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CURRENT & VOLTAGE

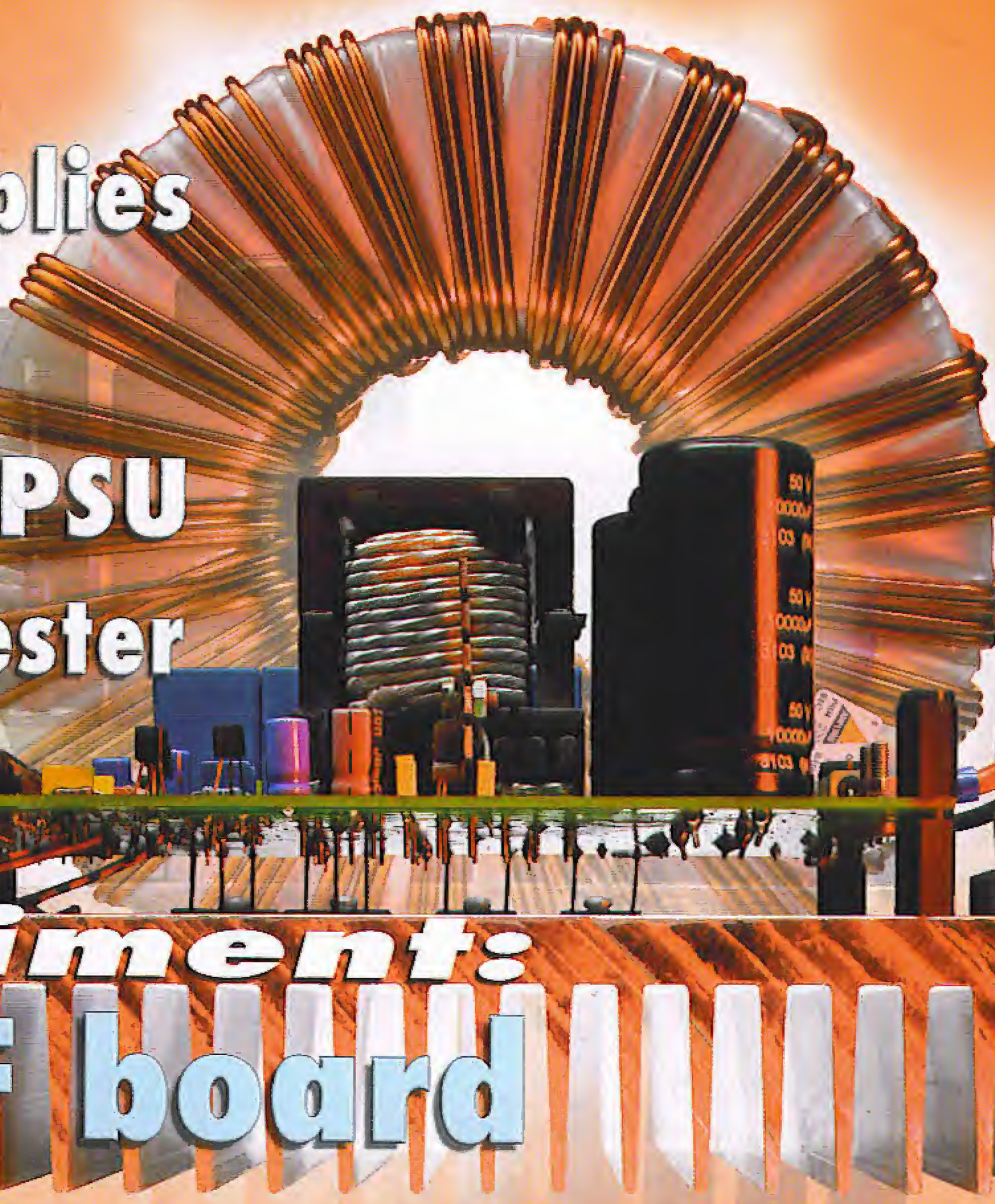
Market research

-31 lab supplies

Build this

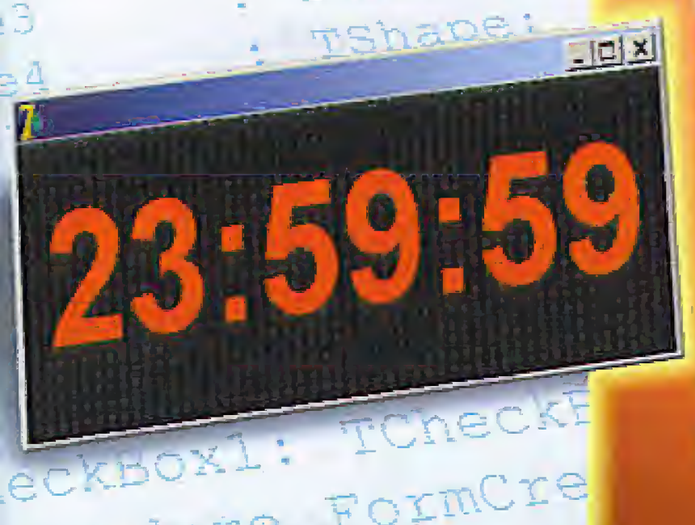
-Smart SMPSU

-PC supply tester



Experiment:

PIC 18F board



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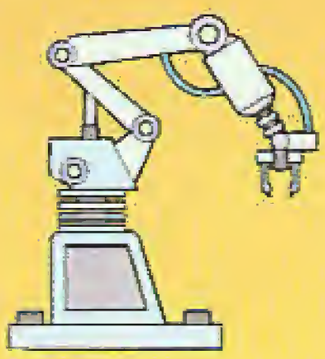
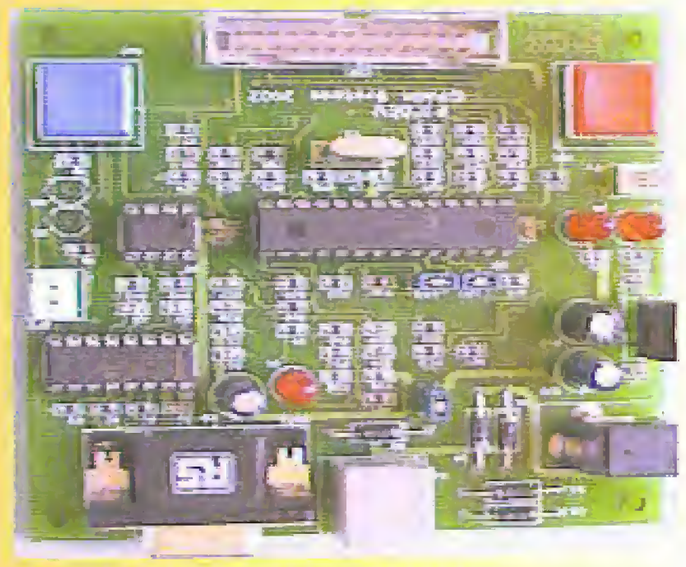


AUTOMATION



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- Cables
- Example scripts

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- Breakout board
- Cables
- Example scripts
- ICD1

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Moreinfo?
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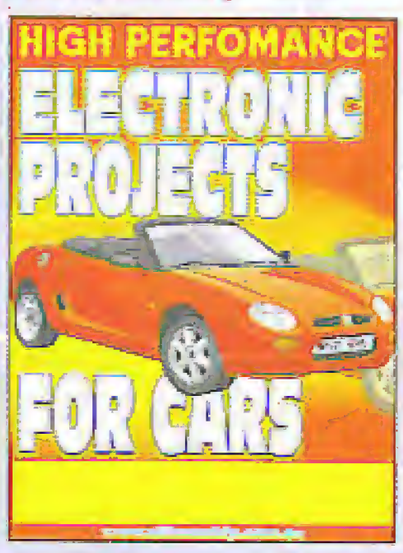
Over 150 pages!

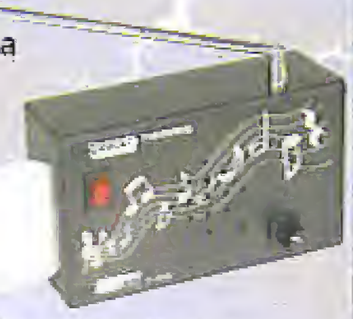


A Cheap Nitrous Fuel Mixture Controller

KC-5382 £7.25
Nitrous oxide systems can be expensive to set up, but now you can do it for much less. This project pulses a fuel injector at a preset rate, adding a fixed amount of nitrous fuel when you activate it. It will save you a bundle on dedicated fuel solenoids and jets. It can also be used to control electronic water pumps, cooling fans, and more. Kit supplied with PCB and all electronic components. *Please check local laws regarding the use of Nitrous Oxide systems in your vehicle.

Theremin Synthesiser

AM-4025 £27.25
This is a built up Theremin from a Jaycar kit. The Theremin is a weird musical instrument that was invented early last century but is still used today. The Beach Boys hit: "Good Vibrations" featured the Theremin. You can have one of these kits (cat no. KC-5295) for £12.95. All kits have first class instructions written in clear English text with plenty of illustrations and component identification.



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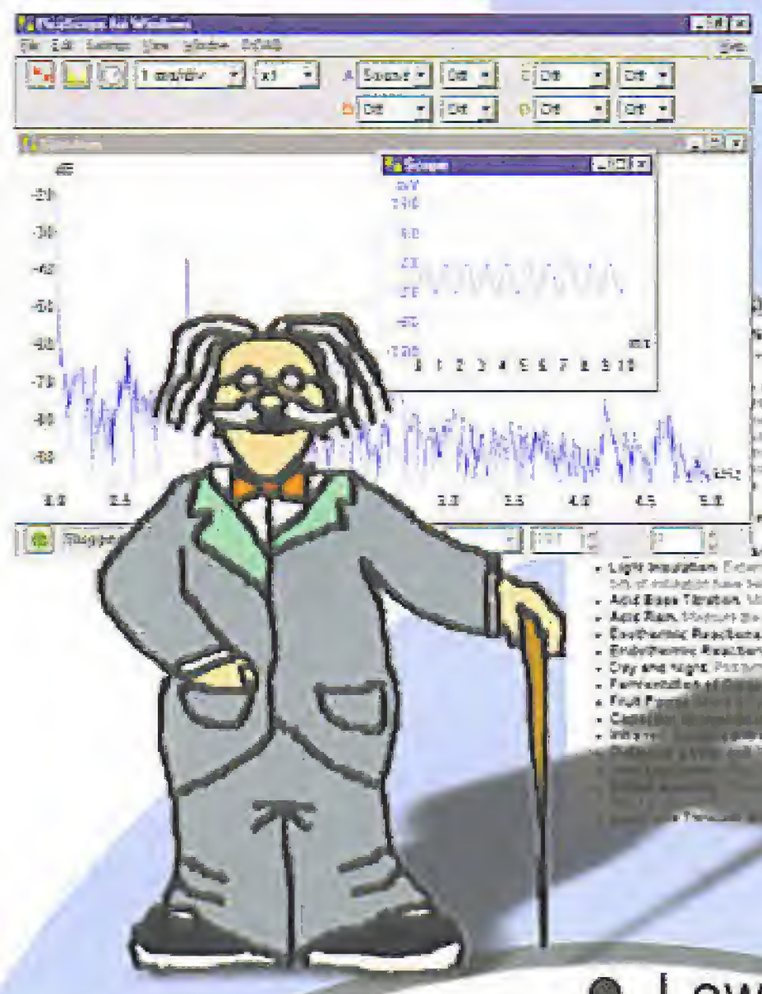
DrDAQ Data Logger



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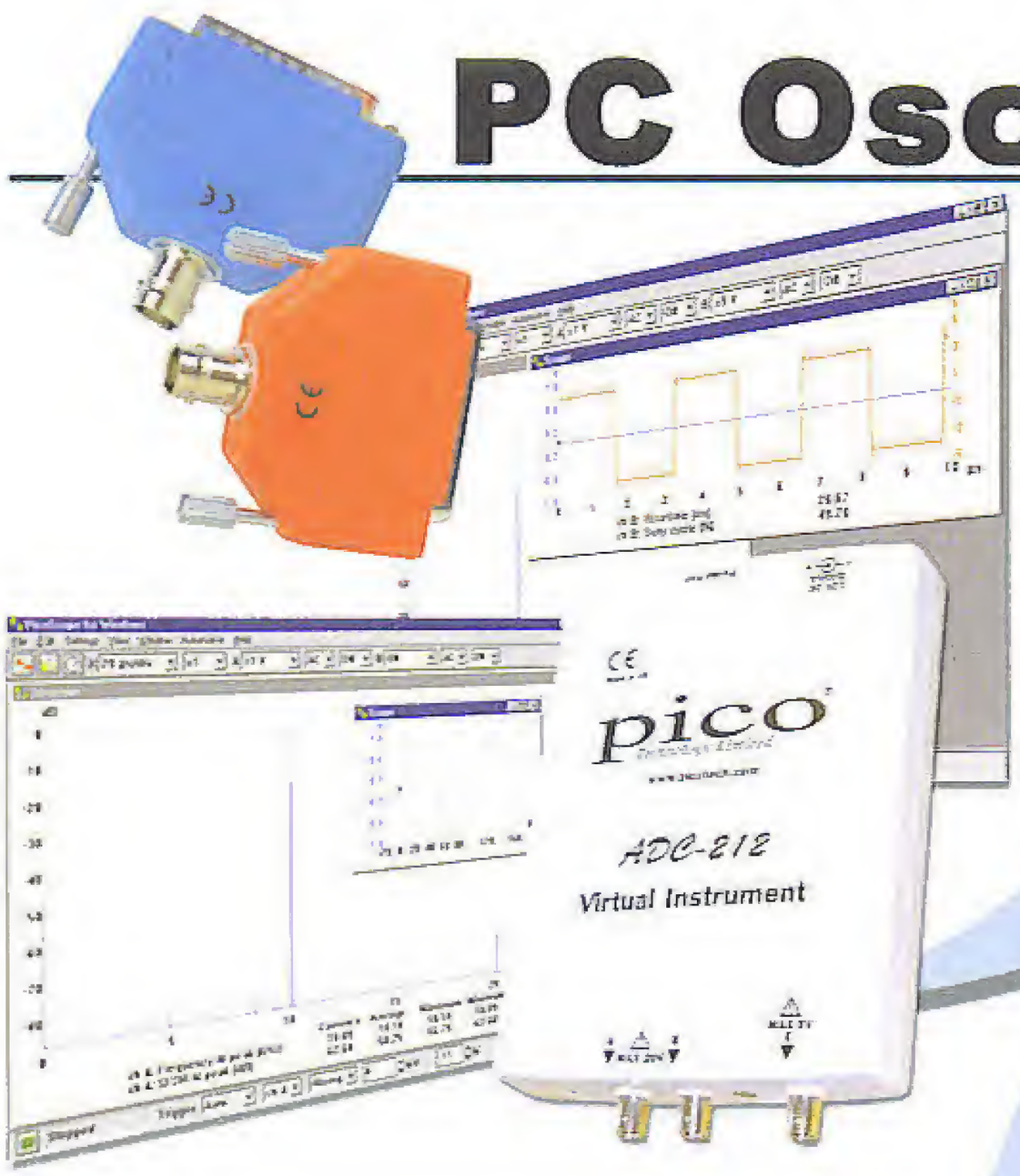

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Up our sleeve

Welcome to Elektor's first issue for the year 2005. Below is our forward publishing plan agreed upon after much debate between various staff. Authors, free-lance designers and advertisers are expressly invited to contribute to these issues by sending relevant article proposals, suggestions for practical projects or press releases to the Editor.

January 2005	POWER SUPPLIES. Benchtop and lab power supplies examined by a team of test engineers.
February 2005	WIRELESS. Various methods for wireless data communications. Tips and solutions to problems.
March 2005	SOUND. Sound amplification, compression technologies (MP3), sound pressure measurement and anti-sound systems.
April 2005	MICROCONTROLLERS. Special programming languages, tools and development kits for microcontrollers.
May 2005	SENSORS. Different types of sensor and associated measurement techniques. Comprehensive solutions and applications (including automotive).
June 2005	ELECTRONICS AND THE ENVIRONMENT. Solar panels with associated control electronics.
July/August 2005	SUMMER CIRCUITS DOUBLE ISSUE. More than 100 small circuits, design ideas and tips. Buying components: overview of suppliers and search methods.
September 2005	TEST AND MEASUREMENT. Test equipment examined by a team of test engineers.
October 2005	SECURITY. Protecting secure information (fingerprint and iris scanning), tracing bugs and protecting homes and buildings.
November 2005	ELECTRONICS SOFTWARE. Design and simulation programs for electronics engineers.
December 2005	OPTOELECTRONICS. Displays, now and in the future (LEDs, plasma, TFT, etc.).

Jan Buiting, Editor

elektor electronics

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Elektor Electronics aims at inspiring people to master electronics at any personal level by presenting construction projects and spotting developments in electronics and information technology.

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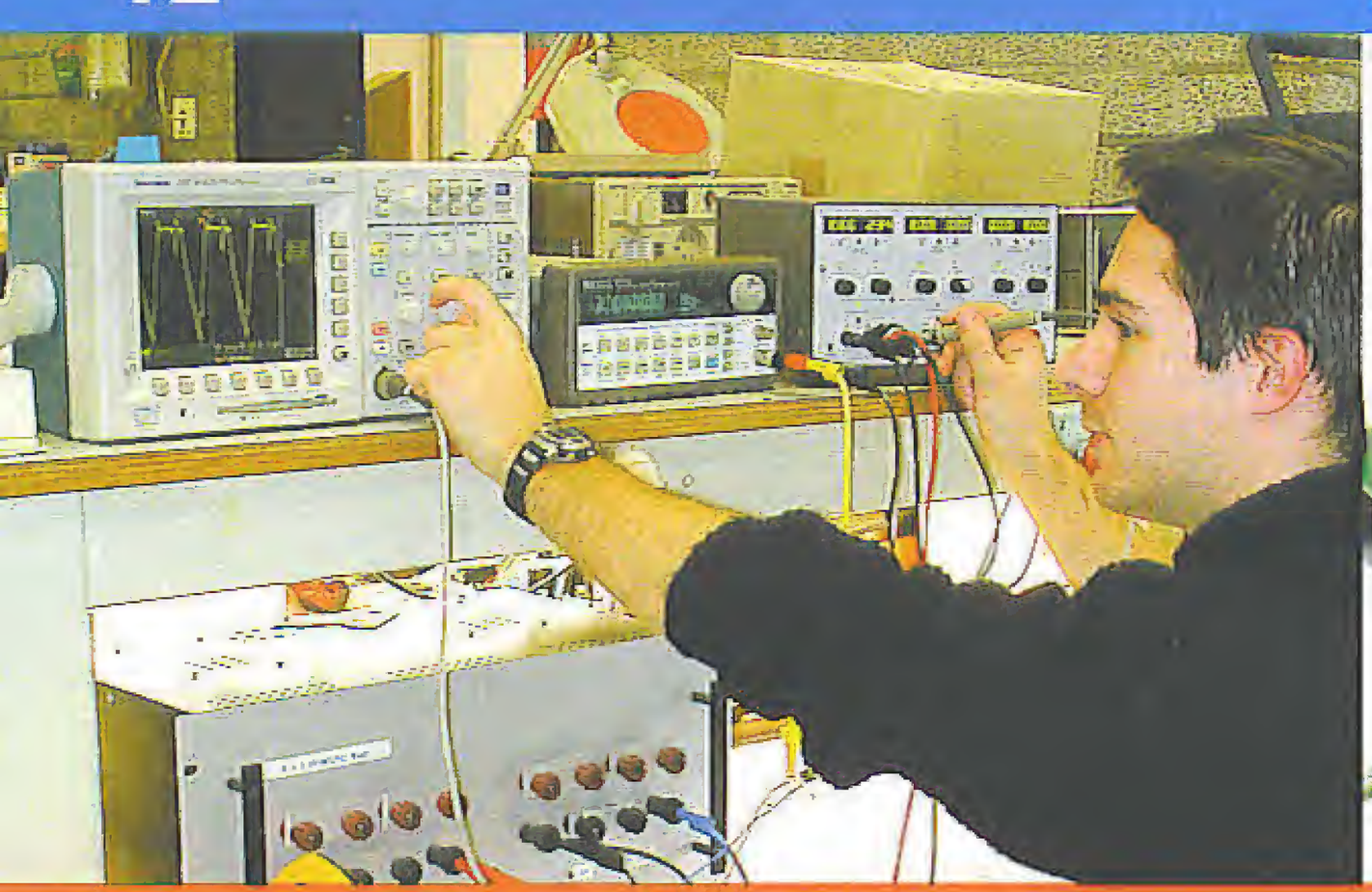

Power to Spare

The fact that a lab supply is part of the standard equipment for every workstation is demonstrated by the enormous number of products available. In this article, we examine a selection of lab supplies, describe the various options and features, and point out what you should look for when buying a power supply.

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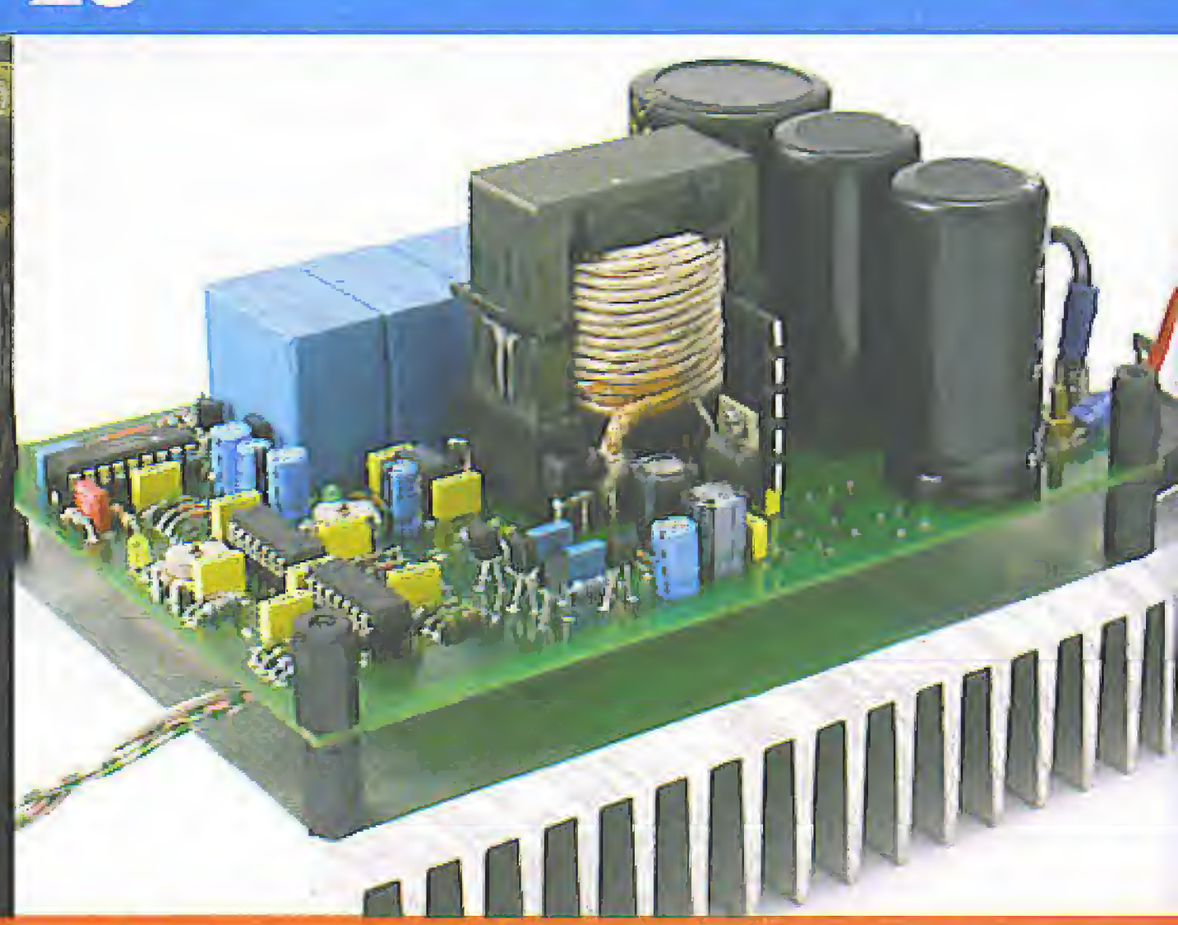

Cuk Converter

The great thing about the Cuk Converter is the absence of particularly exotic components. That means we can right away take the plunge with a 'heavy-duty' dc converter, which is ideal for use with fluctuating energy sources such as solar systems.

Informative Articles

Regulars

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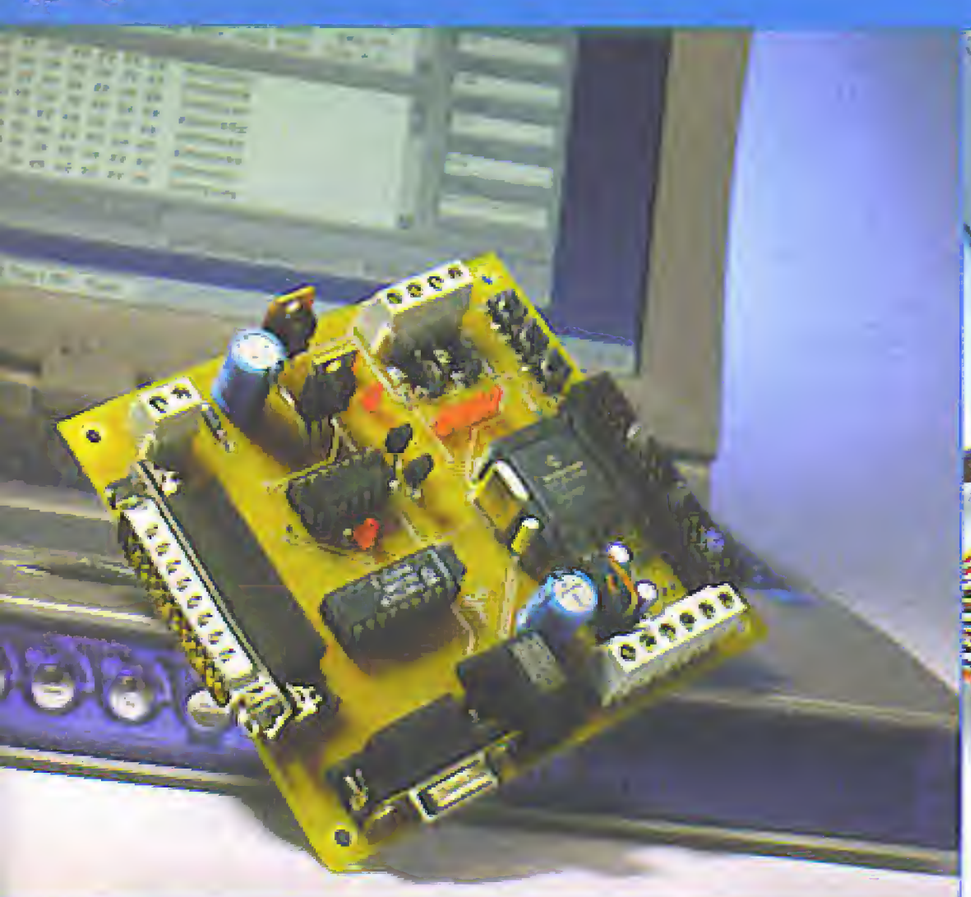

PIC18F Development Board

Peter Moreton's project continues a fine tradition of Elektor Electronics microcontroller articles, and follows in the lineage of the popular PICee board, AVRee and others. The board Peter describes employs the most recent and powerful of Microchip's PIC family, the '18F' series, and specifically, the PIC18F452.

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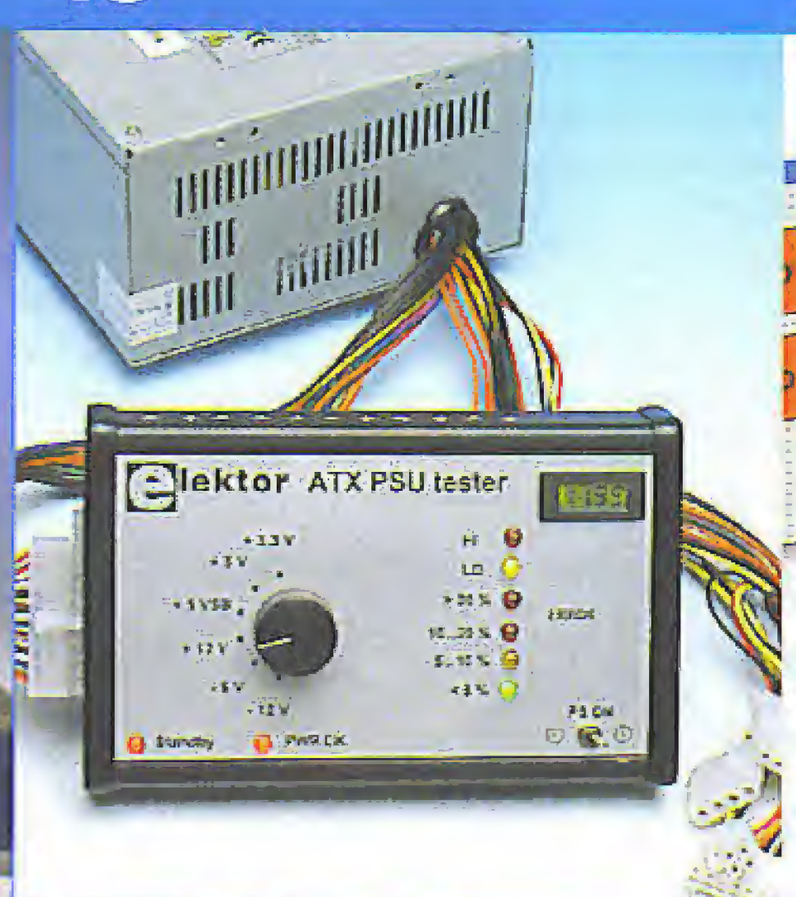

ATX Power Supply Tester

It isn't that easy to check if a second hand ATX style PC power supply still works properly. This dedicated tester makes that job quick and straightforward. All outputs from the power supply can be tested under load and any deviations from the nominal values are shown on six LEDs.

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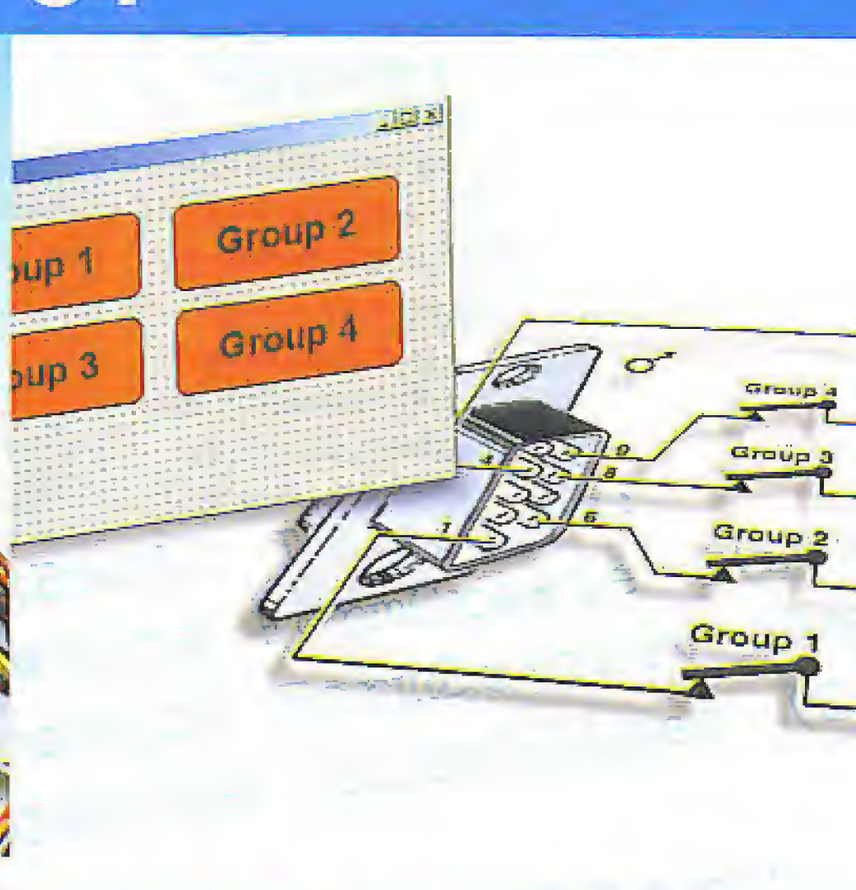


Delphi for Electronic Engineers (1)

We kick off a series about programming in Delphi, which concentrates on the practical side of programming and how it can interact with hardware. As an example, how would you write a Delphi program under Windows and then transfer it to an IC to make an autonomous Delphi controller?

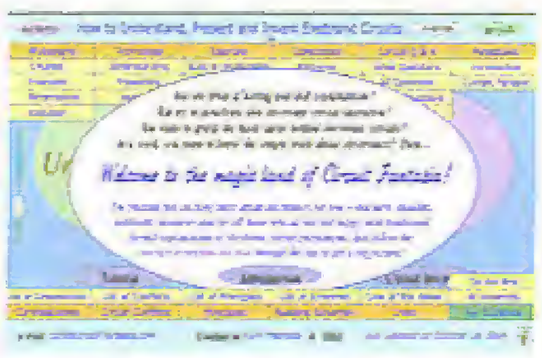
Construction Projects

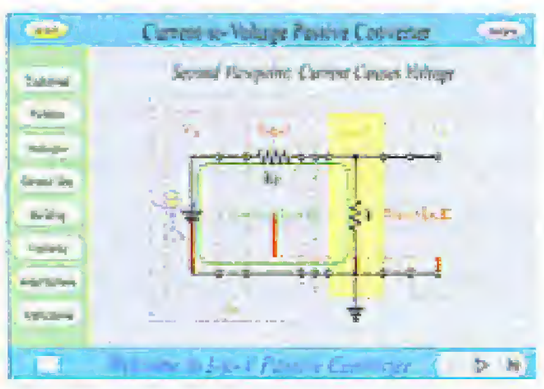
mailbox

Fantastic electronics

Dear Editor — I believe my website http://www.circuit-fantasia.com presents a really novel concept in electronics presentation as an alternative to the classical approach. Here, the electronic circuits are not presented as ready-made circuit solutions. Instead, they are built systematically in consecutive units, every one new circuit based on the previous ones. The site is implemented as an interactive multimedia product consisting of tutorials, collections of circuits, basic principles and heuristic tools. It is intended for creatively thinking students, teachers, hobbyists and inventors.

Cyril Mechkov (Bulgaria)





We've had a look at your website and found it to be very lively indeed; perhaps a bit too animated with so many visually distracting elements. Also, the over-abundant use of sounds will need some getting used to. None the less, an inspired website!

OTL Headphone Amplifier boxed 'US style'

Dear Editor — please have a look at some pictures of my version of the OTL Headphone Amp I built from your article in the January 2004 issue. I have made some mods including using larger filter caps in filament and HV supply; moving transformers away from the PCB and using audiophile (Cerafine caps) and non-polar caps in the output circuit. All of this and other changes (including soft recovery rectifiers) created a very good sounding amp. With Telefunken tubes, the sound is that of the tube... (with a cheap 12AU7, it sounds OK); with the German ECC82, it sounds incredible. I hope you print the pictures, as it did not cost much to build this great sounding amp, and with the cocabola wood on the front, it looks high-end. The cost of building this amp was about U$ 120.

Rick Macdonald (USA)

Thanks Rick for sending the photographs across and compliments on your efforts in building this design.

Synchronize your clocks

Dear Jan — I am the author of the 'Digital Alarm Clock' article published in the February 2004 issue. It's been a very rewarding experience having my project published in an 'A Class' magazine like *Elektor Electronics* and I plan to submit further articles in the near future.

Back to the Digital Alarm Clock project, I received several e-mails from readers over the past months suggesting changes to my original design.

Some of them would require major modifications to the clock's hardware and/or firmware which I respectfully declined to implement. On the other hand, some of them were relatively simple and I decided to put them together in one new firmware version. In summary, this new version will allow the unmodified hardware to do the following:

1. operate with the PIC16F628 instead of the PIC16F84A;
2. give the user conditions to select 1 of 3 different snooze period durations;
3. give the user conditions to make a coarse adjustment to the clock's time base, compensating any major crystal oscillation frequency deviation.

I have sent you two files containing (1) the .asm file with the source code for this new version already tested on my prototype, and (2) a .doc file describing the clock's operation to which I've added an 'Appendix A' describing the features added by the new version. The update will give readers a chance to stick to the original 84A based version or upgrade to the '628 version and add some more functionality to the clock.

Manoel C. Almeida (Brasil)

We are grateful to Mr. Almeida for this information. The updated files may be obtained from the Free Downloads section of our website; look for file number 030096-11.zip under February 2004 items

Exploding bits

Dear Jan — I was appalled to see such a disregard for the personal safety of your readers in your the November 2004 Elektor. The article in question is the 'Vehicle Battery Jogger'.

The statements in question are towards the end of the "Safety" section of the article. To say that the parts could go bang (i.e., explode) and then to suggest the circuit is put in a box is rather unprofessional to say the least. In circuits like this you must put in a device (e.g., slow blow fuse) that is designed to limit current and prevent a part exploding. DO NOT just try to contain the explosion in a box! Ideally this fuse needs to be near the battery and all conductors must be able to carry the fuse blow current. I expect a 5 amp slow blow fuse (or Polyswitch) would be able to cope with the short 40-A pulse, but you need to check this.

Clearly you have not seen the damage that an exploding high wattage resistor can cause, I've seen holes punched through 0.8-mm thick steel from shards off resistors (caused by a random failure and sloppy design practice!). Do your designers expect readers to have the circuit fully enclosed in a box when testing it for the first time? Surely the first time it is switched on is the most likely time of failure! How is the reader supposed to check the voltages, as suggested, if it is not working and in a box! Replacing R8 with a high value (eg 100R) during test would be a good approach. A good designer thinks about how to test a circuit and how to test it safely! I also question the wire gauge used in the harness in the picture, this would surely melt if the circuit failed. Incidentally I do like the new magazine style and... I've been reading Elektor since 1975!

Alan (UK)

You are absolutely right and we apologize for having overlooked the safety aspects of the project to the extent indicated. Most, if not all, problems may be solved by using a 1-A slow-blow fuse near the battery. In-line fuses and matching fuse holders as used in cars are suitable.

Connector parts (2)

Hello Jan — I too had a long search to find the type of connector (single pole) that Richard Austin describes in Mailbox, December 2004. In fact I get them from Farnell — although as Mr Austin found, they do not believe they sell them! I have even suggested to Farnell that they include the item in the connectors and/or test sections; as well as in the Semiconductor hardware section where they are to be found.
Look at page 522 of the Book 2 (May 2004) - Order Code 518-025, but they are not cheap! Hope this helps.

Ian King (UK)

Thanks for your reply. Unfortunately, our design engineers say that the connector you describe is not the one they (and Mr. Austin) are looking for. The search continues...

Improved Atmelisp

In last November's Mailbox I read a question on reading AT micros. I would like to add that I have produced a version of Atmelisp that offers additional functionality, while also allowing BASIC and BASIC-52 programs to be downloaded and uploaded. The program employs either two conventional serial ports or one USB and one RS232 port, where the USB port is used for data communications via a USB/serial converter.
My program has been tested on Windows 98, ME and XP Home Edition. I am offering to supply the binaries to interested readers.

Piet van der Wal (Netherlands)

Interested readers may request Mr. van der Wal's contact details by sending an email to editor@elektor-electronics.co.uk, subject: atmelisp

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Corrections & Updates

Slave Flash for Digital Cameras

October 2004, p. 58-60; 040224-1
The parts list should be corrected to read
R1 = 3kΩ3
R11 = 68kΩ
T4 = BC556

The P89LPC900 (2)

November 2003, p. 30-35; 030161-2
In the circuit diagram and on the PCB, the RTS line is connected to pin 9 of 9-way sub-D connector K6. However, RTS should be connected to pins 7 and 8. The PCB layout has been modified accordingly (free download from our website).

Simple Infrared Control Extender

July/August 2004, p. 56; 030103-1
In the circuit diagram, T1 should be a type BD241, not BD240. The circuit symbol (npn) is correct.

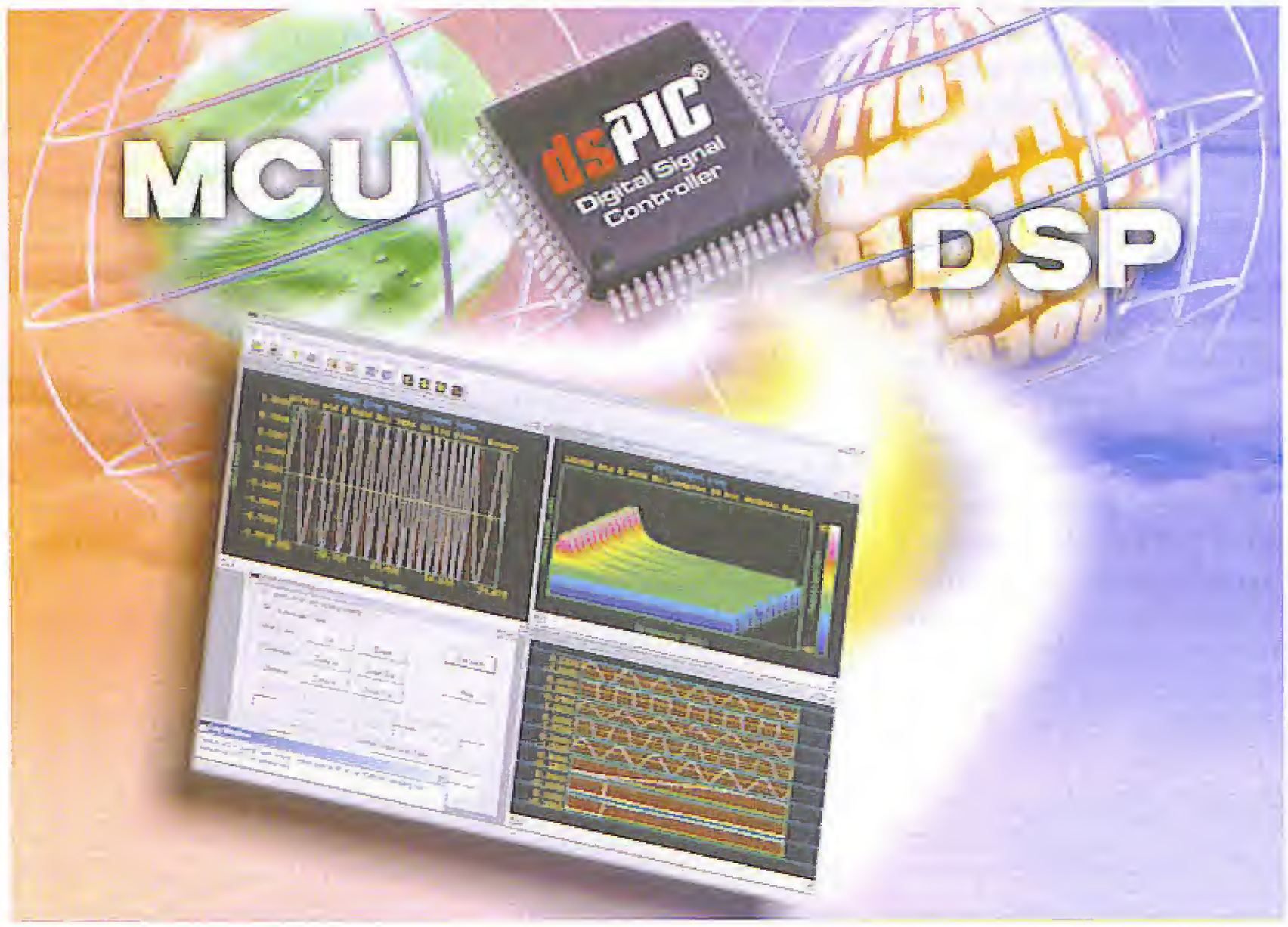
Multi Programmer on USB

June 2004, p. 10-16
In the parts list on page 16, IC4 should read 74LS07, not 74LS04.

MailBox Terms

– Publication of reader's correspondence is at the discretion of the Editor.
– Viewpoints expressed by correspondents are not necessarily those of the Editor or Publisher.
– Correspondence may be translated or edited for length, clarity and style.
– When replying to Mailbox correspondence, please quote issue number.
– Please send your MailBox correspondence to: editor@elektor-electronics.co.uk or Elektor Electronics, The Editor, P.O. Box 190, Tunbridge Wells TN5 7WY, England.

Essential Tools for dsPIC Development



Microchip' Tecnology's dsPIC DSC 16-bit (data) is a modified Harvard RISC machine that combines the control advantages of a high-performance 16-bit microcontroller with the high computation speed of a fully implemented digital signal processor (DSP) to produce a tightly coupled single-chip single-instruction stream solution for embedded systems design. All dsPIC DSCs integrate Flash program memory and most have EEPROM data storage.

Microchip now supply a range of essential software development tools that offer a development-rich environment for the dsPIC® 16-bit Digital Signal Controller (DSC) architecture. The MPLAB® Integrated Development Environment (IDE) and the MPLAB In-Circuit Debugger 2 (ICD 2) and device programmer development platform now support the dsPIC product line.

MPLAB IDE

This tool offers a single development platform for all of Microchip's PIC® microcontrollers and dsPIC DSCs. The MPLAB IDE is easy to use and has all of the enhanced edit/build/debug features an engineer would expect from a modern graphical development environment. The MPLAB IDE integrates not only software, but also all of Microchip's hardware and many third-party tools. In addition, the MPLAB IDE now includes an MPLAB ASM30 assembler and an MPLAB SIM30 simulator to support the dsPIC DSC architecture. It is available free from Microchip's Web site at www.microchip.com/dsPIC.

MPLAB ICD 2 In Circuit Debugger

Early MPLAB ICD 2 users can upgrade their firmware from the Web at no charge to support dsPIC30F products. The MPLAB ICD 2 can connect to the target board via a 3-pin interface to be used as a programmer and serve as a low-cost, in-circuit debugger. The MPLAB ICD 2 is available in two forms, standalone (DV164005) available now for $159 or bundled with a dsPICDEM™ Starter Demonstration Board (DV164030) available now for $209.

C Compilers

The MPLAB C30 C compiler supports the dsPIC DSC product line. Compliant with American National Standards Institute (ANSI) standards, this product supports standard libraries for the dsPIC DSC.
It has multiple optimization levels for speed or performance, to take advantage of the attributes of the dsPIC DSC. The MPLAB C30 C compiler is available now for $895 USD or a time-limited version is available online for free. Other C compilers are available from third parties such as: IAR, HI-TECH and CCS.

Visual Device Initializer

The MPLAB Visual Device Initializer (VDI), a standard plug-in to the MPLAB IDE enables users to configure the entire processor graphically and generates C-callable assembly code with a click of a mouse. The MPLAB VDI does extensive error checking on assignments. It flags errors such as multiple peripherals assigned to one pin, memory and interrupt conflicts as well as selection of operating conditions. The generated code files are seamlessly integrated with the rest of the application code through the MPLAB Projects. Other features of this tool include drag and drop feature selection, one-click configuration and extensive error detection. This tool is available online for free at www.microchip.com/dspic.

