

# ELEKTOR ELECTRONICS

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## BUMPER SUMMER ISSUE

*>50 small projects,  
tips and applications*

- Light That Heats
- I/U Curve Tracer
- Valve Preamplifier (2)
- Signal Module for Model Trains



# Light that heats

## Two centuries of infra-red

By Gregg Grant

### Radiation

There are three types of radiation: firstly the visible variety, secondly the invisible kind and finally *actinic* radiation. Infra-red is radiation of the second kind, noticeable by its heating effect. All three types share four characteristics.

To begin with they can be transmitted through space; secondly they can be refracted; thirdly they can be reflected and finally they are obstructed by a black surface. This last explains — for example — why the photographic plate is a ‘negative’.

### William Herschel

In 1800 the astronomer William Herschel’s paper *An investigation of the powers of prismatic colours to heat and illuminate objects* outlined his discovery of Infra-red radiation. He had been conducting an experiment to discover the heating power of different parts of the spectrum.

He had begun by passing sunlight through a prism with “... thermometers set up on the table beyond the red end of the spectrum,”<sup>1</sup> his aim being to determine if some of the colours in his spectrum gave out more heat than others. His apparatus is illustrated in Figure 1.

As he moved towards the red end of the electromagnetic spectrum, he noted that his thermometers registered a rise in temperature. Herschel then moved the thermometer past the red end of the spectrum so as to note where, exactly, the heating effect disappeared.

However, exactly the reverse happened, the temperature rising higher still. Consequently the region came to be known as the *Infra-red*, or *Beyond the red*, *Infra* being the Latin word for below.

Why below? Simply because red light contains less energy than any other form of visible light and, in terms of energy content, is at the bottom rung. Infra-red, having even less energy, is below it.

### Infra-red wavelengths

The infra-red wavelengths extend from the limit of the visible spectrum, known as the *Near Region*, to the shortest microwaves, or the *Far Region*, as illustrated in Figure 2.

Formerly, light wavelengths were measured in Ångstrom units, after the Swedish physicist and astronomer Anders Jöns Ångstrom, a pioneer of spectroscopy.

Figure 2 illustrates the wavelengths of the various colours in the light spectrum in both Ångstrom units and nano-metres — where one nanometre is equal to 10 Å — which have largely superseded them. Red light is refracted the least; orange, yellow, green and blue are refracted in increasing amounts whilst violet is the colour refracted to the greatest extent.

Having discovered the phenomenon, Herschel was at something of a loss when it came to interpreting what he’d found. Initial impressions among the scientific community were that the sun — apparently — emitted heat rays as well as light rays, the former being refracted to a lesser degree than the latter.

### Macedonio Melloni

Some fifty years after Herschel’s paper was published, the Italian physicist Macedonio Melloni began to answer many of the questions relating to infra-red radiation. In 1846, he had already measured the heating effect of the sun’s light, reflected from the moon at night.

Melloni was also the inventor of the Thermopile, a series of strips of different metals — he used blocks of bismuth and antimony — that produced electric currents when one end was heated. This device enabled physicists to detect not only very weak electric currents, but also very weak heating effects.

In 1850, Melloni used his invention to detect Herschel’s infra-red

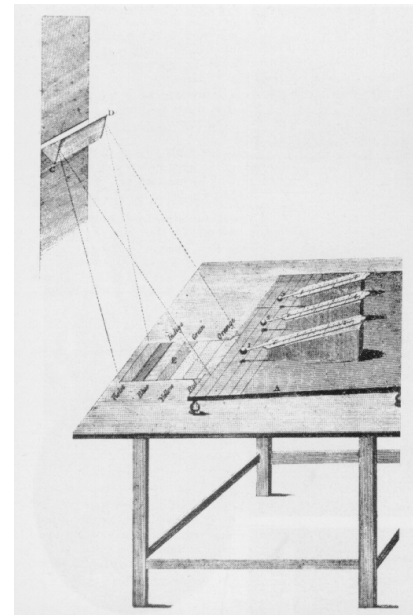


Figure 1. Herschel's apparatus for determining the heating effect of the solar spectrum. (courtesy Ann Ronam Picture Library, Taunton, Somerset).

radiation every bit as delicately as the human eye can detect light. He shortly demonstrated that infra-red displayed all the properties of white light such as interference and polarisation. Therefore infra-red was a wave phenomenon, just as light was, but with this difference: the waves were too long to have an effect on the retina of the human eye.

Yet if “... we had the capacity to use infra-red light, there would be no darkness for us. Even on the blackest nights, every object would be visible, lit by a radiance as great as that provided by a full moon, but with a weird difference. There would be no shadows on the ground, because earth itself would be the principal source of light.”

### Infra-red becomes better understood

In 1879, the Austrian physicist Josef

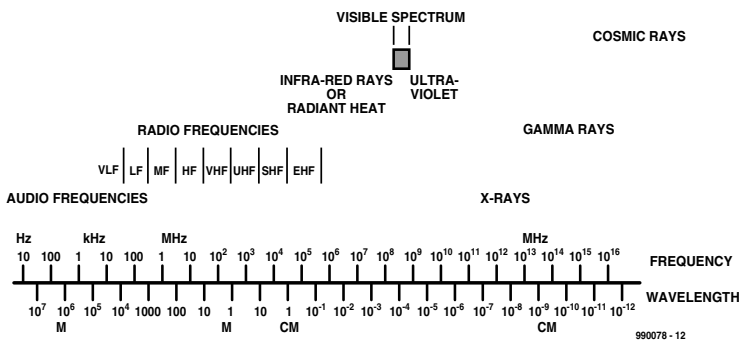


Figure 2. The electromagnetic spectrum, illustrating the location of the infra-red region.

Stefan — who'd been studying the nature of hot bodies, particularly their method of cooling — demonstrated that a body's total radiation was proportional to the fourth power of its temperature. This came to be called Stefan's Law.

Five years later, Stefan's former laboratory assistant, Ludwig Boltzmann, showed that Stefan's Law could be proven from first principles and so it came to be called the Stefan-Boltzmann Law. If, for example, a body's temperature tripled from 1,000 to 3,000 K, its radiant output would increase by  $3 \times 3 \times 3 \times 3$ , or 81 times. This meant that no matter how cold a radiating source was, it could still be detected because, when studied at infra-red, it would seem as bright as if its temperature

were multiplied by itself four times!

This of course was a very speedy rise indeed, one which surprised the scientific community of the day. Nevertheless the law was soon put to the test, as a technique for establishing the surface temperature of the sun. This turned out to be around 5,700 K.

Another early application of infra-red was in photography. In 1887 William Abney, the renowned British photographic scientist and discoverer of the Abney Effect, developed techniques for detecting infra-red radiation with photographs and used them to observe the sun's spectrum, far into this particular area of the solar spectrum.

In 1905, the American astronomer-physicist William Coblentz became Chief of the

Radiometry Section of the National Bureau of Standards, a post he'd retain for the next 40 years. With his colleagues Edison Pettit and Seth Barnes Nicholson, he concentrated primarily on infra-red spectroscopy. Throughout the 1920s, they carried out the first systematic infra-red observations of stellar objects, among which were not only stars and planets, but also gas clouds and nebulae.

In the course of this work, Coblentz became the first man to accurately estab-

lish the constants of black body radiation, thus confirming Planck's Law. Nicholson too had a distinguished career in planetary science, becoming the discoverer of the ninth, tenth and eleventh moons of Jupiter. These observations were possible of course because the "...infra-red range of the spectrum is so sensitive that it can detect objects whose temperatures are only a few degrees above absolute zero."<sup>3</sup> And no-where has this been more evident than in aerospace science.

## The Space Age

On April 1st 1960, the Americans launched the Television Infra-Red Observation Satellite, or TIROS, which "...took 23,000 pictures of the Earth and its clouds over a period of 78 days. Meteorologists the world over were ecstatic."<sup>4</sup> This can be considered the start of the most revealing period so far in man's history where his planetary home was concerned. For the first time, the peoples of the Earth could see just how accurate the early explorers and mapmakers had been, in their portrayal of the planet's major landmasses and seas.

Seven years later two American scientists, F.J. Low and D. Kleinmann, began a search for galaxies emitting energy at infra-red wavelengths and in the following year two more American researchers, Eric Becklin and Gerry Neugebauer, reported their observations of the galactic centre at infra-red frequencies. By 1970, Low and Kleinmann had reported a number of galaxies emitting in the infra-red band, and Neugebauer and his colleague Robert Leighton had completed their survey of the sky at the relatively short infra-red wavelength of  $2.2 \mu\text{m}$ , identifying no less than 20,000 sources in the northern hemisphere alone!

In January 1983, the Infra-Red Astronomical Satellite (IRAS) — shown in figure three — was launched, designed to detect infra-red radiation from space. Carrying a 60-cm reflecting telescope which — along with the infra-red detectors — was cooled to 2 K by liquid helium, this vehicle was a "... joint endeavour by the United States, the Netherlands and Great Britain."<sup>5</sup>

Its beryllium primary mirror had an aperture of 57 centimetres (cms), and there was what amounted to a small laboratory of instruments in the telescope's focal plane. It had a total of 62 detectors, 15 or 16 being used for each of the four infra-red wavelengths. The same segment of the sky was observed by at least two of the detectors, and so a 'true' reading was one that had been registered by both detectors.

During its 10 months of operation it per-

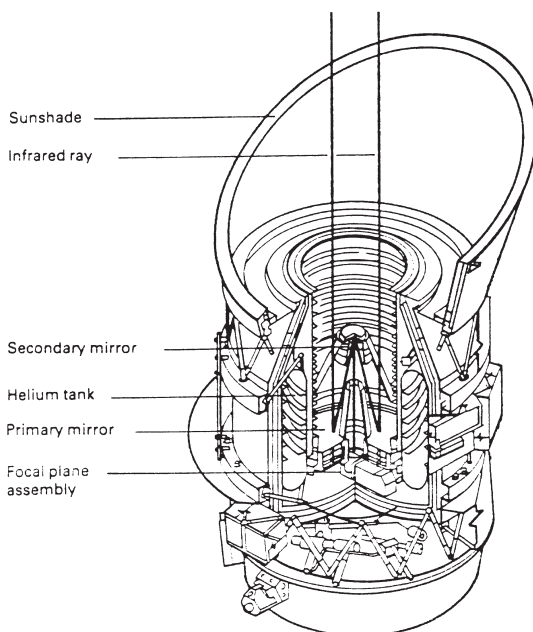


Figure 3. The IRAS satellite.

formed splendidly, discovering a large number of infra-red sources among which were eight galaxies. It also discovered evidence of planet formation around stars outside the solar system before — as expected — the liquid helium coolant ran out, in November 1983. In all, this remarkable satellite recorded some 600,000 objects, among which was the asteroid 3200 Phaethon, the source of the Geminid meteorite shower. This was the first such body to be discovered by a space craft.

One of the galaxies unveiled — IRAS F10214 + 4724 — subsequently proved to be the most luminous object ever found in the universe. This IRAS discovery was later studied by a team of American and British astronomers, using ground-based optical telescopes. It proved to be an astonishing 16,000 million light years away from us!

Another discovery was the existence of extremely cold clouds of hydrocarbons — which astronomers termed infra-red cirrus — in interstellar space. Moreover, infra-red radiation from these gas and dust clouds between stars strongly suggested that they were mainly composed of cellulose, the substance of all plant-cell walls and natural fibres, and still the most abundant organic material on earth.

Shortly after IRAS's cryogenic fluid was exhausted, the European Space Agency (ESA) decided to dedicate another vehicle to infra-red investigation: the Infra-red Space Observatory, or ISO, satellite. Given the advances in monitoring technology and space vehicle construction, ISO represented about a 1000-fold increase in overall sensitivity and a 10-fold increase in resolution over the IRAS vehicle.

Launched in November 1995, this vehicle made many important discoveries, undoubtedly the most interesting being that water — that good old basic piece of chemistry H<sub>2</sub>O — was much more abundant in the universe than had been thought hitherto. The satellite had an estimated operational life of 18 months and in November 1997, it finally suffered the same fate as its predecessor IRAS: Its cooling fluid was exhausted.

ISO's launch was the culmination of 12 years of close co-operation between Europe's scientific communities and aerospace industries. Consequently, ESA's 2000 Project plans to follow up ISO's success by launching yet another infra-red investigative probe: the Far Infra-Red and Submillimetre Space Telescope, or FIRST, in 2006. Work is already in hand on vehicle development and the investigations will concentrate on the 70 to 1000 micron wavelength.

Presently of course Earth-monitoring satellites proliferate and "Meteosat is Europe's contribution to the ring of geo-synchronous

weather satellites that keeps the earth under continuous observation." <sup>6</sup> Positioned over Africa, its orbit being synchronised with the Earth's rotation, this weather-watcher generates images every 30 minutes, its infra-red radiometers taking the temperature of the cloud tops, enabling the build-up of a temperature profile of the planet's atmosphere.

Ground-based telescopes too are also used for infra-red working, they being provided with special interference filters and cryogenic detector systems. The latter eliminate obstructions by infra-red radiation released by the detection equipment itself.

A good example of a ground-based infra-red telescope in the United Kingdom Infra-Red Telescope, (UKIRT), the largest instrument of its kind in the world. Its location — at the summit of Mauna Kea on Hawaii, which peaks at 14,000 feet or over 4,000 metres — is crucial, for atmospheric water vapour is a powerful absorber of infra-red radiation. Equipped with a remote control arrangement, its 3.8-metre mirror has the accuracy to detect even the sub-millimetric waves usually captured by radio telescopes.

