THE INTERNATIONAL JOURNAL FOR RECREATIONAL ELECTRONICS
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Elektor Electronics USA

The QTC Loop Antenna
Real-Time Atari ST Clock
Stepper Motor Board
Universal Battery Charger
Timecode Interface

DIGITAL PHASE METER

Elektor Electronics USA

June 1991
Volume 1
Number 9

CONTENTS

Apologies
We regret that owing to circumstances beyond our control the "Timecode interface for slide controller" had to be postponed after this month's front cover had already been printed.

In next month's issue

- **As usual in our July issue, more than 50 small but interesting articles presenting new and practical ideas, concepts, and developments on all aspects of electronics**

PLUS

- Timecode interface for slide controller – Part 1
- Multi I/O for IBM
- Black-and-white video digitizer
- Radio data systems
- Modern LED clock
- Logic analyser - Part 5
- Measurement techniques – Part 6
- Laser - Part 3
- One-shot solid-state relay timer
- 8088 single-board computer

Front cover
This month's project in our measurement series features a digital phase meter. This is a rare instrument, even in the laboratory or workshop of audio and hi-fi engineers. Many engineers and technicians measure phase shift with the aid of an oscilloscope (Lissajous figures). That is not a very accurate method: the phase meter presented is accurate to within 0.5° over the frequency range 10 Hz to 20 kHz.

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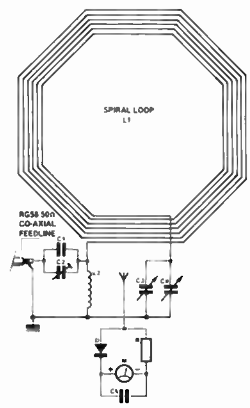
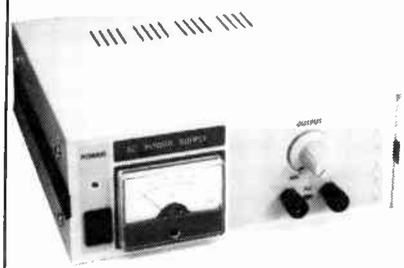


QTC loop antenna - p. 40



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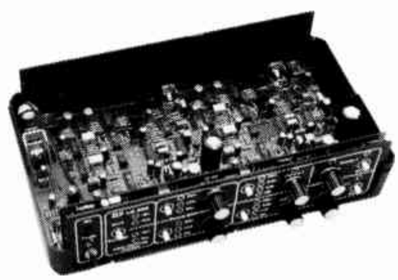

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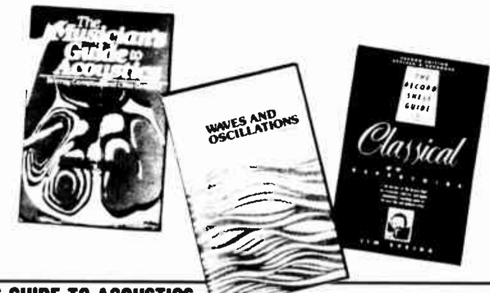
OLD COLONY'S NEW REFERENCE TOOLS!



COMPACT DISC PLAYER MAINTENANCE AND REPAIR — **BKT16** — **$14.95**

Gordon McComb, John Cook

Complete with a preventive maintenance schedule you can follow, this well-illustrated guide walks the reader through the steps involved in taking apart, cleaning, and lubricating a CD player. And if problems do occur, the troubleshooting techniques in this book provide easy relief. The book also includes background information on the theory and operation of CD players, what criteria you should use when shopping for one, a list of major manufacturers, a "similar model" cross reference table for troubleshooting, and a handy glossary. 1987, 245pp., 7 ½ × 9 ½, softbound.

DESIGN AND BUILD AUDIO AMPLIFIERS —INCLUDING DIGITAL CIRCUITS — **BKT17** — **$19.95**

Mannie Horowitz

This second edition is a complete course in designing and building audio circuits for all electronics applications, covering JFETs, equivalent noise generators, and much more. Whether you need a preamp, amp, power amp, mixer, tone modification circuit, power supply, or special accessory, here is all the data you need to create completely up-to-date circuits. 1980, 350pp., 5 × 8, softbound.

HOW TO MAKE PRINTED CIRCUIT BOARDS —WITH 17 PROJECTS — **BKT18** — **$15.95**

Calvin R. Graf

In addition to general workshop principles, in this book Graf discusses tools and safety habits and offers a complete refresher course on electronics theory, schematic diagrams, and soldering. He also explains design and layout as well as numerous types of boards and wiring. Key subjects covered include: how to get from an electronic schematic to a printed circuit board; etching a printed circuit board; cleaning, drilling, and mounting electronic parts onto the board; soldering and desoldering components; a listing of commercially available electronic project kits; and the various types of diagrams used in electronics, including block, pictorial, layout, and wiring. 1988, 207pp., 7 × 9, softbound.

TROUBLESHOOTING AND REPAIRING AUDIO EQUIPMENT — **BKT19** — **$18.95**

Homer L. Davidson

This volume supplies all the basic information you need, along with specific examples, to fix stereo components, compact disc players, telephone answering machines, and much more. The detailed discussion of servicing and repair procedures for individual items includes probable causes of malfunctions and tips on difficult-to-diagnose problems. Scores of photos, diagrams, and drawings are used, as well as actual manufacturers' schematics and service literature. In addition to the equipment above, the book also covers auto CD players, compact cassette tape decks and portable stereo players, boombox cassette players, deluxe amplifiers, auto stereo cassettes, and stereo turntables and speakers. 1987, 325pp., 7 ½ × 9 ½, softbound.

ACOUSTICS: WAVES AND OSCILLATIONS — **BKW2** — **$34.95**

S. N. Sen

The result of the need in an honors course at Jadavpur University for a better text, this rare yet refreshing book supplements the physical bases of acoustics with mathematical and experimental details wherever possible. Topics include simple harmonic motion; theory of forced vibration and resonance; theory of coupled oscillations; vibration in an extended medium; vibration of strings, bars, tuning forks, membranes, rings, and air columns; reflection, refraction, diffraction, reception, and transformation of sound; sound measurement and analysis; acoustics of building; recording and reproduction of sound; and ultrasonics. India, 1990, 234pp., 6 ½ × 10, hardbound.

THE MUSICIAN'S GUIDE TO ACOUSTICS — **BKS35** — **$27.95**

Murray Campbell, Clive Greated

The result of the authors' fifteen-plus years of lecturing on musical acoustics to students at Edinburgh (U.K.) University, this book is a must for everyone with some musical background who feels the need for a clearer understanding of the practical basis of their art. While reasonable familiarity with musical notation and terminology is required to make best use of the book, only elementary mathematics is needed. Chapters include The Creation and Transmission of Musical Sounds; Hearing Musical Sounds; Anatomy of a Musical Note; Playing in Tune; Sound Production in Musical Instruments; Bowed and Plucked Stringed Instruments; Stringed Keyboard, Woodwind, Brass, and Percussion Instruments (one chapter each); Organs; The Human Voice; Electronic Instruments; and The Musical Environment. 1987, 612pp., 6 ½ × 9 ½, hardbound.

SEMICONDUCTOR CROSS REFERENCE DATA BOOK — **BKS37** — **$19.95**

Engineers of Howard W. Sams & Company

Old Colony Sound Lab uses cross references all the time, every day. Of all the versions available for semiconductors, this is easily one of the very best. Sams' engineers have assembled replacement data for over 319,000 registered type and part numbers, including those for the United States, Europe, and the Far East, and present it here in a very easy-to-read and use format. Four suppliers are featured: NTE Electronics, Radio Shack, Philips ECG, and RCA. Semiconductors covered include bipolar transistors, FETs, diodes, rectifiers, ICs, SCRs, LEDs, modules, and thermal devices. 1991, 520pp., 8 ½ × 11, softbound.

THE RECORD SHELF GUIDE TO THE CLASSICAL REPERTOIRE — **BKSM1** — **$16.95**

Jim Svejda

From the host of American Public Radio's "The Record Shelf," this classy book is an irreverent, selective, and highly opinionated recordings guide to the best in CDs, LPs, and cassettes. Just as on his radio show, the author tries to include something pointed, interesting, amusing, or enlightening about each work, and then suggests which of the available recordings should be bought. 1988, 462pp., 6 × 9, softbound.

THE FOUNDATIONS OF ACOUSTICS: BASIC MATHEMATICS AND BASIC ACOUSTICS — **BKSV2** — **$189.95**

Eugen Skudrzyk

The goal of this book is to provide the acoustician with a mathematically-based insight into the physical phenomena of acoustics. Combining into one volume such subjects as mathematics, dynamics, hydrodynamics, physics, statistics, signal processing, and electrical theory, the author comes up with a powerful reference for the academic or professional acoustician. Well illustrated. Austria, 1971, 790pp., 7 ½ × 10, hardbound.

AUDIO AMPLIFIER CONSTRUCTION — **BKEV10** — **$7.95**

R. A. Penfold

The purpose of this book is to provide the reader with a wide range of preamplifier and power amplifier designs that will hopefully fill almost anyone's needs. The preamp circuits include low noise microphone and RIAA types, a tape head preamp, a guitar preamp, and various tone controls. The power amplifier designs range from low-power, battery-operated to 100W MOSFET types. Also included is a 12V bridge amp capable of giving up to 18W output. All of the circuits are relatively easy to construct using the PCB or stripboard designs given. Where necessary any setting-up procedures are described, but in most cases no setting-up or test gear is required in order to successfully complete the project. Most of the designs should be within the capabilities of constructors with limited experience as well as more advanced hobbyists. United Kingdom, 1983, 128pp., 4 ⅜ × 7, softbound.

SALE ENDS JULY 1! BUY THREE, TAKE 10% OFF!

AUDIO ENTHUSIAST'S HANDBOOK — **BKEV12**
B. B. Babani — **$4.95**

This book discusses a number of audio and hi-fi topics, including record/playback curves, stylus compliance, vinyl recordings then and now, evaluating loudness, acoustic feedback, hi-fi vs. stereo, stereo tape track standards, equipment performance figures, and tracking error's cause, effect, and cure. United Kingdom, 1975, 96pp., 4 ⅜ × 7, softbound.

BUILD YOUR OWN SOLID STATE HI-FI AND AUDIO ACCESSORIES — **BKEV13** — **$4.95**
M. H. Babani, editor

This volume presents the reader with the design and construction plans for a variety of useful projects, including a stereo decoder, three-channel stereo mixer, FET preamp for ceramic PUs, microphone preamp with adjustable bass response, stereo dynamic noise filter, speaker protector, and voice-operated relay. United Kingdom, 1976, 96pp., 4 ⅜ × 7, softbound.

DIGITAL AUDIO PROJECTS — **BKEV14**
R. A. Penfold — **$9.95**

The first section of this book takes a look at the basic principles involved in converting an audio signal into digital form and then converting it back again to an analog signal. It also deals with some practical aspects that have to be borne in mind when considering digital audio projects. The second section contains some useful and extremely interesting practical circuits for constructors to build and experiment with. The projects are not highly complex, but nonetheless they are probably beyond the range of complete beginners. United Kingdom, 1988, 96pp., 4 ⅜ × 7, softbound.

ELECTRONIC CIRCUITS FOR THE COMPUTER CONTROL OF MODEL RAILWAYS — **BKEV15** — **$9.95**
R. A. Penfold

This innovative book is an examination of the problem of interfacing the computer to the layout. It includes projects consisting of various types of controllers, including a high-quality pulse type, as well as circuits for train position sensing, signal and electric points control, sound effects, and more. Projects are equally adaptable to large or small layouts. United Kingdom, 1986, 96pp., 4 ⅜ × 7, softbound.

MODEL RAILWAY PROJECTS — **BKEV16**
R. A. Penfold — **$6.95**

This handbook provides a number of useful but reasonably simple projects for the model railway enthusiast to build, including such things as controllers and signals and sound effects units. Stripboard layouts are provided for each project. United Kingdom, 1981, 112pp., 4 ⅜ × 7, softbound.

MODEL RAILROAD SPECIAL! — **BKEV/RR** — **$14.95**

Both *Electronic Circuits for the Computer Control of Model Railways* (BKEV15) and *Model Railway Projects* (BKEV16), at a savings of $1.95!

INTERNATIONAL TRANSISTOR EQUIVALENTS GUIDE — **BKEV17**
Adrian Michaels — **$11.95**

This book, one of two transistor guides recommended by Old Colony, is designed to help the user find possible substitutes for a popular, user-oriented selection of modern transistors. It includes devices produced by over 100 manufacturers, and wherever possible the equivalents are subdivided into European, American, and Japanese types. Also shown are the material type, polarity, and manufacturer, as well as an indication of device use or application. United Kingdom, 1981, 1990, 320pp., 4 ⅜ × 7, softbound.

THE WOOD EFFECT — **BKMA1**
R. C. Johnsen — **$12.95**

According to the author, masked by random combination with other distortions in the music reproduction chain an unsuspected major contributor has lain hidden: aural sensitivity to "phase inversion," the Wood Effect. In this book the results of an extensive study of the Wood Effect are reported and discussed, including an exhaustive survey of the relevant literature. Although no means are proposed to correct countless errors, customary practice in acoustics and audio is severely scrutinized. BKMA1's subtitle is "Unaccounted Contributor to Error and Confusion in Acoustics and Audio." 1988, 99pp., 6 × 9, softbound.

THE HOMEBUILT DYNAMO: DYNAMO DESIGN AND CONSTRUCTION WITH CERAMIC MAGNETS — **BKTF1** — **$64.95**
Alfred T. Forbes

We added this book to our offerings not just because it is a physically handsome volume, but also because it is unique and, as many reviewers have pointed out, an experimenter's "delight." In 1969, Al Forbes and his wife decided to live the simple life and retreated to a parcel of undeveloped land. Soon enough, they needed a generator. This book is the extremely detailed account of how Al built one from scratch. But it is more than that: it's a head-on encounter with just about every principle of electricity, magnetism, and hands-on construction known to man. Along the way, incidentally, the reader runs into how to build precision wire-winding jigs, a small lifting magnet, a foot-powered version of the dynamo, a diamond saw, a sheet metal cutter, and a 139-pound flywheel. With more than 300 illustrations, this volume is slowly becoming a worldwide cult favorite among do-it-yourselfers everywhere. New Zealand, 182pp., 8 ½ × 12, hardbound.

THE VTL VACUUM TUBE LOGIC BOOK — **BKVT1**
David Manley — **$12.95**

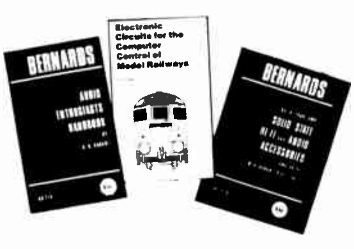
This third edition of every tube freak's must-have book is replete with tube matter of every description, including circuits, specifications, reviews, and history, presented with more than a liberal dash of humor and puckishness. 1991, 120pp., 5 ½ × 8 ½, softbound.

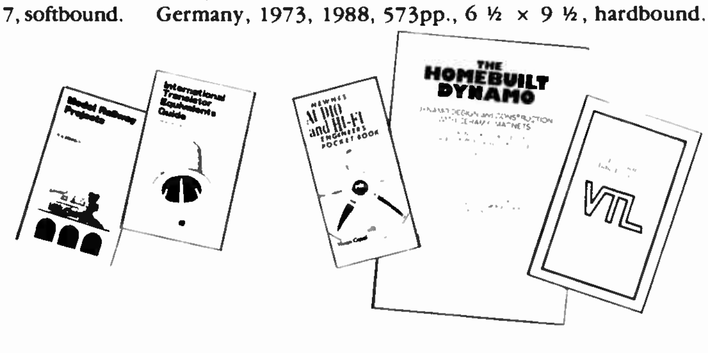
AUDIO AND HI-FI ENGINEER'S POCKET BOOK — **BKHN1** — **$27.95**
Vivian Capel

This book is a concise collection of practical and relevant data for anyone working on sound systems. The topics covered include microphones, record players, compact discs, tape recording, high-quality radio, amplifiers, loudspeakers, and public address systems. A lengthy section on acoustics is included for dealing with most aspects a technician is likely to encounter, from human hearing to sound insulation, and qualities such as heat and magnetism are covered as well. This is a pocket book, in a very handy size. United Kingdom, 1988, 190pp., 3 ¾ × 7 ¾, hardbound.

STRUCTURE-BORNE SOUND — **BKSV4**
L. Cremer, M. Heckl — **$84.95**

Translated from the German and revised by E. E. Ungar, this second edition is a thorough introduction to structural vibrations, with emphasis on those at audio frequencies, and the attendant radiation of sound. The book presents in-depth discussions of fundamental principles and basic problems, in order to enable the reader to understand and solve his own. Included are chapters on the measurement and generation of vibrations and sound; the various types of structural wave motions; structural damping and its effects; impedances and vibration responses of the important types of structures; the attenuation of vibrations, and sound radiation from structures. Germany, 1973, 1988, 573pp., 6 ½ × 9 ½, hardbound.





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OLD COLONY SOUND LAB

HOW TO USE OP AMPS — **BKEV3**
E. A. Parr — **$9.95**

Parr's book is a designer's guide covering many operational amplifiers which serves both as a source book for circuits and as a reference book for design calculations. The approach is as nonmathematical as possible and is thus equally understandable by the hobbyist or the engineer. United Kingdom, 1982, 160pp., 4 ⅜ × 7, softbound.

AUDIO PROJECTS — **BKEV4**
F. G. Rayer — **$6.95**

This book covers in detail the construction of a wide range of audio projects, including preamps, power amps, mixers, tone controls, and many others. All are fairly easy to build, and to that end the author has included a number of board layouts and wiring diagrams. United Kingdom, 1981, 96pp., 4 ⅜ × 7, softbound.

AN INTRODUCTION TO LOUDSPEAKERS AND ENCLOSURE DESIGN — **BKEV5**
V. Capel — **$9.95**

In this volume may be all you need to know about the theory and operation of speakers and the various boxes into which they may be fitted. The book also includes the complete design and construction details for the inexpensive but high quality enclosure called the "Kapellmeister." United Kingdom, 1988, 160pp., 4 ⅜ × 7, softbound.

MODERN OP-AMP PROJECTS — **BKEV6**
R. A. Penfold — **$6.95**

BKEV6 includes a wide range of construction projects which make use of the specialized operational amplifiers available today, including low noise, low distortion, ultra-high input impedance, low slew rate, and high output current types. Circuits using transconductance types are also included. United Kingdom, 1982, 112pp., 4 ⅜ × 7, softbound.

HOW TO GET YOUR ELECTRONICS PROJECTS WORKING — **BKEV7**
R. A. Penfold — **$6.95**

We have all built circuits from magazines and books only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building projects.

Chapter 1 deals with mechanical faults such as tracing dry joints, short circuits, broken PCB tracks, and so forth. The construction and use of a tristate continuity tester to help in the above is also covered. Chapter 2 deals with linear analog circuits and also covers the use and construction of a signal injector/tracer which can be used to locate and isolate faulty areas.

Chapter 3 considers ways of testing the more common components such as resistors, capacitors, op amps, diodes, transistors, SCRs, unijunctions, and so forth, with the aid of only a limited amount of test equipment. Chapter 4 deals with both TTL and CMOS logic circuits and includes the use and construction of a pulse generator to help in fault-finding. United Kingdom, 1982, 96pp., 4 ⅜ × 7, softbound.

CONCERT HALL ACOUSTICS — **BKSV3**
Yoichi Ando — **$69.95**

Number 17 in the Springer Series in Electrophysics, this book provides an interdisciplinary approach to solving acoustic design problems in concert halls. Considered one of the original sources in this field, the volume explains in detail the importance and interrelationship of total sound energy, delay of early reflections, reverberation, and the "spatial-binaural criterion," a measure of the spatial impression of the sound field. Germany, 1985, 151pp., 6 ¼ x 9 ⅜, hardbound.

ACOUSTICS SOURCE BOOK — **BKMH5**
Sybil P. Parker, editor-in-chief — **$39.95**

This widely-sought member of the McGraw-Hill Science Reference Series is an accumulation and explanation of all that has to do with acoustics, focusing on basic concepts, sound production, sound transmission, sound detection, and practical applications. One of the clearest and most basic references on acoustics available today. 1988, 333pp., 7 × 9 ½, hardbound.

LISTENING: AN INTRODUCTION TO THE PERCEPTION OF AUDITORY EVENTS — **BKMT1**
Stephen Handel — **$39.95**

This book combines broad coverage of acoustics, speech and music perception, psychophysics, and auditory physiology in a lively introduction to the perception of music and speech events. Coherence and clarity are the hallmarks of this book, and the author's strategy is to discuss specific points in detail rather than every possible thing superficially. All in all very fascinating, especially the treatment of the physiology and neurophysiology of the auditory system. 1989, 597pp., 6 ½ × 9 ½, hardbound.

AUDITORY PERCEPTION — **BKMX1**
F. Alton Everest — **$159.95**

This thorough, inventive, and understandable audio training course on psychoacoustics comes complete with eight lessons on four tapes and a manual with hundreds of technical diagrams illustrating the concepts. The aural examples and classic experiments enable the student to clearly and quickly comprehend the complexity of the hearing process. Topics include the perception of delayed sounds, auditory filters, masking of critical bands, the perception of pitch, timbre, and much more. 1986, 104pp., 5 ½ × 8 ½, softbound, 4 cassettes, vinyl case for all.

POWER ELECTRONICS HANDBOOK: COMPONENTS, CIRCUITS, AND APPLICATIONS — **BKB4**
F. F. Mazda — **$79.95**

The purpose of this book is to provide all the information required by power electronics engineers. It describes the design of power circuits used for a variety of applications, the characteristics of power semiconductor devices, and how they are used in power circuits. The author's approach is to give the maximum amount of information in a concise form, with the emphasis on the practical rather than the theoretical. United Kingdom, 1990, 417pp., 6 ½ × 9 ½, hardbound.

AUDIO ELECTRONICS REFERENCE BOOK — **BKBL1**
Alan R. Sinclair, editor — **$164.95**

Written by a team of expert, specialist contributors, this volume is of interest and profit to audio design and service engineers and technicians, as well as any amateur users of audio equipment who want to learn the technology of the art. BKBL1 is both a summary and a guide to the new state of audio, and includes in its coverage those areas where professional and amateur audio have begun to overlap, such as electronic music and public address systems. United Kingdom, 1989, 615pp., 6 ½ × 9 ½, hardbound.

TROUBLESHOOTING AND REPAIRING COMPACT DISC PLAYERS — **BKT20**
Homer L. Davidson — **$18.95**

This is an invaluable reference for both the electronics technician and the do-it-yourselfer alike. With it, you'll be able to troubleshoot and repair servo control loops, remote control systems, optical lenses and laser assemblies, and much more! Detailed examples of actual repair and adjustment procedures and a chapter on the care and handling of the discs themselves further enhance the usefulness of this book. 1989, 337pp., 7 ½ × 9 ½, softbound.

OLD COLONY SOUND LAB

INCREDIBLE INTRODUCTORY BOOK SALE!

LOUDSPEAKERS, VOLUME 1 — **BKAS1/1**
Raymond E. Cooke, editor — **$29.95**
From The Audio Engineering Society's Anthology Series, 61 papers, covering the years 1953 to 1977, written by the world's greatest transducer experts and inventors on the design, construction, and operation of loudspeakers. 1980, 448pp., 8 ¼ × 11 ¼, softbound.

LOUDSPEAKERS, VOLUME 2 — **BKAS1/2**
Raymond E. Cooke, editor — **$29.95**
Also from The Audio Engineering Society's Anthology Series, 49 papers from 1978 to 1983 by experts in loudspeaker technology, extending the work initiated in Volume 1. 1984, 464pp., 8 ¼ × 11 ¼, softbound.

LOUDSPEAKERS SET! — **BKAS/S**
Raymond E. Cooke, editor — **$53.95**
From The Audio Engineering Society's Anthology Series, both BKAS1/1 (Volume 1) and BKAS1/2 (Volume 2) as above, at a savings of $5.95!

MICROPHONES — **BKAS2**
Louis A. Abbagnaro, editor — **$29.95**
Sixty-three papers covering calibration and testing, general purpose microphones, directional microphones, miniature types, and associated electronic circuits. From The Audio Engineering Society's Anthology Series. 1979, 392pp., 8 ¼ × 11 ¼, softbound.

SOUND REINFORCEMENT — **BKAS3**
David L. Klepper, editor — **$29.95**
Seventy-three papers dealing with the significant aspects of the development of sound-reinforcement technology and its practical application to sound system design and installation. From The Audio Engineering Society's Anthology Series. 1978, 339pp., 8 ¼ × 11 ¼, softbound.

STEREOPHONIC TECHNIQUES — **BKAS4**
John M. Eargle, editor — **$29.95**
From The Audio Engineering Society's Anthology Series, 67 articles and documents on the history, development, and applications of stereophonic techniques for studio technology, broadcasting, and consumer use. 1986, 390pp., 8 ¼ × 11 ¼, softbound.

SPICE: A GUIDE TO CIRCUIT SIMULATION & ANALYSIS USING PSPICE — **BKPH2** — **$19.95**
Paul W. Tuinenga
Designed as a reference on PSpice for the design and analysis of analog circuits, this book clearly explains how to use the features of PSpice to solve common electrical and electronic problems, as well as some in nonelectrical areas. Topics include DC operation, transfer functions, frequency response, and noise analysis. SPICE is an acronym for Simulation Program with Integrated Circuit Emphasis, and PSpice is a SPICE-derived simulator created by MicroSim Corporation. Companion software for the book is available (see below). 1988, 200pp., 7 × 9 ½, softbound.

SPICE BOOK/SOFTWARE SPECIAL! — **BKPH2/S** — **$27.95**
Student-version software to accompany BKPH2 is available for both the IBM PC and Macintosh II. The PSpice program can simulate circuits of up to five nodes and ten transistors, with the parameters inserted by the user. Special BKPH2/S includes both the book and one software package at a savings of $4.95!
Software packages available (be sure to specify!):
SOF-SPC1B5GD IBM PC
SOF-SPC2B5GD IBM PS 2
SOF-SPC1M3GD Macintosh II

TIME DELAY SPECTROMETRY — **BKAS5**
John R. Prohs, editor — **$29.95**
From The Audio Engineering Society's Anthology Series, 32 articles of the works of Richard C. Heyser on measurement, analysis, and perception, reprinted from the pages of the *Journal of the Audio Engineering Society* and other publications representative of the field, including *Audio* magazine and that of IREE Australia. The anthology serves as a memorial to the author's work and as fundamental material for future developments in audio, and will undoubtedly provide the stimulus for expanded discussion. 1988, 280pp., 8 ¼ × 11 ¼, softbound.

AUDIO IN DIGITAL TIMES: CONFERENCE PROCEEDINGS — **BKAS6** — **$34.95**
Forty-four papers presented by experts on digital audio at The Audio Engineering Society's Seventh International Conference held in Toronto on 14–17 May 1989. Digital audio, from the history, basics, hardware, and software, to the ins and outs, was the topic of the conference. Illustrated with many figures and tables. 1990, 384pp., 8 ¼ × 11 ¼, softbound.

THE SOUND OF AUDIO: CONFERENCE PROCEEDINGS — **BKAS7** — **$34.95**
Twenty-four papers presented by authors highly regarded in the engineering community at The Audio Engineering Society's Eighth International Conference held in Washington, D.C., on 3–6 May 1990. The topics were devoted to the progress of sound, including measurement, recording, and reproduction. Textbook style, fully illustrated. 1990, 384pp., 8 ¼ × 11 ¼, softbound.

DIGITAL AUDIO: COLLECTED PAPERS — **BKAS8**
Barry Blessner, et al., editors — **$34.95**
First publication of papers presented at The Audio Engineering Society's Premiere International Conference held in Rye, N.Y., on 3–6 June 1982, authored by the world's leading experts in the application of digital techniques in the field of audio engineering. Twenty-five of the 27 papers are transcribed, edited, and published for the first time. Subjects include basics, converters, measurements, rate conversion, recording formats, error correction, manufacturing, and applications. Includes a Soundsheet disk with audio demonstrations of digitally synthesized sounds. 1983, 268pp., 8 ¼ × 11 ¼, softbound.

MICROPHONES: TECHNOLOGY AND TECHNIQUE — **BKB3**
John Borwick — **$29.95**
Beginning with a brief history of the relevant technology, this book then goes on to explain the basic theory of acoustics, electricity, and magnetism. The working principles and design of all types of microphones are explained in considerable detail, with examples of popular current models and descriptions of microphone accessories. The second half of the book provides guidelines on the creative balance techniques to be used for musical instruments, voices, and ensembles of all kinds, in both classical and pop music. Production methods are outlined both for studios and for on location, with notes on public address operations for live shows. Borwick is considered THE authority. United Kingdom, 1990, 241pp., 7 ½ × 9 ½, softbound.

THE ART OF ELECTRONICS — **BKC1**
Paul Horowitz, Windfield Hill — **$54.95**
Completely up-to-date with the latest technology and standards, this second edition features completely rewritten chapters on microcomputers and microprocessors, digital electronics, and low-power and micro-power design (both analog and digital). Many new tables have been added, including ones for A/D and D/A converters, digital logic components, and low-power devices. The quintessential electronics text and reference. 1989, 1100pp., 7 ½ × 10 1¼, hardbound.

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HARD-TO-FIND BARGAINS FROM AROUND THE WORLD!

ACOUSTICAL MEASUREMENTS — **BKAC1**
Leo L. Beranek — **$44.95**

Here is a completely revised edition of the famous text by the well-known authority, with more than half the pages and chapters revised or completely rewritten to cover new developments in acoustical instruments and measurement procedures, including sound and vibration meters, intensity meters, spectrum analyzers, recorders, computers, and noise measurement devices. 1948, 1989, 841pp., 5 ¾ × 8 ¾, hardbound.

ACOUSTICS—AN INTRODUCTION TO ITS PHYSICAL PRINCIPLES AND APPLICATIONS — **BKAC2**
Allan D. Pierce — **$37.95**

This volume introduces the physical principles and theoretical basis of acoustics, concentrating on those concepts and points of view that have proven useful in applications and phenomena such as noise control, underwater sound, architectural acoustics, audio engineering, nondestructive testing, remote sensing, and medical ultrasonics. The text is supplemented by problems and their answers. 1981, 1989, 678pp., 6 ¼ × 9 ½, hardbound.

EXPERIMENTS IN HEARING — **BKAC3**
Georg von Békésy — **$27.95**

Considered obligatory reading for all those who want to claim literacy in the auditory sciences, this classic on hearing contains many of the vital roots of contemporary auditory knowledge. 1960, 1989, 760pp., 6 × 9, softbound.

ACOUSTICAL DESIGNING IN ARCHITECTURE — **BKAC4**
Vern O. Knudsen, Cyril M. Harris — **$27.95**

This book is a comprehensive, nonmathematical treatment of architectural acoustics, completely revised with new illustrations and updated to eliminate obsolete materials. In handbook format, it covers all the general principles of acoustical designing and includes specific applications. 1950, 1980, 408pp., 5 3/8 × 8 ½, softbound.

ACOUSTICS — **BKAC5**
Leo L. Beranek — **$27.95**

This volume is an indispensable source of practical acoustical concept and theory for acoustical and electrical engineers, scientists, and consultants, with new information on microphones, loudspeakers and speaker enclosures, room acoustics, and acoustical applications of electromechanical circuit theory. 1954, 1986, 491pp., 6 × 9, softbound.

MARQUETRY AND INLAY: TWENTY DECORATIVE PROJECTS — **BKT21**
Alan and Gill Bridgewater — **$15.95**

Complete with 200 illustrations, a glossary, and an introduction to tools and techniques, BKT21 provides step-by-step directions for easy-to-do projects. This book gives woodworkers an opportunity to add a valuable new skill to their repertoire—inserting fine woods and decorative veneers into finished surfaces. 1989, 192pp., 7 × 10, softbound.

TONMEISTER TECHNOLOGY: RECORDING ENVIRONMENTS, SOUND SOURCES AND MICROPHONE TECHNIQUES — **BKTE1**
Michael Dickreiter — **$19.95**

Recently translated from the German by Stephen F. Temmer, this rare book for the first time provides an English-language reference integrating music and musical engineering. Used by the German Broadcasting System Technical Training Center as a text to train people who graduate from a music conservatory and opt to go into broadcast, TV, recording, or sound reinforcement engineering, this book will appeal to neophytes as well as professionals in the music and audio engineering fields. Profusely illustrated, with every other page illustrations. 1984, 1989, 142pp., 6 × 9, softbound.

HEARING: ITS PSYCHOLOGY AND PHYSIOLOGY — **BKAC6**
Stanley Smith Stevens, Hallowell Davis — **$27.95**

This multidisciplinary book leads readers from the fundamentals of the psychophysiology of hearing to a complete understanding of the anatomy and physiology of the ear, including the relationship between stimulus and sensation. 1938, 1983, 512pp., 5 ½ × 8 ½, softbound.

ELECTROACOUSTICS: THE ANALYSIS OF TRANSDUCTION AND ITS HISTORICAL BACKGROUND — **BKAC7**
Frederick V. Hunt — **$27.95**

This volume provides a comprehensive analysis of the conceptual development of electroacoustics, including the origins of echo ranging, the crystal oscillator, the evolution of the dynamic loudspeaker, and electromechanical coupling. 1954, 1982, 260pp., 5 ½ × 8 ½, softbound.

VIBRATION AND SOUND — **BKAC8**
Philip M. Morse — **$27.95**

One of the most widely used texts and references on the science of acoustics, this volume provides students and professionals alike with a broad spectrum of acoustics theory, including wave motion, radiation problems, the propagation of sound waves, and transient phenomena. 1936, 1981, 468pp., 6 × 9, softbound.

ACOUSTICS/HEARING SPECIAL #1 — **BKAC/X2**
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Your choice of TWO from BKAC3 through BKAC8, at a savings of $5.95! Be sure to specify books. (BKAC1 and BKAC2 not eligible.)

ACOUSTICS/HEARING SPECIAL #2 — **BKAC/X3**
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TOTAL HARMONIC OISTORTION —CARTOONS FROM STEREO REVIEW — **BKPB1**
Charles Rodrigues — **$7.95**

This hilarious collection of 118 of the author's classic cartoons on audio, video, and music is the perfect gift and/or a wonderful conversation piece. Also featured are a foreword by William Livingstone and an illustrated autobiographical sketch by Rodrigues himself. One of a kind. 1988, 132pp., 6 ½ × 7, softbound.

SHEET METAL HAND PROCESSES — **BKDE2**
Claude J. Zinngrabe, Fred W. Schumacher — **$13.95**

For help in building that special enclosure, this volume will prove indispensable, introducing the beginning sheet metal technician to basic instruction in the properties and selection of metal and the processes performed with measuring and marking, bench, cutting, piercing, joining, and soldering tools. BKDE2 includes an excellent selection of illustrations, and every process is described in an easy-to- understand, step-by-step fashion. 1974, 209pp., 7 ¾ × 10 ¼, softbound.

CABINETMAKING, PATTERNMAKING, AND MILLWORK — **BKDE4**
Gaspar J. Lewis — **$22.95**

If making your own speaker cabinets has led you into woodworking, this book will be a great addition to your library. Designed for advanced high school, vocational, technical, and apprenticeship programs, it provides the reader with the skills necessary for proficiency in each of the three areas of specialization. Also included are three sections common to all three fields: the nature of wood and its uses; how to use hand tools, portable power tools, and stationary woodworking machines; and methods of joinery. 1981, 438pp., 7 ½ × 9 ½, hardbound.

PLAYING RECESS(ION)

Right in the middle of what economists are now calling a recession, many US electronics vendors are telling some customers they don't want their business. These customers' crime appears to be that they don't need enough. A number of vendors whose primary customer base has been the individual consumer are no longer happy to sell to that base since the big-ticket blandishments of the military/industrial complex in this country are so large and so lucrative that the individual buyer is no longer "interesting."

The problem is made more complex by the habit of US manufacturers to assign exclusive distribution rights to selected companies. The contracts are subject to sudden death shifts, as well. A distributor can come to work on a Monday morning only to discover that his right to sell a line has been lifted summarily and assigned to a competing company.

This accounts, in some measure, for the distributor businesses' resemblance to mayflies, who seem to appear and disappear with equal rapidity. It is now a regular feature of the American business scene where money is the only consideration. We are no longer content to make a living, the object seems to be to make a killing—and to get out fast. Business managerial style is a vicious scramble to the top, a management slot with a golden parachute attached, and the drive to maximize profits at any cost. The cost is usually the company's integrity and financial soundness. Naturally the manager bails out quickly before the full slide into deep troubles begins to occur—or the sudden crash takes place.

With such management style in place, it is not difficult to see why we are in this recession. When sales drop, the retrenchment begins and such managers, or their less fortunate successors, chop and cut into the skilled work force of the company in an effort to save money. When this becomes a pervasive technique throughout industry, everyone becomes a smaller vendor, and a smaller customer. Why should it be surprising that a "recession" results? US business seems to have made recessing stylish lately.

I suggest that such times and such myopia offer opportunities to those of you with courage and imagination. Look around to see what people need. Many needs are unmet. One of the largest is ecological, another is the technological evolution of the home.

As an example of the former, your local service station has a problem with the oil drained from your crankcase. It can no longer be dumped in a hole on the back corner of the parking lot. Service station owners must now pay for disposal. Someone has the bright idea that old oil might be good fuel. Burning it requires a special furnace costing under $3,000. If someone suggested you might permanently cut your fuel oil bill in half by a primary investment of $3,000, what would your response be?

The smart entrepreneur will find a way to sign up the service stations in his area to collect their oil once a month charging a fee of only 25¢ a gallon, buy a second-hand oil delivery truck, sell some lucky homeowners a new furnace and guarantee a fuel oil supply at 50¢ a gallon for as long as nearly every American continues to drive a car.

The American home is being converted into an electronic obstacle course. Service opportunities abound for maintenance of microwaves, intercoms, protection devices, garage door openers, and much else. Terms could be an annual contract, or by the service call. Such an organization would also have a unique opportunity to offer advice and sales of new devices as they inevitably appear. Technology is still fearsome to many and your help could be not only welcome, but worth cash.

Finally, we are better supplied with materials to make pottery throughout suburban America than to build electronic projects. And the crunch is not just a problem for hobbyists. Our mail-order electronics vendors who don't want orders under $50 or $100 are a problem for the many independent development labs throughout the US as well. Such companies build sample quantities of new devices to confirm their integrity. The needs of such companies are quite similar to those of the serious hobbyist. But developers complain constantly about how difficult their life has become because our marketplace in the US is of such a scale that companies outgrow their small customers who helped them get started.

I hope many of you will give serious thought to the opportunities even these few facts suggest. If our current electronics vendors are suffering from gigantism and are uninterested in supplying the small company or the hobbyist, then there's a market asking for help and assistance. The idea I am suggesting here is clearly exemplified by a new advertiser in our classified section this month.

The operation is mail order. Resistors are the product: 1,000+, ±5%, ¼W, carbon film types, arranged neatly in a box of five or ten of each value for under $20 delivered. A neat service with credit cards accepted, an 800 number, and a reorder blank.

The other advertisers in this magazine are, so far as I know, firmly committed to supplying you with the parts you need. If you wish for parts not immediately available, let our advertisers know about it. You will also be seeing more ads from European-based vendors who are eager to hear from you and to help with what you need. Your credit card and your FAX can reach anywhere in the world, as fast as you can dial.

For the adventurous, opportunities abound. The computers and software are plentiful and lots of customers are looking vainly for the good stuff they need to build, rebuild, and design. If you are tired of playing recess and of those who are, get going. And let us know how you are doing.—E.T.D.

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SINGLE-BOARD COMPUTER

Rapid Systems has announced the PX1260, a high-speed, high-performance 33MHz, Intel 386-based CPU module for the PCXI EISA passive backplane. This plug-in CPU module features optional integrated 40Mb hard disk with 3½", 1.44Mb floppy. The PX1260 is based on a single-board computer and is completely enclosed in a metal chassis to keep EMI emissions in and RFI out. Two serial ports, one parallel port, a 3½" floppy, and the keyboard connector and reset button are located on the front of the module.

Applications for the unit include EISA workstations, industrial PCs, production test, modular rugged PCs, factory automation, and networks.

The PX1260 sells for $5,995. For more information, contact Susan Conley, Marketing, Rapid Systems Inc., 433 N. 34th St., Seattle, WA 98103, (206) 547-8311, FAX (206) 548-0322.

LENBROOK DISTRIBUTES NAD IN US

Lenbrook Industries, the Canadian distributor of NAD electronics, will also distribute the entire NAD line of audio and video products in the US. Robert Brown, president of LincolnWood, the former distributor, has been named Director of US Operations for Lenbrook Industries. He will handle the NAD line, as well as the company's PSB speaker line and other anticipated Lenbrook activities in the US.

NAD made this move to divest itself of the direct distribution activity, preferring to put its capital and other resources into research, product development, manufacturing, and international marketing.

ELECTRONICS SCENE

SYN-TECH XTR COMPACT DESKTOP BASE STATIONS

Midland LMR has introduced Syn-Tech XTR™ desktop FM two-way radio base stations, a new series of programmable dispatch units replacing earlier Syn-Tech models.

These compact stations feature programmable RF output power: 2–50W in low-band models (29.7–50MHz), 2–40W in VHF (136–174MHz), or 2–30W in UHF (406–470MHz). All are programmable for up to 22 channels (expandable to 99) and have built-in dual-priority, 40-channels-per-second scanning with operator add/delete capability. Tone and digitally coded squelch are randomly programmable by channel for all standard codes (optional in VHF). Units can be programmed by PC or by an EEPROM programmer. The radios are data-capable and have built-in data ports.

The XTRs include a built-in power supply operating on 110/220V AC, 60/50Hz. A 24-hour digital clock and day/date display are standard, as is a high-quality desktop microphone with PTT lock and monitor keys. Low-band units include a noise blanker. Options include a high-security scrambler, digital voice storage and replay, and tone and DC remotes.

For more information, contact Midland LMR, Marketing Department, 1690 N. Topping, Kansas City, MO 64120, (800) 643-5263, ext. 1690.

ICOM FIRST IN SPACE

Packet radio, used in amateur radio space communications, is now part of the Soviet manned space station, Mir, callsign U2MIR. The packet equipment consists of **Icom America**'s ICOM IC-228A 2-meter FM transceiver and PacComm Handi Packet unit, along with a laptop computer. The equipment was launched to Mir on a Progress M6 resupply "space truck" on January 14. To contact U2MIR, the downlink frequency is 145.55MHz.

CATALOG SUPPLEMENT

For a copy of **Antique Electronic Supply**'s *1991 Catalog Supplement*, contact the company at PO Box 27468, Tempe, AZ 85285-7468, (602) 820-5411, FAX (602) 820-4643.

TEN INSTRUMENTS IN ONE

Global Specialties has announced the PROTOMETER™ 4000, a portable instrument system. The hand-held package features ten test instruments capable of performing 35 measurement functions. The model 4000 packs the power of Global Specialties' complete line of instruments into a 3¾ digit, 4,000-count multimeter case.

The PROTOMETER 4000 combines a digital multimeter capable of measuring DC and AC voltage, DC and AC amps, ohms, plus an autoranging frequency counter, transistor/capacitance tester, and logic probe into a durable drop-resistant case. Standard features include a large LCD display, 4,000-count accuracy, peak hold, and a high-voltage warning indicator.

The rugged construction makes the unit ideal for field service and industrial maintenance applications. Engineered with special heat-resistant components, its current-measuring range is extended up to 20A AC/DC. You can use this one meter to check all electronic components.

The PROTOMETER 4000 sells for $139.95. For more information, contact Global Specialties, 70 Fulton Terrace, New Haven, CT 06512, (203) 624-3103, FAX (203) 468-0060.

AMPLIFIER SPICE MODEL LIBRARY

A free disk containing 176 SPICE models of **Analog Devices**' IC amplifiers is available from the company. The advanced modeling techniques used allow as many poles and zeroes as are needed to shape a model's frequency response accurately to conform to the device. For 26 of the devices, models include voltage and current noise; this allows designers to predict system noise performance as part of the SPICE simulation. The library also includes models of two instrumentation amplifiers.

For more information, contact Analog Devices Literature Center, 70 Shawmut Rd., Canton, MA 02021.

CATALOG OF TEST INSTRUMENTS AND ACCESSORIES

B&K PRECISION has available a 68-page catalog covering the company's line of electronic test instruments, including oscilloscopes, IC comparators, digital multimeters, signal and function generators, power supplies, component testers, video test instruments, probes, and accessories.

The *Test Instruments* catalog (BK-91) provides complete specifications in listings and comparison charts. Key product features are summarized, along with selected product applications. The catalog also describes product accessories to enhance the instruments. These instruments address applications such as engineering, maintenance and repair, field service, education, production-line testing, quality control programs, and research and development.

A glossary of terms for each major product category assists in specifying the correct instrument for a task, as well as provides an educational training aid.

Copies of the catalog are available from B&K PRECISION, Maxtec International Corp., 6470 W. Cortland St., Chicago, IL 60635, (312) 889-1448.

16-CHANNEL A/D DATA-ACQUISITION SYSTEM

BASICON has announced the DAS-1 Data Acquisition System. Suited for the industrial environment, the device provides convenience, saves time, insulates noisy analog signals from the PC, and simplifies gathering information from multiple sources, such as thermocouples, strain gauges, and load cells.

The DAS-1 reads 16 channels of analog signals. For convenience, wires are fastened to an industrial-grade screw terminal quick connect edge connector. This allows test wires to remain in place and enables you to move the DAS-1.

BASICON's software reads and displays information in real-time. All thermocouple probes are pre-calibrated, and a built-in automatic cold junction calibration is included. The software has up to eight alarm conditions for each channel, which can be activated on increment or decrement and which are displayed on the screen. Each alarm can send output addressed by an RS-232 code to any of 255 devices, such as lights, sirens, and valve controls. The DAS-1 is well-suited for use in laboratories and industrial settings.

For analysis of data, the DAS-1 can export information in Lotus 1-2-3 format. It communicates via a 9-pin RS-232 port. The unit has a small size (5½" by 5½" by 2½"), low power requirement (5V DC), a built-in microprocessor, and quick cable disconnect.

For more information, contact William V. Rochat, President, BASICON, Inc., 14273 NW Science Park Dr., Portland, OR 97229, (503) 626-1012, FAX (503) 643-4686.

KITS FOR THE ELECTRONIC MUSICIAN

PAIA Electronics has available its 1991 catalog of kits for the electronic musician. Products include the MV-8 MIDI/Control Voltage processor, a PC-MIDI interface and software package, rack chassis enclosures, and an experimenter's kit. Other products range from a vocal zapper and guitar effects to kits for constructing studio sound processing equipment such as limiters, equalizers, mixers, a vocoder, and more.

The 1991 catalog is available free from PAIA Electronics, Inc., 3200 Teakwood Ln., Edmond, OK 73013, (405) 340-6300.