Digital Filter Design Software Package Digital Filter Design Tools

The Digital Filter Design Software Package simplifies the development of Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) digital filters through a menu-driven and user intuitive interface. Desired filter-frequency specifications are entered and the tool automatically generates the dsPIC DSC filter code and coefficient files ready to use in the MPLAB Integrated Development Environment (IDE). The Digital Filter Design (SW300022) is now available from Microchip for $249 USD.

dsPICworks™ Visual Algorithm Analyzer

The dsPICworks Visual Algorithm Analyzer is used to develop and evaluate design alternatives in simulated frequency and time domain environments. It also supports an extensive set of signal generators, including basic sine, square and triangle wave generators. Advanced generators for window functions, unit step, unit sample, sinc and exponential plus noise functions can be added to any signal. The dsPICworks Visual Algorithm Analyzer can be used to define the desired filter and visually display the simulated performance. Then the companion product Digital Filter Design Tool can be used to generate dsPIC DSC code. The dsPIC-

works Visual Algorithm Analyzer is available for free from the Microchip Web site at www.microchip.com/dsPIC.

Real Time Operating Systems (RTOS)

Microchip has teamed up with CMX Systems to provide its customers with the newest RTOS tools for the dsPIC DSC architecture. CMX has created three RTOS solutions for the dsPIC DSC architecture they include the full-featured CMX-RTX™ for the dsPIC30F, CMX-Tiny+™ for dsPIC30F, optimized for single chip applications, and the CMX-Scheduler™ for dsPIC devices.
CMX-RTX for dsPIC DSCs is a fully preemptive multi-tasking operating system. It features one of the smallest footprints, fastest context-switch times and lowest interrupt latency times. A truly preemptive RTOS allows interrupts to cause an immediate task switch. The CMX-RTX for the dsPIC DSC is available new from CMX.
CMX-Tiny+ for dsPIC DSC is a real-time kernel specially designed for those wishing to conserve on-chip RAM resources. CMX Tiny+ for the dsPIC DSC is available now from CMX.
The CMX-Scheduler for dsPIC DSCs is a real-time, preemptive scheduler that is the result of close collaboration with CMX and Microchip to provide a low-barrier-to-entry, limited-function-ality way to manage application tasks. This software package can be downloaded at no charge from Microchip at www.microchip.com/dsPIC or from CMX at www.cmx.com.

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(047199-3)

New PC Oscilloscopes

Fluke has announced new enhancements to its dual-input ScopeMeter 190 Series of hand-held oscilloscopes, increasing their power to analyse signals. Ideal for engineers working in service and engineering applications, all the colour and monochrome models now offer increased waveform resolution, providing even greater signal detail to help uncover anomalies. The 190C colour models also include Frequency Spectrum Analysis using Fast Fourier Transformation (FFT) analysis as a standard feature, as well as two new triggering modes and 'cursor-limited' automatic measurements. With safety certification to 1,000 V CAT II and 600 V CAT III, Fluke ScopeMeters help users to safely solve virtually all electronics measurement problems encountered out in the field. The battery-powered Fluke ScopeMeter 190 Series offer up to 200MHz bandwidth and 2.5 GS/s real time sampling rates, the speed, performance and analysis power usually found only on high-end bench oscilloscopes. Bandwidths start at 60 MHz for the entry level 192B. The waveform memories on all models have been increased by 150%, allowing as many as 3000 samples per channel to be acquired. This greatly increased waveform resolution can be used with the new 16x Zoom function to find tiny details in a long waveform, for example the colour burst in a video signal or a single pulse in a complex data-stream. The high-resolution waveforms can be transferred to a PC running optional FlukeView ScopeMeter software for documenting, archiving and analysis.
All 190C Colour Scopemeters now include Frequency Spectrum Analysis using FFT. This makes it possible to identify individual frequency components in a signal, and to reveal the effects of vibration, signal interference or crosstalk. The standard 'Connect-and-View™' automatic triggering function greatly simplifies triggering, but since manual triggering is sometimes required, two new modes have been added to the 190C colour series. N-cycle triggering ensures stable 'live' images of a signal, for example, in frequency dividers and clocked digital systems. Dual-slope triggering enables triggering on both rising and falling edges, so that any edge will act as a triggering event – especially useful, for example, when making eye-patterns from digital streams. The 190C models now also feature automatic power and Vrms measurements. These can be performed on a specific, user identified portion of a waveform, with the cursors used to define the time-window of interest. This is ideal for measuring power during the first mains cycle after closing the mains switch (to determine the inrush current).
All ScopeMeter models have a large 320 x 240 pixel display, a fast display update rate, up to 1000 V independently floating isolated inputs, a facility for measurement of effective output voltages of variable speed motor drives and frequency inverters and a 5000 counts true-rms multimeter function. A free Fluke ScopeTraining CD contains self-paced oscilloscope Training Modules, one set based on general Oscilloscope Theory, the second set explaining best-practice in the use of Fluke ScopeMeters.

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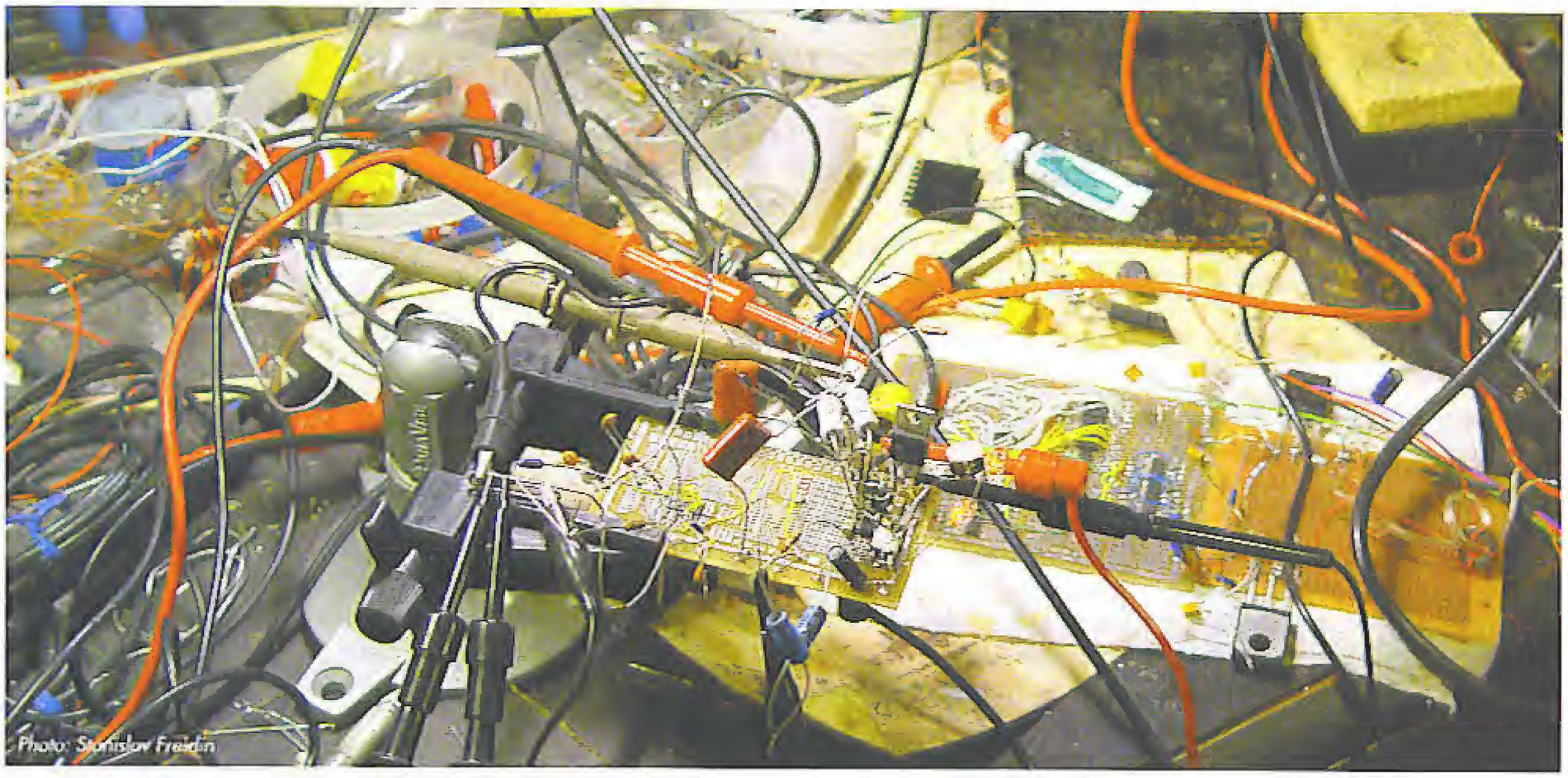
(047199-1)

Power to Spare

31 power supplies side by side

The faithful companion of every electronics fan is his laboratory power supply. It's always ready when you need it, it can provide the right voltage for every project, and it's just about indestructible. The fact that a lab supply is part of the standard equipment for every workstation is demonstrated by the enormous number of products available. In this article, we examine a selection of lab supplies, describe the various options and features, and point out what you should look for when buying a power supply.



Surely it's not a problem with the power supply...

The following pages present brief descriptions of no less than 31 laboratory power supplies. What all of them have in common is that they convert ac mains voltage into a clean, well-regulated dc voltage. At least that's the intention. It won't come as any surprise that not all of them can do this equally well, as you can see from the descriptions.

However, capacity is not the only thing that matters in choosing a suitable power supply, although it naturally forms the starting point.

Power

Nowadays, besides conventional (linear) power supplies, there are also various units available that use switched-mode conversion or a combination of these two conversion methods. Switched-mode power supplies have the advantage that they can provide higher efficiency at lower weight for the same amount of output power, since the necessary transformer is much smaller. Particularly with relatively high-power supplies, this can represent a considerable advantage.

However, before buying a power supply you should determine how much capacity the supply you're looking for should have, in terms of both voltage and current. If you only need to occasionally power relatively simple circuits, a voltage range of 0–12 V is often more than adequate, and a current rating of 1 A may cover all your needs. However, the required current rating can be quite different if you're working with (fast) digital circuits. Although such circuits often operate at fairly low voltages, the amount of current you need can quickly rise to impressive values. Naturally, the same is true for people who need a power supply specifically for working with car equipment. On the other hand, if you use the power supply for developing audio amplifiers, you will probably need high voltages as well as high currents.
It's a good idea to consider this question carefully before you buy, since regardless of whether it's a linear supply or a switched-mode supply, you naturally have do reach deeper in your pocket to get more power.

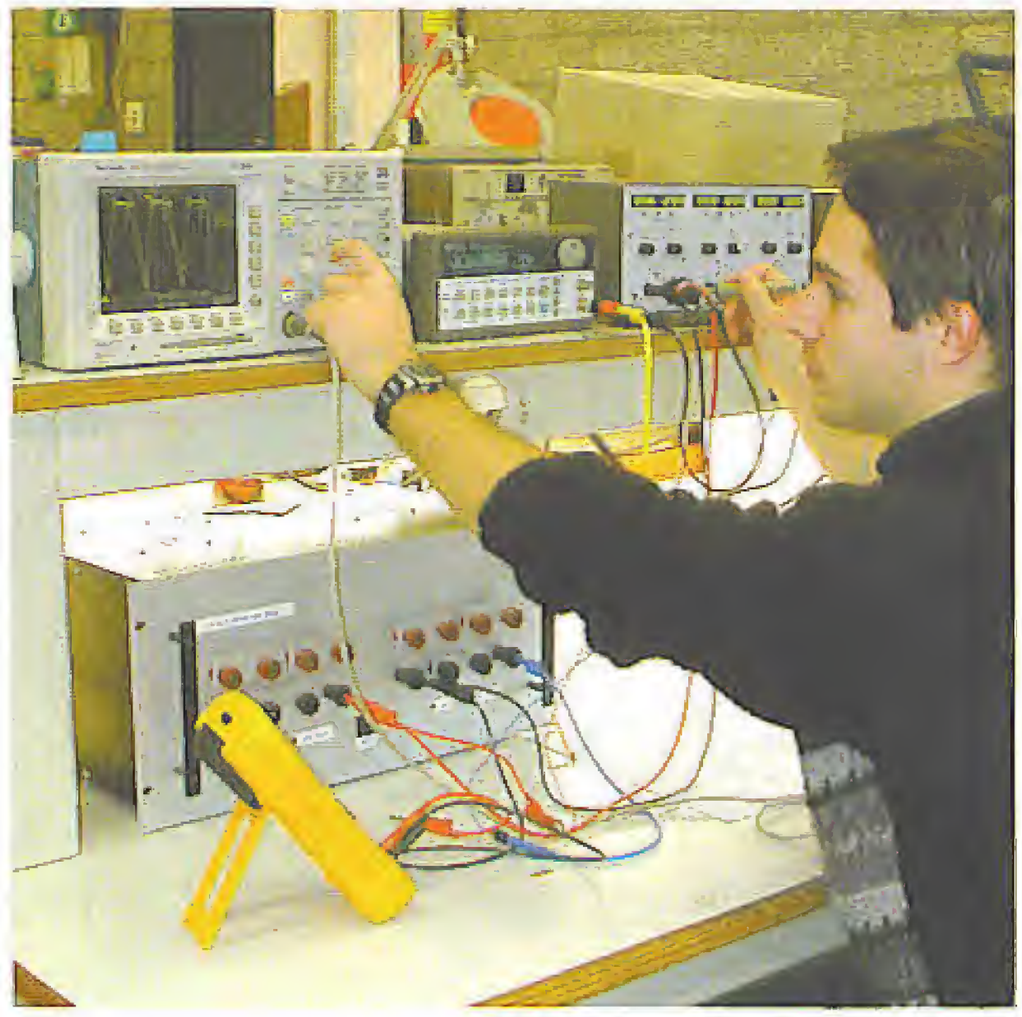
Bells and whistles

Perhaps you would rather spend the extra money on additional features, such as a second output to provide a negative voltage. That can be quite handy for powering circuits from a balanced supply (such as op-amp designs). In this case it's convenient if the two channels can be coupled (tracking mode), so both voltages can be set using a single knob.
There are also a few other important considerations and things to look for. Fine-adjustment controls for voltage and current, for example, are not a matter of course. If it's necessary to be able to precisely adjust these parameters for your applications, we recommend selecting a power supply with digital controls for these adjustments. Digital knobs are more convenient for making fine adjustments, since there's no mechanical limit on their range of adjustment. With an analogue potentiometer, at some point you simply run out of range, and then you have to resort to the coarse-adjustment knob. Of course, conventional potentiometers have the advantage of providing continuous adjustment, instead of using discrete increments like their digital counterparts. Incidentally, a ten-turn potentiometer is also a reasonable alternative, although it has the drawback that if a relatively large adjustment is necessary, you literally have to twiddle your fingers for a while before you get the voltage or current you want.
For adjusting the settings, you'll naturally need a voltmeter and an ammeter. All the supplies we examined here have this measurement capability on board. Most of them even have separate meters for voltage and current. The test team's preference is for LED displays, since, they are generally easier to read than LC displays and can be read more quickly than moving-coil meters.

Remote control

It's also possible to make settings and read values remotely. The simplest method is to use an analogue voltage (or resistance) to control the output voltage. Other possible interfaces include RS232, USB, and of course the professional General Purpose Interface Bus (GPIB).

Test engineers: Arjan Floris
Marcel Koenders
Project editor: David Daamen
Project support: Suseite de Leeuw



Some of the power supplies also perform the actual regulation at a distance. Such units have separate 'sense' terminals that are used to measure the voltage to be regulated at the load instead of at the supply output.

Outputs

As already mentioned, it can be convenient to have several outputs available. Besides units with several adjustable outputs, there are also power supplies available with one or more fixed-voltage outputs in addition to a 'normal' adjustable output. The fixed voltage is usually 5 V or 12 V.
Most lab supplies nowadays are fitted with sockets that accept banana plugs. The familiar combined banana jack and terminal post is slowly vanishing from the scene. This has to do with legal regulations related to shock protection. With certain power supplies (particularly if they are connected in series), the output voltage can be quite high. Under such conditions, terminal posts are naturally taboo. Incidentally, it's also convenient if the power supply has a separate switch for disabling the output, in order to prevent switch-on phenomena from reaching the connected circuitry.

Measured results

In order to judge the quality of the power supplies, we made measurements to check two important specifications for each unit: ripple and load regulation.
Most readers will probably know what ripple is: it's simply the residual ac voltage found at the output following conversion of the mains voltage. With a conventional power supply (transformer, rectifier, regulator circuit and associated filter), the ripple is usually a low-amplitude signal with a frequency of 100 Hz.
With a switched-mode power supply, the frequency of the ripple voltage is determined by the switching frequency used in the supply. This is also the case with supplies based on a combination of these two methods. Naturally, it goes without saying that the lower the ripple voltage is, the better (see also the *Terminology* inset below).

Load regulation

What's more interesting than the ripple is how a power supply handles a 'difficult' load. Ideally, the output voltage (or current) should remain constant under all conditions. None of the supplies can actually manage this in practice, but that's a perfectly normal situation. Most manufacturers also specify how well the power supply can handle a difficult load. This is usually given in the form of 'load regulation', which specifies the maximum change in the output level for a sudden change in the load.
Elsewhere in this issue, you can read more about our testing methods and how you can test power supplies yourself. Refer also to the *Terminology* inset in the survey section on the following pages.

(040406-1)

Terminology

Conversion

Linear power supplies use a transformer to convert the mains voltage to a lower ac voltage, which is then rectified and filtered (smoothed). Switched-mode power supplies first rectify the mains voltage, and this rectified voltage is then converted into an ac voltage at a relatively high frequency. This allows a much smaller transformer to be used for conversion to a lower voltage. These two techniques can also be used sequentially (mixed mode).

Output

In the output-range specification, the smallest possible increments for adjusting the voltage and current are shown in parentheses. Naturally, this does not apply to power supplies with analogue adjustment (using a potentiometer).

Ripple

The ripple, which is the residual ac voltage at the mains frequency or switching frequency, is given as an rms ac voltage measured with a bandwidth of 300 kHz. The inaccuracy of the meter used for the measurements (Fluke 187) is included in the stated values. The load and dc voltage for the measurement are stated in parentheses.

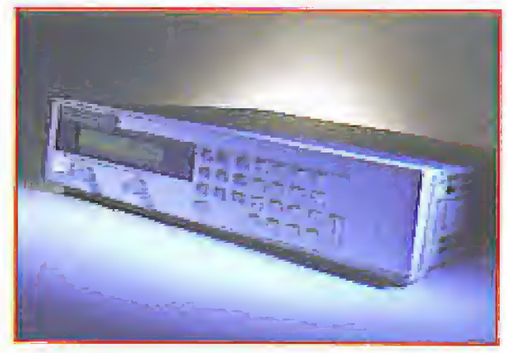
Load regulation

The stated values are maximum values. The following values are given in the order listed: the peak voltage of the overshoot when the load is disconnected (U_p), the duration of this overshoot (t_p), and the (quasi)static deviation from the set value (U_s). These values include the inaccuracy of the instrument (Tektronix TDS3020) and reading errors. The load consists of a fixed part and a variable having the same value, which is switched in parallel with the fixed part at a rate of 300 Hz with $U_{out} = 0.33\ U_{max}$. The load regulation values cannot be directly compared with each other, since each of the supplies was set to a different voltage for this test. However, the individual values do provide an indication of the quality of the design and regulation of the power supply (lower values are better).

Recommended retail price (RRP)

Unless otherwise stated, this is the recommended retail price including VAT, as specified by the supplier who provided the unit.

Agilent 6642A



This PSU is clearly intended for use in special configurations. This is evident from the extremely rugged construction and the fact that the output terminals are located at the rear side.

Conversion	linear
Output	0-20 V (Δ 5 mV) @ 0-10 A (Δ 3 mA)
Adjustment	numeric keypad and rotary control
Readout	2 x LED display (I and V separately)
Ripple	< 0.3 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 1.1 V / 50 µs (V_p/t_p) – 0.1V (V_s) (8/4 Ω)
Interface	analogue, GPIB
Dimensions	70 x 124 x 350 mm (w x h x d) – 14.2 kg
RRP	£ 1547 (€ 2256)

Agilent E3616A

A extremely well finished, quiet PSU. Sense inputs are available to measure the voltage at the source. Provisions for slave/master mode.

Conversion	linear
Output	0-35 V (Δ 10 mV) @ 0-1.7 A (Δ 1 mA)
Adjustment	2 x 10-turn rotary control (I and V separately)
Readout	2 x LED display (I and V separately)
Ripple	< 0.2 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 0.8 V / 55 µs (V_p/t_p) – 7.0 mV (V_s) (24/12 Ω)
Interface	analogue, GPIB
Dimensions	212 x 88 x 345 mm (w x h x d) – 5.5 kg
RRP	£ 397 (€ 579)

B+K Precision 1621A

Remarkably, different colours are used for the I and V displays.

Conversion	linear
Output	0-18 V (Δ 100 mV) @ 0-5 A (Δ 10 mA)
Adjustment	4 x rotary control (I and V, coarse/fine; analogue)
Readout	2 x 3-digit LED display (I and V separately)
Ripple	< 0.1 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 0.8 V / 40 µs (V_p/t_p) – 5.4 mV (V_s) (8/4 Ω)
Interface	slave/master mode for series or parallel configuration
Dimensions	205 x 115 x 270 mm (w x h x d) – 7,4 kg
RRP	£ 131 (€ 191.25) (excl. VAT)

B+K Precision 1665

This supply features active temperature controlled cooling.

Conversion	switch-mode
Output	0-20 V (Δ 10 mV) @ 0-10 A (Δ 10 mA)
Adjustment	4 x rotary control (I en V, coarse/fine, analogue)
Readout	2 x 4-digit LED display (I and V separately)
Ripple	< 0.3 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 0.2 V / 1.5 ms (V_p/t_p) – *see text below
Dimensions	205 x 115 x 275 mm (w x h x d) – 3 kg
RRP	£ 123 (€ 178.50) (excl. VAT)

* inadequate suppression of resonance effects at dynamic loads. Using our test method it is not possible to state the static error. However the error is invariably within the manufacturer's specifications (533 mV).

Delta EST150

With this rugged supply, channels 1 and 2 may be coupled. It is also possible to operate several of these PSUs is a parallel or series configuration. In this way a maximum voltage of 600 V may be obtained; the output current is even infinite. Remarkably this PSU has passive cooling, i.e., a noisy fan is missing!

Conversion	switch-mode
Output 1 en 2	0-20 V (Δ 6 mV) @ 0-2.5 A (Δ 0.75 mA) (0.03 %)
Adjustment	4 x 10-turn rotary control (I and V separately)
Readout	4 x 3-digit LED display (I and V separately)
Output 3	0-10 V (Δ 3 mV) @ 0-5 A (Δ 1.5 mA) (0.03 %)
Adjustment	2 x 10-turn rotary control (I and V separately)
Readout	2 x 3-digit LED display (I and V separately)
Ripple	< 0.3 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 0.2 V / 0.5 ms (V_p/t_p) – 8.8 mV (V_s) (8/4 Ω)
Dimensions	222 x 132 x 180 (w x h x d) – 3.5 kg
RRP	£ 571 (€ 840)

Delta SM15-100

This supply is not only impressive in respect of performance, but also feature-packed. All interface options you can imagine are available. Naturally, power supplies of this type operate in series, parallel, master and slave mode. This rugged PSU is completed with a very quiet temperature controlled fan.

** Although the results are well within the manufacturer's 'maximum error' specifications (250 mV), the load regulation is disregarded in this case. Considering the current capacity of this PSU, the 'test load' used was deemed insufficient to evaluate the supply's behaviour within its normal operating range.*

Conversion	switch-mode
Output	0-15 V (Δ 4.5 mV) @ 0-100 A (Δ 30 mA) (0.03 %)
Adjustment	rotary control (analogue)
Readout	2 x digital (I and V separately)
Ripple	< 2.1 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	*see text below
Interface	analogue, RS232, GPIB, Ethernet
Dimensions	442 x 89 x 365 mm (w x h x d) – 10.6 kg
RRP	£ 1108 (€ 1630)

Elipse EPS1803

Although the displays are a bit small, they do match the general size of the PSU, which will require little space on the workbench. The PSU has passive cooling and although the general layout is rudimentary (which also applies to the manual), the PSU does have a separate switch for its output, and 'remote sensing' terminals are available.

Conversion	linear
Output	0-18 V (Δ 10 mV) @ 0-3 A (Δ 10 mA)
Adjustment	1 x rotary control (I), 2 x rotary control (V: 'fine', 'coarse')
Readout	2 x 4-digit LED display (I and V separately)
Ripple	< 0.1 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 2.0 V / 68 µs (V_p/t_p) – 19 mV (V_s) (8/4 Ω)
Interface	analogue
Dimensions	215 x 113 x 376 mm (b x h d) – 5.6 kg
RRP	£ 249 (€ 366.60)

Elektro Automatik PS3232-025

This supply lacks a 'fine' adjustment. Channels 1 and 2 may be configured in series or parallel mode.

Conversion	linear
Output 1 en 2	0-32 V (Δ 100 mV) @ 0-2.5 A (Δ 10 mA)
Adjustment	4 x rotary control (I and V separately)
Readout	4 x 3-digit LED display (I and V separately)
Output 3	3-6 V @ 2 A
Adjustment	potentiometer
Ripple	< 0.4 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 0.5 V / 0,2 ms (V_p/t_p) – 60 mV (V_s) (8/4 Ω)
Dimensions	355 x 132 x 320 mm (w x h x d) – 13 kg
RRP	£ 246 (€ 362)

ELV HY1503D

A simple power supply in a sturdy case. The displays have excellent legibility.

Conversion	linear
Output	0-15 V @ 0-3 A
Adjustment	2 x rotary control (analogue)
Readout	2 x 3-digit LC display (I and V separately)
Ripple	< 0.4 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 0.5 V / 33 µs (V_p/t_p) – 9.5 mV (V_s) (8/4 Ω)
Dimensions	95 x 160 x 230 mm (w x h x d) – approx. 4.5 kg
RRP	£ 42.50 (€ 62.50)

ELV PPS7330

This is the only supply in this overview that comes with a USB interface allowing the instrument to be programmed for timed operation using the associated software. This PSU features temperature controlled active cooling, a separate output on/off switch and a 'store/recall' function. At a lower price this PSU also comes as a kit (with or without USB).

Conversion	linear
Output	0-30 V (Δ 10 mV) @ 0-3 A (Δ 1 mA)
Adjustment	1 x rotary control (digital) in combination with pushbuttons
Readout	2 x 4-digit LED display (I and V separately)
Ripple	< 0.5 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 0.3 V / 33 µs (V_p/t_p) – 27 mV (V_s) (8/4 Ω)
Interface	USB (including software)
Dimensions	350 x 110 x 210 mm (w x h x d) – 3 kg
RRP	£ 176 (€ 259)

ELV SNNT4005PC

Conversion	mixed mode
Output	0-40 V (Δ 10 mV) @ 0-5 A (Δ 10 mA)
Adjustment	rotary control (digital)
Readout	back-lit LC display (I, V and P at 4 digits)
Ripple	< 3.4 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 1.0 V / 2.2 ms (V_p/t_p) – 0.2 V (V_s) (8/4 Ω)
Interface	RS232 (optional)
Dimensions	275 x 135 x 300 mm (w x h x d) – approx. 3 kg
RRP	£ 135 (€ 199)

This PSU is slow to respond to control changes. The 'moderate' impression created by this behaviour matches the rest of the instrument: the knobs do not turn smoothly and the rotary control jams. The fan was found to be very noisy. On the positive side, voltage, current and power limits may be set on the instrument, while the controls may be locked to protect erroneous operation.

GMC LPS32K

Conversion	switch-mode
Output	0-36 V (< 4 V: Δ 1 mV, >4 V Δ 10 mV) @ 0-3 A (Δ 1 mA)
Adjustment	numeric keypad and 1x rotary control
Readout	2-line LC display (I, V and P simultaneously; 3 digits each)
Ripple	< 1.2 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 1.9 V / 55 µs (V_p/t_p) – 26 mV (V_s) (8/4 Ω)
Interface	RS232/RS485 (optional)
Dimensions	213 x 88 x 250 mm (w x h x d) – 6 kg
RRP	£ 250 (€ 368)

Operating this PSU requires some getting used to, not just because only one rotary control is available. The PSU has a 'save/recall' function and a switch on the outputs. Passwords may be used to protect the controls against erroneous operation.

GW Instek GPS3030DDS

Conversion	linear
Output	0-30 V (Δ 100 mV) @ 0-3 A (Δ 10 mA)
Adjustment	4 x rotary control (I and V separately, both with 'coarse' and 'fine')
Readout	2 x 3-digit LED display (I and V separately)
Ripple	< 0.2 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 2.0 V / 11 µs (V_p/t_p) – 22 mV (V_s) (8/4 Ω)
Interface	analogue
Dimensions	128 x 145 x 285 mm (w x h x d) – 5 kg
RRP	£ 179 (€ 264)

Several of these PSUs may be connected into a master/slave constellation. The supply was found to run fairly hot. Cooling is passive.

GW Instek PSP405

Conversion	switch-mode
Output	0-40 V (Δ 10 mV) @ 0-5 A (Δ 2 mA)
Adjustment	digital rotary control with 'fine' and 'coarse' mode
Readout	back-lit LC display (with I and V in 4 digits)
Ripple	< 2.2 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 0.4 V / 0.8 ms (V_p/t_p) – 71 mV (V_s) (8/4 Ω)
Interface	RS232
Dimensions	225 x 100 x 305 mm (w x h x d) – 4 kg
RRP	£ 204 (€ 300)

Cooling from a fan with three selectable levels. The output may be switched on and off with a separate button and the controls may be 'locked'.

Hameg HM7042-5

Conversion	mixed
Output 1 en 2	0-32 V (Δ 10 mV) @ 0-2 A (Δ 1 mA)
Adjustment	2 x V rotary control (analogue, 'coarse'/'fine'), 1 x I rotary control (analogue)
Readout	4 x 4-digit LED display (I and V separately)
Output 3	0-5.5 V @ 0-5 A
Adjustment	2 x rotary control (analogue, I and V separately)
Readout	2 x 4-digit LED display (I and V separately)
Ripple	< 0.2 mV_{RMS} (24 Ω @ 1/3 V_{max})
Load regulation	< 0.2 V / 11 µs (V_p/t_p) – 10 mV (V_s) (24/12 Ω)
Dimensions	285 x 90 x 389 mm (w x h x d) – 7.4 kg

The control buttons are fairly small, but the PSU does have an extra button to switch the output on and off. The fan is quiet and temperature controlled.

RRP £ 376 (€ 554)

Hameg HM7044

Despite the multitude of buttons and extensive features (including tracking and copying channel settings), this instrument remains easy to control thanks to a well designed user interface. The individual channels of this supply are also suitable for series and parallel operation.
The quality of the load response cannot be expressed in numbers. Even if we disregard switch-on and switch-off effects, at the load frequency used this supply has trouble getting back to the set value. The static error however remains within the manufacturer's specifications (100 mV).

Conversion	mixed
Output 1 t/m 4	0-32 V (Δ 10 mV) @ 0-3 A (Δ 1 mA)
Adjustment	keypad and rotary control (digital)
Readout	8 x 4-digit LED display (I and V separately)
Ripple	< 0.4 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	*see text below
Interface	RS232
Dimensions	285 x 125 x 380 mm (w x h x d) – 8.5 kg
RRP	£ 1161 (€ 1708)

Hameg HM8142

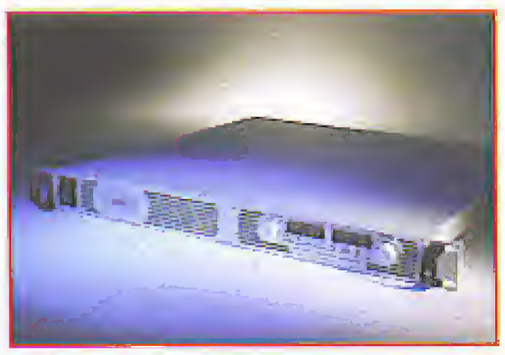
With this supply, more than average attention has been given to the user interface. Moreover, this instrument offers a few extras like 'remote sense' mode, an optional external keypad and an output switch.

Conversion	linear
Output 1 t/m 4	0-30 V (Δ 10 mV) @ 0-1 A (Δ 10 mA)
Adjustment	2 x rotary control, pushbuttons for 'fine' adjustment
Readout	4 x digital (I and V separately)
Output 3	5 V @ 2 A
Ripple	< 2.5 mV_{RMS} (24 Ω @ 1/3 V_{max})
Load regulation	< 1.6 V / 0.2 ms (V_p/t_p) – 22 mV (V_s) (24/12 Ω)
Interface	GPIB, RS232 (incl. software)
Dimensions	285 x 85 x 365 mm (w x h x d) – 10 kg
RRP	£ 797 (€ 1173.92)

HQ-POWER PS603

This supply is 'basic' in every respect; for example the user manual consists of just two pages. The performance is however exemplary. Not available to the UK market because of incompatible mains plug.

Conversion	linear
Output 1	0-30 V @ 0-2.5 A
Adjustment	2 x rotary control (analogue)
Readout	2 x analogue (I and V separately)
Output 2	12 V @ 1 A
Output 3	5 V @ 1 A
Ripple	< 0.2 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 0.9 V / 77 µs (V_p/t_p) – 19 mV (V_s) (8/4 Ω)
Dimensions	150 x 145 x 200 mm (w x h x d) – 2.8 kg
RRP	£ 61 (€ 89.95)



Lambda Genesys GEN6-200

The fan is fairly noisy, however this supply is designed for stacked use without space between units. This power supply is clearly intended for professional applications: the output terminals are located on the rear panel, the instrument is prepared for series and parallel configurations and the options for remote control are extensive.

Conversion	switch-mode
Output	0-6 V (Δ 10 mV) @ 0-200 A (Δ 10 mA)
Adjustment	2 x digital rotary control (I and V separately, individual 'fine' mode)
Readout	2 x 4-digit LED display (I and V separately)
Ripple	< 0.6 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	*see text below
Interface	analogue, RS232 en RS485 (GPIB optional)
Dimensions	423 x 44 x 434 mm (w x h x d) – 8.5 kg
RRP	£ 1150 (€ 1692) (excl. VAT)

** The load regulation is disregarded in this case. Considering the current capacity of this PSU, the 'test load' used was deemed insufficient to evaluate the supply's behaviour within its normal operating rangebecordelen.*

Lambda ZUP20-10

With this supply, provision is made to interconnect several identical instruments. The PSU has an active, controlled cooling. Apart from employing an 'overvoltage protecting', users are able to set a lower limit as well ('underprotection'). The connecting terminals are located on the rear panel.

Conversion	switch-mode
Output	0-20 V (Δ 100 mV) @ 0-10 A (Δ 100 mA)
Adjustment	1 x digital rotary control
Readout	2 x 4-digit LED display (I and V separately)
Ripple	< 0.3 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 1.2 V / 30 µs (V_p/t_p) – 24 mV (V_s) (8/4 Ω)
Interface	analogue, RS232 en RS485 (GPIB optional)
Dimensions	70 x 124 x 350 mm (w x h x d) – 2.8 kg
RRP	£ 652 (€ 959) (excl. VAT)

Motech LPS302

Conversion	linear
Output	0-30 V (Δ 10 mV) @ 0-2 A, < 16 V ; 0-4 A (Δ 2 mA)
Adjustment	pushbuttons
Readout	2-line back-lit LC display (I and V simultaneously)
Ripple	< 0.4 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 0.2 V / 0.2 ms (V_p/t_p) – 58 mV (V_s) (8/4 Ω)
Interface	RS232 (optional)
Dimensions	221 x 86 x 300 mm (w x h x d) – approx. 5.5 kg
RRP	£ 221 (€ 326) (excl. VAT) (p.o.a. for industrial users)

This power supply is clearly aimed at the industry. The desired current and voltage can only be adjusted with buttons, which is less convenient in situations requiring lots of adjustments. The active cooling is powerful at the cost of some added noise.

Motech PPS1002

Conversion	linear
Output	0-18 V (Δ 5 mV) @ 0-4 A (Δ 2 mA)
Adjustment	numeric keypad
Readout	2-line back-lit LC display (I and V simultaneously)
Ripple	< 0.4 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 1.0 V / 55 µs (V_p/i_p) – 23 mV (V_s) (8/4 Ω)
Interface	analogue, GPIB
Dimensions	213 x 132 x 399 mm (w x h x d) – approx. 7 kg
RRP	£ 545 (€ 802) (excl. VAT) (p.o.a. for industrial users)

The display is difficult to read at an angle, which can be a problem in certain lab configurations. This PSU is compatible with National Instrument's Labview and Measurement Studio. Calibration is an option and the supply offers 'remote sensing' functionality. The fan is not temperature-controlled and makes rather more noise than necessary when the PSU is not loaded.

Peaktech 1885

Conversion	switch-mode
Output	0-40 V (Δ 100 mV) @ 0-5 A (Δ 10 mA)
Adjustment	numeric keypad, rotary control (digital)
Readout	LC display (I, V and P at 4 digits)
Ripple	< 0.2 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 0.3 V / 1.8 ms (V_p/i_p) – 73 mV (V_s) (8/4 Ω)
Interface	RS232, RS485 (including software)
Dimensions	193 x 98 x 215 (w x h x d) – 3 kg
RRP	£ 275 (€ 405)

A pity the adjustment knob jams a little. This PSU did not strike us as professional although it does offer a lot of functionality. Bells and whistles include active temperature-driven cooling, 'save/recall' functionality for the settings, a 'lock' button (keyboard and rotary control protection) and a separate button that allows the output to be isolated or switched on.

Peaktech 6035D

Conversion	linear
Output 1	0-30 V (Δ 100 mV) @ 0-3 A (Δ 10 mA)
Adjustment	2 x rotary control (analogue)
Readout	2 x 3-digit LED display (I and V separately)
Output 2	12 V @ 0.5 A
Output 3	5 V @ 0.5 A
Ripple	< 0.2 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 4.9 V / 5.5 µs (V_p/i_p) – 44 mV (V_s) (8/4 Ω)
Dimensions	170 x 260 x 150 (w x h x d) – 5.3 kg
RRP	£ 105 (€ 155)

A good enough supply with proper controls and fine legibility of the displays..

Rohde&Schwarz NGMD35

Conversion	linear
Output 1 en 2	0.01-35 V @ 0.01-1 A
Adjustment	4 x 10-turn rotary control (analogue, I and V separately)
Readout	1 x moving-coil meter (I en V combined)
Ripple	< 0.2 mV_{RMS} (24 Ω @ 1/3 V_{max})
Load regulation	< 1.2 V / 44 µs (V_p/t_p) – 8.8 mV (V_s) (24/12 Ω)
Dimensions	190 x 184 x 278 mm (w x h x d) – 8 kg
RRP	approx. £ 1292 (€ 1900) (excl. VAT)

A no-frills power supply: the moving coil meters now look unusual but of course function just like their digital equivalents.

Toellner TOE8871

This 'pro' has huge terminals at the rear side — fortunately they also accept ordinary banana plugs. As a very handy feature, a click sound is produced by an internal loudspeaker when one of the controls is operated. As a matter of course this instruments has various features found on other professional and high-end instruments, including an 'enable output' input and 'sense' connections for regulating the voltage at the load (instead of at the supply output).

Conversion	linear
Output	0-40 V (Δ 10 mV) @ 0-50 A (Δ 10 mA)
Adjustment	2 x digital rotary control
Readout	2 x 4-digit LED display (I and V separately)
Ripple	< 0.4 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 1.3 V / 5.5 µs (V_p/t_p) – 19 mV (V_s) (8/4 Ω)
Interface	analogue, RS232, GPIB
Dimensions	445 x 147 x 557 mm (w x h x d) – approx. 15 kg
RRP	£ 1839 (€ 2705) (excl. VAT)

Toellner TOE8733-1

A solid and well finished power supply that's beyond any reproach.

Conversion	linear
Output 1 en 2	0-16 V (Δ 10 mV) @ 0-2 A (Δ 1 mA)
Adjustment	4 x 10-turn rotary control (I and V separately)
Readout	2 x LED display (I en V combined)
Output 3	0-7 V (Δ 10 mV) @ 0-5 A (Δ 1 mA)
Adjustment	2 x 10-turn rotary control (I and V separately, analogue)
Readout	1 x digital LED display (I and V combined)
Ripple	< 0.1 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 0.4 V / 44 µs (V_p/t_p) – 4.4 mV (V_s) (8/4 Ω)
Interface	analogue (optional)
Dimensions	264 x 146 x 314 (w x h x d) – 8.6 kg
RRP	£ 765 (€ 1125) (excl. VAT)

TTI E355P

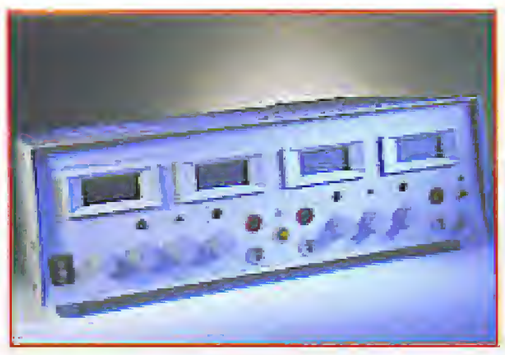
Despite the fact that this supply has passive cooling, the cabinet does not run particularly hot. A switch is available for instant load isolation.

Conversion	mixed
Output	0-35 V (Δ 10 mV) @ 0-5 A (Δ 10 mA)
Adjustment	3 x rotary control (1 x I and separate 'fine'- and 'coarse' control for V)
Readout	1 x 3-digit LED-display (I), 1 x 4-digit LED-display (U)
Ripple	< 1.9 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 1.7 V / 44 µs (V_p/i_p) – 22 mV (V_s) (8/4 Ω)
Interface	RS232 (incl. software and cable)
Dimensions	140 x 160 x 320 mm (w x h x d) – < 4.4 kg
RRP	£ 335 (€ 494)

Voltcraft DPS2010

A small delay may be observed between operating the rotary control and the changed value on the display. This makes the supply a little difficult to control. A further peculiarity is that 'unlocking' the supply controls is barely noticeable when the keyboard is enabled. This makes unlocking haphazard and rather awkward. The output on/off switch however is very useful and handy.

Conversion	mixed
Output	0-20 V (Δ 10 mV) @ 0-10 A (Δ 10 mA)
Adjustment	rotary control ('coarse' and 'fine')
Readout	back-lit LC display (I, V and P simultaneously)
Ripple	< 1.1 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 1.1 V / 1,7 ms (V_p/t_p) – 22 mV (V_s) (8/4 Ω)
Interface	RS232
Dimensions	275 x 135 x 300 (w x h x d) – 3 kg
RRP	£ 142 (€ 209)



Voltcraft PS2403PRO

Although this PSU runs very hot (passive cooling), our general impression is positive even if the transformer was found to produce some hum.

Conversion	linear
Output 1 en 2	0-40 V (Δ 100 mV) @ 0-3 A (Δ 10 mA)
Adjustment	1 x I rotary control, 2 x V rotary control ('coarse' and 'fine')
Readout	LC display (I en V displayed separately per channel)
Output 3	3-6 V @ 2 A
Adjustment	potentiometer
Readout	via separate monitor button on LC display of channel 1 and 2
Ripple	< 0.2 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 0.9 V / 0.2 ms (V_p/t_p) – 18 mV (V_s) (8/4 Ω)
Dimensions	380 x 138 x 280 (w x h x d) – 10 kg
RRP	£ 146 (€ 215)

Xantrex XFR60-20

Conversion	switch-mode
Output	0-60 V (Δ 5 mV) @ 0-20 A (Δ 10 mA)
Adjustment	2 x 10-turn rotary control (I and V separately)
Readout	2 x 3-digit LED display (I and V separately)
Ripple	< 5.1 mV_{RMS} (8 Ω @ 1/3 V_{max})
Load regulation	< 4.2 V / 61 µs (V_p/t_p) – 0.2 V (V_s) (8/4 Ω)
Interface	analogue, (optionally GPIB and RS232)
Dimensions	483 x 88 x 533 mm (w x h x d) – approx. 15 kg
RRP	approx. £ 816 (€ 1200)

Unfortunately the fan inside this PSU is fairly noisy but that is not surprising in view of the massive power capacity and the enclosure of this professionally designed power supply. The input and output connections are located at the rear panel (screw clamps). Extra features include an (adjustable) overvoltage protection. The supply comes with a five-year warranty.

Elektor Electronics would like to thank the following companies for making demo power supplies available:

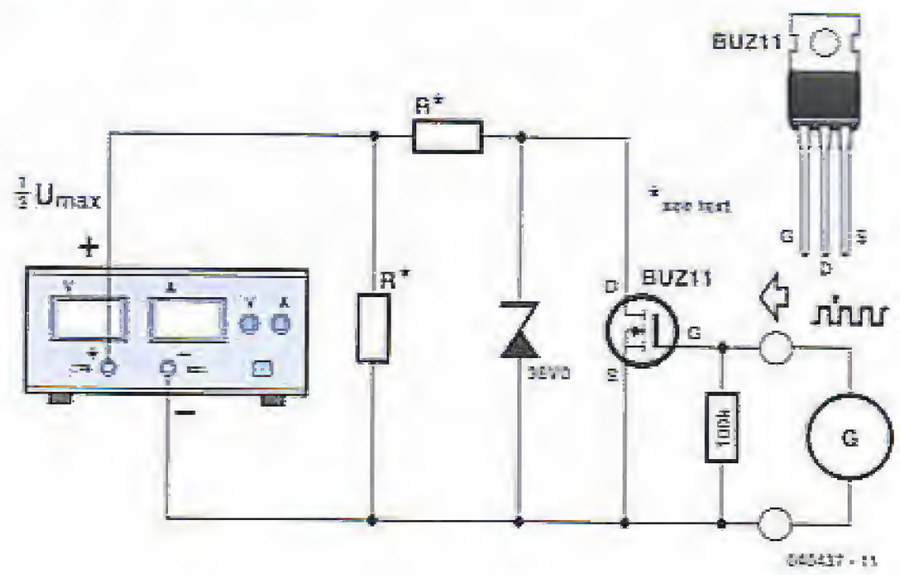
Abtronix	www.abtronix.com	TTI
Agilent	www.agilent.com	Agilent
Air-Parts	www.air-parts.com	Lambda, Toellner
Conrad Electronic	www.conrad.com	Elektro Automatik, Voltcraft
Delta Elektronica	www.delta-elektronika.nl	Delta
Elipse	www.elipse.be	Elipse
EMV Benelux	www.emv.nl	Xantrex
ELV Elekironik	www.elv.de	ELV
GMC-Instruments	www.gmc-instruments.com	GMC
Hameg	www.hameg.com	Hameg
Havé-Digitap	www.have-bv.nl	GW-Instek
Heinz-Günter Lau	www.peaktech.de	Peaktech
MUCO Technologies	www.muco-technologies.nl	Motech
PrinTec	www.printec.nl	BK Precision
Rohde & Schwarz	www.rohde-schwarz.com	Rohde & Schwarz
Velleman	www.velleman.be	HQ-POWER

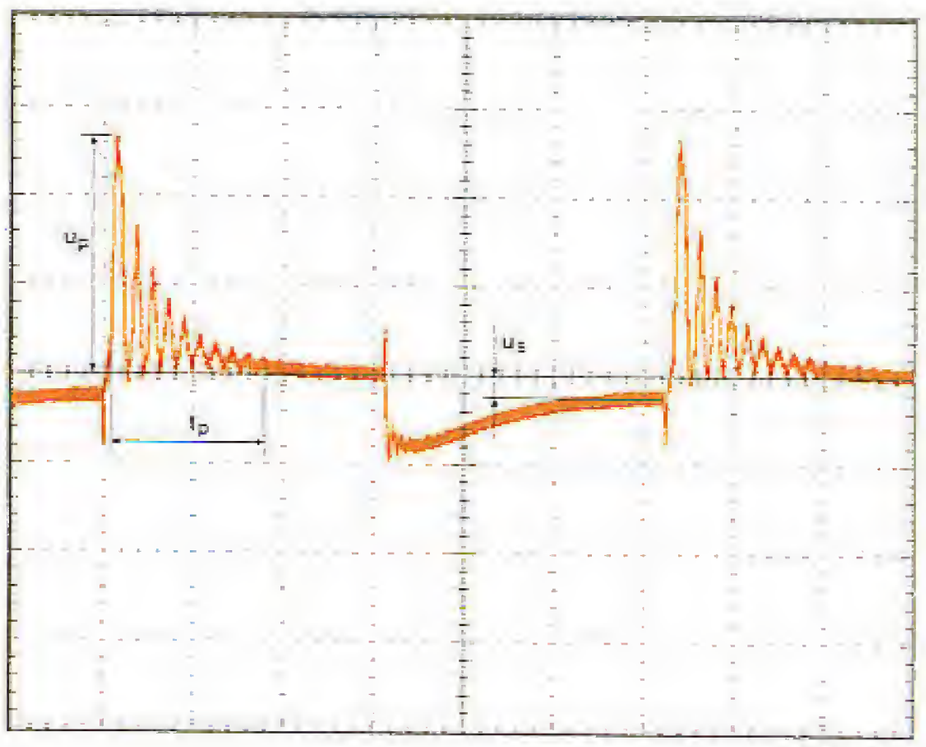
Appendix: PSU Regulation Tester

The measurement method for the 'load regulation' is illustrated in Figure 1. The power supply under test is adjusted to one third of the maximum output voltage. This setting guarantees that the power supply and its variable load are used within their normal operating areas. The load consists of a static part to which, under pulse control, an identical load is connected in parallel. The switching frequency is set at 300 Hz, a value obtained from experimentation. Although most supplies will be able to cope with the 300-Hz variable load, the frequency is high enough to give them a rough time. After all, such a load will typically cause an output signal that will closely resemble the one indicated in Figure 2. This image was produced using an AC-coupled oscilloscope — hence you will see the 'alternating voltage' component resulting from the second load being switched on and off under pulse control. We first come across a peak as a result of the load being switched off (V_p). This peak is damped within a time t_p. Next, the voltage can be seen to sag a little when the load is switched on and rises gradually. However, until the load is switched off again, the output voltage does not return to the original value. The remaining difference is called V_s.