Infra-red instruments have been "... used to make maps of the dark terrain of Jupiter's moon Io, to detect a mysterious 'white spot' on Saturn, to observe oceans of oil on Saturn's moon Titan and to observe stars hidden by dust at the centre of the galaxy." <sup>7</sup>

## Infra-Red Today

Infra-red technology was — originally — developed for military purposes. As early as 1942 "... EMI's camera-tube department developed an infra-red image converter of which over 250,000 were eventually made." <sup>8</sup> Today, the military connection remains strong, infra-red technology being employed in night-vision equipment and anti-armour ordnance, a good example of which is the Milan anti-tank guided weapon, or ATGW.

Weighing a mere 7 kilos and with a range of 2,000 metres, Milan's goniometer — which detects the infra-red heat component of, for

example, a vehicle's exhaust — automatically maintains the projectile's course to its target.

Another area of infra-red technology with military applications is infra-red photography, which is used to detect camouflage, of both personnel and equipment, which it can do in fog and haze, the sort of conditions that not only scatters visible light, but are also all too common on a battlefield.

Infra-red technology has also invaded scores of other areas of activity from archaeology and criminology to search and rescue. We have all seen how such equipment, in the hands of police helicopter crews, have detected intruders, escaping criminals and joy-riders through television programmes such as *Police, Camera Action!* and the more recent *Beware: Bad Drivers*.

In other spheres too such as medicine, printing and (of course) the humble greenhouse, infra-red radiation has proved that it has far more applications than its discoverer ever imagined!

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## References

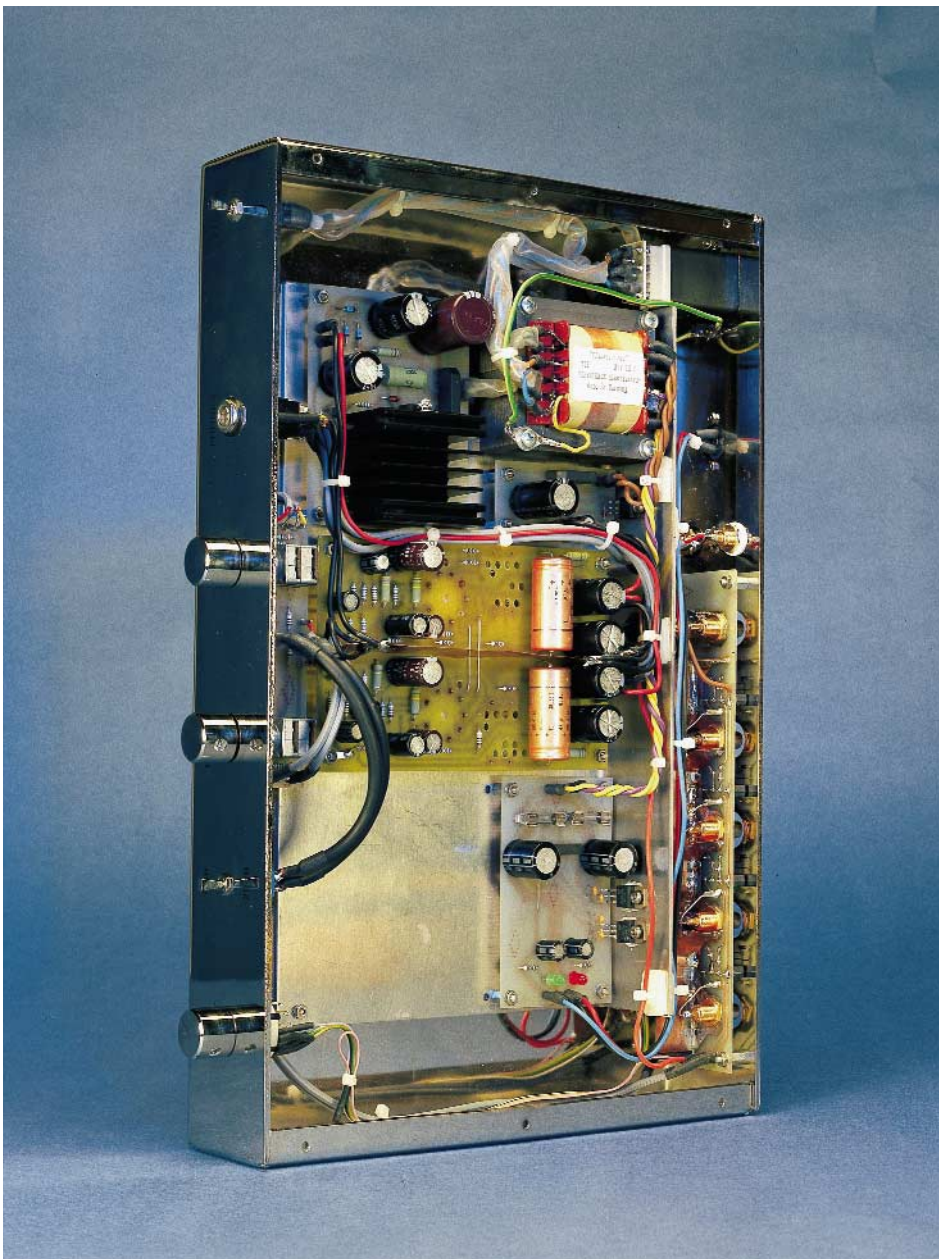
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# Valve Preamplifier (2)

## Construction, first part

Design by G. Haas

You should use only the best components to build a high-end amplifier, if you want to achieve and maintain the specified performance figures.



It is also important that you observe the suggestions given in the text and the components lists, and avoid using inferior-quality 'equivalent' types. All printed circuit boards sup-

### Please Note, corrections to part I

The dashed connection between R9 and the anode of valve V1b is not an optional wire link. As indicated by the PCB component mounting plan, resistor R9 may be fitted in one of two positions marked R9 and R9\*. In pentode mode (default), the resistor is fitted in position R9, i.e., connecting the suppressor grid (g2) to the +324 V anode voltage. This configuration is shown in the circuit diagram, Figure 5. The dashed connection has no meaning.

The quasi-pentode configuration requires the resistor to be fitted in position R9\*, i.e., between the suppressor grid and the anode.

Figure 6 does not show two back-emf suppression diodes across the relay coils. These diodes are however present on the board, as well as included in the parts list.

In Figure 7, R10 should be 390 k $\Omega$  (not 100 k $\Omega$ ), and C6 should be 220  $\mu$ F (not 1000 $\mu$ F).

**COMPONENTS LIST**  
Input Board

**Resistors:**

R1-R8 = 100kΩ

Rx = see text

Rel1-Rel8 = SIL reed relay, 12V, 1 make contact

**Miscellaneous:**

K1-K9 = cinch sockets, chassis mount

Two cinch sockets, chassis mount, for recorder outputs

S1 = rotary switch, 1 pole, 4 contacts, break before make

Solder pins

Copper foil

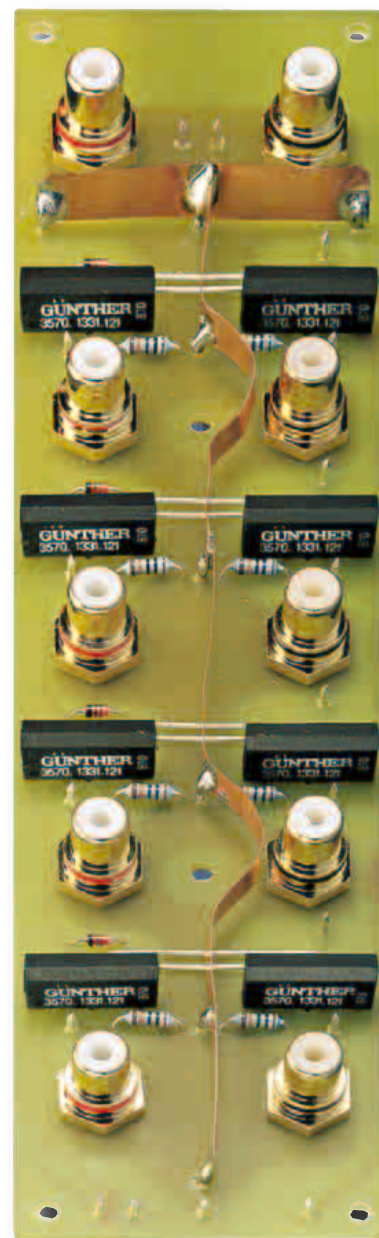
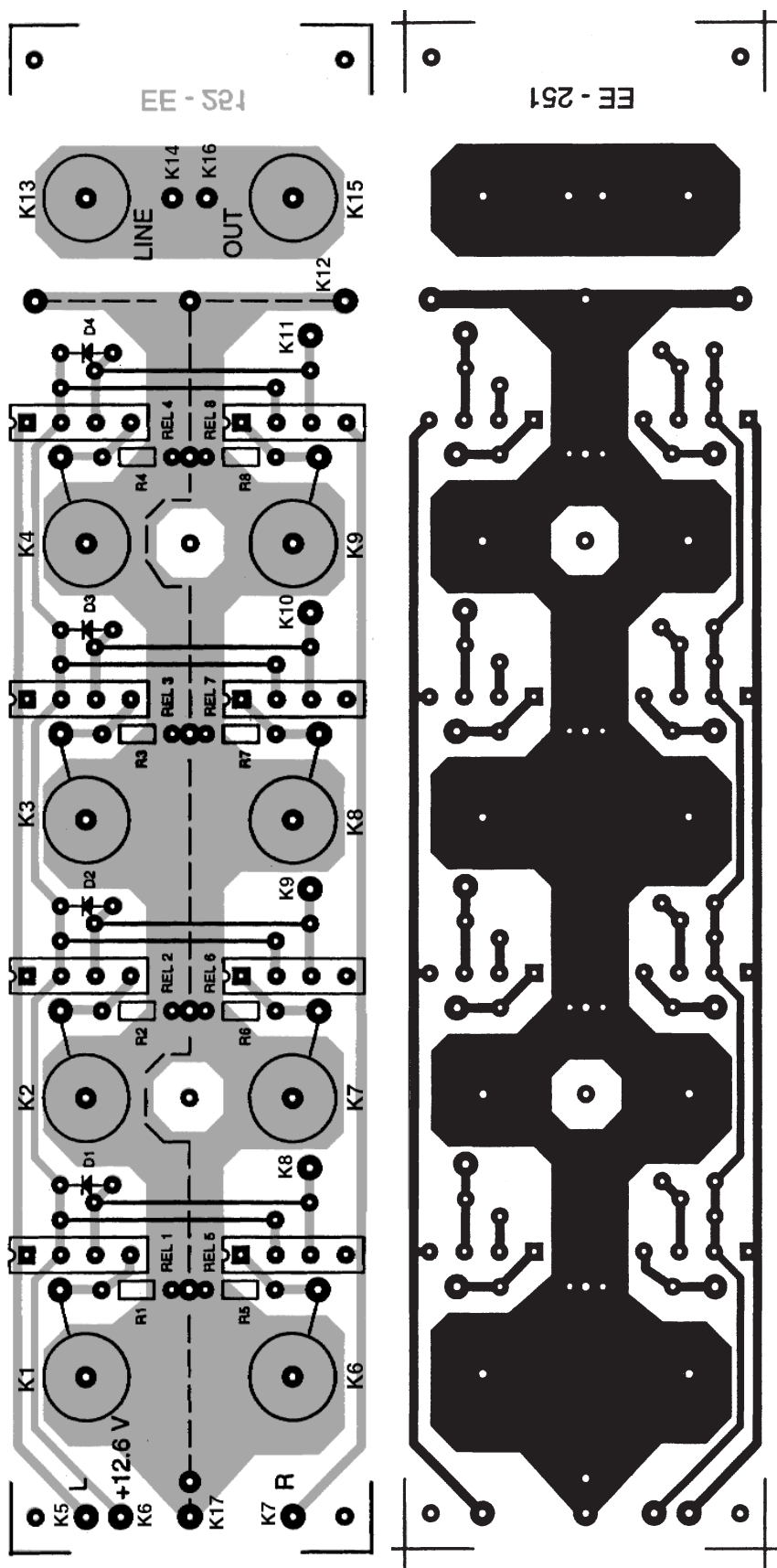
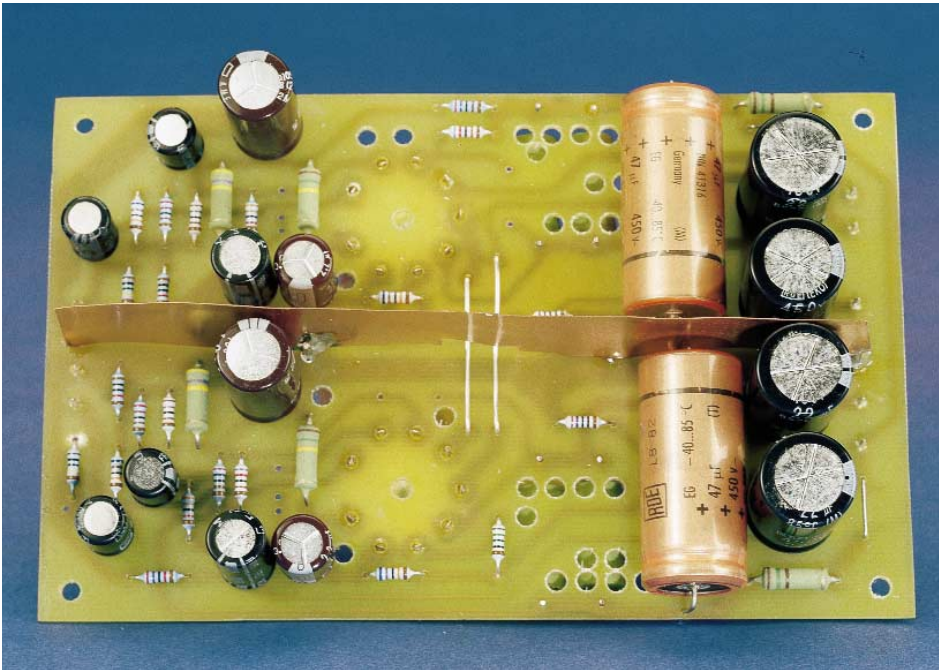


Figure 1. Relay board: printed circuit board track layout, component layout and photograph.



plied by Experience Electronics for this project are made using fibre-glass-reinforced epoxy with a 70- $\mu\text{m}$  copper lamination. All resistors in the components list are 1-percent tolerance, 0.7-W metal film types, unless otherwise indicated, with a lead spacing of 10 mm. The 2-W and 4.5-W resistors are metal oxide types with a tolerance of 5 percent, and have lead spacings of 15 mm and 25 mm respectively. The gold-plated Cinch sockets, as well as the potentiometers, should of course be very high quality.