MICROMATH BBS NOW ON-LINE

MicroMath Scientific Software has announced the installation of a computer bulletin board. The board's main emphasis is the Special Interest Forum, which facilitates communication between scientists and engineers. It allows professionals direct access to each other, giving them more resources in solving many complex challenges. The bulletin board acts as a clearinghouse for ideas and solutions for these and other needs.

Services provided are e-mail or two-station teleconferences, classified ads, customer product feedback on MicroMath products, and registration of MicroMath products. Future services will include spec sheets on products, an electronic newsletter, application specific examples and notes for evaluating products, product demonstration materials, and professional overnight slide preparation from MicroMath plot files.

The board has no user connect charges and runs on a 33MHz 80386 PC. Phones lines are "hunt grouped," making all lines accessible through a single phone number. These lines are connected to modems supporting 1200 and 2400bps. The bulletin board supports two simultaneous log-ons and will be expanded as needed. It can be accessed 24 hours a day at (801) 943-0397.

MULTIPLIER ICs FOR VARIED APPLICATIONS

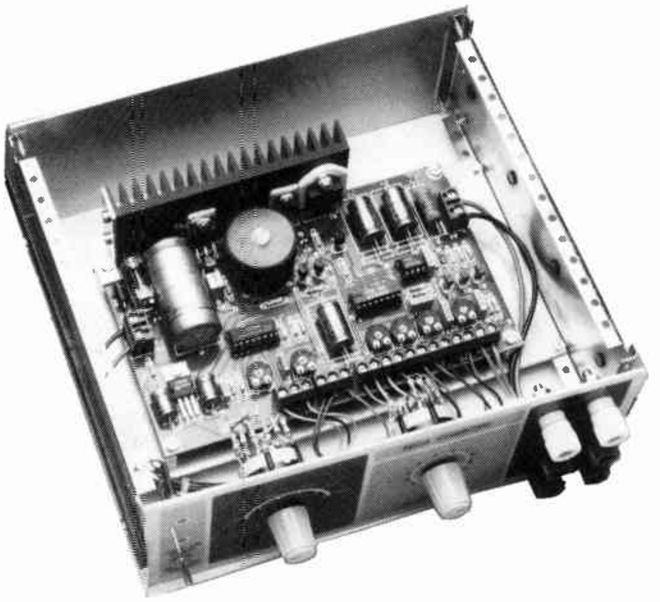
Analog Devices' monolithic AD734 analog multiplier/divider operates with a small signal and full-power bandwidth of 10MHz. It also offers a slew rate of 450V/μS, a signal-to-noise ratio of 94dB, and a conversion accuracy of 0.25% for high-grade devices.

As a four-quadrant multiplier, the AD734 can function as an oscillator, filter, or voltage-controlled amplifier. When connected as a two-quadrant divider, the device can function as an automatic gain control amplifier or an RMS/DC converter. Direct divide mode lets you optimize dynamic range for varying input signal spans. Applications include audio systems, sonar, analytical instrumentation, and RF and IF signal processing.

The AD633 is a four-quadrant multiplier. Intended for medium- and high-volume systems, its full-scale accuracy is 2% and requires no external components for operation. Applications include power measurement, watthour meters, motor control, and gamma-correction for projection TV.

The AD734AQ sells for $10.55 (100s) and the AD633JN for $3.38 (1,000s). For more information, contact Analog Devices, Inc., 181 Ballardvale St., Wilmington, MA 01887, (617) 937-1428.

UNIVERSAL Ni-Cd BATTERY CHARGER



by A. Rigby

Ni-Cd batteries are now used in so much everyday equipment that most households need at least one suitable charger. The one presented here can be used to charge virtually all current Ni-Cd batteries.

THE charger is based on the Telefunken Type U2400B processor, which has been specially developed for this application. This device contains most of the logic circuits necessary for automatically controlling the charging of Ni-Cd batteries.

Initially, charging takes place during a predetermined period of time, after which trickle charging takes over. The trickle charging, which may continue for long periods of time, ensures that the battery capacity does not degrade during the life of the battery.

The charger has a number of safety features. For instance, if the temperature of the battery becomes too high or when the e.m.f. of the battery rises above a certain (predetermined) value, the charging cycle is discontinued immediately. The processor then assumes its stand-by mode and remains there until the temperature or the e.m.f. drops below its limiting value.

A flow diagram of the charging process is given in Fig. 2. After the battery has been connected and the start reset operated, the processor first arranges for the battery to be discharged. During the discharge cycle, the temperature of the battery ($T<T_{max}$) and its e.m.f. ($U<U_{min}$) are monitored continually. When the e.m.f. drops to the level of U_{min}, the processor assumes that the battery has been discharged completely, and sets its discharge register. The circuit then switches to the charging mode. During charging the lapsed charging time is compared with the preset charging time ($t>t_{max}$) and the e.m.f. with the maximum (preset) voltage ($U>U_{max}$). Furthermore, the content of the discharge register and the battery temperature are monitored constantly. At the end of the preset charging time ($t>t_{max}$), the charging cycle is terminated and the processor actuates the trickle charging mode.

As already mentioned, if during charging one of the preset parameters is exceeded, charging is discontinued. At the same time, the status of the error register is increased by 1 and reread. If no error occurred previously, the status of the counter after the present error will be smaller than 2($Z<2$). If the counter status is smaller than 2, the e.m.f. and temperature of the battery are checked once again; if these are all right, the charging process is continued. If the content of the error register is greater than, or equal to, 2, charging is continued or stopped, depending on the position of a switch as explained later.

As is seen in Fig. 1, the processor needs only a few external components to perform the functions discussed so far. During the discharge cycle, the e.m.f. of the battery is monitored via U_{min} (pin 6). In this, use is made of a switchable voltage divider, R_{35}–R_{43}-R_3–P_2, which attenuates the battery voltage. During the discharge cycle, output DIS(charge) (pin 10) is active and high. The discharging is assumed complete when the voltage level at pin 6 drops below the level (0.53 V) of the internal reference voltage.

During charging, output LOAD (pin 12) becomes active and high; the battery voltage is then applied to pin 4 (U_{max}) via potential divider R_{35}–R_{43}-R_2-P_1. If the voltage at pin 4 is higher than the internal reference potential, the processor switches to the stand-by mode.

Since it is important for the user to know in which state the processor is, two LEDs are driven via STATUS output pin 9. Table 1 shows the operation of these diodes in the various modes.

A reference voltage of 3 V (nominal) is applied to pin 7, the PWM input, switch S_1, network R_4-C_2, voltage divider R_5-R_6 and the two series-connected LEDs.

Series combination R_4–C_2 at the input of the internal oscillator, pin 3, is a frequency-determining network .

Monitoring of the battery temperature is accomplished by R_6, which has a negative temperature coefficient. The potential at junction R_5–R_6 is monitored via input U_{temp} (pin 5). The charging process is stopped when the battery temperature reaches 40 °C; the resistance of R_6 is then about 440Ω.

The position of switch S_1 determines the selection made by the processor when two or more errors in the charging process have been signalled. If the switch is connected to the reference voltage, charging is continued even when two (but no more) errors have occurred; if it is connected to earth, however, full charging is discontinued and trickle charging commenced.

The charging time is preset via the TIME input, pin 13. When the internal 200 Hz oscillator is used, a high level at pin 13 sets the charging time to 1 hour. When the pin is connected to earth (low level), the charging time is 30 minutes.

The timer may also be driven by an ex-

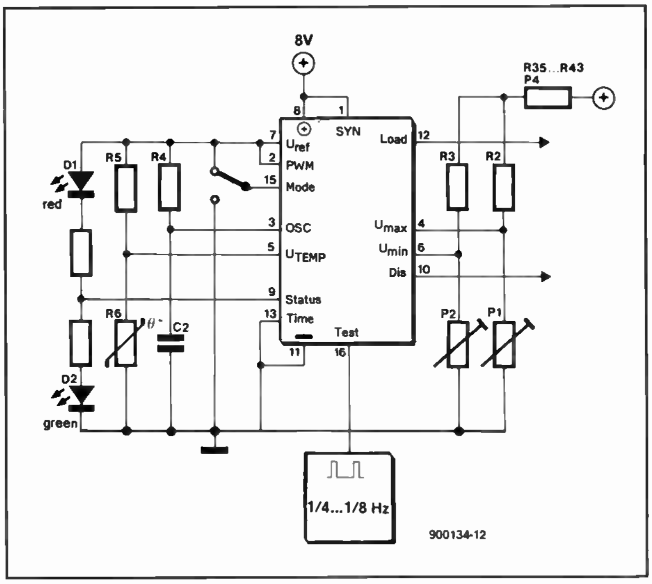


Fig. 1. Basic circuit for the U2400B processor.

Table 1

D_1	D_2	S_1	Function
(red)	(green)		
on	off	x	no battery connected; battery faulty or battery flat
flashes	off	x	discharge cycle
off	flashes	x	charging cycle
off	on	x	trickle charge mode
flashes	flashes	E	charging continues after two errors
on	off	D	trickle charging after two errors

x = irrelevant
E = connected to U_{ref}
D = connected to earth

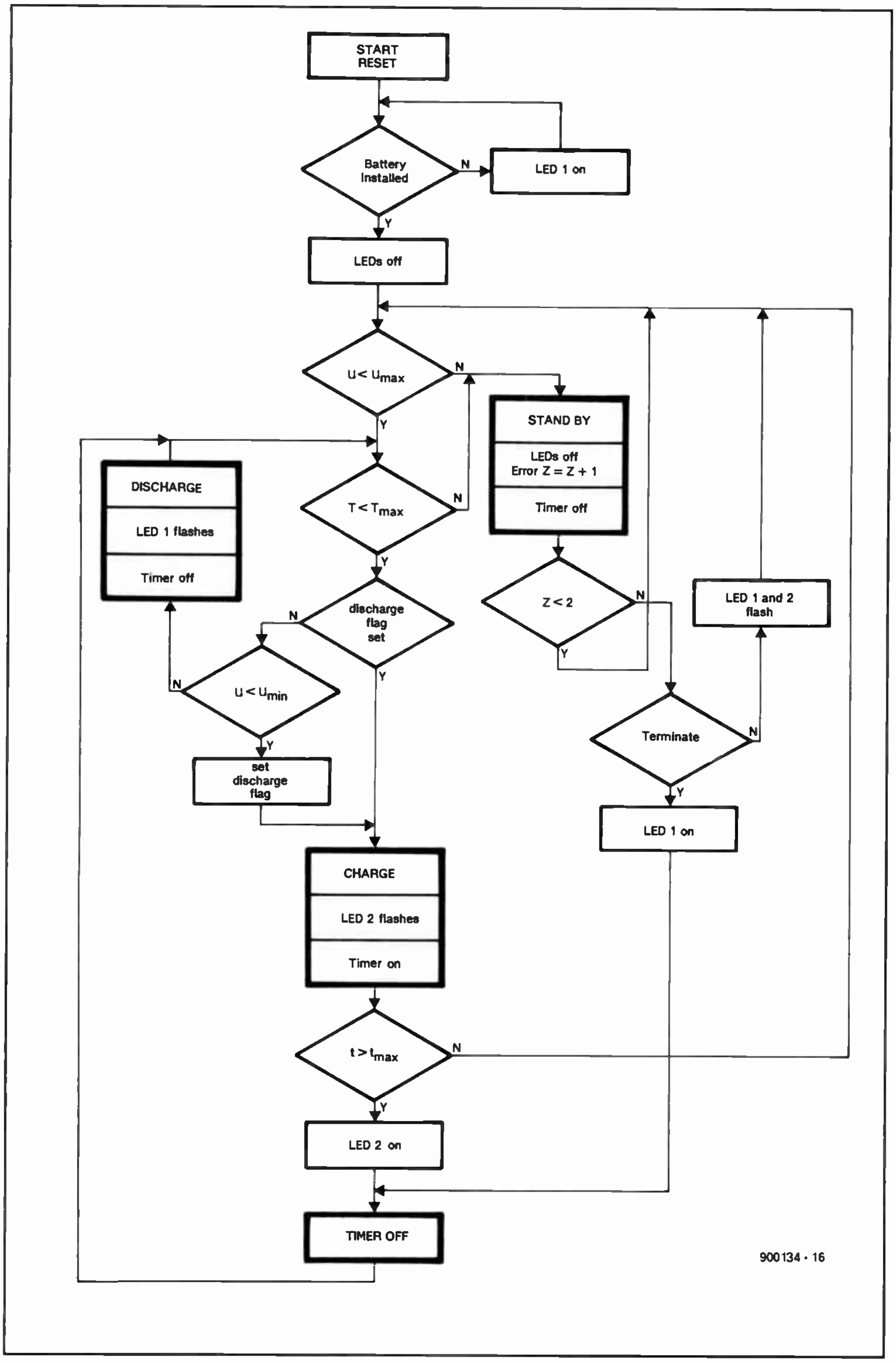


Fig. 2. Flow diagram of the battery charger.

ternal clock, connected to pin 16; pin 13 must then be earthed. The internal 200 Hz oscillator then provides the clock signals for the remaining functions of the processor. A frequency of 0.5 Hz at pin 16 sets the charging time to 1 hour; halving that frequency doubles the time. An external clock based on a 4060 IC as shown in Fig. 8 can provide frequencies down to 0.125 Hz, which would give a charging time of 4 hours.

Charging

In a practical charger, the processor does not drive a simple transistor, but a fairly complex current source, controlled as shown in Fig. 3. The charging current flows through R_{22}, resulting in a potential drop across this resistor that is directly proportional to the charging current:

$$U_{R22} = I_{load}R_{22}.$$

This voltage is used for controlling the charging current. Note that the negative battery voltage, U_{bat}, is in reality more positive than the supply voltage, U_V, because the positive terminal of the battery is connected to a second, higher supply voltage.

Since transistor T_5 is connected as a diode, the emitter of T_6 is connected to U_V at all times. Therefore, the potential drop across the emitter resistor, R_e, which is the quivalent of R_{29}–R_{34}–P_6 in Fig. 8, is exactly the same as that across R_{22}:

$$U_{Re} = U_{R22} = I_{Re}R_e.$$

As an example, assume that $R_{22} = 0.1\ \Omega$, $I_{load} = 1$ A, and that a current of 1 mA is required through the transistor. The drop across R_{22} is 100 mV, so that

$$R_e = 100\times10^{-3}/10^{-3} = 100\ \Omega.$$

Since the emitter current is now known, the voltage drop across the collector resistor is:

$$U_{Rc} = 1.2\times10^3\times10^{-3} = 1.2\text{ V}.$$

This makes it clear that a change in the charging current results in a change in the voltage at F_B. That voltage may, therefore, be used for the control of a regulatory circuit in a switch-mode power supply.

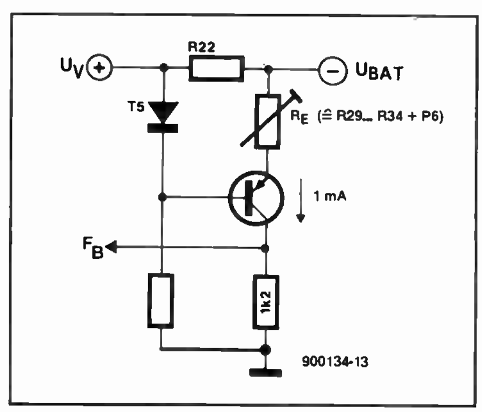


Fig. 3. Part of the circuit controlling the charging current.

Switch-mode power supply

A switch-mode power supply is used to enable the charger to cater for the simultaneous charging of, say, up to ten batteries; a conventional mains supply could be used, but the dissipation in this will be quite large when only a few batteries are being charged.

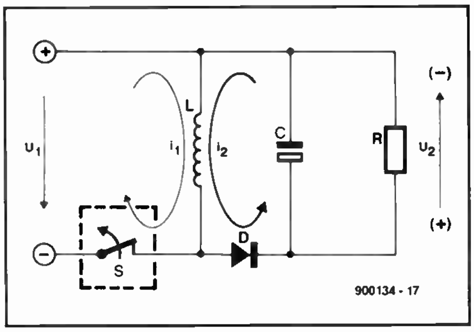


Fig. 4. Concept of a switch-mode power supply.

The basic operation of such a supply is shown in Fig. 4. Electronic switch S is switched on and off by electrical circuits. When it is closed, a current i_1 flows from the ⊕ supply terminal to earth via inductor L, resulting in a magnetic field around the inductor. Diode D is switched off and capacitor C, therefore, has no influence on the circuit, although it can discharge via load resistance R (representing the batteries to be charged).

When S is opened, the self-inductance of L causes a current i_2 in the opposite direction from i_1 and this charges C via the diode.

The level of output voltage U_2 depends on the properties of the inductor, the switching logics and the on-off ratio of the switch. In the present charger, a commercial inductor is used: it is not advisable to wind this yourself.

The circuit of the supply used is shown in Fig. 5. It is based on Linear Technology's Type LT 1070. A 40 kHz oscillator provides a train of rectangular pulses that are used to switch a transistor via a driver stage. The duty factor is determined primarily by the output voltage of the (differential) error amplifier.

The collector voltage of T_6 is 1.2 V when the regulator is in a stable condition. Because of its internal reference voltage of 1.24 V, the error amplifier then has no effect on the switching behaviour of the output transistor. When the charging current increases to too high a level, U_c rises, and the output of the error amplifier goes low. This results in an alteration of the on-off ratio of he transistor, which lowers the charging current.

Zener diode D_6 limits the voltage to 18 V.

Discharging

The discharge circuit shown in Fig. 6 has some points in common with the circuit in Fig. 3. Again, use is made of the voltage drop across emitter resistor R_{22}. The supply voltage and the battery voltage have, of course, changed places, since the discharge current flows into a different direction from the charging current.

The non-inverting input of the comparator in the collector circuit of T_3 is held at 2.7 V by zener diode D_3.

The value of R_{14} is determined by the collector current (1 mA) and the reference voltage:

$$R_{14} = 2.7/10^{-3} = 2.7\ \text{k}\Omega.$$

The connected batteries are discharged via R_{22} and T_8, which, with T_7, forms a darlington at the output of the comparator.

Voltage monitoring

The processor continually monitors the battery voltage via its pins 4 and 6. Since these inputs measure the voltage with respect to earth and the negative terminal of the battery is connected to the ⊕ supply rail, a simple circuit like that in Fig. 1 can not be used. This means that the battery voltage must be converted so that it *can* be measured with respect to earth.

To this end, a network as shown in Fig. 7 is used. The entire battery voltage is dropped across the emitter resistance, R_e, consisting of resistors R_{35}–R_{43}—see Fig. 8. Since R_e has a value of 1 kΩ per connected battery, the collector current, I_c, through T_1 is

$$I_c = n{\times}U_z/n{\times}R_e = U_z/R_e,$$

where U_z is the zener voltage.

When the batteries are charged, the collector current is $1.45/10^3 = 1.45$ mA, and the voltage drop across R_1 and potential dividers R_2–P_1 and R_3–P_2 is 1.74 V. This voltage has the correct polarity with respect to earth. The correct operating point is set with the two potentiometers: how many batteries are connected to the charger is then no longer of importance.

The complete circuit

Large parts of the diagram in Fig. 8 have already been discussed. Note that the switch-mode power supply operates only if pin 1 of the LT 1070 is connected to earth via the LOAD output of the processor and T_4.

Since the resistors at like positions of S_{4a} and S_{4b} have the same value, the discharge and charging currents of batteries are iden-

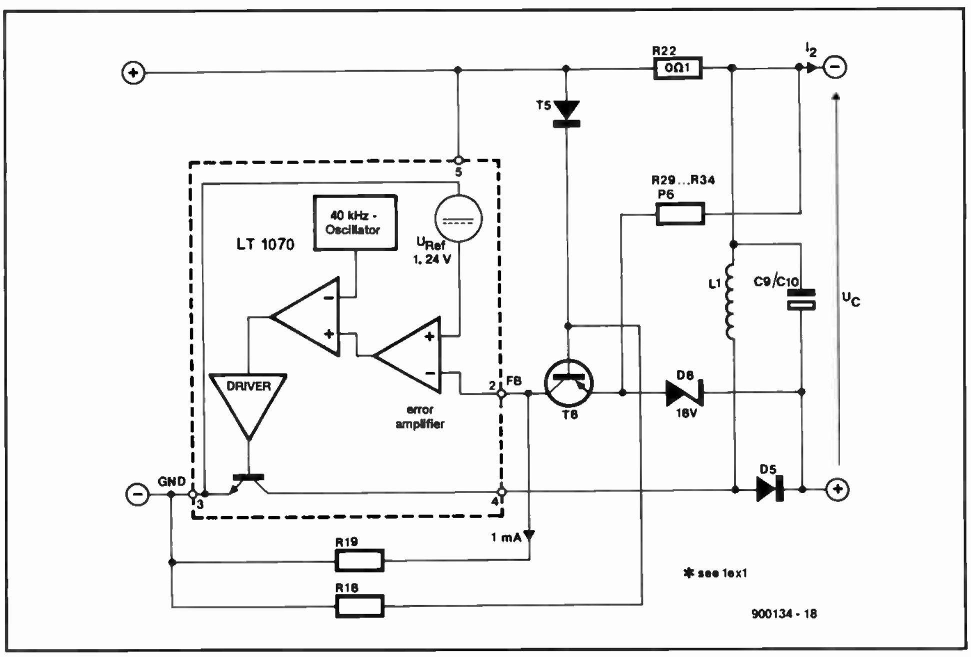


Fig. 5. The switch-mode power supply – see also Fig. 8.

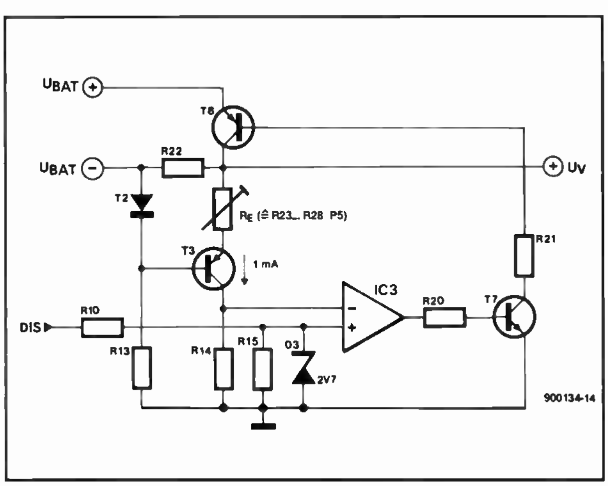


Fig. 6. Circuit for controlling the discharge current. The Dis output of the U2400B provides the reference voltage for IC3.

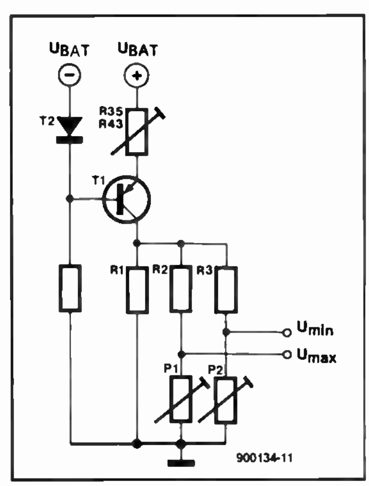


Fig. 7. Circuit for measuring the battery voltage with respect to earth.

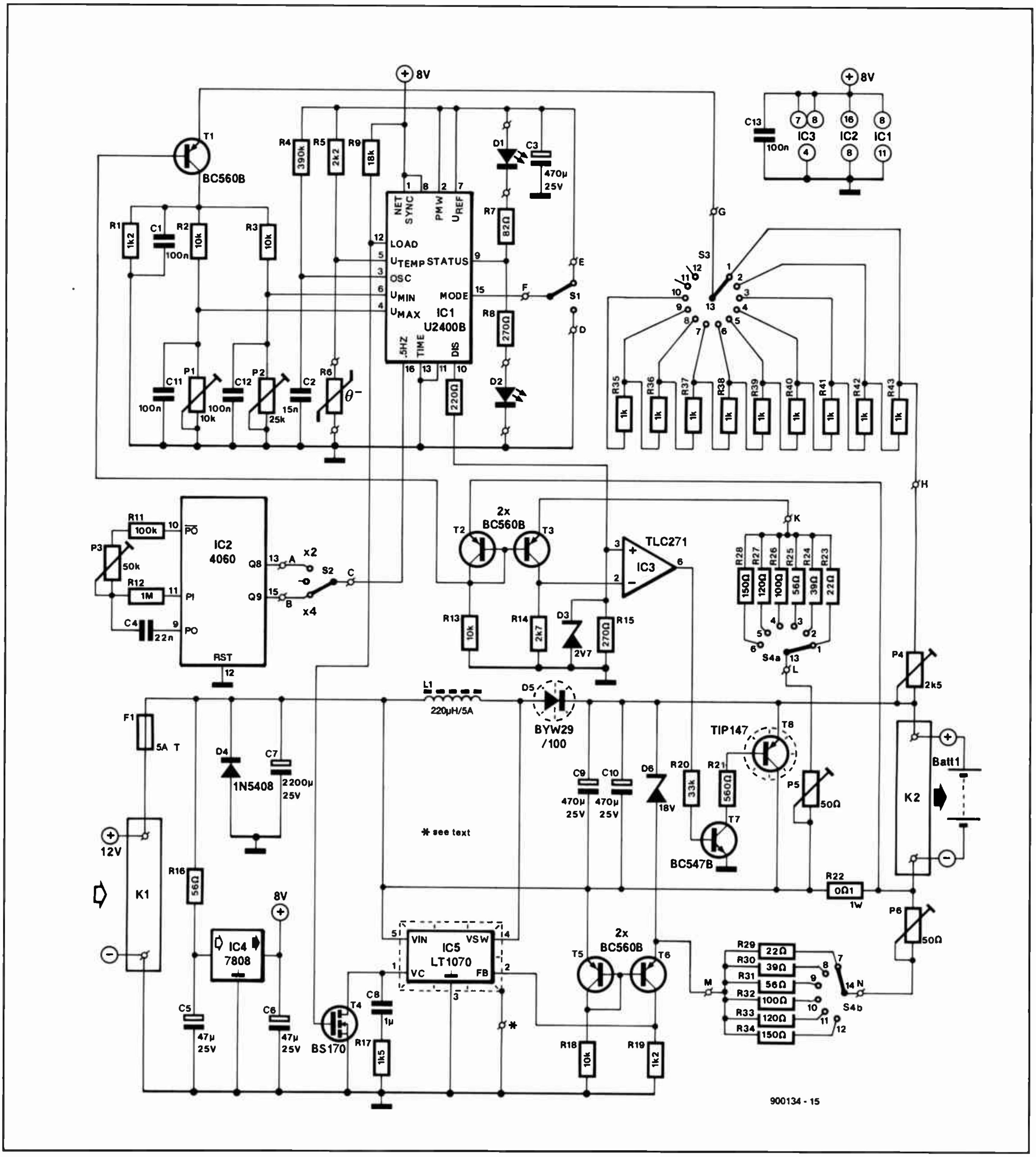


Fig. 8. Complete circuit diagram of the Ni-Cd battery charger.

tical. It is, of course, essential that switch S_3 is set to the correct number of connected batteries (maximum 10).

Switch S_1 selects the mode to be used when one or two errors are detected during the charging process—see Table 1.

When S_2 is in its centre position, the processor uses the standard time setting (of charging) of 1 hour. Its pin 13 is then connected to earth. If this meets all your requirements, the external clock generator consisting of the 4060 (IC_2), R_{11}, R_{12}, C_4, P_3, and S_2, may be omitted.

Otherwise, R_{11}, R_{12}, P_3, and C_4, set the frequency of the oscillator in the 4060 at 100–150 Hz. The divider on board the 4060 provides the required signal frequencies at outputs Q_8 and Q_9. The charging times of 2 and 4 hours respectively associated with these frequencies enable U7 and U11 size batteries to be charged in accordance with manufacturers' specifications.

Preset P_3 enables the correct setting of 2-hour (position A) and 4-hour (position B) charging periods. Should that not be possible, the value of C_4 may be increased (longer periods) or reduced (shorter periods). If a standard time of 30 minutes is wanted instead of 1 hour (S_2 in centre position), disconnect pin 13 of the U2400B from earth.

If C_4 is replaced by a 10 nF type, periods of 30 minutes (S_2 in centre position), 1 hour (S_2 in position A), and 2 hours (S_2 in position B), may be selected

For trickle charging the normal charging circuit is used, but the on-off ratio is ar-

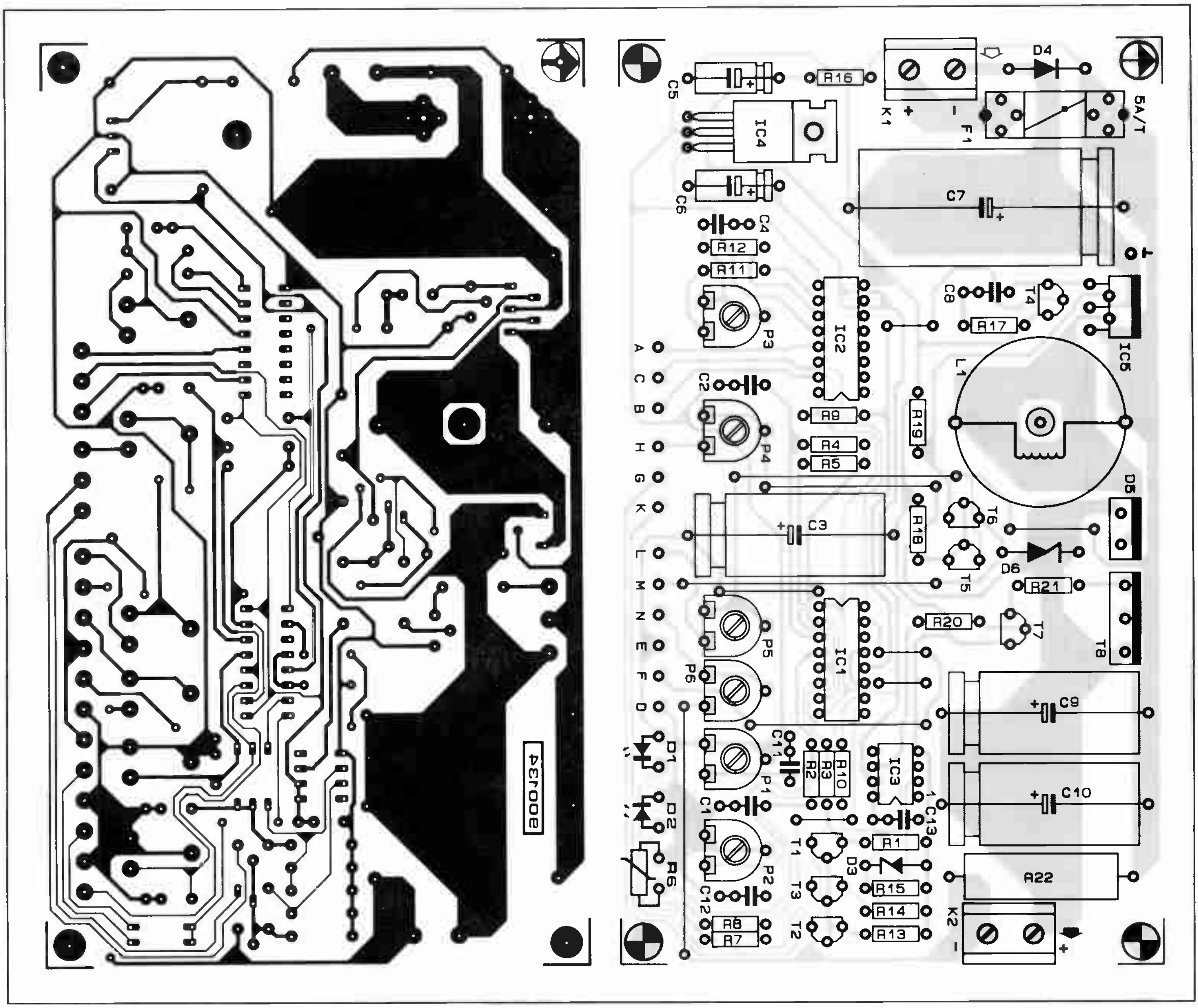


Fig. 9. Component layout and mirror image of track layout of the printed-circuit board for the Ni-Cd battery charger.

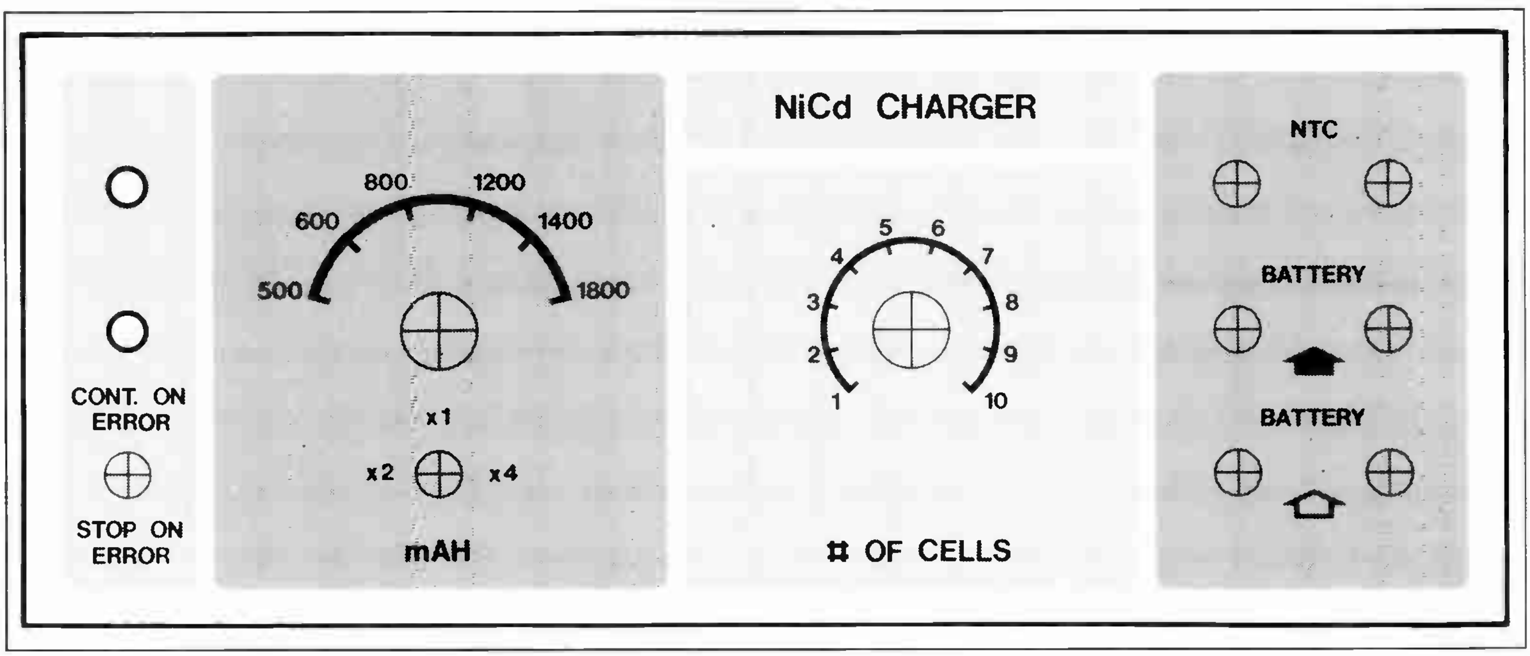


Fig. 10. A front panel foil for the battery charger (196×77 mm) is available through our Readers' Services.

ranged at 1:179, which reduces the average charging current of 1800 mA to 10 mA.

The level of the discharge and charging currents is independent of the selected charging period and may be set to six fixed values with S_4. If it is required for a battery to be charged completely in 30 minutes, the charging current selected must have twice the value of the battery capacity. The charging current in mA corresponds to the capacities shown on the front panel—see Fig. 10. That is, in position 500 mAh, the charging current is 500 mA. Independent of this, the charging current may be doubled by shunting R_{22} with a second 0.1 Ω, 1 W, resistor. This may, however, be done only if the total consumption, $I_{load} \times U_{load}$ does not exceed 25 W, otherwise the switched-mode power supply may become overloaded. Furthermore, the maximum current through the inductor, the fuse rating (max. 8 A), and the maximum discharge current (max. 10 A) must be observed.

Construction

The battery charger is best constructed on the printed-circuit board shown in Fig. 9.

Pay good attention to the polarity of a number of components and make sure that firm solder connections are made where large currents are likely to flow.

The components that need cooling, i.e., IC_5, D_5, and T_8, are located at the edge of the board to enable them to be fitted direct to a suitable heat sink (≥3.2 K W^{-1} at a consumption of ≤25 W).

Make sure that the rear of the LT1070 is electrically bonded to the earth connection specially provided between the supply connections for C_7 and IC_5.

All presets are conveniently grouped at one side of the board.

Resistors R_{23}–R_{43} are not located on the board, but are soldered direct to the rotary switches. These switches are intended to be fitted to the front panel. Their sections that must be connected to the board are marked G/H, K/L, and M/N.

The sockets for connecting the NTC resistor, R_6, the supply (K_1) and the batteries (K_2) are located at the right-hand side of the front panel.

Calibration

There are quite a few calibrations to be carried out, but fortunately they are not very critical. In the first place, do not yet fit IC_1.

1. Set S_4 to 500 (mA), S_3 to 8 (batteries), S_2 to its centre position, and all presets to the centre of their travel.
2. Connect a 12 V, 2 A supply to K_1 (observe polarity!).
3. Connect an auxiliary supply of 8 V to K_2 (observe polarity!).
4. Connect a multimeter between the ⊕ pin of K_2 and point G on the board, and adjust P_4 until the measured voltage is *exactly* the same as that between the pins of K_2.
5. Set S_3 to position 10 and adjust P_2 until with an auxiliary voltage of 8–8.5 V on K_2, a voltage of 0.53 V is measured between junction P_2–R_3–C_{12} and earth. This ensures that all batteries are first discharged to an e.m.f. of 0.8–0.85 V.
6. Set S_3 to position 10 and adjust P_1 until with an auxiliary voltage of 10× the maximum specified (by manufacturer) cell voltage on K_2, a potential of 0.53 V is measured between junction P_1–R_2–C_{11} and earth. The maximum cell voltage is normally about 1.65 V, but may vary from 1.55 V to 1.7 V.
7. The external clock is adjusted with the aid of P_3 and this is best done on an oscilloscope. The frequency of the signal at pin 6 of IC_2 must be 1 Hz. If you have no oscilloscope, use a logic tester with LED indication: the flashing of the LED may be compared with the second hand of a watch.
8. Remove the auxiliary voltage from K_2, switch off the supply voltage, and fit IC_1 and R_6. In an emergency, a normal 1 kΩ resistor may be used for R_6.
9. Connect a partially discharged 500 mAh battery to K_2, set S_4 to 500 and S_3 to 1.
10. Reconnect the 12 V supply to K_1, whereupon the red LED will come on.
11. Connect a digital multimeter (set to 1–2 A d.c.) in series with the battery. About 2 seconds after the connection with the battery is made, the red LED goes out and discharging of the battery begins. Adjust P_5 till the multimeter reads 500 mA.
12. After a little while, the battery will be discharged and charging will commence, indicated by the coming on of the green LED. The current through the multimeter will then change direction: adjust P_6 until it has a value of 500 mA.
13. The battery charger is now ready for use.

Finally

Before charging is begun, always set the various switches to the correct position. The charger can then be switched on and the batteries connected to it. When a different set of batteries or battery is connected to the charger, reset the processor by briefly switching off the supply. ■

PARTS LIST

Resistors:
R1, R19 = 1.2 kΩ
R2, R3, R13, R18 = 10 kΩ
R4 = 390 kΩ
R5 = 2.2 kΩ
R6 = 1 kΩ NTC
R7 = 82 Ω
R8, R15 = 270 Ω
R9 = 18 kΩ
R10 = 200 Ω
R11 = 100 kΩ
R12 = 1 MΩ
R14 = 2.7 kΩ
R16, R25, R31 = 56 Ω
R17 = 1.5 kΩ
R20 = 33 kΩ
R21 = 560 Ω
R22 = 0.1 Ω, 1 W
R23, R29 = 22 Ω
R24, R30 = 39 Ω
R26, R32 = 100 Ω
R27, R33 = 120 Ω
R28, R34 = 150 Ω
R35–R43 = 1 kΩ
P1 = 10 kΩ preset
P2 = 25 kΩ preset
P3 = 50 kΩ preset
P4 = 2.5 kΩ preset
P5, P6 = 50 Ω preset.

Capacitors:
C1, C11, C12, C13 = 100 nF
C2 = 15 nF
C3, C9, C10 = 470 µF, 25 V
C4 = 22 nF
C5, C6 = 47 µF, 25 V
C7 = 200 µF, 25 V
C8 = 1 µF

Inductors:
L1 = choke 200 µH, 5 A

Semiconductors:
D1 = LED, red
D2 = LED, green
D3 = zener, 2.7 V, 400 mW
D4 = 1N5408
D5 = BYW 29/100
D6 = zener, 18 V, 400 mW
T1, T2, T3, T5, T6 = BC560B
T4 = BS170
T7 = BC547B
T8 = TIP147
IC1 = U2400B
IC2 = 4060
IC3 = TLC271
IC4 = 7808
IC5 = LT1070

Miscellaneous:
S1 = miniature C/O switch
S2 = miniature C/O switch with centre position
S3 = rotary switch, 1 pole, 12 positions
S4 = rotary switch, 2 poles, 6 positions
F1 = fuse, 5 A, complete with holder
K1, K2 = 2-way terminal block
Heat sink, 100×38×15 mm
PCB 900134
Front panel foil 900134-F

Estimated cost: £45–£55

LOGIC ANALYSER - PART 4

by K. Nischalke and H.J. Schulz

In this penultimate instalment of the article (which was delayed by circumstances beyond our control), the power supply and the interfaces for the IBM and Atari are discussed, and that completes the hardware for the logic analyser. In the final instalment, the necessary software will be introduced.

THE DESIGN of the power supply is not revolutionary and yet it is unconventional, because the analyser, owing to the number of fast logic circuits, consumes quite a lot of power. The circuit diagram of the power supply is given in Fig. 16.

So as to keep the supply relatively simple and compact, five low-power voltage regulators, instead of one heavy-duty type, are used: one for each board contained in the analyser. This design has the advantage that when a certain board is not used, its supply can also be omitted. Furthermore, the cooling becomes a lot easier.

The supply consists of two independent sections, of which the main one is based on transformer Tr$_2$, bridge rectifier D$_2$–D$_5$, and voltage regulators IC$_{65}$–IC$_{69}$. The section based on Tr$_1$, bridge rectifier D$_6$–D$_9$, and regulators IC$_{70}$ and IC$_{71}$ is is intended for probes that can cope with input voltages up to ±12 V. If such a probe is not envisaged, this section may simply be omitted.

Mains transformer Tr$_2$ is rated at 5 A to handle the whole analyser. The rating can be reduced by 1 A for each RAM card that is omitted.

The five regulators are of the well-known 78xx type, but here rated at 2 A (S-type). This is because the current drain of the RAM cards is just about 1 A and it would be disturbing if the current limiting of the regulator would come into action regularly (low voltage).

The PCB for the supply is shown in Fig. 17. It has the same format as the bus board and the two may, therefore, if the enclosure allows, be fastened together with the aid of suitable spacers (track sides facing, of course). Such an arrangement would place the 5 V and 12 V connections of the boards close together.

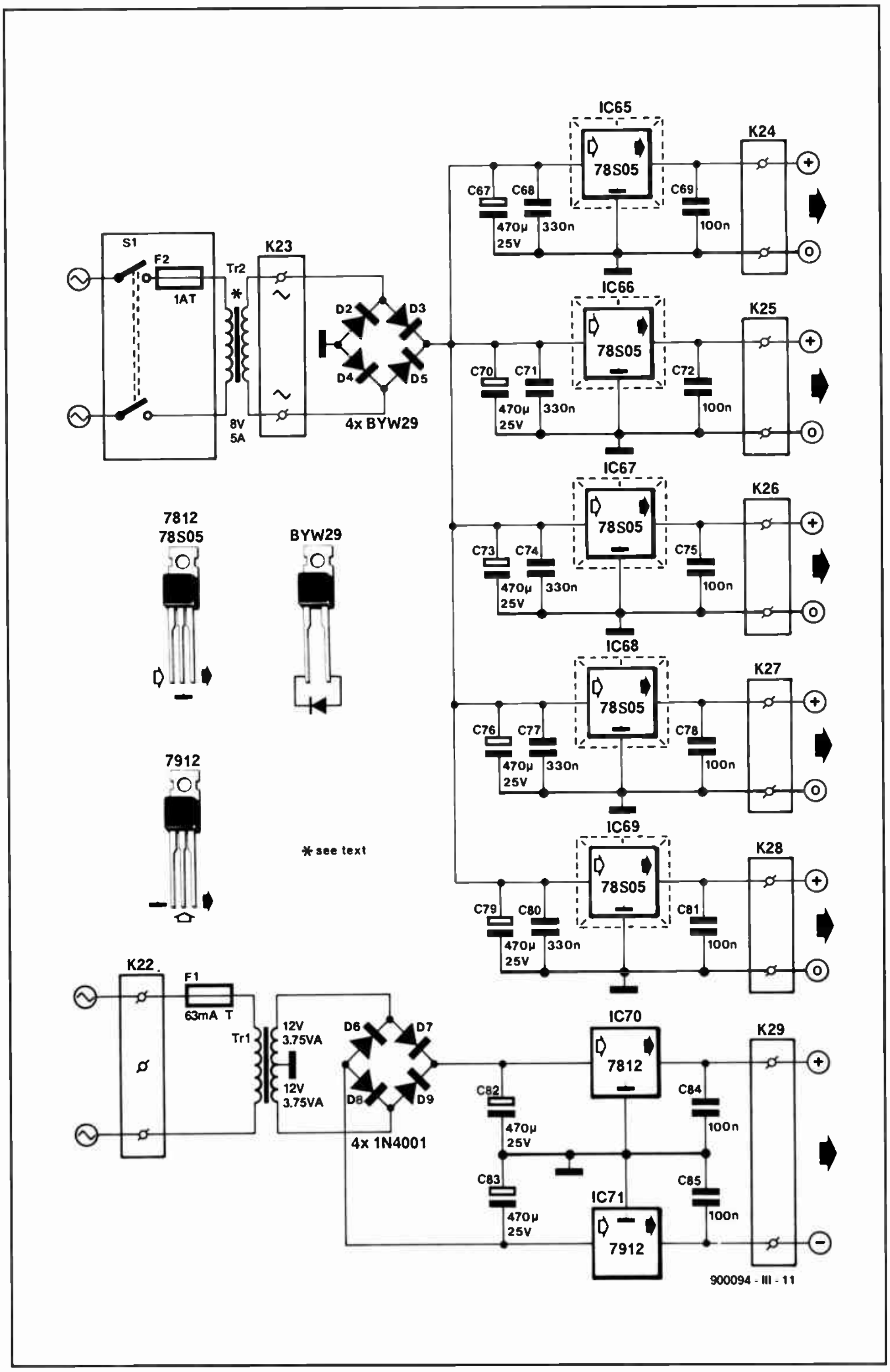


Fig. 16. Circuit diagram of the power supply; the section based on Tr1 is for use only if probes that accommodate input voltages up to ±12 V are to be used.