The screenshot shown in Figure 2 only serves to explain the measured parameters. Fortunately, in practice the ratios are different and t_p will be much shorter resulting in a smaller surface area under the peak(s). And that's good news because the surface area determines the energy contained in the peak. The smaller the surface area, the better because this energy can damage, or in any case harm, the load connected to the PSU. This is crucial with, for example, digital circuitry; an integrated circuit operating at 3.3 V may not be powered at a much higher voltage for a considerable period.

Here, the ubiquitous BUZ11 is used but any reasonably compatible type will do just as well. We drove the FET gate with a positive voltage between 0 and 10 V by connecting a 300-Hz square-wave generator adjusted to an output level of 5 V_{pp} with a DC-offset of 2.5 V. Zener diode D1 protects the FET against a too high output voltage (accidentally) set on the PSU under examination.





(040437-11)

Cuk Topology

Little-known but still highly interesting

Georg Gerads

The topology of the Cuk converter was first published in the 1980s, but it is rarely encountered in practice even today. However, this circuit concept offers enticing advantages for many power supply applications.

The Cuk converter is a capacitively coupled converter that generates an adjustable output voltage and current by periodically charging a capacitor. As the circuit (in its simplest form) does not provide electrical isolation between the input and output, it is suitable for secondary-side switched-mode power supplies or chargers.

Symmetry

Figure 1 illustrates the operating principle of the Cuk converter. The output voltage can adjusted anywhere between 0 V and a several times the input voltage by varying the duty cycle of switch S. This circuit thus combines the characteristics of a step-down converter and a step-up converter, while using only a single semiconductor switch and just one inductor. This outstanding property gives designers access to a wide range of highly interesting applications. If the converter is used as a battery charger, a battery having any desired voltage can not only be charged from a 12-V storage battery, but also discharged back into the storage battery. It makes no difference whether the battery in question is (for example) a 6-V battery or a 60-V battery. When the battery is discharged, the energy is fed back into the original battery with a high level of efficiency, instead of being dissipated as heat in a resistor or semiconductor device in the usual manner. Not only does this save energy, it also allows batteries to be quickly discharged at high currents.

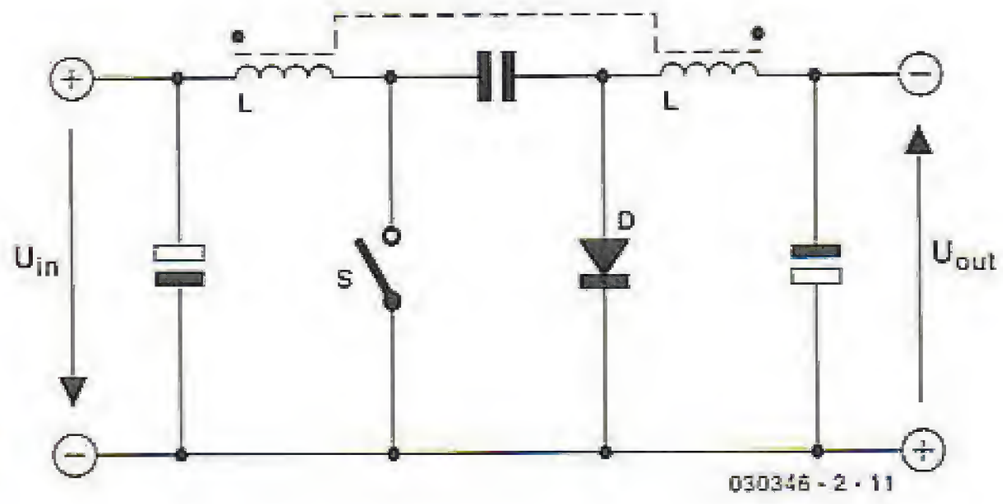


Figure 1. The topology of the Cuk converter...

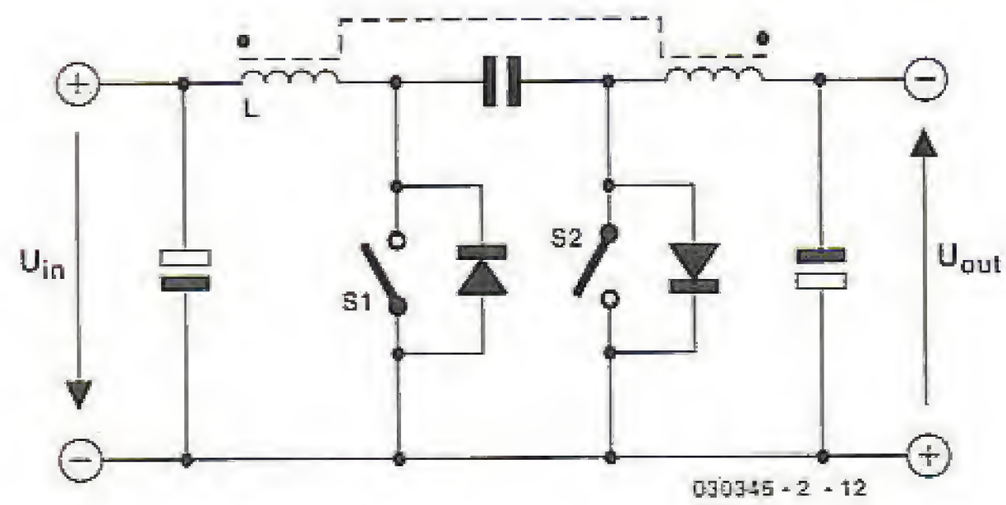


Figure 2. ...is symmetrical...

Another interesting application results from the symmetry of the circuit. If diode D is replaced by a second switch and FETs or IGBTs with integrated free-wheeling diodes are used in the implementation, the result is a bidirectional converter (**Figure 2**). When T1 is driven, energy is transferred from voltage source U_{in} to U_{out}, while when T2 is driven, energy is transferred in the opposite direction. Here again the values of U_{in} and U_{out} are not important, and the desired current level is determined by the duty cycle of whichever transistor is being driven.

Voltage isolation

For certain applications, such as primary-side switched-mode power supplies, the input and output voltages must be isolated from each other.

This is also possible with the Cuk converter. As shown in **Figure 3**, the input and output can be isolated using an additional capacitor and a high-frequency or 'planar' transformer. A planar transformer has a core that contains relatively little ferrite and has an extremely large cross section. Using such a transformer, it is possible to obtain winding voltages of 100 V or more, and 5 kW of power in a 150-g package can easily be achieved thanks to the small number of turns required at 500 kHz (see www.paytongroup.com).

This version of the circuit also retains all the other properties. Any desired voltage ratio can be set using the turns ratio and capacitance ratio shown in the circuit diagram. In the isolated version of the circuit, the overall efficiency

FOR SWITCHED-MODE POWER SUPPLIES

is lower due to the additional magnetisation losses and conversion losses in the transformer. An efficiency of more than 96% can easily be achieved by the circuit without a transformer, but 92% or better is still possible with a transformer.
Besides the fact that the circuit configuration is the same for all power levels, the Cuk converter can also be used over a wide range of powers. The topology is equally suitable for small power supplies in the watt range and larger power supplies in the kilowatt range.

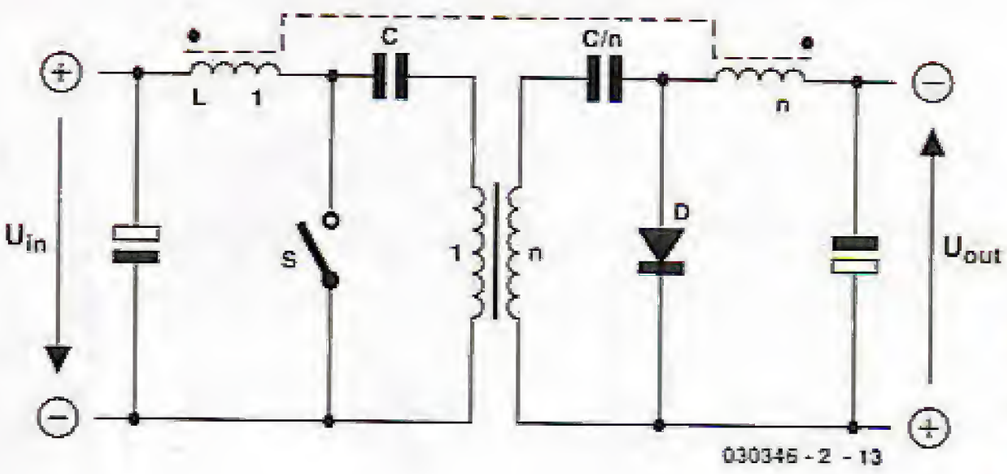


Figure 3. ...and can also be made to provide voltage isolation.

Operation

To understand how the converter works, you need to have a basic understanding of how inductors behave. When a dc voltage is applied to an inductor, the current increases linearly from an initial value of zero with a slope $di/dt = U/L$. When the voltage is switched off, the current decreases, again with a linear slope. This is accompanied by a negative voltage across the inductor. As an inductor cannot accumulate a dc voltage, the magnitude of the negative voltage assumes a level such that the areas of the voltage–time rectangles F1 and F2 in **Figure 4** are identical.
The negative voltage across the inductor depends on the duty cycle, which is the ratio of the 'on' and 'off' times of the switch. At a 50% duty cycle, the amplitudes of the applied and induced voltage are the same (b); below 50% the amplitude of the induced voltage is less than that of the applied voltage (a), and above 50% it is greater (c).

$$U_{L-} = (1 - a) / a\ U_{in}$$

Very high negative voltages occur at large duty cycles. This must be taken into account during circuit design by selecting suitable semiconductor devices and limiting the maximum possible duty cycle.
These observations presume that there is a free-wheeling circuit that accepts the current from the inductor after the switch is opened. If such a circuit is not present, the amplitude of the voltage across the inductor will rise to such a high level that flashover will occur at the switch. Even in this case, the areas of F1 and F2 are still equal. The allowable saturation inductance (which is proportional to the area of F1) must also be taken into account in designing the inductor. If the saturation inductance is exceeded, the inductor loses its inductive properties and instead behaves like a short circuit. If this happens, the current no longer increases linearly, but instead rises to a value that is limited only by the ohmic resistance of the coil. This means that the risk of saturation does not depend on the power level, but only on the voltage and frequency.

In a Cuk converter, switch S is periodically closed and opened with a duty factor *a*. When S is closed, the voltage across the inductor is equal to the input voltage. The behaviour of the voltage and current are shown in **Figure 5a**. After S is opened, current i_{i2} continues to flow through the free-wheeling diode D and charges capacitor C to $U_{in} + U_L$, as shown in **Figure 5b**.
If switch S is now closed again, the capacitor at the output is charged to $U_C - U_L$. As a result, the output voltage is equal to the inductor voltage shown in Figure 5b, which means the voltage during the free-wheeling interval. This voltage depends only on the duty cycle *a*, and as previously stated, it can be adjusted to a value anywhere between 0 V and a several times the input voltage.
The circuit has the same form for all power levels. The amplitude of the output voltage can be considerably greater than that of the input voltage with a high duty cycle, while

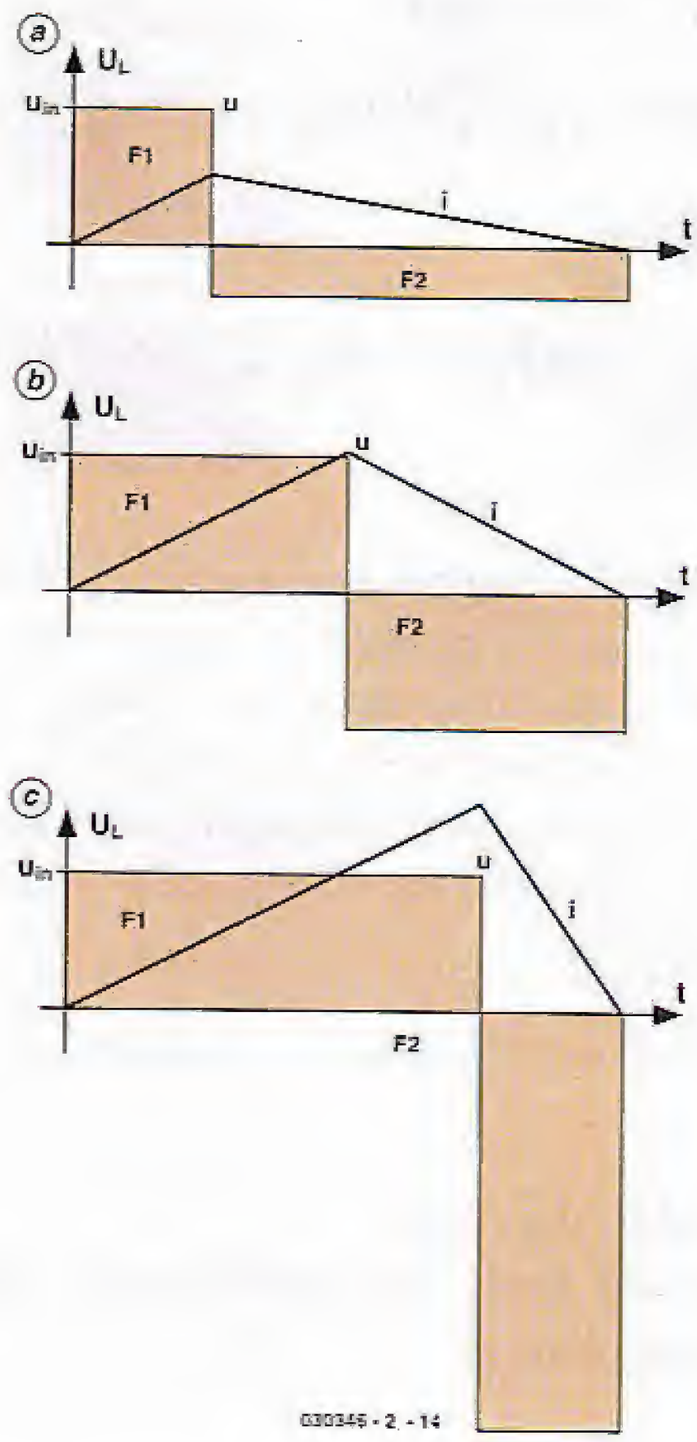


Figure 4. The voltage–time area is always the same, regardless of the dut cycle.

Slobodan M. Cuk

As a professor and head of the Power Electronics Group at the renowned California Institute of Technology (Caltech), Dr Slobodan Cuk (pronounce: "chook") and his colleague Robert Middlebrook developed switched-mode power supply applications in the late 1970s based on a topology that was just as clever as it was novel. This 'CuKonverter' technology is distinguished by constant input and output currents, in which respect it resembles conventional dc converters. Since its invention, the CuKonverter has been marketed for industrial and military applications by the company TESLAco. Besides serving as head of this company, Dr Cuk still gives courses on the subject of power electronics and switched-mode converters.

His principal 'literary' work consists of three practically oriented volumes titled *Advances in Switched-Mode Power Conversion*, which contain the collected working papers of the Caltech Power Electronics Group. They are available from TESLAco (http://www.teslaco.com/teslaco.html)

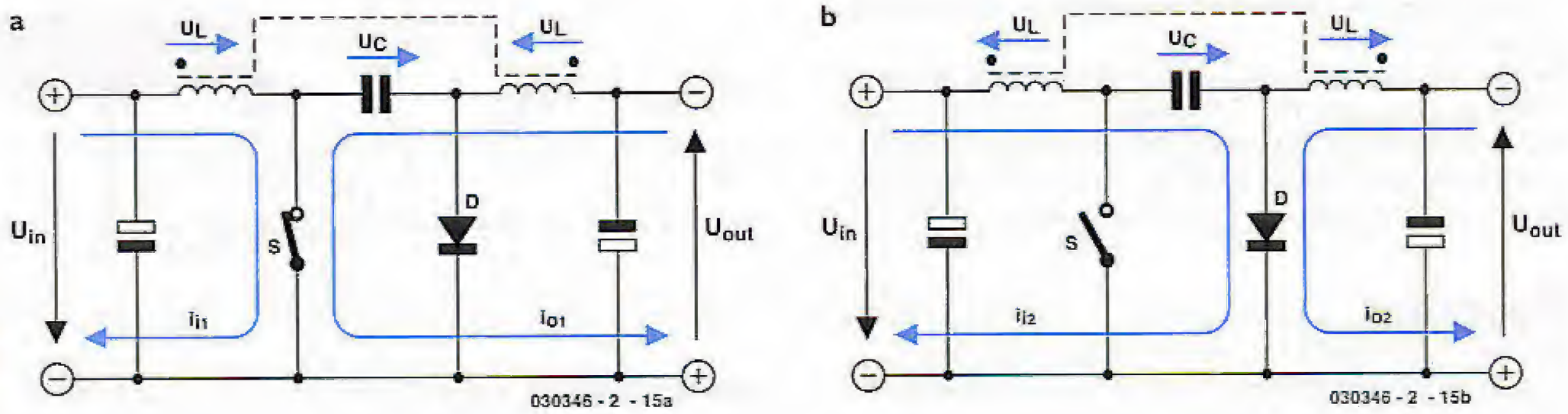


Figure 5. Voltage and current curves of the Cuk converter.

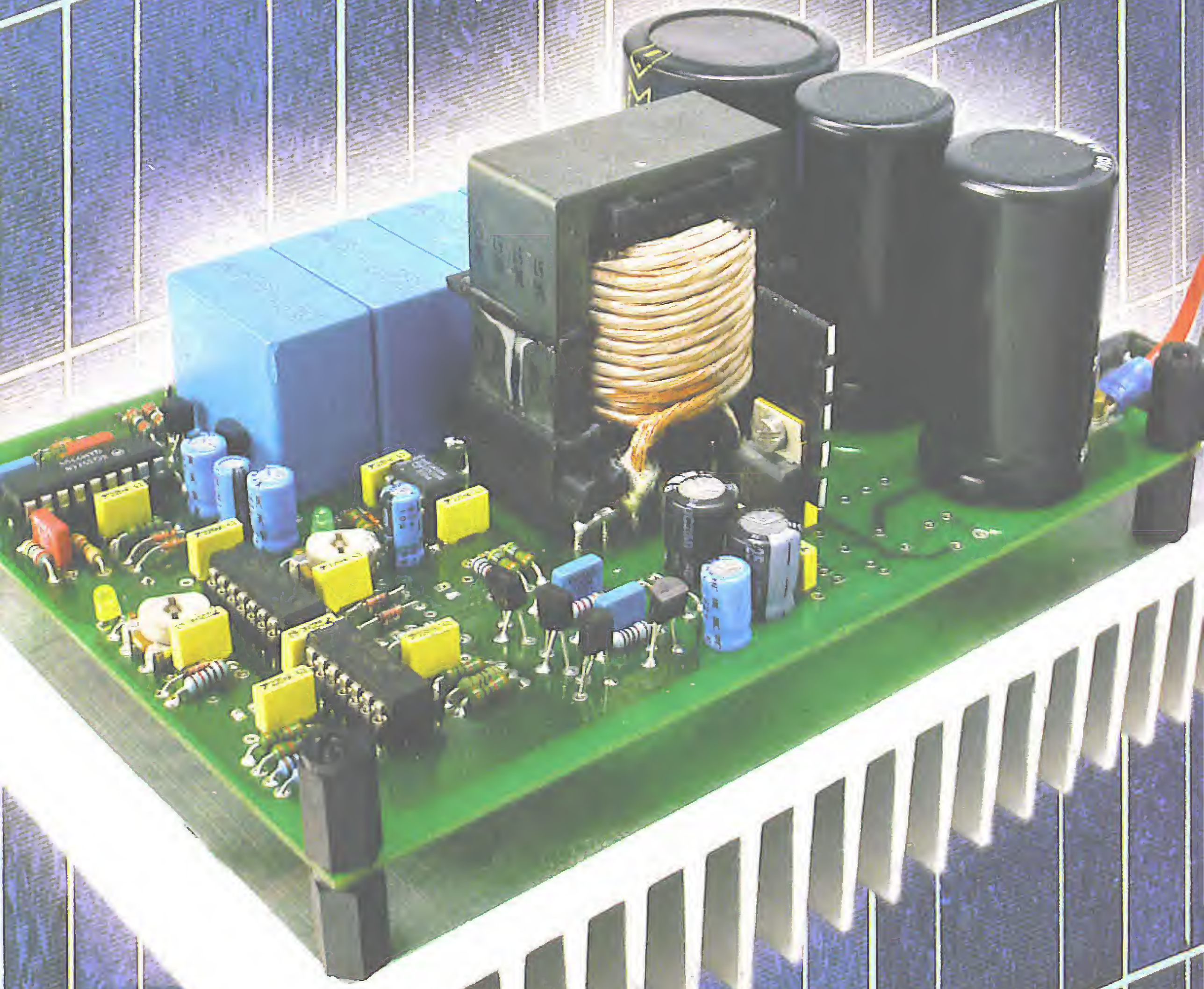
the output current can be vastly greater than the input current with a low duty cycle. The currents and applied voltages that the switching transistor and diode have to handle must be taken into account in selecting suitable components and designing the circuit. Measures must also be taken to limit the maximum current and duty cycle, in order to protect the components under all load conditions.

(030346-1)

Cuk Converter

Georg Gerads

The operating principle of the Cuk Converter avoids the need for particularly exotic components. That means we can right away take the plunge with a 'heavy-duty' dc converter, which is ideal for use with fluctuating energy sources such as solar systems.



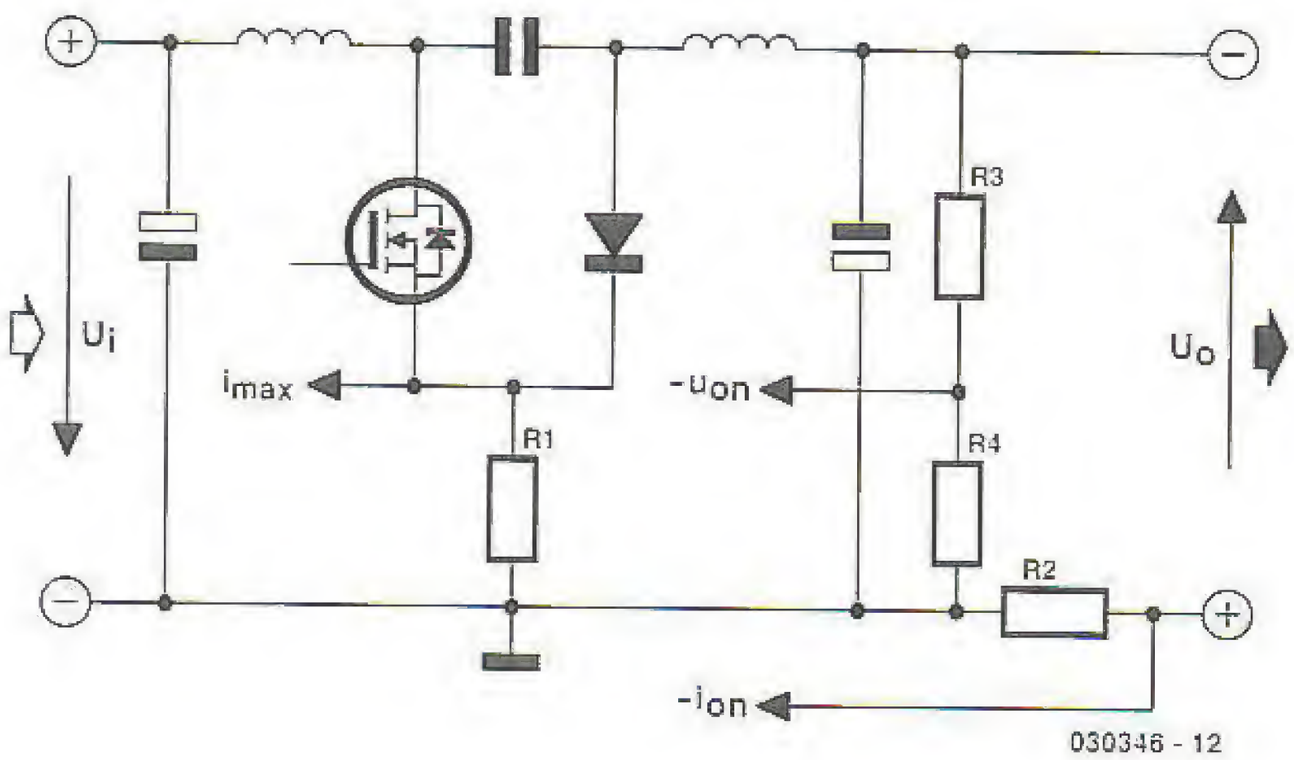


Figure 1. The input current, output current and output voltage can be measured as shown here.

Cuk Converter specifications

Type	Secondary-side switched-mode
Topology	CuK
Input voltage	20–45 VDC 18–35 VAC
Output voltage	0–100 V
Output current	0–5 A
Power	500 W
Continuous power	U_{in} = 35 V 500 W U_{in} = 30 V 400 W U_{in} = 25 V 300 W
Efficiency	> 85 %

The Cuk Converter[1] topology yields a theoretically infinite variety of currents and voltages. Consequently, all relevant parameters must be monitored, and conditions that could destroy the semiconductor devices used in the circuit must be avoided. The important parameters are the input current, the output voltage and the output current. **Figure 1** shows how these quantities are measured. The voltage across the source resistor of the switching transistor (R1) is used to limit the input current i_i and set the short-circuit protection level. The output voltage U_o is regulated by monitoring the voltage U_{on} obtained using voltage divider R3/R4, and the output current i_o is measured by simply inserting a sense resistor (R2) in the output lead.

Measurement circuitry power supply

U_{on} and i_{on} are negative with respect to ground, so the circuit requires a bipolar power supply. If the Cuk Converter is operated from a transformer, the negative supply voltage can easily be generated using the capacitor charge-transfer arrangement shown in **Figure 2**. Besides the bridge rectifier and smoothing capacitor, this requires two additional diodes and capacitors. Of course, the negative supply can only power a light load, but that's all we need here.

If the circuit is operated from a battery, the negative auxiliary voltage can be generated by using a simple charge pump to periodically transfer charge to and from a capacitor , as shown in **Figure 3**. In this case, the switch actually consists of an astable multivibrator followed by a power stage. The printed circuit board for the Cuk Converter is designed to accommodate both options and the unnecessary components can simply be omitted.

A control transformer with a secondary voltage of 24 VAC and a 500-VA power rating is a good choice for the power supply. Suitable types are readily available and quite inexpensive. Without a load, such a transformer will provide a voltage of around 35 V after rectification. This is also the upper limit for the input voltage of the two fixed voltage regulators.

Naturally, even higher secondary voltages can also be used. This improves the efficiency of the circuit, since the power stage can by operated with a smaller duty cycle and lower current levels. However, in this case you must do something to reduce the voltage at the regulator inputs, such as inserting Zener diodes in series with the input leads. These Zener diodes must be able to dissipate a rather hefty amount of power.

Bridge rectifier B1 also has to be able to dissipate a relatively large amount of power (as much as 15 W). The total thermal resistance to ambient for the high-power devices and heat sink should not exceed 1 K/W. It is recommended to fit the components to a heat sink, but if this is not possible, a small fan should be used.

Power section

The power section of the Cuk Converter (see **Figure 4**) corresponds to the block diagram in nearly all respects. Some of the components are present in duplicate or triplicate, in order to handle the rather high currents. The circuit's high-power switching element is formed by two power MOSFETs made by Ixys, a California-based semiconductor manufacturer (see www.ixys.com/deurope.html for distribution information). The type IXFK90N30 transistor can be used with drain–source voltages up to 300 V and currents up to 90 A (at 25 °C), and it has an integrated source–drain diode with a recovery time less than 250 ns. The 'on' resistance of the drain–source channel is specified as 33 mΩ in the data sheet. In principle, it is also possible to use IBGTs rated at 25 A (at 150 mΩ and 1.8 V).

Diodes D1 and D2 are DSEP60-06A epitaxial soft-recovery diodes from the same manufacturer. They have a specified reverse blocking voltage of 600 V and a forward current rating of 60–70 A. Although this type of diode switches extremely fast (with a recovery time of only 35 ns), it avoids the severe current spikes generated by fast-recovery diodes. If you wish to use a different type, ensure that it has a recovery time of less than 50 ns and a

[1] For good measure we should mention that 'Cuk converter' is a trademark of the TESLAco company. Cuk is pronounced /chook/.

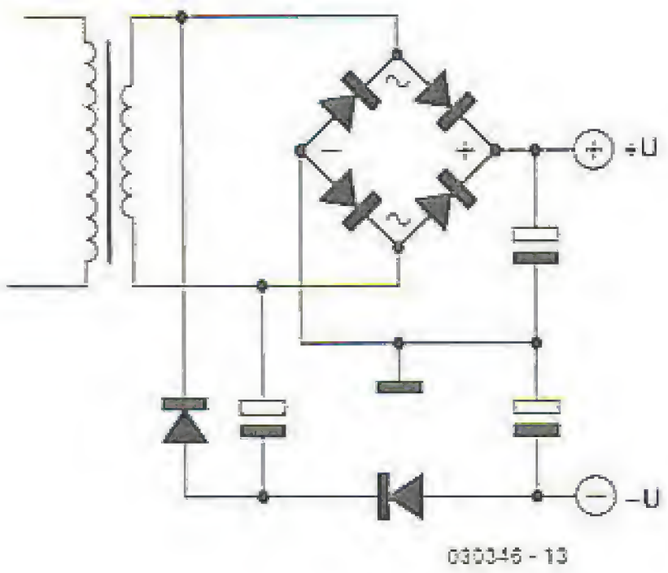


Figure 2. The negative auxiliary voltage can be generated by a capacitive charge-transfer circuit...

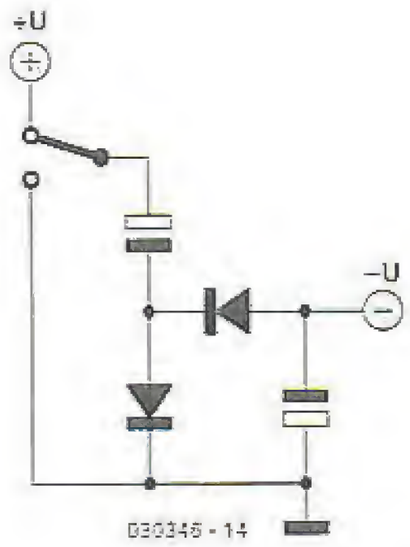


Figure 3. ... or by using a simple charge pump.

forward current rating of at least 30 A. The transistors and diodes must have a specified maximum breakdown voltage of 300 V or more.
The capacitive coupling is provided by four MKT capacitors connected in parallel. 10 µF at 250 V is not exactly a standard catalogue item, but it is certainly available (Vishay 373 series; available from RS Components, Bürklin and Spoerle).

Inductor

Unlike most comparable high-power switched-mode regulators, the design of the inductor is not critical with the Cuk Converter, since it conducts a continuous current instead of being switched. The Epcos type E42/21/20 core, which is made from N27 core material, is quite suitable, readily available and a real bargain at less than 7 pounds (including mounting hardware). The core accessories include a plastic coil former and a sheet-metal clamp for securing the core. In our lab prototype, the job was handled by an LCC type E-45220A core. Spacers cut from 1.5-mm PCB material create a gap with a width of 1.5 mm, which in the case of an E-section core corresponds to an air gap of 3 mm in the magnetic path. Type ETD49 and E47/20/16 cores are also suitable, but the base of the coil former for these types doesn't match the circuit board layout.
Regardless of which type of core is used, 32 turns of 1-mm diameter RF litz (multi-stranded) wire must be wound on the former for each winding, with the wires for the two coils simply being wound in parallel.
Solid enamelled copper wire can also be used, but the insulation breakdown voltage of enamelled copper wire is not all that high. Consequently, the primary winding should be wound first, followed by the secondary, and paper strips must be placed between the layers of the windings.
In either case, pay particular attention to the direction of the windings, since otherwise things will go bang.

Control loops

For monitoring the currents and voltages in the power section and driving the switching transistors, we use a type 3526 IC, which is available from several manufacturers (including TI and ST). Although this is a special-purpose IC, it is a well-proven industry standard and thus fairly well known. Detailed information for this IC is available from the manufacturer's data sheet, so here the block diagram of this pulse-width modulator IC (**Figure 5**) is sufficient for understanding how it works. The 3526 is a PWM controller for push-pull converters, so the drive signals at its outputs (OUT A and OUT B) are pulse-width modulated according to the value of the control variable. The output signals have a maximum duty cycle of 50 % less the dead time, with a phase offset of 180 degrees. Diodes D10 and D11 combine the two output signals. This yields a PWM signal with a duty cycle ranging from 0 to 100 %, less two dead-time intervals.

The internal output drivers obtain their operating voltage via VC (pin 14). As can be seen, R27 limits the current through these transistors to prevent them from becoming excessively saturated, so they won't generate undesirable current spikes during switching transients (both transistors 'on'). The internal transistors don't require a lot of current, since they only have to provide the base currents for a pair of external driver transistors (T3 and T4), which in turn drive the power MOSFETs (T1 and T2).

The period of the oscillator is set to just under 20 μs (equivalent to 50 kHz) by C17 and R28, while R29 sets the dead time to 6 μs. The internal PWM latch is clocked by the oscillator, but it is also affected by the error amplifier (+ERR on pin 1) and the current sense inputs (+CS and –CS). The –ERR input is connected to COMP, so the error amplifier acts as a voltage follower. That's all we need here, since external opamps (IC1 and IC2) are used to amplify and condition the two measured variables U_{on}

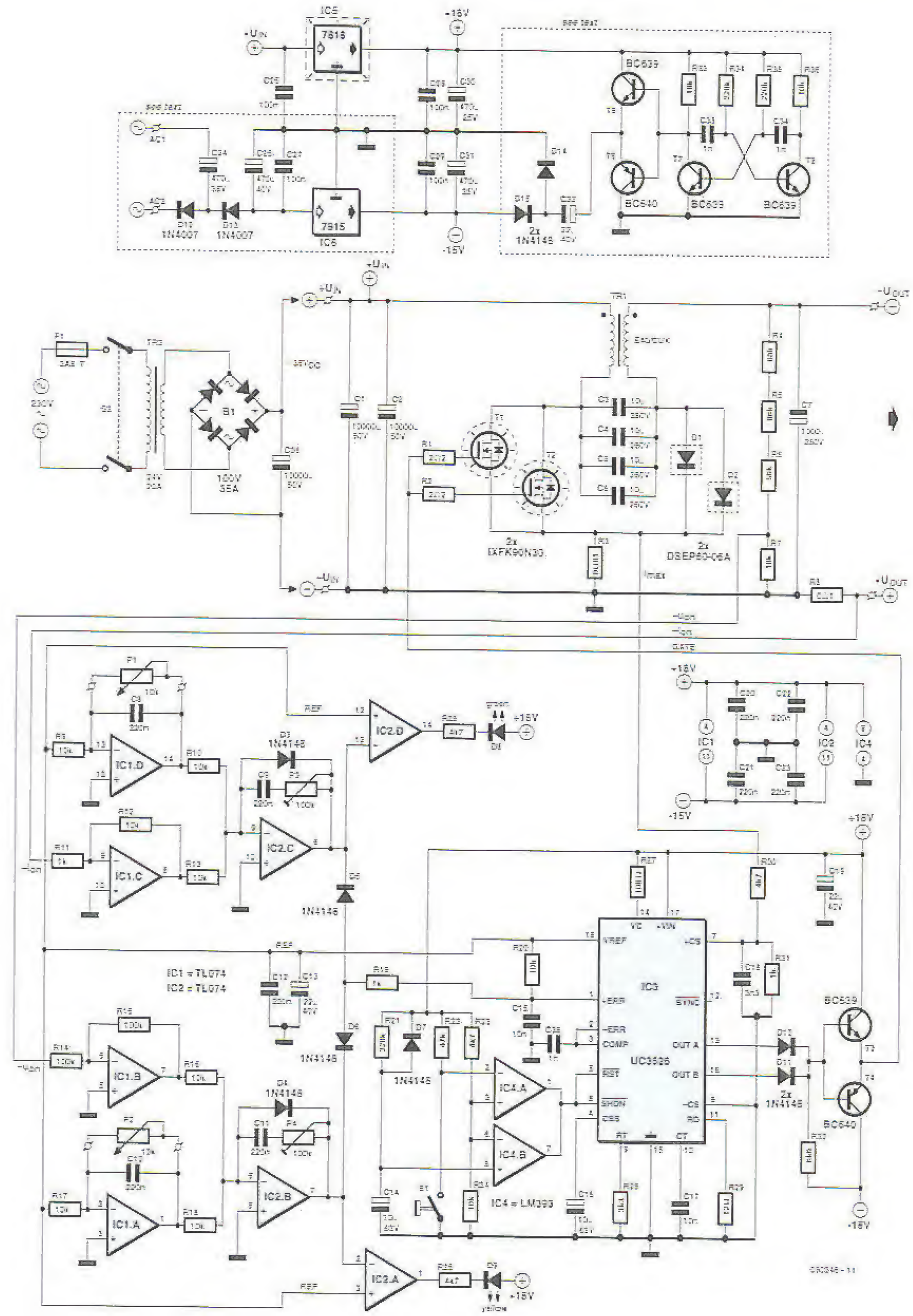


Figure 4. The complete, detailed circuit diagram of the Cuk Converter.

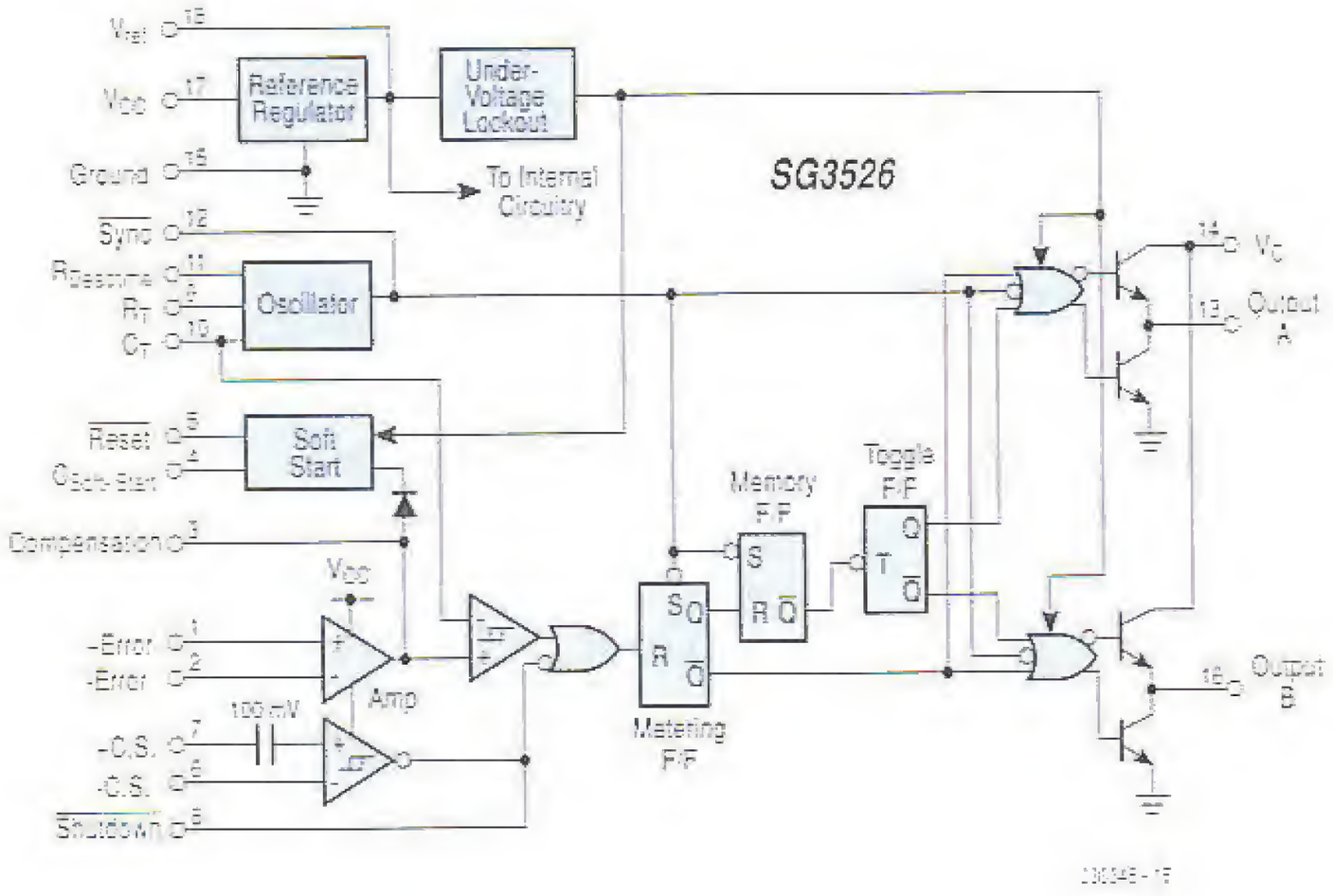


Figure 5. Internal configuration of the 3526.

and I_{on} to suit the requirements of the 3526. This isn't all that simple, since the measured quantities are negative with respect to ground and must be inverted before they can be used by the PWM controller IC.

The reference voltage output VREF (pin 18), which provides exactly +5 V, is used for the signal conditioning circuitry. Opamps IC1d and IC1a invert the reference voltage and allow set-point values in the range of 0 to –5 V to be set by adjusting P1 and P2. The measured quantities, which represent the actual values, are amplified by a factor of –10 by IC1c (for the output current) and IC1b (for the output voltage) and summed with the set-point voltages. Sense resistor R8 and voltage divider R4–R7 are dimensioned such that the voltage at the output of IC1b or IC1c is +5 V for an output current of 5 A or an output voltage of 100 V, respectively.

Each circuit has a control amplifier (IC2b or IC2c) at its output, and the output voltage of the control amplifier is regulated such that the sum of the negative set-point value and the positive actual value is exactly zero. The two signals are ORed via D5 and D6, which causes the lower of the two voltages to reach the input to the error amplifier inside the 3526 and thus determine the duty cycle of the PWM modulator.