Before we discuss the construction of the circuit boards, a few words about the enclosure are in order. Even the best electronics, no matter how clever the design may be, is of no use if it is not housed in a suitable enclosure. With valve

## COMPONENTS LIST

### Amplifier Board

(one channel)

#### Resistors:

- R1 = 680k $\Omega$
- R2 = 1k $\Omega$
- R3 = 10k $\Omega$
- R4 = 33k $\Omega$
- R5 = 2k $\Omega$
- R6 = 150k $\Omega$ , 2W
- R7 = 470k $\Omega$ , 2W
- R8 = 2k $\Omega$

- R9 = 8k $\Omega$
- R10 = 680k $\Omega$
- R11 = 150 $\Omega$
- R12 = 270 $\Omega$
- R13 = 27k $\Omega$
- R14 = 150 $\Omega$ , 2W
- R15,R16 = 6k $\Omega$ , 4.5W

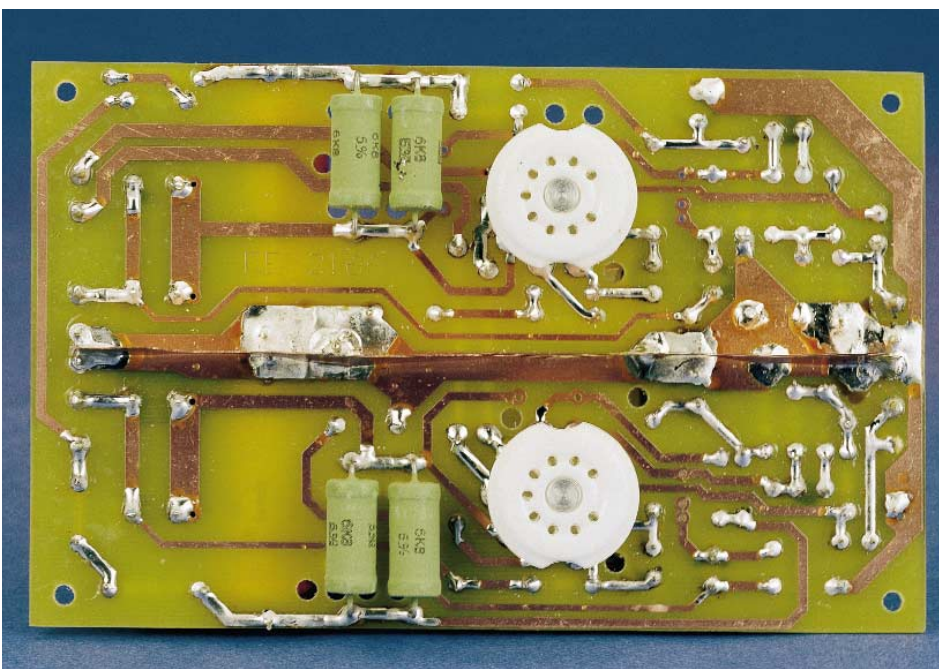
#### Capacitors:

- C1 = 1 $\mu\text{F}$  63V, 5mm raster
- C2 = 10 $\mu\text{F}$  400V, 5mm raster
- C3 = 47 $\mu\text{F}$  40V, 5mm raster
- C4 = 2 $\mu\text{F}$  400V, 5mm raster

- C5 = 220 $\mu\text{F}$  40V, 5mm raster
- C6 = 47 $\mu\text{F}$  450V, size 18.5x41mm
- C7,C8 = 22 $\mu\text{F}$  400V, 7.5mm raster
- C9 = see text

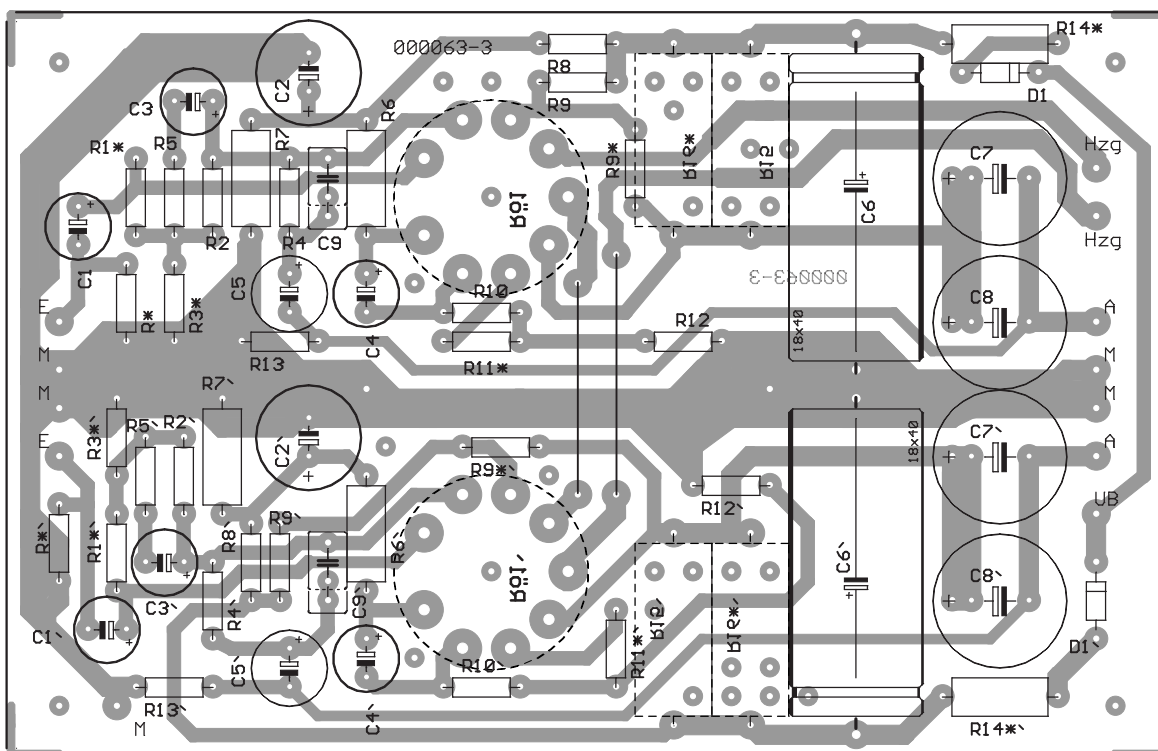
#### Miscellaneous:

- D1 = see text
- VI (Rö1) = ECL86
- 1 ceramic 'Noval' (9-pin) socket, PCB mount
- Copper foil
- Solder pins



amplifiers in particular, given their high working voltages, electrical safety is a primary consideration! A metal enclosure, connected to the protective earth lead, provides both safety and screening. If the enclosure also has an attractive appearance, there will be nothing to disturb your listening pleasure.

All circuit modules are housed in an aluminium enclosure. The advantage of aluminium is that it is non-magnetic, so that it avoids magnetic distortions. In addition, it has very good design properties. The enclosure used here has rivitless joints, and the surface is polished and covered by bright nickel plating. Nickel has a warm tone, in contrast to the bluish tone of chrome, and this optically reinforces the 'flair' of a valve amplifier. In order to avoid having an



excessive number of screws visible on the top surface of the enclosure, a mounting plate is used to fit all of the electronics. This plate is then

screwed to the chassis using eight bright-nickel-plated Phillips screws. In this way, you can produce a visually attractive piece of equipment.

### Board stuffing

Now you can start with stuffing the boards. Start with the relay board, as shown in **Figure 1**. The Cinch sockets are screwed to the

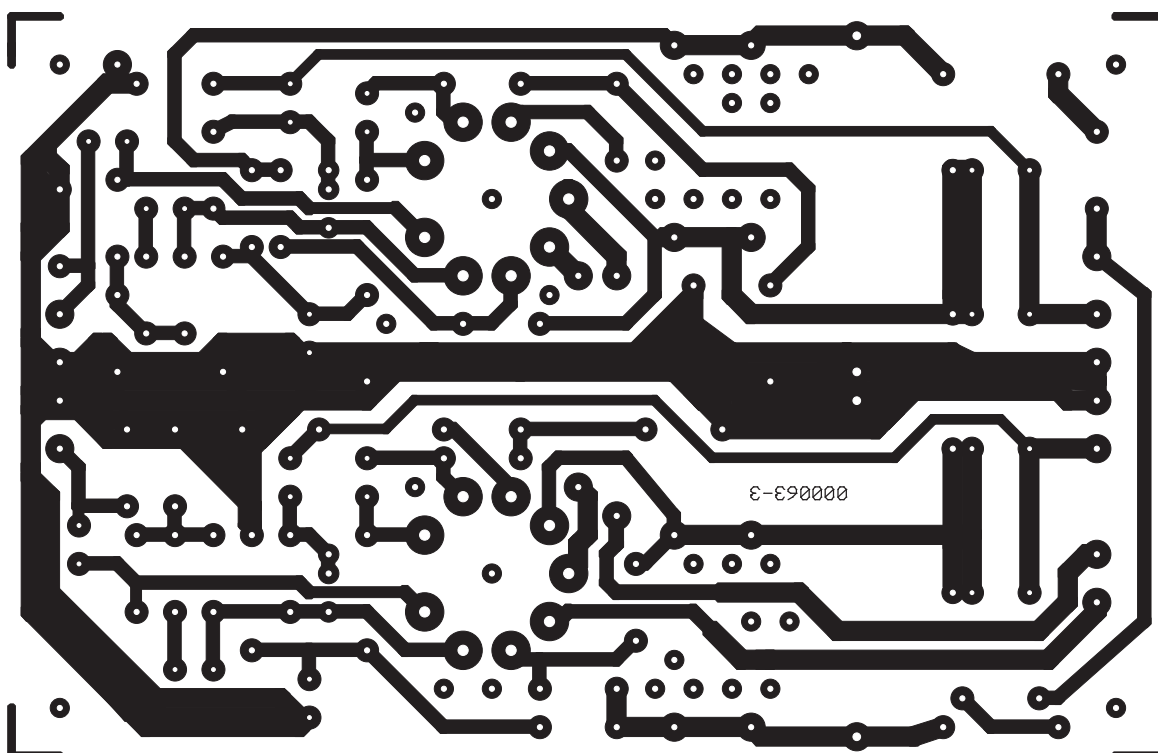


Figure 2. The amplifier board is laid out symmetrically, with the two valves in the middle.



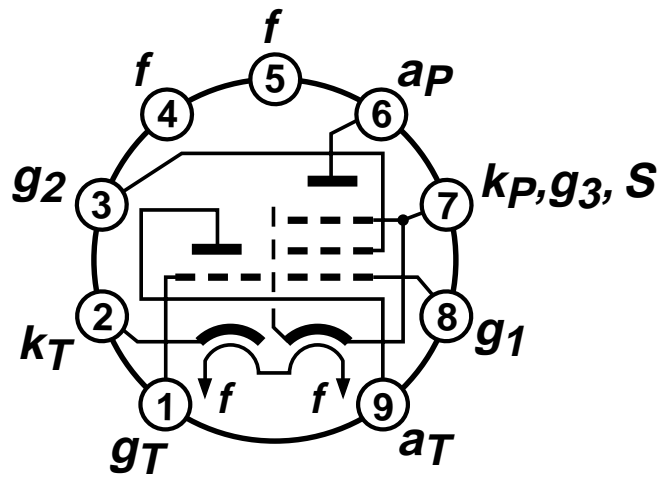
board. You must first tin the tracks at the points of contact, to assure good connections. Apply a drop of solder to each fastening nut to secure it. This guarantees long-term, reliable earth connections. If there is contact resistance in the earth connection at this location, interference is an unavoidable consequence. The photograph shows the construction of the circuit board and the placement of the components. Strips of 0.15-mm thick copper foil are soldered between the sockets. These provide screening on both sides, and between the two channels. In this regard, we can remark that in many modern pieces of equipment, you will find pairs of Cinch sockets in plastic modules that can be screwed to the rear panel of the enclosure, with pins that can be soldered directly to the circuit board. These may be less costly for the manufacturer, and they are easy to mount, but using such modules here will impair the channel separation of the entire device, due to the close spacing of the sockets and the lack of screening.