Atari interface

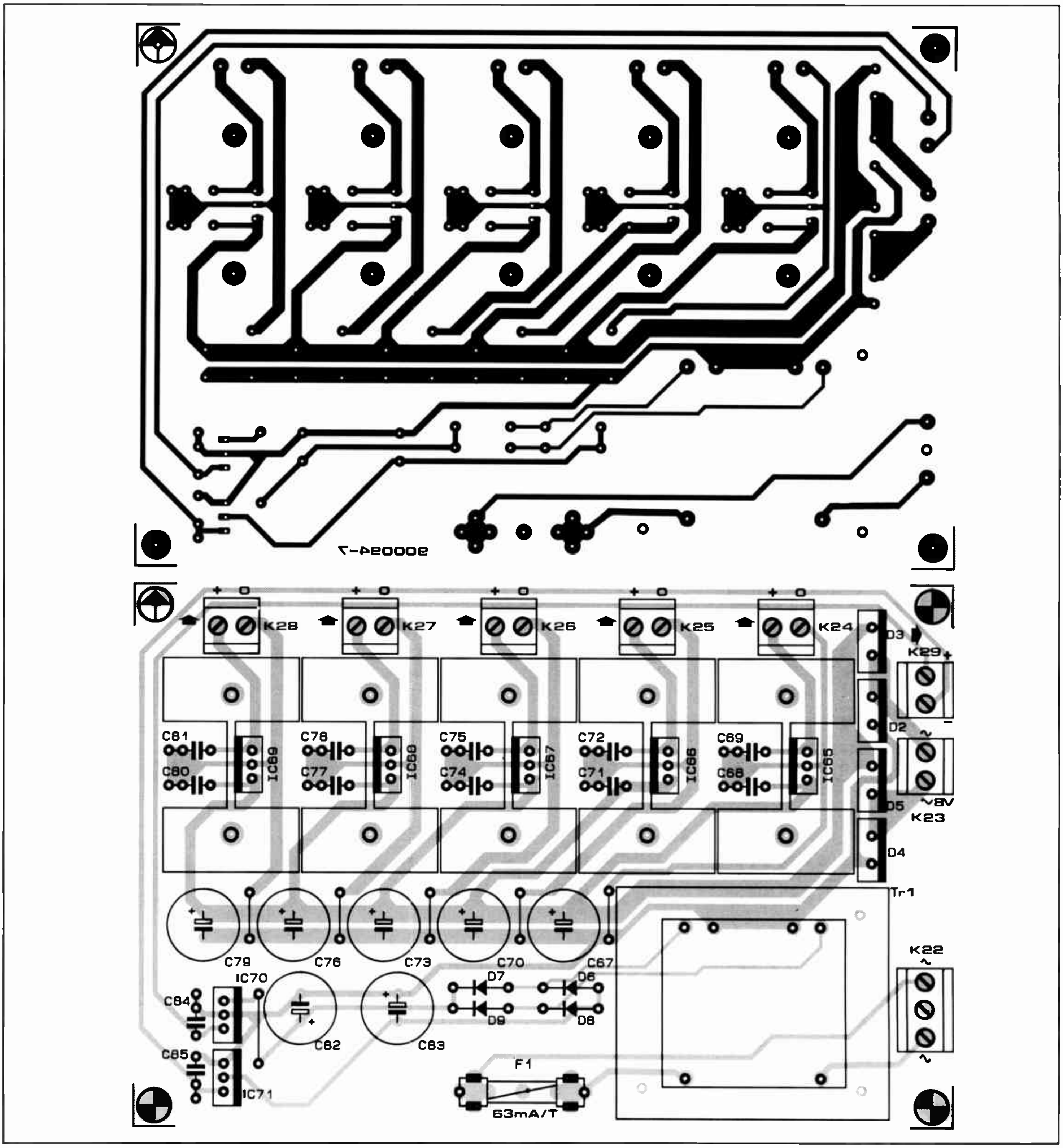
Communication between an Atari and the logic analyser is via the hard-disk slot emerging at the rear of the computer via a D-type connector.

The present interface is not strictly a special hard-disk interface, but a DMA interface to which a maximum of eight external apparatuses may be connected in parallel. Addressing the apparatuses separately prevents any conflict between them. This means also that the hard disk may remain connected.

The circuit diagram of the interface is

Fig. 17. Photograph of the completed power supply board.

Fig. 18. The printed-circuit board for the power supply has the same dimensions as the busboard. It has no provision for Tr2.



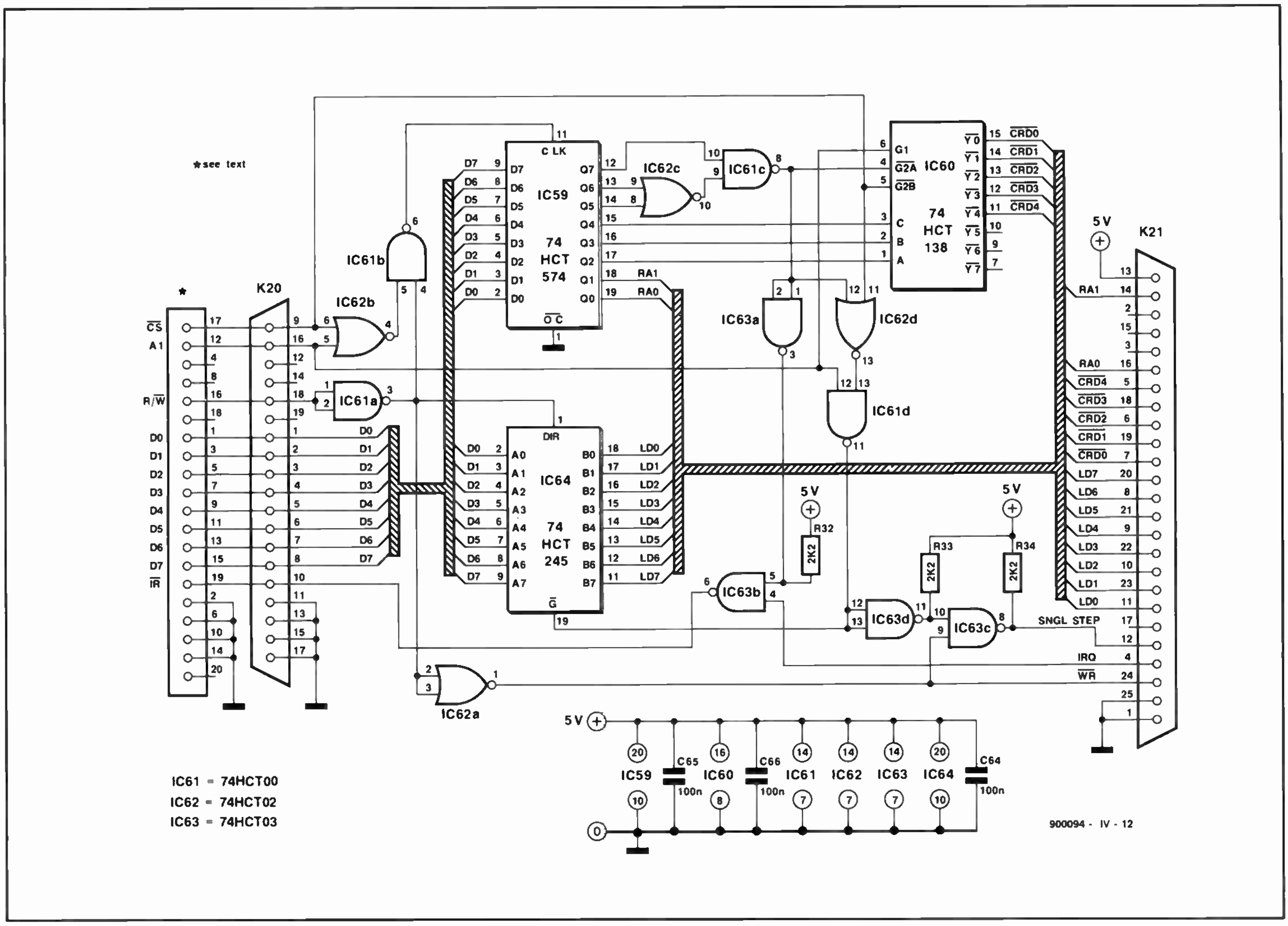


Fig. 19. Circuit diagram of the interface for Atari computers.

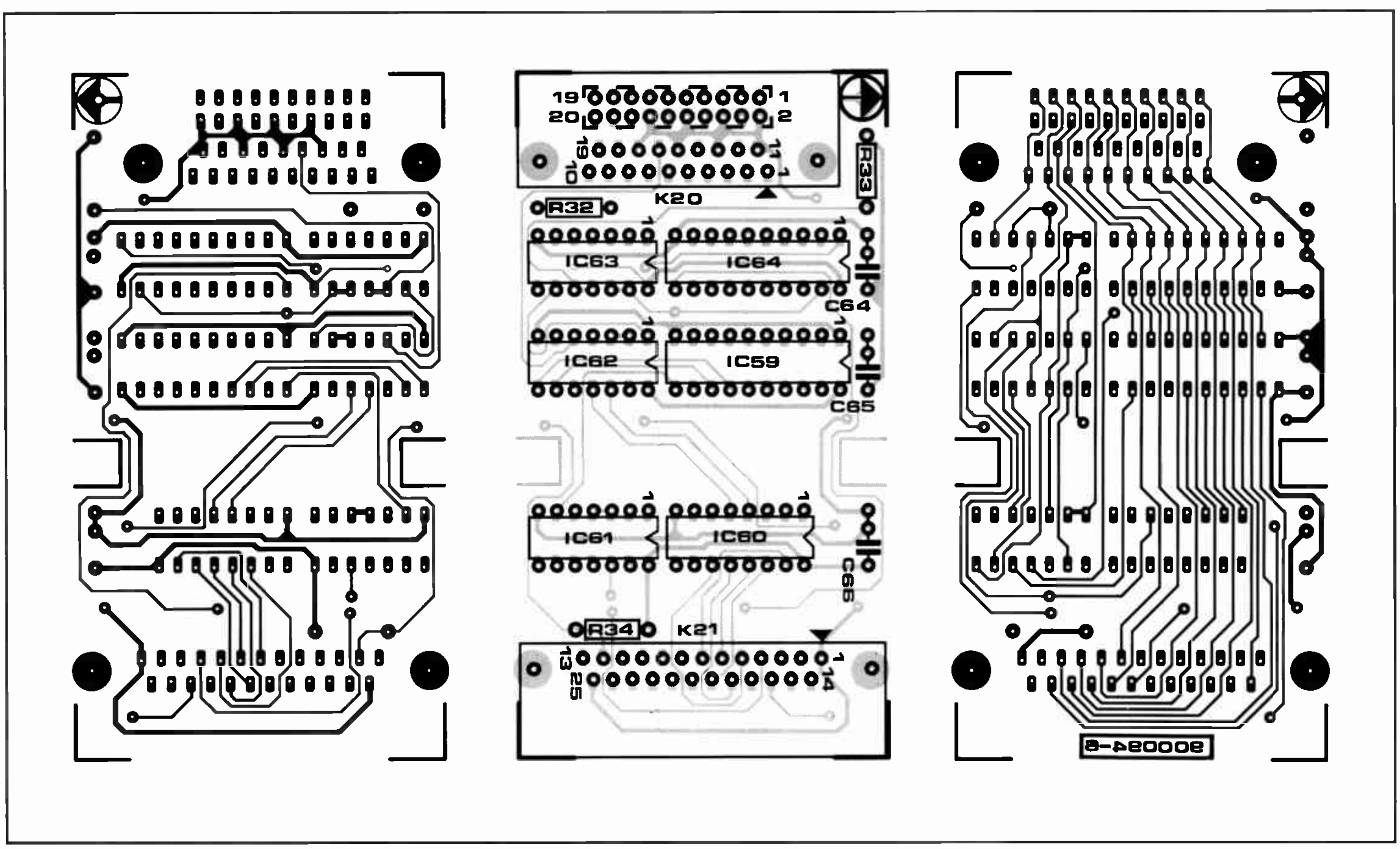


Fig. 20. The printed-circuit board for the Atari interface.

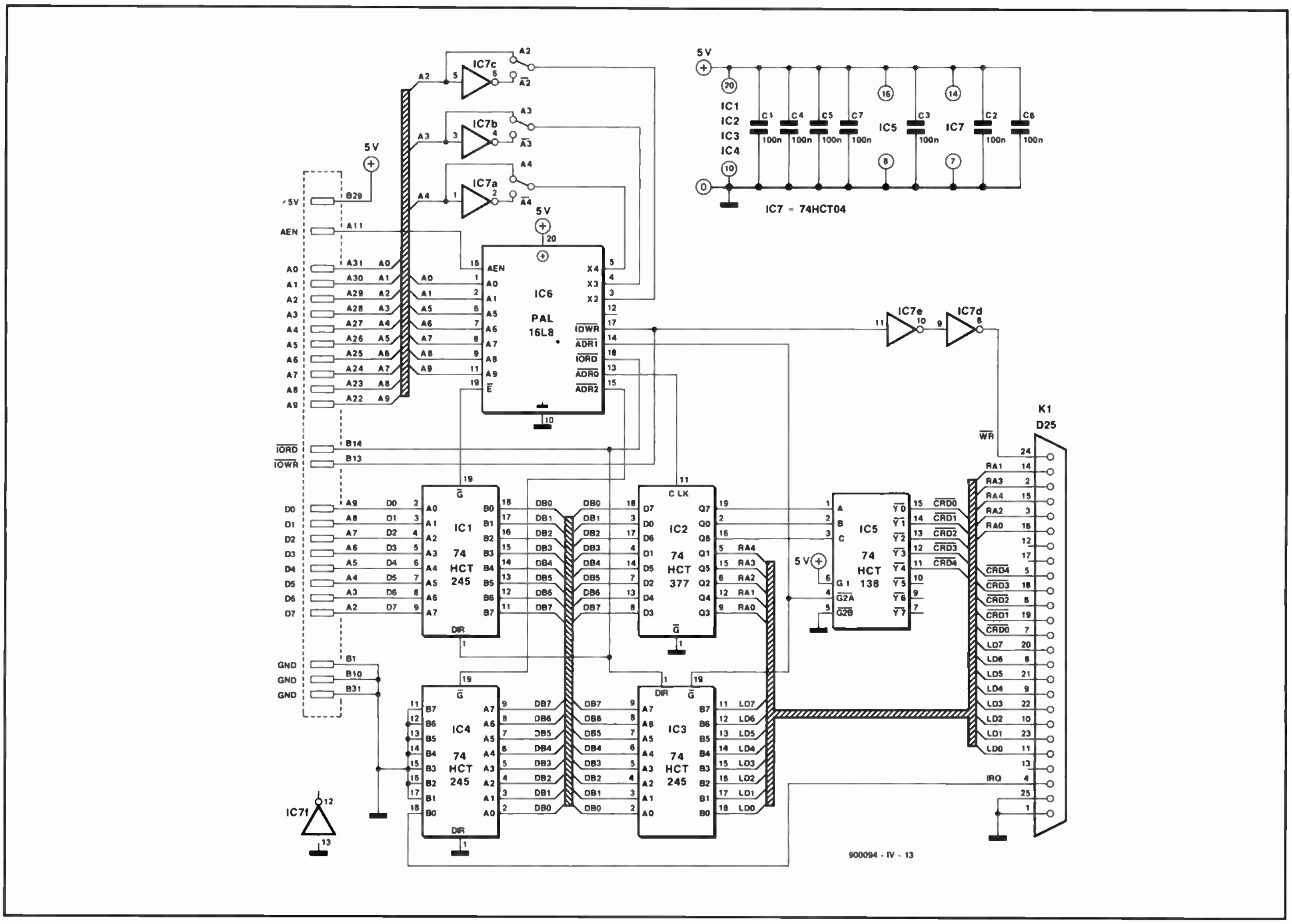


Fig. 21. Circuit diagram of the IBM interface.

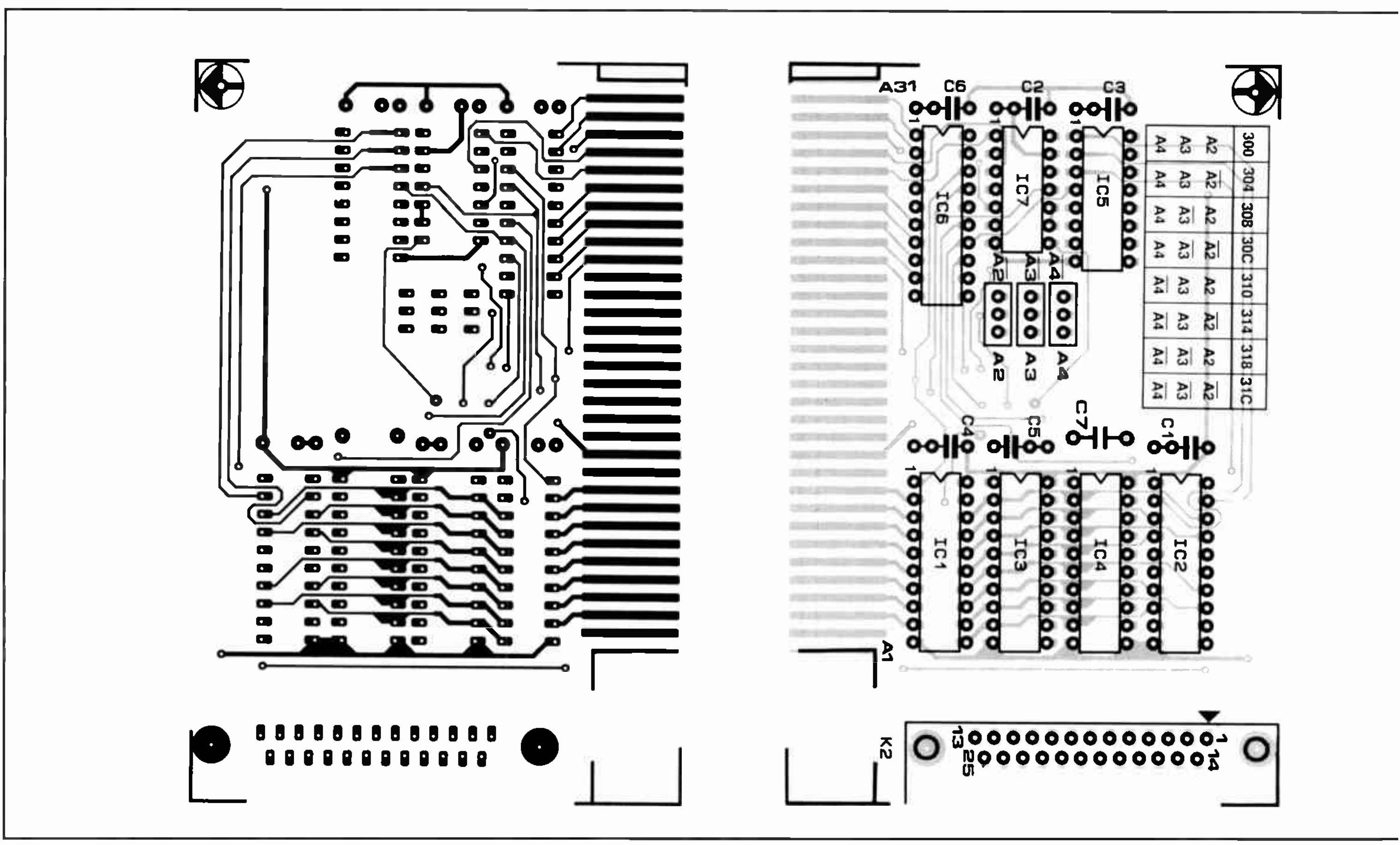


Fig. 22. The printed-circuit board for the IBM interface is designed as a slot-in card.

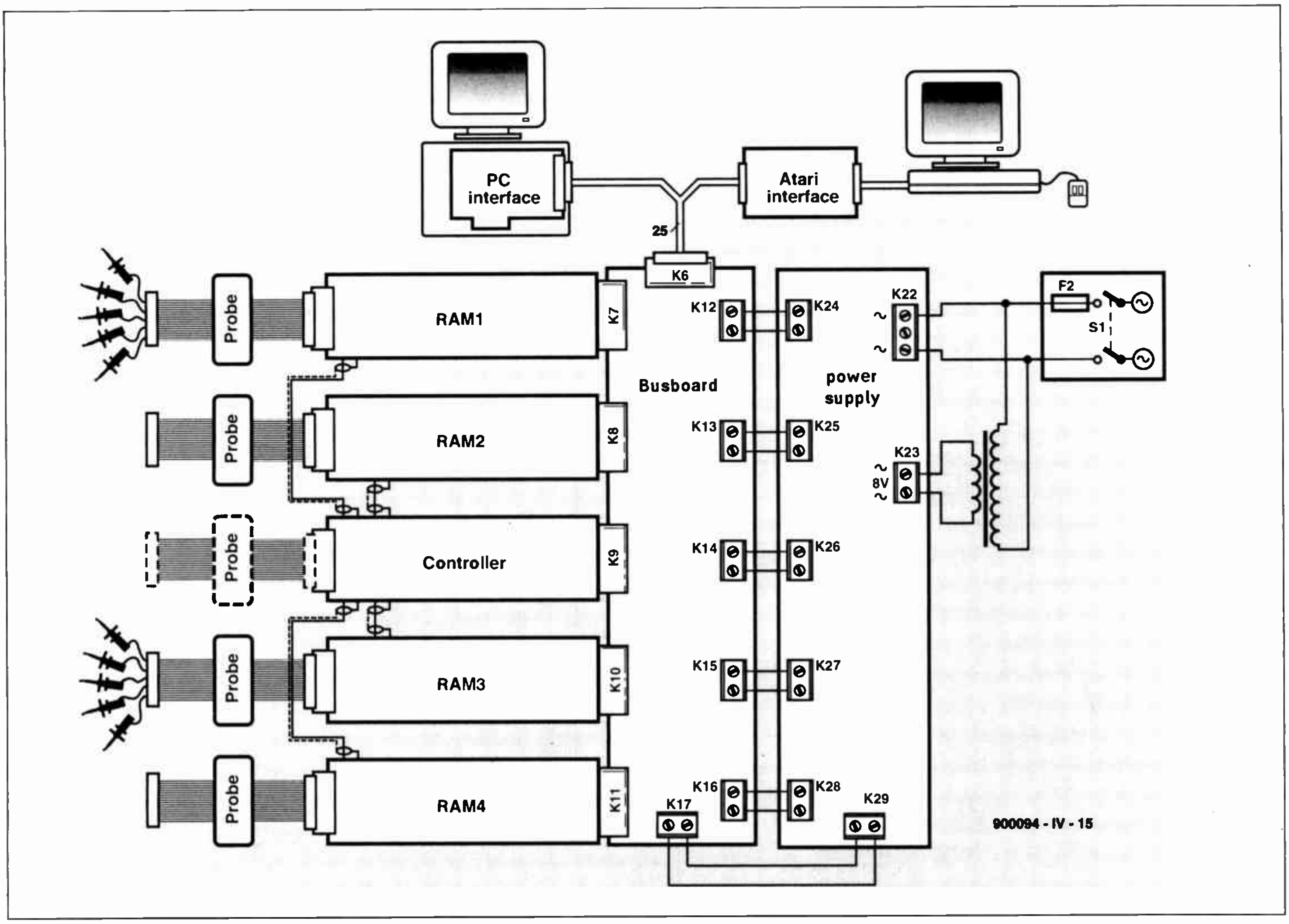
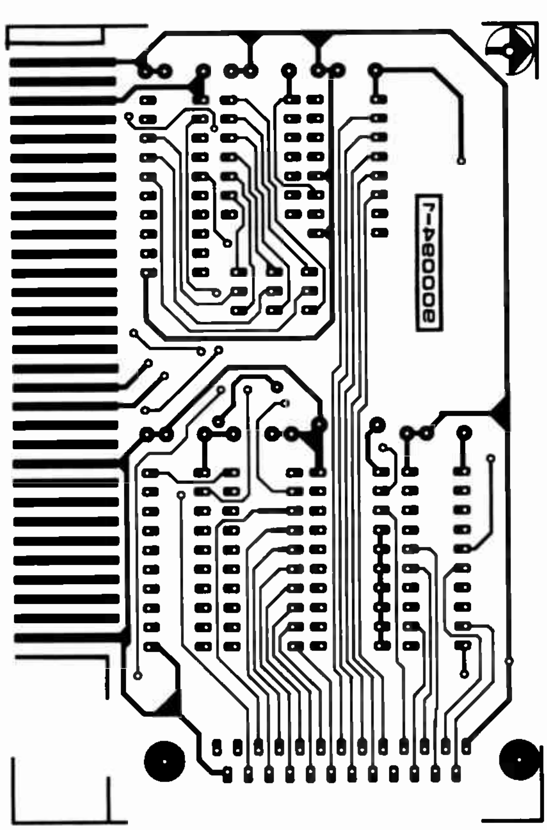


Fig. 23. Overview of the logic analyser and the wiring between the various boards.



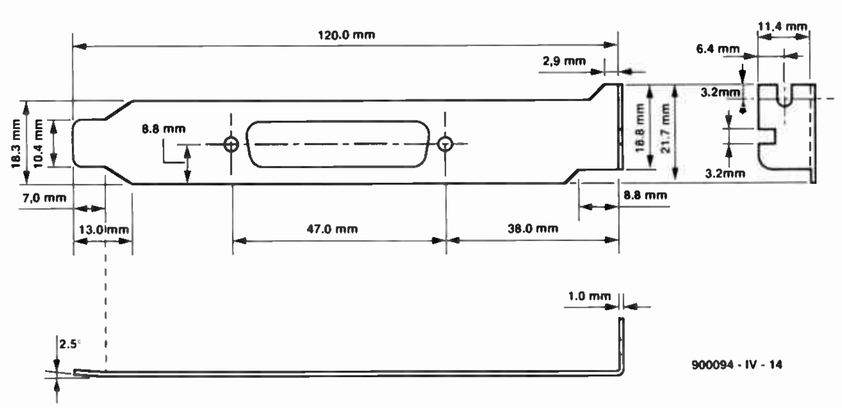


Fig. 24. The IBM interface print should be secured with a fixing plate as shown here.

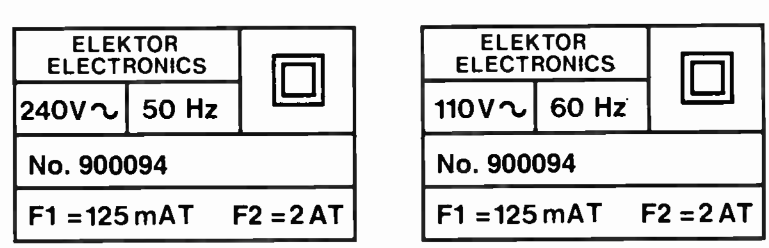


Fig. 25. Suggested labels for the rear panel of the logic analyser.

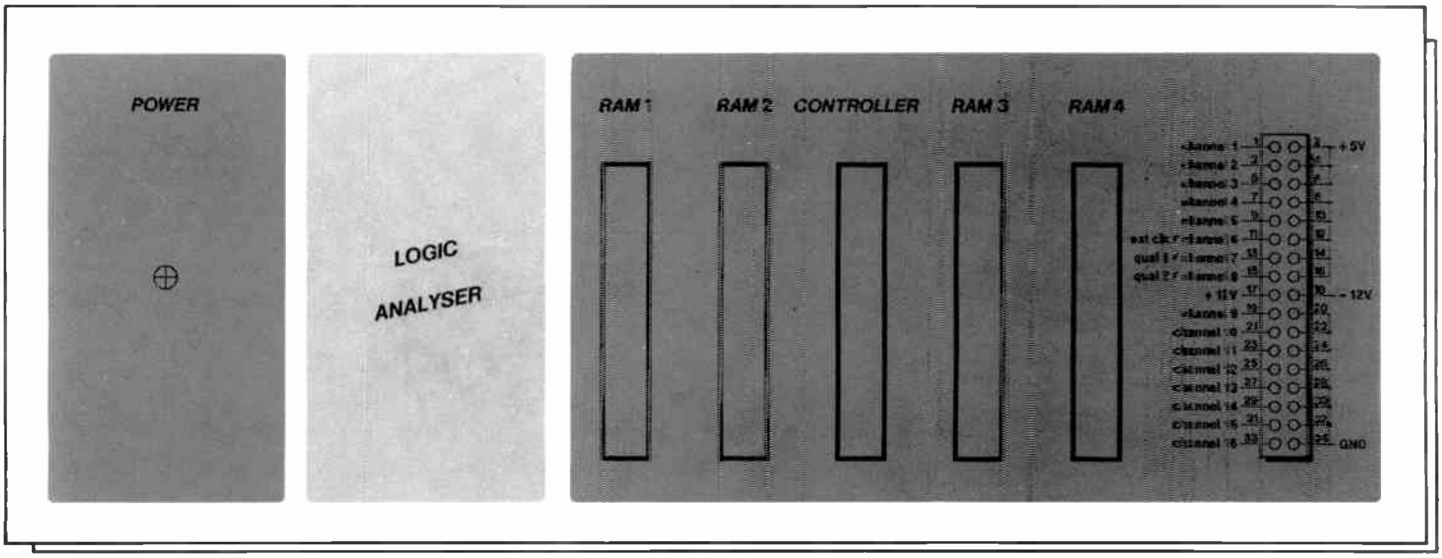


Fig. 26. The front panel for the logic analyser is available through our Readers Services.

PARTS LISTS

Power supply

Capacitors:
C67, C70, C73, C76, C79, C82, C83 = 470 µF, 25 V
C68, C71, C74, C77, C80 = 330 nF
C69, C72, C75, C78, C81, C84, C85 = 100 nF

Semiconductors:
D2–D5 = BYW29
D6–D9 = 1N4001
IC65–IC69 = 78S05
IC70 = 7812
IC71 = 7912

Miscellaneous:
K23–K29 = 2-way terminal block, 5-cm centre
K22 = 3-way terminal block, 5-cm centre
Tr1 = mains transformer, 12 V, 3.75 VA
Tr2 = mains transformer 8 V, 5 A
S1 = mains on/off switch with integral fuse holder
F1 = fuseholder and fuse, 63 mA, delayed action
F2 = fuse, 1 A, delayed action
Five heat sinks for IC65–IC69
PCB 900094-7

Atari interface

Resistors:
R32–R34 = 2.2 kΩ

Capacitors:
C64–C66 = 100 nF

Semiconductors:
IC59 = 74HCT574
IC60 = 74HCT138
IC61 = 74HCT00
IC62 = 74HCT02
IC63 = 74HCT03
IC64 = 74HCT245

Miscellanous:
K20 = 19-pole male D connector or 20-way box header (see text)
K21 = 25-pole female D connector for PCB mounting
PCB 900094-6

IBM interface

Capacitors:
C1–C7 = 100 nF

Semiconductors:
IC1, IC3, IC4 = 74HCT245
IC2 = 74HCT377
IC5 = 74HCT138
IC6 = PAL16L8 (Order No. 5973)
IC7 = 74HCT04

Miscellaneous:
K1 = 25-pole female D connector for PCB mounting
Fixing plate (see Fig. 22)
PCB 900094-1

shown in Fig. 19. The DMA interface can access two addresses in the circuit via line A1. The control register, IC$_{59}$, is at one of these addresses (A1 = 0). The address of the apparatus must be written in the three most significant bits of this register in order to actuate the analyser.

The logic analyser has address 4; whether that is stored in the control register is checked by gates IC$_{61c}$ and IC$_{62c}$.

The output signal of IC$_{61c}$ enables or disables the various inputs and outputs of the interface.

The remaining bits of the control register are used to address the various registers in the analyser proper: Q0 and Q1 provide the two address lines for the register, while Q2–Q4 control address decoder IC$_{60}$, which generates the five card-select signals.

When the interface is actuated by the four highest bits of the control register, data may be sent to and from the logic analyser via bidirectional buffer IC$_{64}$. The buffer is addressed when A1 is high. The direction of the data transport is determined by the read/write> line.

The single-step signal is produced by IC$_{63c}$ and IC$_{63d}$ from the strobe signal for the data bus and the WR> signal.

Atari interface board

The board for the Atari interface has been designed as a sort of adapter plug (see Fig. 20 and 27) that can be inserted at the rear of the computer. The PCB-type 19-way male D connector for this is, however, not easily available in many locations. There is, therefore, the possibility to use a box header (which is much more readily available) in the K20 position. Starting at pin 1, the wires in the cable

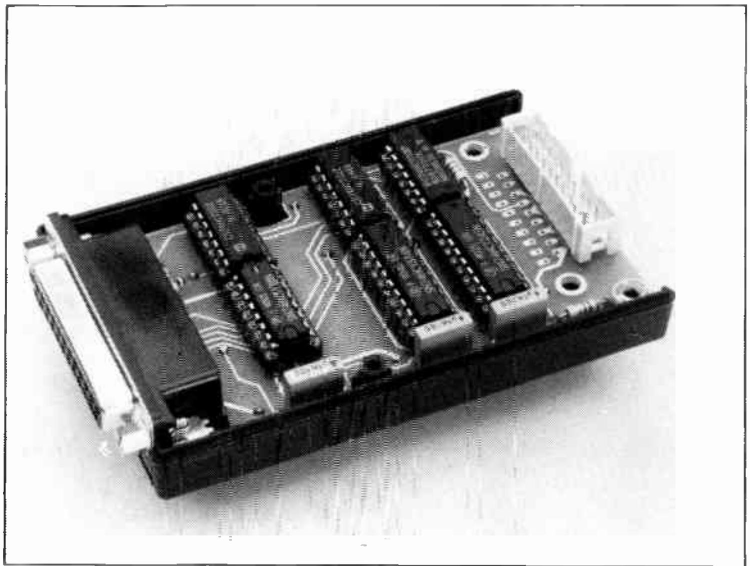


Fig. 27. Photograph of completed Atari interface board.

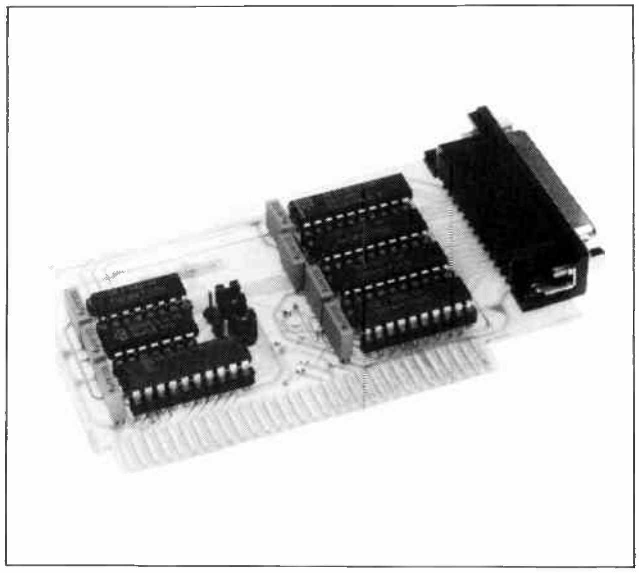


Fig. 28. Photograph of completed IBM interface board.

are soldered or crimped as follows: 1 to 1; 2 to 11; 3 to 2; 4 to 12; 5 to 3; and so on; only pin 20 of the box header is not used.

No such difficulties are envisaged with K_{21}. The cable between the interface and the logic analyser may be a standard computer accessory: 25-way with male and female connectors. It should, however, not be longer than one metre.

IBM interface

The interface for IBM XT and AT computers consists of not much more than a number of digital inputs and outputs—see Fig. 21. The data bus for the computer is buffered by IC_1. This is not necessary for the address lines of the computer, since most lines are connected to only one input. There are, nevertheless, three address lines that, depending on the position of the jumpers near IC_6, are loaded with up to two inputs. Circuit IC_6 is the address decoder of the interface.

The basic address of the card may be arranged in steps of four addresses from 300_{hex} to $31C_{hex}$ with the aid of jumpers and inverters in lines A2–A4.

Four addresses emanate from the address decoder (a PAL): an enable signal for the data bus buffer (E>) and three select signals for controlling the three individual addresses on the interface card: ADR0–ADR2.

The address register is found at basic address +0. The address with which a card and a register are addressed on that card is written in the address register.

The data register is found at basic address +1, via which data are written to, or read from, the logic analyser. Simultaneous with the reading or writing, card select decoder IC_5 is enabled via the ADR1 line to ensure that the cards of the analyser are connected to the bus only when this really necessary.

The IRQ signal from the analyser enters via basic address +2 on the interface card. This is processed as data, and not as an interrupt.

IBM interface board

The dimensions of the PCB for the IBM interface are determined solely by those of the two connectors—see Fig. 22 and 28. Since the electronics do not need much space, it has been possible to include a table on the board that indicates what jumpers are required to place a certain basic address for the card.

To prevent the card being pulled from the slot by the connecting cable, it is essential that the board is provided with a fixing plate with which it can be fastened securely on to the computer. Such a plate can be made as shown in Fig. 24.

For the connection between the interface and the computer the same sort of cable as for the Atari may be used.

Overview

An overview of the logic analyser and all that may go with it is shown in Fig. 23.

The control card is always connected to the centre connector of the bus board to ensure that when several RAM cards are used, the connections between these cards and the control card remain as short as feasible.

Before the RAM cards are built in, a 10 kΩ resistor must be soldered at the track side between pins 11 and 16 of IC_{29}. This resistor suppresses any reflections that may occur at that end of the clock line to the shift registers.

There is not much wiring in the analyser because most connections are contained on the bus board. What wiring there is comes mainly from the power supply. ■

VIDEO A-D/D-A CONVERTER

PART 2: A 30-MHz VIDEO ADC/DAC DEVELOPMENT BOARD

Following last month's introduction into the basic operation of the two main integrated circuits in the design, the TDA8708 and the TDA8702, this second and last instalment focuses on the more practical side of things. Are you triggered? Here is a high-speed video A-D/D-A converter board aimed at helping you on the way with your own video experiments.

P. Godon (Philips Components, Paris)

Continued from the May 1991 issue

The block diagram of the development board, Fig. 8, shows the two converter ICs surrounded by quite a few sockets, switches and connectors. The switches, K1 through K9, are actually jumpers that allow different modes of operation to be selected. The BNC sockets, K10 through K17, are the analogue

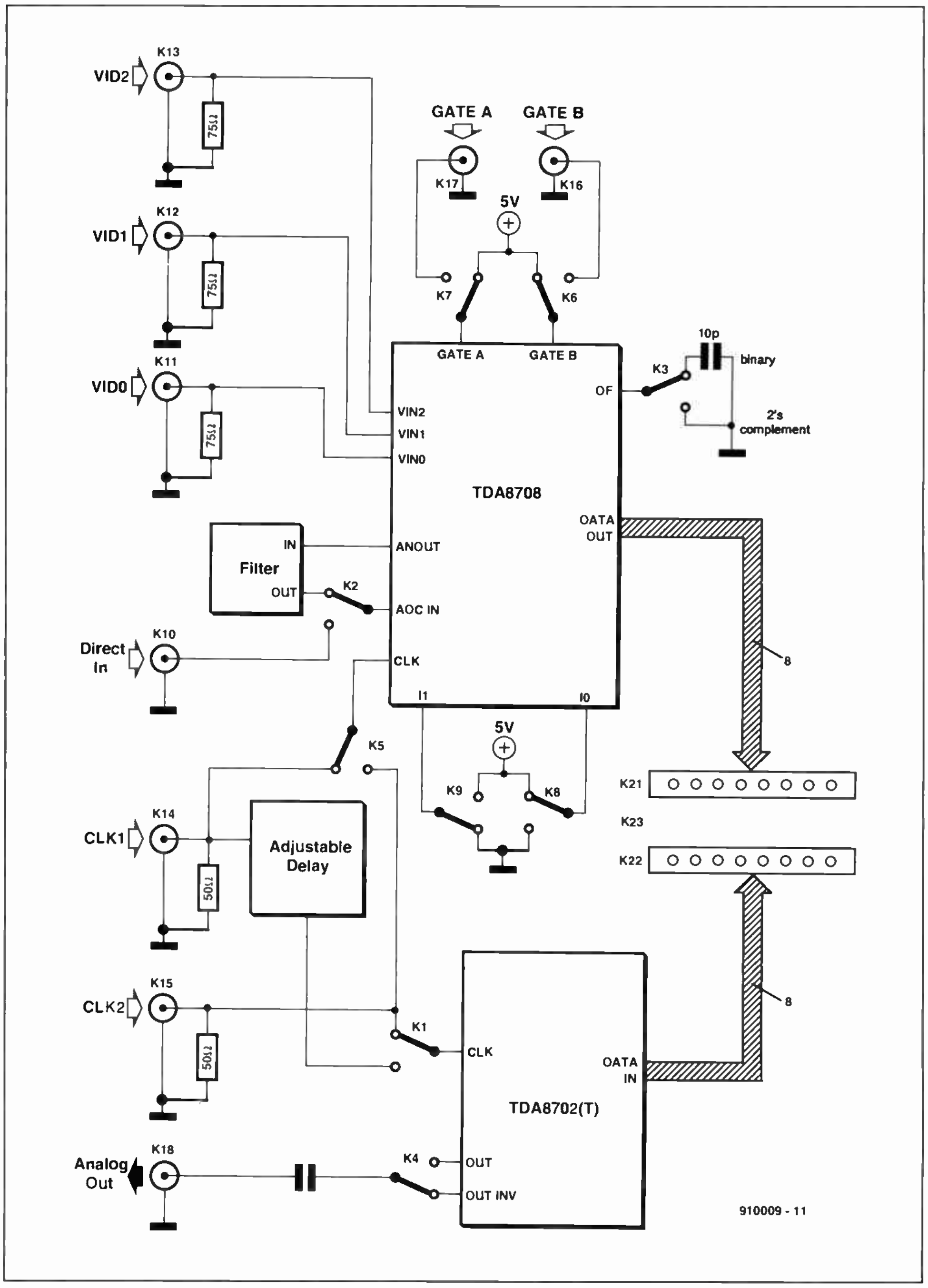


Fig. 8. Block diagram of the video processor card. Most of the switches shown here are wire jumpers to select different modes of operation.

Table 8. Connector overview

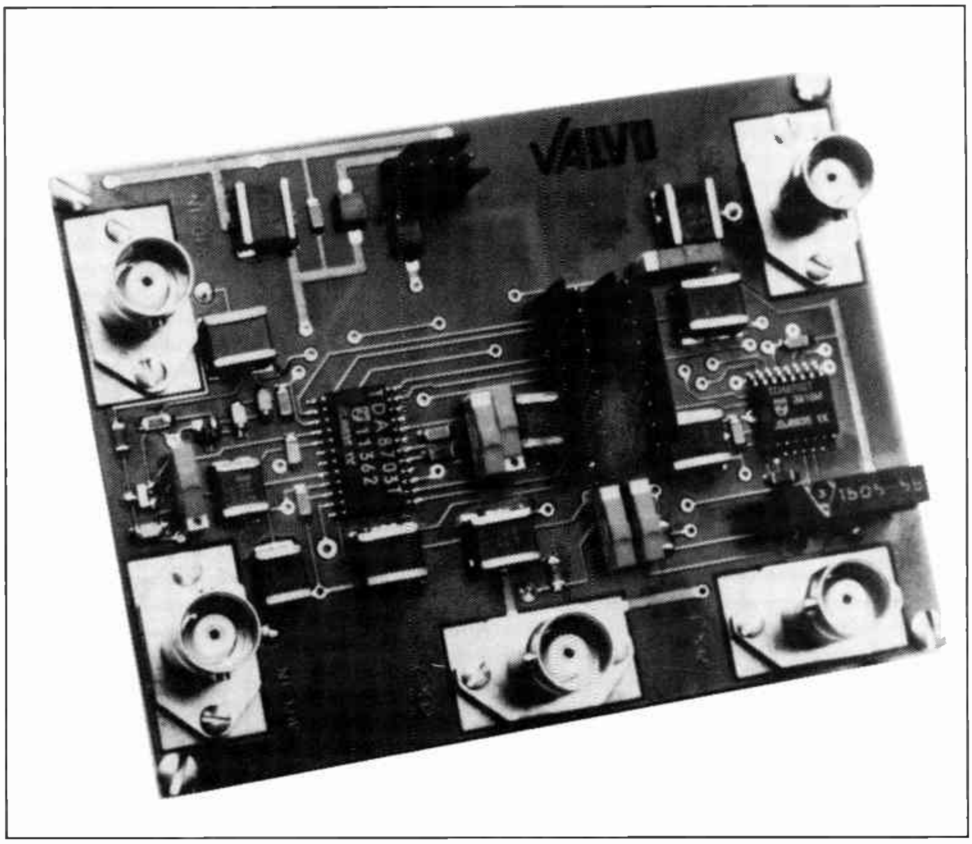
Connector	Type	Function	Connector	Type	Function
K1	jumper	Clock 2 / delayed Clock 1	K13	BNC socket	ADC input 2
K2	jumper	Video input / direct input	K14	BNC socket	Clock input 1
K3	jumper	ADC output: binary or 2's complement	K15	BNC socket	Clock input 2
K4	jumper	DAC output: true or inverted	K16	BNC socket	Mode gate B
K5	jumper	Clock 1 / Clock 2	K17	BNC socket	Mode gate A
K6	jumper	Gate B active / disabled (+5 V)	K18	BNC socket	DAC analogue output
K7	jumper	Gate A active / disabled (+5 V)	K19	PCB pin	Clock delay
K8	jumper	Video input selection: Bit 0=H / Bit 0=L	K20	PCB header	Supply voltages
K9	jumper	Video input selection: Bit 1=L / Bit 0=H	K21	PCB header	ADC output
K10	BNC socket	ADC direct input	K22	PCB header	DAC input
K11	BNC socket	ADC input 0	K23	32-way DIN	combined ADC output and DAC input
K12	BNC socket	ADC input 1			

video inputs and the digital control inputs. The analogue output signal of the DAC is available on socket K18. The board is linked to a computer or microprocessor system via connectors K21 and K22, or K23. All digital inputs and outputs of the board are TTL compatible.

The development board is connected to analogue and digital 5-V power supplies via K20. Two separate power supplies are required to ensure the best possible decoupling of the analogue and digital sections.

The 'adjustable delay' block is formed by an integrated circuit that has not been discussed last month. This IC, a Type 1505-5B from Data Delay Devices, contains a stepped delay line. The signal applied to the CLK1 input of the board, K14, can be delayed in steps of 1 ns to a maximum of 5 ns. The delay line has a d.c. resistance of 0.7 Ω and an impedance of about 100 Ω.

Finally, the resistors shown in the block diagram ensure that video sources are terminated in 75 Ω, and the clock inputs in 50 Ω.