The 3526 input is connected via R20 to +5 V, which corresponds to the maximum duty cycle. The lowest voltage on the control amplifier outputs thus always dominates the control loop. The duty cycle always adjusts to meet the demands of whichever control ampli-

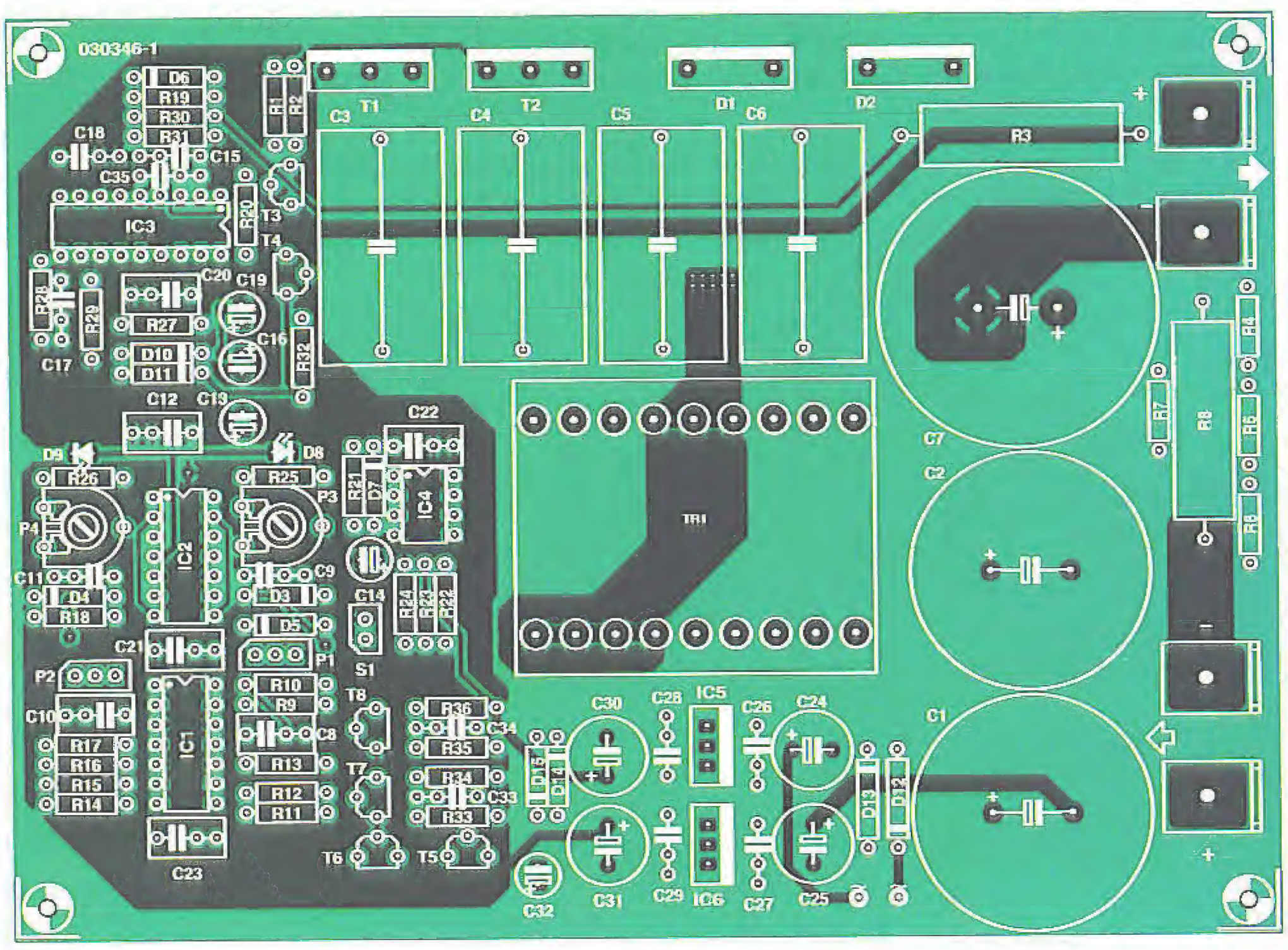
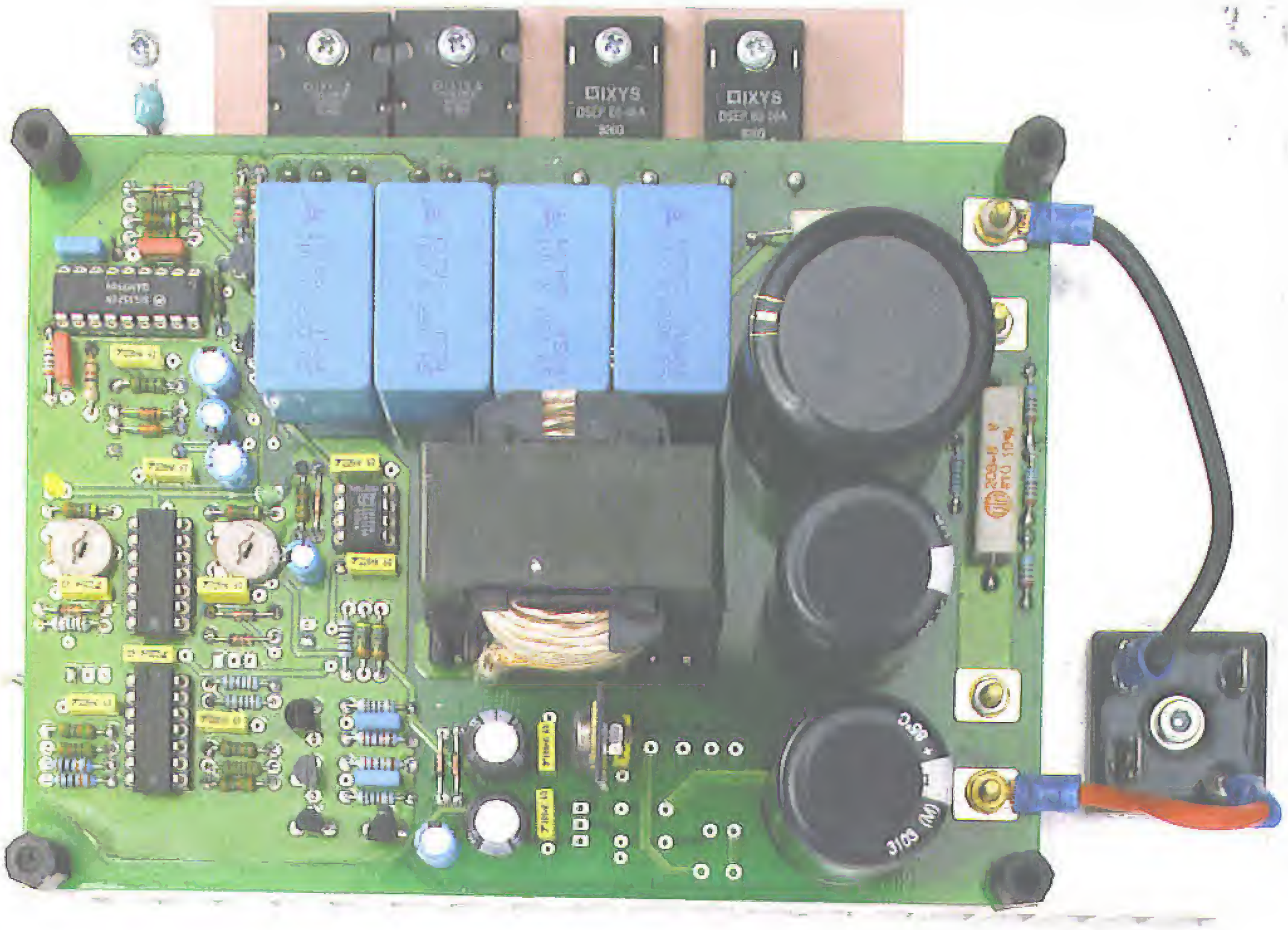


Figure 6. A double-sided layout is used for the printed circuit board.

fier is effectively 'in the loop'.
The two remaining opamps (IC2a and IC2d) are used as comparators to visually indicate when the upper voltage limit or upper current limit is reached. They allow the user to see whether the circuit is operating under voltage control or current control.
The measured quantity for the input current (i_{max}) is easier to handle. Here the 3526 provides an internal Schmitt-trigger comparator with a 100-mV fixed reference voltage. If the measured voltage reaches this value (after being divided by R30/R31 and smoothed somewhat by C18), the comparator triggers a shutdown. The PWM modulator will not start up again until the measured voltage drops below 80 mV.
Finally, a soft-start function is implemented using R21, C14 and IC4b, and manual reset capability is provided by R22, S1 and IC4a. The outputs of the these two comparators are ORed together and connected to the Reset and Shutdown inputs of the 3526. Connecting theses two pins together causes the IC to execute a soft start after each overcurrent event.
A thermostatic switch (normally open) can be connected in parallel with S1 to monitor the temperature of the heat sink. A PTC thermistor could be used for the same purpose. Thermistors have extremely steep characteristic curves. For a type with a rated temperature of 60 °C, the resistance rises from a few ohms to the megaohm range when the temperature increases from 50 °C to 70 °C. This means that any type with a rated temperature of 50–70 °C is suitable, such as the B59901-D60-A40 or any other type with a '50', '60' or '70' in the middle of the type number.
The 3526 has internal undervoltage protection and overtemperature protection, which also trigger a shutdown.

Construction and alignment

A printed circuit board for a DC voltage converter in this power range requires a carefully designed layout (**Figure 6**), which usually has to be double-sided due to the necessary ground-plane area. The measurement amplifiers, control circuitry and power circuitry are clearly separated from each other, and 'sensitive' connections are keep a short as possible and as broad as necessary. The large ground planes protect the measurement and control circuitry against undesirable electronic interference.
Before starting to fit the components to the board, place inductor TR1 aside, since it will only be fitted during the alignment process. You should fit feedback capacitors C9 and C11 for IC2c and IC2b, but immediately short them out by connecting short wire bridges across them (on the component side).
Next you have to decide whether the negative auxiliary voltage should be generated by the transformer or the on-board charge pump. Fit the corresponding components, as well as all of the control electronics. Potentiometers P1 and P2 are connected using pin headers, wired such that they have minimum resistance when adjusted fully counter-clockwise. The LEDs can later be relocated to the front panel using pin headers as well. The ICs can be fitted in sockets. Pay attention to the correct orientation of the numerous diodes, the ICs and the small electrolytic capacitors. Fitting the components for the power section, including the AMP screw terminals for the input



COMPONENTS LIST

Resistors:
R1,R2 = 2Ω2
R3 = 0Ω01 3W horizontal
R4,R5 = 68kΩ
R6 = 56kΩ
R7,R9,R10,R12,R13,R16,R17,R18,R20, R24,R33,R36 = 10kΩ
R8 = 0Ω1 3W horizontal
R11,R19,R31 = 1kΩ
R14,R15 = 100kΩ
R21,R34,R35 = 220kΩ
R22 = 47kΩ
R23,R25,R26,R30 = 4kΩ7
R27 = 100Ω
R28 = 3kΩ3
R29 = 12Ω
R32 = 6kΩ8
P1,P2 = 10kΩ mono potentiometer
P3,P4 = 100kΩ preset

Capacitors:
C1,C2 = 10,000µF, 50V radial, ∅ 30mm, lead pitch 10mm
C3-C6 = 10µF, 250V MKT, 18x31.5mm, lead pitch 27.5mm (Vishay 373)
C7 = 1000µF 250V radial
C8-C12,C20-C23 = 220nF
C13,C19,C32 = 22µF 40V radial
C14,C16 = 10µF 63 V radial
C15,C17 = 10nF
C18 = 3nF3
C26,C28,C29 = 100nF
C30,C31 = 470µF 25V radial
C33,C34,C35 = 1nF

Semiconductors:
D1,D2 = DSEP60-06A (Ixys)
D3-D7,D10,D11,D14,D15 = 1N4148
D8 = LED, green, low current
D9 = LED, yellow, low current
IC1,IC2 = TL074
IC3 = UC3526 (TI) or SG3526 (ST)
IC4 = LM393
IC5 = 7818 with clip-on heatsink
T1,T2 = IXFK90N30 (Ixys)
T3,T5,T7,T8 = BC639
T4,T6 = BC640

Miscellaneous:
S1 = pushbutton and/or thermal fuse or PTC
TR1 = E42/21/20 core with coil former and mounting clamp (standard stock item from RS Electronics)
1m 1mm² RF litz wire, or 1mm² enamelled copper wire
Heatsink <1K/W (<0.35K/W when thermal fuse not triggered)
PCB, order code **030346-1** (from The PCB Shop)

Leave open:
C24 = 470µF, 35V radial
C25 = 470µF, 40V radial
C27 = 100nF
D12,D14 = 1N4007
IC6 = 7915

Not on PCB:
B1 = bridge rectifier 100V piv, 35A (secure to heatsink)
C36 = 10,000µF, 50V radial (additional ripple reduction at direct voltages below 35V)
TR2 = mains transformer, 24V, 20A
F1 = Fuse, 2.5AT (slow) with fuse holder
S2 = double pole mains on/off switch for Tr2

and output voltages, should not present any problems. Bend the leads of the power semiconductors so they can later be attached to the heat sink.

At this stage, it is already possible to perform initial testing and alignment after a thorough visual examination. Connect a laboratory power supply (35 V, with the current limiting set to several tens of milliampères) to the input terminals, and connect the two potentiometers to the pin headers. Now adjust the gain of the current control amplifier (using P3) and the voltage control amplifier (using P4) such that the voltage measured at pin 1 of the 3526 can be continuously adjusted from 0 V to 5 V using P1 or P2, respectively. After this, turn P2 fully clockwise and P1 fully counter-clockwise. Using an oscilloscope, check that the MOSFETs are being properly driven with a PWM signal having a frequency of approximately 40 kHz (as measured on R1 and R2). The duty cycle of this signal can be adjusted over the range of 0–90 % by rotating the current-limit potentiometer (P1).

The control amplifiers cannot presently regulate the loop, since capacitors C9 and C11 are shorted out and the loop is open because the inductor has not yet been fitted. As a result, the duty cycle can be directly adjusted using the potentiometers. Only something that can be controlled can also regulate a controller.

Now it's time to fit the inductor and attach the fully assembled board to the heat sink in 'piggy-back' fashion, as shown in the title photo for this article. using eight previously drilled and tapped holes in the heat sink. As the drain and cathode voltages of the power semiconductors are present on their cooling tabs, these components must of course be properly insulated from the heat sink using the standard methods.

This is a good time to fit the assembled module into a suitable enclosure along with its power supply, and then wire everything together except the mains transformer. Instead of using the transformer, you should first operate the circuit from a laboratory power supply with current limiting. Restricting the power reduces the risk of destroying any components if there is an assembly error.

The wiring and connectors used for the input and output must be able to handle the amount of power drawn or supplied by the Cuk Converter. Don't forget to turn P1 fully counter-clockwise and P2 fully clockwise (100-V setting)! Now we come to the serious work. Connect a hefty power resistor, an incandescent lamp or a halogen floodlight to the output to provide an output load, and connect a voltmeter to the output of IC1d. The output of IC2b will remain 'stuck' and cannot affect anything. Now slowly increase the load current from 0 to the maximum value by adjusting P1.

Next, perform the above procedure the other way around: first rotate P1 fully clockwise (5-A setting), and then use the voltage control (P2) to slowly increase the output voltage to its maximum value of 100 V. Naturally, a current of 5 A can only be achieved if the load resistance is not more than 20 Ω (100 V ÷ 5 A), and 100 V can only be achieved if the load resistance is 20 Ω or more.

However, you're not finished yet, since only part of the circuit's control function is operating. Adjust both potentiometers to their minimum settings, and then cut away both wire bridges to enable operation with the full closed-loop control characteristic. Now slowly increase the setting of P1 again. If the inductor starts to make squealing noises, slightly reduce the gain of the control amplifier by adjusting P3 (the maximum current will still be 5 A). Finally, repeat this procedure for the voltage control stage.

Warning. The circuit generates dangerous voltages. No part must be touched when the circuit is in operation and all relevant electrical safety precautions should be observed.

PIC18Flash Dev

Continuing where the '16 series left off...

Peter Moreton

elopment Board

The development system described in this article continues a fine tradition of Elektor Electronics microcontroller articles, and follows in the lineage of the popular PICee board, AVRee and others. The board described here employs the most recent and powerful of Microchip's PIC family, the '18F' series, and specifically, the PIC18F452.

The PIC18F452 has become the *de-facto* standard part of the 18F series, and is an obvious choice for people wishing to move on from designs using the ubiquitous PIC16F84 and 16F877 devices.

PIC18flash offers the usual development board features of a processor, clock, some LED's, some pushbuttons, an interface to a standard 2×20 line LCD display, an RS232 port, a piezo ceramic sounder and DC power regulation. Special features are:

- On-board hardware for ICSP (In-Circuit Serial Programming)
- Power I/O for real-world devices such as solenoids, stepping and DC motors.
- An interface to the Microchip 'ICD-2' debugger

With this hardware, the free Microchip 'MPLAB' development environment and a free demonstration copy of the 'C18' compiler, you are able to develop PIC 'C' code on a standard PC, and upload it to the PIC18Flash board to build sophisticated control systems for many applications including robotics, home automation, security and more. A 'C18' example program is provided, demonstrating how each subsystem of the PIC18Flash board is accessed from the 'C' environment. As a self contained development environment, the PIC18Flash board provides an excellent platform for educators and individuals wishing to enter the world of microcontrollers.

Circuit Description

The circuit diagram of the development system is shown in **Figure 1**. Much of the circuit techniques will be quite familiar to *Elektor Electronics* readers, and the 78xx-based power supplies (IC1; IC2, IC9) and MAX232 RS232 serial interface (IC5) constellations have appeared countless times beforehand.

The PIC18F452, IC6, is configured in a standard manner, with the possible exception of the secondary 32.768 kHz watch crystal, X1, being provided to allow real-time clock systems to be implemented without consideration of the master clock frequency. The master clock runs at 4 MHz (X2), giving a throughput of 1 MIPS, and this can be internally multiplied by a 4×PLL to 16 MHz, which results in a processor throughput of 4 MIPS. Users requiring still more performance can substitute a 10-MHz crystal, giving 10 MIPS when used with the 4×PLL.

The 4 MHz 'f_{osc}' value is not chosen arbitrarily; this clock rate is a good 'fit' with the PIC's USART baud rate generator and enables the generation of RS232 data at 1.2 to 76.8 kbps with an accuracy of better than 0.16%.
Processor pins assigned to SPI and I²C communications are routed to header K8 for expansion purposes; it is intended that any add-on hardware would communicate solely by these protocols and any communication to a host computer would be via RS232. The SPI/I²C header also delivers a spare processor pin ($\overline{W}$; pin 7 on K8) which can be used for example to bit-bang other protocols such as the Dallas One-Wire interface.

In order that the PIC18Flash can perform some real work, the basic board is equipped with several power devices intended to permit the control of relays, solenoids, lamps, DC motors and stepper motors. Two separately powered Infineon TLE4207 H-bridges, IC3 and IC4, are provided, which permit the bidirectional control of two DC motors, or one bipolar stepper motor. Two power MOSFET switches are also provided. Via connector K6, they can be used to control resistive or inductive loads such as solenoids and lamps.

A pinheader, K7, for the ubiquitous 2?20 character LCD module is provided, and this is configured as a standard 4-bit interface, with the only unusual feature being the use (via the RC2 line) of the PIC's PWM module to provide software control of display contrast.

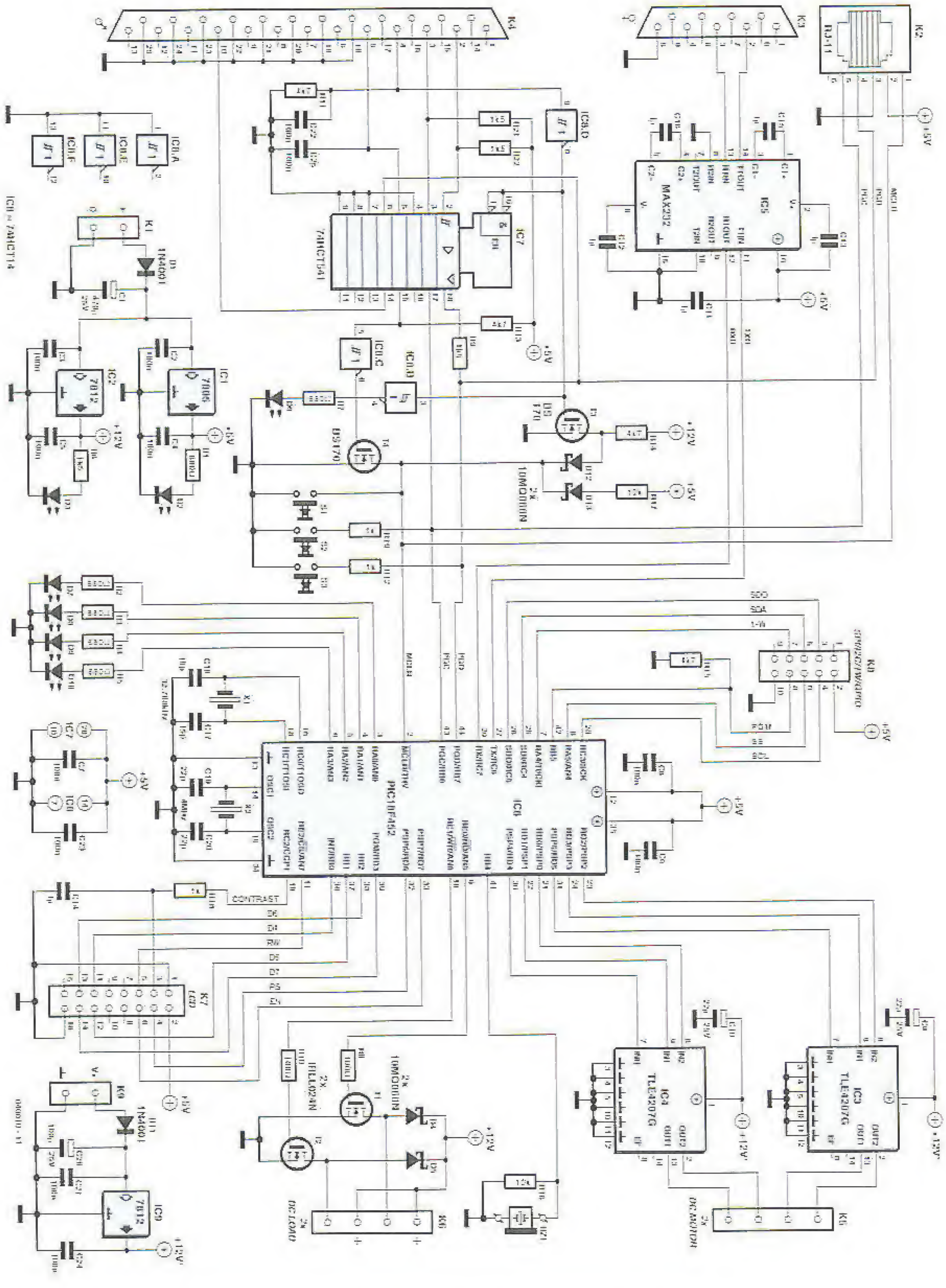


Figure 1. The circuit diagram of the PIC18Flash board reveals a classic microcontroller design.

Finally, an RJ-11 header, K2, is provided to enable the use of Microchip's ICD-2 in circuit programmer / debugger, which enables the target hardware to be debugged in real-time. The user should take care not to use the onboard (MTSP) programmer and the ICD-2 interface at the same time!

Introducing the MTSP programmer

An important feature of the PIC18Flash system is the provision of onboard programming electronics. This enables the user to flash the microcontroller without having to remove the PIC from its socket and load it into a standalone programmer.

In 1996, the 'Tait Classic' programmer design was widely published, enabling the PIC16 series to be programmed using a PC parallel port and some simple software. Since then, many variations on the Tait theme

have appeared, and several good software programmers have been written with (David) Tait hardware support.
The original Tait design does not work correctly with the PIC18F series, so we present a new implementation of the Tait standard, compliant with the PIC18F and with a low component count. The design is called MTSP – '*My Tait Serial Programmer*'. (note that 'serial' indicates that the hardware programs the PIC serially, using a PC parallel interface.)

The MTSP design criteria were:
- Must support HVP (high voltage programming). LVP (low voltage) programmers are easier to construct, but if the user inadvertently un-sets the LVP enable bit, then LVP is disabled and the part can only be re-programmed in a HVP programmer.
- Must use a standard interface, and be supported by a good, public domain software programmer. MTSP implements the 'Tait Classic' or 'Tait Serial' interface and can be programmed using the freeware 'IC-Prog'.
- Must be able to remain in circuit during the program-test-debug cycle. MTSP tri-states PGD/PGC and raises MCLR to allow the target processor to run while not in program mode.

The MTSP port is accessed via 'printer' connector K4.

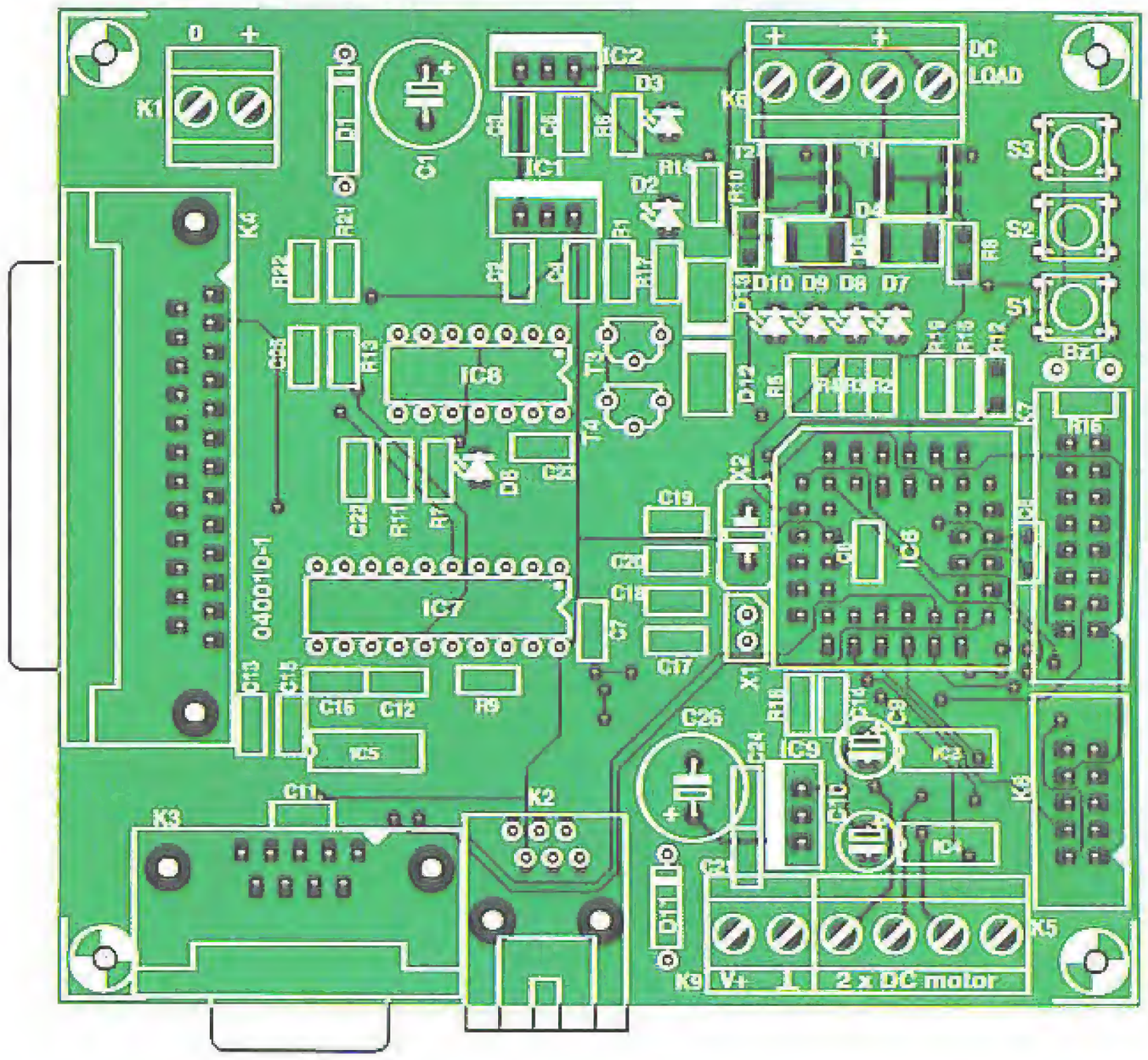


Figure 2. PCB artwork designed for the PIC18Flash board (board available ready-made).

Printed circuit board assembly

The PIC18Flash board (**Figure 2**) uses a mixture of pin-thru-hole and SMD technologies in order to produce a PCB that is both compact and yet quite easy to assemble. Ready-made printed circuit boards for this project (double-sided, through-plated) are available from our Readers Services under no. **040010-1**. All surface mount components are '1206' size or larger, and can be soldered using a fine soldering iron and tweezers. Similarly, there are several surface mount ICs to be fitted.
It is advisable to assemble the PCB in the following sequence:

1. Power supply. Once the PSU parts are installed, test that 5 V and 12 V exist and the PSU LEDs D2 and D3 light up.
2. All SMD resistors, capacitors and remaining LED's.
3. All small-outline ICs.
4. All remaining pin-thru-hole (leaded) parts.

COMPONENTS LIST

Resistors:
All resistors SMD, case shape 1206

R1-R5,R7 = 680Ω
R6,R9,R21,R22 = 1kΩ5
R8,R10 = 100Ω
R11,R13,R14,R15 = 4kΩ7
R12,R18,R19,R20 = 1kΩ
R16,R17 = 10kΩ

Capacitors:
All capacitors SMD, case shape 1206 unless otherwise indicated
C1 = 470µF 25V radial
C2-C8,C21-C25 = 100nF
C9,C10 = 22µF 25V radial
C11-C16 = 1µF
C17,C18 = 15pF
C19,C20 = 22pF
C26 = 470µF 25V radial

Semiconductors:
D1,D11 = 1N4001
D2,D3,D6-D10 = LED
D4,D5,D12,D13 = 10MQ060N
T1,T2 = IRLL024N
T3,T4 = BS170
IC1 = 7805
IC2,IC9 = 7812
IC3,IC4 = TLE4207G
IC5 = MAX232ACSE (SMD case)
IC6 = PIC18F452-I/L
IC7 = 74HCT541
IC8 = 74HCT14

Miscellaneous:
K1,K9 = 2-way PCB terminal block, lead pitch 5mm
K2 = 6-way RJ11 connector, PCB mount
K3 = 9-way sub-D socket (female), angled pins, PCB mount
K4 = 25- way sub-D plug (male), angled pins, PCB mount
K5,K6 = 4-way PCB terminal block, lead pitch 5mm (or 2 off 2-way)
K7 = 16-way boxheader
K8 = 10- way boxheader
S1,S2,S3 = miniature pushbutton, 1 make contact, e.g., DTS61K (6 x 6mm)
BZ1 = AC buzzer
X1 = 32.768kHz quartz crystal
X2 = 4MHz quartz crystal
44-pin PLCC socket for IC6.
20-pin DIL socke for IC7
14-way DIL socket for IC8
PCB, order code **040010-1**, see Readers Services page
Disk, misc. software utilities, order code **040010-11** or Free Download

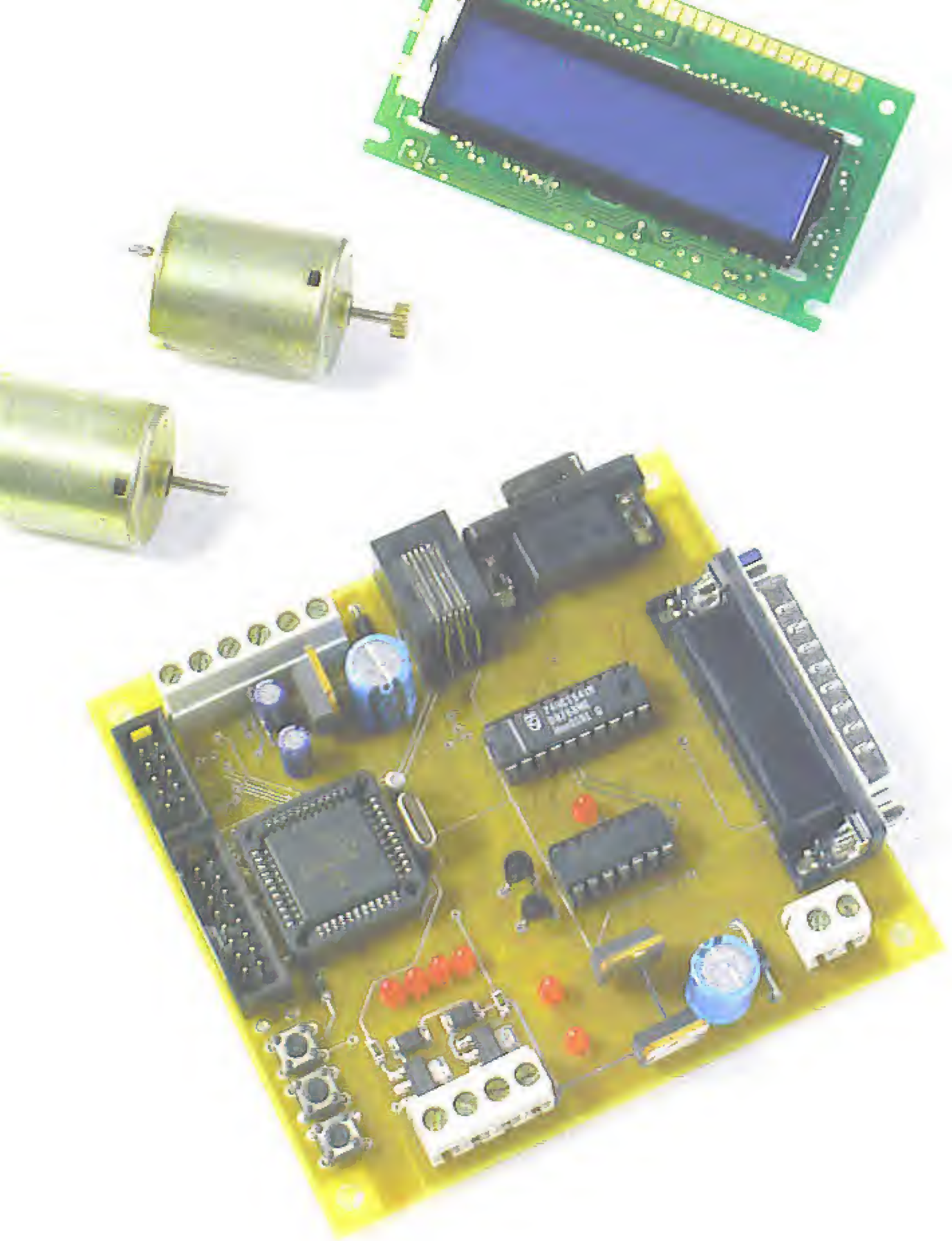


Figure 3. Our finished and tested prototype of the PIC18Flash development board.

We recommend fitting the 74HCT541 and the 74HCT14 in sockets.

Once the board is fully populated, apply a power supply of roughly 15 VDC to K1 and confirm that the PIC18Flash board draws a quiescent current of around 50 mA. Once the board has powered up correctly, it is time to attach an LC display, flash the CPU and test each subsystem on the board.

Flashing the demo firmware

Traditionally, one writes and loads a 'flash-an-LED' or 'Hello World' program to test a microcontroller board. Here, a successfully blinking LED confirms that the CPU is powered, has a viable clock, and is executing code. We have provided self-test firmware which not only flashes LEDs but also exercises the serial port, the sounder, the LCD, the MOSFET switches, the H-Bridges and the real time clock. The constructor should upload this demo firmware, *PIC18flash.hex* to the microcontroller using the *IC-Prog* programming software to fully test the PCB. The source code, *PIC18flash.c* can then be used as a template for further developments.

Configuring IC-Prog

Download the archive files icprog105c.zip and icprog_driver.zip from www.ic-prog.com and extract icprog.exe and icprog.sys to a suitable folder on your hard drive.

If you are running Windows 2000 or Windows XP, you should enable access to the parallel port as follows: right click on icprog.exe, and select the *Compatibility* tab. Check the *Run this program in compatibility mode for* option and select *Windows 2000* in the drop down box; see **Figure 3.**

Now run icprog.exe and you will be prompted to configure the programmer interface; see **Figure 4.**
Select *Settings, Options, Misc* and select the *Enable NT/2000/XP Driver* checkbox, and set *Process Priority* to *High;* see **Figure 5.**

Click 'Yes' to install the *icprog.sys* driver when prompted and finally select the PIC18F452 microcontroller type as shown in **Figure 6.**

Uploading the demo firmware using IC-Prog

Download the Elektor PIC18Flash demonstration firmware, file number 040010-11.zip from the Free Downloads page at www.elektor-electronics.co.uk and unpack the zip file to a suitable folder.

Connect a short parallel cable between the PC printer port and the PIC18Flash MTSP port K4, run IC-Prog and select **File, Open File, PIC18flash.hex**. Now click **Command, Program All** to upload the demo firmware. At the end of the program / verify sequence, the PIC CPU will start to run, and will begin to cycle through a sequence of hardware subsystem tests.
Each test is depicted on the LCD display and are:

1. **LCD display test.** Data is displayed on the LCD display.
2. **Speaker test.** A sequence of audio tones is generated.
3. **LED test.** The on-board LEDs are illuminated in sequence.
4. **DC Load test.** 12-V DC loads connected to JPXX and JPXX are energized.
5. **H-Bridge test.** 12-V DC motors connected to K5 are spun in forward and reverse directions.
6. **RS232 comms test.** Data is emitted from the RS232 port, K3, at a baudrate of 9600,8,N,1 and this data can be viewed by connecting the port to a PC COM port and using Hyperterminal or similar to display the data stream.
7. **Real Time Clock (RTC) test.** Tests the 32-kHz crystal timebase and runs forever. Hours and Minutes can be incremented using the pushbuttons.

PIC18F452 Features

The PIC18F452 has a similar pinout to the venerable PIC16F877 and as such is a natural upgrade to that device, but offers much higher capabilities and performance:

- High Performance Harvard RISC CPU optimized for C compiler usage
- Linear program and data memory,
- 32K Flash ROM, 1536 bytes RAM, 256 bytes EEPROM
- 10 MIPS performance at 40 MHz clock
- 16 bit instructions, 8 bit data path
- 4 separate Timer modules (Timer0,1,2,3)
- 25-mA sink & source current
- 3 external interrupt pins
- High & low priority level assignments for interrupts
- Secondary oscillator for timekeeping using a watch xtal
- 2 capture compare (CCP) & pulse width modulation (PWM) modules
- Master Synchronous Serial Port (MSSP) supporting SPI & I2C
- Addressable USART supporting RS232 and RS485
- Parallel slave port (PSP)
- 10 bit analogue to digital converter (ADC)
- Programmable low voltage detection and brown out reset
- 100,000 erase/write cycle endurance on Flash ROM
- 1,000,000 erase/write cycle endurance on EEPROM
- EEPROM data retention of >40 years
- Self-programmable, and programmed code protection
- Power on reset, power up timer, oscillator startup timer
- Low power sleep mode
- x4 PLL on main oscillator
- In circuit programming (ICSP) and in circuit debugging (ICD)
- Wide operating voltage of 2.0 V to 5.5 V

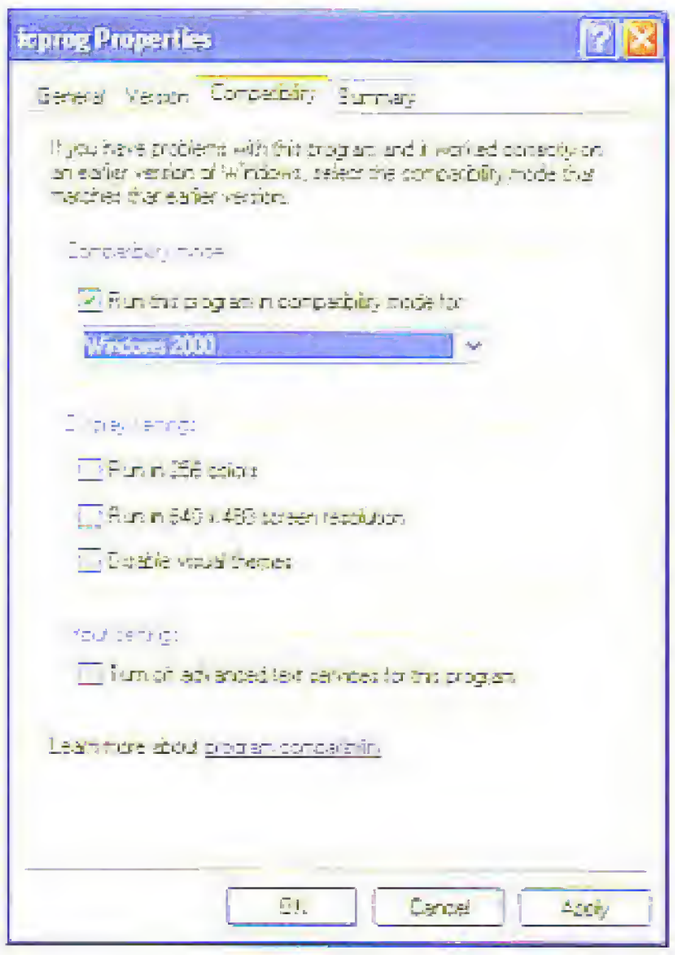


Figure 4. IC-Prog properties.

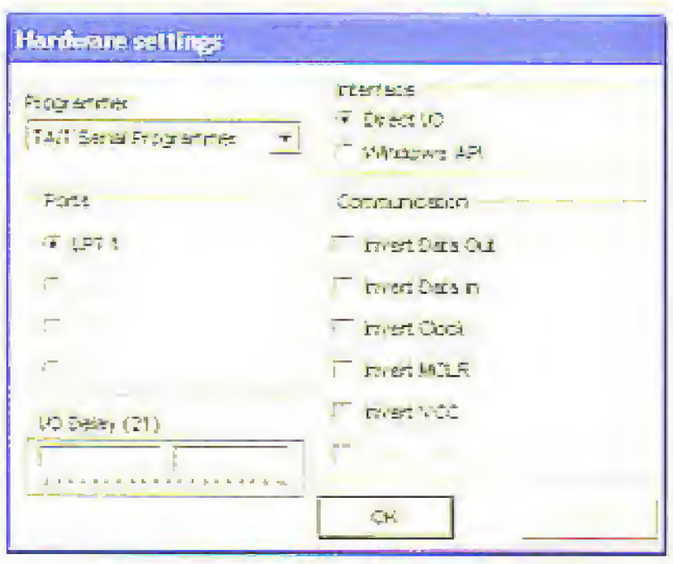


Figure 5. IC-Prog Programming.

About the Author

Peter Moreton (42) has been involved with computers and electronics since his youth. Working for various international banks, he has architected computer networks that span the globe. He welcomes email correspondence at peter.moreton@virgin.net and will host firmware updates and circuit ideas at: http://freespace.virgin.net/peter.moreton

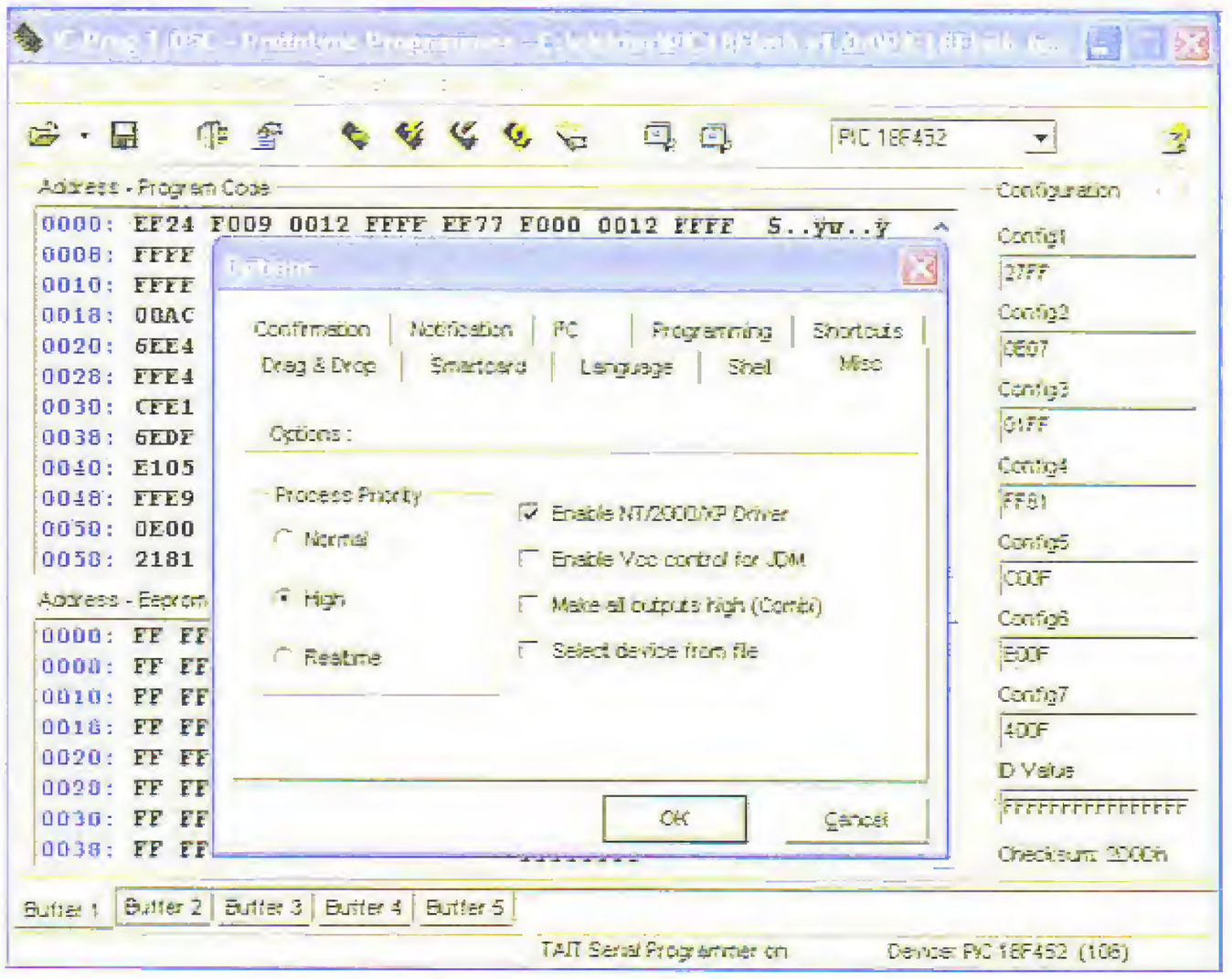


Figure 6. IC-Prog Driver.

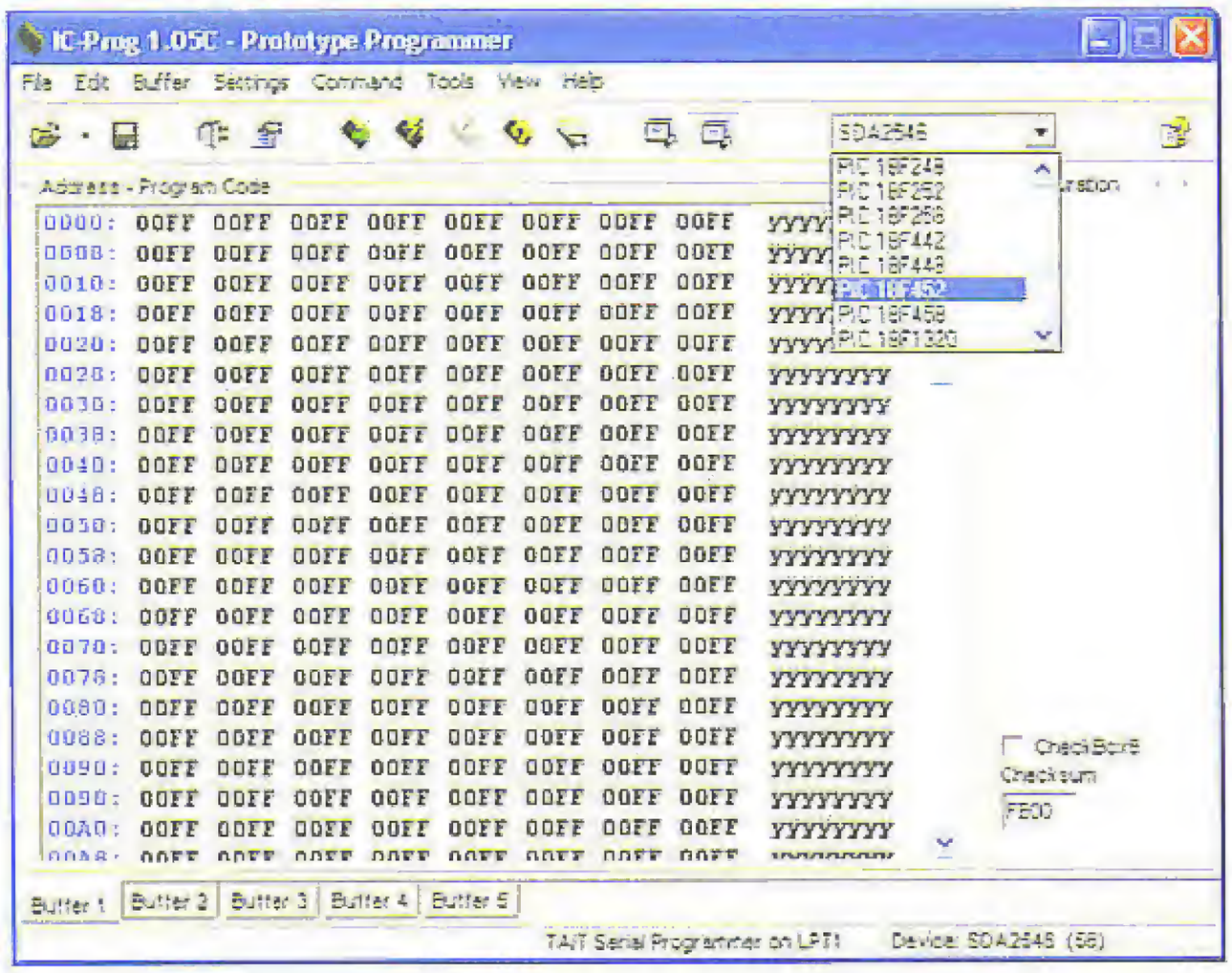


Figure 7. IC-Prog uC Selection.