Since soldering the nuts requires a lot of heat, this should be done first, before any other components are fitted. After this, you can insert the resistors, diodes, relays and solder posts.

The main circuit board with the amplifier, as shown in **Figure 2**, is laid out so that it can be used for other applications by adding or omitting components. Use a wire bridge in place of zener diode D1, which is marked with a star on the circuit board. This diode is only used as an option for other applications, in which the amplifier circuit is operated from a higher supply voltage. The good qualities of a stabilised power supply are retained by the low impedance of the zener diode. A high-valued series resistor would only degrade the quality of the supply voltage.

You should pay attention to certain details when inserting the components in the circuit board. In order to make the valves protrude nicely from the chassis, so that they are readily visible, the valve sockets are mounted on the solder side of the circuit board. This also ensures good heat dissipation. The socket pin assignments are shown in **Figure 3**. Power resistors R15 and R16, which become quite warm, are also mounted on the solder side, separated from the board by a certain amount, in order to improve their heat dissipation. It also doesn't hurt to make a series of ventilation holes in the circuit board in unused areas. This avoids the creation of heat pockets. All other components are mounted on the component side, as usual. The board is mounted to the chassis using suitable spacers.

There is not a lot to say about fitting the



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Figure 3. Pin assignments of the ECL86, viewing the pins from the bottom.

$k_p$	pentode cathode	$g_3$	pentode suppressor grid
$s$	internal shield	$f$	filament
$g_T$	triode grid	$k_T$	triode cathode
$g_2$	pentode screen grid	$a_p$	pentode anode
$g_1$	pentode signal grid	$a_T$	triode anode



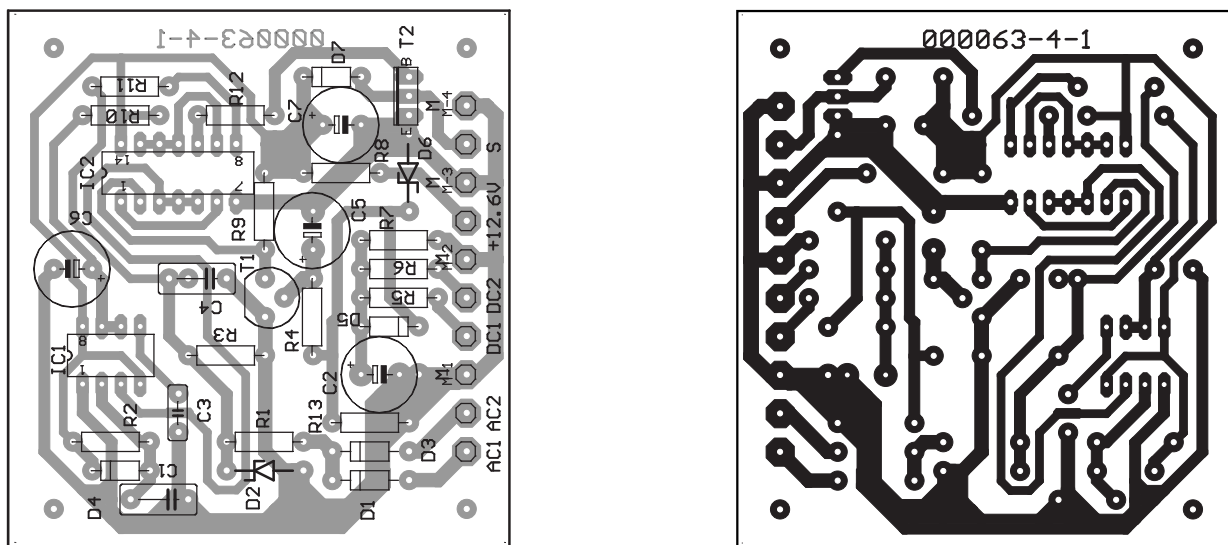


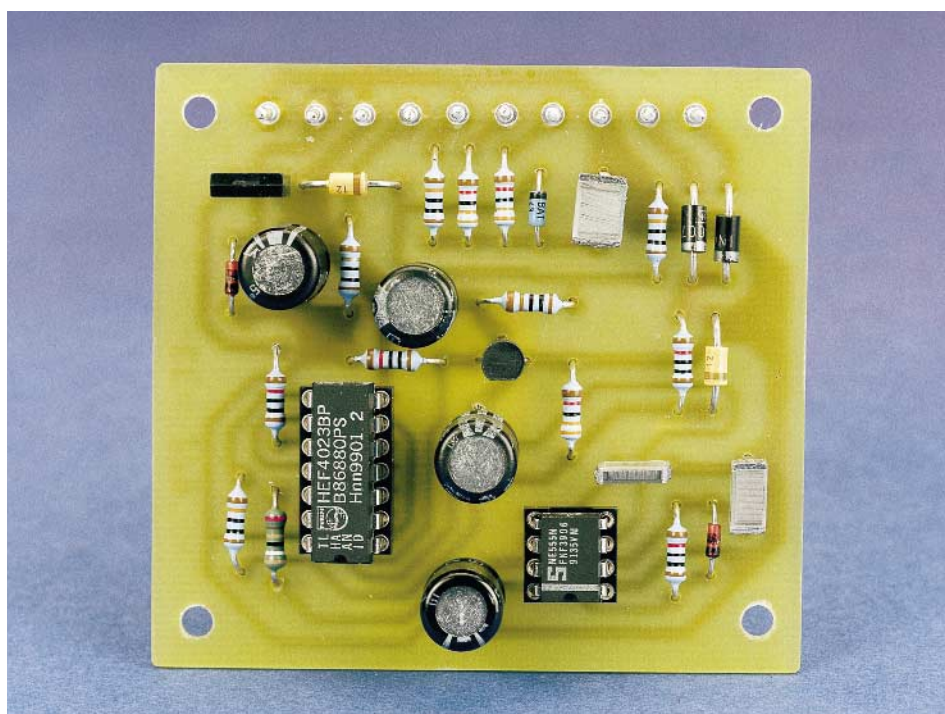
Figure 4. Printed circuit boards for the protective circuitry.

components to the protection circuit board (Figure 4). Sockets may be used for the DIL ICs. If you pay attention (as always) to the correct locations and polarisations of all components, everything will be OK.

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**Note:**

Kits, PCBs and parts for the Valve Pre-amplifier are available from Experience Electronics, Weststrasse 1, D-8942 Herbrechtingen, Germany. Tel. (+49) 7324 5318, fax (+49) 7324 2553. Email: experience.electronics@t-online.de



**COMPONENTS LIST**  
Protection Circuit

**Resistors:**

- R1,R2 = 10kΩ
- R3 = 33kΩ
- R4 = 1kΩ
- R5,6 = 33kΩ
- R7 = 100kΩ
- R8 = 10Ω
- R9 = 10kΩ
- R10 = 390kΩ
- R11 = 100kΩ
- R12 = 10kΩ

R13 = 100kΩ

**Capacitors:**

- C1 = 0.22μF MKT, raster 7.5mm
- C2 = 0.33μF MKT, raster 7.5mm
- C3 = 10nF ceramic, raster 5mm
- C4,C5 = 1μF 63V, raster 5mm
- C6 = 220μF 40V, raster 5mm
- C7 = 47μF 40V, raster 5mm

**Semiconductors:**

- D1,D3 = 1N4007
- D2,D6 = zener diode 12 V, 1.3W
- D4,D7 = 1N4148

- D5 = BAT43
- T1 = BC546B
- T2 = BD139-16
- IC1 = 555
- IC2 = 4023

**Miscellaneous:**

- 1 off 8-way DIL IC socket, gold-plated contacts
- 1 off 14-way DIL IC socket, gold-plated contacts
- Solder pins

# I/U curve tracer

driven via the PC printer port

Source: Maxim Integrated Products

With a set of Maxim A/D and D/A converters and a handful of other components, you can make a curve tracer that can be driven from the printer port of a PC. A simple BASIC program takes care of the communication between the PC and the measurement circuit, and also converts the measured values into graphic form for display on the monitor.

Not long ago, it was common practice to measure the I/U characteristics of a semiconductor device using an X-Y oscilloscope and a suitable measuring circuit. An electronics engineer can extract a lot of information about the operation of the semiconductor from these curves.

In the present computer age, the I/U curve may well have dropped into obscurity, but it is still useful for evaluating a number of specific semiconductor characteristics. The only difference is that we no longer need an oscilloscope, since we can instead employ the versatile PC.

With the measurement circuit presented here, which comes from Maxim, the I/U characteristics of a semiconductor or IC can be measured and then displayed on the monitor. This is made possible by the use of two serial-interface ICs: a 12-bit DAC and a 12-bit ADC. A short BASIC program looks after controlling the circuit and displaying the data on the screen. Since the circuit is designed for use with a standard PC printer port, the interaction between the circuit and the computer is very simple.

## The hardware

Figure 1 shows the schematic diagram of the hardware. IC4 is a 12-bit D/A converter that is configured for a bipolar output voltage with a range of plus and minus 2.048 V. The opamp IC6a, which is connected to the  $V_{out}$  pin, amplifies this voltage by a factor of 2, so that a voltage ranging between plus and minus 4.096 V is present at the output of IC6a. IC7 in turn converts this voltage into a current that is proportional to the voltage. This is the

test current for the device being measured.

The current ranges from  $\pm 40 \mu A$  to  $\pm 40 mA$ , depending on the value selected for the resistance of  $R_{SENSE}$  (100  $\Omega$ , 1 k $\Omega$ , 10 k $\Omega$  or 100 k $\Omega$ ). The

maximum output current is approximately equal to the value of the output voltage of IC6a (4.096 V) divided by the value of  $R_{SENSE}$ .

The current through the DUT (device under test) produces a voltage drop

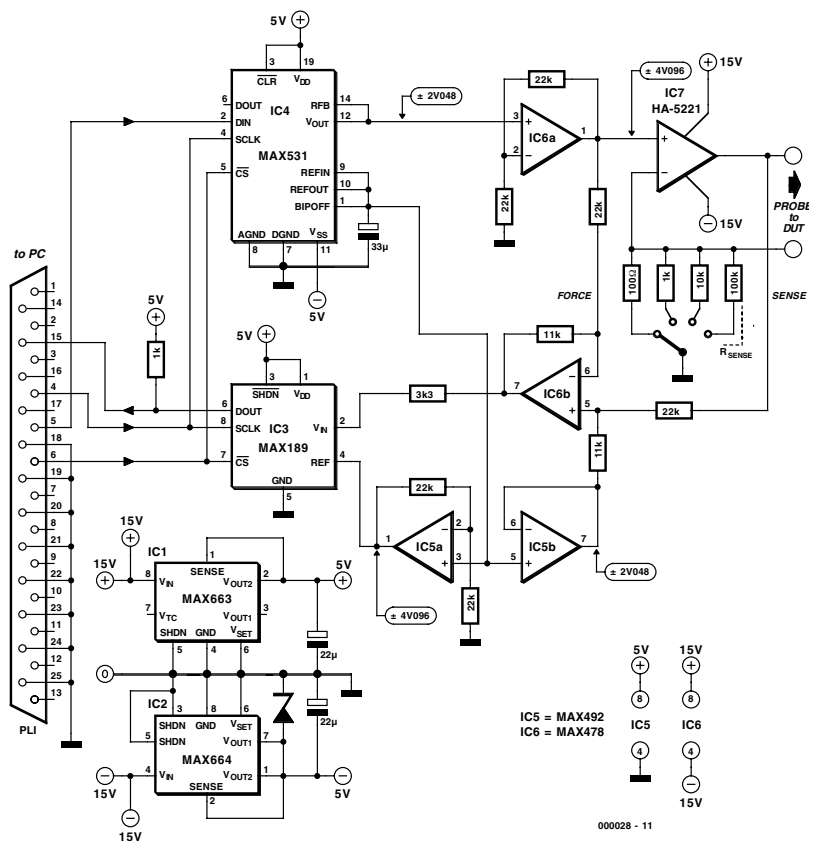


Figure 1. The main components of the circuit are a set of Maxim serial-interface A/D and D/A converters.

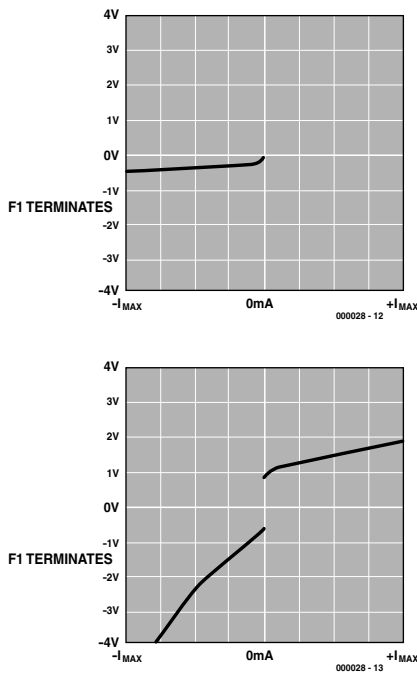


Figure 2. Two examples of measured I/U curves: (a) shows a Schottky diode, while (b) shows a more complex analogue IC.

across the component. This voltage is measured by the difference amplifier IC6b. In order to avoid an offset error that depends on the value of the selected current-sensing resistor, the signal for the inverting input of this opamp is taken from the low-impedance non-inverting input of IC7. The disadvantage of this is a fixed error equal to the input offset of IC7.