The development circuit

The circuit diagram of the video A-D/D-A card is given in Fig. 10. As discussed last month, the TDA8708 stores the current analogue value at the first leading edge of the clock signal, after the 1.5-V threshold is exceeded. You will also recall that the digital equivalent of the analogue value appears at the output after a delay, T_d, of 8 to 20 ns. At the next trailing edge of the clock signal, the DAC copies the digital information, and supplies the corresponding analogue value after the conversion delay, t_d, of 3 ns. Hence, the video input signal is subject to a total delay, T_v, of

$$T_v = T_d + ½f + t_d$$

At relatively high clock frequencies, say, 30 MHz, it may happen that the minimum required delay time between the A-to-D and D-to-A conversions is not available. The DAC requires that the input data remain stable for at least 0.3 ns. Since the time between the leading and the trailing edge is only 17 ns for a 30-MHz clock signal, it is readily seen that the DAC may have trouble loading stable data when the required delay, T_d, is yet to be subtracted. This potential problem is eliminated by the previously mentioned delay line, IC3, which delays the trailing edge of the clock 1 to 6 ns, depending on the selected 'tap' (jumper K19). This compensation ensures the correct operation of the conversion processes when relatively high clock speeds are used. The diagram in Fig. 9 shows the combined timing of the ADC and the DAC, along with the data setup times and associated delays.

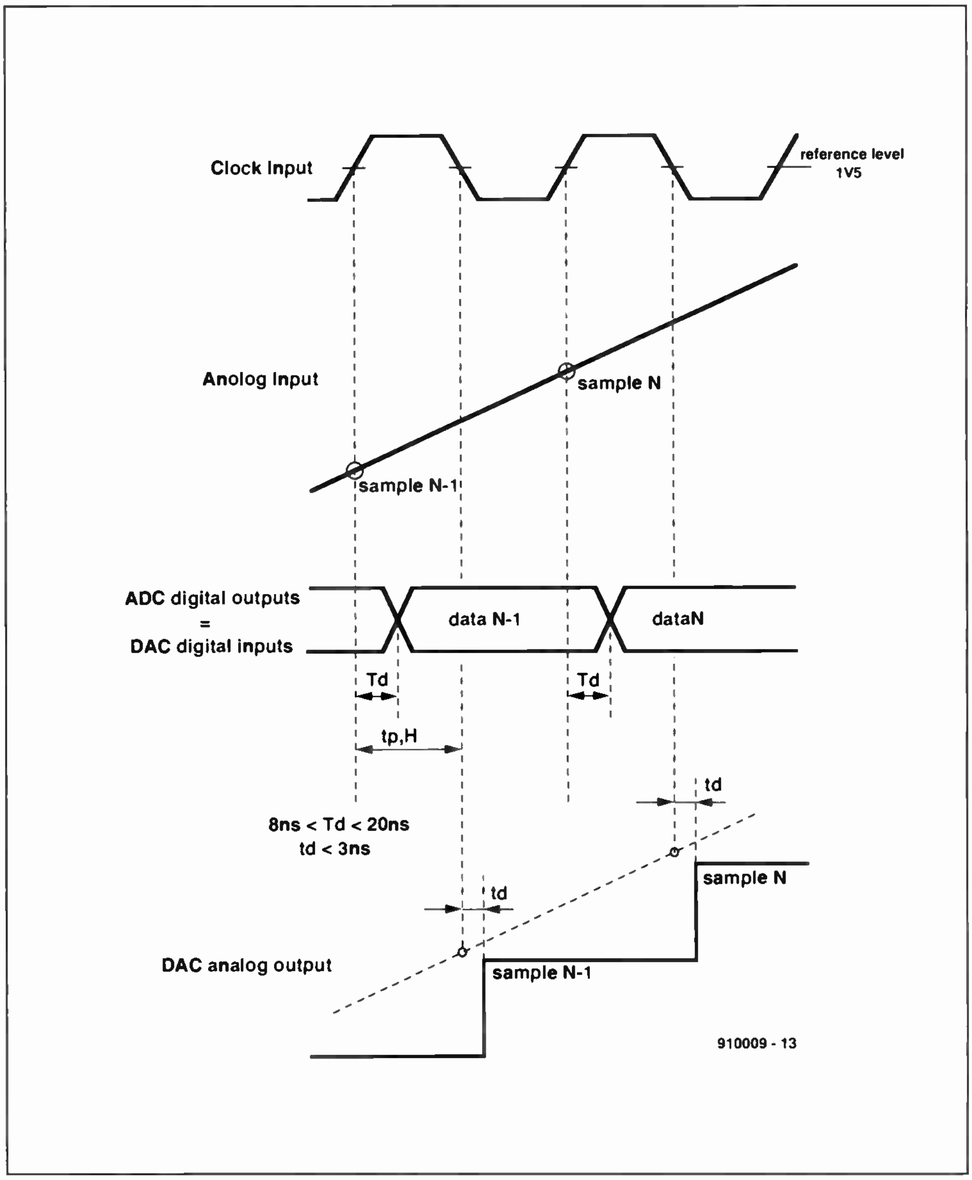


Fig. 9. Overview of conversion timing and data setup times for the ADC and the DAC.

Construction

In view of the speed of the signals involved, the video A-D/D-A circuit is best built on a printed-circuit board of the design shown in Fig. 11. The board is double-sided, but not

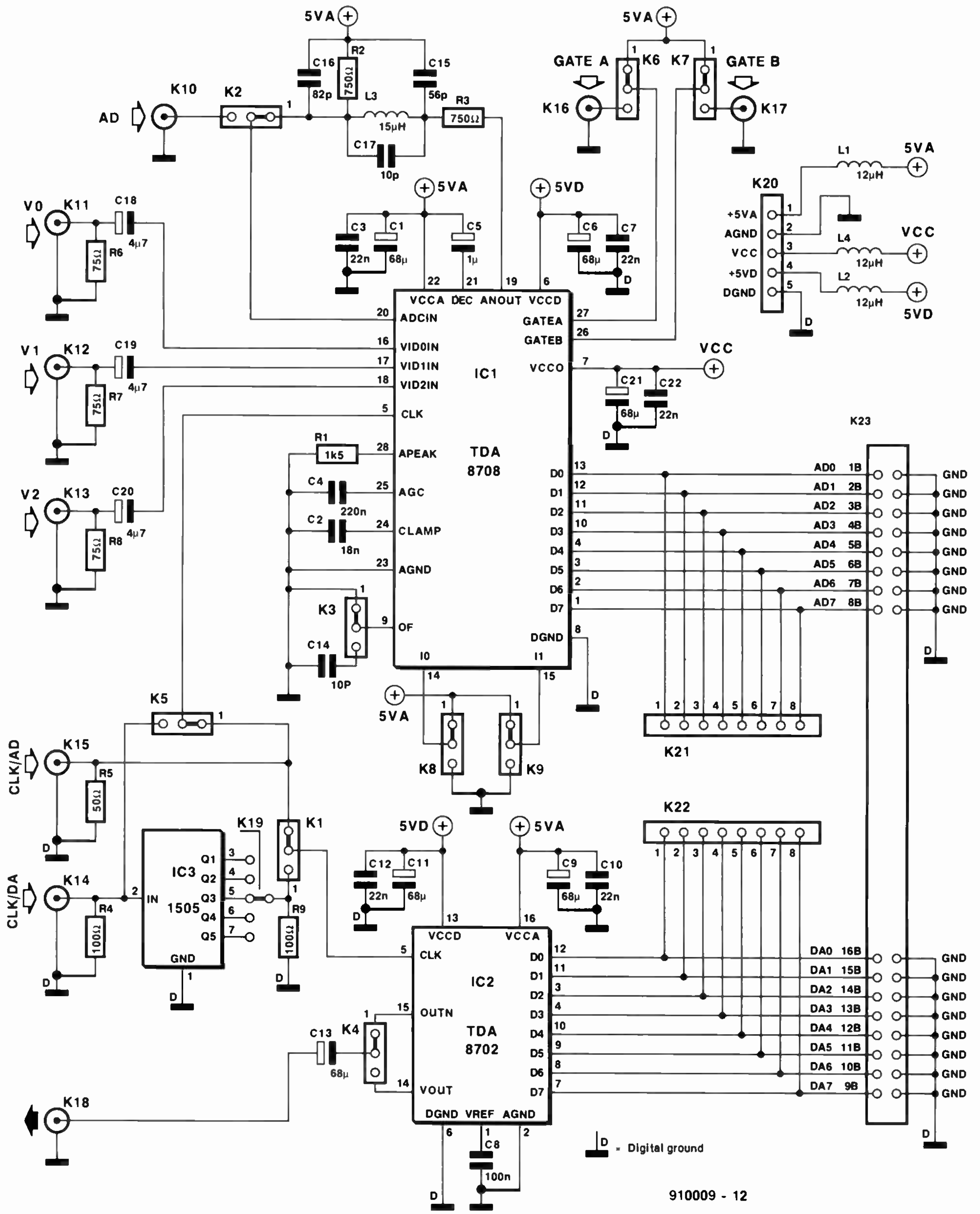


Fig. 10. Circuit diagram of the ADC/DAC converter card. You have the digitized video signal available at a resolution of 8 bits between connectors K21 and K22. A separate connector, K23, allows the card to be connected to a computer bus.

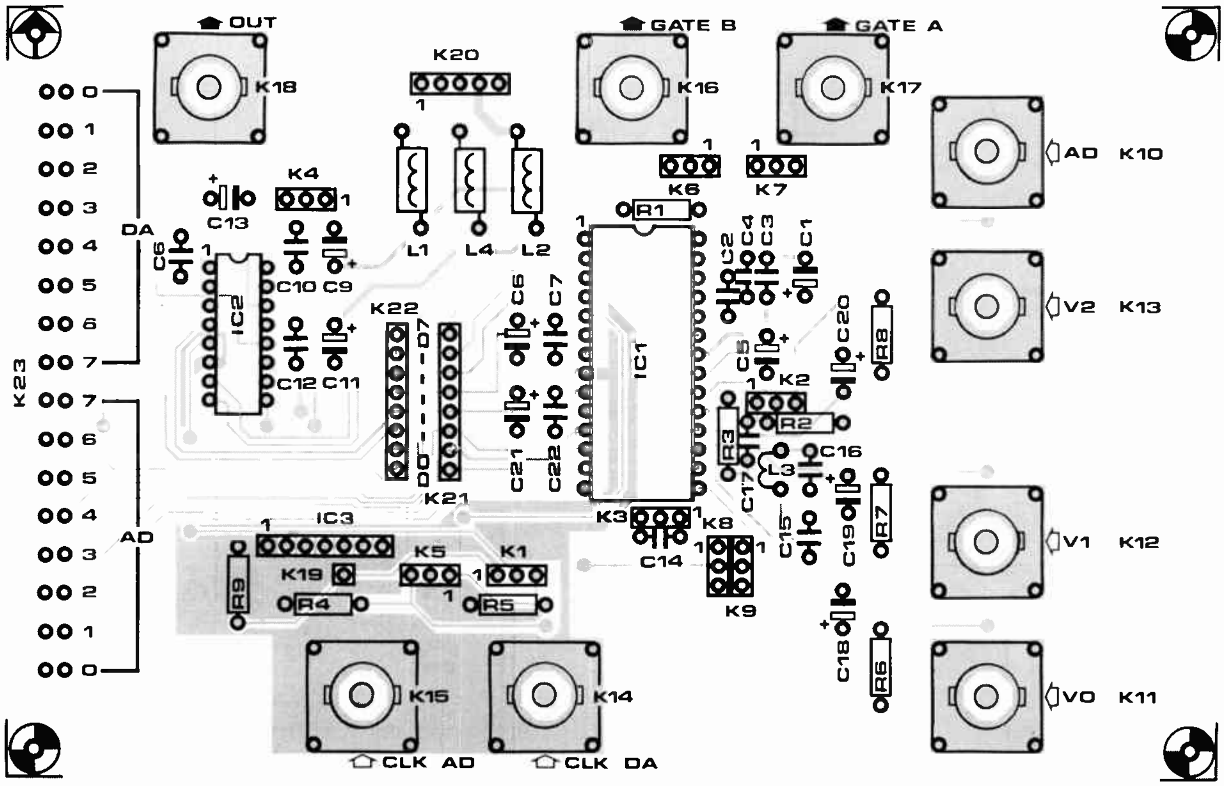


Fig. 11a. Component mounting plan of the double-sided printed circuit board. Note that the board is designed for PCB-mount BNC sockets.

through-plated. Its design allows BNC sockets to be fitted without coaxial cables, which reduces parasitic capacitance to a minimum.

Most of the PCB headers and jumper blocks on the board can be made from single-row and double-row pin headers, which are available in strips of 36 and 72 pins with a spacing of 0.1 inch. Headers K21 and K22, for instance, are 8-pin pieces cut from a larger strip.

Connector K23 is a 32-way angled type to DIN41612. It allows the digital data inputs of the DAC, and the digital outputs of the ADC, to be connected to a microprocessor system bus. For a straight link between the ADC and the DAC, interconnect the corresponding pins on K21 and K22. Finally, note that although an SMA (surface-mount assembly) version of the development board is shown in Fig. 11, all components on the board shown in Fig. 10 have standard sizes. ■

COMPONENTS LIST

Resistors:

1	1kΩ5	R1
2	750Ω	R2;R3
2	100Ω	R4;R9
4	75Ω	R5 - R8

Capacitors:

6	68µF 6V3	C21
1	18nF	C2
5	22nF	C3;C7;C10; C12;C22
1	220nF	C4
1	1µF 10V	C5
1	100nF	C8
2	10pF	C14;C17
1	56pF	C15
1	82pF	C16
3	4µF7 10V	C18;C19;C20

Inductors:

3	12µH	L1;L2;L4
1	15µH	L3

Miscellaneous:

1	TDA8708	IC1
1	TDA8702	IC2
1	1505-5b *	IC3

Miscellaneous:

9	3-pin PCB header	K1 - K9
9	PCB-mount BNC socket	K10 - K18
1	solder pin	K19
1	5-pin PCB header	K20
2	8-pin PCB header	K21;K22
1	32-way angled connector to DIN41612	K23

0.1-inch jumpers as required

* UK distributor: BFI Ibexsa Electronics • Burnt Ash Road • Quarrywood Estate • Aylesford • Kent ME20 7NA. Tel. (0622 882467), Fax (0622) 882469.

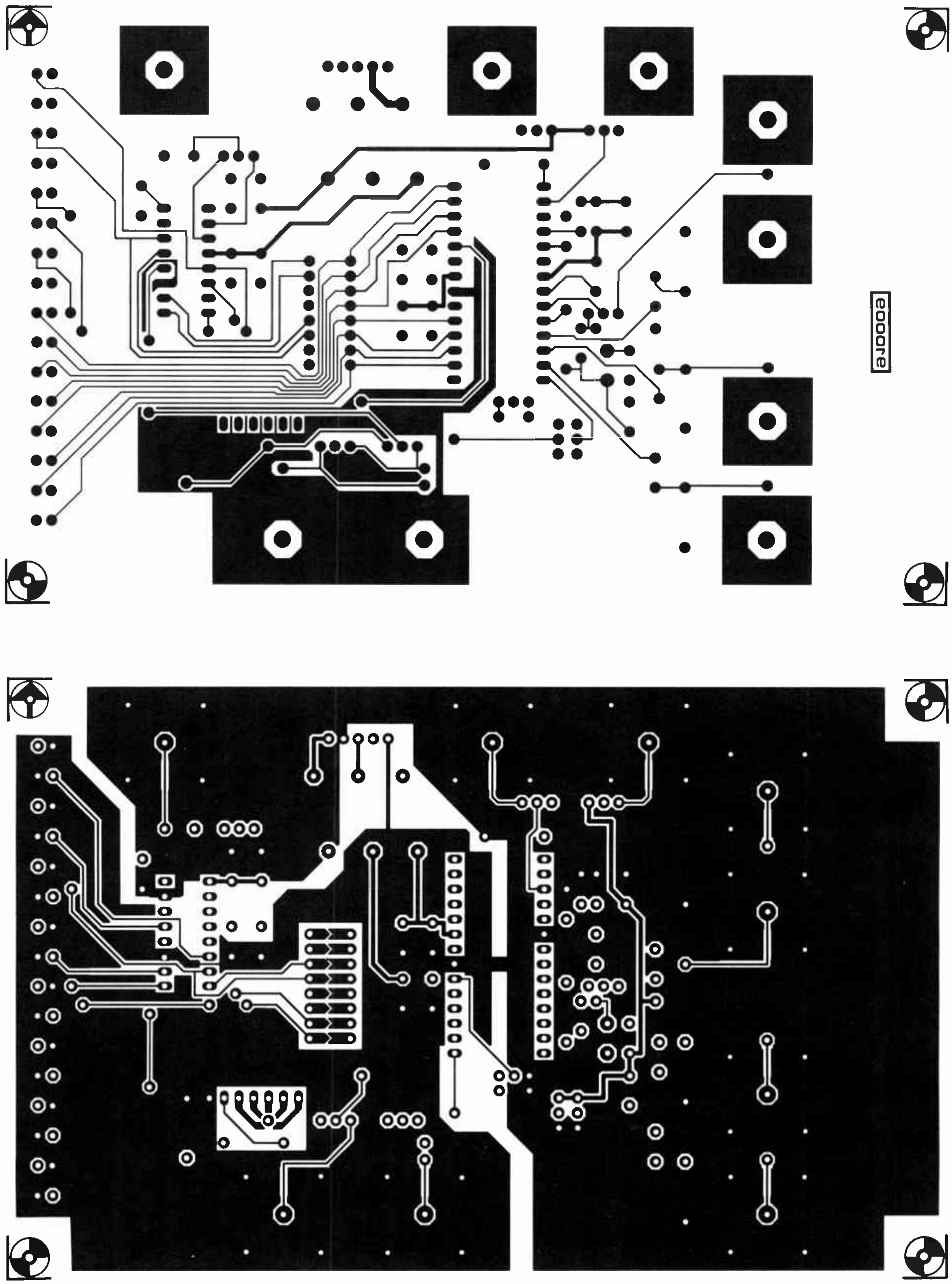


Fig. 11b. Solder side (above) and component side (below) of the PCB for the video ADC/DAC card.

DIGITAL PHASE METER

by R. Lucassen

Phase meters are rare instruments, even in the laboratory or workshop of audio and hi-fi engineers and enthusiasts. Perhaps that is because until the advent of reliable digital techniques it was fairly difficult to design an accurate direct-reading phase meter. In one commercial catalogue published in the 1970s, a phase meter is advertised as having "an accuracy of about 3 degrees from 10 Hz to 30 kHz". Clearly, for modern audio equipment, that is no longer acceptable. Another reason may be that a phase meter is a fairly specialized instrument: many engineers and technicians measure phase shift with the aid of Lissajous figures (which do not give very accurate results either). The phase meter presented in this article is accurate to within 0.5° over the frequency range 10 Hz to 20 kHz.

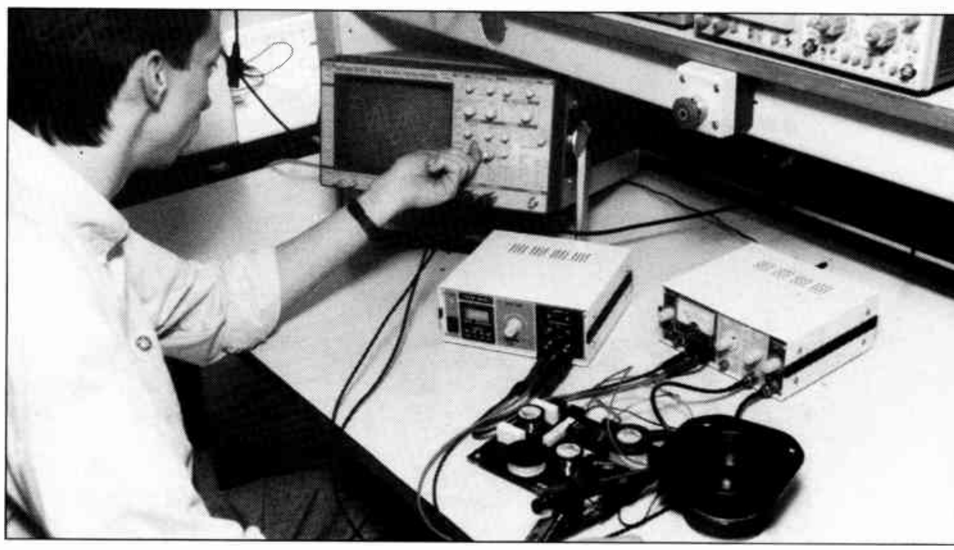
THE PHASE shift between two electrical signals is of great importance in most branches of electronic engineering, but more particularly in audio engineering. In all circuits containing capacitors or inductors or both, frequency-dependent phase shifts will occur and these will affect the wanted operation of many circuits. There are, of course, circuits, such as filters, where phase shift is one of the design parameters.

The basic design of the phase meter may be gleaned from the block diagram in Fig. 1. Note, however, that, for the sake of simplicity, an analogue meter has been substituted for the LED display with which the instrument is actually equipped.

The analogue signals presented to the display section are digitized before they are processed. Since alternating signals are involved, this is quite simple: the positive part of the signals is converted to a logic low (0) and the negative part to a logic high (1). The timing diagram in Fig. 2 shows the analogue input signals (A and B) together with their digitized variants (A′ and B′). The use of the digitized signals as the clock for a bistable (US: flip-flop) ensures a perfectly symmetrical (i.e., duty factor is 50%) digital output signal at a frequency equal to half that of the input signal. This guarantees that differing lengths of positive and negative half periods, noise and other spurious signals have no effect on the accuracy of the measurements.

The time difference between the leading edges of the signals emanating from the bistables is a measure of the phase shift between the two input signals. The output of the XOR gate is high during this time difference. The ratio of the width of the logic high signal at the output of the XOR gate to that of the output signal of bistable FF_1 gives the phase shift, which only has to be converted into degrees.

The width of the output pulse of the XOR



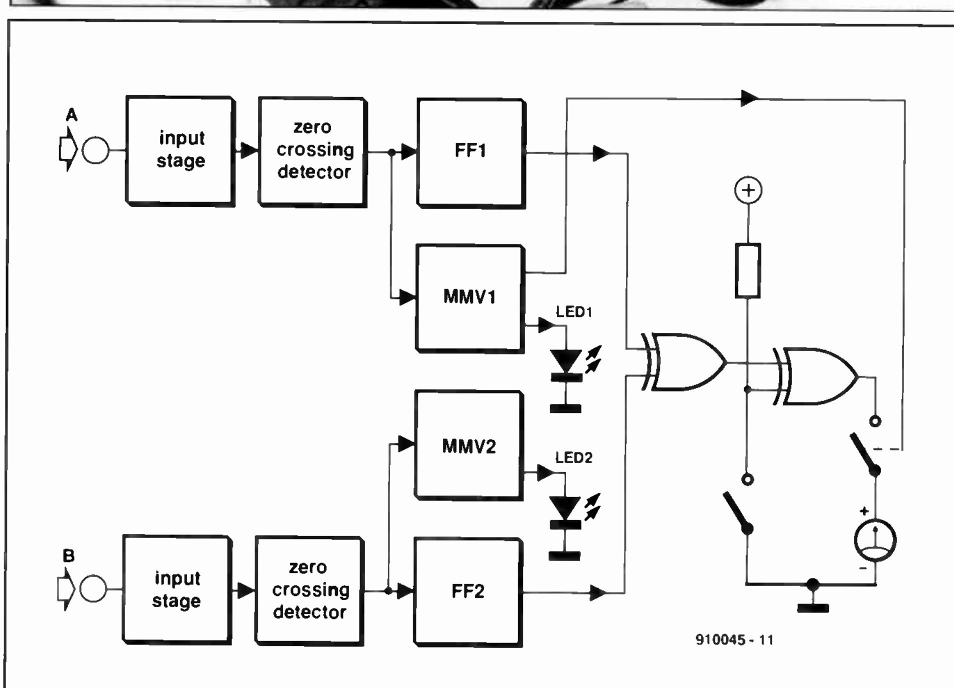


Fig. 1. Block diagram of the digital phase meter.

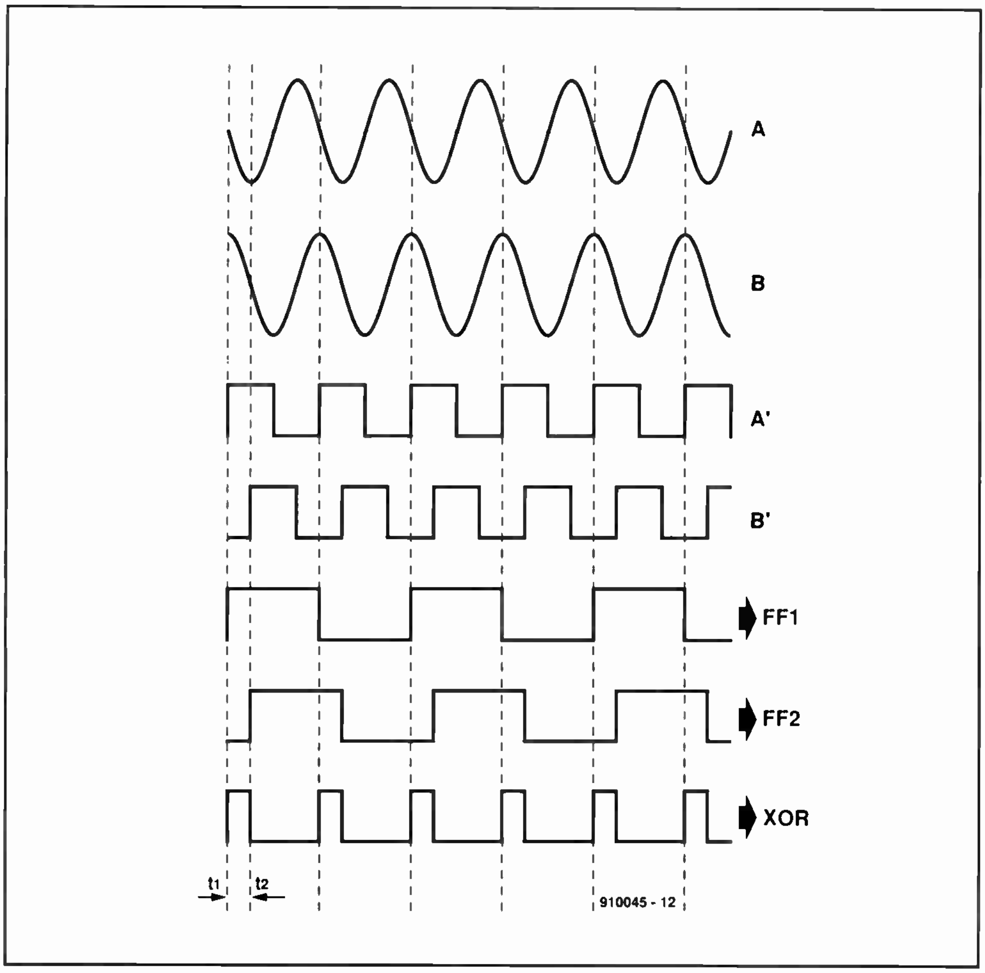


Fig. 2. Timing diagram of the analogue-to-digital conversion section.

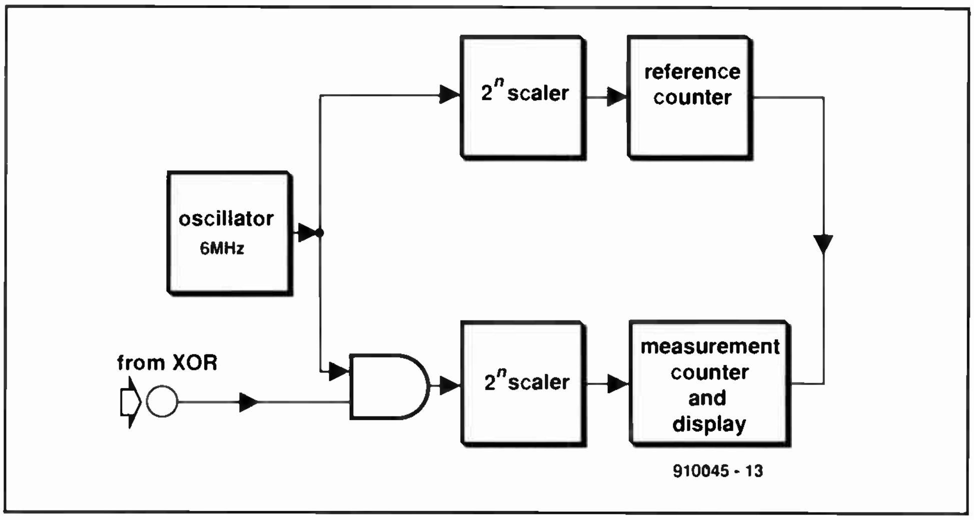


Fig. 3. Block diagram of the digital measuring section.

gate indicates at all times by how much signal B lags signal A. Therefore, the pulse represents a phase difference of 0–360°. Since it may also be of interest to measure the lag of signal A with respect to signal B, there is a second XOR gate whose output may be inverted.

Monostables MMV_1 and MMV_2 indicate by LEDs that usable signals, that is, signals whose phase difference is to be measured, exist at the associated inputs. Furthermore, the output of MMV_1 is used to actuate the meter. If only signal A is present, the meter must remain stably in the centre position. If it does not, the input signal is unstable and, therefore, not suitable for measurements.

Since the width of the pulse at the output of the XOR gate is a measure of the phase shift, it would seem that a simple analogue interface in the form of an integrator would be sufficient for driving a moving meter. That would, however, present certain difficulties, such as a strong dependence on temperature and the fact that to obtain a stable meter deflection a high integration constant would have to be used. That would make the measurement very slow and the instrument inconvenient to use.

A digital meter was therefore chosen, which can accurately indicate any phase difference between 0° and 360° with a resolution of 1°. The diagram in Fig. 3 shows how this meter operates.

A central clock frequency of 6 MHz is used, which is applied continually to one branch of the circuit, and to the other branch only when the output of the XOR gate of the phase comparator is high. In both branches, the clock pulses are divided by 2^n before they are applied to the respective stage. Factor n is set manually. Note that since division takes place after the AND gate, this gate has no effect on the accuracy of the measurement.

As soon as the content of the reference counter has reached a value of 3,600, one output of the counter goes high to indicate that the measurement is complete and that $3{,}600/2^n$ pulses were processed during it.

At the instant the reference counter has counted 3,600 pulses, the display memory is prompted to take over the contents of the reference counter. The display will then show the number of counted pulses, that is, when the phase shift is 0°, no pulses were counted; if the phase shift is 360°, 3,600 pulses were counted. The last digit of the number of pulses is omitted to make the display read the number of degrees.

Note that the accuracy of the measurement depends on the ratio of the measuring time to the frequency of the reference signal. The measurand is therefore sampled at a frequency of 6 MHz. Even at the highest signal frequency of 20 kHz, the error introduced by this is negligible

Furthermore, the design of the instrument arranges that counting always starts at the beginning of a period. Therefore, it is never known how much of the last period is measured and steps must consequently be taken to ensure that the last period has negligible influence on the measurement. This is done by taking many periods per measurement. For instance, a measurement over 10 periods has a possible error of 10%, whereas over 200 periods the error would be only 0.5%. Because of that, the instrument contains a counter (in the error indicating circuit) that monitors over how many signal periods a measurement. was spread.

Circuit description

The instrument is constructed on three printed-circuit boards; the associated circuits are shown in Fig. 4, 5 and 6.

Figure 4 is the circuit diagram for the motherboard. The power supply is a straightforward, conventional type with a bridge rectifier and two integrated regulators.

The buffered and possibly attenuated (–20 dB) signal is applied to terminals A and B. Input A is used as the reference signal and for actuating the metering section.

The incoming analogue signal is converted into a digital signal in IC_{12} (channel A) and IC_{14} (channel B). The offset of these

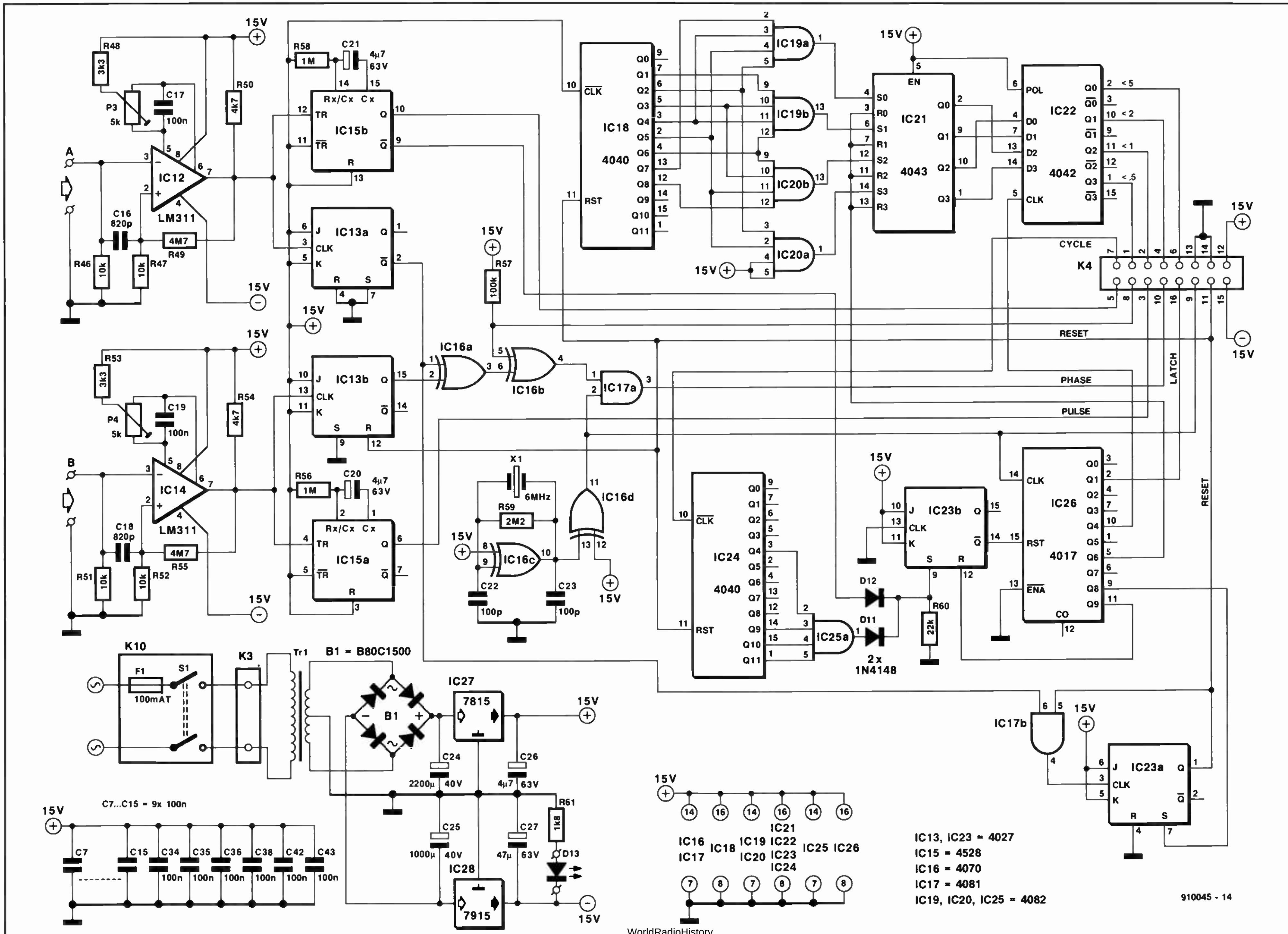


Fig. 4. Diagram of the circuit contained on the mother board.

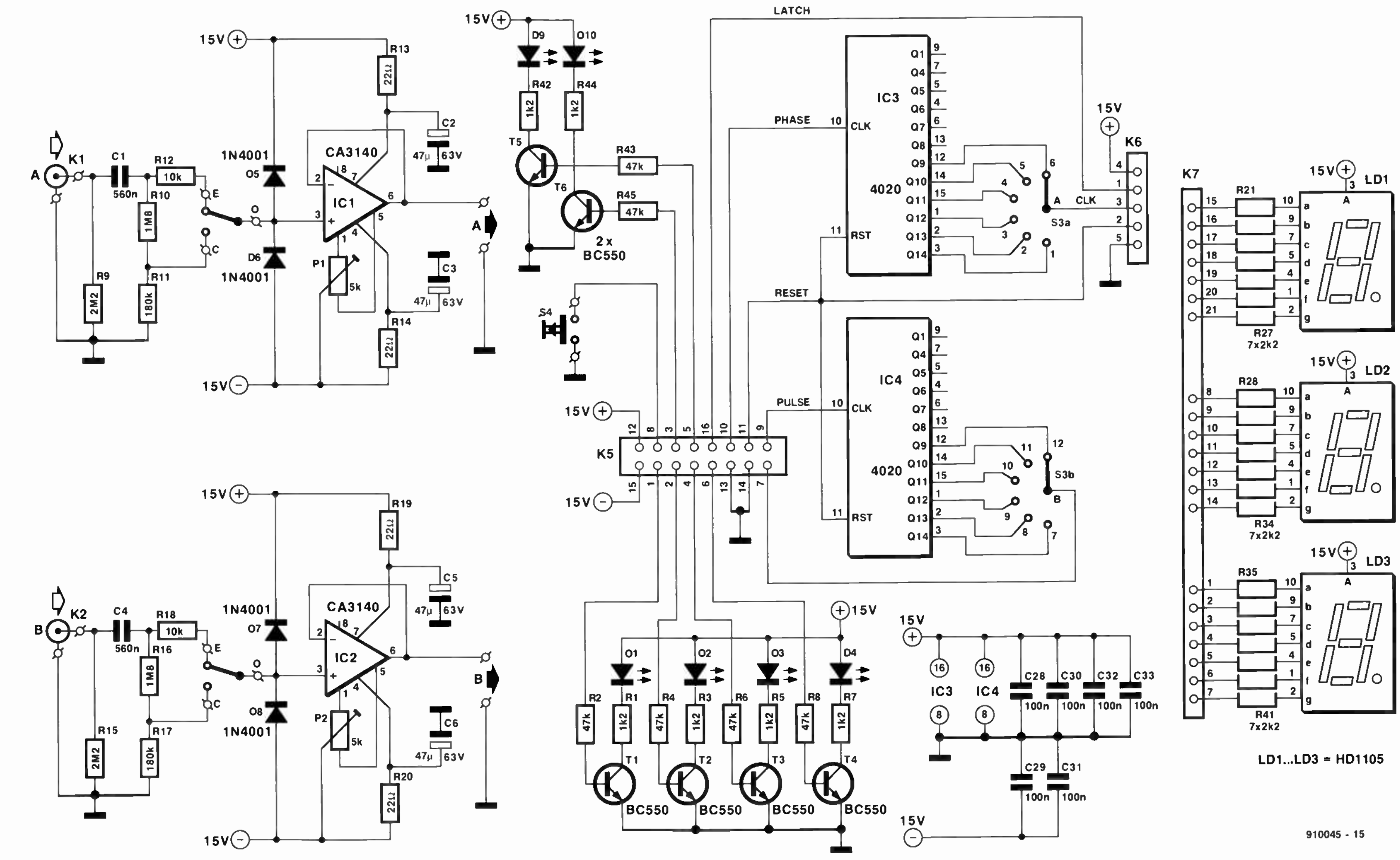


Fig. 5. Diagram of the circuit containing the displays, input stages, and selector switches.

opamps is compensated by presets P_3 and P_4 respectively. Bistables IC_{13a} and IC_{13b} split the digitized signal into a symmetrical signal (duty factor = 50%) that is suitable for measurements.

Monostables IC_{15a} and IC_{15b} actuate the LEDs (D_9 and D_{10}) on the front panel to indicate that suitable signals are input. At the same time, IC_{15b} enables the reference counter via its Q output.

The outputs of IC_{13a} and IC_{13b} are combined via XOR gate IC_{16a}. Another XOR gate, IC_{16b}, and switch S_4 on the front panel make it possible to invert the phase difference as discussed before.

Finally, IC_{17a} combines the output of the phase comparator with the clock frequency (6 MHz). When the output of XOR gate IC_{16a} is high, the clock is passed on and the measurement may be carried out.

The clock signal is generated by a crystal oscillator based on IC_{16c} and buffered by IC_{16d} before it is applied to the relevant stages.

At the end of the measurement, a reset cycle is started by IC_{24}. As soon as this IC has counted 3,600 pulses, IC_{23b} is set via IC_{25a} and OR gate D_{11}–D_{12} and in its turn resets decade scaler IC_{26}. This actuates the latch signal, whereupon the counter state is transferred to the display drivers (further discussed later on). Subsequently, IC_{22} receives a clock pulse and stores data concerning any measurement error, after which IC_{21} is reset. All relevant measurement data are then stored and the remainder of the circuit is reset via bistable IC_{23a}. When the reset cycle is over, IC_{23a} is returned to the relevant output state via AND gate IC_{17b}. At the same time, IC_{24} is reset by the clock pulse that appears at the Q9 output of IC_{26}. The circuit is then ready for the next measurement.

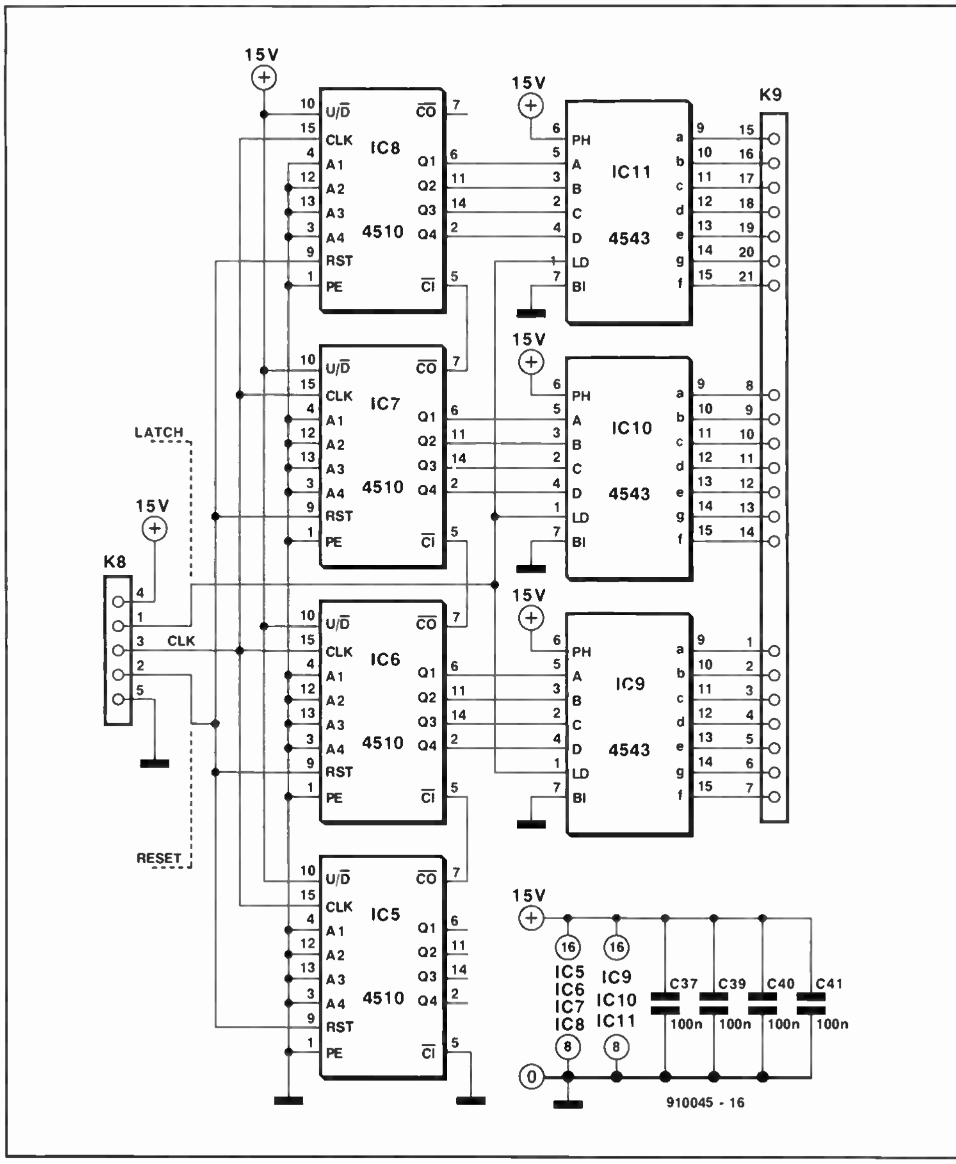


Fig. 6. Diagram of the logic circuits for the LED displays.