Compiling the demo firmware using MPLAB/C18

The demo firmware is written in 'C' and designed to be used as a basis for custom application development, since it provides a template showing how each of the PIC18Flash subsystems can be manipulated from the 'C' environment.

You should download and install the latest releases of MPLAB and C18demo from www.microchip.com, and from within MPLAB, select Project, Open, PIC18flash.mcp. 'C' source code can now be edited and then compiled by hitting F10 and the resultant HEX file uploaded to the PIC18Flash system.

Using an RS232 bootloader

There are three ways to load firmware into PIC18Flash:

1. *MTSP* using the parallel port;
2. *ICD-2* using the RJ-11 port;
3. *RS232 bootloader*.

The *MTSP* method provides a low-cost method of bootstrapping code into the uC, whereas the *ICD-2* approach requires an expensive external debugger, but — on the positive side — enables firmware to be debugged in real time within MPLAB.

An *RS232 bootloader* is a small 'stub' program that is initially flashed into the microcontroller by a traditional programmer. At power-up it communicates with a PC through the serial interface in order to erase and program the microcontroller's flash memory. If no PC client communication is detected, the bootloader passes control to the main firmware application on the uC.

The *RS232 bootloader* method requires only a Windows COM port and enables firmware upgrades to be easily applied to products 'in the field'. To take advantage of this programming method, the user must first use MTSP or ICD-2 to initially flash the bootloader code. Once the bootloader is in place, you can use a PC bootloader client to upload your PIC *.hex firmware.
There are many freeware bootloaders available on the Internet, and we have tested several suited to use with the PIC18F, including the *Tiny Bootloader* which is included in the support zip file, and is described in the **inset**.

A TinyBoot Tutorial

To enable the PIC18Flash board for serial loading of firmware, simply follow these steps:

1. Using the IC-Prog/MTSP programmer, upload Tinybld18F.hex to the PIC18Flash board.
2. Connect a spare COM port to the PIC18Flash board using a DB9–DB9 cable (this RS232 cable should not be crossed, i.e., pins 2 and 3 should be 'straight through').
3. Run TinybldWin.exe; select the COM port; select an application firmware hex file (e.g., PIC18flash.hex); cycle the PIC18flash power supply and within 5 seconds of applying power, click Write Flash.

The Tinyboot bootloader (**Figure 8**) is configured to watch for hex data arriving on the RS232 port for 5 seconds from power-up or reset, after which time the firmware application code will be activated.

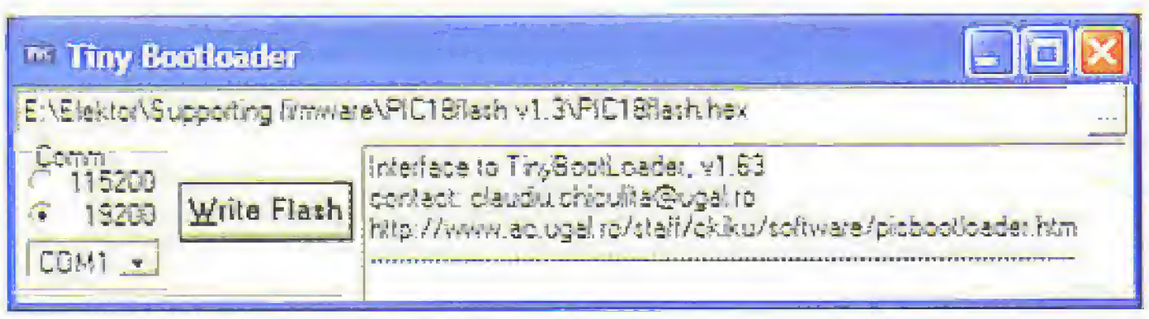


Figure 8. Tiny BootLoader in action.

Web Links

Microchip: www.microchip.com
IC-Prog: www.ic-prog.com
Basic18: www.midwest-software.com
Tiny Boot:
www.ac.ugal.ro/staff/ckiku/software/picbootloader.htm

Further reading

Goodbye '16, Welcome PIC18F, Elektor Electronics October and November 2003.

Constant Current from 1 to 100 V?

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Development Systems for 16-bit dsPICs

Microchip now supply a range of 19 new tools and application aids to enhance development for their dsPIC® 16-bit Digital Signal Controller (DSC) architecture. A series of essential software development tools, high-level libraries, application designs and development boards give designers the resources they need.

The development tools include the MPLAB® Integrated Development Environment (IDE). The MPLAB In-Circuit Debugger 2 (ICD 2), also a device programmer, now supports the dsPIC DSC architecture. In fact, these tools are the platform for all of Microchip's microcontrollers and DSCs.
Additional software tools include the MPLAB Visual Device Initializer (VDI), as well as three Real Time Operating Systems (RTOS) from CMX. In addition, there is a filter design package and its companion dsPICworks™ Visual Algorithm Analyser.
Microchip is also introducing several high-level and utility libraries that give developers the ability to add powerful functionality to their application with a minimal learning curve. Initial high-level libraries include software modems, TCP/IP, and motor control. Microchip also offers free DSP, Math and Peripheral utility libraries. The four new hardware development boards are ideal prototyping tools to develop and validate designs with Microchip's dsPIC DSC architecture. The dsPICDEM™ Starter Demonstration Board allows the user to easily validate a development idea using the dsPIC30F6012 (144KB Flash). The dsPIC30F2010-based (12 KB Flash) dsPICDEM 28-pin Starter Demonstration Board enables the user to validate a development tool setup using a 28-pin SDIP or SOIC dsPIC30F device. The dsPIC30F6014-based (144 KB Flash) dsPICDEM 1.1 General Purpose Development Board provides the application designer with a powerful development tool to become familiar with the dsPIC30F 16-bit architecture. The dsPIC30F6014 also features on the dsPICDEM Connectivity Development Boards. These provide the developer a basic connectivity platform for developing and evaluating various connectivity solutions.

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Whistle Beacon

Model aircraft sometimes have the unpleasant property of choosing their own landing field, and doing so in terrain where they are hard to see. In such cases, the model finder described here can make the search easier.

An unplanned landing is already bad enough, but to make matters worse, it sometimes happens in a cornfield. That often means searching criss-cross through the field for several hours and considerable damage to the field, which neither the farmer nor the insurance company finds especially pleasant. This whistle beacon circuit will at least help you find your model more quickly, by emitting a loud signal if the transmitter is switched off or the joystick is moved past a previously programmed position. The searchers (and unfortunately, the farmer as well) can hardly help hearing this signal.

The circuit is designed to avoid sacrificing a receiver channel. The model finder can be inserted between the receiver and the servo as necessary. The only thing that requires attention is to ensure that the connector on the circuit board matches the pin assignment of the servo cable (see **Figure 1**).

Receiver signal evaluation

Many commercial model finders evaluate the absence of the remote control signal as the criterion for enabling the alarm generator. What they forget is that if the transmitter is switched off, a large number of noise signals are intermittently present at the receiver output, and the downstream electronics can mistake these signals for control signals. The circuit shown in **Figure 2** refuses to be misled by such signals, since it compares the received signal with a reference signal and only responds if the pulse width of the received signal is less than a predefined value.

The evaluation circuit primarily consists of a pair of retriggerable monostable multivibrators (IC1) whose timing characteristics are determined by external circuitry. IC1a generates a reference pulse at its output (pin 13) in response to a rising edge of the input signal (clock signal from the receiver).

An acoustic emergency transmitter for model aircraft

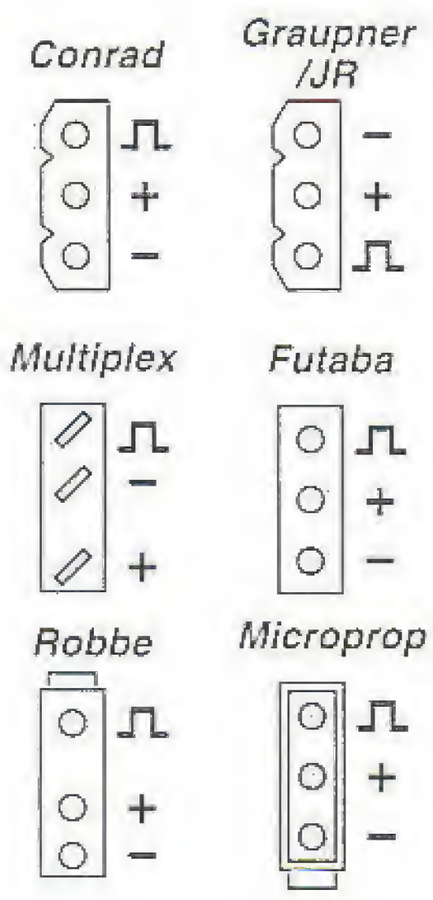

Figure 1. Pin assignments for the most commonly used servo cables.

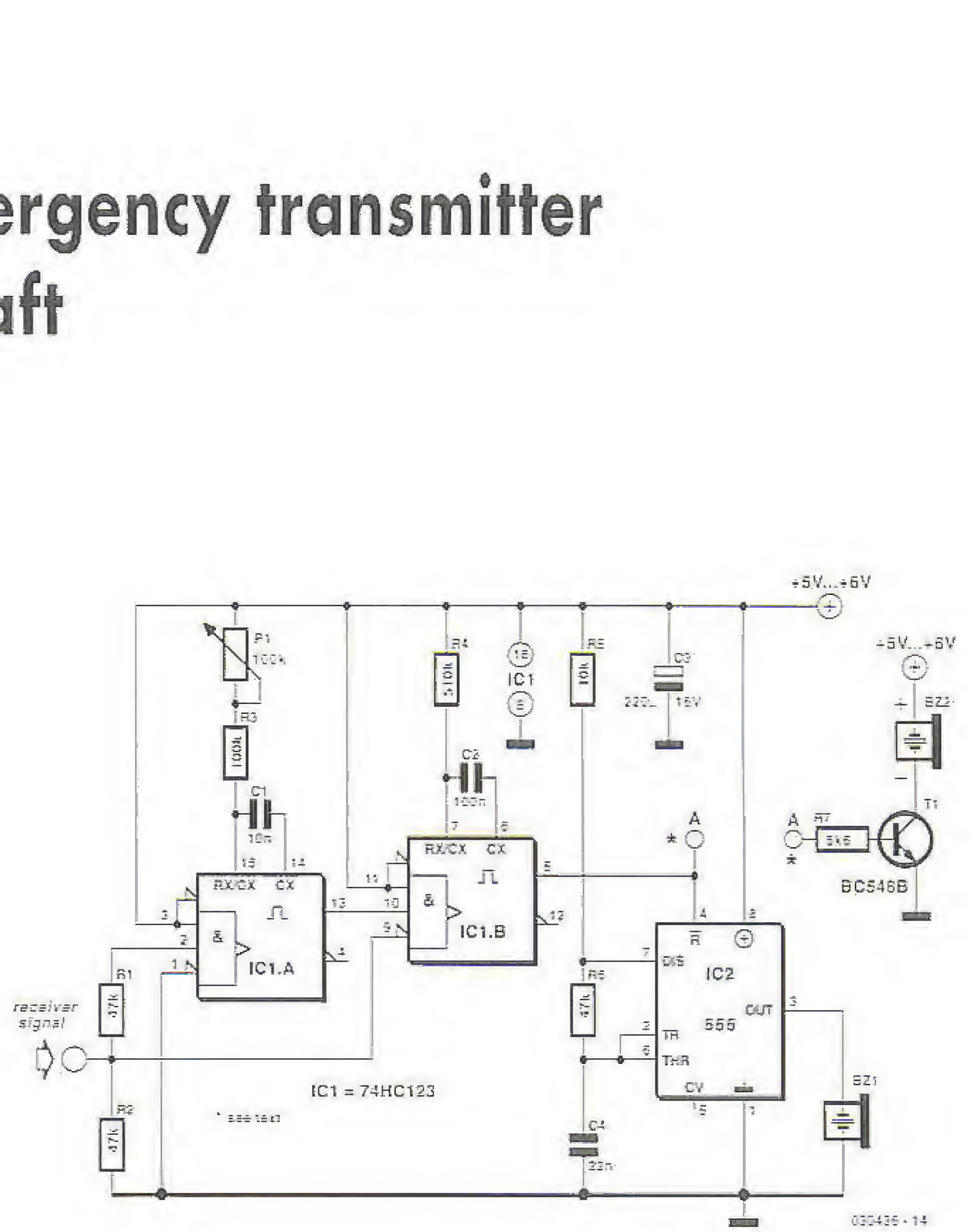

Figure 2. The model-finder circuit monitors the signal from the remote control transmitter.

The width of this pulse can be set between approximately 1 ms and 2 ms using trimpot P1. IC1b is triggered on the falling edge of the signal at the output of IC1a if the signal coming from the receiver has a Low level. The switching signal is taken from the output of IC1b (pin 5). If the signal from the receiver drops below the pulse width defined by the user, pin 5 will have a High level, which energises the following oscillator stage.

The oscillator is built using a 555 timer IC. This IC can drive a piezo acoustic transducer (without integrated electronics) without any additional circuitry. The frequency-determining components (R4, R5 and C4) set the frequency of the oscillator to around 4 kHz. C4 is charged by R5 and R6 in series and discharged via R6 alone. The oscillator is enabled when the reset input (pin 4) has a High level. A 220-Ω resistor can also be inserted in series with the transducer to reduce the loudness; this will also change the frequency.

Alternatively, a transducer with integrated electronics can be used to reduce the complexity of the circuitry. In this case, a driver transistor and acoustic transducer are connected at point A instead of IC2. The integrated electronics then takes over the task of the oscillator (IC2) and drives the piezoelectric wafer in the transducer at a frequency of around 2–3 kHz. Naturally, this arrangement will not work with a transducer lacking integrated electronics, which cannot be visually distinguished from a type that has its own oscillator.

In the relevant specialist magazines, commercial vendors of model finders try to outdo each other with the loudness of their circuitry. For our models, we find a transducer with a sound pressure level greater than 85 dB(A) to be fully adequate. Naturally, the sound must be able to actually emerge via a hole or a perforated region of the enclosure.

Calibration

The only calibration point in the circuit is the threshold for enabling the acoustic transducer. This can be set using trimpot P1. With the transmitter switched on, P1 should be rotated until no tone can be heard at any joystick position. With the transmitter switched off, P1 should be rotated until the tone starts to sound. Of course, you can also adjust the model finder to enable the transducer at a certain joystick position.

030436 - 1

Note:
A model-finder function is also implemented in the multi-purpose IC for modellers described in the January and February 2002 issues of Elektor Electronics.

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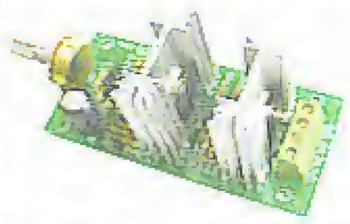
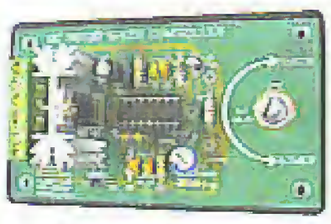


Controls the speed of most common DC motors (rated up to 32VDC/5A) in both the forward and reverse direction. The range of control is from fully OFF to fully ON in both directions. The direction and speed are controlled using a single potentiometer. Screw terminal block for connections.
Kit Order Code: 3166KT - **£14.95**
Assembled Order Code: AS3166 - **£24.95**

DC Motor Speed Controller (5A/100V)



Control the speed of almost any common DC motor rated up to 100V/5A. Pulse width modulation output for maximum motor torque at all speeds. Supply: 5-15VDC. Box supplied. Dimensions (mm): 60Wx100Lx60H.
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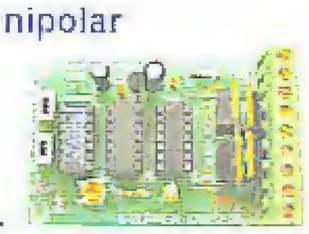
Assembled Order Code: AS3067 - **£19.95**

NEW! PC / Standalone Unipolar Stepper Motor Driver



Drives any 5, 6 or 8-lead unipolar stepper motor rated up to 6 Amps max. Provides speed and direction control. Operates in stand-alone or PC-controlled mode. Up to six 3179 driver boards can be connected to a single parallel port. Supply: 9V DC. PCB: 80x50mm.
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Assembled Order Code: AS3179 - **£16.95**
Assembled Order Code: AS3113 - **£24.95**

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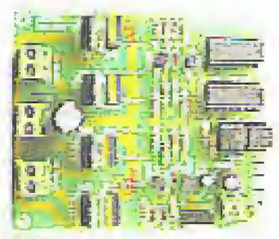

Drive any bi-polar stepper motor using externally supplied 5V levels for stepping and direction control. These usually come from software running on a computer. Supply: 8-30V DC. PCB: 75x85mm.
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Assembled Order Code: AS3158 - **£26.95**

Most items are available in kit form (KT suffix) or assembled and ready for use (AS prefix).

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Assembled Order Code: AS3145 - **£26.95**
Additional DS1820 Sensors - **£3.95 each**

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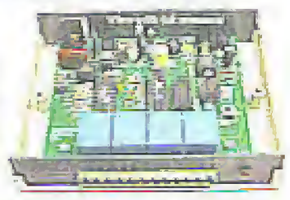

Call your phone number using a DTMF phone from anywhere in the world and remotely turn on/off any of the 4 relays as desired. User settable Security Password, Anti-Tamper, Rings to Answer, Auto Hang-up and Lockout. Includes plastic case. Not BT approved. 130x110x30mm. Power: 12VDC.
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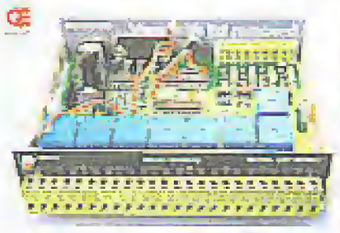
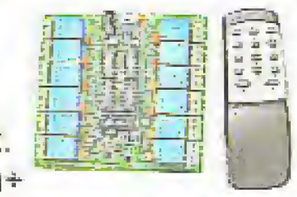
Assembled Order Code: AS3140 - **£49.95**

Serial Isolated I/O Module



Computer controlled 8-channel relay board. 5A mains rated relay outputs. 4 isolated digital inputs. Useful in a variety of control and sensing applications. Controlled via serial port for programming (using our new Windows interface, terminal emulator or batch files). Includes plastic case 130x100x30mm. Power Supply: 12VDC/500mA.
Kit Order Code: 3108KT - **£54.95**
Assembled Order Code: AS3108 - **£64.95**

Infrared RC Relay Board



Individually control 12 on-board relays with included infrared remote control unit. Toggle or momentary. 15m+ range. 112x122mm. Supply: 12VDC/0.5A
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Assembled Order Code: AS3142 - **£51.95**

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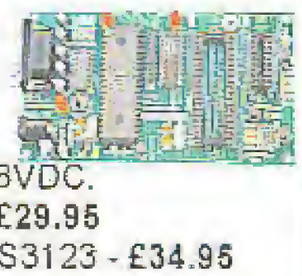
ATMEL 89xxxx Programmer



Uses serial port and any standard terminal comms program. 4 LED's display the status. ZIF sockets not included. Supply: 16-18VDC.
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New ATX 2.2 specification

This tester was designed for recent ATX power supplies, but it is also ready for use with new power supplies described in version 2.2 of the ATX specification. These have a main connector with 24 pins instead of 20 (75 Watt extra for use by PCI Express cards).

There is a curiosity in the new specification regarding the -5 V connection. According to version 2.2 of the specification it is no longer used and the pin in question (20) is marked as NC (not connected). However, according to the manuals of several motherboards with a new 24-pin connector the -5 V is still present. So keep in mind that when you test a power supply with a 24-pin connector the -5 V output may or may not exist. The -5 V should always be present on a 20-way connector.

The change from 20 to 24-pin connectors is compatible with the older 20-pin connectors, with an extra +3.3 V, +5 V, +12 V and ground added to one end. An older ATX power supply with a 20-pin connector fits in a 24-pin socket and can only be inserted one way, so mistakes aren't possible.

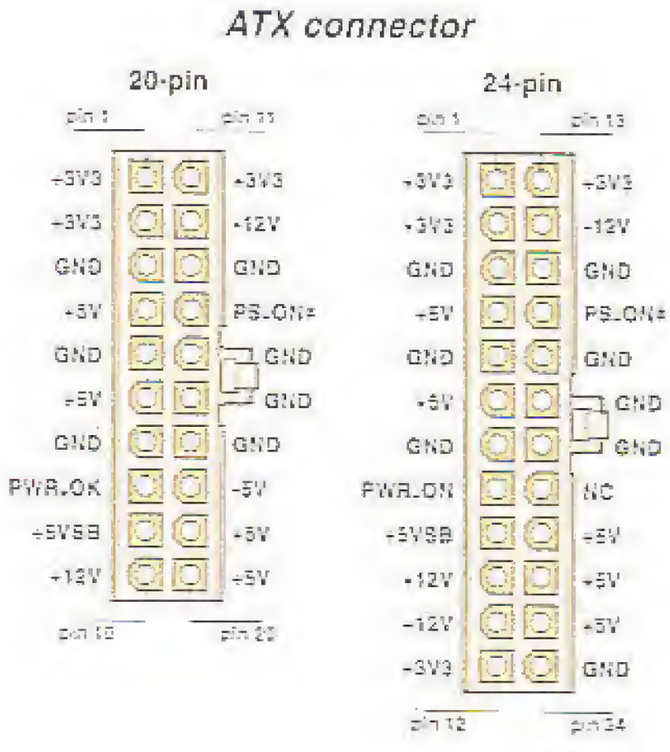


Figure 1. The pin-outs for 20 and 24-pin ATX power connectors.

Apart from the power supply and this tester, you'll only need a mains cable (and socket!). All outputs from the power supply can be tested under load and any deviations from the nominal values are shown on 6 LEDs.

Although the power supply in a PC has little bearing on its overall speed, there are times when it needs to be replaced. This may be because the old power supply has simply given up the ghost, and sometimes the internal fan has become too noisy, or an upgrade of the PC has increased the power requirements above that what the old power supply can deliver.
ATX power supplies are available from virtually every computer shop. When you buy a new power supply it is obviously safe to assume it will be in perfect working order. But when you buy a (used) power supply at a computer fair or boot fair you want to be sure that it works *before* you fit it into the case and connect it to the motherboard. A quick test would be very useful then. The true hobbyists may also want to investigate the exact fault in a broken power supply. But it isn't a straightforward job to test a PC power supply with a multimeter.
The power supply tester described here is a very useful and compact tool. We have to admit that you probably won't need it very often. But once you have acquired one, word will spread amongst your circle of friends and you shouldn't be surprised when you're called to 'quickly' check a PC power supply for them.

What is measured?

Our tester doesn't require a separate power supply, as it takes its power from the PC power supply under test. All you need to do is plug the power supply into the tester and then use a mains lead to connect it to the mains. A rotary switch is then be used to quickly check all the output voltages. The percentage deviation of a selected output is shown on 6 LEDs. Two of these LEDs show whether the deviation is positive or negative and the other four indicate the percentage difference from the required output voltage.
For output voltages that are connected to more than one pin only the first pin is tested. (A power supply generates only a single +5 V supply, even though it is made available on several pins.)
There is a 26-pin header (K2) on the PCB that can be used to test each pin individually. The outputs are connected through 1 kΩ resistors to protect them against short circuits. If you connect an extension lead to this header you can use a multimeter to take measurements from any pin.

A look at the circuit

An ATX power supply has a total of 6 output voltages, which all have to be tested: +3.3 V, +5 V, +5 V for

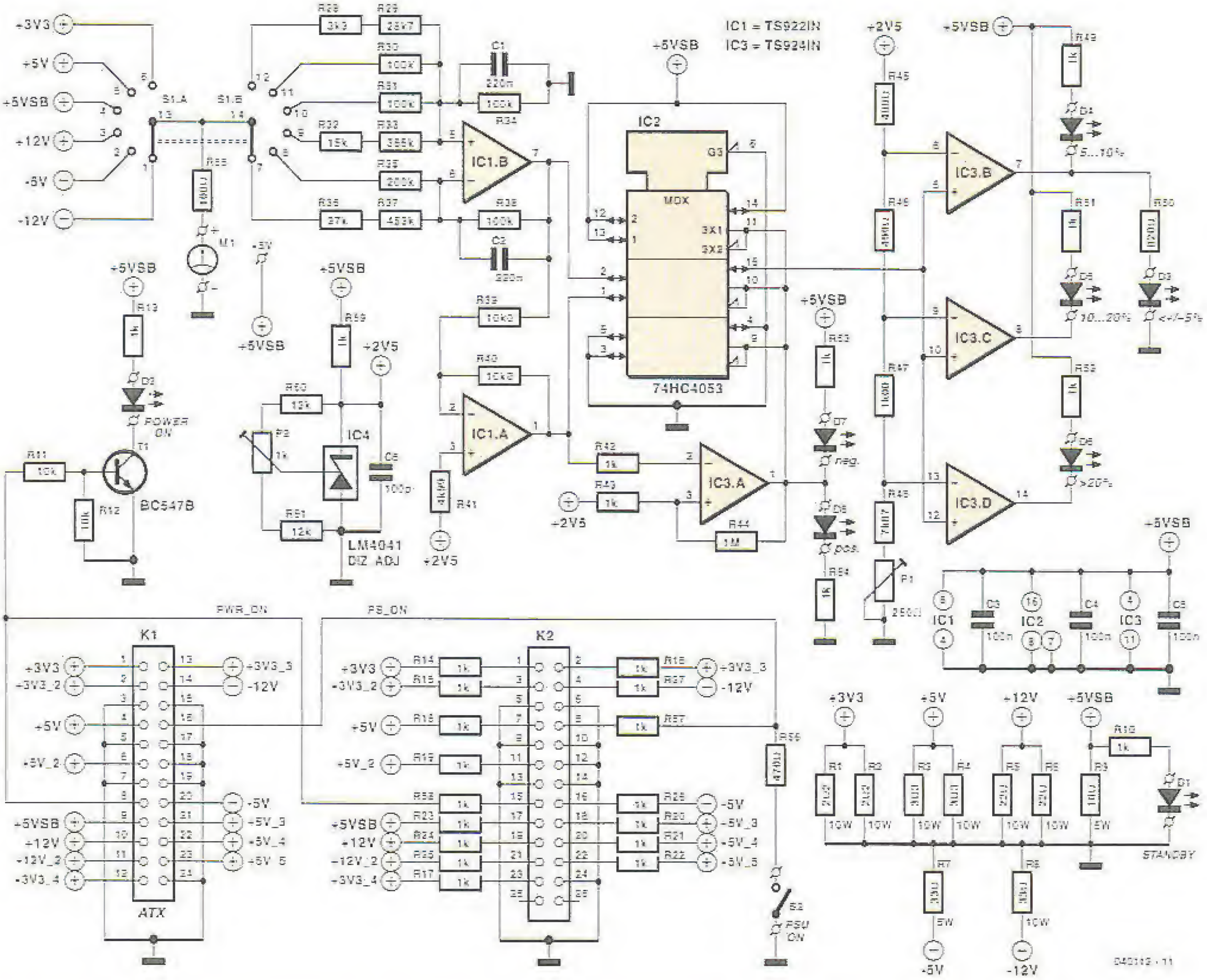


Figure 2. The measurement circuit itself is fairly small. A lot of room is taken up by the power resistors (R1-R9), which load the power supply.

standby, +12 V, –5 V and –12 V. The standby voltage (+5VSB) is always present as long as the mains is connected. This voltage is therefore used as the supply for the tester (**Figure 1**). LED D1 is driven directly from the +5VSB supply and hence indicates that the mains is turned on and that the power supply has at least a working standby voltage.

The power supply is turned on by closing switch S2. This pulls pin PS_ON sufficiently low via R56. According to the specification this pin should be <0.8 V at 1.6 mA. A value of 470 Ω for R56 achieves this. The PWR_ON output, also called PWR_GOOD or PWR_OK, is used by the power supply to show that the most important outputs (+12 V, +5 V and +3.3 V) are within their limits and can supply a nominal current. When this signal is active, D2 lights up. Since this output can only source 200 µA at a minimum voltage of 2.4 V, a buffer stage consisting of R11, R12 and T1 has been added.

Once the mains is turned on (and D1 and D2 are lit), S1 is used to select the voltage that is connected to the input of amplifier IC1b.

S1 is a 2-pole 6-way rotary switch (it has to be a break-before-make type, otherwise you'll introduce shorts in the outputs). The first switch selects the supply voltage to be tested. The common output of this switch is also connected to a PCB pin (via a 100 Ω resistor for protection). It is possible to connect a small voltmeter module to this pin, so that the absolute value of the selected voltage can be seen. Next to the connection for the meter (M1) is an extra PCB pin with +5 V for the voltmeter module.

The selected voltage makes its way via the common of S1b to one of the potential dividers connected to the inputs of IC1b.

Each resistor combination gives the right amount of attenuation to the chosen voltage such that the output of IC1b will be a nominal 2.5 V at every position of S1. There is no need for a symmetrical power supply to measure negative voltages because IC1b is a rail-to-rail type opamp. With positive voltages IC1b functions as a non-inverting buffer. The two negative supply voltages are inverted and attenuated.

We now take a small jump to the tolerance LEDs in the circuit (D3-D8). According to the ATX specification all voltages should be within ±5%, with the exception of -12 V, which may be ±10%. We have therefore chosen four tolerance ranges that are covered by the LEDs: <5% (green LED D3), 5-10% (yellow LED D4), 10-20% (red LED D5) and >20% (second red LED D6). The range division at 10% was used to give you the choice whether to accept that deviation or

Circuit details

The potential dividers for IC1b have been designed as accurately as possible through the use of resistors from the E96 series. Three of the dividers are made with a (large) E96 and a (small) E12 resistor to get as close to the theoretical value as possible. Since the value of the E12 resistor is much smaller than that of the E96 resistor connected in series, it only has a small effect on the total tolerance. Hence a resistor from the E12 series is suitable here.

Although capacitor C6, which is connected in parallel to reference zener IC4, is not essential according to the data sheet, a little bit of HF decoupling never does any harm with a switched mode power supply.

R41 reduces the effect of the input bias current of opamp IC1a, keeping any error limited mainly to that from the tolerance of resistors R39 and R40.

A small amount of hysteresis is required around IC3a to make it switch cleanly. This does introduce a small error near the zero point as far as a positive or negative deviation concerns (±0.1%), but this is very small compared to the tolerance levels we're looking at.

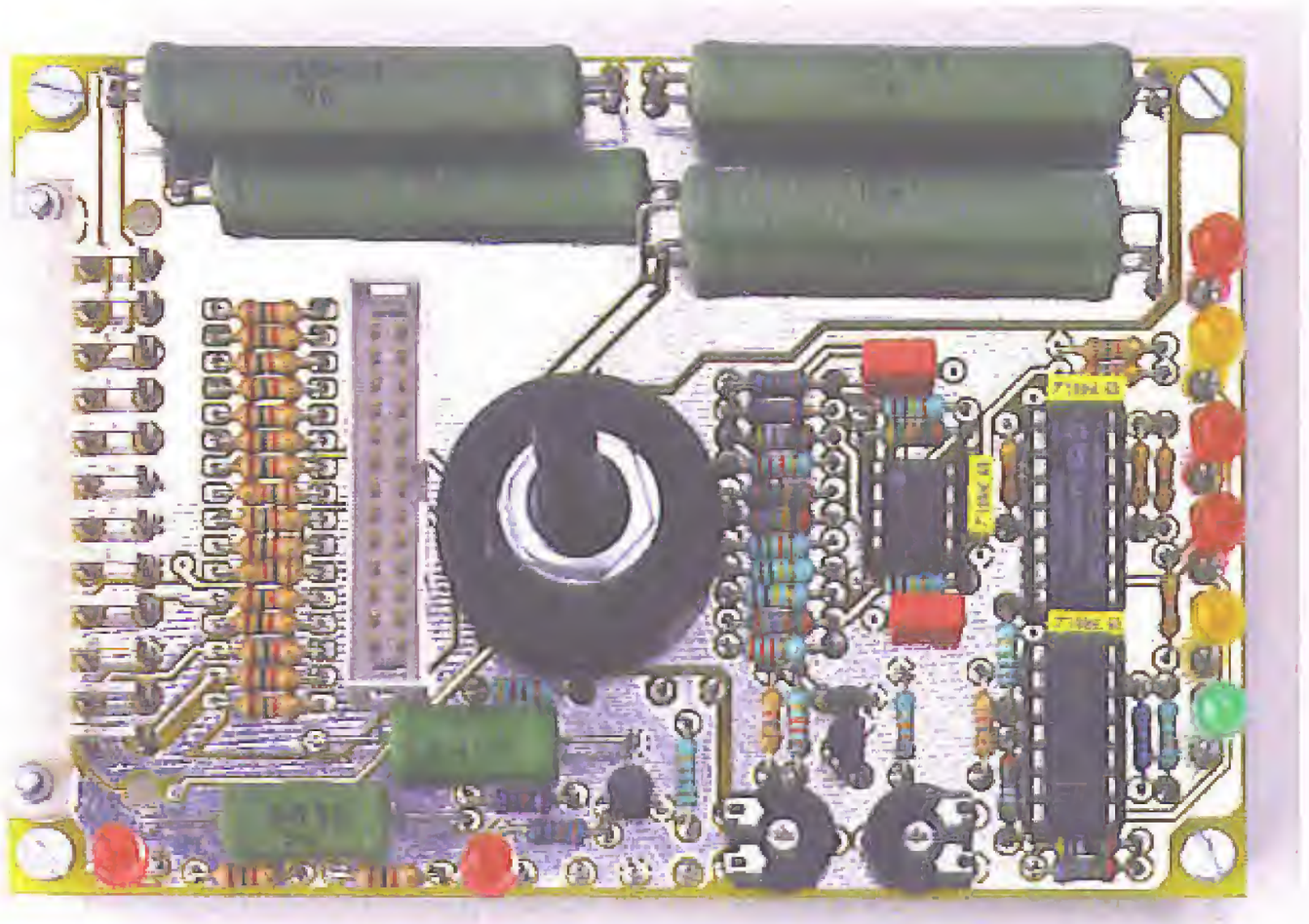
For IC3b-d, which are used as comparators, we have intentionally used opamps rather than real comparators because these usually have open-collector outputs. These wouldn't be suitable for this purpose.

The reference voltages (via R45-R48 and P1) for the comparators are 5%, 10% and 20% lower than the main 2.5 V reference (2.375 V, 2.25 V and 2 V respectively). Resistors R45 and R46 in the potential divider should of course have been exactly 500 Ω, but 499 Ω is a difference of only 0.2%, which is much less than the tolerance of the resistors themselves.

not. A difference of more than 20% is not acceptable in any case.
These LEDs are driven by comparators IC3b-d, which have their inverting inputs connected to a potential divider (R45-R48 and P1). This determines the tolerance ranges with respect to the 2.5 V reference voltage. P1 is used to set the reference levels as accurately as possible.
This just leaves the section that joins the output signal from IC1b to the LEDs. This output signal is nominally 2.5 V and may be a bit more or less when it deviates. But the comparator circuit built round IC3b-d can only indicate negative differences. To get round this problem IC1a inverts the output signal from IC1b. This is followed by an analogue switch that can be controlled using a digital signal. This switch is part of IC2 (a triple analogue multiplexer). The output signal from IC1b and the inverted one from IC1a are connected to inputs Y0 and Y1 of an analogue switch (pins 2 and 1 on IC2). The output of IC1a is also connected to opamp IC3a, which acts as a comparator and compares the signal with the 2.5 V reference voltage. The output of IC3a acts as the control signal for the analogue switch. When the deviation is negative (<2.5 V), IC3a switches pin 2 of IC2 to the output (pin 15), which is connected to the comparators. When the deviation is positive (>2.5 V), the inverted signal (pin 1) is connected to pin 15. In this way LEDs D3-D6 always show the deviation compared to the nominal value. The output of comparator IC3a is also connected to two LEDs, which indicate if the measured voltage is greater or smaller than the nominal value. The yellow LED (D7) is lit when the voltage is lower and the red LED (D8) indicates that the voltage is higher than the reference voltage.
The 2.5 V reference voltage mentioned a few times previously is supplied by an LM4041DIZ-ADJ (IC4) made by National Semiconductor. This voltage can be adjusted to exactly 2.5 V with preset P2.
All outputs from the ATX power supply are provided with a resistive load, where some outputs are loaded more than others. The +3.3 V and +5 V outputs often require a minimum load for the power supply to operate correctly, and are therefore loaded more heavily. To avoid excessive heat generation we haven't taken the maximum power from the supply, but have limited it to some 45 W (R1 to R9).

Construction

The PCB designed for the tester is shown in **Figure 3**. The dimensions of the PCB have been kept as small as possible and are not based on any particular enclosure. The ATX power supply connector is on the edge of the PCB, so that this can stick out through the side of an enclosure.



COMPONENTS LIST

Resistors:

R1,R2 = 2Ω2 10W
R3,R4 = 3Ω3 10W
R5,R6 = 22Ω 10W
R7 = 33Ω 5W
R8 = 33Ω 10W
R9 = 10Ω 5W
R10,R13-R27,R42,R43,R49,R51-R54,R57,R58,R59 = 1kΩ
R11,R12 = 10 kΩ
R28 = 3kΩ3
R29 = 28kΩ7
R30,R31,R34,R38 = 100 kΩ
R32 = 15kΩ
R33 = 365kΩ
R35 = 200kΩ
R36 = 27kΩ
R37 = 453kΩ
R39,R40 = 10kΩ0
R41 = 4kΩ99
R44 = 1MΩ
R45,R46 = 499Ω
R47 = 1kΩ00
R48 = 7kΩ87
R50 = 820Ω
R55 = 100Ω
R56 = 470Ω
R60,R61 = 12kΩ
P1 = 250Ω preset
P2 = 1kΩ preset

Capacitors:

C1,C2 = 220nF
C3...C5 = 100nF
C6 = 100pF

Semiconductors:

D1,D2,D5,D6,D8 = LED, red, low-current
D3 = LED, green, low-current
D4,D7 = LED, yellow, low-current
T1 = BC547B
IC1 = TS922IN (ST Microelectronics, Farnell # 332-6275)
IC2 = 74HC4053
IC3 = TS924IN (ST Microelectronics, Farnell # 332-6299)
IC4 = LM4041DIZ_ADJ (National Semiconductor, Farnell # 271-263)

Miscellaneous:

K1 = 24-way angled ATX header, PCB mount (Molex 39291248, Farnell # 413-8508)
K2 = 26-way boxheader (2x13)
S1 = 2 pole 6 position rotary switch, PCB mount
S2 = on/off switch, 1 contact
Optionally:
M1 = $3^1/_2$-digit LCD volimeter module, range 0-20 V (e.g., Farnell # 422-0146)
Enclosure: e.g., type 1455L1601BK (Hammond Manufacturing)

PCB, order code **040112-1**, see Readers Services page

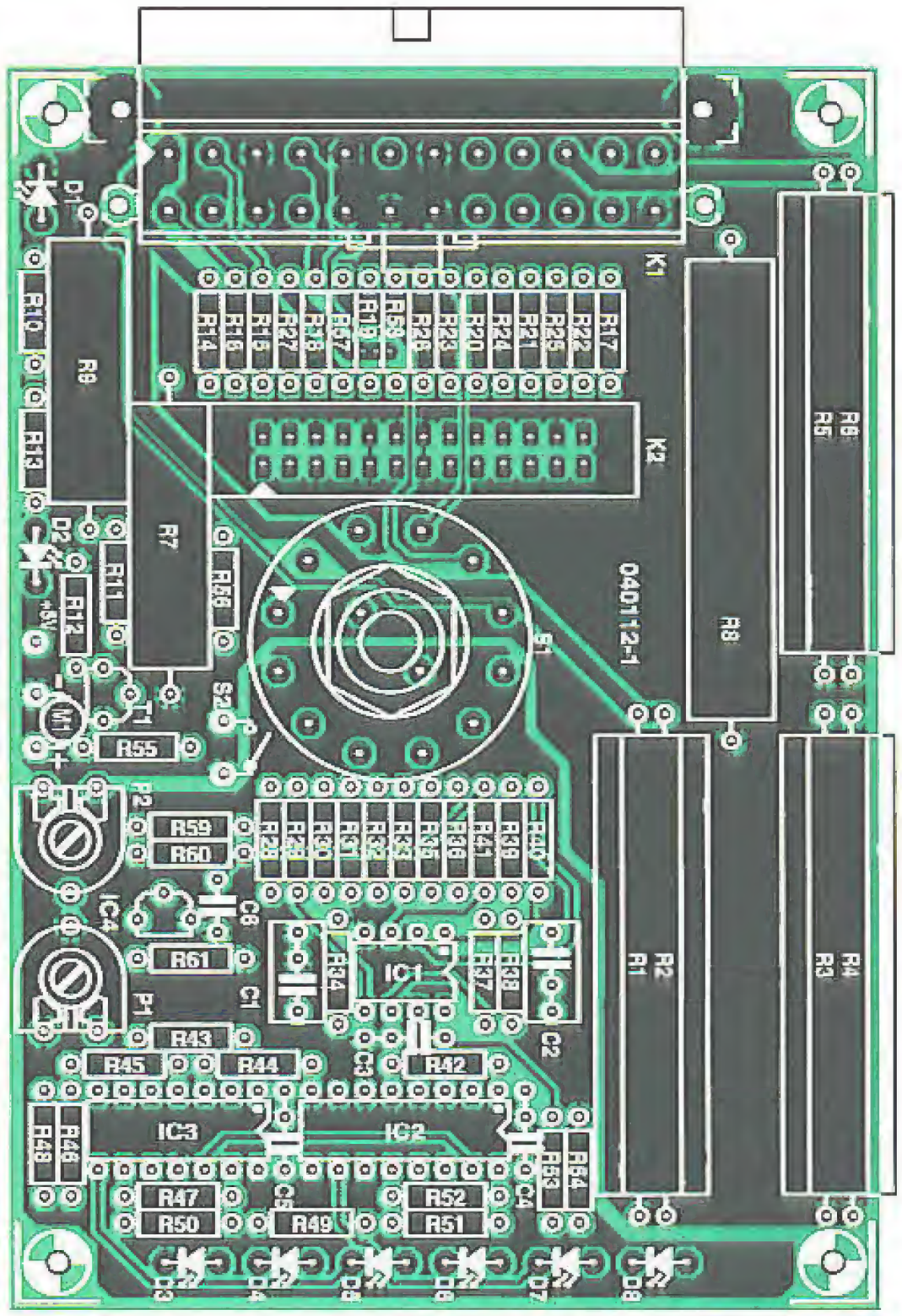


Figure 3. There is room on the PCB for all components. The power resistors are mounted on top of each other.

This makes it much easier to insert the connector from an ATX power supply.

There are no 'special' parts on the PCB. As long as you take care with the polarity and values of all components, and solder neatly, you shouldn't have any problems with the construction.

All the power resistors are also mounted on the PCB. Due to the heat these generate they should be mounted at least 2 or 3 mm above the PCB, otherwise the PCB will give off smells. (The resistors will do that in the beginning anyway). Resistors R1, R3 and R5 are mounted another 2 to 3 mm above R2, R4 and R6. This method of construction leaves enough air around the power resistors for ventilation.

Before you mount the board into an enclosure or drill any holes, you should make a careful note of the distance between the rotary switch and the ATX power supply header. The wiring for the LEDs and the on/off switch can be made with thin stranded wire.

Since this circuit generates a fair amount of heat, it is advisable to use a metal enclosure with sufficient (possibly even forced) cooling. A miniature 5 V fan will be essential if you use a small enclosure. This can be connected to the +5 V pin for the voltmeter module. Make sure that you have enough ventilation holes in the enclosure.

To give the tester a professional look, and make it easier to use, we have produced a front panel, which is shown at a reduced size in **Figure 5**.

Calibration and operation

There are two presets on the PCB that can be used to set the tester up accurately, although the circuit works perfectly well when they are set to their mid-position. For those of you who want to set the tester up as accurately as possible we'll explain the calibration procedure.

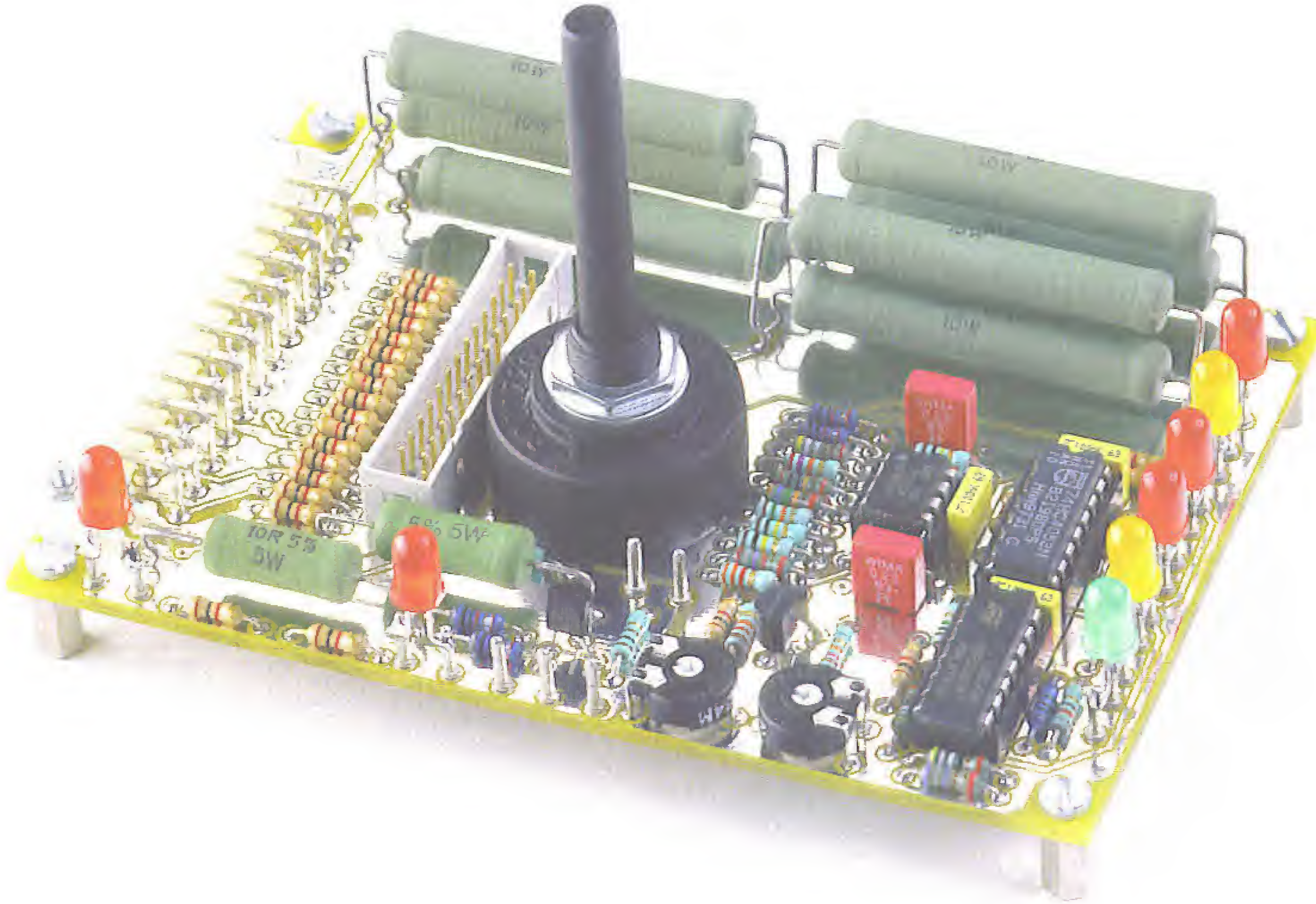


Figure 4. The completed PCB. When the tester is mounted in an enclosure you should make sure that there is plenty of ventilation for the power resistors.