The amplification of the difference amplifier, in combination with the added offset, yields a maximum output swing of 0 to 4.096 V. This is exactly the right range for the unipolar input of the 12-bit A/D converter (IC3). The 3.3-k $\Omega$  resistor in series with the input of the ADC limits the input current in case the output voltage of IC6b should be greater than the supply voltage of IC3.

When a measurement is being made, the software drives the DAC such that it produces a 'staircase' current. The resulting voltage across the DUT is measured by the ADC and then displayed on the PC monitor, with a resolution of 640 x 480 pixels. The two examples shown in **Figure 2** illustrate some typical results. A resolution of 12 bits is actually somewhat luxurious for this applica-

```
'LISTING 1 - BASIC PROGRAM

'LPT1 OUT @ &H378, IN @ &H379
'LPT2 OUT @ &H278, IN @ &H279

'25 WAY D TYPE

'SIGNALS TO CIRCUIT
'PIN 4 D2 (OUT) SCLK
'PIN 5 D3 (OUT) DATA OUT (FROM PC)
'PIN 6 D4 (OUT) CS\

'SIGNALS FROM CIRCUIT
'PIN 15 D3 (IN) DATA IN (TO PC). ALSO SIGNALS EOC
'PINS 18-25 ARE GROUND

'INTRODUCTION

PRINT "WELCOME TO THE MAXIM CURRENT-VOLTAGE CURVE TRACER"
PRINT

INTRO:
PRINT "WHERE IS THE CIRCUIT CONNECTED? ENTER 1 FOR LPT1 OR 2 FOR LPT2"
INPUT P%
IF P% = 1 THEN PORT& = &H378 'SET LPT1
IF P% = 2 THEN PORT& = &H278 'SET LPT2
IF P% = 1 OR P% = 2 THEN GOTO INTRO1 'TRAP ERROR
PRINT "WRONG!!!!!! PLEASE TRY AGAIN"
GOTO INTRO
INTRO1:

ON KEY(1) GOSUB FINISH 'F1 EXITS
KEY(1) ON

MAIN: 'MAIN BIT OF PROGRAM

'DEFINE SOME VARIABLES
DIM Y(512) 'ARRAY TO HOLD PLOT DATA
DIM DIN(12) AS INTEGER, DOUT(12) AS INTEGER 'DATA IN AND DATA OUT

'SET UP DISPLAY FOR OUTPUT
CLS 0
SCREEN 12 'VGA SCREEN
WINDOW (-120, -55)-(520, 435) 'DEFINE WINDOW CO-ORDINATES
LINE (0, -5)-(0, 410), 1 'DRAW A FEW LINES
LINE (-5, 0)-(512, 0), 1
LINE (512, -5)-(512, 410), 1
LINE (-5, 410)-(512, 410), 1
LINE (-5, 205)-(512, 205), 1 'CENTRAL AXES
LINE (256, -5)-(256, 410), 1
LINE (-5, 51)-(0, 51), 1 'MARKERS
LINE (-5, 102)-(0, 102), 1
LINE (-5, 153)-(0, 153), 1
LINE (-5, 256)-(0, 256), 1
LINE (-5, 308)-(0, 308), 1
LINE (-5, 359)-(0, 359), 1
LINE (64, -5)-(64, 0), 1
LINE (128, -5)-(128, 0), 1
LINE (192, -5)-(192, 0), 1
LINE (320, -5)-(320, 0), 1
LINE (384, -5)-(384, 0), 1
LINE (448, -5)-(448, 0), 1

COLOR 9 'LABELS
LOCATE 1, 1, 0: PRINT "MAXIM CURRENT-VOLTAGE CURVE TRACER"
LOCATE 20, 1, 0: PRINT "F1 TERMINATES"
LOCATE 2, 12, 0: PRINT "+4V"
LOCATE 15, 13, 0: PRINT "0V"
LOCATE 27, 12, 0: PRINT "-4V"
LOCATE 28, 15, 0: PRINT "-Imax"
LOCATE 28, 46, 0: PRINT "0mA"
LOCATE 28, 75, 0: PRINT "+Imax"

LOCATE 10, 1, 0
PRINT "Rs Imax"
PRINT "100R 40mA"
PRINT "1K 4mA"
PRINT "10K 400uA"
PRINT "100K 40uA"

START: 'START OF PLOT ROUTINE
IDATA& = &H10 'INITIALISE PORT, SCLK=0, CS\=1
OUT PORT&, IDATA&

Z& = 8 'INITIALISE MAX531
```

```

GOSUB IO

FOR X& = 1 TO 511 STEP 1
  Z& = 8 * (X& + 1)
  GOSUB IO

  PSET (X&, Y(X&)), 0
  IF Y(X&) = 0 THEN PSET (X&, Y(X&)), 1
  IF Y(X&) = 205 THEN PSET (X&, Y(X&)), 1
  IF X& = 256 THEN PSET (X&, Y(X&)), 1
  Y(X&) = INT(ODATA& / 10)
  IF Y(X&) > 408 THEN Y(X&) = 409
  IF Y(X&) < 1 THEN Y(X&) = 1
  PSET (X&, Y(X&)), 4
NEXT X&
GOTO START

IO:
ODATA& = &H0
IDATA& = IDATA& AND &HEF
OUT PORT&, IDATA&
WAIT (PORT& + &H1), &H8

IDATA& = IDATA& OR &H4
OUT PORT&, IDATA&
IDATA& = IDATA& AND &HF3
OUT PORT&, IDATA&

FOR SHIFT = 11 TO 0 STEP -1
  DOUT(SHIFT) = (INP(PORT& + &H1) AND &H8)
  ODATA& = ODATA& + DOUT(SHIFT) * 2 ^ (SHIFT - 3)
  IDATA& = IDATA& OR ((Z& AND (2 ^ SHIFT)) / (2 ^ SHIFT) * 8)
  OUT PORT&, IDATA&
  IDATA& = IDATA& OR &H4
  OUT PORT&, IDATA&
  IDATA& = IDATA& AND &HF3
  OUT PORT&, IDATA&
NEXT SHIFT
IDATA& = IDATA& OR &H10
OUT PORT&, IDATA&

RETURN
FINISH:
END
  
```

tion, but the software can be modified to work with higher resolutions, and you could even add a loop to the software for this.

Now we come to a few practical remarks regarding the power supply. IC7 and IC6 need a symmetrical supply voltage of  $\pm 15$  V in order to operate over the desired range. All other ICs need only a  $\pm 5$  V supply. The voltage regulators MAX663 and MAX664 (IC1 and IC2) provide the necessary voltages.

The QBASIC program shown in the accompanying listing starts by asking which printer port the circuit is connected to (1 or 2). After this, the graphic plot of the I/U curve of the device being tested appears on the screen. You can exit the program by pressing the function key F1. Make sure to run the program in true DOS mode, rather than in a DOS box under Windows. QBASIC can usually be found in a folder labelled 'OLDMSDOS' on the Windows CD, or else you should use an old version of MS-DOS.

(000028-1)

The BASIC program 'I-V Curve Tracer' was written by Terry Millward of Maxim UK, and is available at the Maxim web site:

[www.maxim-ic.com/TechSupport/other.htm](http://www.maxim-ic.com/TechSupport/other.htm)

## Serial-interface converters

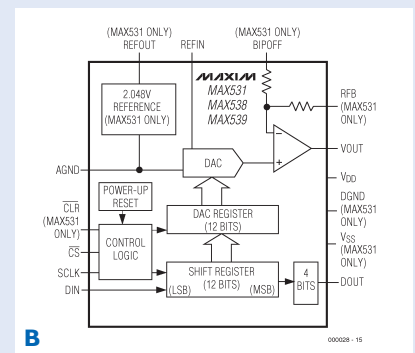
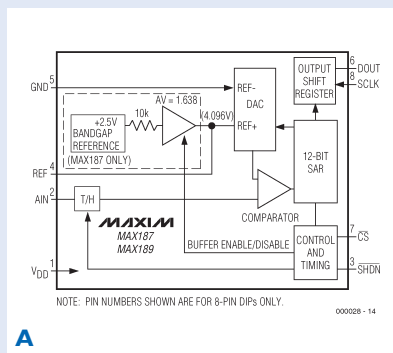
The simplicity of the circuit described in this article is primarily due to the use of a set of serial-interface converters, namely the MAX 189 and MAX 1531. The MAX 189 is a serial A/D converter with a resolution of 12 bits that works with a single +5 V supply. Its input voltage range also lies between 0 and +5 V. The core of this IC is a successive-approximation ADC with a conversion time of 8.5  $\mu$ s. This is complemented by a fast sample and hold circuit (1.5  $\mu$ s), an on-chip clock generator and a fast serial three-wire interface (see the block diagram in **Figure A**).

The conversion rate of the MAX 189 is 25 kilo-samples/s. Thanks to its built-in interface, this IC can be easily connected to a PC or microprocessor, as can be seen in this application. In contrast to its companion MAX 187, the MAX 189 does not have an internal reference, but this is not necessary in this application since the DAC that is used provides the reference voltage. The very low operating power consumption (7.5 mW) makes this IC very suitable for battery-powered applications. In the shutdown mode, the power consumption drops to only 10  $\mu$ W.

The MAX 189 is available in an 8-pin DIP package and a 16-pin SOI package.

The MAX 1531 can be seen as a complement to the MAX 189. Its block diagram is shown in **Figure B**. This 12-bit D/A converter also works with a single +5 V supply. The MAX 1531 was specifically chosen for this application, which requires a bipolar output voltage, since it can also work with a symmetrical  $\pm 5$  V supply. The current consumption of the MAX 1531 is only 260  $\mu$ A, including the internal 2.048 V reference source. The IC is housed in a 16-pin DIP or SOI package. The offset voltage, amplification and linearity are adjusted during manufacturing, so the user does not have to be concerned with them.

The internal output opamp of the MAX 1531 can be configured for an amplification factor of 1 or 2, and for a unipolar or bipolar output voltage. An internal shift register stores the serial data supplied to the IC.

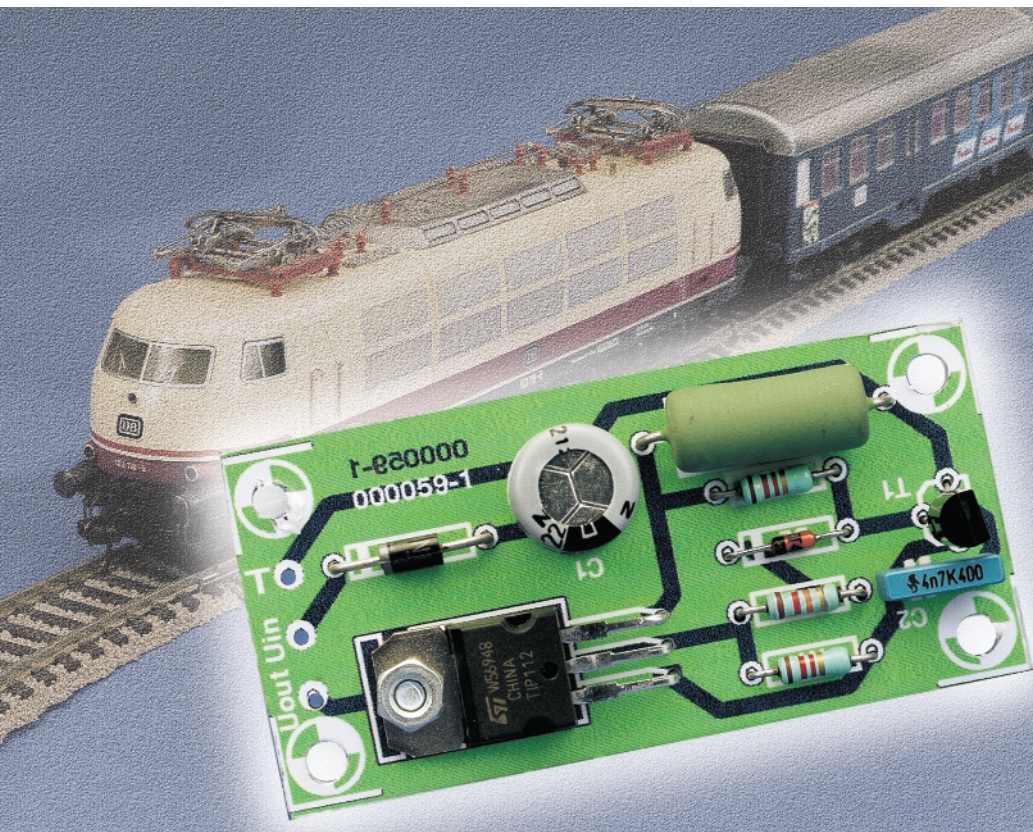


# Signal Module

for EEDTs Pro

Design by H. Prince

On conventionally controlled model railways, it is standard practice to stop a train at a signal by removing power from a section of the track. With digitally controlled model trains, an auxiliary circuit must be used to prevent the locomotive decoder from losing operating power when the train is stopped.