PARTS LIST

Resistors:
R1, R3, R5, R7, R42, R44 = 1.2 kΩ
R2, R4, R6, R8, R43, R45 = 47 kΩ
R9, R15, R59 = 2.2 MΩ
R10, R16 = 1.8 MΩ
R11, R17 = 180 kΩ
R12, R18, R46, R47, R51, R52 = 10 kΩ
R13, R14, R19, R20 = 22 Ω
R21–R41 = 2.2 kΩ
R48, R53 = 3.3 kΩ
R49, R55 = 4.7 MΩ
R50, R54 = 4.7 kΩ
R56, R58 = 1 MΩ
R57 = 100 kΩ
R60 = 22 kΩ
R61 = 1.8 kΩ
P1–P4 = 5 kΩ preset

Capacitors:
C1, C4 = 560 nF
C2, C3, C5, C6, C20, C21,
C26 = 4.7 µF, 63 V, radial
C7–C15, C17, C19, C28–C44 = 100 nF
C16, C18 = 820 pF
C22, C23 = 100 pF
C24 = 2200 µF, 40 V
C25 = 1000 µF, 40 V
C27 = 47 µF, 40 V, radial

Semiconductors:
D1–D4, D9, D10, D13 = LED, 3 mm
D5–D8 = 1N4001
D11, D12 = 1N4148
B1 = B80C1500
T1–T6 = BC550
IC1, IC2 = CA3140+
IC3, IC4 = 4020
IC5–IC8 = 4510
IC9–IC11 = 4543
IC12, IC14 = LM311DP
IC13, IC23 = 4027
IC15 = 4528
IC16 = 4070
IC17 = 4081
IC18, IC24 = 4040
IC19, IC20, IC25 = 4082
IC21 = 4043
IC22 = 4042
IC26 = 4017
IC27 = 7815
IC28 = 7915

Miscellaneous:
K1, K2 = BNC audio socket
K3 = 2-way terminal block,
7.5 mm centre
K4, K5 = 16-way box header
K10 = mains entry plug with integral
fuse holder
S1, S2 = single-pole change-over switch
S3 = rotary switch, 2 poles, 6 positions,
for PCB mounting
S4 = SPST switch
X1 = crystal, 6 MHz
LD1–LD3 = HD1105, common anode
Tr1 = mains transformer, 15 V, 18 VA
F1 = fuse, 100 mA, delayed-action
Mains on-off switch
Enclosure (ABS)
Knob for S3
Heat sinks for voltage regulators
PCB 910045-1
PCB 910045-2
PCB 910045-3
Front panel foil 910045-F

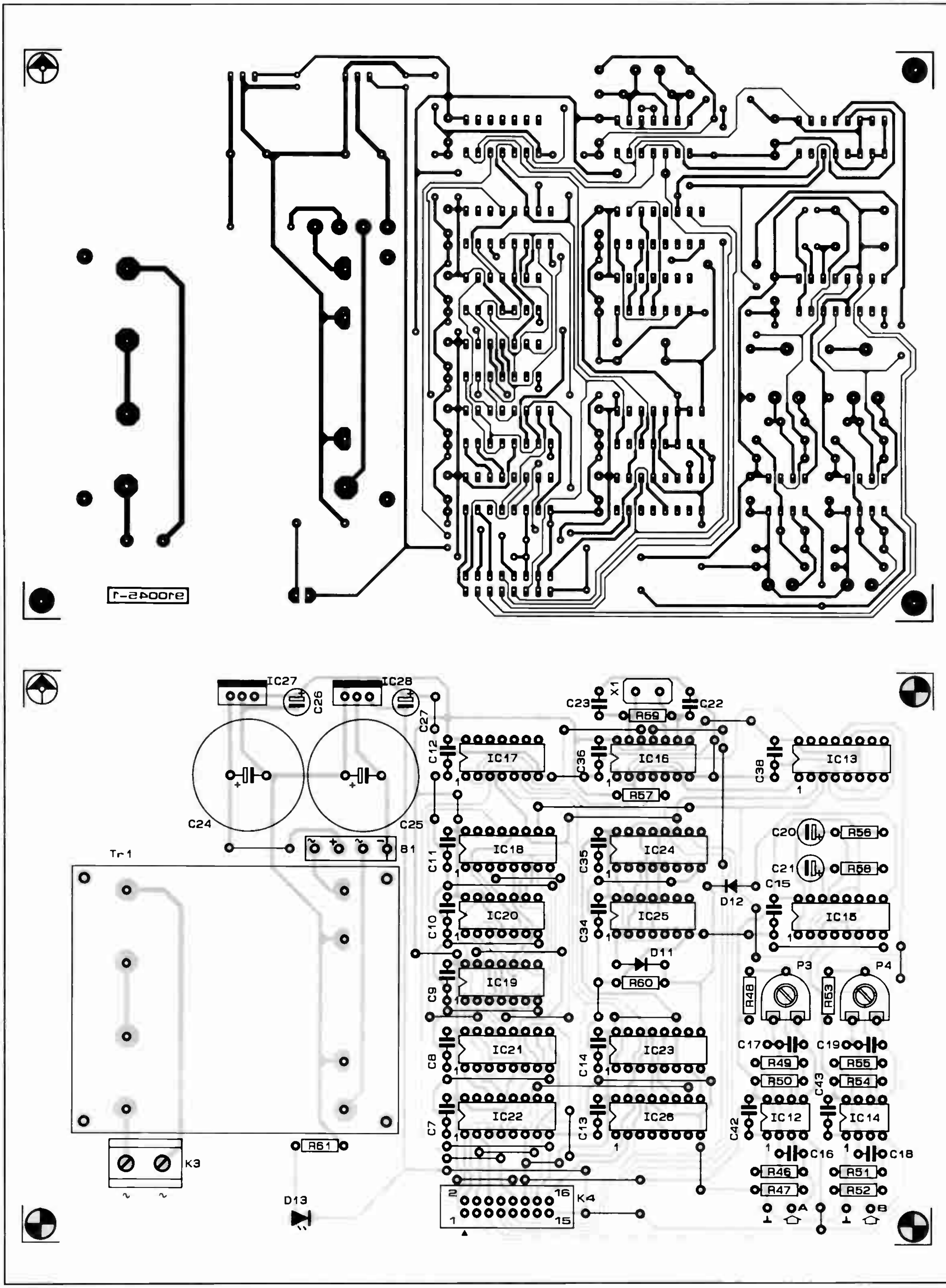


Fig. 7. Printed-circuit mother board.

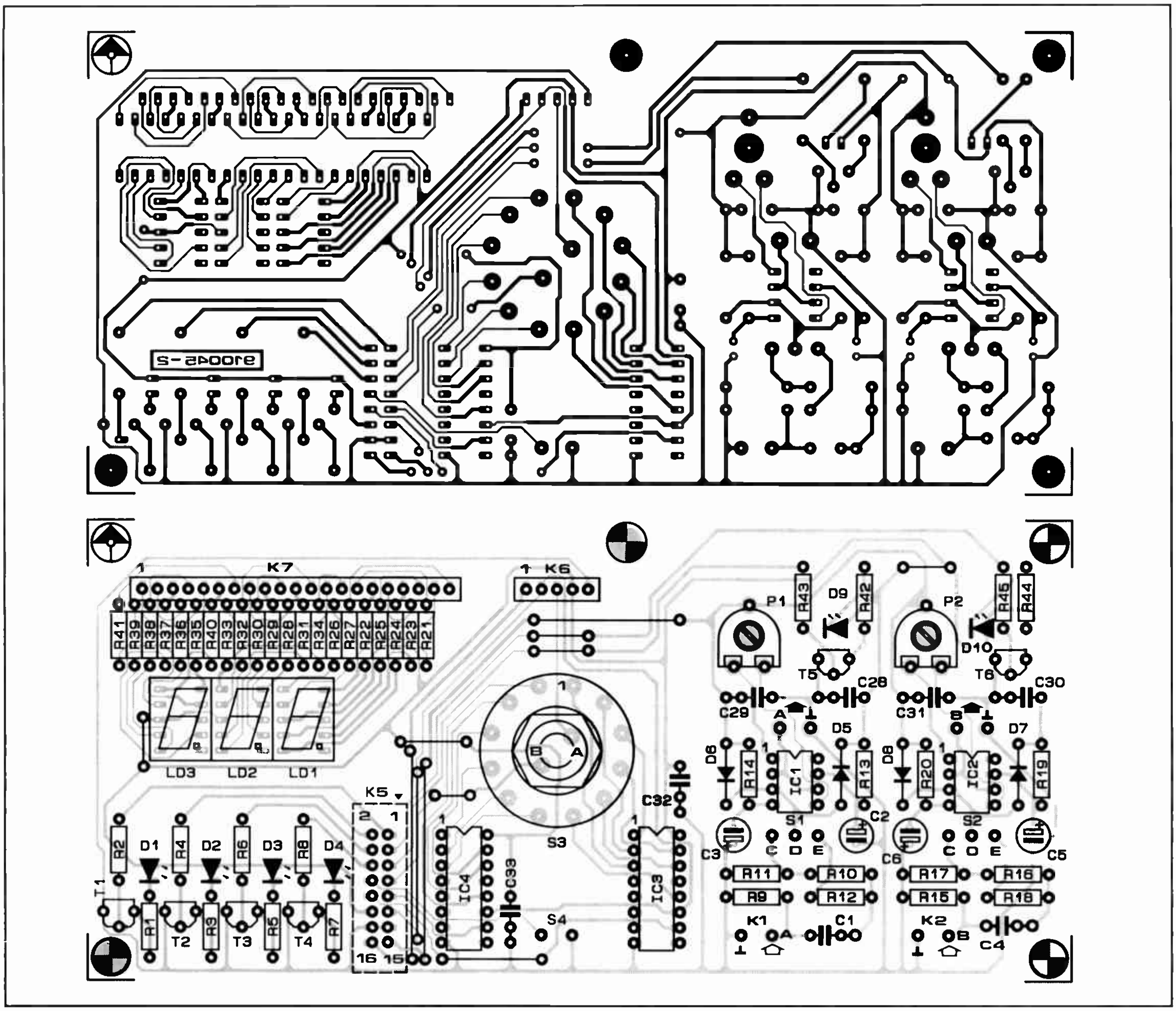


Fig. 8. Printed-circuit board for the displays, input stages, and selector switches.

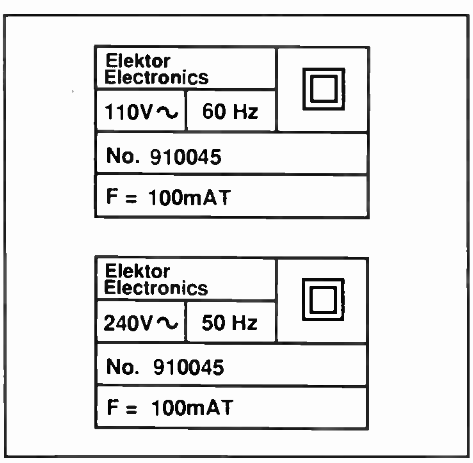


Fig. 9. Suggested labels for the rear panel of the digital phase meter.

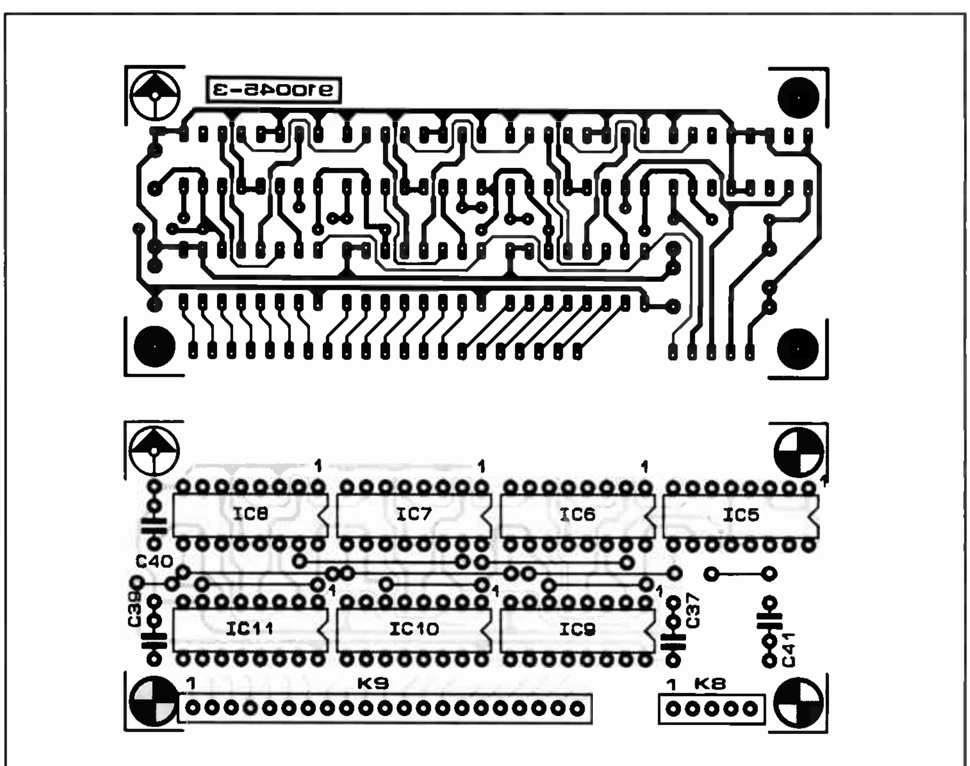


Fig. 10 Printed-circuit board for the logic circuits for the LED displays.

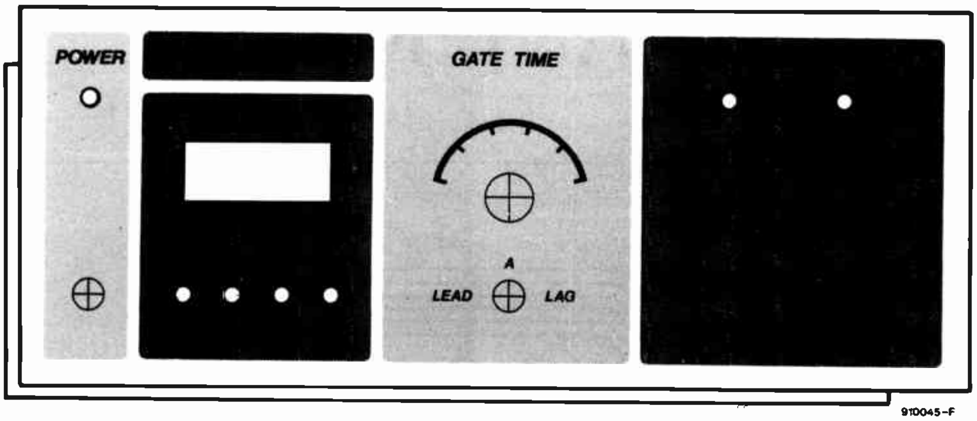


Fig. 11. The front panel foil for the digital phase meter is available through our Readers Services.

As mentioned before, the more periods are used, the more accurate the measurement. The counter in error detector IC_{18} counts the number of periods between the onset of the measurement and the generated latch pulse. Four AND gates decode the result at 360, 180, 90 and 36 periods in one measurement cycle; these counts correspond to errors of 0.5°, 1°, 2°, and 5° respectively. Depending on the number of counted periods, one or more LEDs light; when they all light, the error is negligibly small.

Figure 5 shows the circuit of the displays, the indicators, the input stages and the stage for selecting the measurement duration. The indicator LEDs are driven by transistors: the control lines are connected to relevant points on the mother board via K_5.

The input impedance is about 1 MΩ. Large input signals may be attenuated by 20 dB (S_1 and S_2). All input signals are buffered by Type CA3140 opamps before they are applied to the comparator on the mother board. The inputs of these buffers are protected against overv-voltage by diodes. Presets P_1 and P_2 serve to minimize the offset at the outputs of the opamps.

Circuits IC_3 and IC_4 are programmable 2^n dividers. IC_3 counts the clock pulses passed by AND gate IC_{17a}, that is, the pulses that indicate how long the output of XOR gate IC_{16b} has been high. The number of these pulses depends entirely on the phase shift between the two input signals. IC_4 is the reference counter that receives clock pulses continually.

The scaling factor is set with S_3: it enables the user to select a measurement time that is most suitable for the frequency of the input signal. The error indicators on the display show whether the correct time has been selected.

Figure 6 shows the circuit contained on the third PCB: the seven ICs form the display counter and interface for the LED displays.

The clock pulses to be counted are applied to cascaded counters IC_5–IC_8 via pin 3 of K_8.

As soon as the latch signal is active, the counter state is stored in display drivers IC_9–IC_{11}. The displays, connected with this part of the circuit via K_9, light to show the correct value measured.

The facilities of setting a pre-determined value and choosing up- or down-counting in the Type 4510 ICs are not used.

At the reset command at pin 2 of K_8 the counters are returned to zero and a new measurement cycle can be started. The previous measurement value is retained on the displays because the display drivers are not reset. The next measurement is thus carried out while the displays show the previous result.

Fig. 12. This photograph of the completed digital phase meter shows how the PCB of Fig. 9 is fitted to the PCB in Fig. 8.

Construction

The three PCBs are shown in Fig. 7, 8, and 10. Their population is straightforward, but it is best to begin with boards 2 and 3. Note that the box header on board 2 must be soldered at the track side. Connectors K_8 and K_9 on board 3 may be replaced by right-angle print headers. As a bonus, such headers would ensure a firm mechanical link between boards 2 and 3. In any case, the boards are provided with holes to enable corner braces to be used for strong mechanical interlinking.

Mount the LED displays on board 2 about 1 cm (3/8 in) above the board with the aid of wire-wrap IC sockets.

Connect switches S_1, S_2, and S_4, to the board with short lengths of wire; fit S_3 directly to the board.

Cut the terminal wires of D_1–D_4, and D_9 and D_{10} to about 2 cm (13/16 in): this will ensure that they will be located exactly behind the windows in the fron t panel.

Fit soldering pins at A and B and adjacent earth points at the track side of board 2.

The power-on indicator, D_{13}, is best fitted to the front panel with the aid of an LED clip or superglue.

Fit board 2 on suitable spacers directly behind the front panel. Just prior to tightening the screws, connect the input sockets to the board via short wires. Next, screw the three toggle switches to the front panel.

Finally, mount board 3 at right angles to the track side of board 2 as shown in the photograph in Fig. 12.

Mount the mother board on the bottom plate of the enclosure, after which all necessary electrical connections to the other boards, the power-on LED, and on-off switch to mains entry plug can be made.

Finally, interlink points A and B, and the associated earthing points, on the mother board and board 2 by single screened audio cable.

TECHNICAL DATA	
Measuring range	10 Hz – 20 kHz
Reading	0–360°
Input sensitivity	6 mV peak
Max. input voltage	100 V peak
Attenuation	0 dB or 20 dB
Measurement time	0.3–10 s
Input impedance	1.1 MΩ
Measuring error	≥0.5°

Calibration and use

Calibration of the phase meter is confined to adjusting the four presets.

Short-circuit inputs A and B and adjust P_1 and P_2 for zero output of IC_1 and IC_2.

Remove the short-circuit from the inputs and apply a sinusoidal a.f. signal at a level of about 10 mV to the inputs. Adjust P_3 until comparator IC_{12} toggles exactly at the zero crossing point: check this on an oscilloscope.

Finally, adjust P_4 until the display shows a phase difference of 0°.

Start measuring a phase shift by applying the two signals to the inputs and turning S_3 (gate time) fully clockwise. Then turn the switch anti-clockwise step by step (when the accuracy increases). When the indicator marking a measuring error of 0.5° lights, the optimum position for this measurement has been reached. Since the measurement period increases all the time, it may take a few seconds at low frequencies before the indicator lights. That is, however, the price to be paid for accuracy at low signal frequencies. ■

THE QTC LOOP ANTENNA

The quest for ever reduced sizes of efficient HF transmitting antennas is a compulsive exercise which one has great difficulty in dropping once 'bitten by the bug'. The antenna described here is a new challenge: a directional, compact, table-top loop design with proven excellent performance in the 80-m band.

Richard Q. Marris, G2BZQ

THE lower the HF frequency, the more challenging the idea of being able to use a small antenna. For instance, in the 80 m (3.5 MHz) amateur band, a dipole antenna would be around 42 m long. Many do not have the real estate to accommodate such a dipole, apart from possible planning permission difficulties, and difficulties with leases or neighbours. For apartment dwellers an outside antenna is invariably impossible. For non-amateur applications there are various requirements for discrete and easily portable antennas. As a result, a compact table-top antenna as described here becomes most attractive for many applications.

Small and efficient

Over the years, a number of small table-top HF antennas have been designed, built and air-tested. By far the best has been the spiral loop (Ref. 1) to cover the 3.5 to 3.8 MHz amateur band. This was a very simple 23-inch (approx. 59 cm) diameter octagonal experimental model which I used over the last year with a 7-watt CW transmitter.

It has been useful and fortunate during my experiments that there has been a regular daily 2-way schedule, between 05.00/05.30 a.m. on 3,560 ±5 kHz, with a friend in Stuttgart, Germany. He has entered into the spirit of these experiments, which have proved to be essential, though, of course, much longer distances have been achieved. His transmitter has a power output of about 100 watts feeding an outdoor dipole. As against this, I have been using a spiral loop on a table alongside my low-power transmitter. Strangely enough, looking back over the months, there has been little difference in signal strength reports either way.

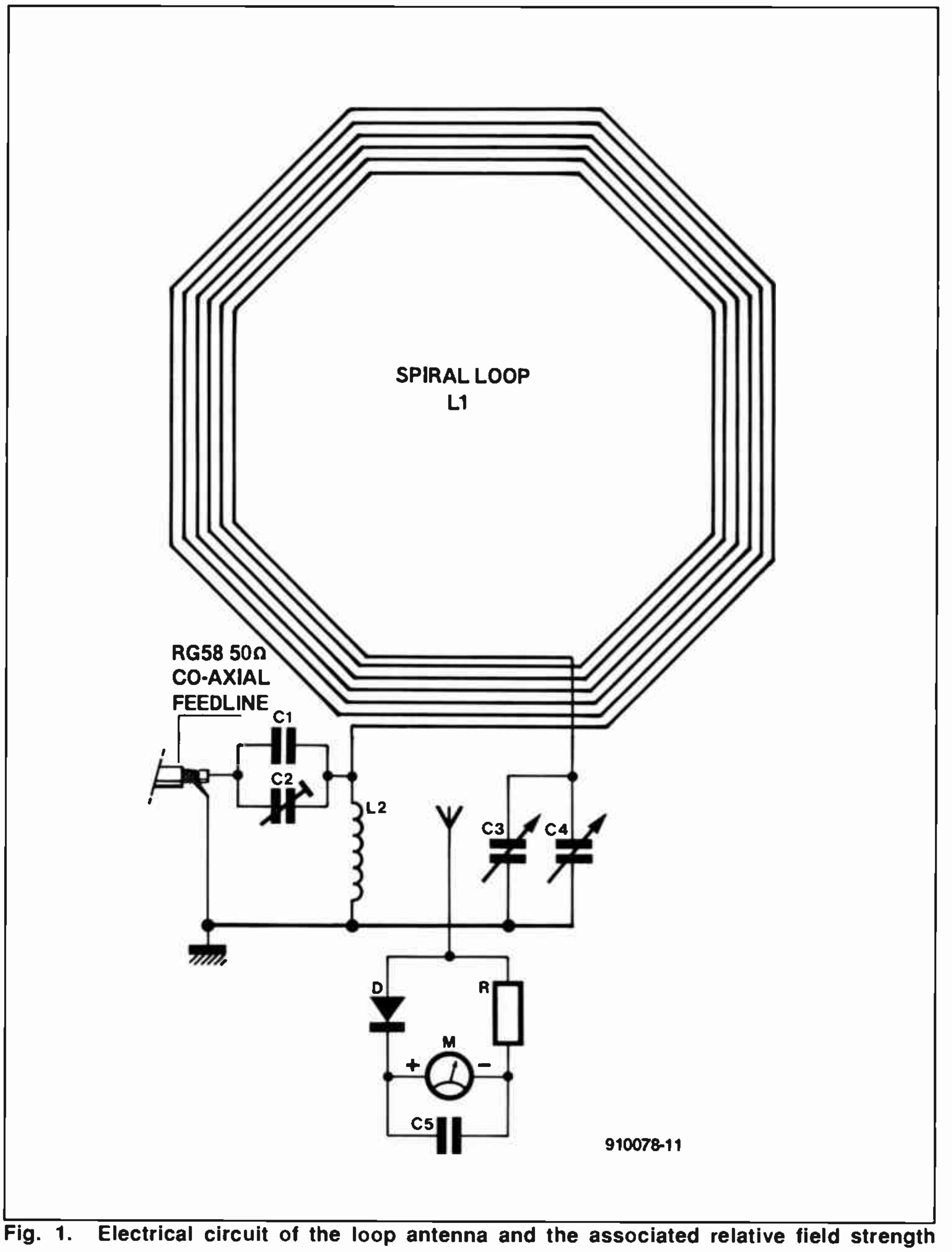


Fig. 1. Electrical circuit of the loop antenna and the associated relative field strength

The tiny amount of textbook information (Ref. 2) available on spiral loops is concerned with direction finding (DF) and not transmission. It is stated that the reception advantages of the spiral loop over a standard box loop, with the turns side-by-side, are mainly greater sensitivity/gain, and a narrower directional polar diagram. Based on experience with the 23-inch diameter spiral loop, and seeking greater efficiency and transmission range, further experiments produced the much more sophisticated and efficient QTC spiral loop. Just in case you do not remember your Q-codes: QTC means "I have a message for you".

The message

is that the new loop antenna has a 30-inch (approx. 76 cm) octagonal configuration, which, although giving as much as 50% increase in loop area, still fits into the table top space available.

The circuit (Fig. 1) shows a 5⅛ turns loop, L1, plus impedance matching coil, L2. The inductors are resonated by variable capacitors C3 and C4. C3 sets the band segment to be used, and C4 is a small bandspread tuner.

A 48-inch (approx. 122 cm) length of RG58 coax cable is fed via C1 and C2, in parallel, to the junction of L1 and L2. Capacitor C2 is a preset variable type providing a fine coupling adjustment.

Maximum radiation is on the outer turns of L1 (H_i–I), and minimum radiation on the inner turns (H_i–E). The radiation pattern (polar diagram) is shown in Fig. 2. It will be realized that the large lobe has to be pointed towards the station to be contacted. In the

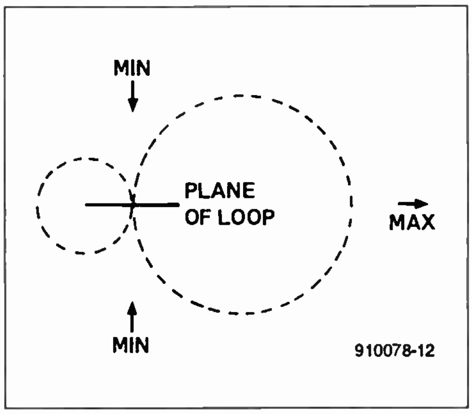


Fig. 2. Theoretical polar radiation pattern of the QTC loop.

author's shack the loop usually stands on a small turntable for simple manual rotation.

The antenna has a built-in tuning meter seen at the bottom of the circuit. This is basically a RF probe of which the sensitivity is reduced to an absolute minimum, so that a 'sample' of the transmitted signal can be taken from the outer turn of L1. The sensitivity of the probe is controlled by the value of resistor *R*, as well as by the length and position of the mini-antenna.

All components are neatly located in a plastic control box as shown in Figs. 3 and 4. The RF meter assembly is mounted in a Terry clip on top of the box, with the diode, the resistor and capacitor C5 wired behind the meter. This method was adopted to enable the tuning assembly to be used on other experimental antenna models.

The complete loop assembly is shown in Fig. 4. When designing such a loop, it is essential that metal parts be avoided, which means that you have to use wood and plastic construction throughout.

Construction

As shown in Figs. 1 and 4, the loop frame consists of eight 'spokes'. These are made of four lengths of moulded hardwood, each 30 inch long, 5⁄8-inch wide and 1⁄4-inch thick (approx. 76.2 × 1.6 × 0.6 cm). A 2BA (5 mm) clearance hole is drilled in the centre of each spoke, and after an application of glue, the spokes are clamped together with a 2BA bolt, overlapping in the order illustrated. The whole is given a polyurethane varnish. A 6-way 2-amp polythene terminal block is screwed to the end of each spoke. These provide the necessary spacing and insulation of the wire turns.

A 23 × 0.8 × 0.8-inch (approx. 58.4 × 2 × 2-cm) vertical wooden support is glued and bracketed to a suitable wooden base, the whole being teak wood stained. The loop frame is then glued and bolted to the top of the vertical support.

The loop winding, L1, uses PVC-covered stranded 7/0.2 mm wire with an outside diameter of 1.2 mm and an electrical rating of 1 kV/1.5 A. After loosening all grub screws in the terminal blocks, the wire is threaded through, turn by turn, for 5⅛ turns starting at the outer left-hand lower frame spoke, and threading through all blocks in a

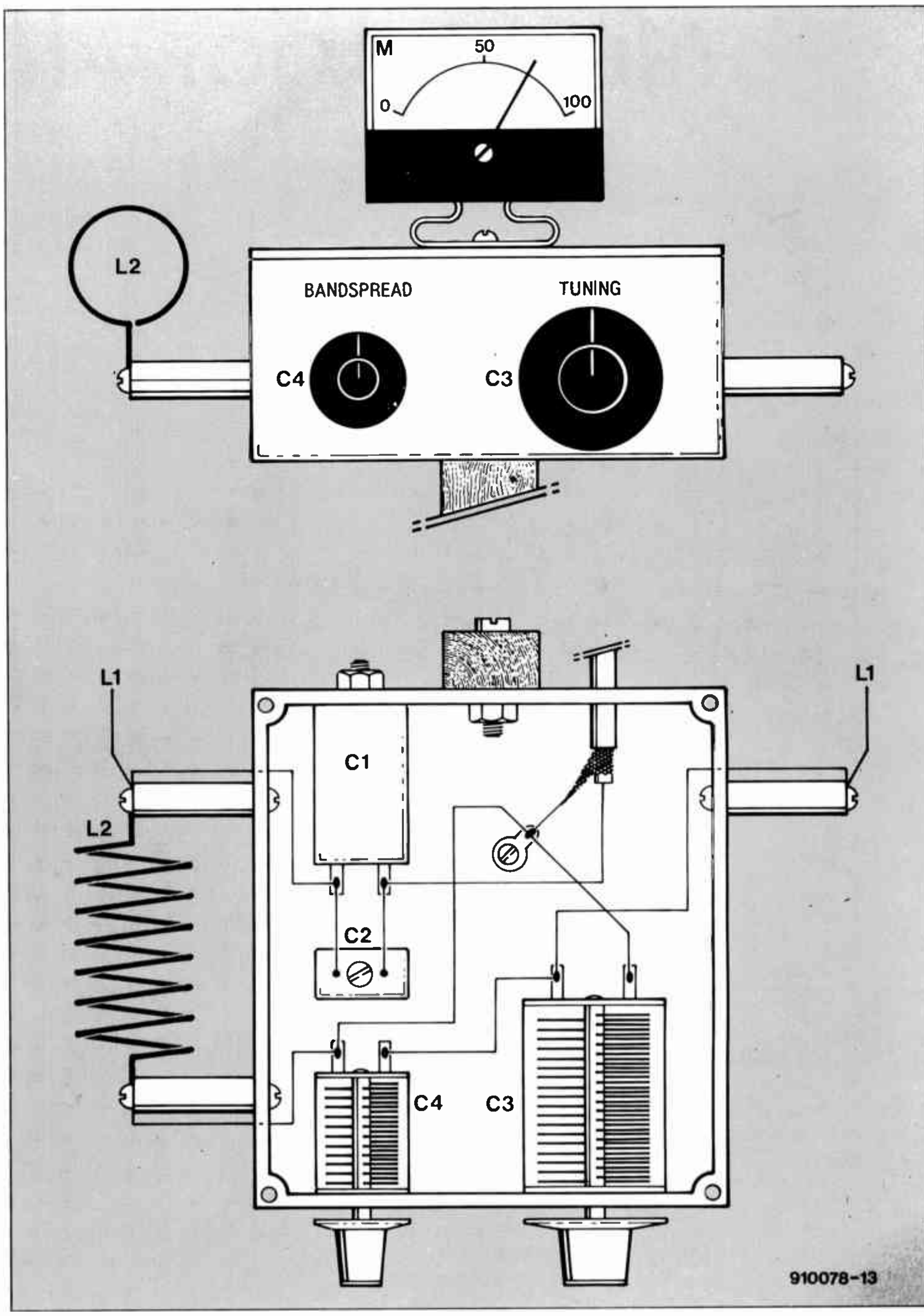
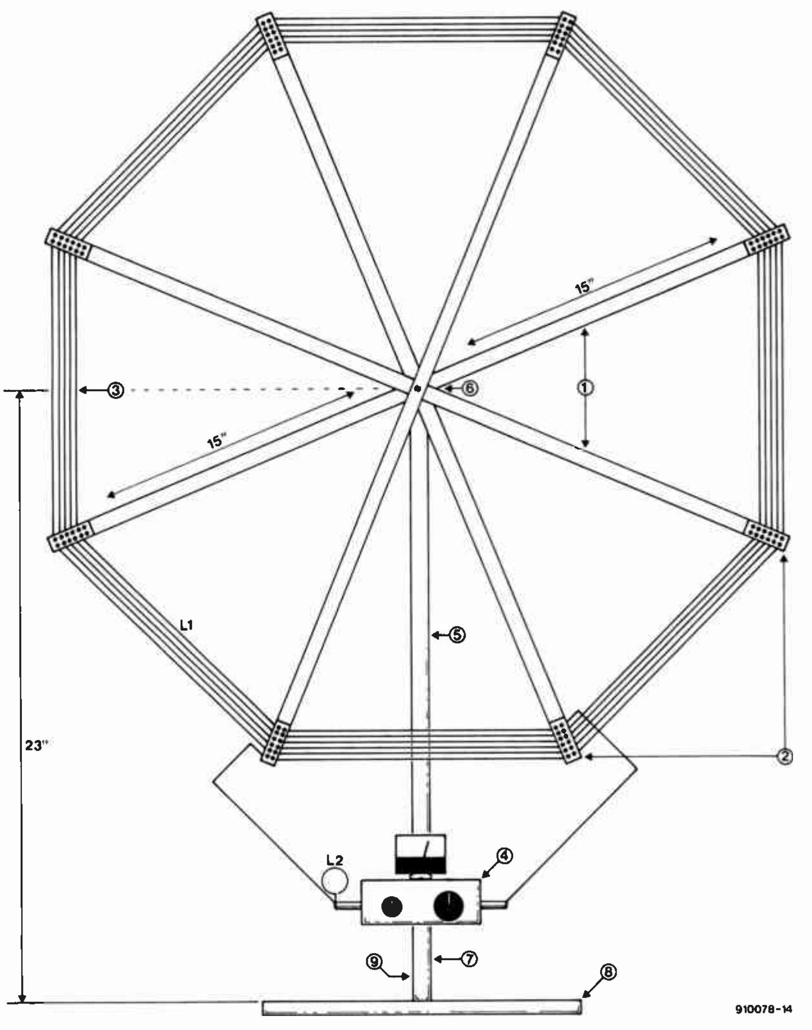


Fig. 3. Mechanical outline of the antenna tuning unit and the field strength indicator.

COMPONENTS LIST

C1 = 3750 pF 500V silver-mica capacitor.
C2 = 100 pF preset capacitor (Jackson C803).
C3 = 75 pF variable capacitor (Jackson C809), plus knob.
C4 = 12.7 pF variable capacitor (Jackson C16), plus knob.
C5 = 22 nF mica capacitor.
M = 250 μA f.s.d. 40 × 40 mm moving coil meter (Maplin LB808).
D = HF silicon diode.
R = 1 kΩ resistor (see text).
L1 = 5⅛ turns of PVC covered stranded 7/0.2 mm wire. Outside diameter: 1.2 mm, 1 kV/1.5 A rating (see text).
L2 = 13 turns 16SWG tinned wire, 1 inch internal diameter (see text).
Feedline = 48 inch RG58 coaxial cable, plus plug to suit transmitter.
Box = ABS box type MB3, 118 × 96 × 45 mm. Maplin ref. LH22.
Terminal blocks = qty. 4 12-way 2 amp terminal block. Maplin ref. FE78.
Spacers = qty. 3 insulated spacer type M3, 30 mm long, Maplin ref. FS40T.
Spokes = qty. 4 8-foot lengths of 5⁄8 × 1⁄4 inch moulded hardwood (DIY store).
Vertical support = 23 × 0.8 × 0.8 inch wood (DIY store).
Wood base = 12 × 8 × 0.5 inch plywood or similar.
2½ inch steel support bracket.



1. 4 lengths moulded hardwood 30" × 5/8" × 1/4". Varnished. 2BA holes drilled in the centre. Glued and bolted together.
2. 8 off 6-way 2-amp polythene terminal blocks used as insulated wire spacers.
3. 5 1/8 turns of PVC stranded wire (for specs see components list).
4. See Fig. 3.
5. Wood vertical support 23" × 0.8" × 0.8", wood stained.
6. 2" × 2BA bolt.
7. Box front vertical support, 4 1/2" × 1/2" × 3/4", wood stained.
8. Wood base 12" × 8" × 1/2" (or similar), wood stained.
9. 2 1/2 steel support bracket behind wood vertical support.
10. Drilled and secured with glue and c/s wood screws.

Note: " = inch = 2.54 cm.

Fig. 4. The construction of the antenna is based on commonly available parts and materials. The 'spokes' are bolted and glued together in the centre.

reducing anti-clockwise spiral. The loop is terminated at the inner of the lower right-hand spoke, as shown in Fig. 4. Wire tails are left at the loop ends for cutting and connecting later. After tightening the loop turns, the insert screws in the terminal blocks are tightened sufficiently to keep the turns straight.

After fitting the variable capacitors and insulating pillars in the box (Fig. 3), the box is bolted to the main vertical support. An extra, smaller, vertical wood member secures the box front to the wood base with screws and glue. The meter assembly is secured to the font lid of the box lid with the aid of a large plastic-coated Terry clip. The RG58 coaxial feedline enters the box at the rear (Fig. 3), and is cleated down to the vertical support and along the wood.

Inductor L_2 is soldered to tags on the two left-hand insulated pillars. It consists of 13 turns of 16SWG (16AWG, approx. 0.6 mm dia.) tinned copper wire wound to 1 inch (2.54 cm) diameter. The turns are then spaced to about 1.5 times the wire thickness. The whole loop assembly is now wired as shown in Figs. 1, 3 and 4.

Testing and operation

Initial tests are made with a receiver. On the prototype with the bandspread, C_4, at mid capacity, it was found that by rotating C_3 the frequency range was 2,500 kHz to 4,500 kHz, which adequately covers the 80-m band (3,500 to 3,800 kHz), with some overlap. In the USA and elsewhere, the 80-m band is extended to 4,000 kHz. Resonance is indicated by a peak of noise and signal strength in the receiver. The radiation pattern can be checked on a selected signal by rotating the loop for maximum signal strength. From Fig. 2 it will be seen that this coincides with the large lobe. Further rotation of the loop through 360 degrees gives a radiation pattern as shown.

In practice, C_4 is set to minimum capacitance, and C_3 is tuned to start of the selected band segment. For instance, if the required operating segment is 3,500 to 3,800 kHz, C_3 is set to about 3,600 kHz (with C_4 at minimum capacitance). Bandspread control C_4 is then used to tune the loop, giving fine tuning over 3,500 to 3,600 kHz, and so on.

The transmitter adjustment is as follows:

1. Connect the transmitter to a 50-Ω dummy load. Set the transmitter to the selected frequency and adjust the P.A. for optimum loading.
2. Remove the dummy load and substitute the loop.
3. Resonate C_4 to the transmitter frequency, and peak the coupling preset adjustment, C_1.
4. It should be possible to use the transmitter at ±20 kHz of the setting up frequency without retuning the loop with C_4. Minor adjustments of C_4 will easily retune the loop outside this bandwidth, as required.

Proceed with the adjustment of the tuning meter. The mini-antenna consists of a few turns of stiff wire wound around a pencil. Remove the wire from the pencil, and position the end of it directly under the bottom turn of L_1. The mini antenna is manipulated up and down so that the meter reads about 3/4 full-scale when the transmitter is correctly loaded. When retuning the transmitter during operation, the meter should always peak around this point, provided the transmitter power is unaltered. Note, however, that the sensitivity of the meter depends also on the value of resistor R and the transmitter power. The value shown, 1 kΩ, is satisfactory for a transmitter power of about 5 to 10 watts. For higher or lower power transmitters, the value of R is changed experimentally.

When operating the antenna it should be kept a loop diameter away from walls, pipes and electrical wiring. It will be noticed that due to the loop directivity the received level of interference is well down on a normal antenna. Best results will be obtained when the large radiation lobe is pointed directly at the station being contacted.

Finally, note that the loop antenna is intended as a low-power device for indoor use. In the interest of safety, a transmitter power of 20 watts should not be exceeded. No doubt the design could be re-engineered for higher power and outdoor use. ■

References:

1. "The Miser's T/R loop antenna" by R.Q. Marris, *Elektor Electronics* November 1990.
2. The Admiralty handbook of Wireless Telegraphy, Volume 2, 1938.

For further reading:

- The ARRL Antenna Book, 14th edition.
- Antennas (2nd edition), 1988, by John D. Kraus (McGraw-Hill).

INTERMEDIATE PROJECT

A series of projects for the not-so-experienced constructor. Although each article will describe in detail the operation, use, construction and, where relevant, the underlying theory of the project, constructors will, none the less, require an elementary knowledge of electronic engineering. Each project in the series will be based on inexpensive and commonly available parts.

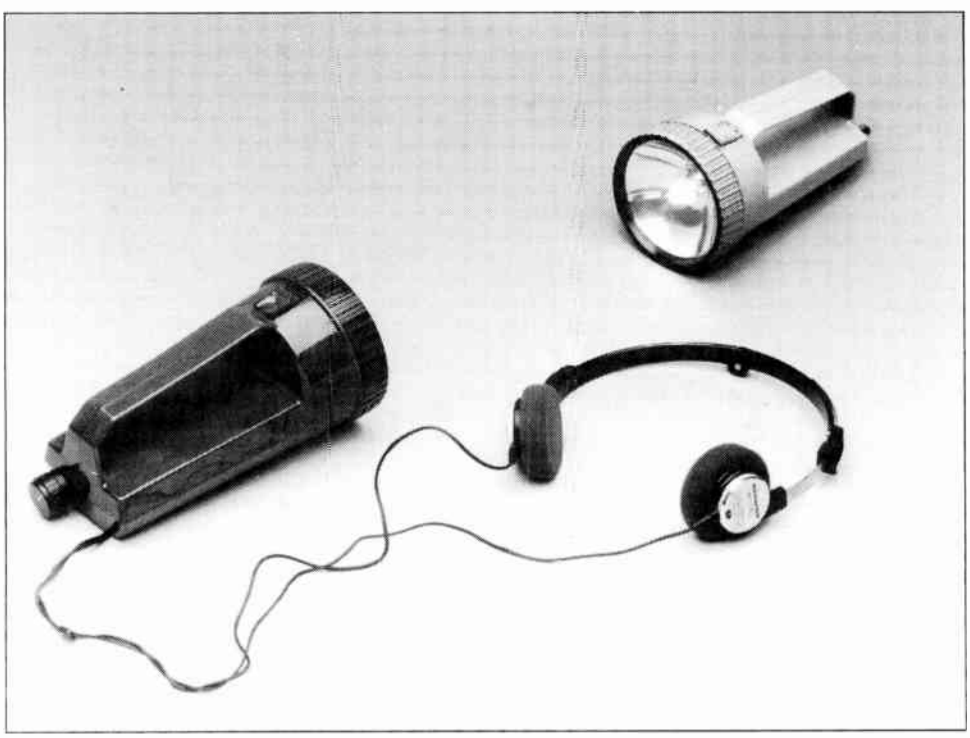
LIGHT TRANSMITTER/RECEIVER

This month we present an experimental circuit to demonstrate that visible light can be modulated and used as a carrier to convey information. Depending on the power of the bulb you use, and the optics for the transmitter and the receiver, this low-cost communication system will carry speech signals over distances of tens to hundreds of metres.

T. Giffard

IN principle, the intensity of a light beam from an electrical source, such as a bulb, can be used as a carrier to convey an audio signal from one point to another. This type of amplitude modulation (AM) can be achieved by using the audio signal to vary the voltage applied to the bulb. The light transceiver described here is intended as an introduction to wireless communication using amplitude modulation. The circuits have been kept simple and can be assembled and put to use in single evening or a rainy afternoon. When used for an experiment rather than a fixed communication link, the transceiver can be even simpler than shown here because existing amplifiers may be used.

Compared to, say, an infra-red emitter there are certain restrictions to the use of common low-voltage bulbs as light sources for an AM-based communication link, and the modulation will not be perfect. Still, the quality of the system will be good enough for a reliable voice link.



On modulation and filaments

Modulating the light intensity of a bulb is not so difficult. However, the relation between the intensity and the filament voltage is not quite as linear as we would like. In practice, the best results are obtained with low-voltage bulbs that have a thin, straight filament. These bulbs, which are used in bicycle rear lights, have a relatively rapid response to filament voltage variations, and are therefore capable of 'following' a speech or music signal.

The response of a bulb to sine-wave modulation can be significantly improved by applying a direct voltage to the filament, and superimposing the sine-wave. In practice, the best results are obtained with the fixed voltage set such that the bulb lights at half the nominal intensity. This also sets the maximum value of the applied alternating voltage, whose peak value may not exceed the direct voltage. When the voltages are equal, the modulation depth is 100%. In the absence of an alternating voltage component, the modulation depth is 0%.

The light transmitter

The circuit of the light transmitter is shown at the left in Fig. 1. It supplies the light source, bulb La1, with a direct voltage as well

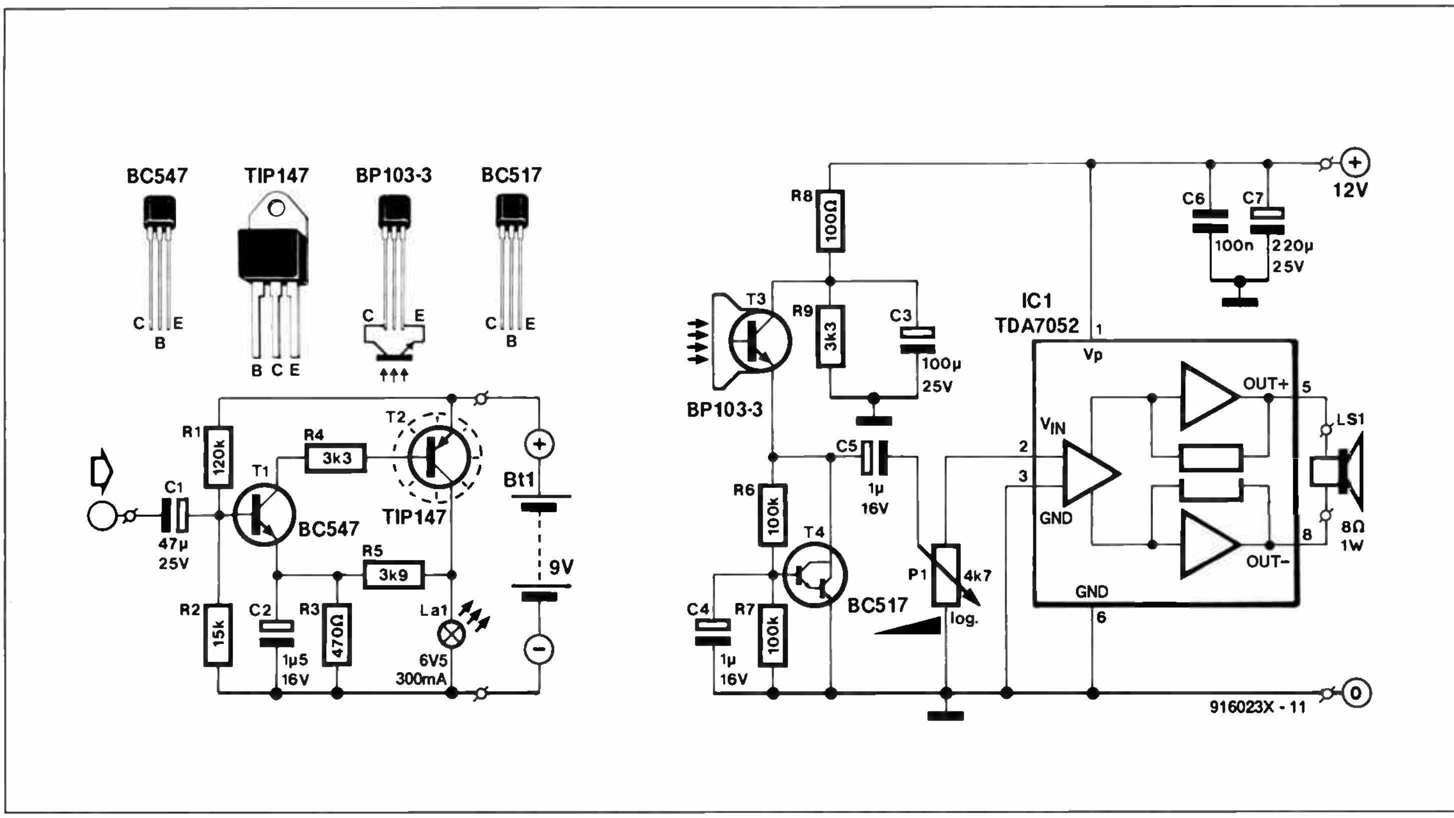


Fig. 1. Circuit diagram of the light transmitter (left) and the associated receiver (right). The IC-based audio amplifier in the receiver, a TDA7052, is optional and may be replaced by any other amplifier you may have available.

as with the modulation signal. The bulb is connected in the collector line of a medium-power transistor, T2, which functions as an amplifier. When there is no input signal, the collector of T2 is at about half the supply voltage. An audio input signal applied to the base of T2 causes the collector voltage to swing between 0 V and the supply voltage. This ensures that La1 is supplied with the optimum voltage for amplitude modulation.