Connect a multimeter between R43 (from the lead nearest P1) and ground. Adjust P2 to give a reading of exactly 2.50 V. Then connect the multimeter between R48 (from the lead nearest the mounting hole) and ground. The voltage at that point should then be adjusted with P1 to give a reading of 2.00 V. And that's it!

The use of the tester is very straightforward. First connect the supply connector (either the 20-pin or the newer 24-pin) from the ATX power supply under test. A 20-way plug is connected to the 'bottom' of the connector on the PCB, i.e. from pin 1 onwards. It won't fit any other way due to the shape of the plug and socket. The power supply should then be connected to the mains, and the mains turned on. The standby LED should now light up. If that isn't the case then the power supply has a serious fault and is best discarded. Turn the power supply on by closing S2. After a short delay LED D2 comes on if the power supply passed its self-test. You then use the rotary switch to select the voltages one by one and read from the LEDs how good the tolerance is. When you're finished you turn of the power supply again with S2. Remember that you shouldn't leave the tester on unnecessarily for long periods, because the power resistors generate a fair amount of heat.

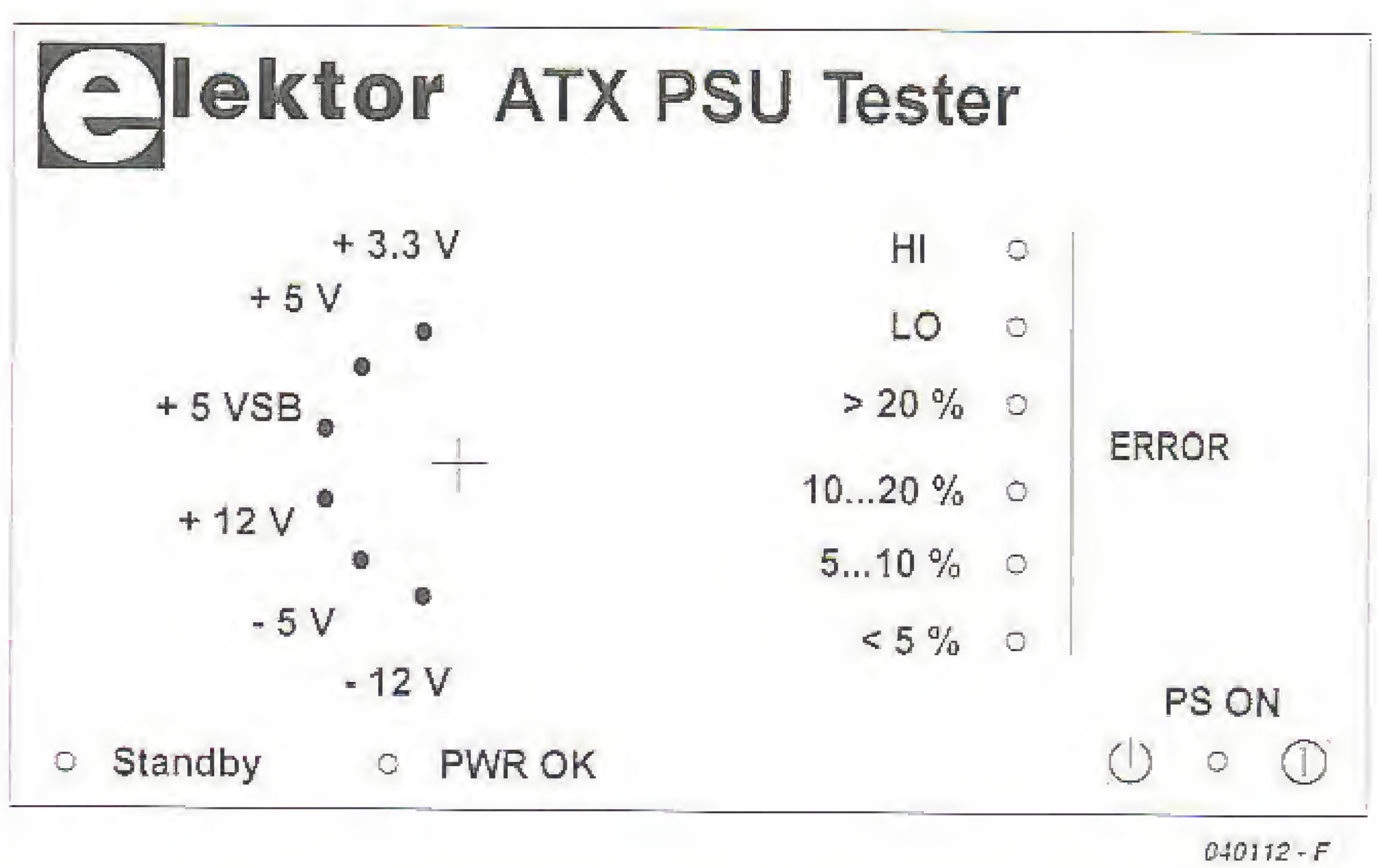
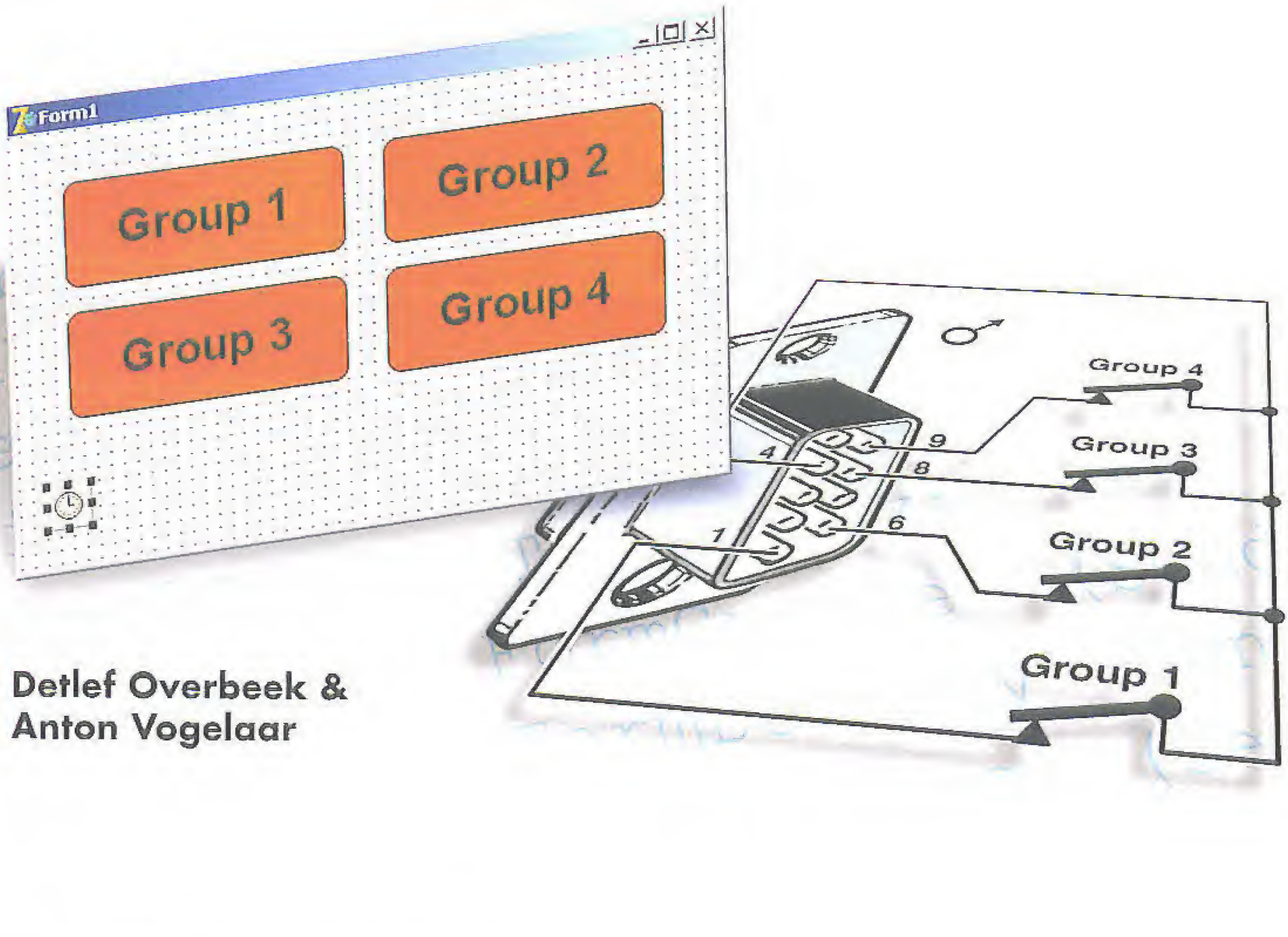


Figure 5. The front panel gives a nice finish to the project and is available as a PDF document.

course

DELPHI FOR ELECTRONIC ENGINEERS

Part 1 – The first steps



Detlef Overbeek &
Anton Vogelaar

This article is the first part in a series about programming in Delphi, which concentrates on the practical side of programming and how it can interact with hardware. As an example, how would you write a Delphi program under Windows and then transfer it to an IC to make an autonomous Delphi controller?

The authors

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Detlef D. Overbeek studied at the former Art Academy in Uirecht (Holland) and followed an education in graphic design. For many years he has worked as a software developer and IT consultant. He specialises in Delphi, website design and development. Detlef is Chairman of the HCC-PGG and he gives courses and lectures in Pascal and the web.

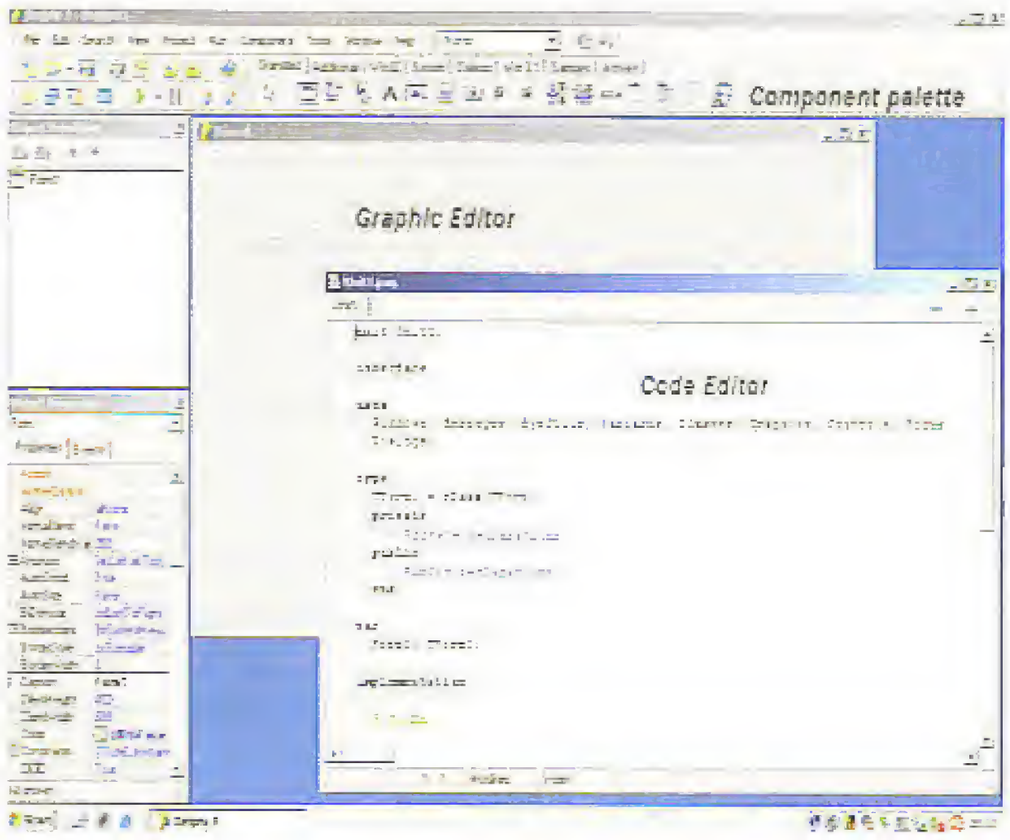


Figure 1. The IDE (Integrated Development Environment) in Delphi.

Delphi is a programming environment based on the 'Pascal' programming language. You could use it to design an aeroplane or create scientific programs, and also for measurement and control equipment and even use it to program ICs, which in turn control other pieces of hardware.

There are several different versions of Delphi 7. The 'Personal' version is the cheapest, but still offers enough functionality for most users. More expensive versions, such as 'Professional', 'Enterprise' or 'Architect' are obviously also suitable for this course, but are not essential. Older versions of Delphi (5 and 6) can also be used. The authors, both of whom are members of the HCC-PGG (Pascal Users Group) in Holland, hope that this course makes Delphi accessible to as many *Elektor Electronics* readers as possible. The Pascal Users Group has made a CD available for only 10 Euros (approx. £6.80), which contains the compleie *Personal Edition* (see inset) and a number of extra files that are used during this course. Once you have received this CD you have to request a (free) registration number from the Borland website before you can use Delphi.

The installation of Delphi is explained in detail in a separate article, which is freely available from the *Elektor Electronics* website (under January 2005, file ref. **040240-11**), and also from the website that the authors have set up especially for this course (see inset). If you already have Delphi installed on your PC you can start straight away.

In this initial article we begin with a small application to familiarise ourselves with Delphi. We then progress a little further and 'build' a digital clock. And finally we design an alarm system that can be put to practical use.
At this point we assume that Delphi 7 Personal Edition has been installed on your PC. First we'll take a look at Delphi and how it should be used.

Delphi is a development environment for writing and testing programs, and runs under the MS Windows operating system. There is an almost identical development environment available for Linux, called Kylix.

Programs written in Delphi make use of the Pascal programming language. Many visual tools are made available to help speed up program development, which is why Delphi is also called a RAD (Rapid Application Development) tool. When you run Delphi for the first time (via *Start/Programs/Borland Delphi 7/Delphi 7*) you'll be greeted with a display as shown in **Figure 1**. This is the Delphi development environment, usually called the IDE (Integrated Development Environment). The IDE consists of the following elements:

– **Menu bar**
(File, Edit, Search...). This menu provides access to all of Delphi's commands. In the next part we will look in more detail at all Delphi components and how they should be used. For now we'll concentrate on those components that are relevant to this article.

– **Speed buttons.**
The most popular commands from the menu can also be accessed via push buttons (speed buttons). If you move the mouse over such a button for a while, you'll see a hint with its description.

– **Component palette.**
The libraries in Delphi contain a large number of components that can be used for creating your own Windows applications. Similar components are put together into component libraries. Such a library is called a VCL (Visual Component Library). Each icon on the component palette represents the code for a component. As an example there is a component for entering text, which is called a memo box.

– **Graphic Editor (Form).**
The graphic editor is the window where all components for an application are put. At the beginning this is empty by default. When you use the mouse to click on an icon from the component palette and then click on the form, the code belonging to that icon is included in the program.

– **Object Inspector.**
(Called via function key F11) Every component has a number of settings and parameters that affect the operation of the component. These can be modified using the *Object Inspector*. From the *Events* tab in the *Object Inspector* you can add links to code that has to be executed as a result of a particular event in that component (mouse click, key press, etc.).

Figure 2. The Form with a Button component.

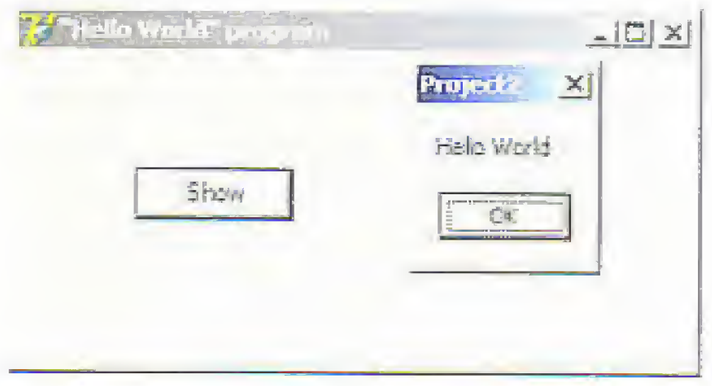


Figure 3. The program is run. A Windows message with "Hello World" appears.

– **Object Tree View.**
Larger programs consist of many componenis. When you click on the name of a component in the *Object TreeView*, the *Object Inspector* shows all properties for that component. If the screen has become very crowded, the *Object TreeView* can be removed by clicking on ihe [X].

– **Code Editor.**
(Function key F12 is used to toggle between the Graphic Editor and the Code Editor) The program code then appears in the *Code Editor* window. Any extra code can be typed in using ihe *Code Editor*. The editor has a lot in common with other programs such as Notepad and Word.

Altering the settings

The possibility of losing programs can be much reduced by altering a few settings within ihe IDE.

From the menu click on *Tools/Environment Options*.
In the Autosave options tick Editor files and Project desktop. The Delphi settings are then stored when you exit. When Delphi is started again, the IDE will look exactly the same as you last left it.
Tick Show compiler progress in Compiling and running. This option gives you a visual indication as the compilation progresses.
Save these settings by clicking on OK.
From the menu click on *Project/Options/Compiler*.
Remove the tick from the Sirict var-strings box in Syntax options to give you more freedom when working with text in the program.
Tick Range checking and Overflow checking in Runtime errors to make fault finding easier during the execution of your programs.
Tick Default to make these settings your default.
Save the settings by clicking on OK.

Our first program

We start with a simple program to get the feel of Delphi. We follow that well-known tradition and write a program that shows the text "Hello World" on the screen. Here's how it's done:

1. Start a new project by choosing *File/New/Application* from the menu.
2. Save the new project and give it a name (It's true that nothing has been entered yet, but this way all changes will be saved automatically with the new name). From the File menu select *File/Save All* and choose or create a directory where the files will be stored. You will be asked for the names for two files, *Unit1.pas* and *Project1.dpr*. You should change the name for these files in a way that reflects their function, for example *UMain.pas* and *HelloWorld.dpr*. The file *Unit1.pas* contains the 'Hello World' program and the file *Project1.dpr* is used by Delphi to store information regarding the project.
3. Now put a TButton component (the 8th icon from the left) from the Standard tab (in the Component palette) on to the Graphic Editor, also called the Form.
4. You can change the size of the form by clicking with the left mouse button on the bottom-right corner of the Form and dragging it with the mouse, whilst keeping the left button pressed down.
5. One of the properties of the Form object is the text shown in the title bar. The default is *Form1*. This can be changed by clicking with the mouse on the Form, making the *Object Inspector* show the properties of Form1. Change the text after Caption to *'Hello World' program*.
6. The text on the Button can be changed by clicking on the Button, making the *Object Inspector* show the properties of Button1. Change the text after Caption to *Show*.
   The project should now look like **Figure 2**.
7. If, during the running of this program *(from the menu bar click on Run/Run or press function key F9), we click on the button we want the message "Hello World"* to appear. But we haven't got to that stage yet. The TButton type button comes from the VCL library. When we click on this button the component has to know what code should be run. This can be specified in the Object Inspector. Click on the Button to make the Object Inspector show the properties of TButton. Next, click on the Events tab in the Object Inspector. The link next to the OnClick event points to the code that is run when that event occurs.
8. If you double-click on the box to the right of the OnClick event the Code Editor appears. The standard code is provided by Delphi.
   This is extended with our code, which is between Begin and End.

```
Procedure TForm1.Button1Click (Sender : TObject);

Begin
   ShowMessage ('Hello World');
   // in single quotes

   // all characters after these forward slash
   // symbols are treated as a comment

End;
```

Observations:

Figure 4.This clock was created in the blink of an eye-lid!

The procedure ShowMessage is made available by the operating system, so there is no need for us to write it. A line of Pascal code must end with a ; (semi-colon). Comments can be written after // or between (* ..... *) or { ..... }

9. The program is then compiled and executed when you press function key F9 (**Figure 3**).

The directory where we saved the project file *Project1.dpr* (or any other name we gave it) also contains an executable file, *Project1.exe*, created by Delphi. This *.exe can be used outside the Delphi IDE for stand-alone use of the program.

Second program - a digital clock

The next example shows how we can create a program to display a digital clock, using Delphi. We'll assume that you are now familiar with all the procedures we used in the "Hello World" program.

1. Start a new project by choosing *File/New/Application* from the menu.
2. Save the new project and give it a name via *File/Save All*.
3. Put a Label from the Standard tab on the Form.
4. Change the following properties of Label1 in the Object Inspector:
   Caption: 00:00:00
   Transparent: True
   this makes the background transparent
   Font: *Click on the button on the right with the 3 dots.*
   A Font window now appears.
   Choose font: Arial
   Font style: Bold
   Size: 100
   Color: Red
   Click on OK to accept the changes.
5. Click anywhere on Form1 and modify the following properties of Form1 in the Object Inspector:
   Caption: Digital Clock
   Color: clBlack
   BorderStyle: bsSingle
   the user can't change the format
   Position: poScreenCenter
   BorderIcons: click on [+] to see more options
   BiMaximize: False
6. Change the size of the Form to fit the display. The Form in the Graphic Editor should now look as shown in **Figure 4**.
7. To make the Label refresh automatically every second, a timer is used. Place a Timer from the System tab on the Form. This timer is visible during the development of the program, but not during its use. This type of component is therefore called a 'non-visual component'. A Timer is really just a mini clock in a component that keeps the same time as the PC.
8. Since the default interval is 1000 ms = 1 s (see Object Inspector), this property doesn't need to be changed. (To make the clock update once per minute this value should be changed to 60000.)
9. In the Events tab of the Object Inspector is an OnTimer event. The procedure linked to this event is called at the end of every timer period.
10. If you double-click on the box to the right of the OnTimer event the Code Editor appears. The standard code is again provided by Delphi.
11. We extend this with a line between the Begin and End:

```
procedure TForm1.Timer1Timer(Sender: TObject);

Begin
   Label1.Caption := TimeToStr (Now)
End;
```

The function TimeToStr converts the time into a string of the form HH:MM:SS. This Delphi function comes from the SysUtils unit. The units that Delphi uses when it searches for unknown procedures and functions are listed after the word 'Uses' at the top of the program. 'Now' is a function that returns the current time and this also comes from the SysUtils unit.

12. The program is compiled and run by pressing function key F9.

The third program – an alarm system

This program provides protection against burglary and fire in a dwelling. The projected dwelling is divided into four zones. If there is an alarm condition in one or more zones this should be indicated both visually and aurally.

The alarm system is implemented as follows. Each zone contains a number of sensors with normally closed contacts, connected in series. In this way a sensor circuit is always closed until an alarm condition occurs in a sensor or the cable is cut.

A number of suitable sensors are shown in **Figure 5**. Since this system makes use of closed circuits, monitoring the alarm installation comes down to detecting whether or not the four sensor loops have breaks in them. The RS232 port in a PC has four inputs that can be used for this.

Should your PC not have a spare RS232 port, or wasn't provided with one, you can use a USB/RS232 converter. (An RS232 port has a 9-way male connector on a PC).

The connection diagram is shown in **Figure 6**.
Pin 4 is used to provide a voltage for the switches. The inputs on pins 1, 6, 8 and 9 will normally see this voltage, or 0 V in an alarm condition.

The program

1. Start a new project by choosing *File/New/Application* from the menu.
2. Save the new project and give it a name via *File/Save All* or hold down the keys Shift+Ctrl+S simultaneously.
3. Put four rectangular Shapes from the Additional tab on

Figure 5. A number of suitable sensors for our alarm system.

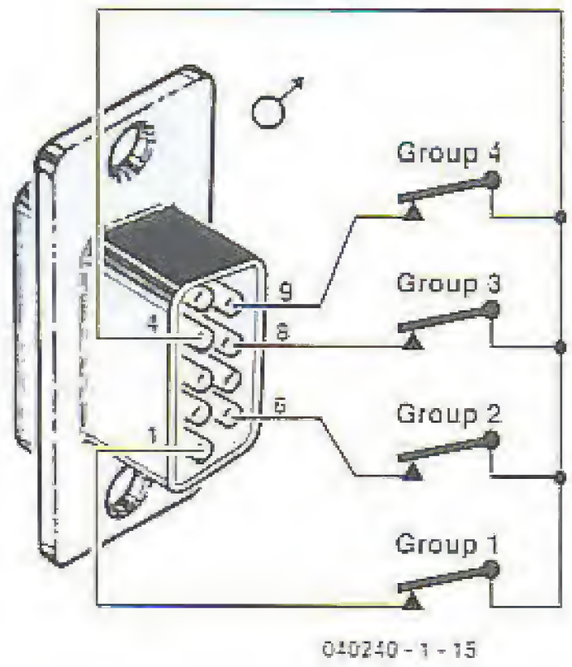


Figure 6. The connection diagram for the four loops on the PC serial port.

the Form and set their properties: Shape = stRoundRect and Brush/Color = clRed.

4. Put a Label from the Standard tab into each of the Shapes and set their properties: Caption = Group 1, Group 2, Group 3 and Group 4, Transparent = True and in the Font-property: Font = Arial, Font style = Bold and Size = 20.
5. Add a Timer from the System tab to the Form so that the state of the alarm sensors can be checked periodically. The Form should now look similar to **Figure 7**.
6. Before the state of the RS232 inputs can be read, the program has to open the communications port. This is done when the programs starts. When the program finishes the port is closed again, making it available for use by other programs. The OnCreate and OnDestroy events are used for this when opening and closing a Form respectively. If you double-click on the boxes to the right of these events in the Object Inspector for Form1, Delphi will add the code for these events in the Code Editor. You should now add our application code between the Begin and End lines (**Listing 1**). This code has references to the as yet undefined variable HComm and the constant PName.

HComm is a handle/number that refers to the communications port used. The value for this handle is returned by the operating system (Windows) via the function CreateFile. If the value of HComm is <= 0, the communications port could not be opened.

Since a PC may have more than one communications port, the constant PName has been added to the program. This contains the name of the communications

Listing 1.

```
Procedure TFMain.FormCreate (Sender : TObject);

Begin
   If HComm <= 0 Then
   Begin
      CloseHandle (HComm); HComm := 0
   End;
   HComm := CreateFile (PChar (PName), GENERIC_READ Or GENERIC_WRITE, 0, Nil,
                        OPEN_EXISTING, FILE_ATTRIBUTE_NORMAL, 0);
   If HComm = Invalid_Handle_Value
      Then ShowMessage ('Unable to open comm port');
End;


Procedure TFMain.FormDestroy (Sender : TObject);

Begin
   If HComm > 0 Then
   Begin
      CloseHandle (HComm); HComm := 0
   End;
End;
```

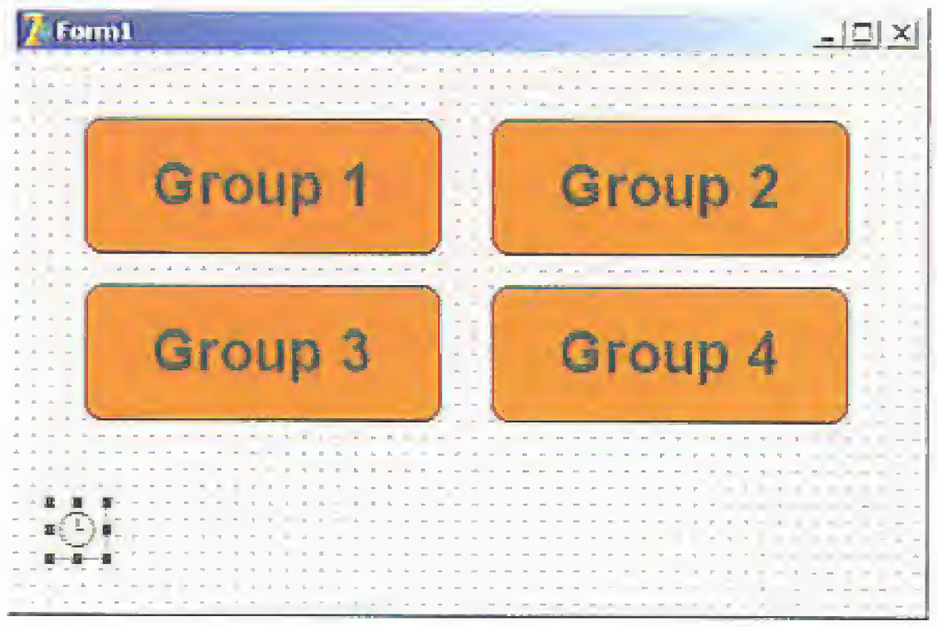


Figure 7. The Form with the components for the alarm program.

Ordering Delphi 7

Borland has made the Personal version of Delphi 7 available cheaply especially for this course. The CD costs € 10.00 (ten euros) and contains Delphi 7 as well as several extra files for this course. It can be paid for by credit card (see website below) or bank transfer (in the EC) by transferring to (please copy exactly):

Bank: ABNAMRO
IBAN: NL31 ABNA 0577002562
BIC: ABNANL2A
Name: DETLEF D. OVERBEEK
Address EDELSTENENBAAN 21 IJSSELSTEIN
Post code: 3402 XA
Country: THE NETHERLANDS
Reference: DELPHI ELEKTOR

IBAN/BIC payments should not incur bank costs when processed correctly — ask you bank for details. Cheques are not acceptable. The HCC PGG has set up a special website in support of this course: www.learningdelphi.info/
Here you can find the most up-to-date news and extra files for the course, as well as credit card payment options.

port we want to use. In other words, if we want to use Com5 the value of PName should be 'Com5'.
The variable HComm and the constant PName are defined in the header (**Listing 2**).

7. In the OnTimer event of the timer, which is called once per second by default, the status inputs are read and the corresponding indicators/Shapes will be set to green (teal) or red, depending on the alarm condition.

The function GetCommModemStatus asks Windows for the state of the inputs of the communications port which is referred to by the value in HComm. The returned value is stored in the variable MdmSts, which is of a Cardinal type (a 32-bit number). The four inputs take up one bit each in MdmSts. By AND-ing this with a mask (see listing 3, the masks are MS_DSR_ON etc.) and testing if the result is '0', we know whether the bit is set or not (**Listing 3**). The result determines whether the Shape takes on a green or red colour.

The SoundAlarm procedure is still commented out, but we'll make use of this later.
Note that occasionally you may have to reset the PC in order to get the RS232 port to work properly.

8. The program can be enhanced with a sound output to draw the attention of the operator. We will use the PC loudspeakers for this. We have included an option to turn off the sound until the alarm condition has passed.

Put a CheckBox from the Standard tab on to the Form. Change the Caption property to "Sound Off".

Listing 2.

```
Type    TForm1  = Class (TForm)
                    Shape1      : TShape;
                    Shape2      : TShape;
                    Shape3      : TShape;
                    Shape4      : TShape;
                    Label1      : TLabel;
                    Label2      : TLabel;
                    Label3      : TLabel;
                    Label4      : TLabel;
                    Timer1      : TTimer;
                      Procedure FormCreate  (Sender : TObject);
Procedure FormDestroy (Sender : TObject);

Private
                  Public
                    HComm       : THandle;
                  End;

Var     Form1   : TForm1;

Const   PName   = 'Com1';
```

Listing 3.

```
Procedure TFMain.Timer1Timer (Sender : TObject);

Var     MdmSts  : Cardinal;

Begin
   If HComm > 0 Then
   Begin
      GetCommModemStatus (HComm, MdmSts);
      If MdmSts And MS_RLSD_ON = 0 Then Shape1.Brush.Color := clRed
                                   Else Shape1.Brush.Color := clTeal;
      If MdmSts And MS_DSR_ON  = 0 Then Shape2.Brush.Color := clRed
                                   Else Shape2.Brush.Color := clTeal;
      If MdmSts And MS_CTS_ON  = 0 Then Shape3.Brush.Color := clRed
                                   Else Shape3.Brush.Color := clTeal;
      If MdmSts And MS_RING_ON = 0 Then Shape4.Brush.Color := clRed
                                   Else Shape4.Brush.Color := clTeal;

      // SoundAlarm;
   End;
End;
```

Define a new procedure in the header, between the words Private and Public: Procedure SoundAlarm;

Remove the comment symbols before SoundAlarm in the OnTimer event

Write the procedure for SoundAlarm. The completed program should now look like **Listing 4**.
In this first instalment we've managed to get through three examples and we may have covered some concepts rather quickly. But we've assumed from the start that those of you who are interested will want to broaden your knowledge of Delphi programming. You'll soon find that programming can be both fun and instructive.

Listing 4.

```
Unit Unit1;
(* Example of a burglar alarm program Elektor / HCC-PGG.
   By Vogelaar Electronics, Bunschoten Netherlands.
   Rev 0.10  09-09-04  Initial release. *)

(* ============================ Interface ============================== *)
Interface

Uses    Windows, Messages, SysUtils, Variants, Classes, Graphics, Controls, Forms,
        Dialogs, ExtCtrls, StdCtrls;

Type    TForm1  = Class (TForm)
                    Shape1      : TShape;
                    Shape2      : TShape;
                    Shape3      : TShape;
                    Shape4      : TShape;
                    Label1      : TLabel;
                    Label2      : TLabel;
                    Label3      : TLabel;
                    Label4      : TLabel;
                    Timer1      : TTimer;
                    CheckBox1: TCheckBox;
                    Procedure FormCreate  (Sender : TObject);
                    Procedure FormDestroy (Sender : TObject);
                    Procedure Timer1Timer (Sender : TObject);
Private
                    Procedure SoundAlarm;
Public
                    HComm       : THandle;
```

```
                End;

Var     Form1    : TForm1;

Const   PName    = 'Com1';

(* ============================== Implementation ============================== *)
Implementation

{$R *.dfm}

Procedure TForm1.FormCreate (Sender : TObject);

Begin
   If HComm <= 0 Then
   Begin
      CloseHandle (HComm); HComm := 0
   End;
   HComm := CreateFile (PChar (PName), GENERIC_READ Or GENERIC_WRITE, 0, Nil,
                        OPEN_EXISTING, FILE_ATTRIBUTE_NORMAL, 0);
   If HComm = Invalid_Handle_Value
      Then ShowMessage ('Unable to open comm port');
End;


Procedure TForm1.FormDestroy (Sender : TObject);

Begin
   If HComm > 0 Then
   Begin
      CloseHandle (HComm); HComm := 0
   End;
End;


Procedure TForm1.SoundAlarm;

Begin
   If Not CheckBox1.Checked And
      ((Shape1.Brush.Color = clRed) Or
       (Shape2.Brush.Color = clRed) Or
       (Shape3.Brush.Color = clRed) Or
       (Shape4.Brush.Color = clRed)) Then Beep
End;


(* ================================ Timer ================================== *)

Procedure TForm1.Timer1Timer (Sender : TObject);

Var     MdmSts   : Cardinal;

Begin
   If HComm > 0 Then
   Begin
      GetCommModemStatus (HComm, MdmSts);
      If MdmSts And MS_RLSD_ON = 0 Then Shape1.Brush.Color := clRed
                                   Else Shape1.Brush.Color := clTeal;
      If MdmSts And MS_DSR_ON  = 0 Then Shape2.Brush.Color := clRed
                                   Else Shape2.Brush.Color := clTeal;
      If MdmSts And MS_CTS_ON  = 0 Then Shape3.Brush.Color := clRed
                                   Else Shape3.Brush.Color := clTeal;
      If MdmSts And MS_RING_ON = 0 Then Shape4.Brush.Color := clRed
                                   Else Shape4.Brush.Color := clTeal;
      SoundAlarm;
   End;
End;

(* ================================ End ================================== *)

End.
```

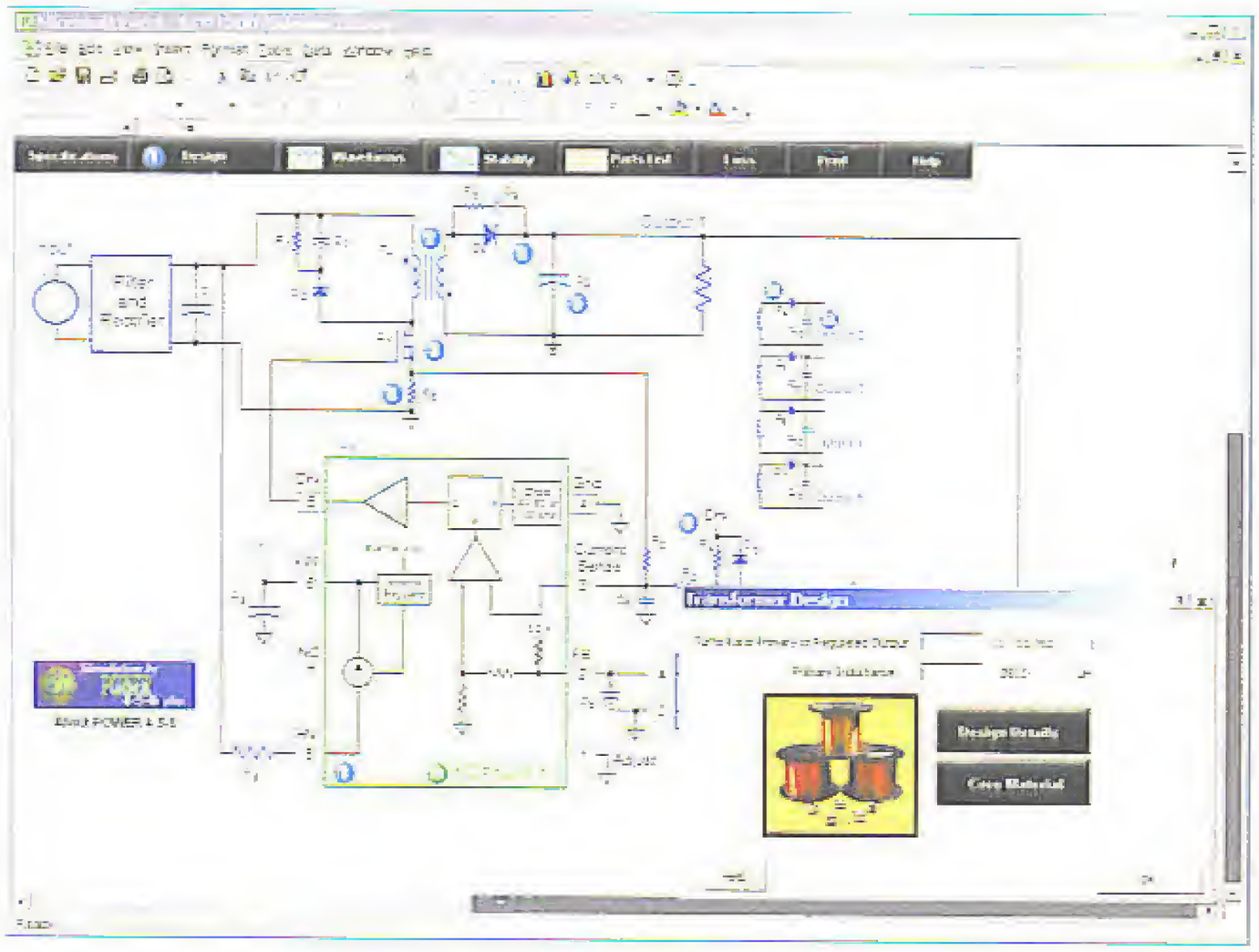
E-ONLINE

Power Supply Design

Information, dimensioning and simulation

Harry Baggen & Karel Walraven

Designing a power supply for one of your circuits can be plain sailing but also turn out to be a surprisingly complex job. Switch-mode power supplies in particular may present a real challenge before useful results are obtained. Fortunately, several semiconductor manufacturers come to our rescue.



A small power supply consisting of a mains transformer, a rectifier, electrolytics and a voltage regulator can be designed and put together by most electronics enthusiast with excellent results. However, switch-mode power supplies (SMPSUs) see increasing use thanks to being smaller, lighter and more efficient than a conventional, linear supply.

Semiconductor manufacturers today offer a wide selection of dedicated, switching ICs for use at the heart of an SMPSU. Dimensioning the circuitry around such ICs is, however, more complex than with a linear counterpart.

In addition to many datasheets and application notes, **Fairchild** offer a *Power Supply Design Toolkit* [1]

that allows users to quickly design a switch-mode power supply. The toolkit can be downloaded in its entirety, but the program may also be used on-line.

With **Linear Technology** we saw clearly laid out tables for switch-mode as well as linear regulators. When a certain component is selected, a compact page appears showing essential data and an application example, which we found very useful. The software available here includes *SwitcherCAD III* [2], which is a Spice-3 simulator comprising the greater part of Linear's switching ICs.

National Semiconductor supplies *WeBENCH* [3] for PSU designers. Once a component has been selected, the program assists in creating the design and then starts simulating it. Next the utility *WebTHERM* may be launched to run a thermal simulation.

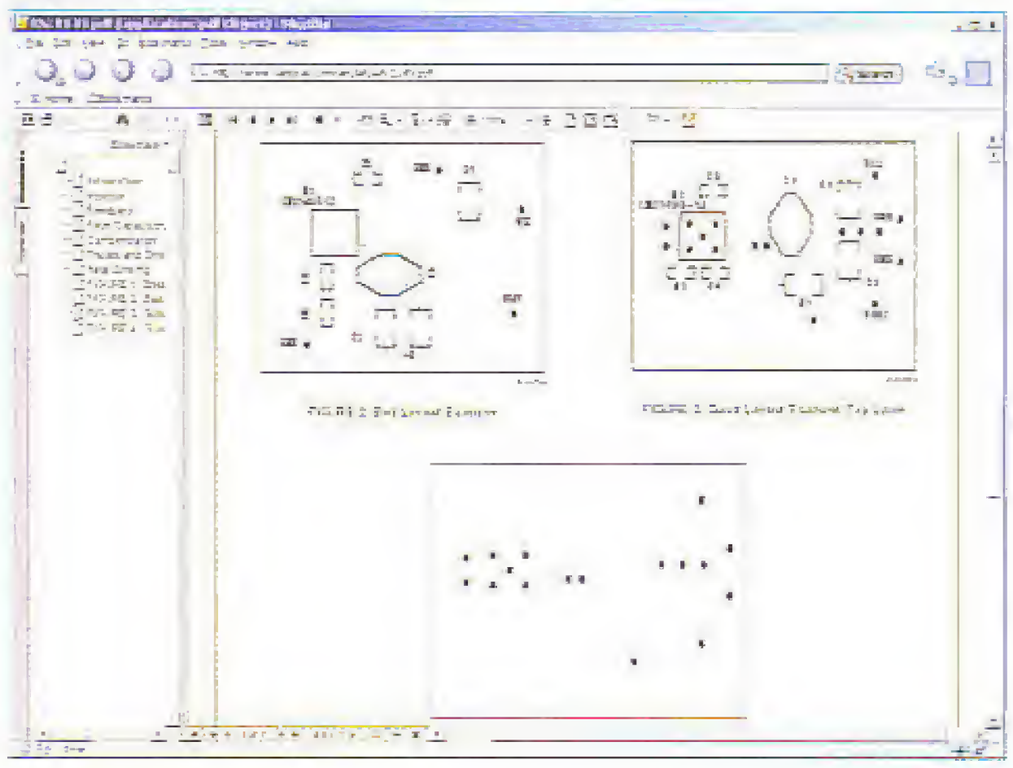
ON Semiconductor also supplies an impressive range of special ICs for switching power supplies. This manufacturer provides software called *Power 4-5-6 Plus* [4] for PSU design and simulation.

Another big player in the arena, **STMicroelectronics** has designed special software called *VIPer Design Software* [5] specially for flyback converters employing ICs from the VIPer series.

On the **Texas Instruments** website we found, among others, *SWIFT Designer Software* [6]. SWIFT is TI's acronym for Switched With Integrated FET Technology; a family of synchronous buck PWM converters that go by type codes like TPS5461x.

In nearly all cases the use or downloading of the above mentioned software requires registering your contact details with the relevant manufacturer. Fortunately, the process is invariably free of charge and obligation.
Besides the IC, when designing a power supply you should also pay attention to the surrounding components like inductors, capacitors and not forgetting the PCB layout (some programs do this for you).
Coils and coil formers are often seen as stumbling blocks when designing a switch-mode power supply. Several brands are currently available like Coilcraft, Fair-rite, Sumida, MicroMetals, Ferroxcube, Magnetics, TDK and Würth. The availability of most of these products is reasonable from mail order companies like Digikey.
The company **Würth** [7] even supplies design kits with an assortment of coils in direct support of the designs of different semiconductor manufacturers.

The choice of the capacitors in a switch-mode power supply is also a critical factor. Special electrolytics are now available marked by a low ESR (equivalent series resistance) which is maintained at higher (switching) frequencies.
As compared with these low-ESR caps, 'ordinary' capacitors have relatively poor filtering abilities hence run much hotter in actual use! Some names you should know in this area include Panasonic, Wima, Vishay Sprague and Epcos.