In conventionally controlled model railways, a switch or relay is used to disconnect power from a section of the track. The train then comes to a stop on the 'dead' section. After power is restored to this section of the track via the switch or relay, the train continues on its way.

A consequence of this approach is that the

front lights of the locomotive, and possibly also the lights of the first car after the locomotive, are extinguished. However, this is accepted as a necessary inconvenience.

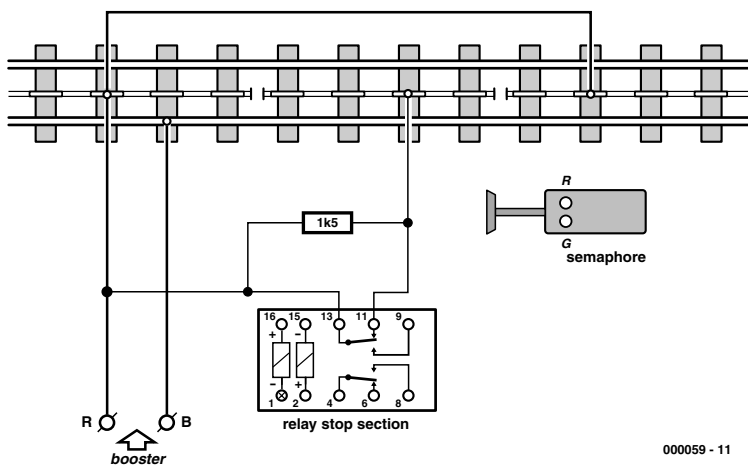
With the advent of digitally controlled model trains, however, this inconvenience turned into a real

problem. If power is completely removed from the locomotive decoder, it eventually loses its stored running settings and all information regarding enabled functions. The first generation of locomotive decoders experienced problems in such a situation within a few minutes, while modern versions can retain information for several hours.

The EEDTs Pro Super Locomotive Decoder is an exception to this rule. Since it writes the information to its EEPROM at the last possible moment, it retains this information forever.

With old format Märklin decoders, the loss of the stored information causes the default settings to be selected. This means that all functions are disabled, the running state is set to zero and the default direction is selected. If the default direction is not the same as the direction that the train was travelling when it entered the dead section of track, it will thus reverse direction when it receives new running information.

To prevent this sort of behaviour, dead sections of track are usually bridged with 1.5 k $\Omega$  resistors, and the lighting and other major power consumers are connected to a zener diode network. This arrangement is shown in **Figure 1**. If a train comes to a stop on such an 'almost dead' section of track, the decoder still



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Figure 1. A 1.5-kΩ resistor can be used to ensure that the locomotive decoder receives adequate power on a 'dead' section of track.

receives enough power to maintain the contents of its memory.

However, the fact that the lights go out when a train enters such a section of track is still annoying, and it looks truly unprofessional if an otherwise so nicely controlled locomotive, with its finely adjusted braking deceleration, stops like a brick on such a section of track.

Fortunately, a special characteristic of the locomotive decoder provides a solution to this problem. If the decoder is fed with a negative supply voltage, any locomotive that is equipped with such a decoder will come to a stop, and the enabled functions will remain active.

This means that the front lighting remains on if it has been enabled, any sound generators that may be present are not suddenly interrupted, and the controlled locomotive decoder bring the train to a gradual stop using its deceleration settings.

The nice thing about this decoder characteristic is that in principle, it also applies to locomotive decoders made by Märklin. The only exception is the first generation of Märklin decoders, which disable the direction-dependent functions when power is interrupted.

Since the EEDTs Pro PC program can be used to automate conventionally constructed model railways

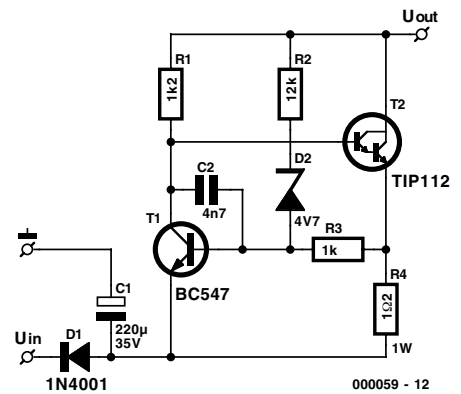
with dead track sections, without any modifications being necessary, the module described here is a welcome addition to the EDiTS toolkit.

### The circuit

It is not possible to simply apply a negative voltage to the rails of a stop section, since the slider contact makes a connection between the stop section rail and the booster output when the locomotive enters such a section of track. The unpleasant consequence of this is that enormous currents can flow. The booster output provides an alternating voltage that switches between -20 and +20 V, so that at any given moment 20 V will be shorted to ground through the slider.

With a three-rail system, a short circuit can be prevented by inserting a length of insulation in the slider rail, so that the slider does not make contact with the rail in the stop section until it has broken contact with the rail in the normal section of the track. With a two-rail system, however, it is not possible to prevent the slider from making contact with the rails of both sections when the locomotive enters a stop section.

The circuit shown in **Figure 2** is thus designed to limit the current to 0.5 ampère. This value has been chosen to allow enough power to be

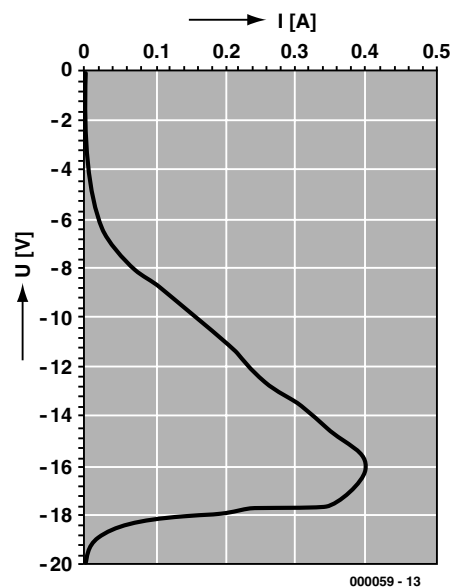


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Figure 2. The electronics of the signalling module consists of two transistors and eight passive components.

provided for locomotive braking, other functions and lighting (if enabled). It should be sufficient in nearly all cases.

Capacitor C1 and diode D1 derive a negative voltage from the rail voltage. When a load is applied to the circuit, T2 is driven into conduction by R1 until the voltage drop across R4 rises to more than around 0.6 V. At this point, T1 starts to conduct. This reduces the drive current to T2, which in turn causes the current through R4 to decrease until a balance is achieved. This occurs when the voltage drop

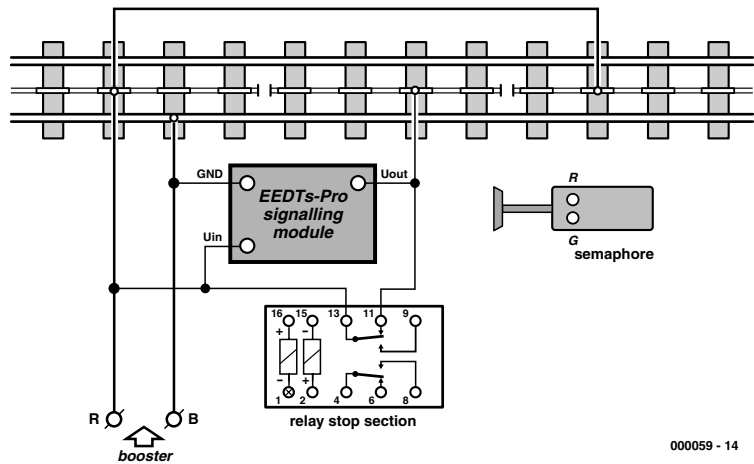


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Figure 3. The current limitation characteristics of the signalling module.

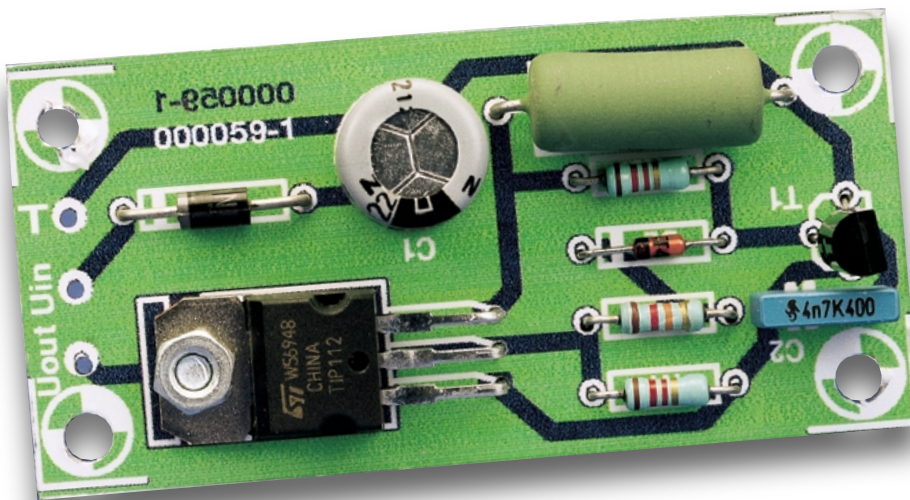
across R4 is 0.6 V. The circuit then limits the current to approximately 500 mA ( $0.6 / 1.2$ ). However, since 20 V can be applied to T2 when the circuit is bridged by the slider, the power dissipated in T2 will be around 10 W (which also puts a heavy additional load on the booster). To prevent this unnecessary waste of power, the circuit has a power limitation network in the form of D2 and R2. These components cause the circuit to work only within the range of -20 V to -15 V. Outside of this range, the circuit will not supply any current (see the diagram in **Figure 3**).

If the voltage across the C-E junction of T2 rises above the zener voltage (4.7 V), T1 is driven even harder. This causes T2 to completely cut off, so that no current at all flows through T2 and R4. Capacitor C2 is included in the circuit to prevent any instability due to feedback.



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Figure 4. Connecting the signalling module to a stop section.



Since this circuit can be short-circuited without any ill effects, it can easily be used to replace the original 1.5-k $\Omega$  resistor shown in **Figure 1**. This means that conventionally wired stop sections can be used without any modifications (see **Figure 4**).

On all two-rail model railways, the rail leads of the locomotive decoder can be connected either way around. This means that the locomotive decoder must be able to interpret both +20 V and -20 V on a stop section. The super decoder responds properly to both voltages. We have not checked whether all reversible-polarity Märklin decoders also respond correctly to a +20 V stop section. However, we expect that they would, so they could also be used on two-rail systems that are fitted with EEDTS Pro signalling modules.

The deceleration (braking) behaviour of the decoder must naturally be taken into account in determining the length of the stop section. Space is often a problem with model railways, but you still must reserve at least half a metre for each stop section.

The layout of the printed circuit board is shown in **Figure 5**. This board is so simple that it is not available ready-made from Readers Services. A handy hobbyist can easily etch such a board himself, or a piece of prototyping board can be used to construct the circuit.

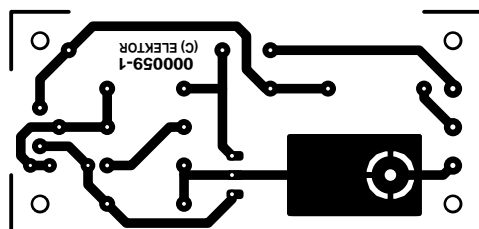
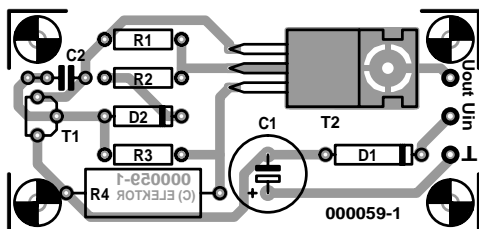


Figure 5. Printed circuit board layout for the signalling module.

## COMPONENTS LIST

### Resistors:

- R1 = 1k $\Omega$
- R2 = 12k $\Omega$
- R3 = 1k $\Omega$
- R4 = 1 $\Omega$ /1W

### Capacitors:

- C1 = 220 $\mu$ F 35V radial
- C2 = 4nF7

### Semiconductors:

- D1 = 1N4001
- D2 = 4V7zener diode
- T1 = BC547
- T2 = TIP112

(000059-1)



# Surge Protection

## Using zener diodes and varistors

Based on a suggestion by Peter Lay Engineering Consultants

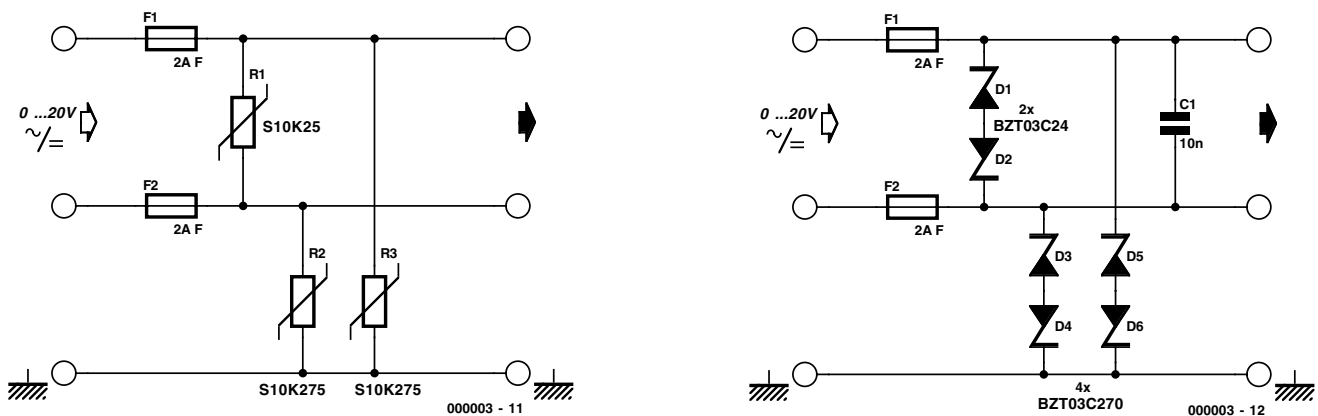


Figure 1. Protective measures on the low-voltage side using varistors and suppressor diodes.

