useful when building a fairly large program, the hobbyist will often be able to manage quite well without a linker utility.

Those of you who find assembly language programming too arduous may avail themselves of higher programming languages such as C or Forth, for which a number of 8051 compilers and interpreters are available, albeit at a cost.

8051 emulators

8051 emulator programs are available that allow 8051 software to be tested by quasi-running it on a PC. Some emulators allow the program under test to be executed in single step mode, while the register contents are displayed. As such, emulators are excellent tools to trace and solve software problems and errors. They, are, however, less useful when the problem is caused by incompatibility between software and hardware. The limitations of the emulator are, therefore, often keenly felt when the program is used to 'mimic' a microcontroller connected to hardware extensions (peripherals). Fortunately, emulators come at quite low prices, which makes the decision to buy one, and so extend one's programming tools, a little easier than with an expensive assembler. For the beginner, too, an emulator can be quite useful since the workings of individual instructions can be traced with great accuracy on the PC screen. However, an EPROM emulator will be much more useful when it comes to the real thing, i.e., testing the real program in actual use.

EPROM emulators

During this course, all programs are run under the control of the EMON51 system monitor, and loaded into RAM. In many cases, however, it is desirable, from a point of view of cost, to omit a RAM, and run the program from an EPROM. To complicate things even further, such a system may not even have a serial interface. The absence of a RAM and a serial interface would appear to limit the possibilities of testing the software under realistic circumstances, as no data can be downloaded to, or called back from, the system under test. In these cases, an EPROM emulator can be great help, since it allows the most up to date version of the program (in object code) to be downloaded into the system. An excellent design for an EPROM emulator is described in Ref. 1.

In-circuit emulators

An even more difficult situation arises when an 8051 with internal ROM is to be used in a project of which the software is as yet under development. Obviously, an EPROM emulator is useless here, simply because there is no EPROM. In-circuit emulators such as the one described in Ref. 2 simulate the operation of the 8051 CPU running a program selected by the user. An in-circuit emulator is also a fine tool to track down hardware errors caused by, for instance, timing problems.

Follow-up processors: 80535 etc.

Although this course may have been your first acquaintance with the 8051 family of microcontrollers, remember that these devices are relatively old already. Their success, however, is mainly due to their having been endowed with the status of 'industry standard'. Whatever that may mean, these processors are found in countless applications. However, when deciding to develop a microcontroller application, do not forget to have a serious look at some of the derivates of the 8051, which include some very interesting processors like Siemens' SAB80C535 and SAB80C537, OKI's MSM80C154, and Philips Components' PCB83C552. These processors are basically upwards compatible devices, which means that they can do everything a 8051 can, when the same software is used.

The follow-up processors have extended features such as additional timers, on-chip A-D converters, an on-chip watchdog timer, more ports and enhanced (faster) arithmetic units. Our course assembler supports these new features because they are accessible via additional SFRs. An 80C535 controller board will be published in a forthcoming issue of *Elektor Electronics*.

Finale: small hardware projects

Although this course is now finished, it is really open-ended since there is no limit to what you can program on an 8051. We have up our sleeve a number of small projects that serve to show you the diversity of the possible applications. The projects themselves will be small, and based on very simple hardware. The idea is not so much to elaborate on the project itself, but rather to demonstrate the wide variety of applications you can develop once the basics of assembly language have been acquired. If you have ideas, let us know! ■

References:

1. "EPROM Emulator II." *Elektor Electronics USA*, September 1992.
2. "8751 Emulator." *Elektor Electronics USA*, March 1992.

LETTERS

FOUR-TERMINAL NETWORKS

I enjoyed reading Mr. Knight's two-part article entitled "Four-Terminal Networks," (*EE*USA 10-11/91) but I have some comments.

1. On page 48 (10/91) of "Finding the Attenuation," paragraph 2 should read: "A desired value of R_0 can be obtained with numerous combinations of R_1 and R_2 depending on the value of the attenuation, N. Looking at *Fig. 7*, for instance, both sections shown have a characteristic resistance of R_0 = 30Ω (check on this for yourself!), but the network on the right will provide a greater degree of attenuation than the one on the left. A desired value of N can be obtained with numerous combinations of R_1 and R_2, depending on the R_0 chosen. If, for instance, in *Fig. 8*, R_1 = 20Ω, R_2 = 12.5Ω, and N = 14dB, R_1 = R_0 = 30Ω; if N is kept at 14dB, and R_1 is made 80Ω and R_2 50Ω, R_1 = R_0 becomes 120Ω.