Internet addresses

[1] Fairchild:
http://www.fairchildsemi.com/designcenter/

[2] Linear Technology:
http://www.linear.com/index.jsp

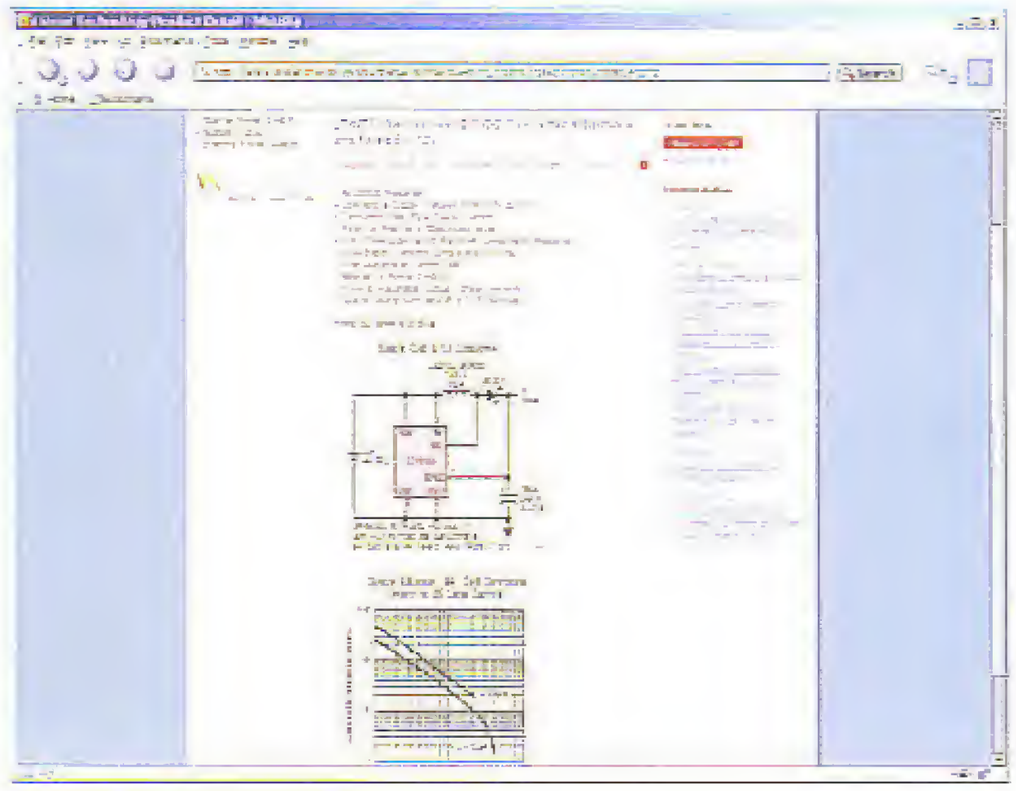
[3] National Semiconductor:
http://www.national.com/appinfo/power/webench/

[4] ON Semiconductor:
http://www.onsemi.com/site/support/models

[5] STMicroelectronics:
http://www.st.com/stonline/prodpres/discrete/vipower/vipfm5.htm - p2

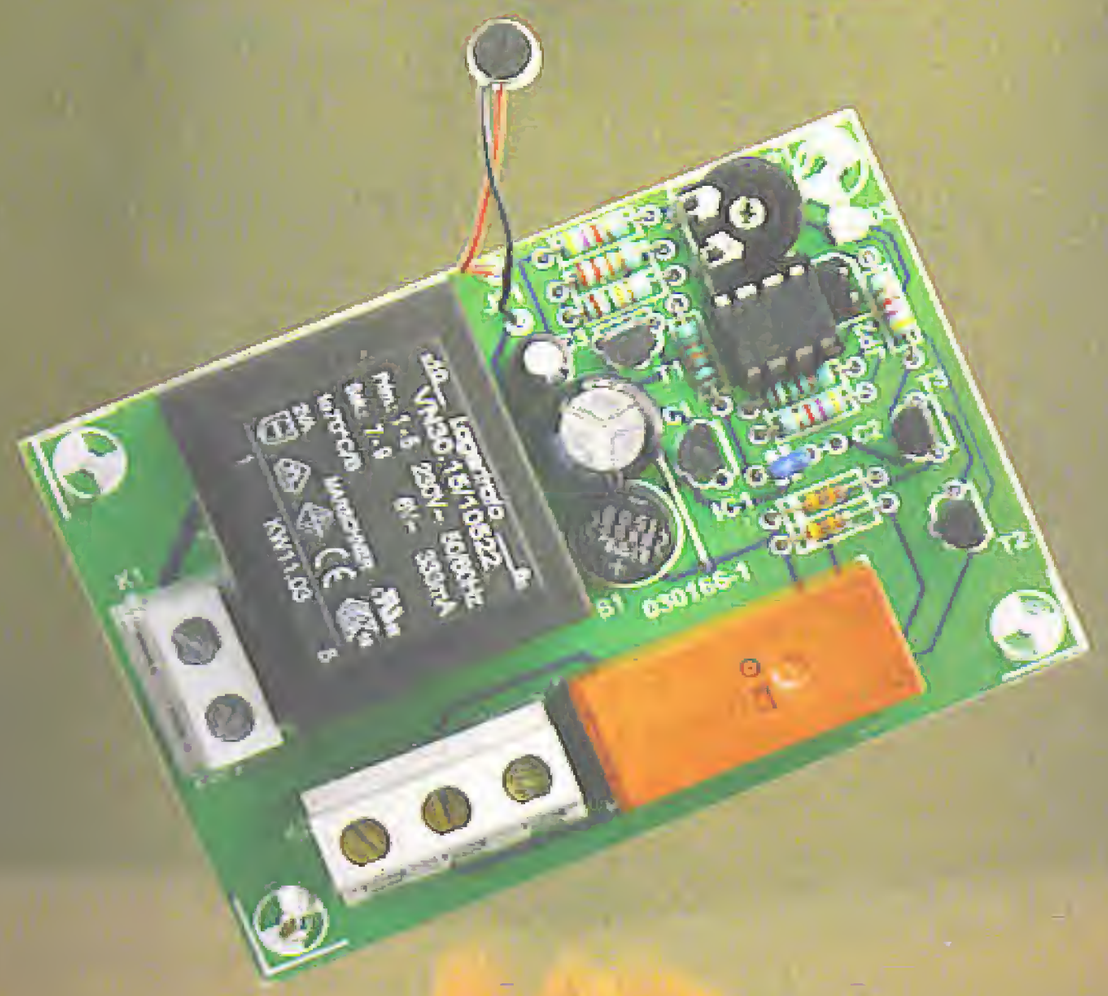
[6] Texas Instruments:
http://focus.ti.com/docs/toolsw/folders/print/swift-sw.html

[7] Würth:
http://www.we-online.com/



Intelligent Clap

Jörg Prim



A clap switch circuit is a classic beginner's project. Equipment can be switched on and off by just clapping your hands. Add a tiny microcontroller and you can easily build-in some more useful features.

Switch

Manual remote control with extras

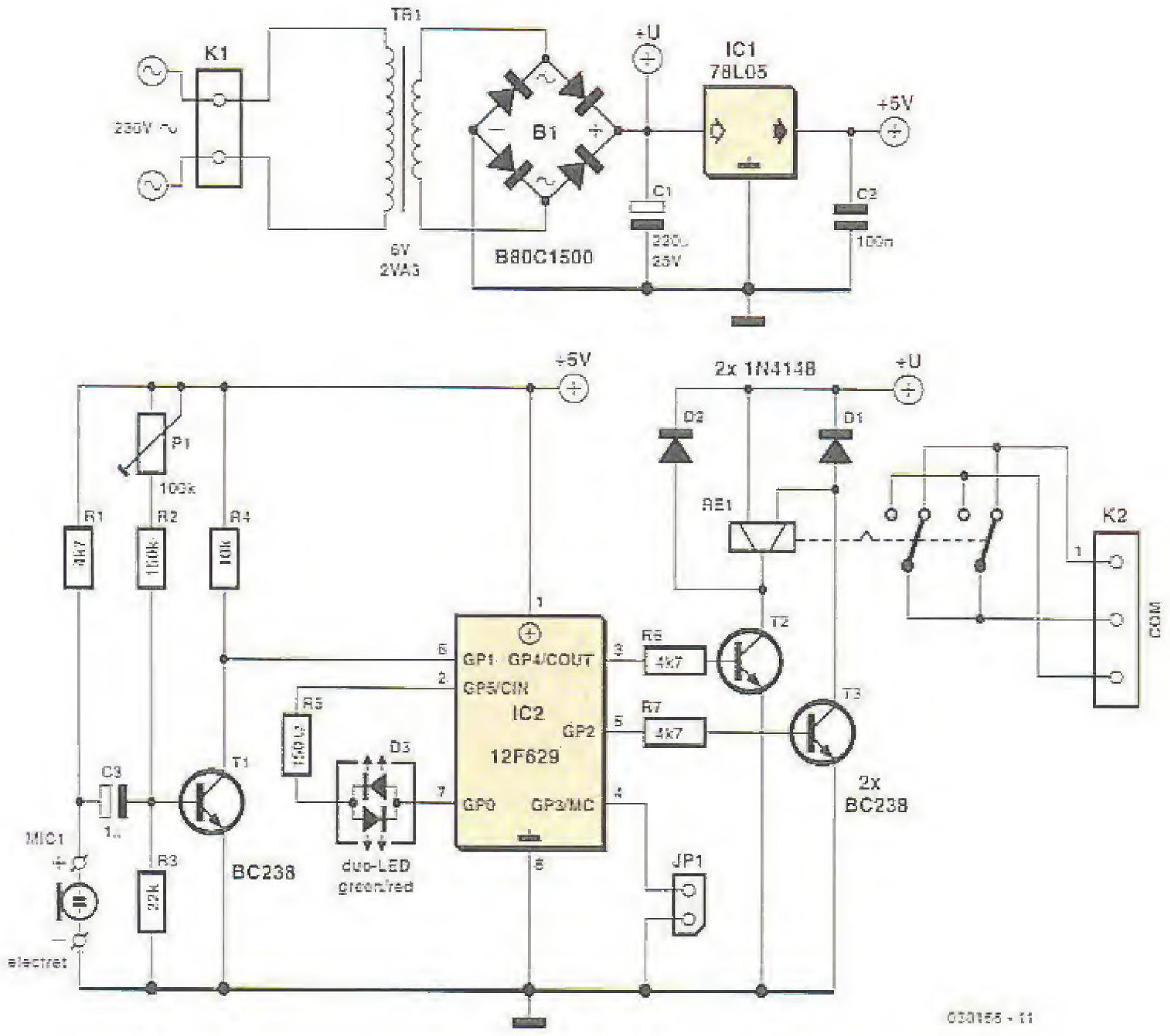


Figure 1. A tiny PIC12F629 samples the input and switches a bistable relay.

The microcontroller in this circuit makes it a simple job to add some useful features that are not seen on other clap switch designs:

- Changeover relay contacts enable the unit to be wired in conjunction with a manual changeover switch so that manual override of the switched equipment is always possible.
- The unit is only responsive to a specific sequence of sounds i.e., two claps within a defined time window.

- A safety feature masks the input for a given time window if misuse (repeated commands) is detected (useful if children have discovered how it works).

The safety feature and two-clap sequence detector can be built using TTL or CMOS flip-flops but by using a single microcontroller the circuit can be greatly simplified. A mains power supply is included so no additional power source is required.

A compact Controller

The Microchip flash PIC12F629 microcontroller is a neat device; the small 8-pin package contains a complete microcontroller including clock generator, reset circuitry, Flash ROM, RAM and EEPROM. Two of the eight pins are used for the supply connections while the remaining six are general-purpose I/O pins. A few of these pins have special function like the comparator inputs. The sound sensitivity of the circuit can be adjusted by programming the comparator threshold level in software.

The circuit diagram in **Figure 1** shows that besides the microcontroller there are very few other components. The two-pin electret microphone produces an electrical signal in response to sound pressure waves. Transistor T1 amplifies the signal and preset P1 allows some adjustment of the circuit sensitivity by altering the bias voltage of T1.

Two of the PIC output pins are used to drive a bistable relay via transistors T2 and T3. This type of relay has two energising coils. A short electrical pulse on one of the coils is enough to switch the relay in one direction while a pulse to the other coil will cause the relay to switch back. This type of relay has two main advantages: the relay is latching in both open and close direction so a short pulse is all that is necessary to switch it. Secondly the latching feature ensures that the relay retains its switched state even during a power failure. Changeover relay con-

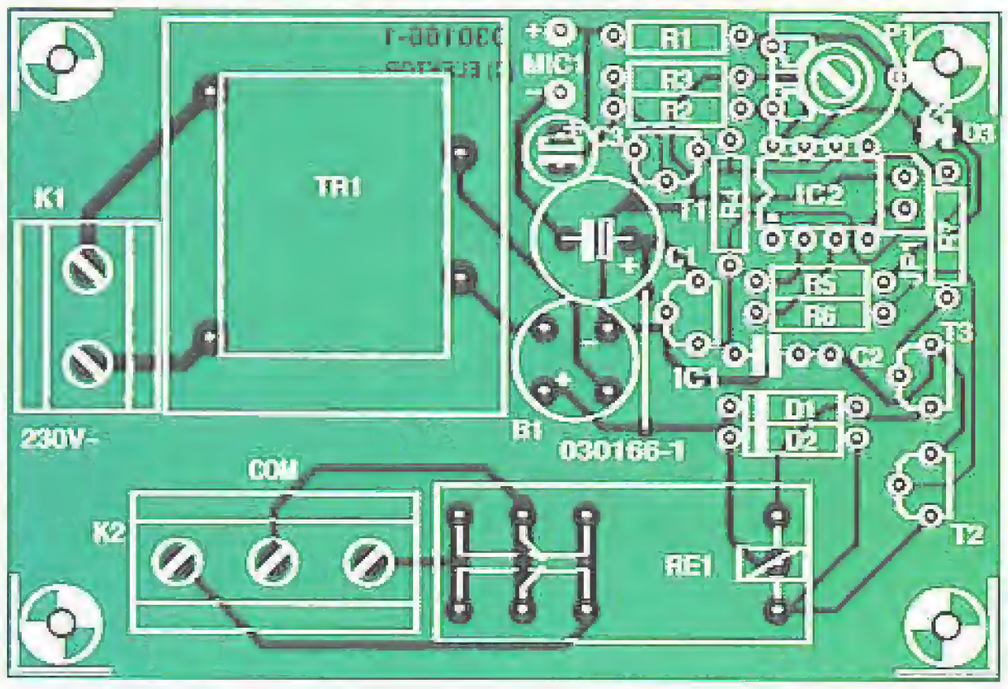


Figure 2. All components apart from the electret microphone are accommodated on the PCB.

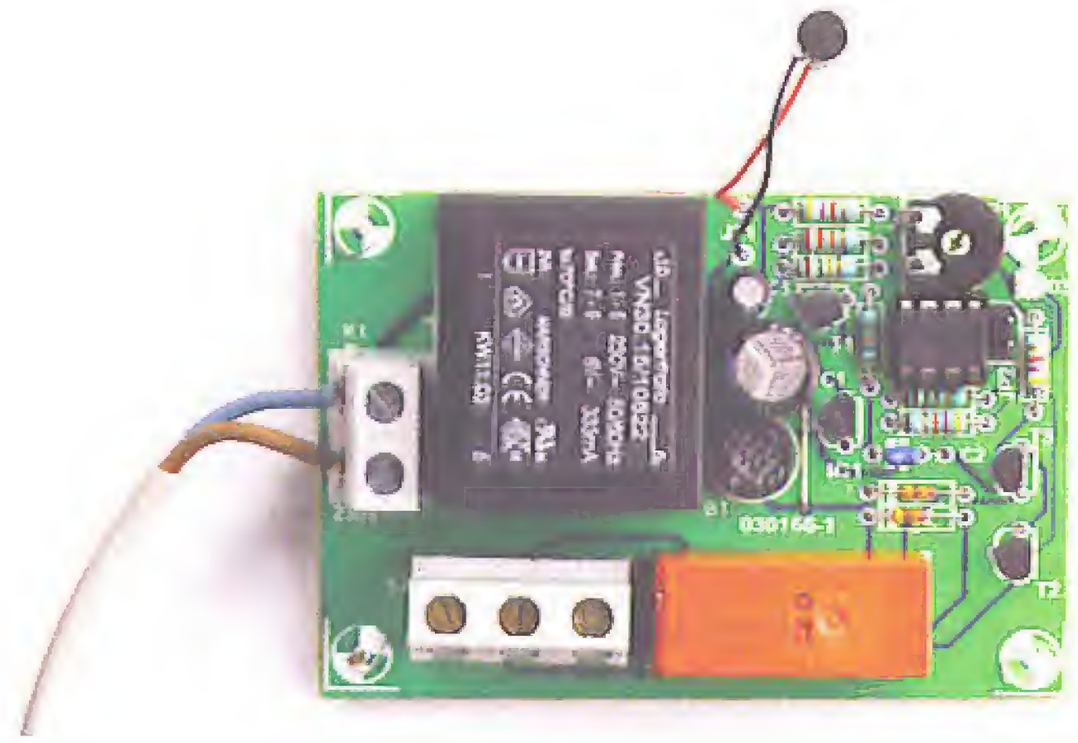
COMPONENTS LIST

Resistors:
R1,R6,R7 = 4kΩ7
R2 = 150kΩ
R3 = 22kΩ
R4 = 10kΩ
R5 = 150Ω
P1 = 100kΩ preset H

Capacitors:
C1 = 220µF 25V radial
C2 = 100nF
C3 = 1µF 16V

Semiconductors:
B1 = B80C1500 (round case, 80V piv, 1.5A)
D1,D2 = 1N4148
D3 = bicolour LED (red/green)
IC1 = 78L05
IC2 = PIC12F629CP, programmed, order code **030166-41**
T1,T2,T3 = BC238 or BC547

Miscellaneous:
JP1 = 2-way pinheader with jumper
K1 = 2-way PCB terminal block, lead pitch 7.5mm
K2 = 3- way PCB terminal block, lead pitch 7.5mm
MIC1 = 2-terminal electret microphone capsule
Re1 = bistable relay, 2 x changeover (e.g., Schrack RT314F12)
Tr1 = mains transformer 1 x 6V, min. 2VA, short-circuit proof (e.g., Marschner VN30.15/10522 or Era 030-7340.0T; Conrad Electronics # 506141)
PCB, order code **030166-1** (see Readers Services page)
Disk, source and hex files, order code **030166-11** or Free Download



tacts enable the unit to be wired together with a changeover type manual switch, allowing the equipment to be switched manually if for any reason the clap switch is switched off.
Pins 2 and 7 are used to switch a two-colour LED providing a visual indication of the switched state of the relay.

The last output pin of the PIC is not used and is connected to a jumper to allow switching software options.

Software

When the signal level at GP1 goes low (clap detected) the program waits for approximately 200 ms during which time the LED glows red. After this period the LED switches to green and the software samples the input for approximately three seconds. If a second clap is detected during this period, the controller switches the output. After switching, the controller ignores any further clap sounds for approximately 10 s and the LED lights red. The output state is stored in EEPROM so that if a power failure occurs the software will switch the correct relay coil when power is re-established.

A safety feature counts each switching event on an internal counter, which is decremented slowly in software. Should this counter exceed a threshold level, the circuit will ignore any input signals for approximately one minute and the LED blinks red. This will ensure that the circuit does not respond to an extended burst of noise (e.g., applause).

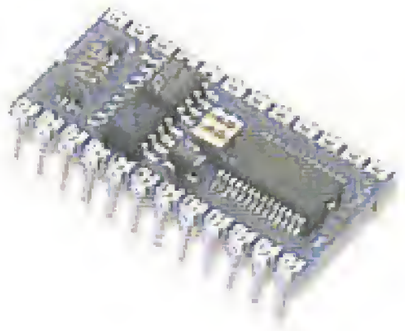
The PCB

The PCB layout shown in **Figure 2** accommodates all components apart from the electret microphone. This is attached to the board at the MIC +/– connections with a length of shielded audio lead (keep the wire length to less than around 10 cm).

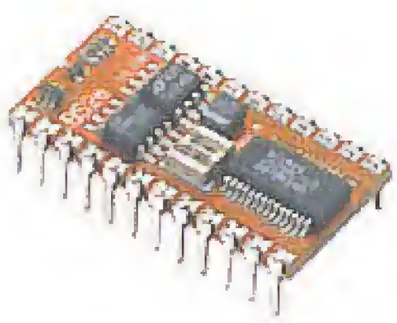
Mounting the components onto the PCB should be quite straightforward. Start by fitting the single wire bridge next to rectifier B1. Ensure that all polarised components (diodes, LEDs, capacitors and the IC) are fitted the correct way round. The LED leads should be trimmed so that when it is soldered to the board it protrudes through a hole in the lid when the case is assembled; alternatively use a translucent enclosure.

Once all components have been fitted and all solder connections have been inspected the PCB can be fitted into an insulated enclosure. The mains input lead will require some form of strain relief. Be aware that some tracks carry lethal voltages. All appropriate safety guidelines **must** therefore be adhered to. A small hole can be made in the lid directly over preset P1 if it is necessary to adjust the sensitivity of the circuit without dismantling the unit. Lastly, don't forget to add perforations in the case so that sound waves can reach the microphone capsule.

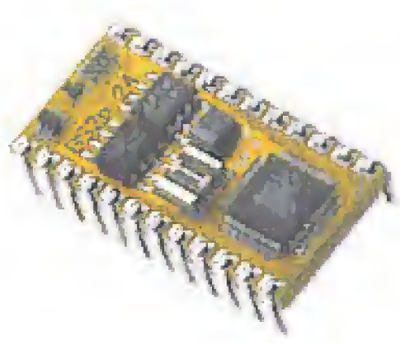
BS2-IC



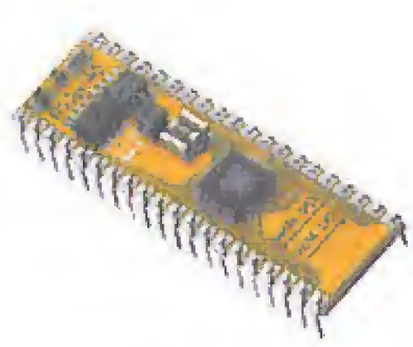
BS2-SX



BS2E-IC



BS2P/24



BS2P/40

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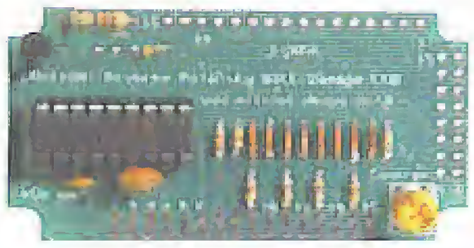

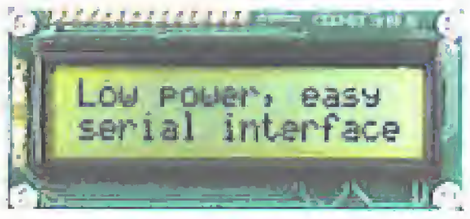

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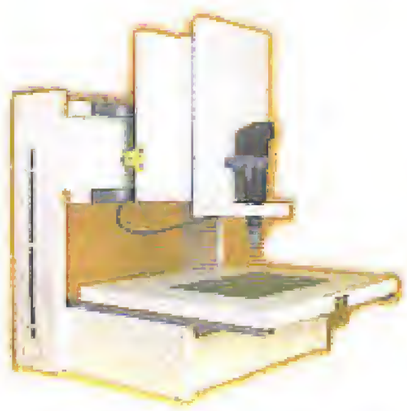
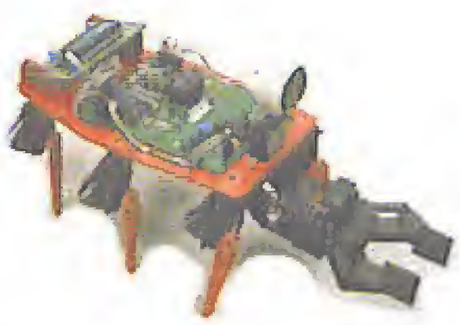


3-Axis Machine



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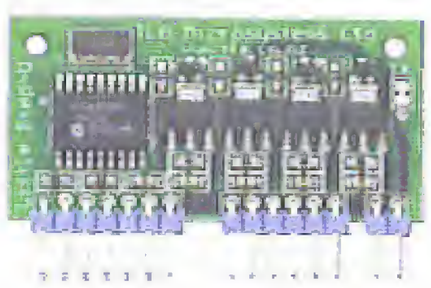
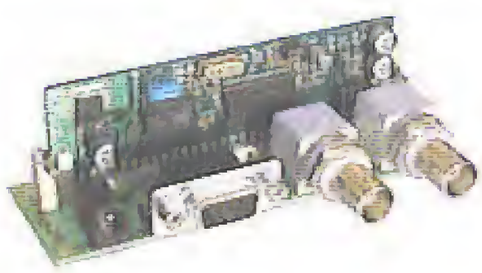
Servo Drivers

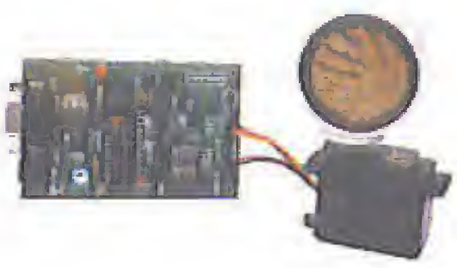


Motor Drivers



On-Screen Displays

DMX Protocol



U/Sound Ranging

Animatronics and Specialist Interface-Control Modules

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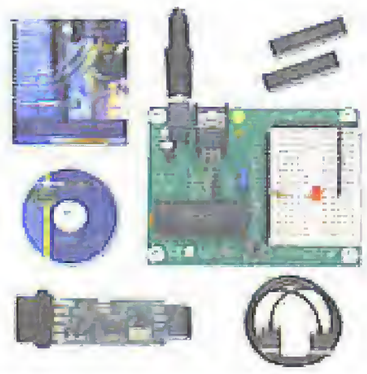

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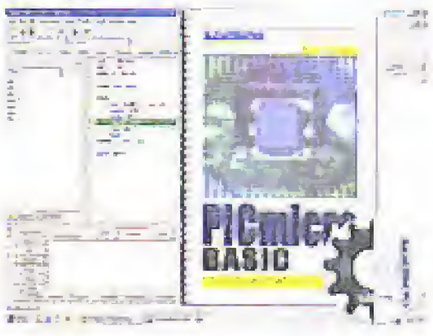

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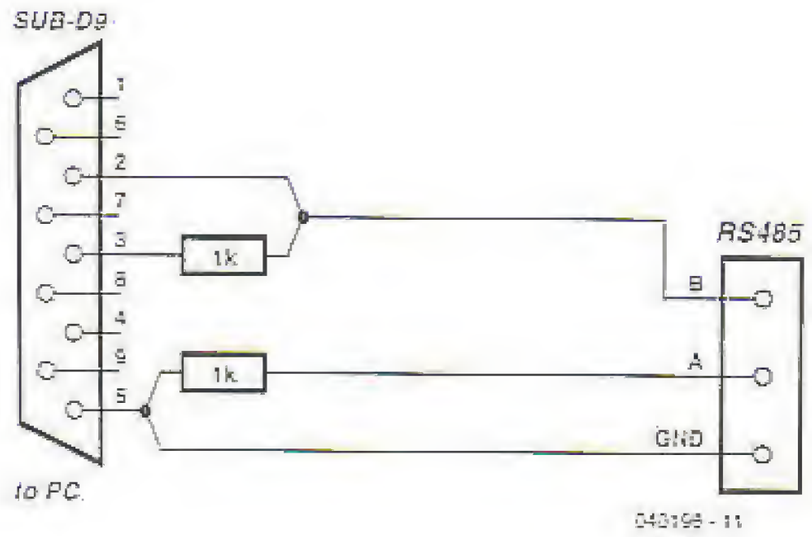
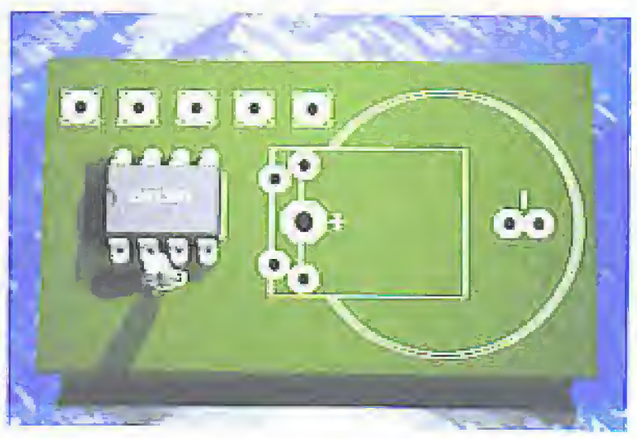
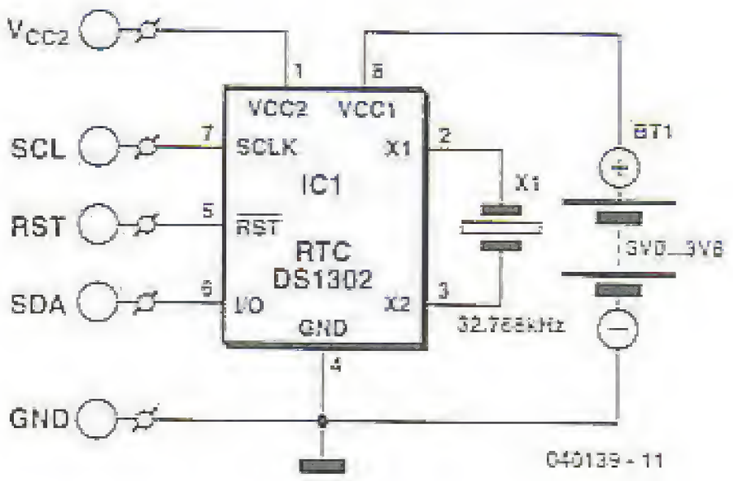






Low-cost RS232-to-RS485 Converter

Jürgen Wickenhäuser

In the November 2003 issue of *Elektor Electronics* we published a neat little 'industrial strength' RS232-to-RS485 converter suitable for use with the MSC1210 board (which was published in the July/August 2003 issue). For a quick test on the bench, a simpler approach is possible, avoiding the need for the MAX232 and LTC485 ICs.
Fortunately, almost all RS232 interfaces work happily with 0 V and 5 V levels. This lets us build an extremely economical RS232-to-RS485 converter. The circuit (see figure) will only work, however, when only one is used at a time: all the other nodes on the network must use proper RS485 drivers, as is the case on the MSC1210 board. This converter has been tested on the bench in a network with forty(!) RS485 nodes.

If none of the RS485 nodes is transmitting, the RS232 TX output of the PC can drive the network via the 1 kΩ resistor. Correct relative voltage levels are ensured by the 1 kΩ pull-down resistor to ground on the A wire. All the other RS485 devices will see the data transmitted by the PC.

Now, if one of the other RS485 devices transmits, its driver will overpower the limited current available from the PC's RS232 TX output via the 1 kΩ series resistor. The PC will then receive the signals from the RS485 bus, as desired.

040198-1

DS1320 Real-time Clock

Benjamin Metz

Some microcontroller applications require a functionality called timekeeping, which is often within the realms of 'software only'. Software timekeeping is not particularly complex as examples showing 'how it's done' are available on the Internet for practically any microcontroller. Unfortunately the method is less suitable for applications requiring higher accuracy; where the power consumption in the standby state has to be minimised; or in the (rare) case of insufficient memory space being available for the timekeeping code.

Fortunately there exists a simple alternative in the form of a dedicated real-time clock. This may sound ambitious but boils down to just one IC and a quartz crystal. The DS1320 is a fine example, requiring just a 2.0 – 5.5 V supply voltage and a cheap 32.768 KHz quartz crystal. Note however that the crystal has to be specified for 6-pF load capacitance.

The DS1320 has two connections for the supply voltage; one for normal operation and one for keeping the time during standby using, for example, a backup battery.

The RTC chip is read out and programmed using the on-board I²C bus. The datasheets supply all the necessary details.
The DS1320 also contains a trickle charging circuit to keep the back-up battery topped up.

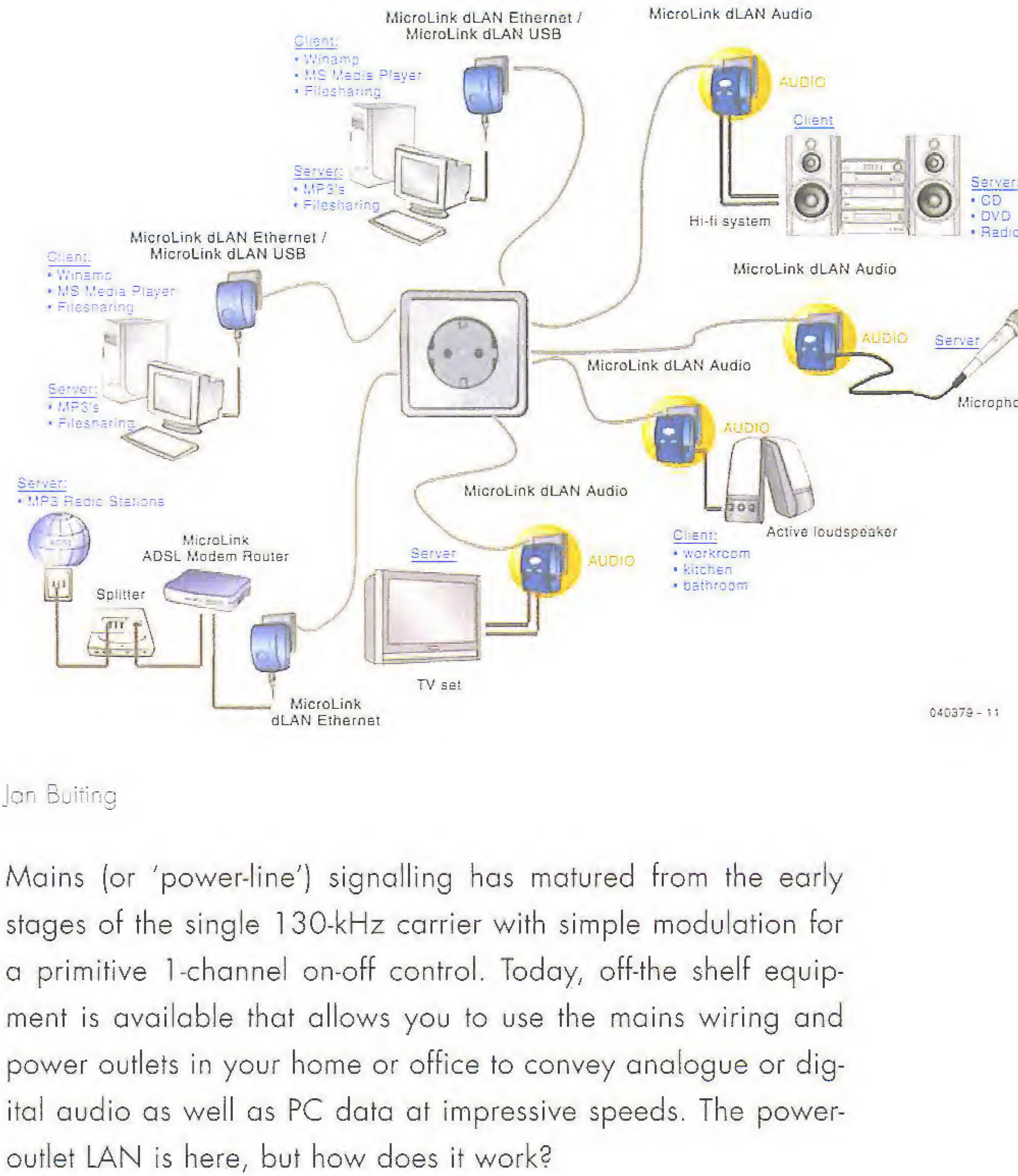
040139-1

Further information:
www.pdfserv.maxim-ic.com/en/ds/DS1302.pdf

Programming example (in MBASIC):
www.basicmicro.com/downloads/docs/DS1302RTC.pdf

Power-Outlet LAN

In-home power lines carry audio and data



040379 - 11

Jan Buiting

Mains (or 'power-line') signalling has matured from the early stages of the single 130-kHz carrier with simple modulation for a primitive 1-channel on-off control. Today, off-the shelf equipment is available that allows you to use the mains wiring and power outlets in your home or office to convey analogue or digital audio as well as PC data at impressive speeds. The power-outlet LAN is here, but how does it work?

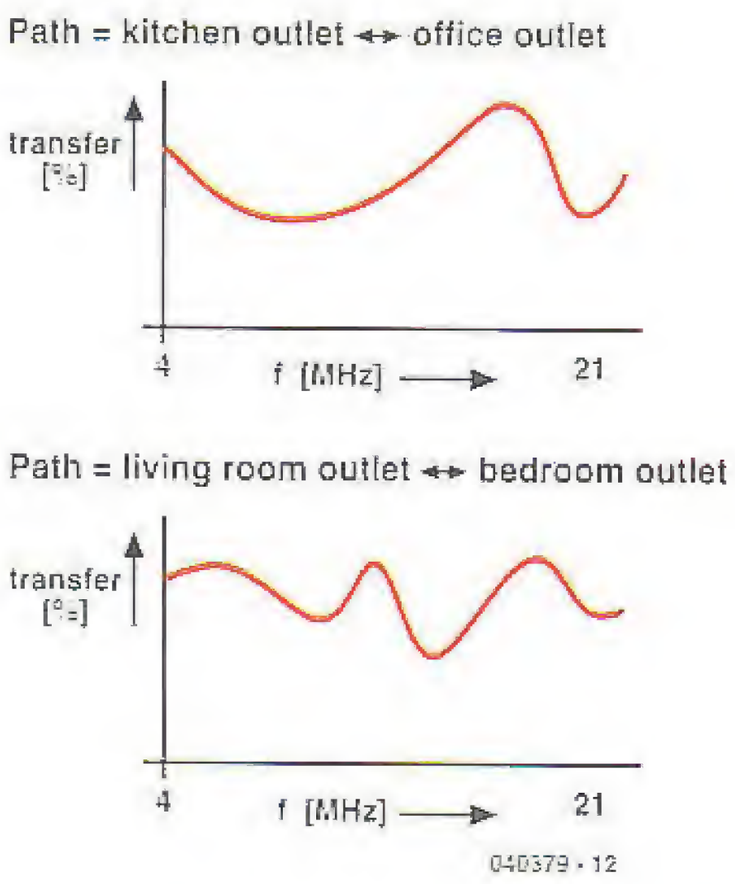
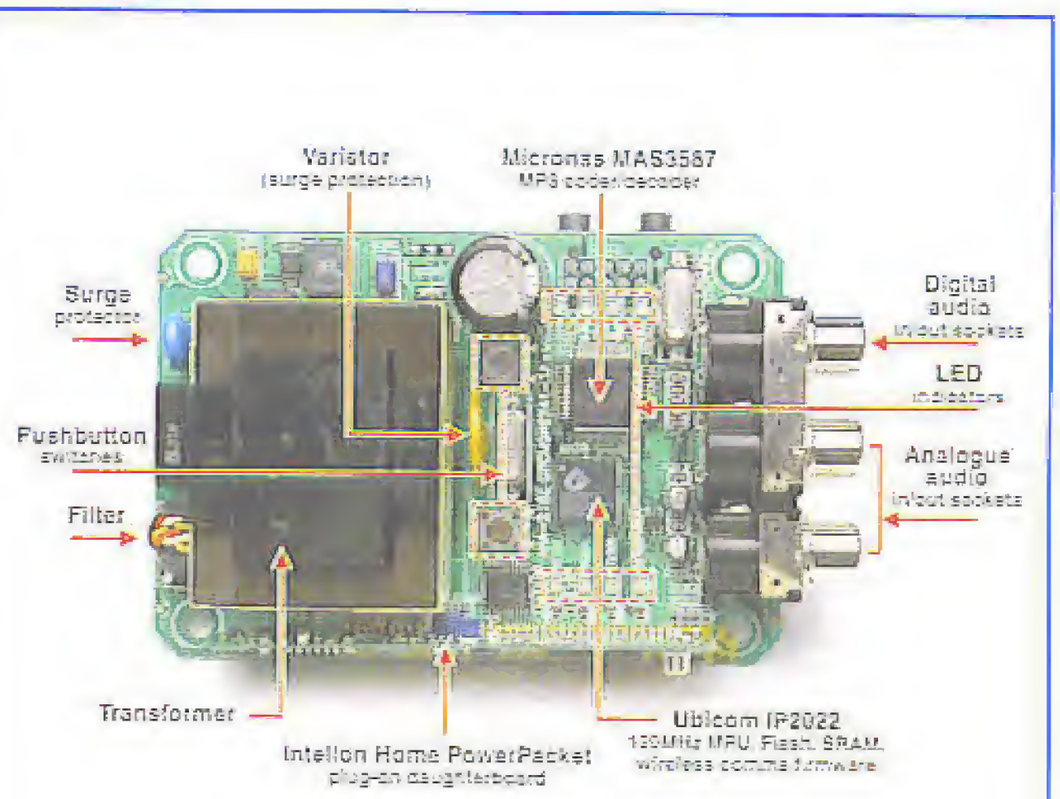


Figure 1. Two examples of transfer (frequency/attenuation) characteristics presented by mains wiring between two power outlets.

When it comes to sending analogue or digital signals over **in-home** mains wiring, i.e., excluding professional systems designed for the national power grid (like the highly controversial Power Line Transmission) a bewildering number of manufacturers claim to have the 'very best' for you at 'incredibly low' prices. In this article we will look at the basic operation of a system that, although fairly pricey, we thought performed adequately. Other products not mentioned here may employ similar methods of operation.

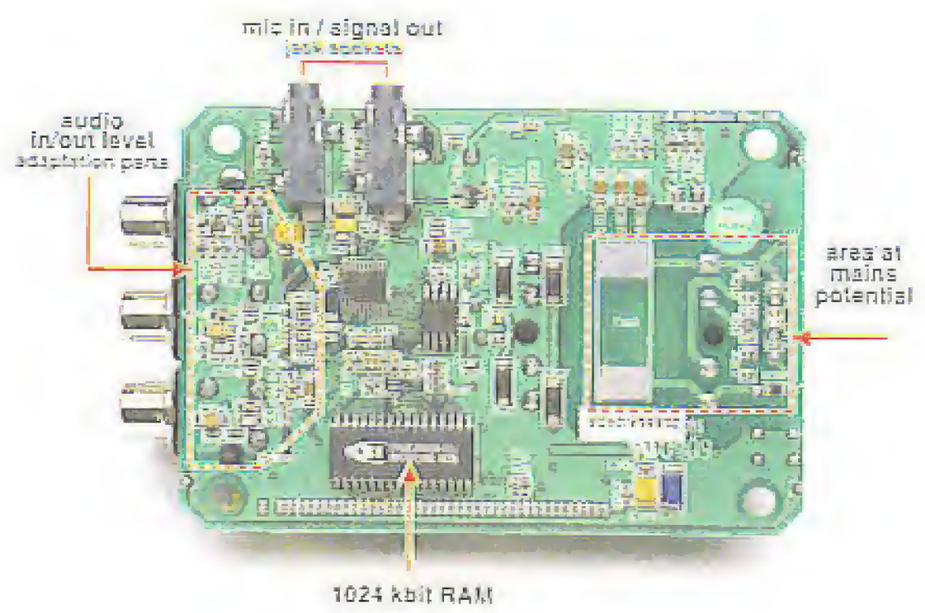
Reshuffling the pack(ets)

Transmission of analogue signals over the mains wiring is now a thing of the past as the technology is fraught with difficulties and invariably yields poor results. Today, we seem to be talking digital only. However, there is still a rather capricious aspect to tackle: the *transfer characteristic* of the mains wiring between sender and transmitter, and that, unfortunately for all digi-whizzos, is 100% analogue in nature. **Figure 1** illustrates that different attenuation characteristics must be taken into account for every outlet-to-outlet path in the home or office. Attenuation may be quite high at certain frequencies used by the signalling system (4.3 to 20.9 MHz). To make the characteristic even more unpredictable, loads connected to certain power outlets may actually cause not only a dynamically changing transfer function but also added noise (electric drills, tube lights etc.). The PowerPacket system employed by Intellon for their HomePlug Power Alliance 1.0 compliant products is capable of continuously and automatically detecting in-band frequencies subject to heavy attenuation. As shown in **Figure 2**, the available frequency band may be used by up to 84 carriers spaced 200 kHz apart. The actual signal encoding method, ODFM, is not discussed here, but we move on straight to the crux of the system — see **Figure 3**: Carriers dropping below a certain threshold set up in the receiver



Inside the box

Using a magnifying glass, educated guesses and the Internet we were able to identify at least the main ICs and building blocks inside a Devolo Microlink dLAN Audio unit. For example, an old faithful we came across was the MAS3587 MP3 coder/encoder chip from our friends at Micronas. Also, were impressed by the use of a hefty MPU like the Ubicom IP2022. Intellon seems to stick to a policy of supplying OEM products only in the form of plug-on Home PowerPacket PCB modules with a single in line pin row connector. From a visual inspection of the printed circuit board shown here we can only conclude that great attention has been given to electrical safety and equipment isolation.



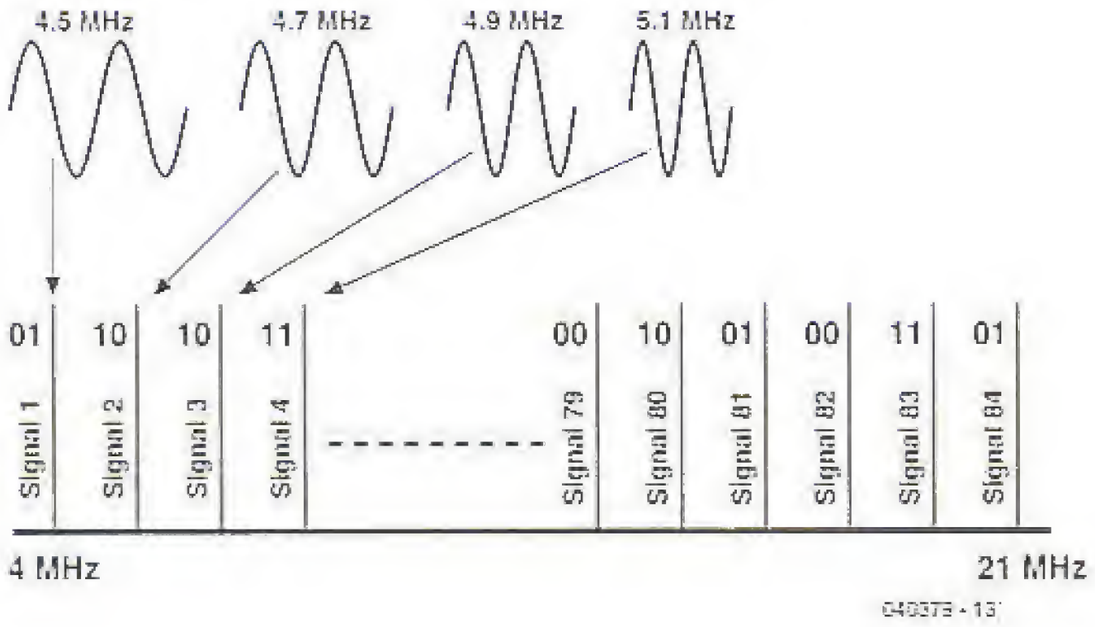


Figure 2. Encoded ODFM signals are distributed over up to 84 carriers within a frequency range of 4.3 to 20.9 MHz.

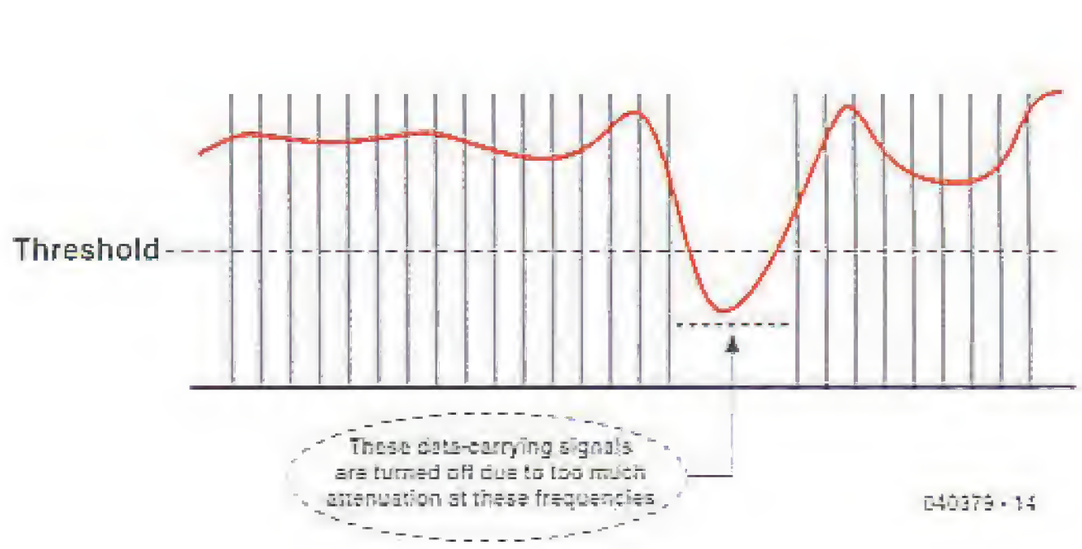


Figure 3. If a certain part of the frequency range is unsuitable for transmission then carriers are switched off and data is re-allocated.

are switched off, and transfer information tells the transmitter to reshuffle ready-encoded ODFM signals across other, suitable, carriers within the band. By regulation, signal levels on the mains wiring must be reduced by several dBs on frequencies inside radio amateur bands.