There is no such thing as complete protection against overvoltage damage due to a lightning strike. However, the risk of a valuable piece of equipment being burned out during a thunderstorm can be strongly reduced with the aid of a relatively simple and inexpensive bit of circuitry.

Excessive voltages due to a lightning strike can force their way into a piece of electronic equipment in a variety of ways. They can travel via the telephone cable, an antenna cable or the mains wiring, or simply through the earth. The mains network is especially at risk in the latter case, since its neutral and protective earth leads are after all connected directly to the earth. Fuses and circuit breakers offer precious little help here, since their response time is several orders of magnitude longer than that of semiconductor devices.

There is of course a variety of components that can be used to protect circuitry against excessive voltages, ranging from gas-discharge tubes to special transient suppressor diodes (Transils). However, certain readily-obtainable and inexpensive 'ordinary' components can also be used as voltage limiters: zener diodes and varistors. Varistors function exactly like two back-to-back zener diodes. In principle, such components could be built right into the mains power connection. However, equipment safety standards (such as BS and VDE) require the live and neutral leads to

be insulated from the protective earth lead for voltages up to 2 kV. If any components are connected between the live or neutral lead and the earth lead, they must have a breakdown voltage of at least 2 kV! Such values are not possible even with varistors, let alone with zener diodes.

This restriction can be avoided by moving to the secondary side of the transformer, where the voltages are lower. It is possible to implement effective measures against excessive voltages here without violating any safety standards. The Philips BZT03-series zener diodes, as used in the circuit shown in Figure 1, are specially designed for transient suppression and react within 10  $\mu$ s. The well-known disk-shaped varistors of the Philips SIOV-S series are even faster; they react to excessive voltages in less than 25 ns. Although SIOV-S varistors can handle current pulses of up to 10 kA, they can do so for a only few microseconds. They are not able to handle the power dissipation of a long-duration overvoltage condition. Suppressor diodes have similar characteristics; their maximum current ratings are lower, but their long-term power dissipation

capacities are significantly higher.

Regardless of whether you choose to use zener diodes or varistors, there is one vital component in both types of circuit: a fast-acting fuse, which comes into action shortly after the zener diode or varistor responds. Such a fuse will melt in a few milliseconds if the actual current is several times the rated current.

Note that the protective circuit should not react if the mains potential is present on the protective earth lead. This condition need not necessarily result from a fault; it can also occur if a Class-I device with a mains filter is operated with the protective earth lead not connected. To this end, devices that do not start to conduct until around 270 to 275 V have been selected for varistors R2 and R3 and zener diodes D3 through D6. This represents the mains voltage plus its tolerance variation, along with the spread in the characteristics of the varistors and diodes.

In contrast, the breakdown voltage of the component that protects the power supply leads should be chosen to correspond to the secondary voltage, plus an allowance for tolerance margins.

(000003-1)

# Make Your Own Front Panels

Professional design using simple tools

by V. Schmidt

Making front panel layouts (for use in machining blank panels) and generating foils for front panels do not impose particularly heavy demands on either the PC itself or the drawing program. As a rule, any drawing program that allows multiple layers to be simultaneously displayed and edited is fully adequate.

Some examples of suitable programs are Designer 3.1 and Draw (both from MicrografX), CorelDraw 3 (from Corel) and AutoCAD.

Usually, the drawing program determines the requirements for the hardware. A 33-MHz 386 processor is adequate for somewhat older software, but modern programs will need a Pentium with at least 16 MB of working memory. Graphics software is usually very computation intensive and thus requires a relatively large amount of memory.

The printer should have a resolution of at least 300 x 300 dpi, although is not important whether you use a laser printer or a colour ink-jet printer. The paper transport mechanism should be able to handle the thickness

of the foil stock, and preferably the paper path through the printer should not be too convoluted.

Special printer paper can be used as a base for the foil, and in addition you will need a clear acrylic lacquer spray for sealing the colour inks or toner.

To finish the job, you only need a paper cutter or paper knife (a scalpel is ideal), scissors and a steel ruler. These tools can be used to cut the foil to size and make cutouts. A prick punch can be used to transfer the locations of drilled holes and the corners of cutouts to the front panel.

The mechanical work on the front panel can be done using an electric drill, a milling machine and files. A miniature drill with a milling accessory is very suitable for doing the milling work.

## Preparations

We can use a small project to illustrate the generation of a front-panel foil and machining the front panel. Our panel will be fitted with a six-position rotary switch, a pushbutton switch, a four-position slide switch, two 5-mm LEDs and two 4-mm panel-mounted jacks.

Before starting the design, you should have a clear idea of the number, dimensions and shapes of all drilled holes and cutouts. Use slide callipers to make the necessary measurements. Only then can you start with the design on the PC.

The scale of the drawing program should be set to 1:1. This can be done with most programs via a menu item. The resolution of the drawing grid should not be set larger than 0.25 mm per division. Make the drawing on a blank page,



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Figure 1. Front panel outline.

rather than using a template with pre-defined borders.

### Graphic design

Make the drawings using three to four layers, as follows:

#### The outline drawing (layer 1)

The first layer contains the outline of the front panel (see Figure 1). This establishes the area that is available for placing the controls and indicators, and at the same time it provides the basis for the dimensioning and layout of the front panel foil.

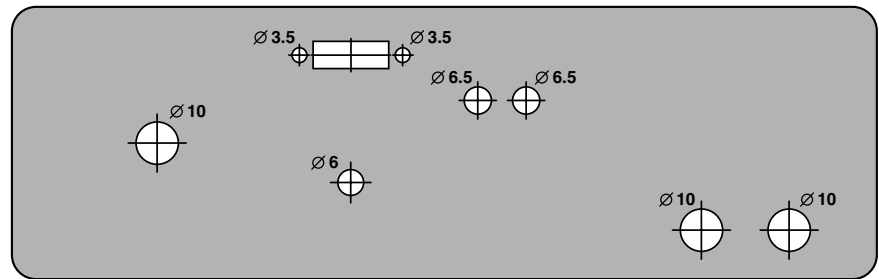
#### The dimensional drawing (layers 2 and 3)

The dimensional drawing contains all the mechanical details needed for machining the front panel. It shows the centres and diameters of all drilled holes and the centres and outlines of all cutouts. In preparing these drawings, take care that the outlines of rotary switches and potentiometers do not extend past the edges of the panel.

The information needed to machine the front panel should be readily evident from the dimensional drawing. In this regard, it is a good idea to provide separate layers for the outlines and the dimensions. Figure 2 shows the drilled holes for the rotary switch and jacks (10 mm diameter), the two LEDs (6.5 mm) and the pushbutton switch (6 mm), as well as the cutout for the slide switch along with its fixing holes. These features can later be transferred to the front panel plate using a prick punch.

#### The front-panel foil graphic design (layer 4)

The third step is the graphic design of the front-panel foil. This contains items such as scales, labels, the model and number of the equipment and so on. Background colour patches, used for example to highlight control elements, are also placed here. You should display the other layers to allow the graphic elements to be correctly positioned. If you also merge in the centre crosses for the drilled holes and cutouts, the subsequent mechanical finishing of the foil will be easier. When doing this, make sure that the layer con-



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Figure 2. Dimensional drawing showing drilled holes and cutouts.

taining the graphic elements is to the front.

In our particular example, a scale with six marked positions is needed for the rotary switch, to indicate the number of batteries. The angle between adjacent positions is 30 degrees. A linear scale with suitable divisions is placed alongside the slide switch, which controls the charging current.

The status display, with its two LEDs, is located in a separate region of the panel. This also contains explanations of the various operating states. The polarity of the output jacks is indicated. Every element of the front foil has a descriptive label, which makes operation easier.

Outlines are placed around each of the most important elements, to emphasize their significance. The model identification of the device also belongs on the front panel.

### Printing

Two different printouts are needed for making a finished front panel: the dimensional drawing, used for the machining of the front panel, and the actual front-panel foil.

The dimensional drawing can be

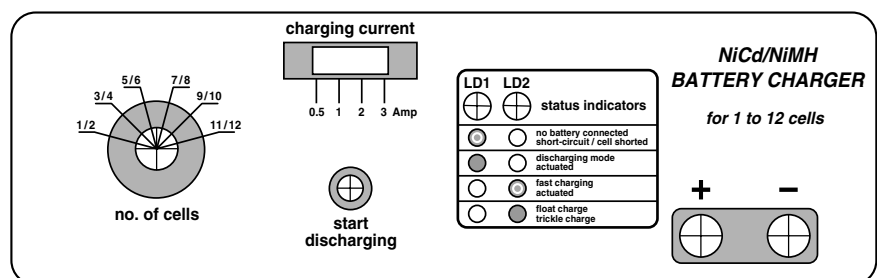
printed on normal paper, while the choice of medium for printing the foil depends on the capabilities of the printer. Normal paper can be used with a laser printer, but special paper must be used with an ink-jet printer to obtain sufficiently sharp edges and optimum colour brilliance.

Layers 1 through 3 are printed out to produce the dimensional drawing, while layers 1, 2 and 4 are printed to produce the foil. The subsequent processing steps are different for the dimensional drawing and the foil. The dimensional drawing can be cut to size and laid aside, while the foil must be inspected to be sure that it is perfectly clean and free of dust. After this, the foil print is sprayed with a lacquer coating. The lacquer must be applied in short bursts, to prevent the ink or toner from dissolving in lacquer and smearing. Apply the lacquer in several coats if necessary. Following this, allow the coated foil to dry thoroughly for at least three hours.

After this, you can cut the foil to size and make all the necessary openings, using scissors and a paper cutter. This completes the preliminary work that is necessary before starting with the machining of the front panel.

### Machining the front panel

First, attach the dimensional drawing (which has been cut to size) to the front panel using



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Figure 3. The finished front-panel foil design.

adhesive tape. Mark the centres of drilled holes and the corners of cutouts using a prick punch. Connect the corner points using a scribe and a steel rule or draughting triangle. After the mechanical work with the drill, milling machine and other tools has been completed, the dimensional drawing can be removed. Check all holes and cutouts using callipers, in order to avoid any unpleasant surprises when the foil is attached to the panel.

This manner of working eliminates the possibility of mistakes in the drafting of the front panel layout, since the dimensional drawing and the foil layout are generated and defined in a single drawing.

If you want to use hidden screws with the front panel, the components that are mounted using these screws must be fixed to the panel before the foil is attached. The foil can subsequently be attached to the machined front panel using a suitable adhesive with a mod-

erately long setting time. Once the foil is properly positioned, secure it with adhesive tape or clamps to prevent it from slipping. When the glue has hardened, you can start with

mounting the controls and indicators. **Figure 4** shows a cross section of the sample front panel, including a potentiometer with a knob.

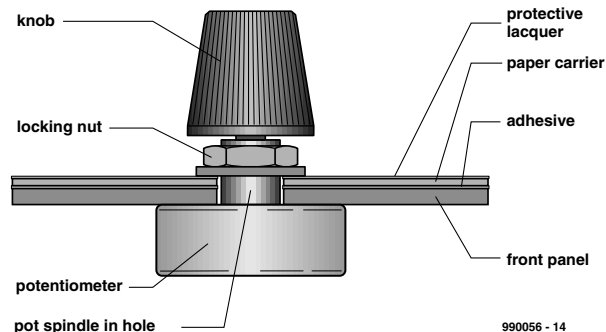


Figure 4. Cross-sectional view of the fully-assembled front panel.

**BASIC-537****February 2000, 000018-1**

In Table 1, the jumpers referred to as J1A-J1C are in fact JP11, JP12 and JP13 on the board.

**537 'Lite' Computer****February 2000, 990054-2**

In Table 1, the jumpers referred to as J1A-J1C are in fact JP11, JP12 and JP13 on the board.

**Low-Impact  
Muscle Stimulator****April 2000, 000041-1**

Although the PCB component overlay shows a footprint for Tr1, the transformer used is connected as an external component. The 100-volt transformers mentioned in the article will not fit on the board and are also too heavy for PCB mounting. It is suggested to mount the transformer at a suitable location in the case, and connect it to the PCB with a few pieces of flexible wire.

The exact type numbers and order codes for the 100-volt

transformers are:

Conrad Electronics #51 61 04  
Monacor/Monarch TR1025LC  
#17.0270; TR1008E #17.0410;  
TR1005 #17.0230.

Although not all of these have a 20-watts winding, any 100-volt transformer with the power rating between 20 and 100 watts should be suitable.