2. Many attenuator designs are tabulated in the literature for various values of N for a specific value of R_0. For instance, if N = 20dB and R_0 = 500Ω, R_1 = 409.1Ω and R_2 = 101.0Ω for the symmetrical T attenuator. For any new R_0' requiring 20dB, $R_1' = R_1(R_0'/500)$ and $R_2 = R_2(R_0'/500)$.

3. There should have been a bibliography and/or references of related material listed for interested parties, since I surmise that your readers range from hobbyists to technicians to engineers.

Joseph A. Lutowski
USA

Steve Knight replies:

1. I think Mr. Lutowski has simply rephrased the paragraph without affecting its content. The object was to show that different attenuations can be obtained for identical values of characteristic resistance R_0. The actual attenuations were not stated, but this was not necessary at this point: a basic fact was being stated.

2. I agree that such tabulated scales are to be found in a number of reference books and are useful to a designer. There was obviously no space in a short article to provide a list. The two expressions Mr. Lutowski gives for any alternative R_0 were not included for the same reason.

3. It is always a problem providing bibliographies, especially for short articles, and again there is a matter of space. A list of British references might not have been suitable for the many overseas readers, while a list of interest to Mr. Lutowski might not have been so to non-American readers. For those reasons, I decided to omit any references from the article.

Editor replies:

I am pleased to read that Mr. Lutowski enjoyed these two articles; they were presented in as simple a manner as possible in an effort to clarify a subject that is difficult for hobbyists and technicians to grasp.

BUILD A CD PLAYER

I read with great interest the project "Build a Compact Disk Player" in the January issue and look forward to the promised "add-ons."

I should be grateful if, in addition to the optical output module, you would consider the design of a variable pitch control (to increase and decrease the pitch of the music by, say, ±12%, and the addition of a cueing system. Both of these features can be found on the Revox/Philips and Technics professional broadcast players and would be useful in the Hospital Radio or Community Radio environment. I appreciate that this request is bound to anger hi-fi purists, but some of us get our enjoyment from playing music to others—in my case with hospital radio.

Martin Clarke
Great Dunmow, United Kingdom

Editor Replies:

The first add-on for the CD player (which can also be used with other equipment) is the AF digital-to-analogue converter published in our July-October 1992 issues, which we trust will be of interest to many readers. As far as pitch control is concerned, have you considered "Pitch Control for CD Players" in our December 1988 issue which, according to our Design and Development Department is still going strong. (Photocopies of the December 1988 article are available for $5 each from the Old Colony service department.—Ed.)

COMPUTERSCOPE

Although I do not build the projects you publish, I have learned a lot from them; you are streets ahead of the competition. My scope recently died and as I have a 286, 20MHz PC, I thought a computer scope would be good, but the one you published in 1986 has no software for a PC and it has a small bandwidth. Would it be possible for you to update that design to include more advanced technology with a bandwidth of, perhaps, 5–10MHz and include PC software? Or, maybe produce a new design from scratch?

Also, would it be possible to run a course on programming in assembly language for, say, Z80-based hardware and software, as 8051s don't grow on trees, you know.

A. Sutton
Leicester, United Kingdom

Editor replies:

We have asked our design department, as well as some of our regular freelance contributors to report on the possibility of updating the "Computerscope" series published in our September (EEUK 9/86 p. 60) and October (EEUK 10/86 p. 41) 1986 issues. Their findings will be published in this column in a few months' time.

Your comments on the 8051 in comparison with the Z80 have been noted. Bear in mind, though, that our research, and that of our associate companies world-wide, indicates waning interest in Z80-based equipment. Moreover, we do not get many offers, if any, from free-lance contributors on this type of equipment. Nevertheless, there is a two-part article on a "Multipurpose Z80 card" in this (EEUSA 6/92, p. 41) and our May (EEUSA 5/92, p. 14) issues.

As to your remarks regarding the price of the 8051, why not use a 8032? The course is geared to both devices without any reservations, but the 8032 is considerably cheaper than the 8051.

GROWING DISSATISFACTION

As a hobbyist, I read many magazines with growing dissatisfaction. Although many projects are of a stand-alone nature, computers and digital equipment cry out to be connected to each other in clever ways. But everyone had different design ideas on how to make the computer. *ETI* had the 68000-based Cortex, *Wireless World* had the Z80-based SC84, *Elektor* had the 6502-based Junior, and so on. Noting that people like souping up computers (like cars), some sensibly had expansion buses: Quarndon Qbus, Tangerine Tanbus, Interak, Acorn Atom bus, BBC Micro, ZX81, Spectrum, PCbus; unfortunately, all completely incompatible with each other. When the product became obsolete, so did the add-ons.