Is it safe?

The Devolo dLAN Audio and dLAN Ethernet units we used for this article are CE certified and carry all relevant approvals regarding electrical safety and isolation for use on 230-V domestic and office mains outlets. Great, but is my data safe from my neighbour's curiosity, supposing he is using a similar dLAN? After all, our homes are connected to one and the same electricity grid? The answer is that your electricity meter and associated circuitry in the metering cupboard will act as a filter that largely prevents those 4-20 MHz signals leaking onto the electricity network and from there onto the neighbour's mains wiring, although this cannot be entirely ruled out in unfavourable situations where a degree of phase coupling is present. More importantly, however, 56-bit DES_{pro} encryption is used in combination with passwords so your data should be pretty secure.

What speed? How many extensions?

Devolo claims a data speed of between 5 and 14 Mbits/s depending on noise levels and, of course, the effective distance between units connected to form a LAN. Such speeds are sufficient for DSL distribution in the home. Although in theory up to 253 units may be connected into a power-outlet LAN, Devolo say that in practice bottleneck situations may occur when more than about 10 units convey data simultaneously.

Web links

www.devolo.de
www.intellon.com

Figure 4. The Devolo dLAN Audio and USB units in their semi-opaque cases.

retronics

Elektor Junior Computer

Jan Buiting

Although the Elektor Junior computer was not the first home-built computer based on the 6502 processor (the KIM and others having achieved spectacular results in the USA) it did become a legendary design with PCB sales in the thousands. The original Junior Computer was designed by Lois Nachimann and Gerard Nachbar burning midnight oil in a special 'computer room' within the Elektor design lab.

Curiously, when the first Junior computer articles started to appear in Elektor May 1980, the use of 'new-fangled' technology like a microprocessor was heavily criticized particularly by readers of the English-language edition of Elektor. This was to change within months, however, as the 'JC' design matured in near-exponential fashion with no competition from other UK publications and several authors from all over the world jumping the bandwagon by making significant contributions to the Junior hardware and software. The 'digibits' were on the loose and as it turned out there was no stopping them.

Dinosaur Junior

The Junior computer is an expandable system based on the MOS Technology 6502 microprocessor, which is attached to 1 K ROM (2708 EPROM) and 1 K RAM (2 x 2114) yes that's 0.000001 Gigabytes. The 'bare' Junior was programmed in hexadecimal words for instructions, addresses and databytes. A ROM-based monitor, a keyboard and a compact display allowed programs and data to be entered and manipulated. Assembly code came later when the JC was attached to a terminal. Such upgrades did require more RAM and ROM, of course. The magazine came up with the goods by publishing DIY memory expansion cards. Expensive it was, though, a fully loaded 4 K RAM PCB setting you back by an amount equivalent to buying two 128-MB Flash USB memory sticks today.

Although the Junior computer may appear extremely primitive in this day and age of DSP MPUs ticking at Gigahertz frequencies, we are sure that many readers have fond memories of running their first 'LED on/off' and 'you-press-I-beep' programs on the Junior and showing them off to family members.

Open-platform

A remarkable thing about the Junior computer, as compared with many other projects published since the mid-1970s, is that it drew in lots of contributions from readers —specifically, 6502 software making clever use of the (scarce) hardware resources or allowing the Junior to communicate with the real world. Examples include a 6502 system monitor, an assembler, a magnetic tape interface, a floppy disk interface and to cap it all, adapted BASIC!

One Junior computer was specially built and adapted for use as a programmer system by our own Software Service at a time when bipolar PROMs like the 82S23 and 82S123 were used in Elektor projects. The system proved utterly reliable and supplied hundreds of PROMs before a more versatile programming system was obtained.

Books and Paperware

Software, hardware, spyware, bloatware, vapourware, whatever next? In the early 1980s, Elektor made a wise move to bundle all published articles on the Junior computer into four magnificent books and four cut-price *Paperware* editions resembling stencilled college curricula. *Paperware 1-4* are now collector's items not for their content or low print run we guess, but because not looking like 'books' they got thrown away easily in house and office moves (including our own!).

Our thanks are due to Mr Dennis Fitzpatrick for parting with his JC bare board.

Says Dennis: "Great little computer, never bothered to do the expansion stuff but I learned a lot. One leg of the board was always missing, I used to use an eraser to balance the board and just got used to it, I suppose".

040090-1

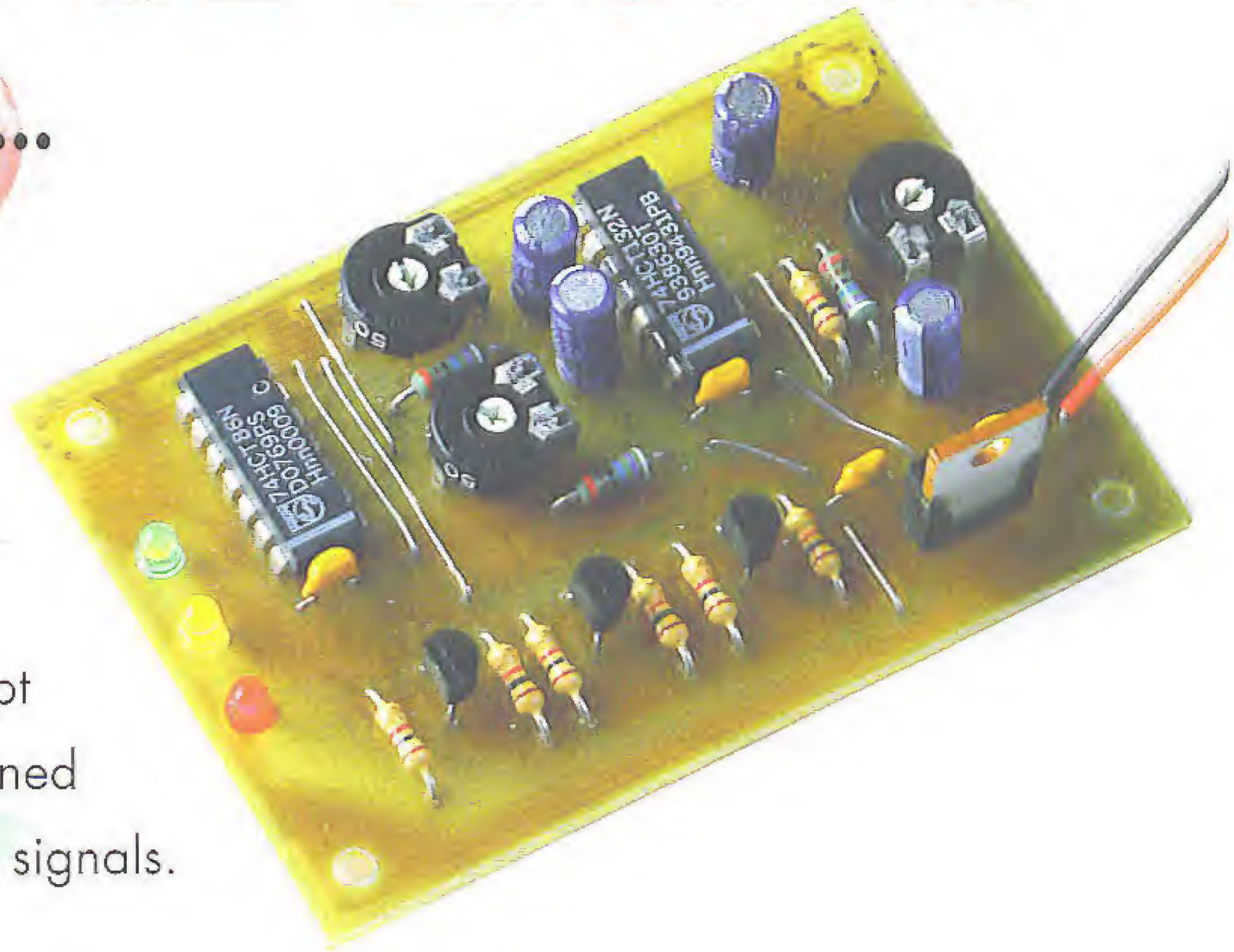
Retronics is a monthly column covering vintage electronics including legendary Elektor designs. Contributions, suggestions and requests are welcomed; please send an email to editor@elektor-electronics.co.uk, subject: Retronics EE.

PLAYFUL LIGHTS

Just three LEDs...

Hubert Maiwald

Here's a recipe to make LEDs produce slow, continuous light effects rather than abrupt changes normally obtained from square-wave drive signals.



If you are after really accurate control of one or more LEDs, the best option by far is pulsewidth modulation (PWM) which is usually obtained from a dedicated PWM chip or a suitably programmed microcontroller. On the other hand, if the blink frequency not terribly important, other, much simpler methods are available. For example, get out two square-wave oscillators running at slightly different frequencies and mix their outputs together in an XOR (exclusive-OR) logic gate. That's all it takes to build a beat-frequency oscillator whose low-frequency output signal may be pulse-width modulated in triangular(-ish) fashion.

Beat-frequency (BFO) or heterodyne oscillators are often used in metal detectors and in RF technology — you will rarely find one used in an audio-frequency application. For example, if the first oscillator operates at 70 Hz and the second, at 70.1 Hz, connecting the two signals together in an XOR gate will produce a pulsewidth modulated triangular signal of just 0.1 Hz that is optically free from interference with 50-Hz (or 60-Hz) light sources.

It takes just a few dead standard parts to take the principle of the BFO from theory to practice. If you would like to employ green and yellow LEDs for lighting purposes and gradually change the colours in a purposely erratic way, then a single IC type 74HCT132 does the job (**Figure 1**).

COMPONENTS LIST

Resistors:
R1,R8,R9,R10 = 1kΩ
R5,R6,R7 = 2kΩ2
R2,R3,R4 = 976Ω 1%
P1,P2,P3 = 50Ω preset

Capacitors:
C1-C4 = 22µF 16V radial
C5-C8 = 100nF

Semiconductors:
D1 = LED, green, low current
D2 = LED, yellow, low current
D3 = LED, red, low current
or:
D1,D2,D3 = RGB LED (e.g., Conrad Electronics # 185388 - 88)
D4 = 1N4148
T1,T2,T3 = BC547
IC1 = 74HCT132
IC2 = 74HCT86
IC3 = 7805

Miscellaneous:
K1 = 9-V PP3 battery with clip-on leads
PCB, available from The PCBShop

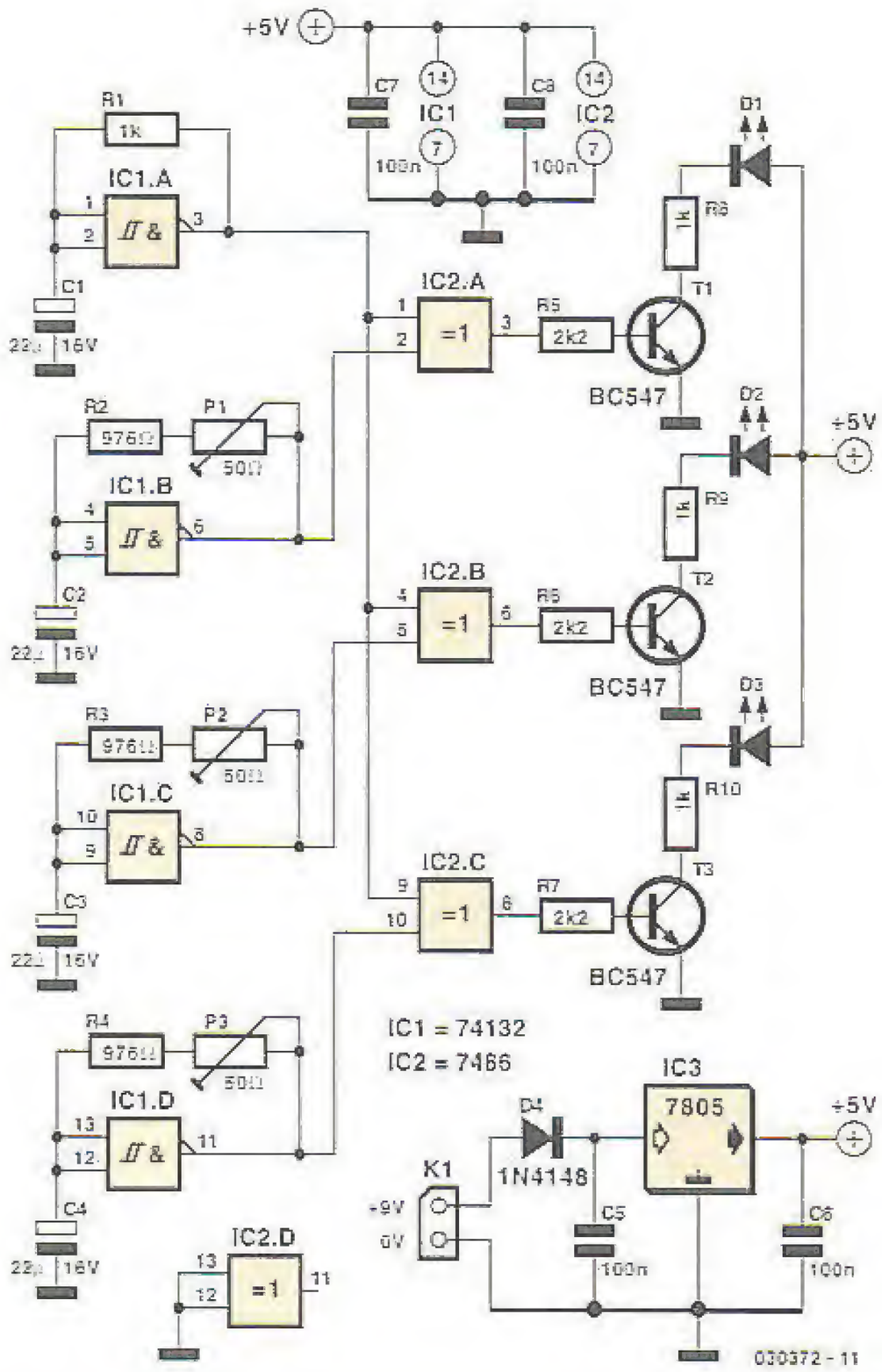
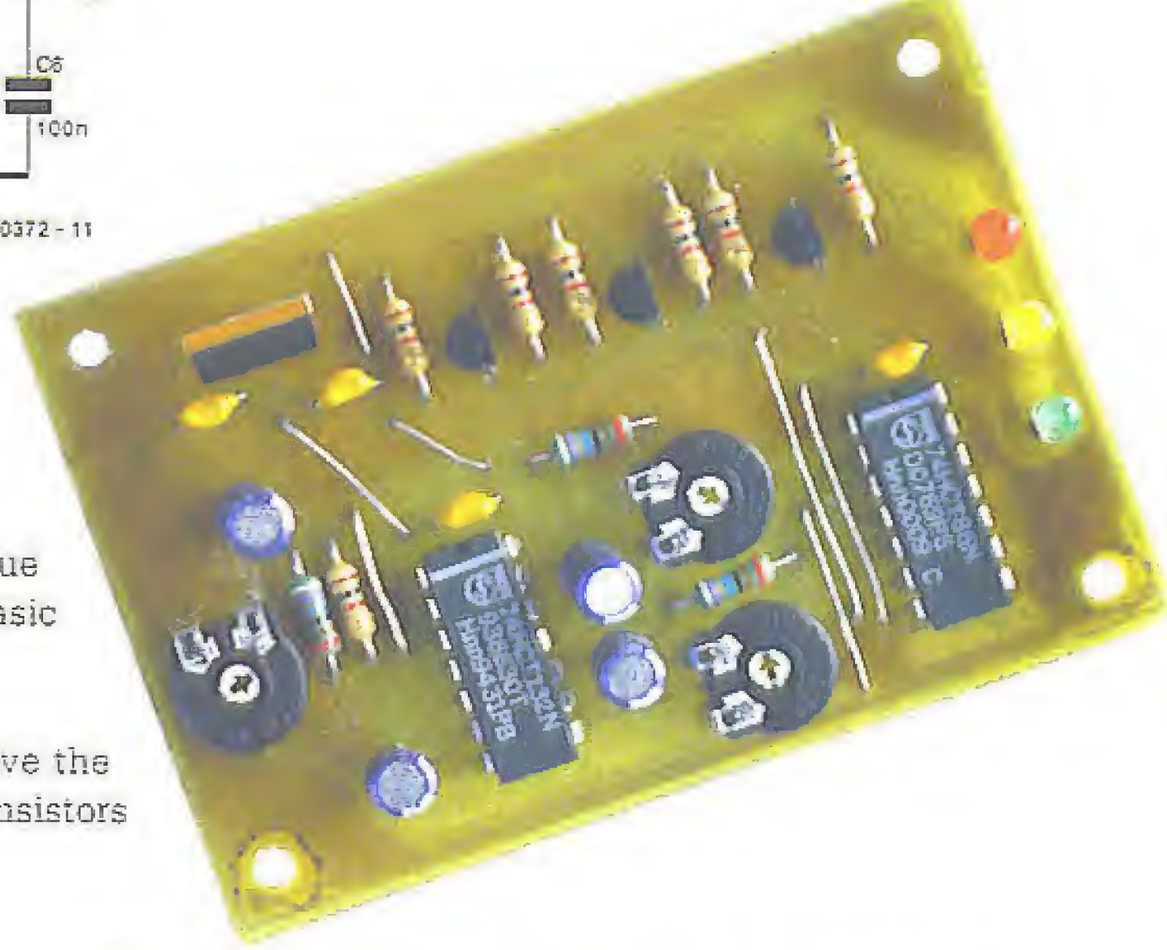


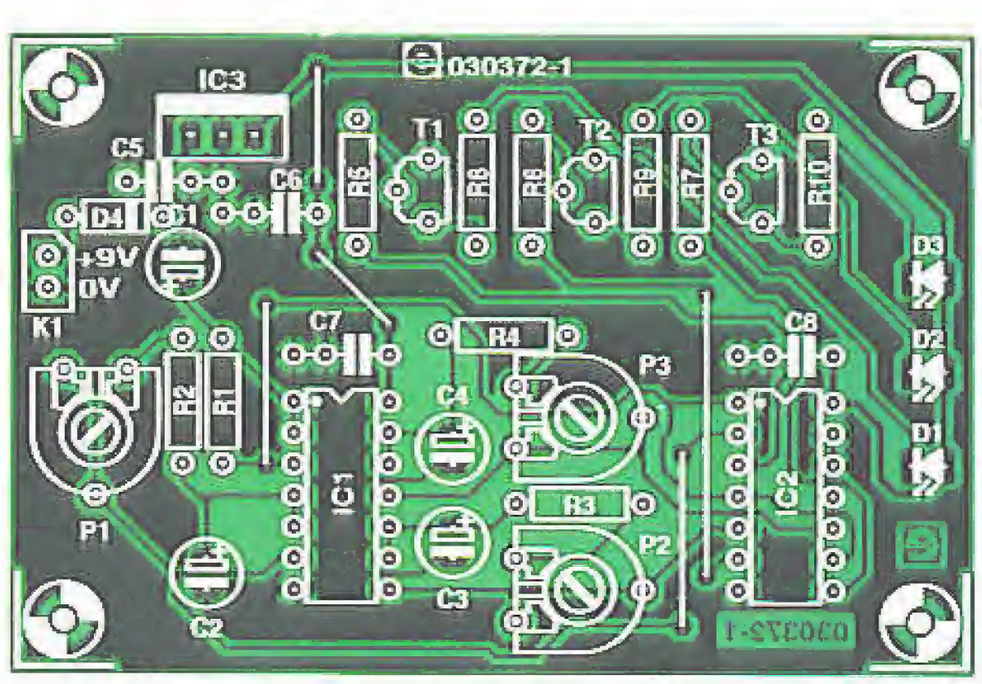
Figure 1. Circuit diagram of the beat-frequency oscillator.

Gate IC1.A forms the basic frequency generator that's connected to all XOR gates. Each gate is complemented by an individual oscillator IC1.B, IC1.C and IC1.D whose oscillation frequency can be individually adjusted (with a preset) to a value very close to the basic frequency.

The XOR gates drive the LEDs by way of transistors whose collector resistors (R8, R9, R10) need to be dimensioned in accordance with the required LED threshold voltage, the supply voltage and the brightness you'd like to achieve. In practice, the brightness changes are not quite triangular, not just because the rectangular oscillator signal does not have a 50% duty cycle, but also as a result of the non-linear current/luminosity characteristics of the LEDs.

A PCB design is given (**Figure 2**) to enable all followers of the *kitchen table* series of mini projects to experiment to their hearts' content. Sockets may be used for the two DIL ICs. With all parts fitted at the right polarity and properly soldered, the circuit should function straight away when K1 is connected to a 9-volt PP3 battery or a suitable mains adaptor.





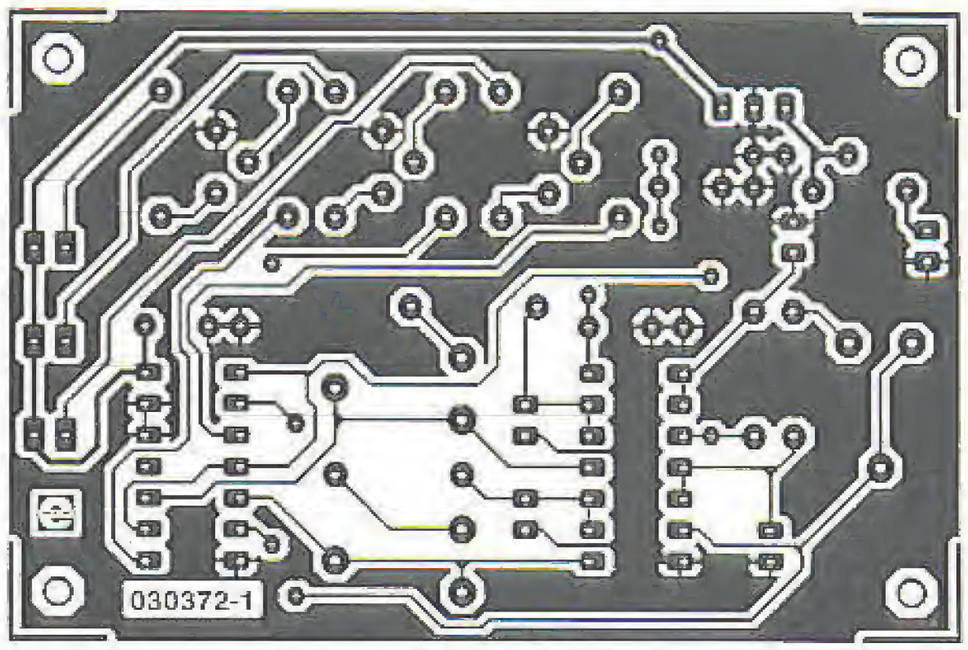


Figure 2. Copper track layout and component mounting plan.

QUIZZ'AWAY

Martin Ohsmann is a Professor of Electrical Engineering and Information Technology at FH Aachen and a long-time contributor to Elektor Electronics. Through Quizz'away he aims at stimulating thought, speculation, construction and simulation as well as raise interesting questions.

Measurements using a probe — never a problem! For sure?

The use of a probe for measurements with the oscilloscope should be customary to most, if not all, designers of electronic circuits. In particular the switchable 1:1/1:10 probe (**Figure 1**) is popular.

With the probe in '1:1' mode you measure at an impedance of 1 MΩ and the signal is not attenuated before it reaches the oscilloscope input (switch in **Figure 2** closed). If you want to measure with a lighter load attached to the object of your investigations then the probe is usually switched to '1:10' mode (switch in **Figure 2** open).

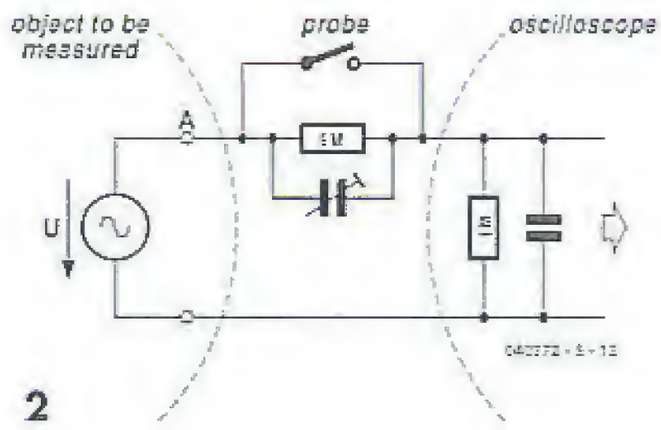
The resulting image on the 'scope will become 10 times smaller because the signal is attenuated ten times in the probe. The trimmer capacitor ensures the voltage divider is as wideband as possible and the division ratio remains as close as possible to 10:1. It's as simple as that, if only the circuit in **Figure 3** did not exist!

If you use a 1:1/1:10 probe to measure the signals between points A and B in this circuit, the image on the 'scope will remain the same if you switch the probe between 1:1 and 1:10 mode. With this simple to build circuit on the bench, most experienced test engineers will be suspicious of their probe. However, it's working just fine!

How do you explain the fact that the scope displays the same signal irrespective of the probe attenuation?

The circuit is certainly worth building because seeing an unchanged signal on the 'scope despite switching the probe is mystifying.

1



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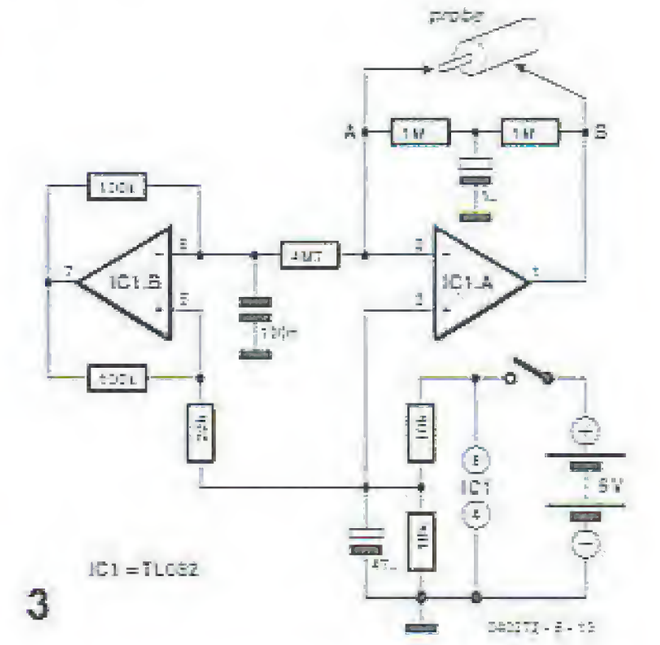

3

Quizz'away and win!

Send in the best answer to this month's Quizz'away question and win a

Voucher for Elektor Electronics products, including a subscription, worth £100

All answers are processed by Martin Ohsmann in co-operation with Elektor editorial staff. Results are not open to discussion or correspondence and a lucky winner is drawn in case of several correct answers.

Please send your answer to this month's Quizz'away problem, by email, fax or letter to:

Quizz'away, Elektor Electronics, PO Box 190, Tunbridge Wells TN5 7WY, England.
Fax (+44) (0)1580 200616.
Email: editor@elektor-electronics.co.uk, subject: 'quizzaway 1-05'.

The closing date is 22 January 2005
(solution published in March 2005 issue).

The outcome of the quiz is final.

The quiz is not open to employees of Segment b.v., its business partners and/or associated publishing houses.

As of the September 2004 issue Quizz'away is a regular feature in Elektor Electronics.
The problems to solve are supplied by Professor Martin Ohsmann of Aachen Technical University.

Solution to the November 2004 problem

(p. 79; energy conversion)

Naturally, you would assume that the circuit has just one lossy element, namely resistor R, which will arrange for all voltages and currents to decrease gradually. Hence all energy would go into the resistor. It is, however, not so simple.

Using the Hint we gave we first look at the 'dual notion' problem. Instead of the parallel connection of two coils, a resistor and a closed switch we get a series connection of two capacitors, a resistor (conductance) and an open switch (**Figure 4**). Before the switch is closed ($t < 0$) the voltage on the left-hand capacitor C1 takes the value $U_1 = U$ while C1 carries a charge $Q = CU$. The left-hand capacitor stores all energy W in the system, amounting to $W_{(0)} = 1/2\ CU^2$. When the switch is closed, charge flows from capacitor C1 onto C2, with the current I initially limited by the resistor. Initially, I will equal U/R but then drop exponentially. If we wait sufficiently long (i.e., infinitely), the voltage on the capacitors will be identical, which also means the capacitors carry the same charge $Q = 2$. The current and voltage curves are shown in **Figure 5**. The resulting voltage is exactly $U/2$ and the total amount of energy stored in the system, $W_{(\infty)} = 1/4CU^2$. This is half the energy originally present in the system ($W_{(0)}$). The rest has been converted into heat by the resistor. Consequently we can write $W_R = 1/4CU^2$ irrespective of resistor R!

Our coil circuit is the 'dual notion' variant of the above: when the switch is opened, the current flowing through L1 initially has to flow on through the resistor because it can only rise slowly in L2. This causes a voltage U on resistor R. Next, with the current through L2 rising, the voltage on R will drop exponentially. The coil current rises to half the start value while the current through I1 drops to half. The answer to the question is, therefore; the resistor turns an amount of energy $W_R = 1/4CU^2 = 0.5$ mWs into heat.

With the capacitor experiment, we can make use of the charge response of the 'top' plate (cf. **Figure 6**, upper drawing) to explain why the end situation is obtained. Does a similar 'retaining quantity' exist in the coil experiment? Assuming ideal coils are used for L1 and L2, they form a loop with infinite conduction (**Figure 6**, lower drawing). However, in infinitely conducting loops, the magnetic flux is constant. After all, if it were to change, a voltage would be induced in the loop (induction principle) Because of the infinite conductivity, it would generate infinite losses. The above could be demonstrated using superconducting coils. However, without superconductors, coil losses (i.e. finite conductivity) will cause the magnetic fields to be reduced relatively quickly. Arguably, it is easier to hand over a charged capacitor than a charged inductor! In switch-mode power supplies however, the above situations are quite common with charges or magnetic fluxes distributing at energy losses.

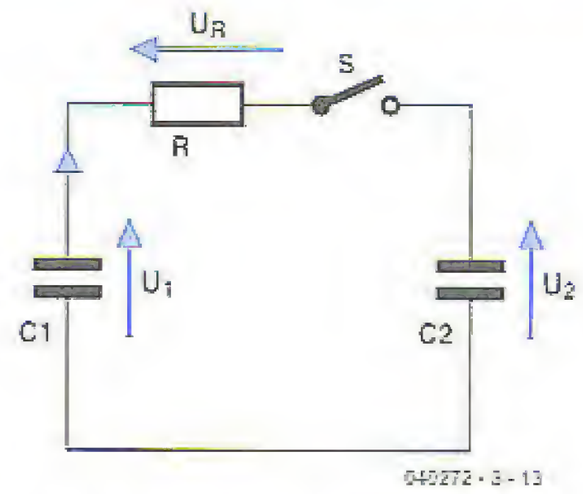

Figure. 4. Circuit with two capacitors.

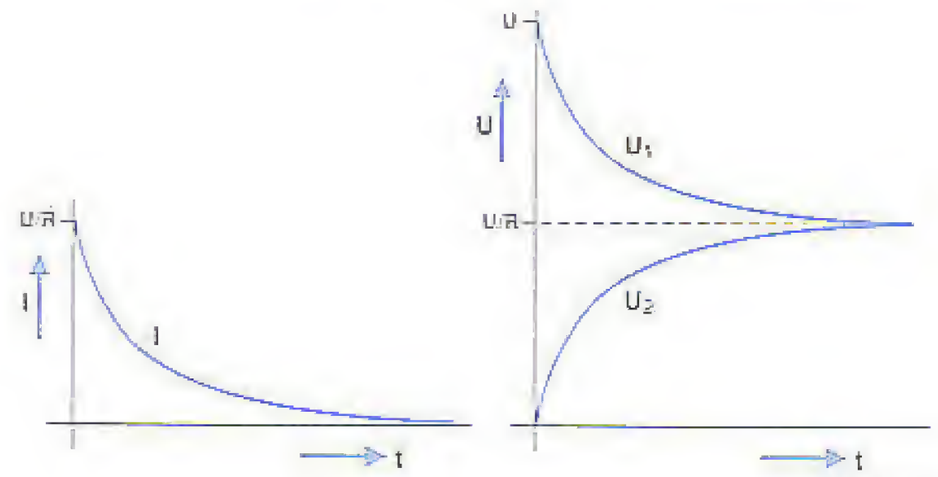

Figure 5. Current and voltage curves.

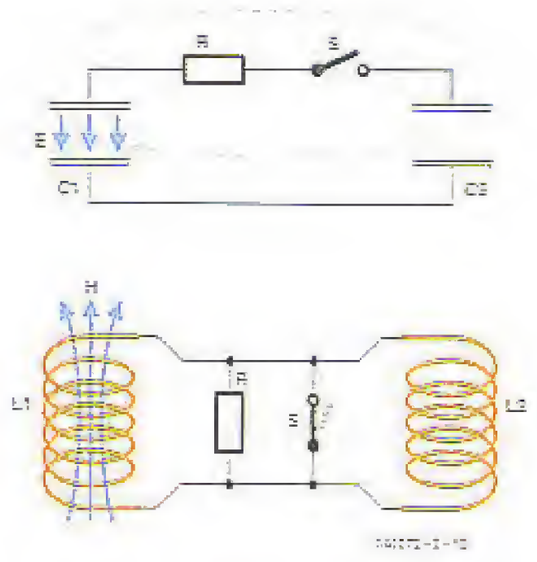

Figure 6. Retention quantities.

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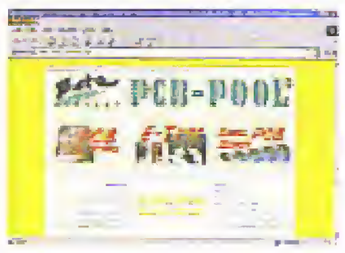

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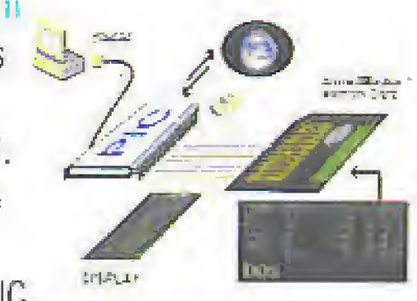

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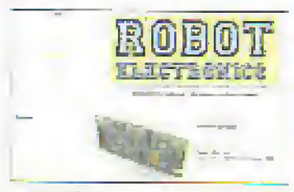

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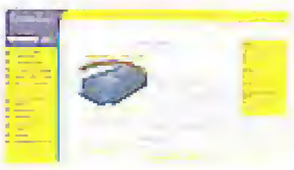

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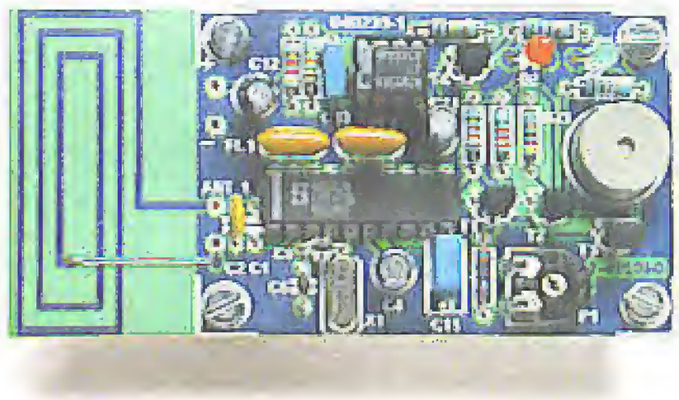
sneak preview

13.56-MHz RFID Detector

This detector will tell you if RFID (radio frequency identification) equipment is active in a shop or warehouse where 'tagged' goods (like clothes) need to be registered as they are moved around by staff or customers. The detector works at 13.56 MHz which is a widely used frequency allocated to RFID pulse senders. Our detector will only signal the presence of an active RFID sender (fixed or portable), that is, it does not read out information from active tags. The detector is a quite sensitive dual-conversion receiver with a PCB track antenna.



Wireless Microphone

Extremely compact RF modules for short-range audio transmission within the new licence-exempt 863/865 MHz frequency band allow a wireless microphone to be built The modules from Circuit Design already contain a compander system and all essential building blocks for audio transmission, so all we need to add is suitable microphone and amplifier interfaces.

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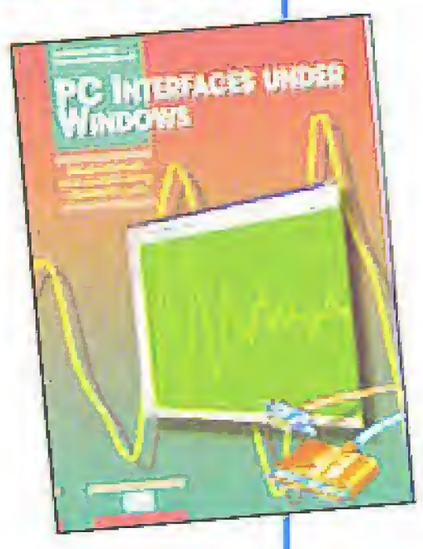

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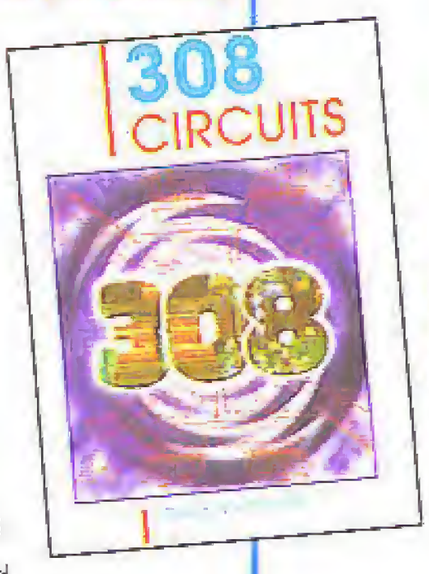

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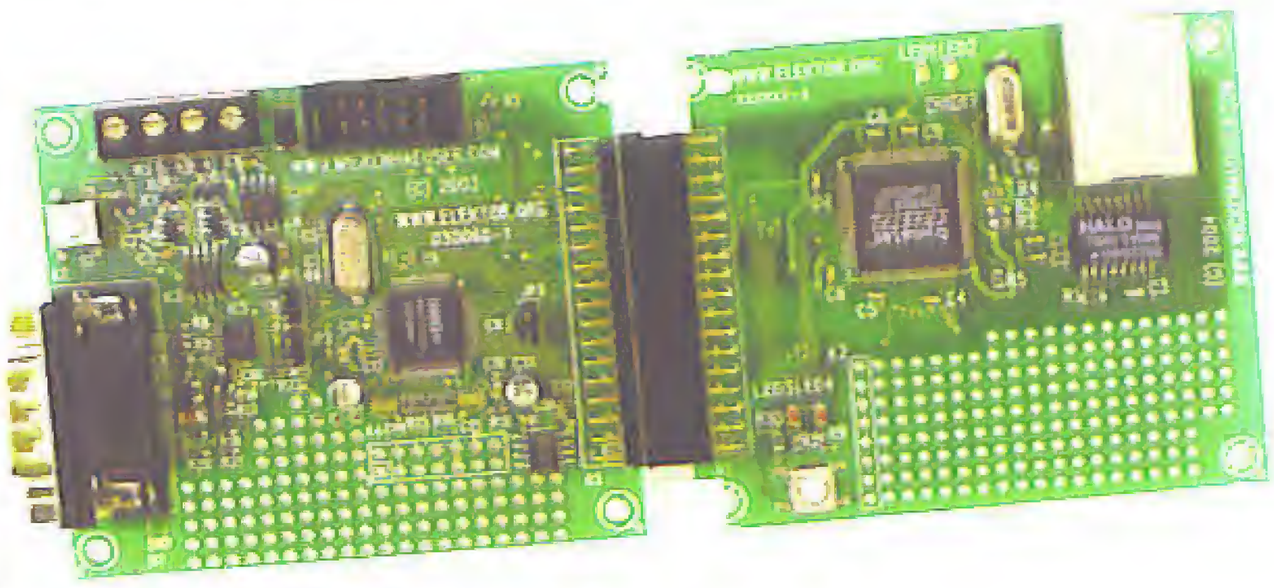

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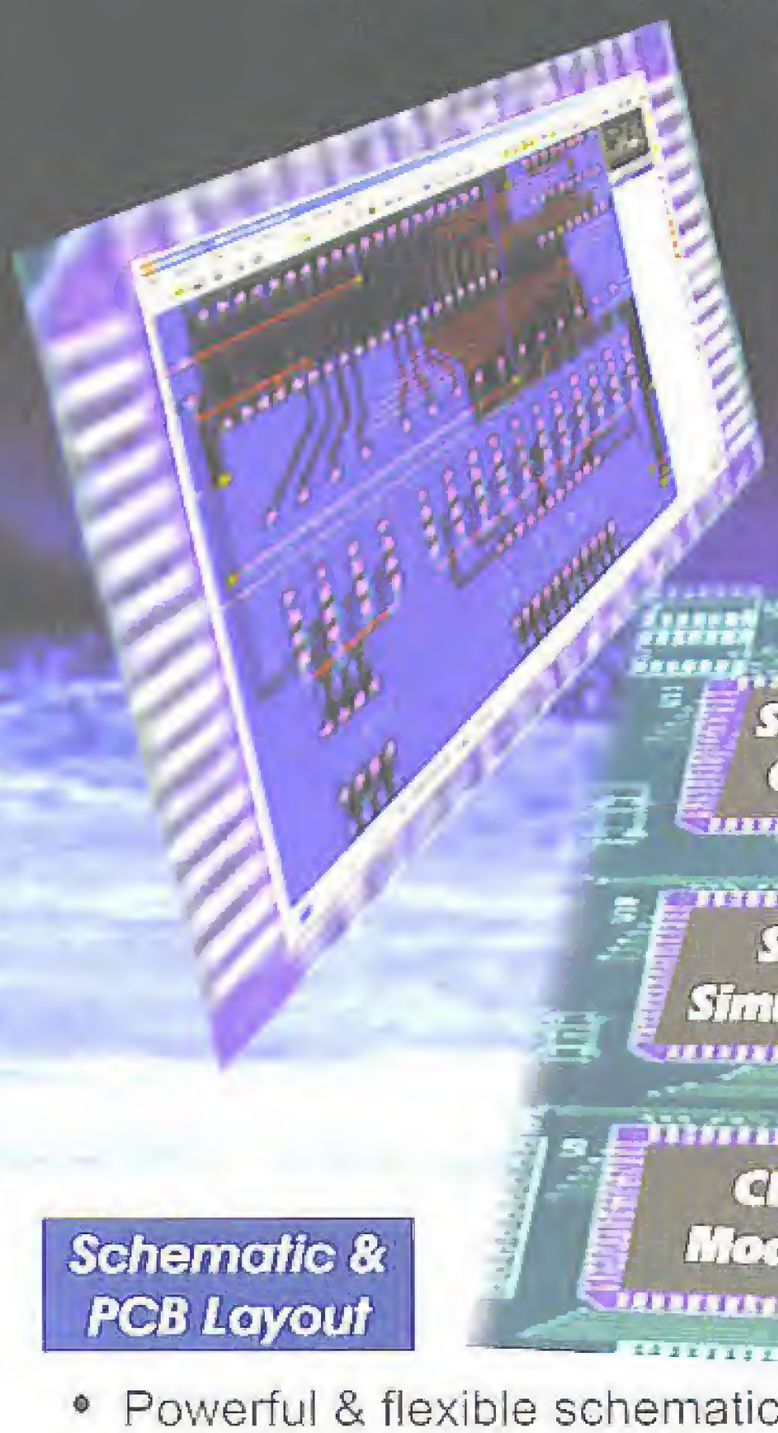

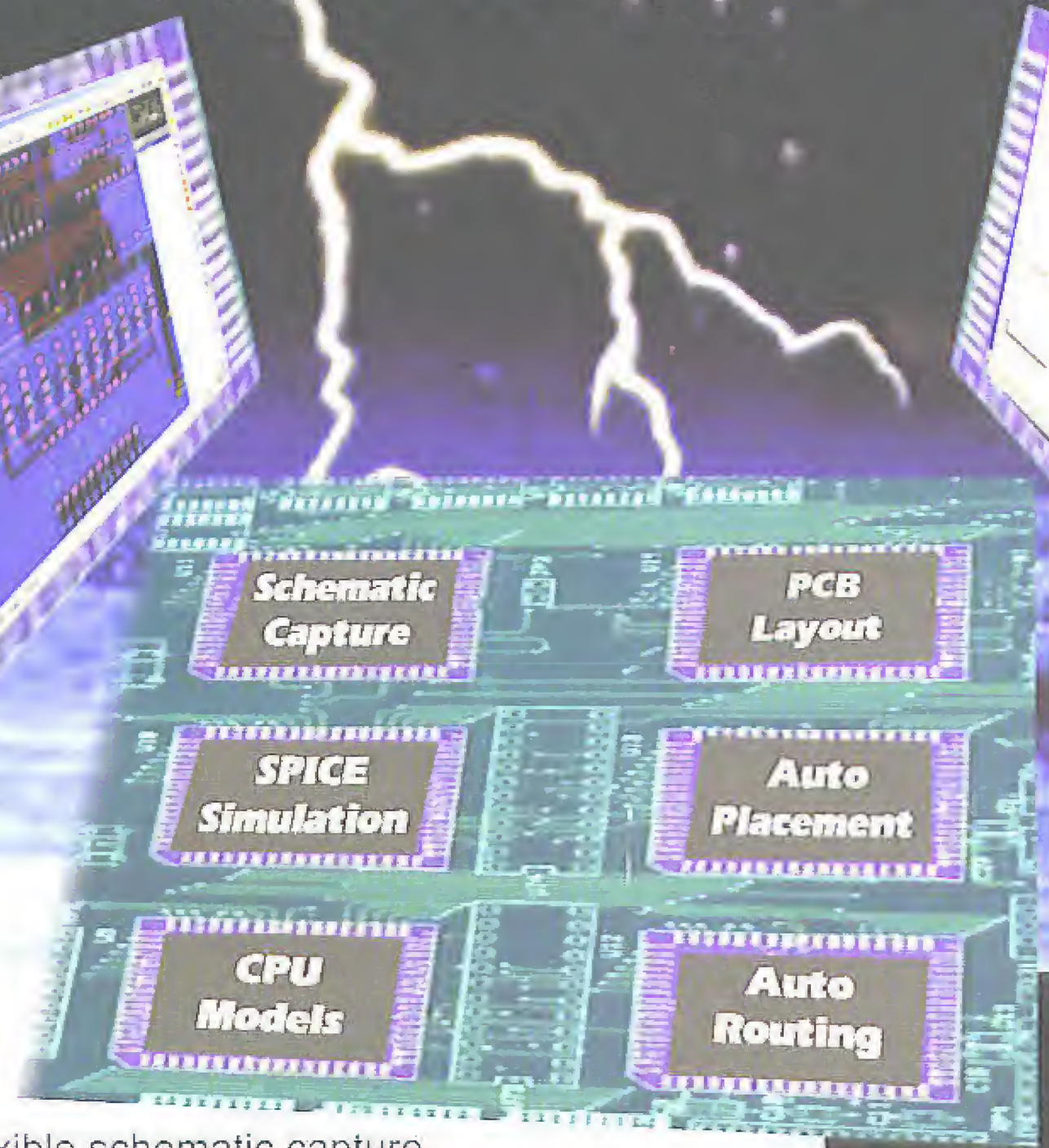

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