Transistor T1 raises the audio input signal and at the same time keeps the quiescent voltage across La1 at about half the supply voltage. The transistor monitors the collector voltage of T2 via resistor R5, and controls the base voltage of T2 accordingly. A decoupling capacitor, C2, prevents T1 acting on the modulation voltage at the collector of T2. The voltage control is effective only when the average collector voltage of T2 is no longer correct. The operation of this type of feed-

COMPONENTS LIST

Resistors:		
1	120kΩ	R1
1	15kΩ	R2
1	470Ω	R3
2	3kΩ3	R4;R9
1	3kΩ9	R5
2	100kΩ	R6;R7
1	100Ω	R8
1	4kΩ7 log. potentiometer	P1
Capacitors:		
1	47µF 25V radial	C1
1	1µF5 16V radial	C2
1	100µF 25V radial	C3
2	1µF 16V radial	C4;C5
1	100nF	C6
1	220µF 25V radial	C7
Semiconductors:		
1	BC547	T1
1	TIP147	T2
1	BP103-3	T3
1	BC517	T4
1	TDA7052	IC1
Miscellaneous:		
1	8Ω 1W loudspeaker	LS1
1	6.5V 0.3A bulb	La1
1	Heat-sink for T2	
2	Printed-circuit board	UPBS-1

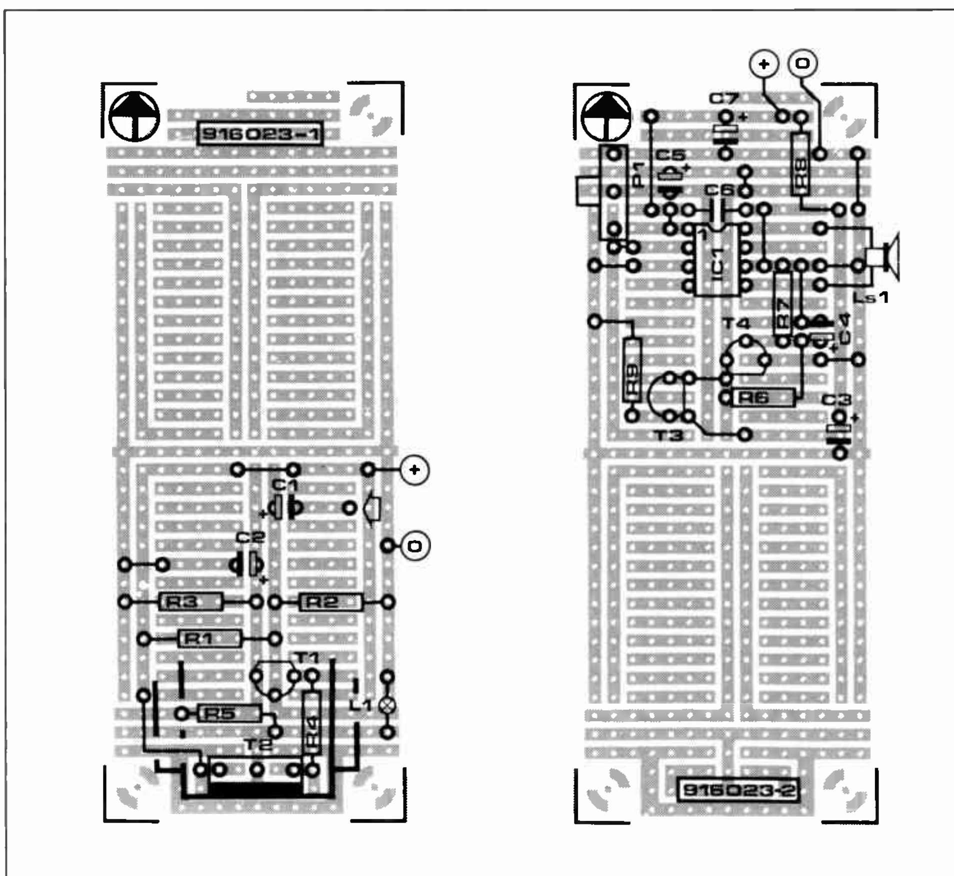


Fig. 2. Compinent mounting plans of the transmitter (left) and the receiver (right). Both are built on ready-made prototyping boards (see the components list).

back is fairly simple. Assuming that the collector voltage of T2 drops, R5 supplies a lower voltage at the emitter of T1. Since the base voltage of T1 is fixed with the aid of a voltage divider, R1-R2, the transistor starts to draw more collector current, resulting in more current fed into the base of T2. Consequently, the collector current of T2 rises, so that the collector voltage rises also. In this way the initial voltage drop is counteracted and the bulb voltage held constant at about 4.5 V.

The light receiver

The main component in the circuit of the light receiver (shown at the right in Fig. 1) is a photo transistor, T3. The collector current of this transistor is a function of the intensity of the light incident on the device. If the incident light is produced by the light transmitter, the emitter voltage of T3 is a copy of the modulation signal applied to the transmitter. The demodulated signal is fed to a small a.f. amplifier, IC1, via coupling capacitor C5 and volume control P1. The a.f. amplifier, a TDA7052, has a voltage gain of about 100.

Returning to the phototransistor, the emitter potential is held constant by a voltage source based on T4. Assuming that the emitter voltage of T3 rises, the base current of T4 rises via resistor R6. Consequently, the collector current of T4 rises, so that the collector voltage drops. This keeps the emitter voltage of the photodiode in check. Like C2 in the transmitter, C4 prevents the voltage stabilizer acting on the modulation signal, which changes much faster than the average emitter voltage of the photodiode.

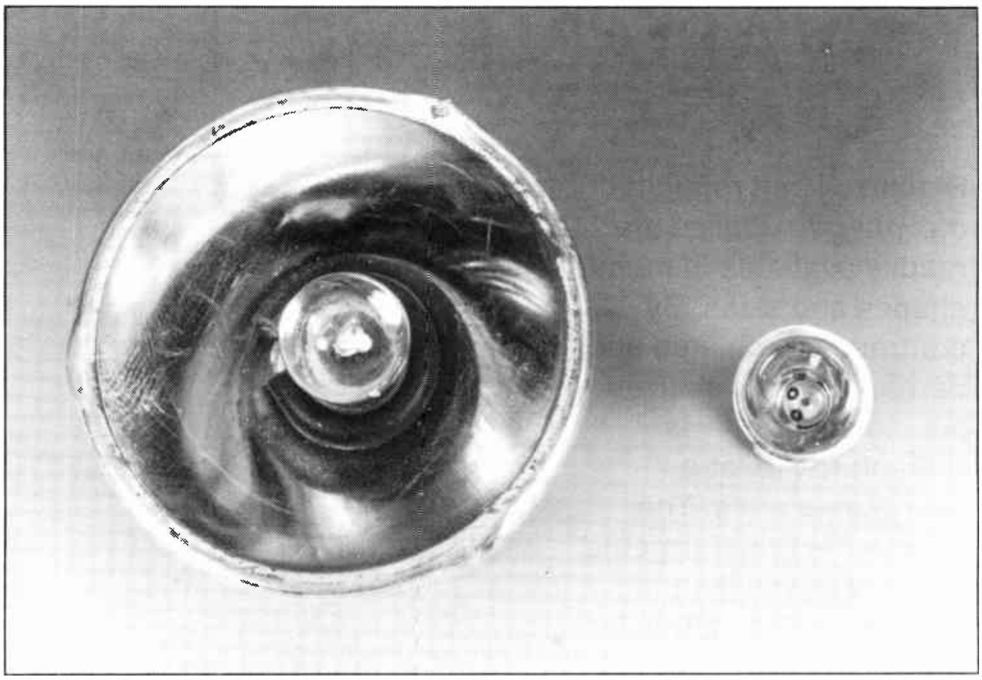


Fig. 4. The transmitter uses a plastic reflector from a pocket torch, while the phototransistor in the receiver is fitted in a reflector of a type normally used for infra-red emitters.

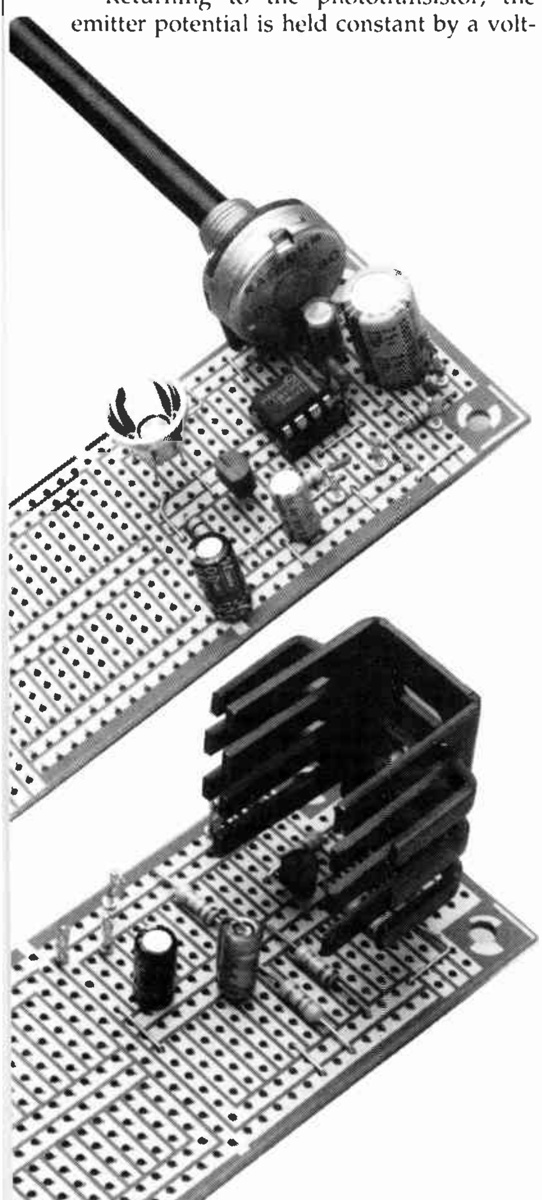


Fig. 4. Prototypes built on two boards type UPBS-1

Construction and use

The transmitter and receiver circuits are so simple that they are easily constructed on prototyping boards as shown in Fig. 2. If you want to make a duplex system where each 'station' consists of a transmitter and a receiver, you will require two prototyping boards (order code UPBS-1). For a one-way light link, a single board may be cut in two to accommodate the transmitter and receiver circuit. The photographs in Fig. 3 show the transmitter and the receiver built on two prototyping boards.

There are several options for the construction of the optics. At the transmitter side, you may use a reflector from a torch (see Fig. 4). At the receiver side, a concave reflector is used of the type found on infra-red remote controls. In most cases, the BP103 phototransistor will fit in the opening for an infra-red LED. It will be clear that the distance covered by the system will depend on the size of the optics used. In general, the larger the diameter of the reflectors, the better (an example of the use of car headlight and a magnifying glass for a long-range infra-red communication system is given in Ref. 1). A few prototypes with different coverage were built in torches as shown in the introductory photograph.

You may also want to experiment with the wattage of the bulb used in the transmitter. Note, however, that relatively high bulb powers require T2 to be fitted with a heatsink.

The transmitter draws a relatively high current, and is best powered by a regulated supply or a rechargeable 9-V battery block. The receiver has a very modest power consumption, and can be supplied from a small mains adapter. In some cases, however, such an adapter may produce an unacceptable hum level in the receiver. Fortunately, the hum is simple to suppress by fitting larger supply decoupling capacitors in positions C3 and C7.

Finally, note that the bulb in the transmitter will emit visible as well as infra-red light. This allows you to use an infra-red sensitive phototransistor such as the BPW40 if the BP103 proves difficult to obtain. ■

Reference:

1. "Long-range infra-red transceiver". *Elektor Electronics* November 1987.

VARIABLE A.C. POWER SUPPLY

Stabilized and regulated d.c. power supplies are readily available in many shapes and sizes. By contrast, a regulated and perhaps even stabilized a.c. power supply is difficult to find at a reasonable price. The adjustable transformer is in many cases the only alternative, but it, too, is pretty expensive. In this article we present a simple 25-V 1-A a.c. power supply that deserves a fixed place on any electronics workbench.

L. Lemon

AN alternating voltage is much more difficult to stabilize than a direct voltage. In fact, there are two quantities that must be stabilized: the voltage proper (or its amplitude), and the frequency. Since it was intended to keep the present supply as simple as possible, frequency stabilization is not provided. The mains frequency is used here because it is fairly stable and suitable for most applications.

Block diagram

The operating principle of the present supply is to stabilize an alternating voltage with the aid of an adjustable potential divider. As shown in the block diagram in Fig. 1, the potential divider is controlled electronically, and forms part of a regulation loop. A power transistor is used as an adjustable resistor in a diode bridge. The bridge is required because the transistor can handle direct current only. Unfortunately, it has two disadvantages: first, it introduces a voltage loss of two times the forward diode voltage; second, because of their threshold voltage, the diodes do not conduct around the zero crossing of the alternating voltage. As shown in the oscilloscope photograph in Fig. 2, the thresholds cause small flattened parts around the zero crossing of the output voltage. In amplifier terminology this effect is known as cross-over distortion. Fortunately, the effect is of little consequence here, and it can be tolerated bearing in mind that we set out to de-

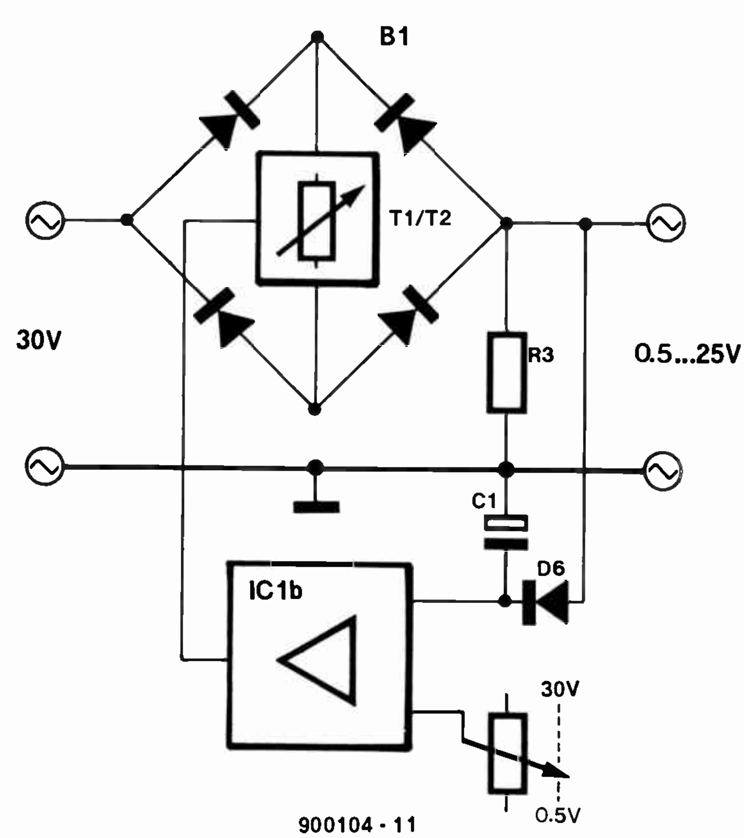


Fig. 1. The alternating voltage is stabilized by comparing the peak value with a preset voltage. The resulting error signal is used to control a variable resistor in a diode bridge.

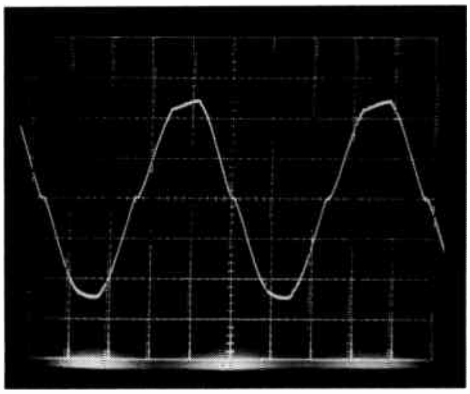


Fig. 2. **Output waveform of the power supply. The cross-over distortion is caused by the small forward drop across the diodes in the rectifier bridge.**

sign a simple a.c. power supply. Along this train of thought, the supply is based on measuring the peak value of the output voltage, rather than the instantaneous voltage, which is far more difficult. The peak voltage exists across C1, which is charged by rectifier D6. A difference amplifier compares the measured peak value with the value set by the output voltage control, potentiometer P2. Differences between the two voltages cause an error signal that serves to adjust the output voltage until the difference is zero, i.e., until the set output voltage is achieved.

Circuit description

The circuit diagram of the variable a.c. power supply is fairly simple — see Fig. 3. The alternating voltage circuit is almost identical with the block diagram. The diode bridge is formed by a bridge rectifier Type B80C3200/2200 (80 V p.i.v., 3.2 A peak, 2.2 A continuous), and the adjustable resistor by transistors T1-T2. Resistor R3 completes the potential divider.

The voltage control circuit is a little more complex than suggested by the block diagram. The peak voltage rectifier, D6-C1, is followed by a potential divider, R4-R5. This prevents the voltage across C1 exceeding the supply voltage of IC1a (the peak value of a 25-V alternating voltage is much greater than 12 V). The output voltage is indicated by a moving-coil meter, M1, which is calibrated for 25-V f.s.d. (full-scale deflection) by preset P1.

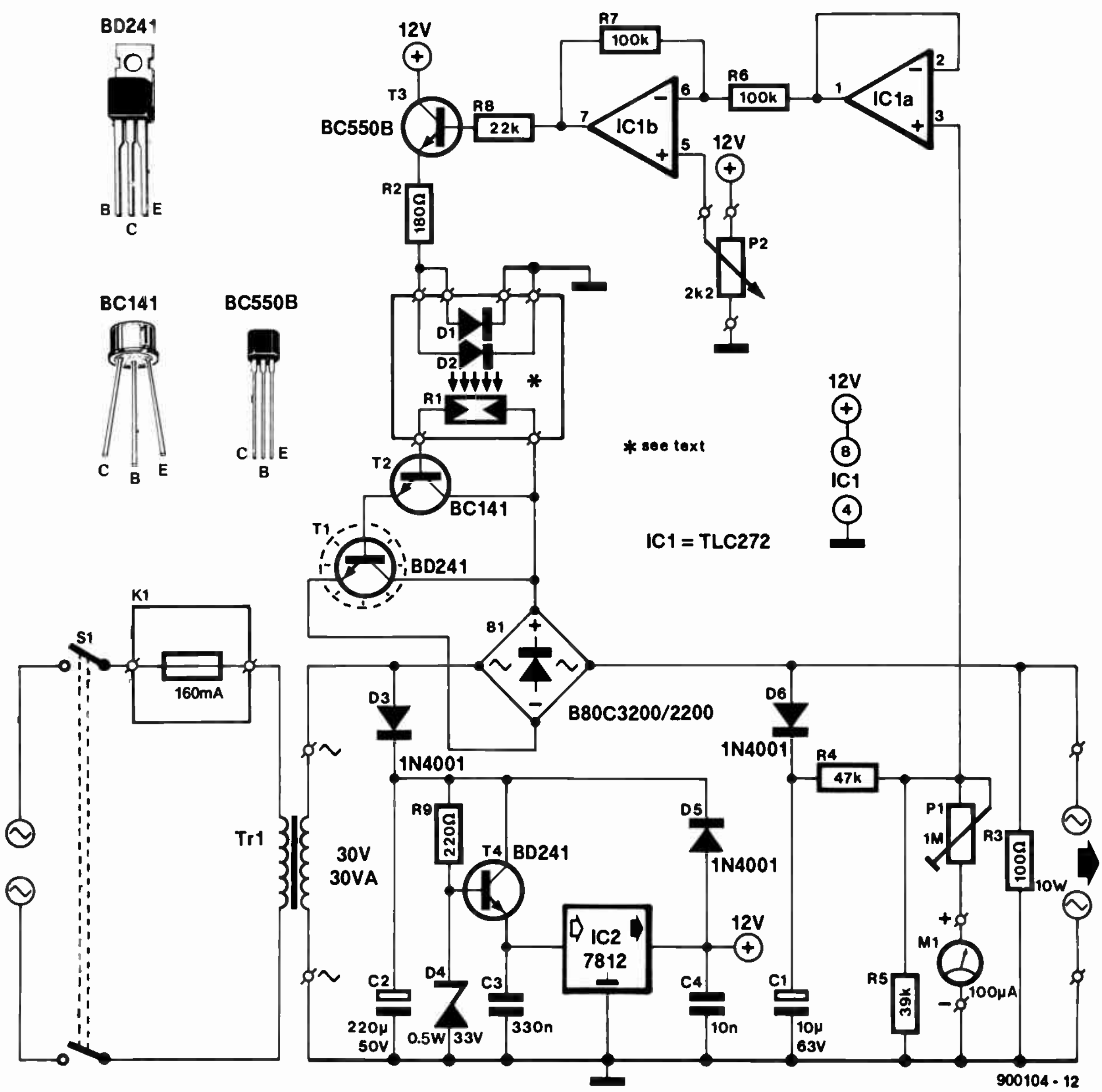


Fig. 3. **Circuit diagram of the a.c. power supply. The optocoupler shown here is a home-made type consisting of two LEDs and an LDR.**

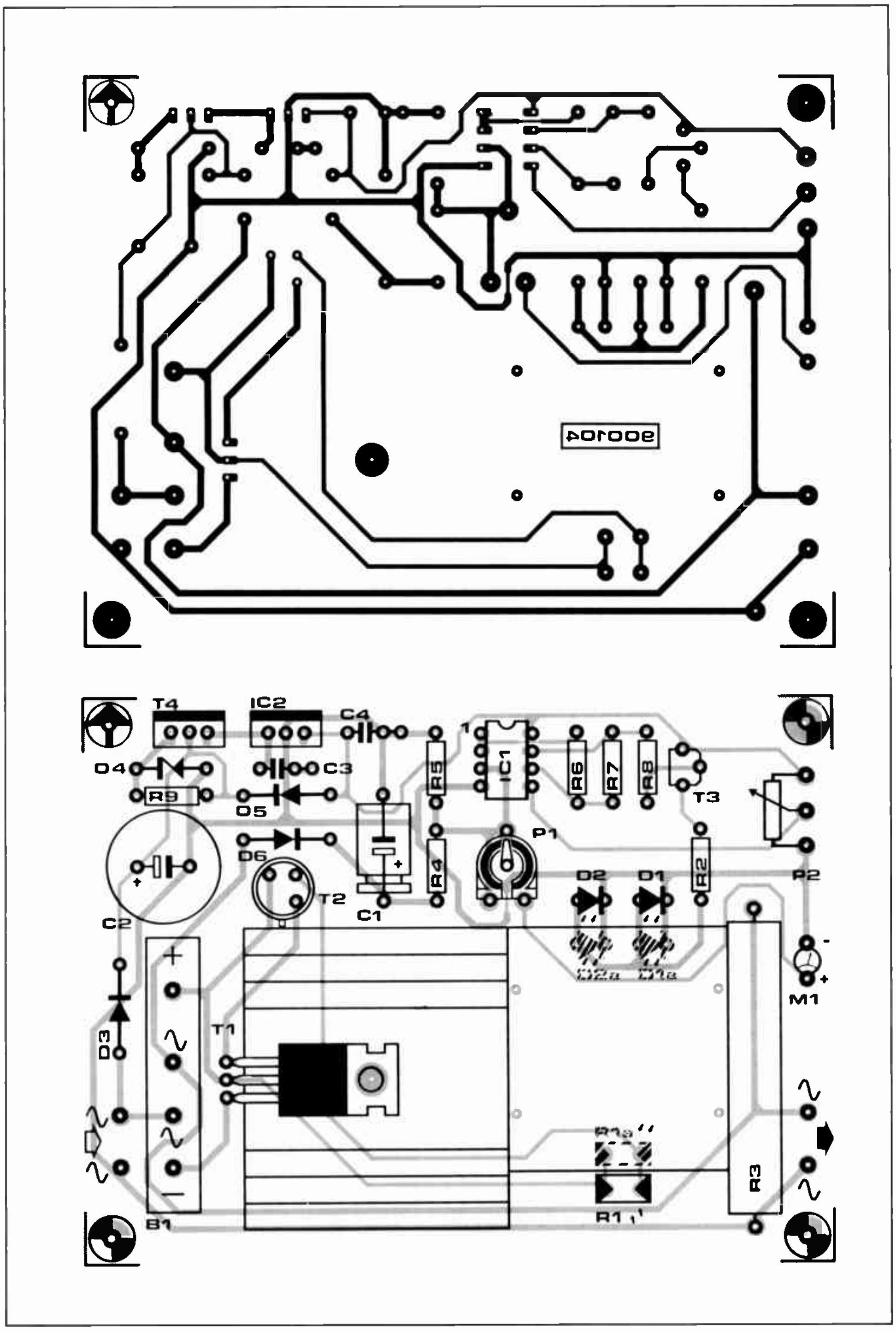


Fig. 4. Single-sided printed circuit board for the a.c. power supply.

COMPONENTS LIST

Resistors:

1	LDR	R1
1	180Ω	R2
1	100Ω 10W	R3
1	47kΩ	R4
1	39kΩ	R5
2	100kΩ	R6;R7
1	22kΩ	R8
1	220Ω	R9
1	1MΩ preset H	P1
1	2kΩ2 lin. potentiometer	P2

Capacitors:

1	10µF 63V axial	C1
1	220µF 50V radial	C2
1	330nF	C3
1	10nF	C4

Semiconductors:

2	red LED	D1;D2
3	1N4001	D3;D5;D6
1	33V 0.4W zener diode	D4
1	B80C3200/2200	B1
2	BD241	T1;T4
1	BC141	T2
1	BC550B	T3
1	TLC272	IC1
1	7812	IC2

Miscellaneous:

1	double-pole mains switch	S1
1	mains appliance socket with integral fuseholder	K1
1	mains transformer 30V @1A, e.g., ILP 11013 (220V mains) or ILP 13013 (240V mains)	Tr1
1	100µA moving-coil meter	M1
1	160mA fuse (slow)	
1	heat-sink for T1; 7K/W	
2	heat-sink for T4 and IC2; 30K/W	
1	printed-circuit board	900104
1	front-panel foil	900104-F
1	enclosure LC850 (manufacturer: Telet; supplier: C-I Electronics)	

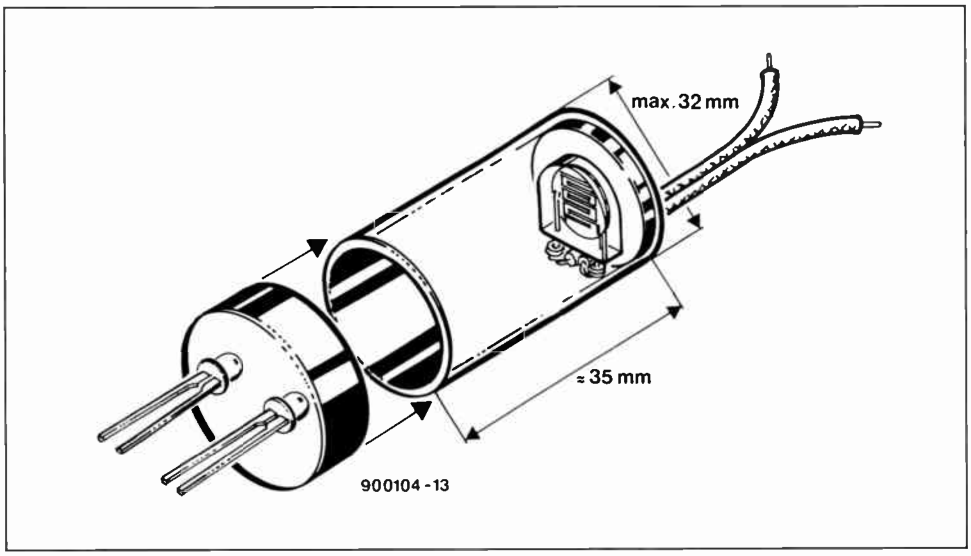


Fig. 5. Basic construction of the home-made optocoupler.

Opamp IC1a buffers the voltage supplied by R4-R5, and drives IC1b, the difference amplifier proper. Potentiometer P2 forms the output voltage control. The voltage at its wiper is compared with the voltage supplied by IC1a. The error voltage supplied by IC1b is buffered by T3, and used to control the intensity of two parallel-connected LEDs in an optocoupler. The LDR (light-dependent resistor) at the other side of the optocoupler determines the resistance formed by T1.

Unfortunately, the power supply has some shortcomings because of the use of a power transistor as an adjustable resistor in the regulating circuit. For one thing, the resistance can not become nought since T1 will introduce a minimum drop of about 2.5 V. Add that to the drop across the diodes, and you will realize that the total voltage loss introduced by the regulator is about 4 V. Similarly, T1 can never be turned off completely.

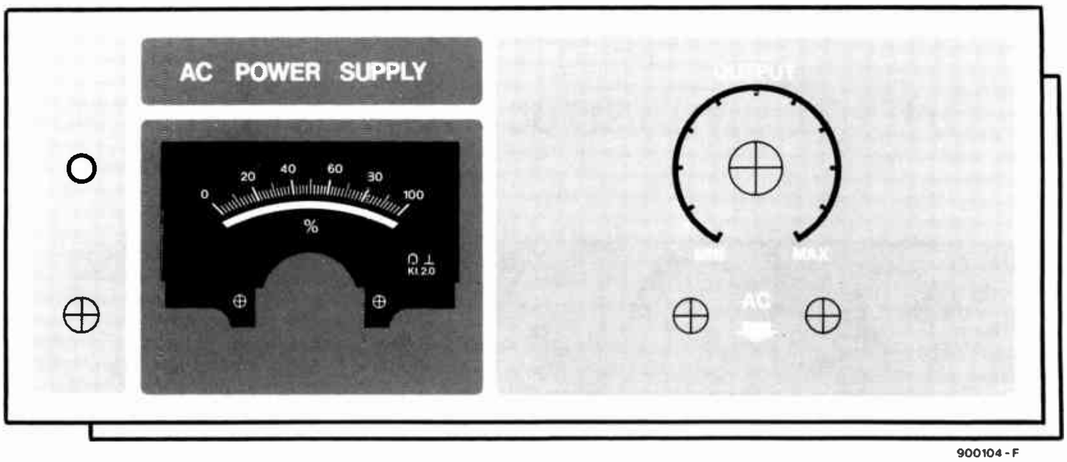


Fig. 6. Layout of the front panel foil (shown here at about 70% of true size). This foil is available ready-made through the Readers Services.

This means that the supply can not be set to an output voltage of 0 V. Fortunately, the actual minimum output voltage is quite low at a value smaller than 0.5 V.

The regulation circuit is powered by the mains transformer via rectifier D3-C2. Components R9, D4 and T4 reduce the rectified voltage to about 33 V, which can then be safely applied to the input of a 12-V regulator, IC2.

Construction

The construction of the power supply is straightforward if you use the printed-circuit board shown in Fig. 4. The optocoupler is a home-made device. The construction is shown in Fig. 5. Use a length of PVC tubing, a (black) spool of a photographic film, or cut a piece of thin, black decoration cardboard to size and roll it into a tube.

The printed-circuit board enables the LDR and the LEDs to be connected in two ways, allowing you to determine where the respective component terminals exit from the optocoupler assembly.

The heat-sinks of T4 and IC2 need not be large — in most cases, two pieces of aluminium of an area of about 15 mm^2 will do. Make sure that the heat-sinks do not touch. Alternatively, IC2 and T4 may be mounted on a common heat-sink, provided both components are fitted with insulating washers.

The power supply is housed in a metal enclosure Type LC850 from Telet. The dimensions of the blue-and-grey self-adhesive front-panel foil for the supply (Fig. 6) are geared to this type of enclosure..

The two toroid transformers stated in the components list have two 15-V secondary windings, which must be connected in series to obtain the required 30 V.

The power supply has only one adjustment. Connect an a.c. voltmeter to the supply and set an output voltage of 25 V. Next, adjust P1 until the moving-coil meter indicates the same value. ■

CORRECTIONS

6-metre band converter

April 1991, p. 38-43

The components list and the inductor overview in the top left hand corner of the circuit diagram should be corrected to read:

L1, L2 = 301KN0800.

Capacitor C16 (4.7 pF) must not be fitted on the board.

Finally, a few constructional tips:

- Fit a 10 nF ceramic decoupling capacitor at junction L7-R36.
- Fit a 18 kΩ resistor between the base of T3 and ground. This reduces the Q factor of L2, and prevents too high signal levels at the base of T3.
- For improved tuning, inductor L9 may be replaced by a Toko Type 113KN2K1026HM.

Multifunction measurement card for PCs

January and February 1991

We understand that the 79L08 (IC17) is no longer manufactured and, therefore, difficult to obtain. Here, the IC may be replaced by a 7908, which, although physically larger than the 79L08, is pin-compatible, and should fit on the PCB.

Dimmer for halogen lights

April 1991, p. 54-58

In the circuit diagram of the transmitter, Fig. 2, pin 14 of the MV500 should be shown connected to pin 13, not to junction R1-R2-C2. The relevant printed-circuit board (Fig. 6) is all right.

RDS decoder

February 1991, p. 59

Line A0 between the 80C32 control board and the LC display is not used to reset the display, but to select between registers and data.

We understand that the SAF7579T and the associated 4.332 MHz quartz crystal are difficult to obtain through Philips Components distributors. These parts are available from C-I Electronics, P.O. Box 22089, 6360 AB Nuth, Holland. For prices and ordering information see C-I's advertisement on page 6 of the May 1991 issue.

S-VHS-to-RGB converter

October 1990, p. 35-40

Relays Re1 and Re2 must be types with a coil voltage of 5 V, not 12 V as indicated in the components list. Constructors who have already used 12-V relays may connect the coils in parallel rather than in series.

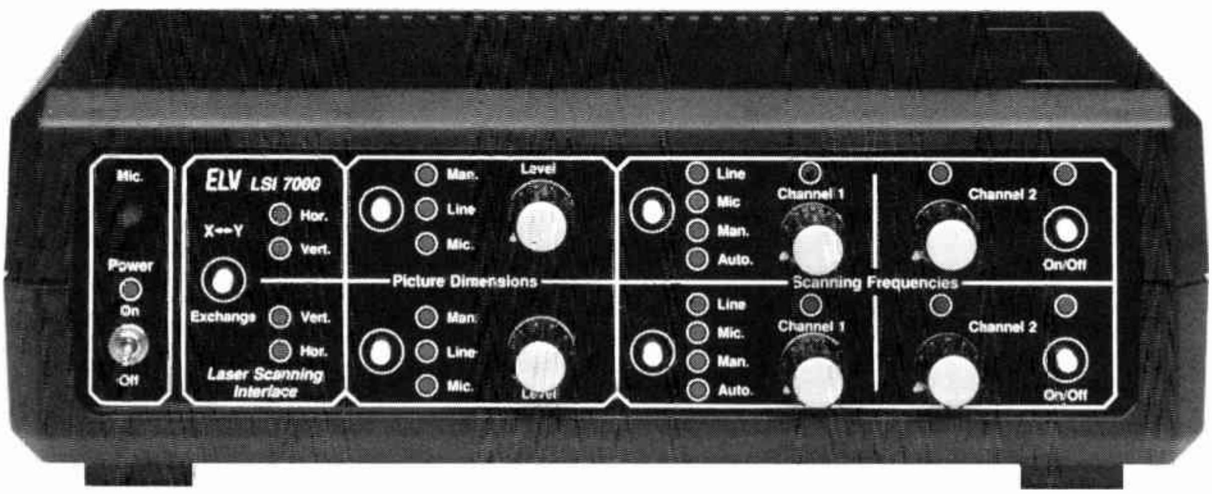
Suitable 5-V relays for this project are the 3573-1231.051 from Günther, and the V23100-V4305-C000 from Siemens.

The components list should me modified to read:

6 33nF C57-C62

LASER

PART 2: CONTROL UNIT LSI7000 (CIRCUIT DESCRIPTIONS)



Following last month's description of the laser exciter and the mirror galvanometer assembly we now turn to a state-of-the art electronic control unit for the show laser.

Continued from the May 1991 issue.

The laser control unit described here is a fairly complex design capable of producing attractive laser patterns. The complete control unit contains some 250 resistors, 100 capacitors and 40 integrated circuits. Fortunately, the assembly of the kit is pretty easy, although it will require several hours of careful soldering work. More about this next month, though, as the present instalment deals mainly with circuit descriptions.

Pretty sine-waves

Many of you will be familiar with Lissajous patterns on an oscilloscope. Being rather static, Lissajous patterns would appear to be less suitable as show effects for a laser as discussed here. Bear in mind, however, that an oscilloscope produces such patterns when fed with two fixed signals only. A first step towards the creation of moving Lissajous patterns is simply to replace one of the fixed signals by a music signal (or, more generally, an audio signal). The result is a pretty erratic type of pattern on the scope. Some static patterns can be interesting, too, and are simple to produce by increasing the number of sine-waves. The present laser control unit supplies four sine-waves that allow a wide variety of patterns to be created.

The block diagram in Fig. 8 is fairly complex, and indicative of the number of components used to build the laser control unit. The output of the circuit is formed by two 1-watt a.f. power stages that drive the coils in the mirror galvanometers. An electronic double-pole changeover switch fitted ahead of the power output stages allows you to swap the drive signals produced by the two audio interface channels, left and right.

Since the right and left channels are virtually identical, the circuit description will refer to one channel only, in this case, the left one. The input signals for the power output stages are supplied by an electronic potentiometer that allows you to control, independently, the signal frequency (i.e., the shape of the pattern) and the signal amplitude (i.e., the size of the pattern).

There are three sources for the amplitude control signal, which is selected via electronic switches. When the constant voltage source is selected, you can control the size of the pattern via the LEVEL potentiometer. The level information is obtained from an envelope detector when the LINE, LS (loudspeaker) or microphone signal is selected. The LEVEL potentiometer then enables you to set the maximum pattern size reached at a certain level of the input signal.

The LINE, LS and microphone signals may be used to create the laser patterns. In addition to these sources, two sine-wave generators are available of which the output frequency can be set manually as well as by means of a timer circuit. Before these signals are applied to the electronic potentiometer, they are taken through a frequency compensation circuit that serves to correct the frequency response of the mirror galvanometers. Additionally, the audio signals are taken through a 150-Hz low-pass filter that suppresses signal components that can not be reproduced anyway.

The audio signal may be supplied by the microphone contained in the laser control unit. This microphone is used to drive both channels via a compressor circuit that ensures a fairly constant drive level. The same goes for the LINE and LS signals, which are also taken through a compressor. The difference between the LINE and the LS input is mainly the required signal level. The LINE inputs accept relatively small signals (line level), while the LS inputs can be driven with higher voltages as supplied, for instance, by the loudspeaker output of an a.f. power amplifier.

Two sine-wave generators are available on each channel of the laser control unit. A switch, marked CHANNEL 2 ON/OFF, is used to select one sine-wave or the sum signal of two sine-waves. The frequency of these is determined by applying a control voltage to the generators. The control voltages can be set manually or by means of a generator that supplies a slow triangular voltage. The

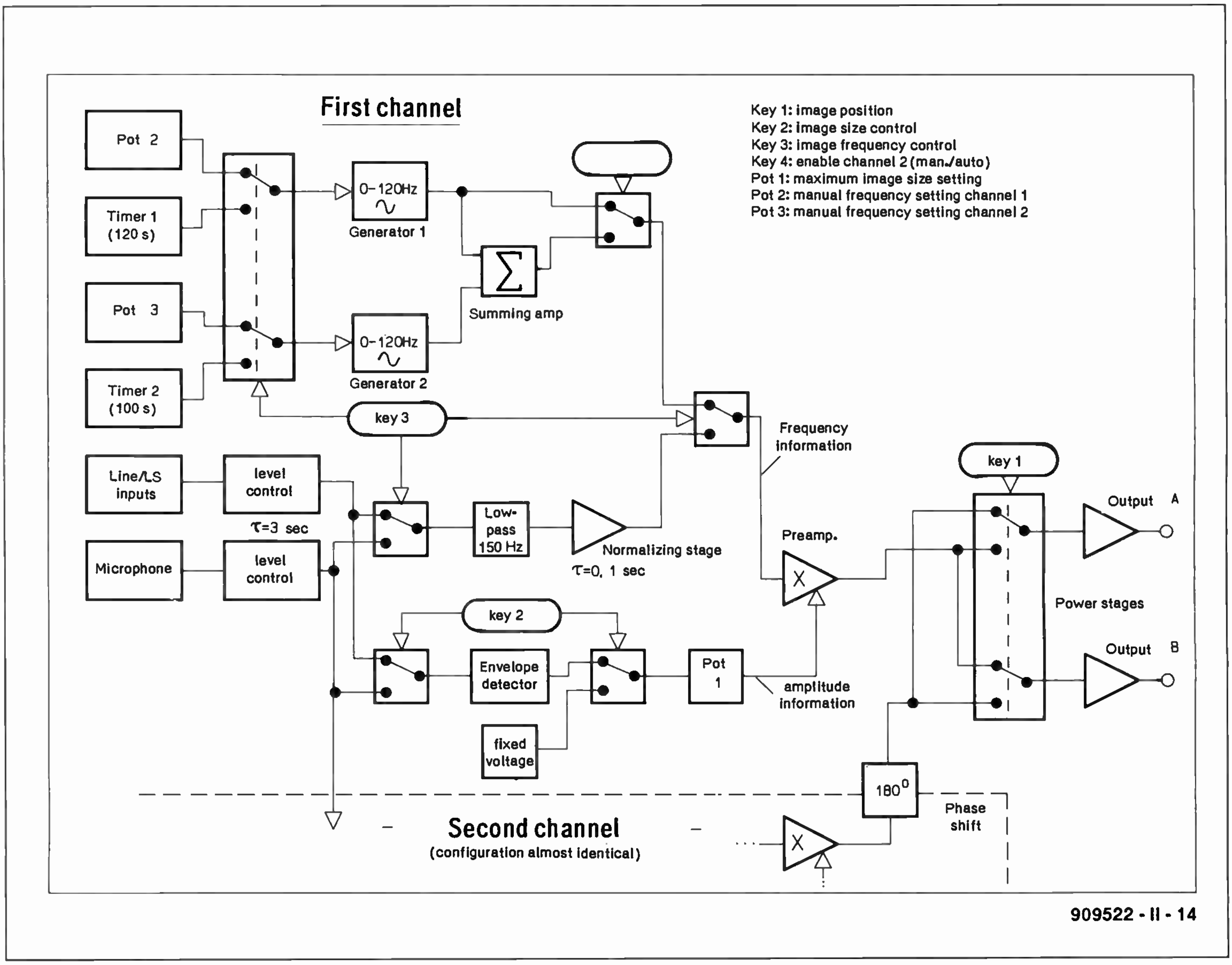


Fig. 8. **Block diagram of the laser control unit.**

period time of the triangle is about 100 s, but the actual value is slightly different for each of the four generators in the control unit. The differences are such that it takes more than 24 hours (theoretically) before the same pattern is repeated.

Circuit diagram

The circuit diagram, Fig. 9, of the laser control unit follows the block diagram quite closely. For the sake of simplicity a few blocks are drawn in Fig. 2 that contain circuits discussed in detail further on.

The LINE and LS signals are applied to the circuit via sockets Bu1 to Bu4, which are connected via a potential divider for the right and left channel. This means that the LS socket and the LINE socket next to it can not be used simultaneously. Fortunately, the high impedance of the potential divider prevents damage to equipment when the LS and LINE inputs are accidentally used at the same time. The input signals are first fed to a compressor, whose operation is discussed further on.

The microphone is a small electret type with a built-in FET amplifier. It is connected to terminals ST1, ST2 and ST3. The microphone signal is amplified by IC1 before it is applied to the compressor. The three compressors are followed by the input selection switches that enable the signals to be routed in one of two directions: to the frequency-determining circuits, or to the amplitude-determining circuits.

In the frequency-determining branch, the signal is first applied to a 150-Hz filter set up around T1 (T3 for the right channel). Then follows another switch, this time for the selection between the audio source and the generator. After the frequency compensation the signal arrives at electronic potentiometer IC4.

In the amplitude-determining branch the audio signal is fed to T2 and T4, which form an envelope detector. The switch contact that follows the detector allows the size of the patterns to be controlled manually or by the envelope waveform of the audio signal. The latter function requires a constant voltage, which is obtained from a regulated supply voltage with the aid of a potential divider. The amplitude control signal is subsequently amplified to allow the final size of the laser pattern to be set by the LEVEL control, R26-R40. Next, the level information is applied to the control inputs of an electronic potentiometer, IC4. The output signal of IC4 is buffered by IC2b and IC3b before it arrives at the switch contacts that allow you to determine the channel assignment (left/right; L/R) for the horizonal and vertical (H/V) deflection of the laser beam. From the poles of the H/V-L/R switches the signal is taken to the inputs of the two power amplifiers that drive the mirror galvanometers.

The generators

There are two almost identical generators in the laser control unit. The difference between them is the value of a single resistor. Figure 10 shows the circuit diagram of the generator for the left channel. All components are numbered from 100 onwards. For the right channel, the corresponding components are identified as 2xx. Note, however, that resistor R62 in the left channel appears as R64 in the right channel.

The heart of the generator is formed by two integrated circuits Type XR2206, a well-known function generator from Exar. The frequency of the output sine-wave produced by the generator is determined by a control voltage obtained either from potentiometer R141-R147 via an amplifier, or from a generator.