I worked as a technical author, writing manuals for the makers of the STEbus, for four years. The STEbus has solved a lot of problems for industry. Why doesn't the amateur world hear about industrial solutions?

Computers exist to save human time. It is a waste of time re-inventing the wheel. You could design, build and debug your own computer from scratch, but it would swallow vast amounts of time.

If you really must publish designs for single-board computers, make it a STEbus one. Your readers can then buy hundreds of boards off the shelf from a range of suppliers: from an 8031 to an 80386, digital I/O, analogue I/O, SCSI, Ethernet, modems, power supplies, signal conditioners, and many more.

Keith Howell
Cambridge, United Kingdom

Editor Replies:

Since I am a great advocate of standardization on a world-wide basis (particularly where computers and television are concerned), I agree with you and have passed your letter to our chief design engineer. Many discussions will, no doubt, ensue!

S-VHS/CVBS TO RGB CONVERTER

A colleague and I successfully built two working versions of the S-VHS/CVBS to RGB converter. Currently you are running a series on ELV's Audio Video Processor Type AVP300.

I wish to upgrade the PAL decoder TDA 4510 (on the converter) to the multi-standard TDA 4650 for PAL/SECAM operation on satellite channels. Using the circuit of *Fig. 4* in the June '92 issue (7.15MHz crystal not fitted) we replaced the TDA 4510 chip. There was no problem in decoding PAL, but alas no SECAM, even if the (Mullard) TDA 4650 was forced into the SECAM mode by hauling Pin 27 above 9V. Replacing the chrominance filtering by a filter from a TDA 3591 based SECAM surplus board supplied by SENDZ again allowed us to decode PAL, but no adjustment of R102 would allow us to decode SECAM. Note that the TDA 3591 board when supplied with a sandcastle pulse would successfully detect on Pin 6 (of the TDA 3591) the presence of a SECAM signal.

Such a project would be of interest to many of your readers who have built, or are considering building, the original project; could you possibly breadboard the modification, or at least comment on any problems envisioned with the design? If it is purely a set-up problem, is there a simple adjustment procedure using a signal generator (with NBFM modulation) as opposed to requiring a SECAM video TV Signal Pattern Generator?

N.G. Douglas
Burnham, United Kingdom

Editor Replies:

Your letter has been passed to our Design and Development Department, who have taken up the matter with Mr. Reelsen (since none of the prototypes are in our possession). Unfortunately, at the time of preparing this issue of the magazine (mid-September), they have no clear solution to the problem. As soon as we have, we shall be in direct personal contact with you. Sorry for the delay.

FREEWAY CORDLESS PHONE

I wonder whether any fellow readers can help. Recently my (owned, not rented) Freeway phone was disabled by a nearby lightning strike. Trying to get it repaired has proved very difficult.

In the end, I attempted the repair myself and after hours of work finally found one dud transistor (No. 15, a 2SA1015) in the base unit. Replacing this has restored all functions but one, namely ringing to indicate an incoming call. Outgoing calls are OK, and if the phone is picked up after another parallel phone rings, the call is there. The base-to-handset paging system works, so I believe the remaining fault must be very minor, even though I have been totally unable to locate it.

I understand this model of phone is particularly susceptible to lightning damage. Can anyone help; is there a sympathetic telephone engineer out there?

I noticed several mistakes in the July/August issue, particularly the circuit diagram given for the "Audible Fluid Level Indicator" on page 63 is the same as that for the Smartec temperature sensor on page 79.

I.M. Tasker
Grantham, United Kingdom

Editor Replies:

We regret that of the various engineers and technicians we have approached, none has any experience with Freeway phones; we hope, therefore, that one of our readers may be able to help—sorry we cannot in this instance! The few regrettable mistakes in the July/August issue were caused by a mix-up in photographic plates between prepress and printers—sorry! They have been put right in the September issue (see page 58).

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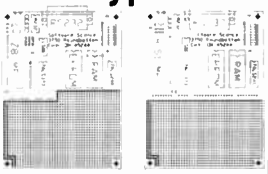

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Apart from the actual data, the book contains much other useful information, such as comparisons between and second sources for all important IC families; addresses of manufacturers and their representatives; and overviews of all peripheral chips (including many that could not be included in this book) that are available from various manufacturers.

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8214	2.00	8741	7.00
8216	1.25	8742	7.00
8224	1.25	8748	7.00
8228	1.75	8749	7.00
8237-5	2.80	8755	7.00
8243	1.75	80286-8 PLCC	8.50
8250	2.95	80287-8	125.00
(16450)	6.50	80287-10	135.00
(16550)	13.00	V-20-10MHZ	6.50

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. . . but two new products from ATI have taken the audio world by storm! LMS and LEAP have revolutionized the way loudspeakers are designed and tested.