The circuit for the automatic frequency control of the sine-wave generator may look

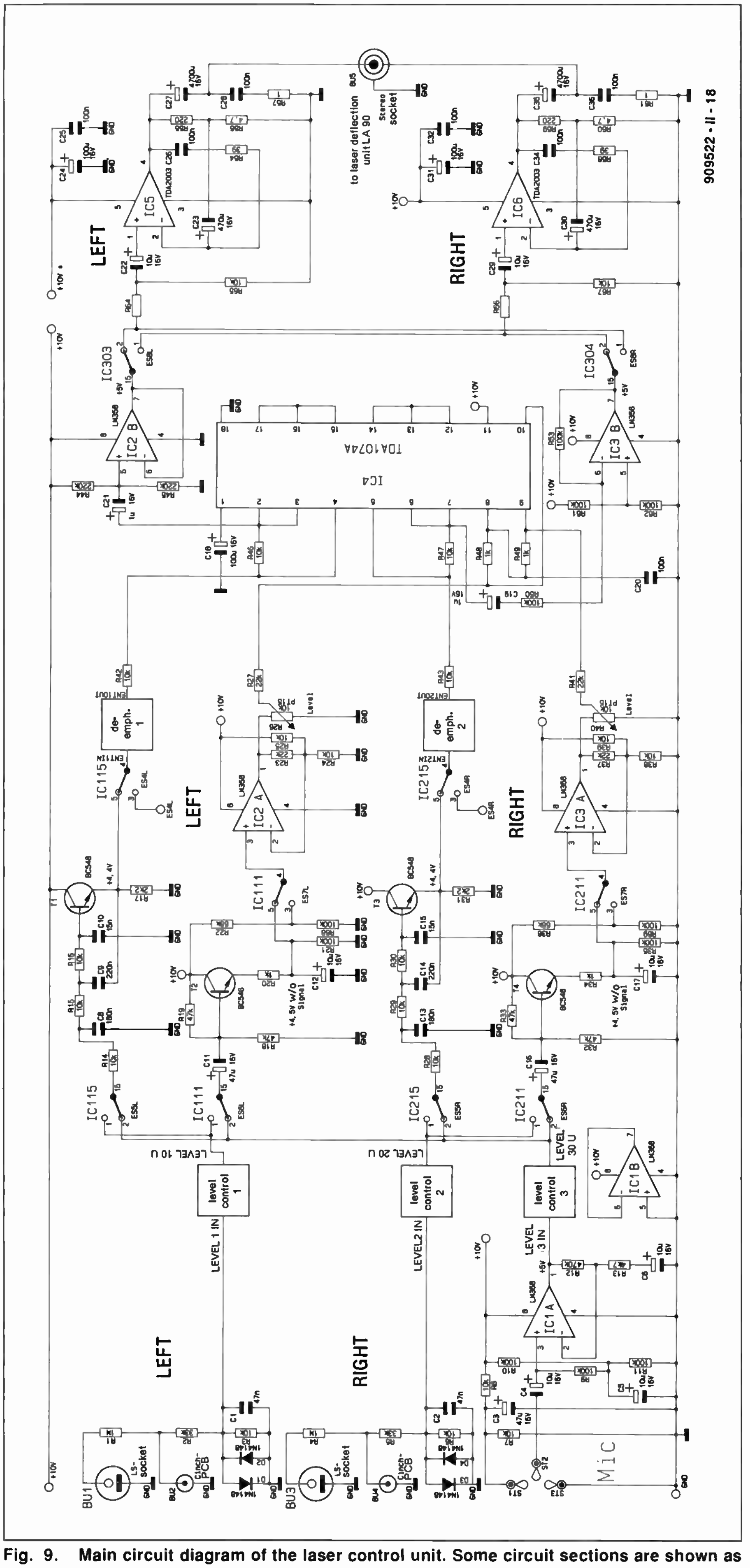


Fig. 9. Main circuit diagram of the laser control unit. Some circuit sections are shown as modules here.

unusual at a first glance. Fortunately, it operates in a rather simple way. Opamps IC103a and IC103b form two Schmitt-triggers set up as square-wave generators. Concentrating on IC103a for the moment, we see that the opamp is wired to function as a Schmitt-trigger by means of resistors R137, R138 and R139. The Schmitt-trigger is turned into a square-wave generator by components R140 and C119. A square wave is, however, not what we are after if we want the sine-wave generator to produce a continuous frequency range. Fortunately, the capacitor, C119, has on it a triangular waveform that does allow a true, linear, VCO (voltage-controlled oscillator) function to be realized. The capacitor voltage, which is a triangular waveform with a period time of about 100 s, is buffered by opamps IC103c and IC103d. Note that the period time is chosen slightly differently for the other generator. This is done to prevent the laser repeating the same pattern after 100 s when the 'automatic' mode is used. The differently set period times ensure that it takes at least 24 hours before a pattern is repeated (this is based on the assumption that component tolerances have no effect).

The generator circuit is followed by a summing amplifier, IC107, that serves to add the two sine-waves. Electronic switch IC115 allows you to select either the output signal of IC105 only, or the mixed output of the two sine-wave generators.

The compressor

The circuit diagram of the compressor is shown in Fig. 11. The component numbers refer to the left channel — the circuit of the right channel compressor is identical, with component numbers in the '200' range. The component numbers in the microphone compressor start at 300.

Opamp IC101b supplies a stable and adequately decoupled reference voltage to the circuit. The a.f. input signal is applied to the compressor via capacitor C101. Opamp IC101a forms an amplifier whose gain is determined by FET T101, which functions as a voltage-controlled resistance. The output signal level of IC101a is monitored with the aid of a further opamp, IC101d, whose output is connected to a rectifier, D101-D102-C104. To close the a.f. level control loop in the compressor, the direct voltage supplied by the rectifier is fed to the gate of FET T101. The gate voltage determines the a.c. resistance of the drain-source junction, and thus the gain of IC101a. The compressor has an inverse level control characteristic, which means that its gain is reduced as the input signal level increases. In this manner, the compressor ensures that the mirror driver circuits are provided with a reasonably constant input signal.

Frequency compensation

As discussed last month, the deflection of the mirror galvanometers is frequency dependent, i.e., not linear. To linearize the response, a frequency compensation circuit is used —

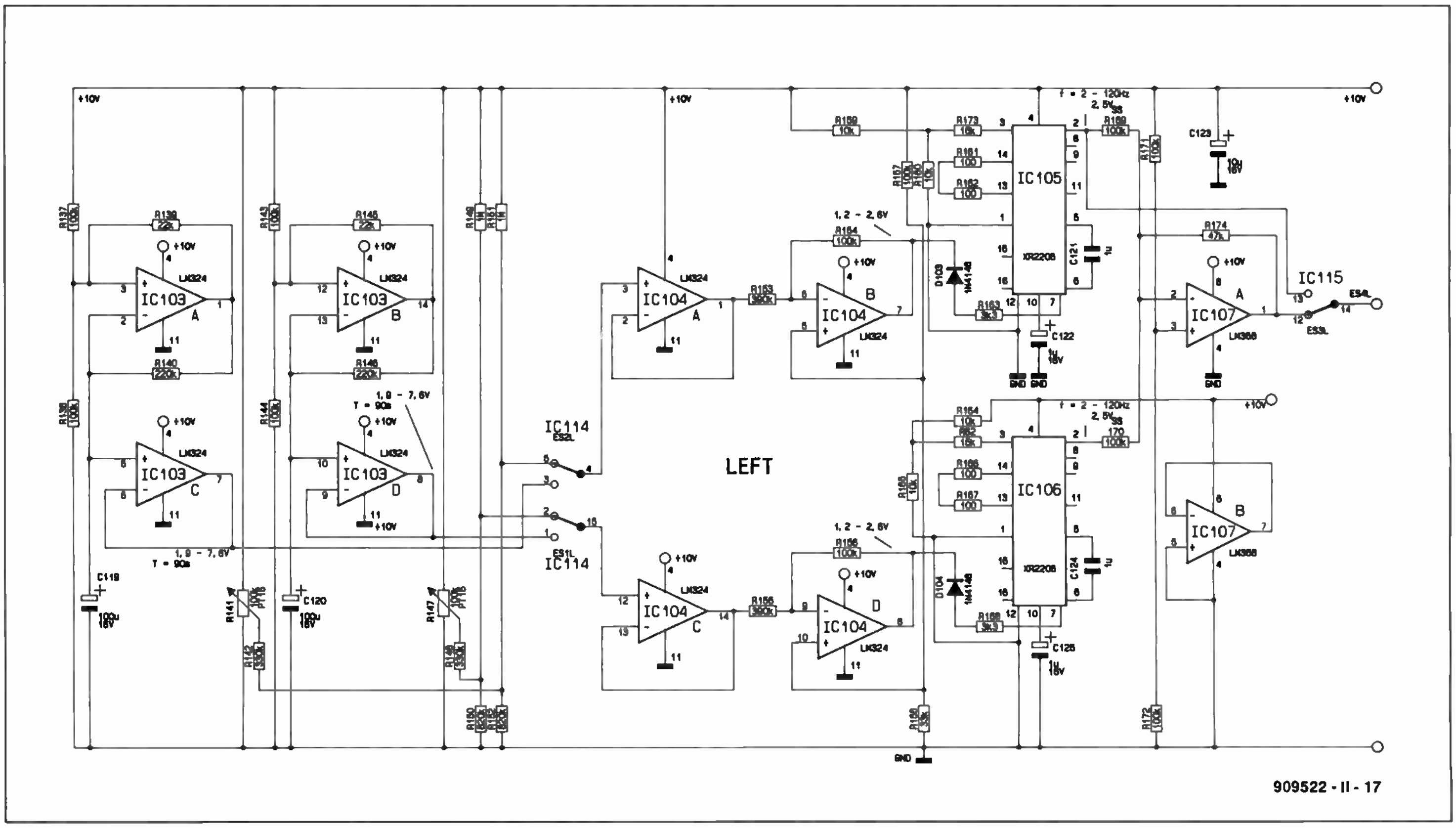


Fig. 10. Generator circuit for the left channel. The right channel is identical, with part numbers in the 200 range.

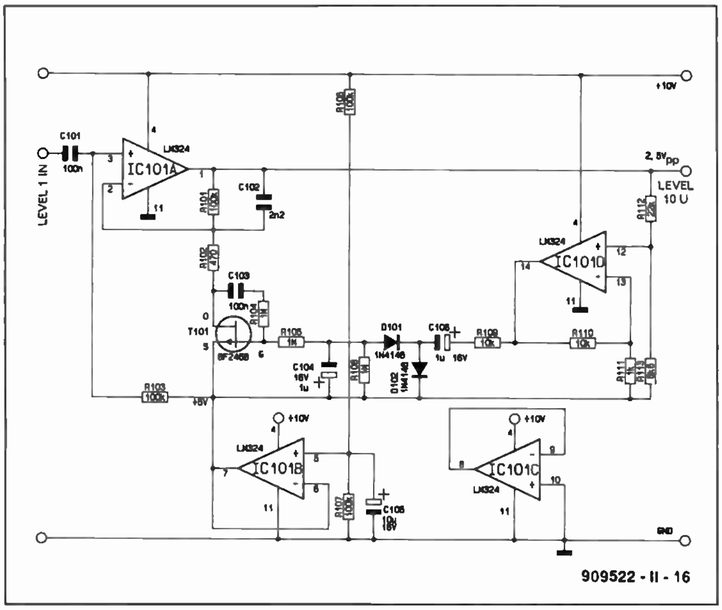


Fig. 11. Compressor circuit (left channel). The component numbers for the (identical) right channel are in the 200 range, and those for the microphone channel in the 300 range.

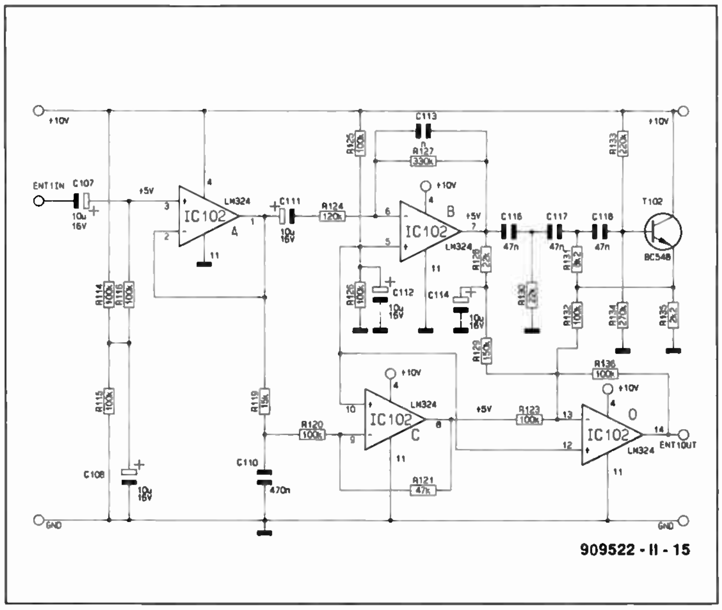


Fig. 12. Frequency compensation circuit for the mirror galvanometer driver in the left channel. A number of filters are used to linearize the frequency response of the mirror over a small range.

see Fig. 12. The circuit starts with a buffer, IC102a, and ends with a summing amplifier, IC102d. The latter adds the signals supplied by a number of filter sections in the circuit via resistors R123, R129 and R132. A filter based on T102 provides a rising filter slope from 50 Hz onwards. The falling slope of the filter response is set to start at about 200 Hz with the aid of R127 and C113. Returning to the low end of the filter response, components R119-C110 create a falling slope from 15 Hz onwards, i.e., before the rising part which starts at 50 Hz. The last filter section, R128-C114, serves to correct the filter response for frequencies below 15 Hz.

The result of all this filtering and summing is a virtually linear response of the mirror galvanometers, i.e., their deflection is independent of the signal frequency when the signal level is held constant.

Next time

The above descriptions cover most of the operation of the laser and the associated control unit. In next month's final instalment we will complete the description by discussing the way in which the electronic switches are controlled. The article will be closed with a description of the way in which the laser control unit is built and operated. ❑

A complete kit of parts for the laser control unit (LSI7000) is available from the designers' exclusive worldwide distributors:

ELV France
B.P. 40
F-57480 Sierck-les-Bains
FRANCE

Telephone: +33 82837213
Facsimile: +33 82838180

LIGHT SWITCH WITH TV REMOTE CONTROL

Why not use the infra-red remote control, that magic little box supplied with every TV set these days, for applications other than channel hopping and turning the volume up when your favourite pop group appears on the screen? The simple IR receiver discussed here responds to most types of TV remote controls, and can be used to switch lights and other appliances on and off.

J. Ruffell, from an idea by M. Dupessey

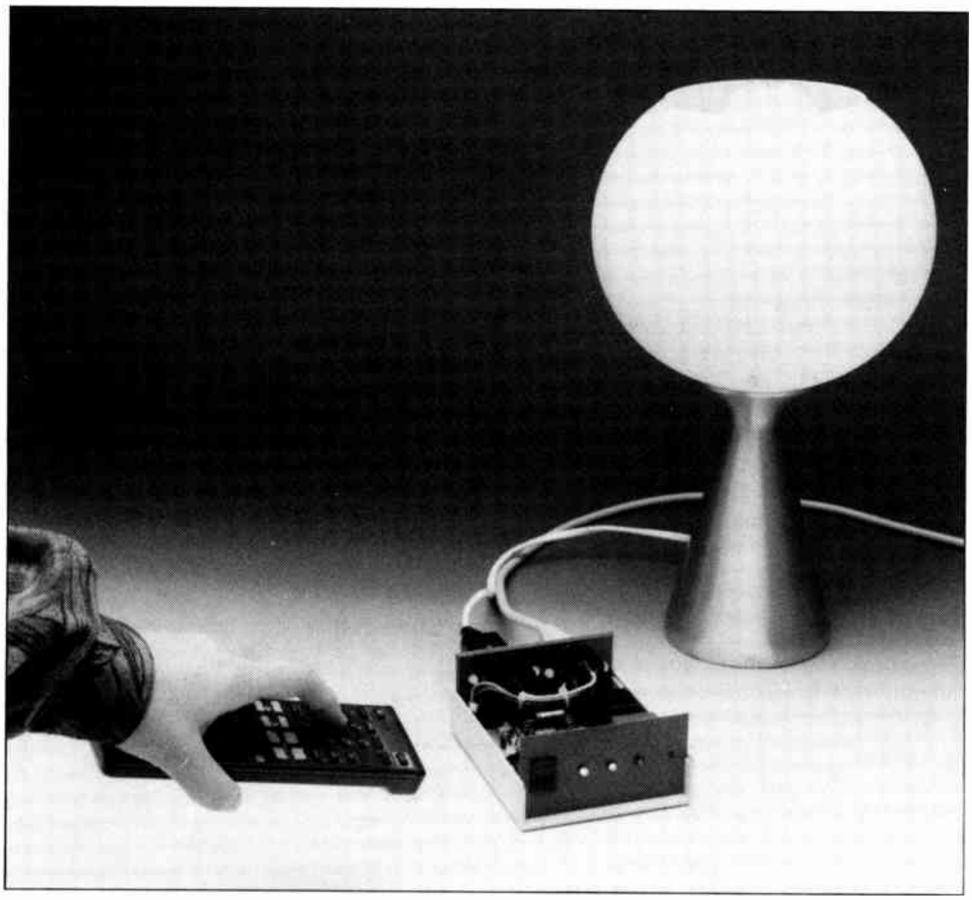
PRACTICALLY all TV sets these days are supplied with an infra-red remote control. Provided they have not been dropped too often, or chewed on by our beloved pets (we mean domestic animals including parrots and budgerigars), these handy little boxes allow us to remain comfortably seated in front of the 'tube' and exercise total control over the channel selection and a plethora of other settings of the TV set.

As shown in this article, it is perfectly possible to use a remote control box for an application not foreseen by the manufacturer. The general idea is illustrated in Fig. 1: here, the IR remote control is used to switch a light on and off. In some cases, it is even possible to switch the TV set on and off as well, although this requires a small change in the receiver. Note, however, that many modern TV sets already have a standby/active function controlled via the IR box.

Single-chip IR receiver

The IR receiver is based on an integrated circuit Type TDE4061 from Siemens. The internal diagram of the chip is given in Fig. 3. The main technical characteristics are:

- Low stand-by current: 650 μA;
- Supply voltage range: 4 V to 6.5 V;
- Frequency range up to 200 kHz
- Available with and without demodulator output (TDE4061/TDE4060);
- No inductor required in external circuit;
- High ambient light rejection;
- Bipolar technology couples good high-frequency behaviour with a low current consumption;
- Suitable for battery supply.



The input of the TDE4061 (see Fig. 3) is connected to an infra-red photodiode, which unfortunately not only 'sees' the signal from the IR remote control box, but also visible light, 100-Hz interference from incandescent bulbs, and a part of the light spectrum emitted by fluorescent tubes.

The input stage is followed by a bandpass filter that serves to extract the IR remote control signals from the interference. The demodulator block drawn in Fig. 3 is not available in the TDE4060.

A current sink circuit is provided to suppress low-frequency currents supplied by the photodiode, and stabilize the bias at the input of the IR preamplifier at 1.4 V. The gain of the preamplifier is automatically controlled to ensure optimum drive of the bandpass filter.

The IFR (infra-red) input of the TDE4061 forms a high impedance, and is suitable for input currents in the nano-ampere range. Hence, the anode of the photodiode is connected direct to the IFR input.

The output of the TDE4061, Q, supplies a demodulated digital signal. An example of an output signal is shown in Fig. 2 for the Aristona (Philips) remote control Type RC4520. Note that the pulse lengths, T1 to T4, shown in the diagram depend on the IR remote control used.

Circuit description

As shown in Fig. 4, very little is required to build an IR receiver based on the TDE4061. In the following description, some points will be noted that may be of interest to those of you who want to use the TDE4061 for their own applications.

The IR photodiode, D3, is a Type BPW41N from Telefunken. It is forward biased via resistor R5, and supplies a photocurrent to the IFR input of the TDE4061.

Capacitor C1 and resistor R5 form a low-pass filter at the IFR input that serves to suppress interference. The capacitor at the CREG input of the TDE4061, C5, determines the time constant of the preamplifier. The value of this capacitor is set to 470 nF to suit the bi-phase-coded signals emitted by most modern IR remote controls. The capacitor must be made smaller when an IR system is used that does not supply run-in signals for the gain control circuit of the receiver. In these cases, C5 may be reduced to about 10 nF. Do not go lower than this value to prevent oscillation.

The capacitor at the Cs input of the TDE4061, C7, gives the preamplifier a high-pass characteristic, and works in conjunction with GREG and the double-T network at the RC1 and RC2 connections of the IC. These components determine the settling behaviour of the TDE4061 following fast signal changes. The Cs capacitor tunes the receiver to the carrier emitted by the IR remote control. Depending on the carrier frequency, C7 is 100 nF (for 30 kHz systems) or 10 nF (for 120 kHz systems).

The bandpass filter that follows the IR preamplifier improves the signal-to-noise ratio of the IR signal and reduces the jitter on the digital output signal. The external double-T *R-C* bandpass filter connected to the RC1 and RC2 pins of the TDE4061 must provide a d.c. path, and have a band-stop (notch) characteristic. The notch frequency, f_c, is made equal to the IR carrier frequency. It is given by

$$f_c = 1/(RC) \qquad \text{[Hz]}$$

where R=R6=R7, and C=C9=C2. Note that R8=R/2, and C8=2C. To keep the voltage drop across the filter within reason, R must not be made larger than 100 kΩ. The values

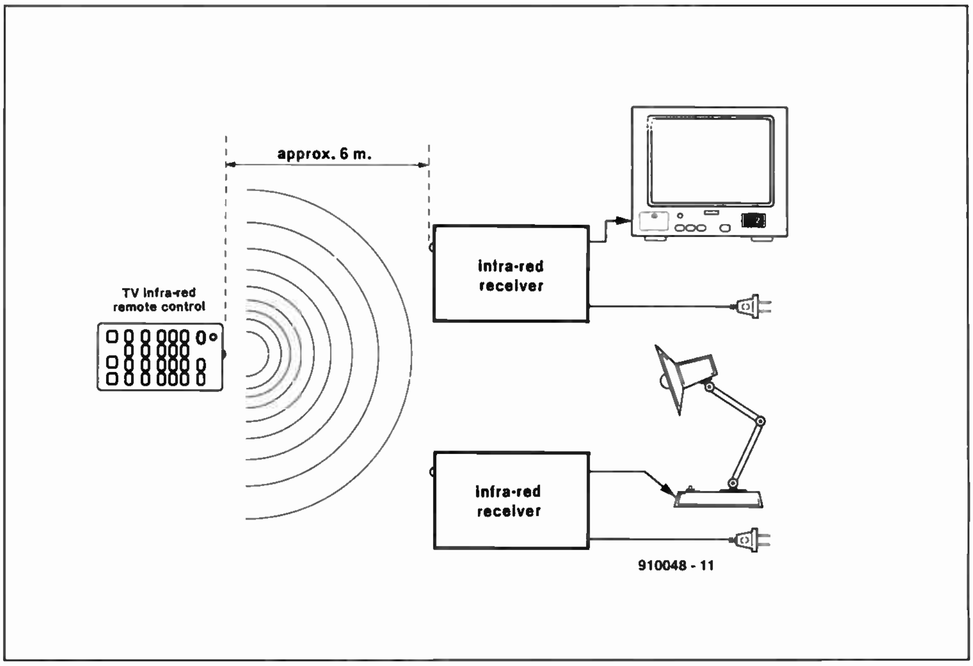


Fig. 1. The remote control supplied with the TV set is used to control a light.

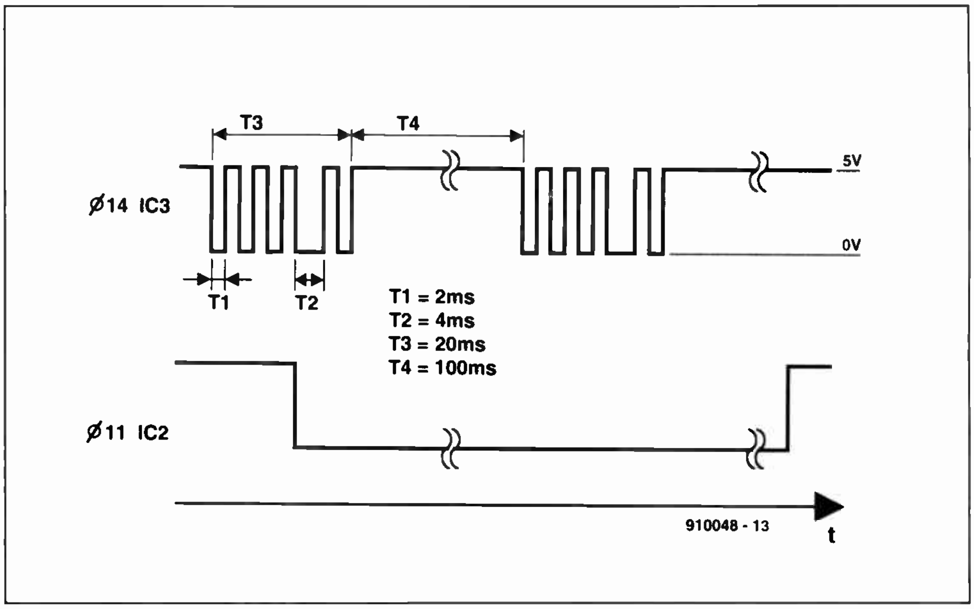


Fig. 2. Response of the TDE4061 to a typical datastream produced by a TV remote control.

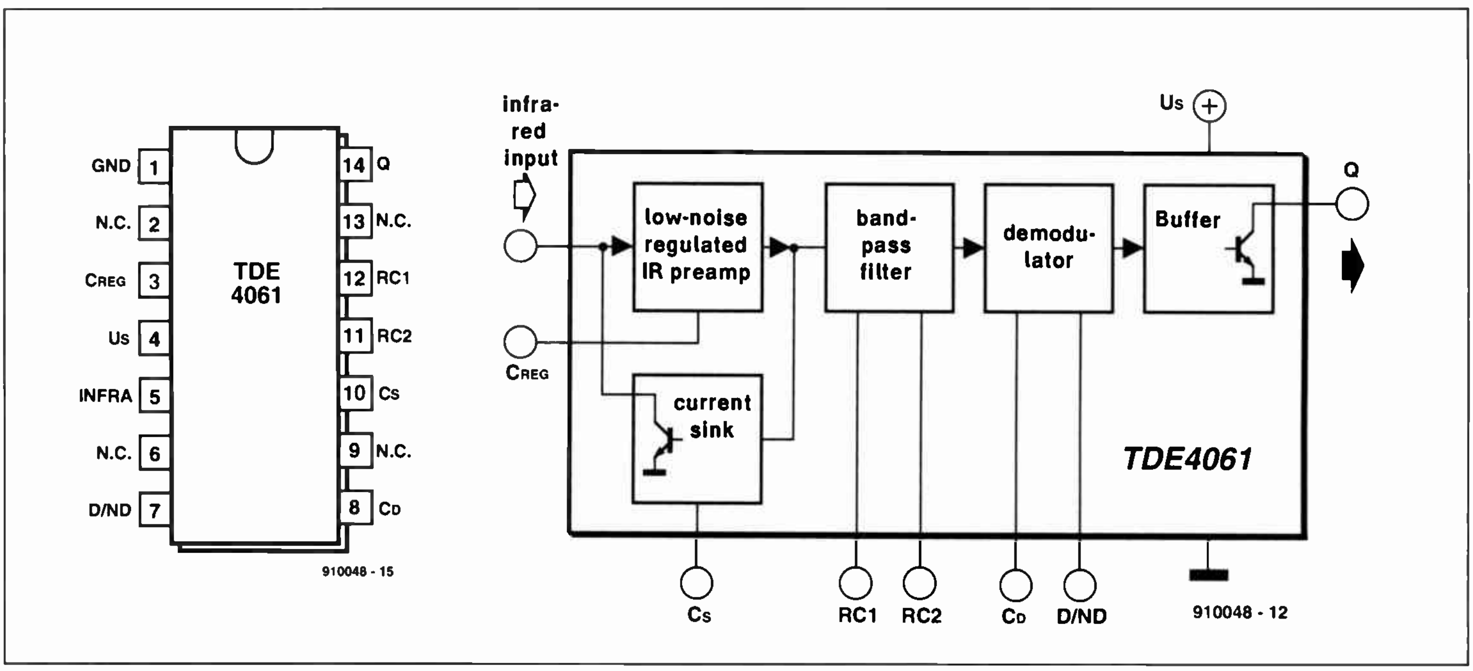


Fig. 3. Functional diagram and pinning of the TDE4061 infra-red receiver IC from Siemens.

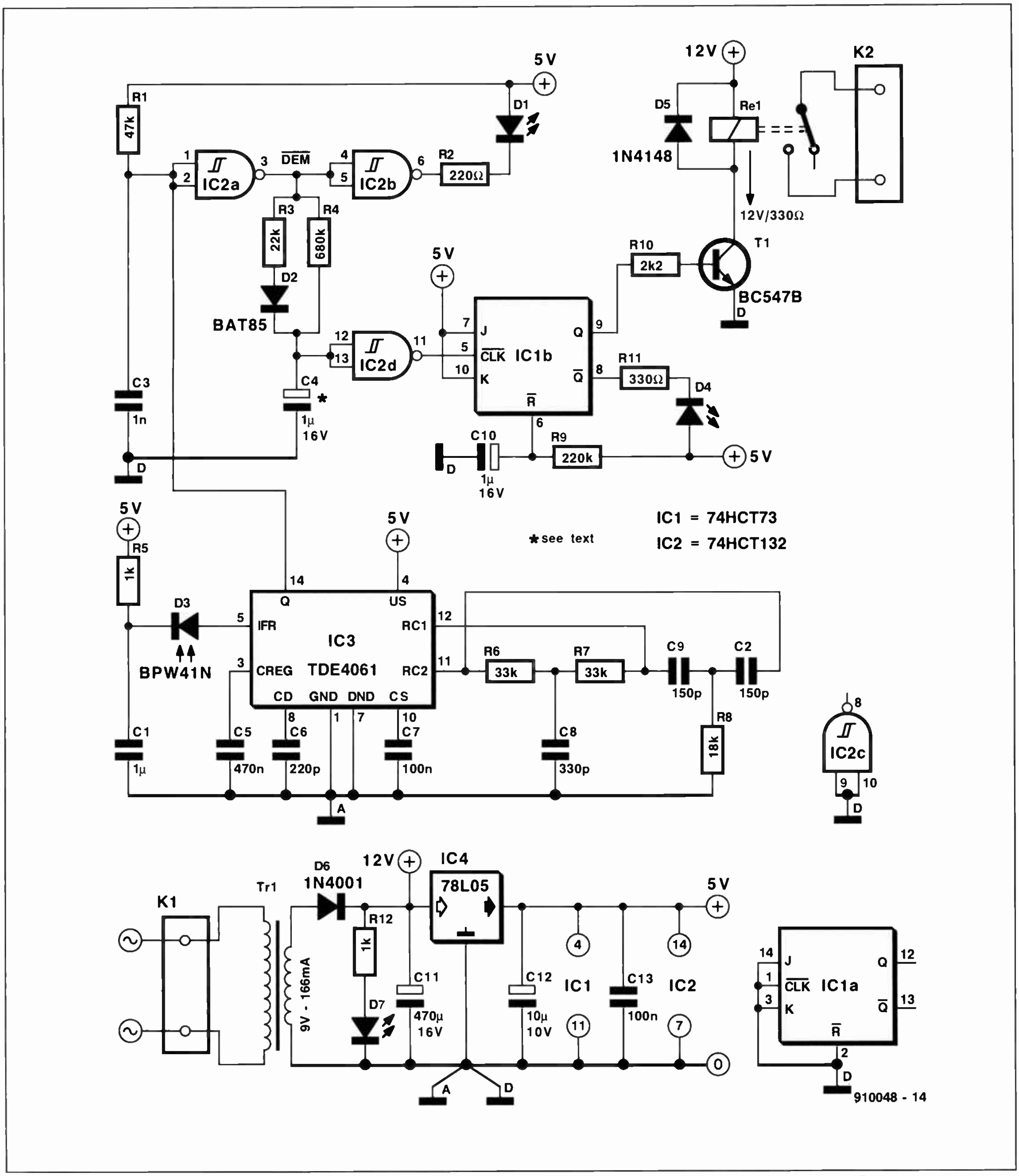


Fig. 4. Circuit diagram of the remote control receiver. The load to be switched is connected to the contact of relay Re1.

of the external filter components may have to be changed experimentally to suit the previously mentioned pulse lengths supplied by the IR remote control.

The output of the TDE4061, Q, is of the open-collector type. When the output transistor is switched on, the maximum collector current is 1 mA. In designs where the output signal is fed back to the input, oscillation may occur if the output current is not kept smaller than about 200 μA. Note that this type of feedback is not applied in the present circuit.

The digital pulse train supplied by the TDE4061 is inverted by a Schmitt-trigger gate, IC2a, and subsequently rectified by D2-C4 to obtain an on/off control signal. Every trailing edge of the switching signal supplied by IC2d causes J-K bistable IC1b to toggle, so that the relay, Re1, is actuated or de-actuated. This creates a simple on/off toggle function.

The load controlled via the IR system is connected to the contact of Re1. LED D1 lights in the rhythm of the pulses when an IR signal is received. When the Q output of IC1b is logic high, transistor T1 conducts, and the relay is actuated. The complementary output, $\overline{Q}$, of the bistable is then low, and LED D4 lights to indicate the relay status.

The response of the receiver to IR control signals is determined by the value of C4. This capacitor effectively turns the pulse train

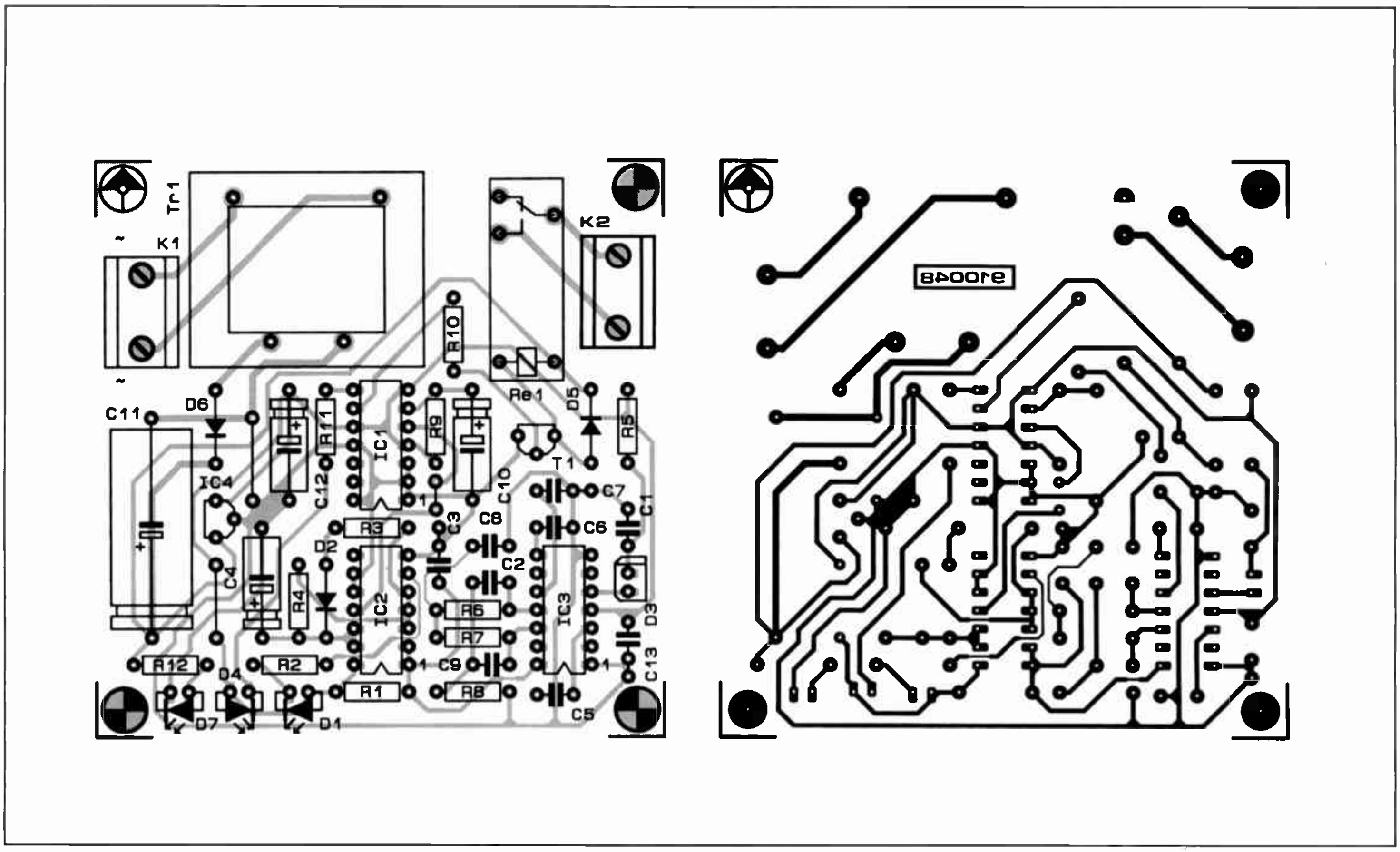


Fig. 5. Single-sided printed circuit board for the IR remote control receiver.

COMPONENTS LIST

Resistors:

1	47kΩ	R1
1	220Ω	R2
1	22kΩ	R3
1	680kΩ	R4
2	1kΩ	R5;R12
2	33kΩ	R6;R7
1	18kΩ	R8
1	220kΩ	R9
1	2k2	R10
1	330Ω	R11

Capacitors:

1	1μF solid	C1
2	150pF	C2;C9
1	1nF	C3
1	1μF 16V (see text)	C4
1	470nF	C5
1	220pF	C6
2	100nF	C7;C13
1	330pF	C8
1	1μF 16V	C10
1	470μF 16V	C11
1	10μF 10V	C12

Semiconductors:

1	green LED dia. 3mm	D1
1	BAT85	D2
1	BPW41N (Telefunken)	D3
1	yellow LED dia. 3mm	D4
1	1N4148	D5
1	1N4001	D6
1	red LED dia. 3mm	D7
1	BC547B	T1
1	74HCT73	IC1
1	74HCT132	IC2
1	TDE4061 (Siemens)	IC3
1	78L05	IC4

Miscellaneous:

1	3-way 5mm pitch PCB terminal block	K1
1	2-way 5mm pitch PCB terminal block	K2
1	12V/330Ω PCB mount relay, e.g., Siemens V23127-B2-A101	Re1
1	9V/166mA PCB-mount mains transformer, e.g., Monarch VTR-1109/IV	Tr1
1	Printed circuit board	910048

into an on/off pulse with a much longer period. This is achieved by a relatively small resistor and a diode, R3-D2, through which the capacitor charges, and a relatively large resistor, R4, through which the capacitor discharges.

The receiver is completed by a standard 5-V regulated supply based on an 78L05, IC4.

Construction

The IR receiver is a compact unit because all components are fitted on a single printed-circuit board, which is shown in Fig. 5. Start the construction by fitting the three wire links on the board. Next, fit the resistors, the diodes, the capacitors, and the active components. Use sockets for the ICs, which are not plugged in until the board is completely assembled.

Complete the construction of the board by mounting the transformer, the relay and the soldering pins. The three LEDs are fitted such that their faces protrude from holes in the plastic enclosure. The infra-red diode, D3, is fitted on the front panel of the case. It is secured such that its light-sensitive area can 'see' the remote control. The light-sensitive area of the BPW41N is located at the centre of the flat front side of the device.

After finishing the construction of the PCB, connect the mains cable to K1, a 3-way PCB mount terminal block of which the centre pin is cut off. Next, connect the load to K2.

To enable you to experiment with different values, the PCB allows capacitors with two different lead spacings to be fitted in positions C3, C7 and C13.

Practical use

With most remote control boxes the usable range of the receiver will be greater than 5 metres. Since the response time of the receiver is relatively short at a few tens of milliseconds, the unit must be installed at some distance from the TV set to prevent it being triggered by control commands intended for the TV set. If you still want to locate the receiver close to the TV set, increase the value of C4 to, say, 47 μF. This results in a much longer response time to remote control commands. ■

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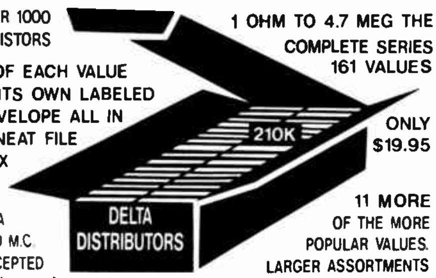

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REAL-TIME CLOCK FOR ATARI ST

The Atari ST is a user-friendly computer supported by a massive amount of excellent software. Unfortunately, early models of the ST lack a clock circuit that keeps ticking when the computer is switched off. The circuit presented here overcomes this problem.

F. Dossche

ALTHOUGH the design of the Atari ST computer is modern by any standard, a real-time clock (RTC) is provided only on the latest models. This is surprising because the main rival of the ST, the IBM PC or compatible, has had an RTC as an option or a standard feature longer than many of you will care to remember. Owing to the absence of an RTC, many Atari ST users are forced to set the date and time, every time the computer is switched on. To help out the thousands of faithful owners of older ST models, we have developed a real-time clock that is inexpensive and simple to build.

One of the most attractive features of the Atari ST is the number of interfaces. One of these interfaces, the printer port, is used here to connect the real-time clock to the computer. We hasten to add that you will be able to use the printer as before, since the RTC is inserted between it and the Centronics port, for which only a very small modification is required.

Up-to-date with the RTC

Of the real-time clock ICs currently available, the MSM5832 from OKI and the MC146818 from Motorola are probably the best known and widest used. The Motorola IC has an advantage over the MSM5832 in offering an 8-bit wide databus, and a 50-byte non-volatile RAM (random access memory). The data retention is achieved with an external rechargeable battery.

Here, the Motorola IC is used, although no use is made of its internal RAM. The 8-bit databus of the RTC chip allows the control software to be kept fairly simple, and in addition affords the possibility to implement further extensions circuits on the Centronics port. The control software for the present project is supplied on disk in the form of a source listing written in C. This program may be used as the basis for further hardware or software functions that you may wish to add. The hardware presented here, and the object code compiled with the aid of the C program, can be used to develop a 'desk accessory' to support the new clock function.

Returning to the hardware, the circuit diagram of the clock extension is shown in Fig. 1. The heart of the circuit is the RTC chip from Motorola. Besides four logic gates and two bistables, the circuit contains a handful of discrete parts used mainly to implement a battery back-up function for the RTC. The two bistables and one I/O line on the computer's main board serve to direct the data on the Centronics bus either to the printer or the real-time clock. In addition, one of the bistables indicates whether the 8-bit word sent to the clock circuit is intended to select an address location, or to be stored as data in the RTC.

The real-time clock sits between the Centronics port on the computer and the Centronics input of the printer. Hence, it has an input an output connector.

At the left in the circuit diagram we find connector K1 which links the circuit to the computer. Two new signals appear on this connector on pins 16 and 17. Pin 16, normally the $\overline{\text{RESET}}$ line, is not used by the Atari ST, and now carries the computer's 5-V supply voltage. Since the $\overline{\text{RESET}}$ signal is active low according to the Centronics standard, placing +5 V on pin 16 has no effect on the printer (anyway, the ST is not capable of issuing a reset via this line).

Pin 17 of K1 is connected to an unused I/O line in the computer, and serves to direct data either to the RTC or to the printer. The I/O line is found on pin 14 of the sound generator IC in the ST, the Yamaha YM-2149. Although not used in the hardware of the ST, this I/O line is supported by the BIOS (basic input/output system), which makes it perfect for the present application. Pin 17 on the Centronics connector is chosen because it is not used on the ST or the printer. Do, however, check that the cable between the computer and the RTC has a wire for the signal on pin 17. In general, most serial cables for

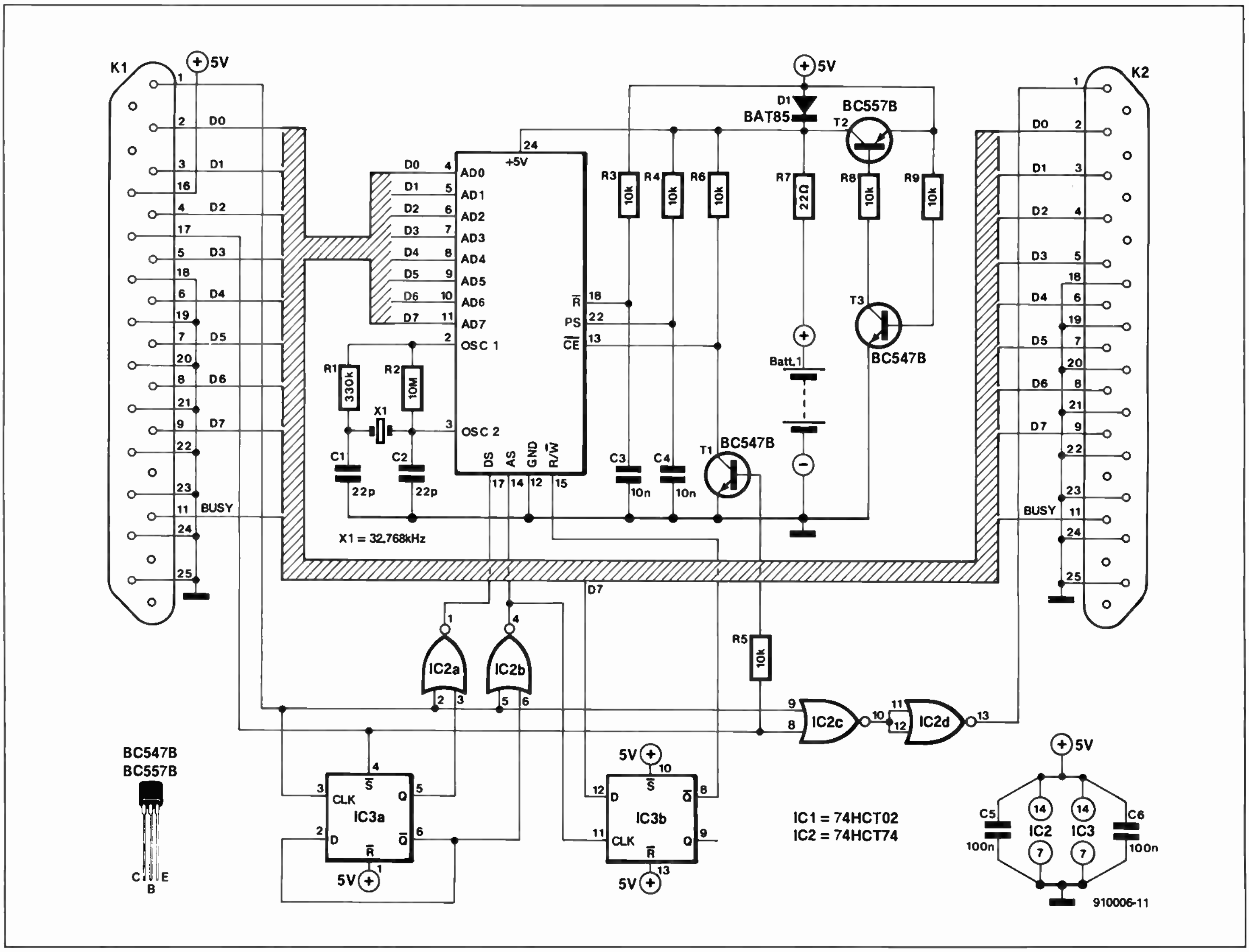


Fig. 1. Circuit diagram of the real-time clock.

PCs have a wire for each of the 25 pins, and will, therefore, meet our requirement. You may also decide to make your own 25-way cable, which has the advantage that it can be made shorter than most ready-made cables. These are usually 1 m or 2 m long, and quite bulky for our application. A home-made cable may be produced by a short length of 25-way ribbon cable terminated in an IDC-style male 25-way D-connector at one end, and a female D-connector at the other end.

Returning to the circuit diagram, the signal at pin 17 of K1 enables bistable IC3a by making the S̄ line logic high. This results in any changes at the set and the reset inputs of IC3a being ignored, so that the bistable remains in the 'set' state because the SET line was active last. Also, the strobe signal for the printer (connected to K2) is blocked by gates IC2c and IC2d, and the enable input of the RTC is actuated via transistor T1. Next, an RTC address is passed to the circuit via the Centronics datalines. The most-significant bit, D7, indicates a read or a write operation to or from the RTC registers.

A pulse on the strobe line (pin 1 of K1) is fed to the AS input of the RTC chip via bistable IC3a and gate IC2b. This pulse is used to transfer an 8-bit word on the Centronics datalines to the RTC, or vice versa, as indicated by the level of databit D7. After the strobe pulse, the inverted level of D7 is applied to the R/W̄ input of IC1. When the next strobe pulse occurs, IC3a toggles because the Q̄ output of this bistable is connected to its D (data-) input. The pulse is subsequently fed to the DS (data strobe) input of IC1 via IC2a. Data may be read before the end of the second strobe pulse. When this is finished, the computer will de-actuate the 'select' line (pin 17 on K1). The printer can then be used again, and the clock operates. The above sequence is used to store the time and date in the RTC, and also to read these back into the computer, allowing the system clock in the ST to copy the RTC information. Gone are the days when you had to set the system clock every time the ST was switched on.

The rest of the circuit is fairly simple. The PCB has two options for charging the battery. The simplest is by means of diode D1. When the ST is switched on, the battery is charged via D1 and R7. The RTC is also powered via the diode. This must be a Schottky type to ensure a low voltage drop. Remember, the charge current can become too small when the computer supply voltage is on the low side, when the battery voltage is on the high side. This is prevented by a diode with a low voltage drop.

If you can not secure the BAT85 or an equivalent Schottky diode, add the circuit based on T2 and T3. When the computer is switched on, T3 starts to conduct and switches on T2. By virtue of the relatively low collector-emitter voltage of T2, the charge current for the battery is sufficiently high. When the computer is switched off, T3 blocks and turns off T2, so that the battery takes over the supply of IC1. Note that the transistor-based supply is an alternative to the single Schottky diode — components T2, T3, R8 and R9 are not fitted if you use a BAT85.

The R̄ĒS̄Ē T̄ and PS inputs of IC1 are taken logic high briefly after the supply is switched on. This ends the low-power standby state of the RTC, and causes it to switch to normal operation.

A quartz crystal, X1, together with C1, C2, R1, R2 and two gates in IC2 form an oscillator that supplies a clock of 32.768 kHz to the RTC. This frequency is used in most battery-powered clocks and electronic wrist-watches.

Construction

The construction of the real-time clock unit will present little difficulty if the printed-circuit board shown in Fig. 2 is used. Start the construction by fitting the wire links and the connectors. Note that K1 is a male type, and K2 a female type. If you swap them acciden-

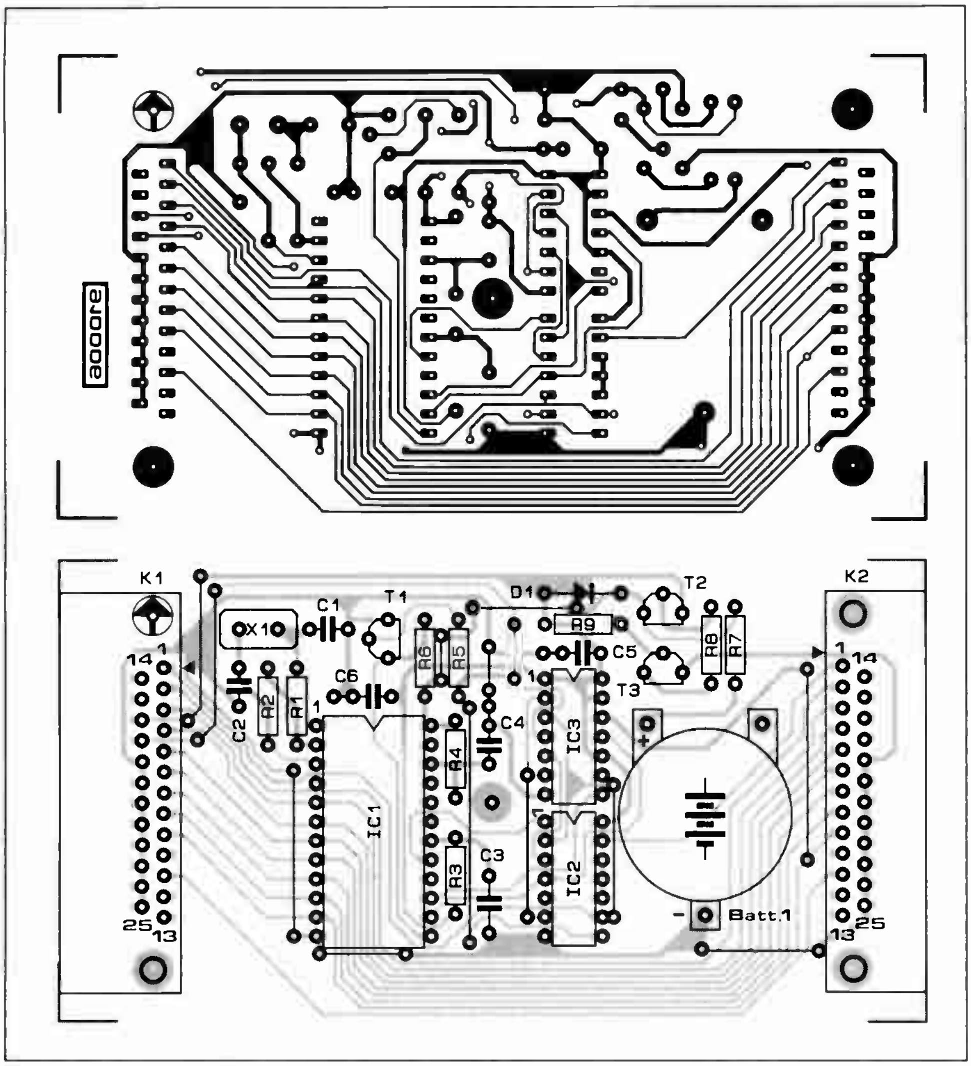


Fig. 2. Single-sided printed circuit board for the real-time clock.

COMPONENTS LIST

Resistors:		
1	330kΩ	R1
1	10MΩ	R2
6	10kΩ	R3-R6;R8;R9
1	22Ω	R7
Capacitors:		
2	22pF	C1;C2
2	10nF	C3;C4
2	100nF	C5;C6
Semiconductors:		
1	BAT85	D1
2	BC547B	T1;T3
1	BC557B	T2
1	MC146818	IC1
1	74HCT02	IC2
1	74HCT74	IC3
Miscellaneous:		
1	25-way male sub-D connector with angled pins, for PCB mounting	K1
1	25-way female sub-D connector with angled pins, for PCB mounting	K2
1	32.768 kHz quartz crystal	X1
1	3.6V NiCd battery	Batt.1
1	ABS enclosure; size approx. 120×70×30mm	
1	Printed circuit board	910006
1	Diskette with control software	ESS1621

tally, you will be unable to connect the circuit properly to the input and output cables.

Proceed with fitting the remaining parts on the board. IC sockets are not strictly required. If you do decide to use them, be sure to buy good quality types.

The completed printed circuit board fits into an ABS enclosure of dimensions 120×70×30 mm. The side panels of the enclosure are cut to allow the connectors to protrude.

A small modification is required in the computer before the RTC can be connected. Although the 'operation' is really no more than soldering two wires, it may still take you an hour or so to complete because the computer has to be disassembled. After removing the floppy disk drive and the switching power supply module, you should be able to see the printer connector and the Yamaha chip. Take the main board out of the enclosure, and remove the metal screen at both sides. This means that you have to bend a couple of small metal brackets with the aid of tweezers. After turning the main PCB, you should have access to the sound generator connections. Run a wire from pin 14 of the Yamaha chip to pin 16 of the printer connector, and another wire from pin 40 of the Yamaha chip (+5 V) to pin 17 of the printer connector. This completes the modification. Re-assemble the computer.

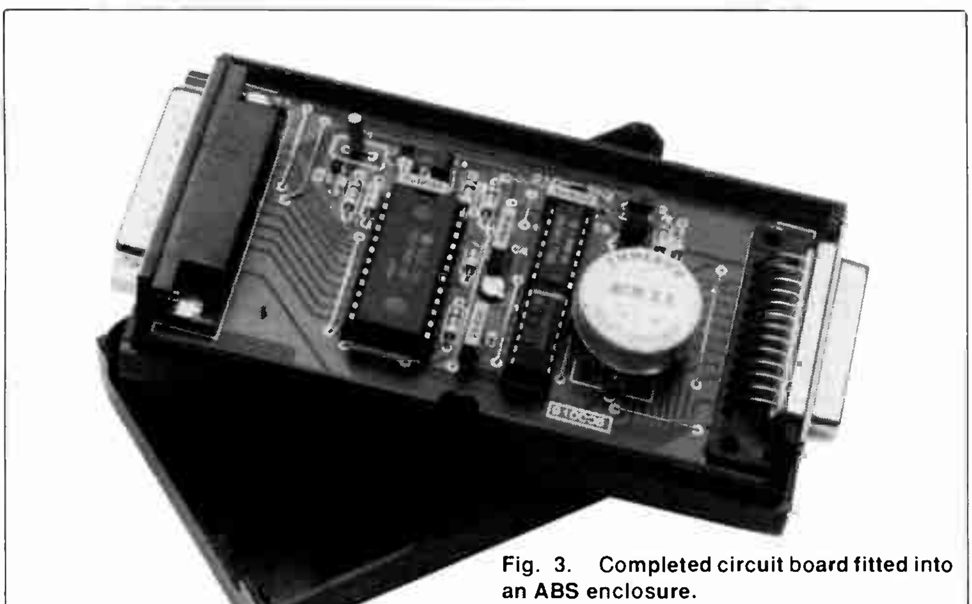


Fig. 3. Completed circuit board fitted into an ABS enclosure.

Software

As usual, hardware is never complete without the appropriate software. The clock unit described here is supported by a control program on disk, which may be ordered through our Readers Services. The disk contains the ready-to-go desk accessory for the clock, as well as the source listing used to compile the machine code. As already mentioned, this listing is intended for those of you who want extra features for the clock, such as a programmable alarm. You may also want to use the 50-byte non-volatile RAM area in the RTC chip.

The source code can be converted into a control program with the aid of, for example, the Mark-Williams C compiler. This is not strictly required, though, since you can simply copy the control program on the floppy disk (supplied by us) to your system disk. Every time the computer is switched on, the program will automatically copy the RTC data to the system clock. Now, is that up-to-date or not? ■

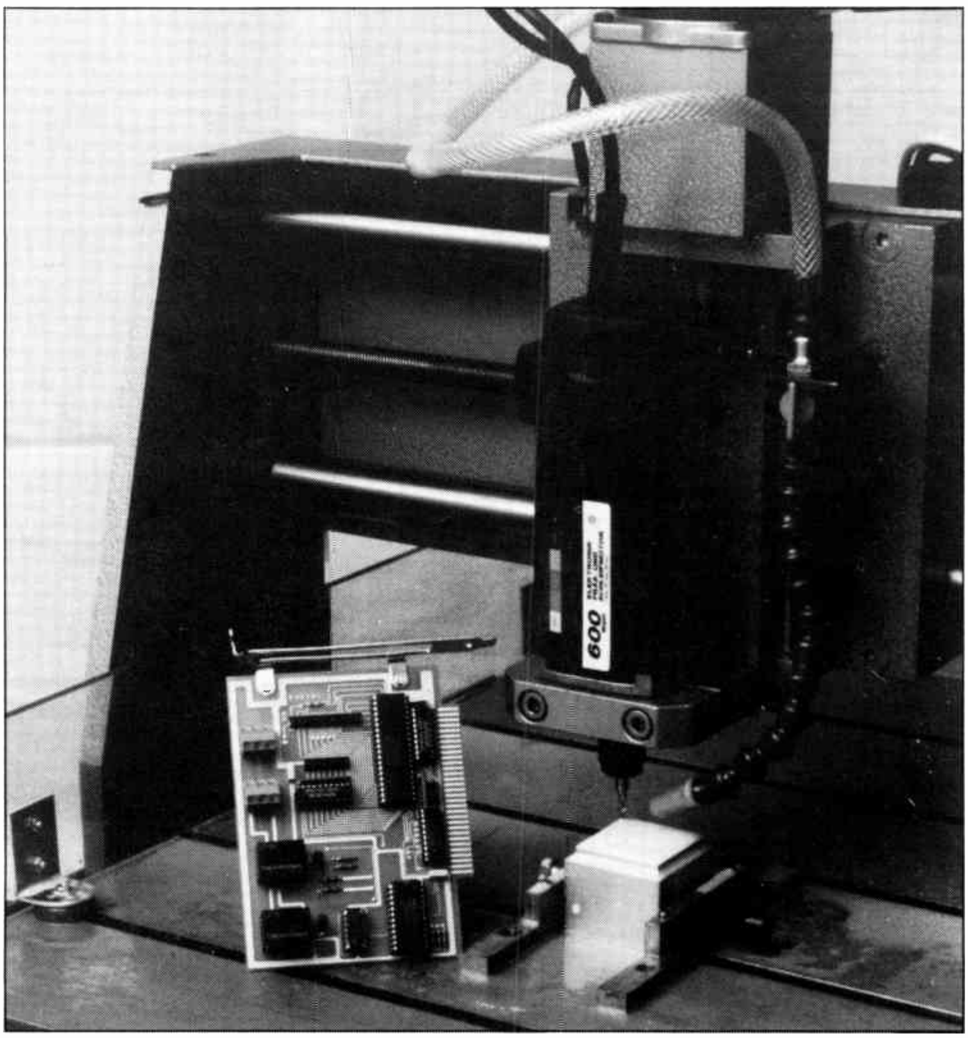
STEPPER MOTOR BOARD

PART 1: PC INSERTION CARD AND CONTROL SOFTWARE

Getting a stepper motor to work properly invariably seems to require either a lot of discrete electronics, or an expensive dedicated integrated circuit. However, since the actual commands for stepper motors are almost always supplied by a computer, it is a challenging idea to economize on the hardware, and have the software do the work.

H. Kolter

STEPPER motor controls are available in many shapes and sizes, ranging from complex to ultra-simple, and based on a variety of integrated circuits, including the MC3479, the L297/298 and the TDA1024, all of which have been used in projects described in this magazine. By contrast, the control described here is not based on any of these ICs. None the less, it is versatile, simple to build and relatively cheap.



The circuit described has evolved as part of a PC-controlled professional milling machine that accepts CNC-format data to the Gerber standard. CNC stands for computer numerical control.

The concept

The above application was aimed at developing a complete milling machine for very accurate processing of aluminium, steel and plastic workpieces. When the project was initiated, there was the choice between (1) 'intelligent' motor control with relatively simple control software, and (2) a simpler controller with powerful, complex, software. To ensure the best possible results in regard of speed and accuracy of the system, the first option requires the motor control to be geared accurately to the specific features of the milling machine.

The second option has the advantage that changes to the machine, or extensions, are easier to support with appropriate software extensions. Since the electronics and the milling machine were developed roughly at the same time, the choice of the stepper motor control was clearly in favour of the second option: simple hardware and complex software.

In practice, the computing power required for the system can only be provided by a PC-AT or a compatible machine with a clock speed of at least 16 MHz. The computer program consists of an interpreter that reads drill and fraise data produced to the Gerber standard, and converts these into stepper motor commands.

The interpreter uses a configuration file that contains various system parameters such as the type of stepper motor (bipolar or unipolar, rotation per step, maximum step rate, etc.), and the main properties of the milling machine (spindle pitch, number of idle steps on spindle reversal, etc.). These parameters can be changed easily and allow the control system to be rapidly 'customized' for a particular application.

In line with the different functions, the electronics are divided into two parts. One part is an insertion card for IBM PCs, the other a larger board, which is fitted external to the PC, and contains the power drivers.

The PC insertion card described here is basically a digital I/O card based on the familiar 8255 PPI (programmable peripheral interface) from Intel. The 'half-size' insertion card offers 24 input/output lines, and has an additional timer/counter IC Type 8253, a quartz oscillator and two relays. The quartz oscillator makes the timing of the I/O card independent of the computer speed. The two relays have changeover contacts and are suitable for switching mains loads.

The power driver board (to be described in part 2 of this article) has a fairly large power supply and 16 optocouplers that afford electrical isolation between the computer and the stepper motors. TTL buffers are provided between the optocouplers and the 16 power drivers. These buffers are also used to drive a LED-based readout that signals the active status of all stepper motor windings. The readout will be found particularly useful when a machine is first connected, or during program debugging.

Circuit description

The PC interface shown in Fig. 1 is a more or less standard design based on the 8255 PPI. Apart from the data and address signals, the extension card uses a few control signals on the IBM slot, $\overline{\text{IOWR}}$ which indicates write activity in the I/O memory area, $\overline{\text{IORD}}$ which has the same function form read operations, and, of course, RESET. The extension card is powered by the computer via the extension bus.

The datalines are buffered with a 74LS245 octal bidirectional driver. The buffered datalines are connected to the PPI (the 8255) and the PIT (programmable Interface Timer/counter; the 8253). A single PAL (programmable array logic), IC3, handles all address decoding. It uses address line A3 through A9 and the $\overline{\text{IORD}}$ and $\overline{\text{IOWR}}$ signals to generate chip select signals CS0, CS1, CS2 and CS3, and in addition the enable signal and the direction control signal for the databus buffer, IC2.

The I/O lines of ports A and B of IC1 are available on a double row PCB pin header, K2. Port C is connected to the outputs of the programmable timer, IC5. Connections PC4 and PC5 switch the two relays via darlington transistors T1-T2. In most cases, a value of 1 kΩ will be adequate for R5 and R6. These resistors may need to be made smaller, however, when the relays do not come on reliably. The minimum value of R5 and R6 is 330 Ω.

PPI line PC3 has a special use here as it is connected to an external emergency switch that stops the entire system. Normally, PC3 is held at +5 V by a pull-up resistor, R4. The two remaining port lines, PC6 and PC7, are not used here.

The internal block diagram of the 8253 counter/timer is shown in Fig. 2. The three 16-bit counters, numbered 0, 1 and 2, are identical and can be preset to count down. The counters operate independently and can be programmed separately. The counter values can be read from the 8253 without blocking the clock signal. The preset values are loaded with the aid of four control words stored in the control word register. Since this has only one address, two bits, SC0 and SC1,

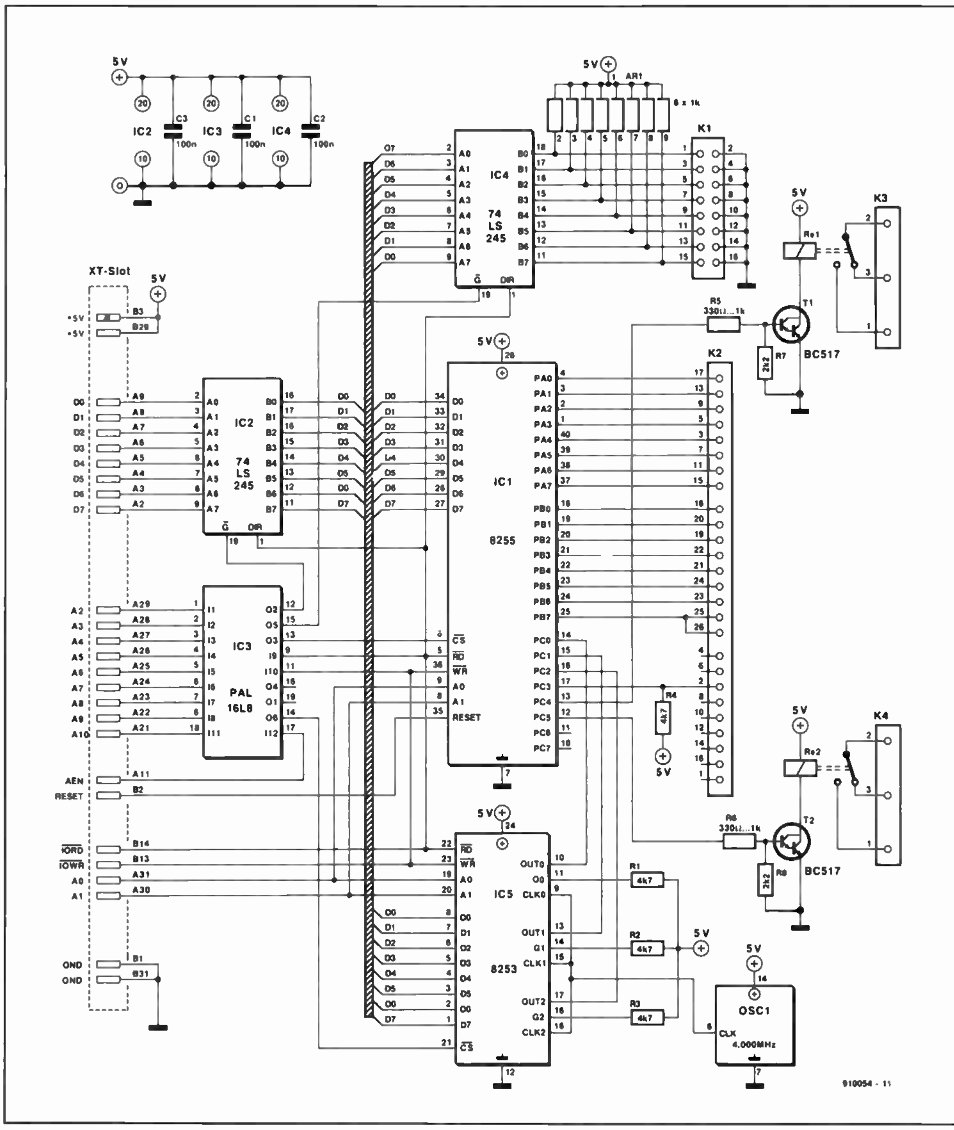


Fig. 1. Circuit diagram of the PC insertion card.

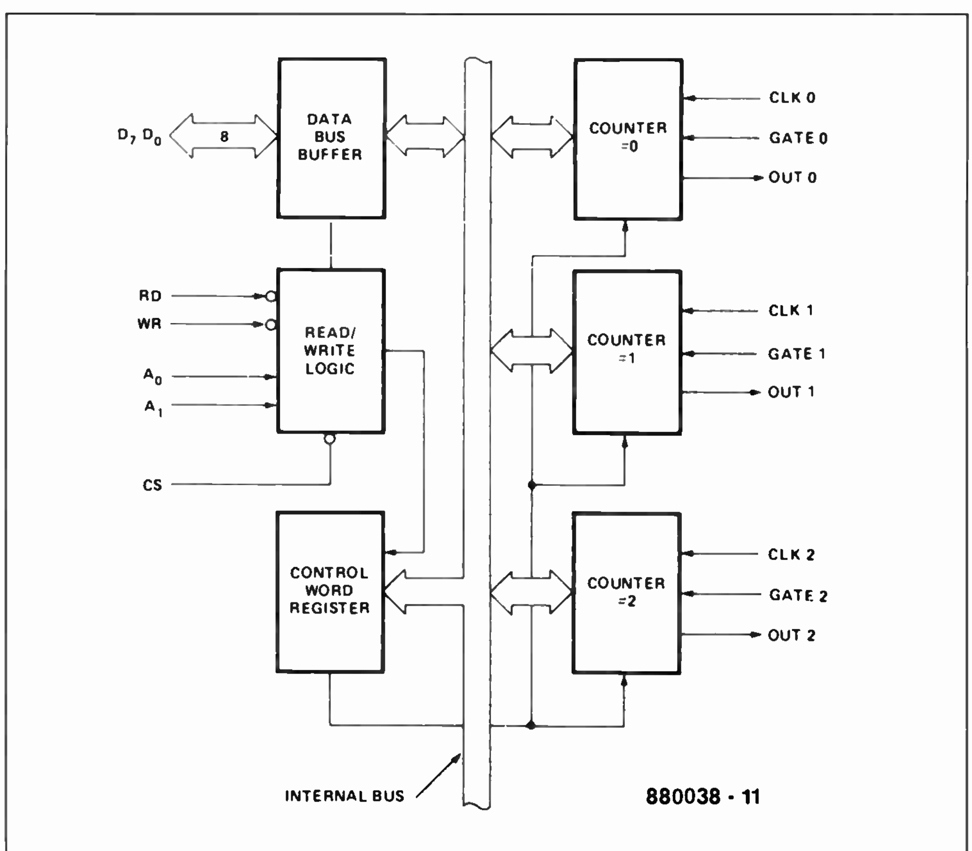


Fig. 2. Block diagram of the 8255 Programmable Peripheral Interface (PPI).

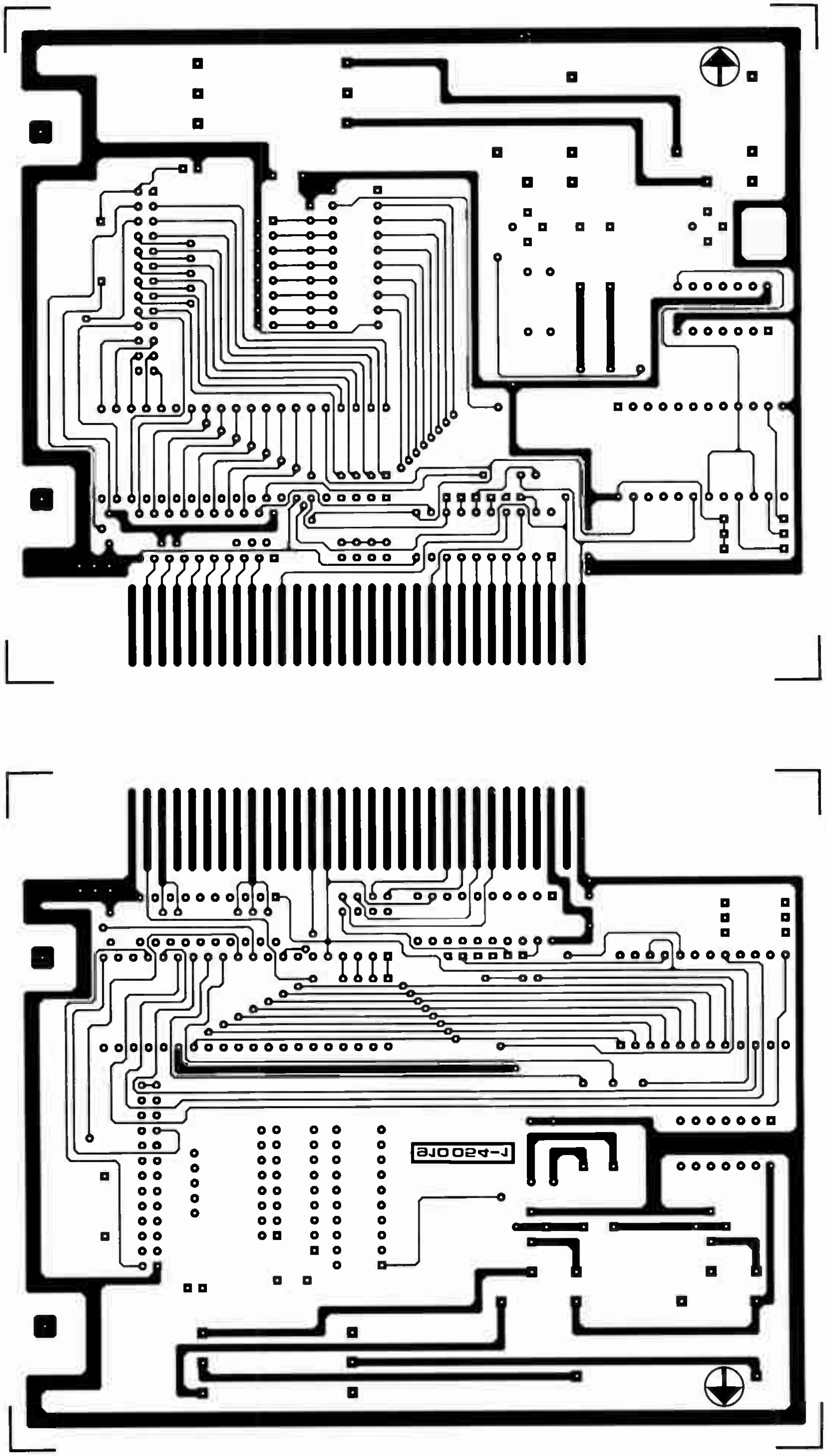


Fig. 3a. Track layouts of the component side and the solder side of the PC insertion card.

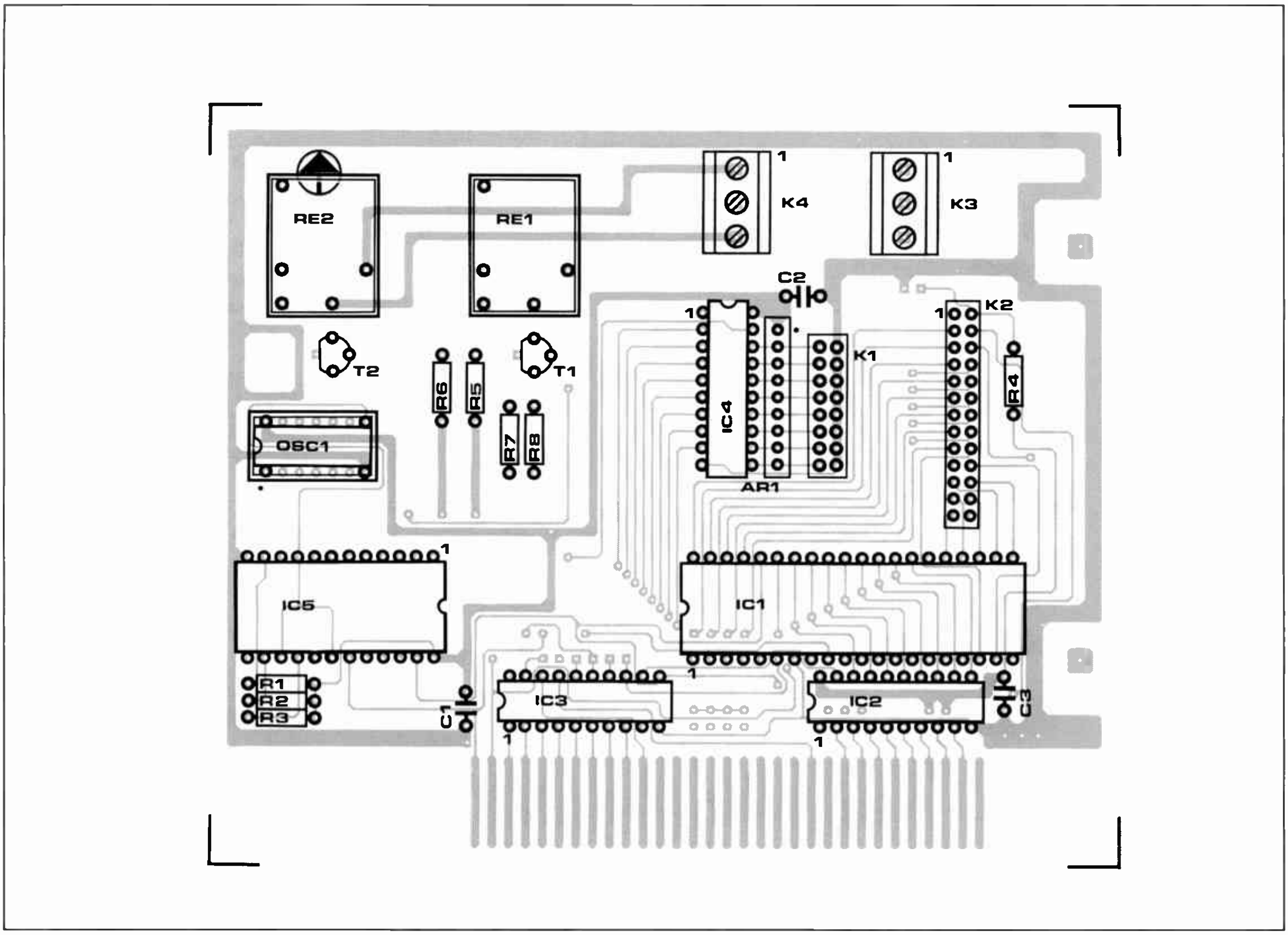


Fig. 3a. Component mounting plan of the PC insertion card.

COMPONENTS LIST

Resistors:

4	4kΩ7	R1 - R4
2	1kΩ (see text)	R5;R6
2	2kΩ2	R7;R8
1	8×4kΩ7 array	AR1

Capacitors:

3	100nF	C1;C2;C3

Semiconductors:

1	8255	IC1
2	74LS245	IC2;IC4
1	16L8 (ESS 6011)	IC3
1	8253	IC5
2	BC517	T1;T2

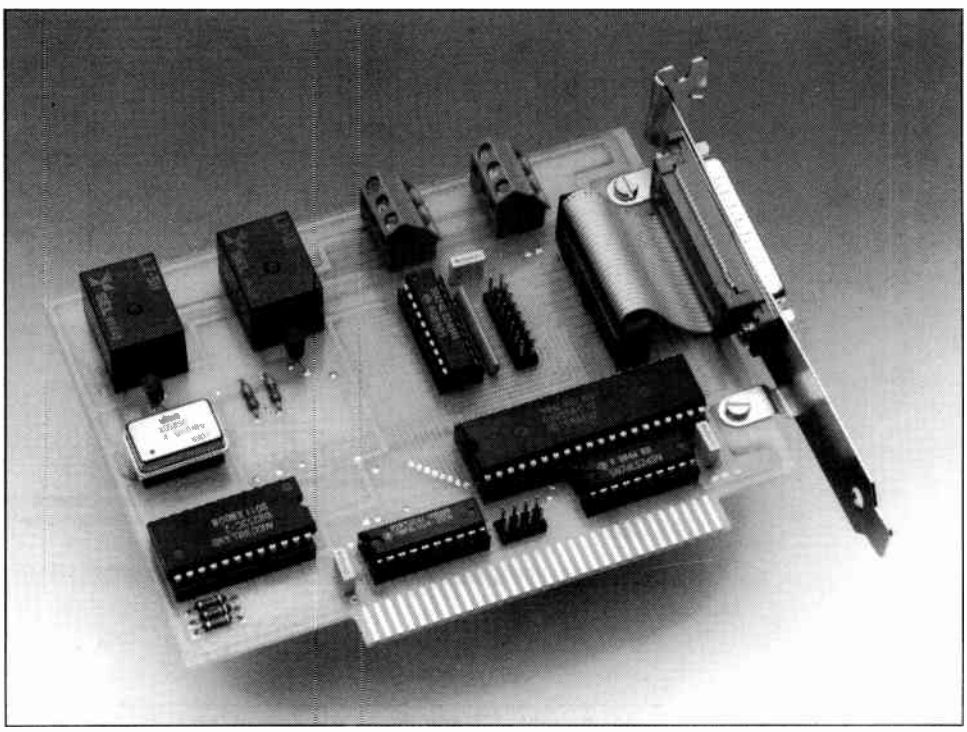
Miscellaneous:

1	4-MHz oscillator block	Osc1
2	PCB-mount 5V changeover relay	Re1;Re2
1	16-way 2-row PCB pin header	K1
1	26-way 2-row PCB pin header	K2
2	3-way PCB terminal block	K3;K4
1	printed-circuit board	910054-1

indicate the counter for which the control word is intended.

Returning to the circuit diagram in Fig. 1, the CLK0 through CLK3 inputs of the 8253 are supplied with a 4-MHz clock signal generated by oscillator block OSC1. All three gate (Gx) inputs of the counter/timer are tied to +5 V via pull-up resistors.

The 8253 is programmed to operate as a frequency divider. Depending on the preset value, a counter divides the oscillator frequency down to a particular value, for instance, 100 Hz, which is then passed to PPI port C. By loading different counter preset



values, the step duration of the stepper motors is made independent of the computer's speed.

IC4, a 74LS245, forms an 8-bit input port which is used to signal the status of a set of end switches fitted on the milling machine. The eight input lines of the port are held at +5 V with the aid of pull-up resistors. The end switches wired to K1 should, therefore, connect to ground when active.

The address assignment of the ports on the insertion card, and their functions, are summarized in Tables 1 and 2.

Construction

Populating the double-sided through-plated board (Fig. 3) should not cause difficulty. To make sure the card remains secure in the PC slot, you will need to secure it to a metal bracket as found on other insertion cards. Here, it is best to use (or make) a bracket with a relatively large vertical clearance that allows the two flatcables and the relay wires to pass.

Switch the computer off, fit the I/O card into a free slot, and secure the card to the metal frame at the rear of the PC. Switch on the PC, and check that a frequency of 4 MHz is present at pins 9, 15 and 18 of IC5. In case the PC will not boot up with the I/O card inserted, you are probably faced with a short-circuit on the board, or a faulty IC.

The data in Tables 1 and 2, and a few lines of BASIC or Pascal, allow the card to be checked for correct operation. For instance, reading address [base+8] (IC4) should return $1111\ 1111_2$, which equals FF_H, or 256 decimal. Next, connect two or three jumpers to K1 to pull the input datalines logic low. Run the read test again, when the result should match the set bit pattern (a jumper produces a logic low).

Next, test the PPI by writing to the control register at address [base+3] ($0DE3_H$). Set all ports to output, then make all port lines logic high. The relays should come on.

The scope of this article does not allow a more detailed description of the way in which the 8255 and the 8253 are programmed. Fortunately, plenty of literature is available that covers the practical use of these ICs in great detail.

Software

A number of different, fairly complex computer programs are required before the fraising machine can be made to work. The first step in making a fraised product is to draw it with the aid of a CAD program, such as AutoCAD or AutoSketch, and save the drawing file in the DXF format. Next, a program called AutoPack-II is used to convert the DXF file into a format suitable for further processing. AutoPack-II is a 2½-dimension version of the 3-dimension program AutoPack. None the less, AutoPack-II allows you to view the workpiece in 3-D to the ISO standard. Also, all side views of the workpiece can be displayed at the same time, and the program is capable of calculating the curve described by the fraise. This curve is called fraise equidistant because the radius of the fraise itself is taken into account.

The fraise file generated by AutoPack-II consists of a set of so-called Gerber commands. The actual control software for the milling machine is a converter called CNC-DIN. Written in C, it reads the Gerber data and converts these into commands for the stepper motor board described here. CNC-DIN is available from the author, and allows you set a number of parameters related to the hardware. These parameters include the type of stepper motor used (2-phase or 4-phase), the number of steps per revolution, etc. The parameters and their settings are stored in a configuration file that can be modified as required for your own hardware. Figure 4 lists the G (Gerber-) functions to DIN-66025 that are supported by CNC-DIN. ❑

Part 2 of this article will describe the motor driver board. Tables 1 and 2 mentioned here will be included in Part 2.

G routines supported by CNC-DIN
All dimensions in mm, DIN 66025.

Example of Syntax:
10 G00 x17.34 y200.0
20 G01 x10.90 y20.90

%	start of program
‘	remark
G00	Target point direction characteristic (x, y, z). Move to target point. Fraise carrier speed.
G01	Straight interpolation of target point (x, y, z). Fraise from current point to indicated target point. Fraise speed.
G02	Circle interpolation, clockwise. (xakt, yakt, x, y, i, j) current point (xakt, yakt), target point (x, y), centre of circle (i, j). Fraise an arc based circle information, from current point to target point.
G03	Circle interpolation, anti-clockwise. See G02.
G04	Spindle idle time. (f) idle time in seconds.
M58	Switch of spindle motor relay.
M59	Switch on spindle motor relay.
M08	Switch on pump for drill coolant.
M09	Switch off pump for drilling coolant.
G90	All absolute data.
G91	All incremental data.
G94	Spindle shift speed in mm/min. (x, y, z) speed indication for single spindle.
M30	end of program.

Fig. 4. Overview of Gerber commands supported by the CNC-DIN converter program.

Note:
The program CNC-DIN mentioned in this article is available from
Kolter Elektronik • Steinstrasse 22 • W-5042 Erfstadt • Germany. • Telephone: +49 (2235) 76707, Fax: +49 (2235) 72048.

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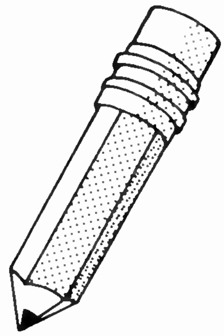

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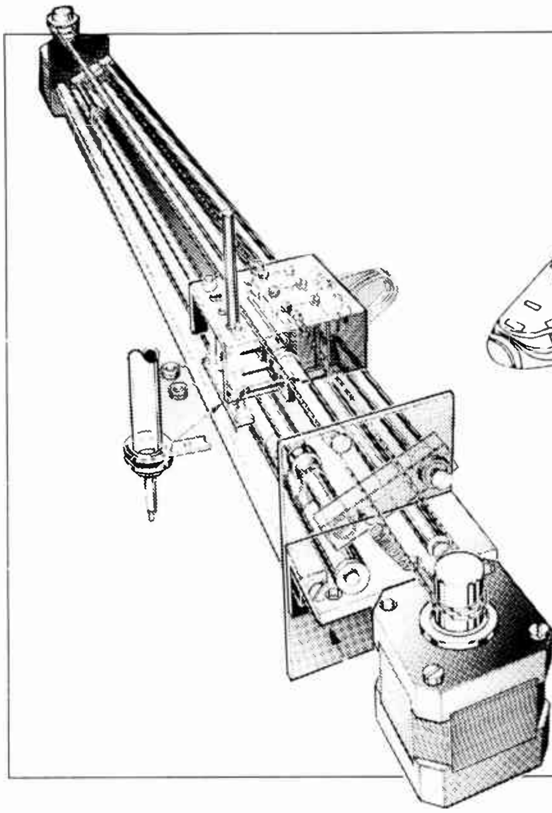

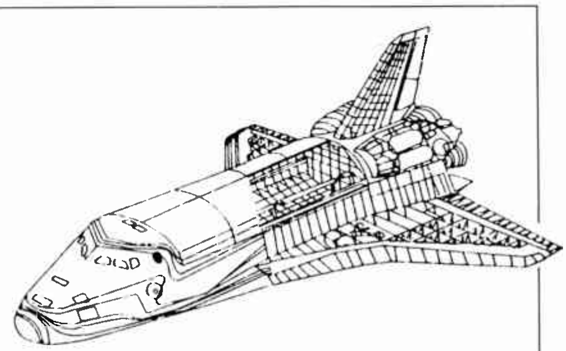

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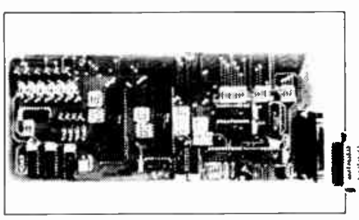

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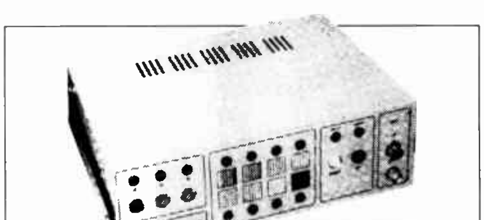

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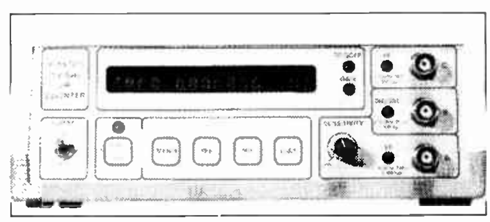

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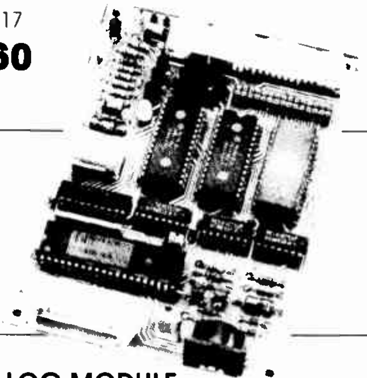

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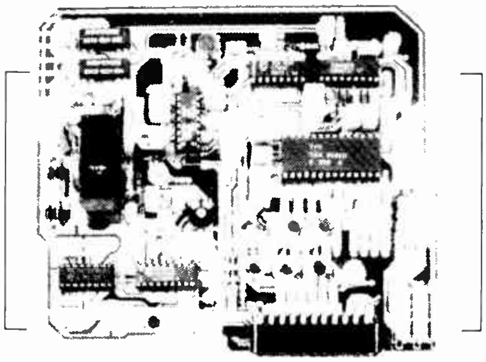

Following last month's introduction into the main characteristics of the Super-VHS system, we close off the article with details of a practical converter circuit that allows an S-VHS-VRC or camcorder to be connected to the RGB inputs of a colour TV or monitor. The circuit presented here forms a state-of-the-art approach to all-analogue picture standard conversion, and is based on the latest in IC technology available for this purpose.

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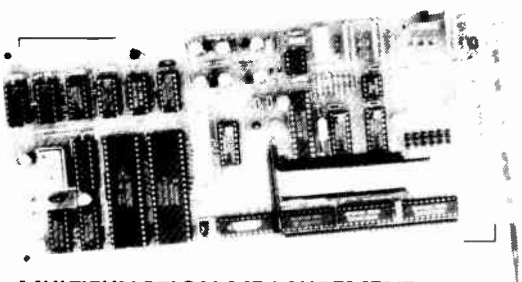

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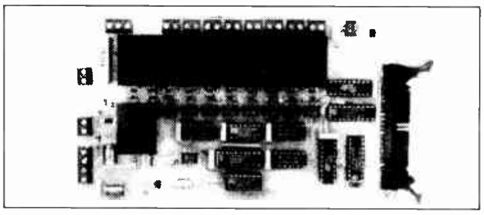

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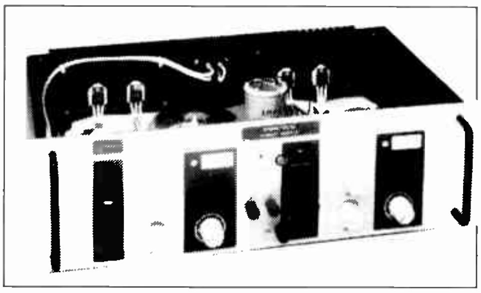

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  - Outputs 2 x 0 - 40 V at 2 x 0 - 5 A
- **Mode: Tracking**
  - two indentical, series connected, power supplies.
  - Outputs ± 0 - ± 40 V at 0 - 5 A; 0 - 80 V at 0 - 5 A
  - Voltage and current of *slave* follow *master*
- **Mode: parallel**
  - two identical, parallel connected, power supplies.
  - Outputs 0.6 - 39.4 V at 0 - 10 A
- **Maximum output voltage:** 0 - 40 V (at full load); 48 V (no load)
- **Maximum output current::** 5 A
- **Ripple:** 10 mV (no load); 50 mV (at full load)
- **Voltage difference in tracking mode:** 50 mV

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