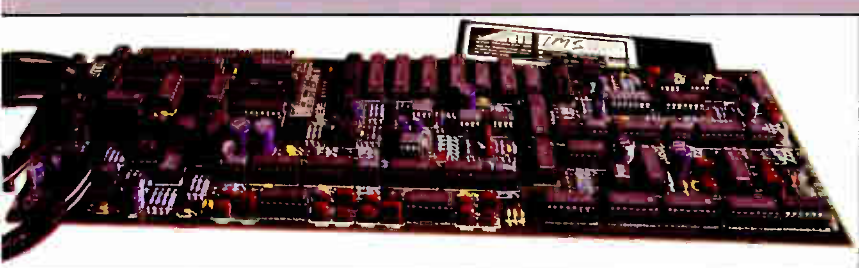
Now you can have audio analysis and electroacoustical measurements using ***real data,*** as well as mathematical simulations.

LMS Loudspeaker Measurement System

At last, there is a complete and affordable analyzer system that provides data suitable for real electro-acoustic engineering purposes. LMS uses its own precision calibrated reference microphone, a PC/AT slot card, and simple menu-driven control software.

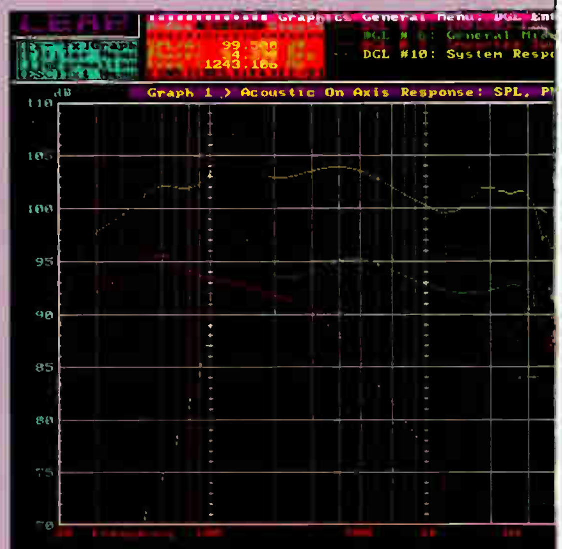
Whether your application is loudspeaker development, automobile audio, room acoustics, industrial environments, or production testing, LMS is the perfect tool for you. LMS can gather data for and perform over 50 different acoustic and electrical tests including SPL Response, Gated SPL Curves, Rub/Buzz Test, Voltage in dBm (gated or non-gated), Auto-Impedance Measurements, Transform Functions in dB, Nyquist Plots, Polar Plots, and Inverse FFT. LMS generates metering graphics and curve displays, and Hilbert Transform calculations for Phase Curve generation, and it can do so much more.

LMS includes a large number of post-processing features and tools to allow you to manipulate data to your needs. Nothing else AT ANY PRICE even comes close! Call us!



LEAP Loudspeaker Enclosure Analysis Program

Now there is one software program that can do it all! LEAP is a powerful full-featured system for electro-acoustic design and analysis.



LEAP 4.1 features include Passive Network/Active Filter Database Libraries, an Optimizer for Passive Networks and Active Filters, Conjugate Network/Crossover Network Designer, Data Import/Export System, and Speaker Parameter Measurement/Motor Coefficient/Impedance Calculator. All this in addition to the basic Transducer/Enclosure System for all TSL, ECL, DGL database functions and box design capabilities.

- Import SPL and Z Data from LMS, MLSSA, AP System 1, and TEF
- Generate 19 pairs of graphs for analysis with complete print support for Dot Matrix, HPGL, PCL, and PostScript
- Compute freq. dependent Revc and Levc
- Derive Phase from Magnitude
- Combine system response on Crossover Design
- Time Offset Correction
- Calculate Voltage/Current/Impedance

Join the distinguished list of LEAP and LMS users: Altec Lansing, JBL, Orion, Yorkville Sound, NEAR, Snell Acoustics, BBC Speakers, Hartkey Systems, Cerwin-Vega, Radian, Lucasfilm, Standford Acoustics, BEST, SCV Audio, Scientific Fidelity, Wavefront Acoustics, Peavey Electronics, Clair Bros., Renkus Heinz, Elipson, TAD/Pioneer, Swans Speakers, Sparkomatic, Rockford/Fosgate, Polk Audio, Joiner-Rose, Sony, Alpine, Bose, Tannoy, Infinity, VIFA, and many more.

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