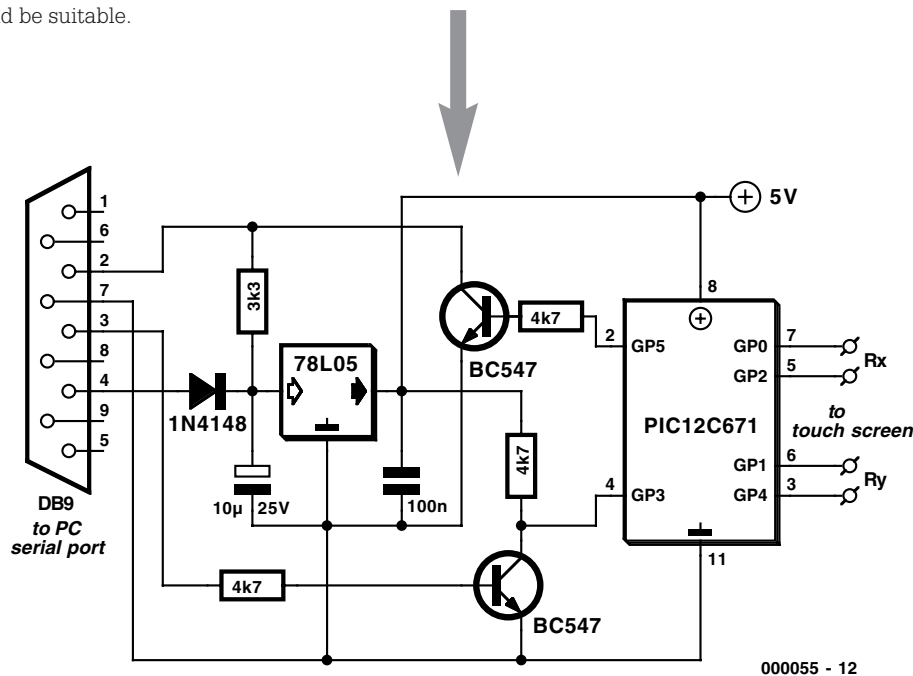
**Working with a Touch Screen****May 2000, 000055-1**

The ground line shown in the circuit diagram is in fact the  $-10\text{ V}$  line from pin 7 of the serial port connector. A corrected diagram is given here. In this diagram we've also added the pin numbers on the PIC12C671.

**MP3 Basics & Chipsets**

In Figure 6, the decoder/ADC should have been identified as a TL7231MD, not a DAC3550.

In Figure 7, the central micro-controller should have identified as an ST7 device, not a PIC17C756.



# Curve Plotting with HP-GL/2

By H. Bednarczyk

send plotter strings to your printer

The printer and plotter language HP-GL/2 is also good for plotting curves computed by a running program. You only need to know how...

not described in the literature: how is it possible to print or plot a curve of which the co-ordinates are calculated in an executing program?

## The Pascal Solution

What follows should provide a simple solution to this problem. The HP-GL/2 instruction

```
PU 100,200 PD 3000,5000
```

will draw a straight line between two points whose printer co-ordinates are (100,200) and (3000,5000). For this to work correctly the instruction must be sent to the printer as a string. In PASCAL the corresponding instruction is:

```
WRITE(1st, 'PU 100,200 PD 3000,5000');
```

This works fine, but what happens if these co-ordinates are not predefined values but are in fact variables that will only be assigned values during program execution?

As a first guess, maybe this would work:

```
x1:=100;y1:=200;x2:=3000;y2:=5000;
```

```
WRITE(1st, 'PU x1,y1 PDx2,y2');
```

Alas, this was unsuccessful. With just a little thought, it became clear that the numerical values in the original HP-GL/2 instruction are an integral part of the strings sent to the printer. Numerical variables as well as constants are however not strings. The original instruction must therefore be parsed into strings and (numerical) variables, and sent bit by bit to the printer:

```
WRITE(1st, a1, a2, a3, ... an);
```

Also, it is important to realise that the comma in the HP-GL/2 instruction must be treated as a string and sent to the printer. The comma in the last WRITE instruction should remain as it is. The corrected instruction now looks like this:

```
WRITE(1st, 'PU', x1, ',', y1, 'PD', x2, ',', y2);
```

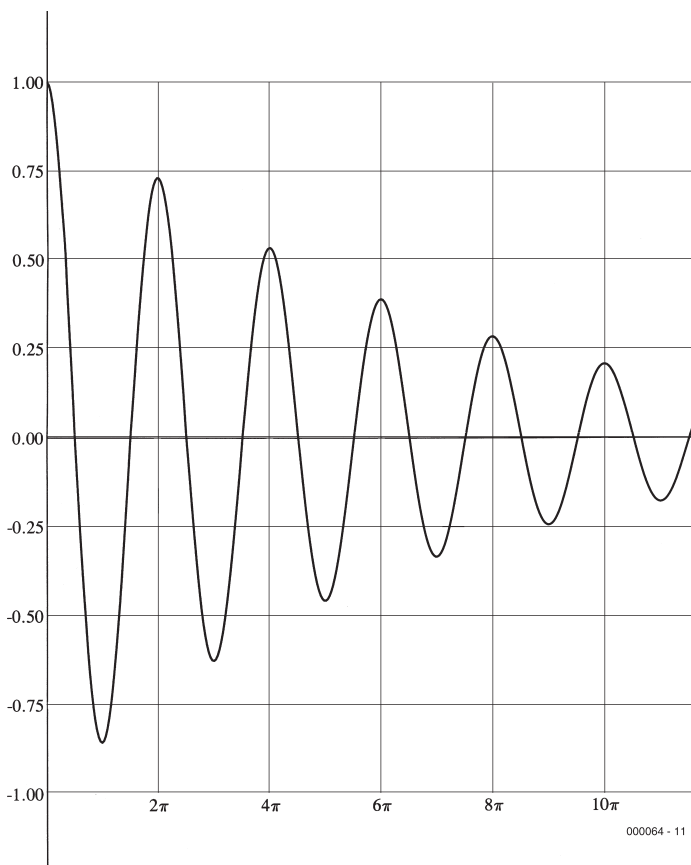
Better legibility is ensured if the comma is represented by its ASCII value #44:

```
WRITE(1st, 'PU', x1, #44, x2, 'PD', x2, #44, y2);
```

Both versions correctly accepted the calculated co-ordinates.

## Source code

This short description of the software is included in the source-text along with some fur-



The language HP-GL/2 (Hewlett-Packard's standardized Graphics Language) is so widespread on today's printers and plotters that it seems a shame not to make more use of its capabilities. There is no need for any additional special software because you will find that HP-GL interfaces perfectly well with existing languages. It is also flexible and has a good instruction set. And, above all else, as you would expect from HP, it is very well documented! There is, however, one feature that is

ther explanations.

The WRITE instruction in the procedures **Hpinitt** and **HPexit** provide a simple method to jump in and out of HP-GL/2. Similarly, **Hfont** allows you to configure the printed character parameters by using P1, (the character set) and P4 (the character size). Also included in this procedure is the initialisation of the (virtual) pen SP1 and the definition of the asterisk (\*) as the end-of-text marker. You will also notice the parsing in strings and user parameters (p1, p4). Details of the remaining parameters can be found in the literature. The designation of the character set table 341 is specific to HP-GL/2, and is dealt with on Code Page 437. It is needed if you specify any Greek symbols. The **Function** listing:

$y(n) = y_0 + \text{amp} \cdot \exp(-a \cdot n) \cdot \cos(c \cdot n)$  will trace out a polygon with a step width of 20 printer units. The printed output line is perceived as a continuous curve.

If you look at the **Co-ordinate Grid** routine we can see how  $2n\pi$  is printed out from  $2 \cdot n$ , followed by #227 (the ASCII-code for  $\pi$ ).

Lastly we see the **Top\_Caption** routine where a text string can be entered as parameters. PW will control the printed line density.

The printout in the picture was generated on an HP LaserJet 4P, 6MB, PostScript Module. The operating system used on the PC was DOS 6.3, the compiler, Borland PASCAL 7.0.

Because PASCAL 7.0 also runs under Windows, printing and plotting experiments may also be successful on that platform.

Using the principles that we have outlined here, it would also be relatively easy to adapt these routines to perform the same printer functions in other high-level languages.

(000064-1)

#### For further reading:

*The HP-GL/2 and HP RTL Reference Guide 3. Edition.*

Hewlett-Packard Company, 1997, Addison Wesley Publ.

Internet:

<http://www.hp.com/designjet/techome.htm>

## Pascal Listing

```
PROGRAM Draw_Curves_using_HPGL2;

USES dos,printer;
CONST xpr=7900; ypr=10800;   {Max. printer co-ordinates}
      x0=600; y0=5400;      {Origin 0,0}
      amp=4000; a=0.005; c=0.1; {Parameter f. amp*exp(-a*n)*cos(c*n)}
      j=20;                  {Step size in printer units}
VAR n,p1,p4,y: INTEGER;     {p1.....character set table}
                               {p4.....font size }
    p: EXTENDED; text: STRING;

PROCEDURE HPinit;
  BEGIN WRITE(lst,#27'E'#27%0B'); END;
PROCEDURE HPexit;
  BEGIN WRITE(lst,#27%0A'#27'E'); END;
PROCEDURE Hfont;
  BEGIN WRITE(lst,'SD 1','p1','2,1,4','p4','5,0,6,0,7,5 SP1 DT*'); END;

BEGIN
HPinit;
p1:=341; p4:=14; Hfont;

{-----Function-----}
WRITE(lst,'PW0.5 PU',x0,#44,y0+amp);
FOR n:=0 TO (xpr-x0) div j DO
  BEGIN
  y:=ROUND(y0+amp*exp(-a*n)*cos(c*n));
  WRITE(lst,'PD',x0+j*n,#44,y);
  END;

{-----}

{-----Co-ordinate_System-----}
WRITE(lst,'PW0.35 PU',x0,#44,y0,'PD',xpr,#44,y0,
        'PU',x0,#44,0,'PD',x0,#44,ypr);

{-----}

{-----Co-ordinate_Grid-----}
FOR n:=-4 TO 4 DO
  WRITE(lst,'PW0.05 PU',x0,#44,y0+n*1000,'LO18LB',0.25*n:1:2,'*',
        'PD',xpr,#44,y0+n*1000);
p:=2*pi*j/c;
FOR n:=1 TO 5 DO
  WRITE(lst,'PU',ROUND(x0+n*p),#44,y0-amp,'LO16LB',2*n,#227,'*',
        'PD',ROUND(x0+n*p),#44,y0+amp);

{-----}

{-----Top_Caption-----}
p4:=18; Hfont;
text:='Damped Oscillation using HP-GL/2';
WRITE(lst,'PU',(xpr-x0) div 2,#44,ypr-200,
        'LO16LB',text,'*');

{-----}

HPexit;
END.
```

## On Project Disk #006005-I:

Hp_elekt.	EXE	Executable Program Curve plotting
Hp_elekt.	PAS	Pascal source text for curve plotting with HP-GL

# Implementing the I<sup>2</sup>C bus

## New instructions for MCS-51 BASIC

Design by H.-J. Böhling

The popular but already somewhat outdated programming language MCS-51 BASIC does not have any instructions for controlling an I<sup>2</sup>C bus. Fortunately, it's easy to add home-made instructions to this version of BASIC.

More than twelve years ago, when Intel's development engineers made their BASIC interpreter (which was actually intended for internal, experimental use) available to the general public in the form of the mask-programmed 8052-AH-BASIC microcontroller, the development of I<sup>2</sup>C communications was still in its infancy. It's thus no surprise that no thought was given to instructions for controlling an I<sup>2</sup>C bus. Of course, it is possible to program an I<sup>2</sup>C interface using the regular instructions, since there is no minimum clock frequency specified for I<sup>2</sup>C communications. If you want to address only a few I<sup>2</sup>C components, you can easily incorporate the routines Send Byte, Get Byte, Start and Stop, as shown in Listing 1, into your own programs. These routines use port P1.6 as the serial data line (SDA) and port P1.5 as the serial clock line (SCL). The circuitry external to the microcontroller is limited to four components, as shown in Figure 1. However, this solution does not have much to offer in terms of speed.

Since its first release, MCS-51 BASIC has been freed from the rigid shell of the original special microcontroller. It is now used quite often in a variety of different versions, including those employed in Elektor projects. It is almost unique among high-level languages in the ease with which it can be extended with supplementary instructions. The author has thus implemented the previously described routines as MCS-51 BASIC instructions, with which a clock rate of around 40 kHz can be achieved. Using these four new instructions (I2COUT, I2CGET, I2CSTART and I2CSTOP) is

```

10 REM *****
20 REM * I2C-Communication with MCS-51-BASIC *
30 REM * over Ports 1.5 (SCL) and 1.6 (SDA) *
40 REM *
50 REM * (C) H.-J. Boehling 07.29.99 *
60 REM * www.germany.net/teilnehmer/101.107378 *
70 REM * www.isis.de/members/~boehling *
80 REM *****
90 REM
100 CLKL=0DFH : CLKH=20H : DATL=0BFH : DATH=40H
110 REM +++ I2C Test +++++
120 REM This test sends out value 0 to 255 to a PCF8574 and read it
back
130 ADDR=040H : REM I2C address
140 FOR BYTEOUT=0 TO 255
150 GOSUB 270
160 IF (ACK.OR.OUT)>0 THEN 220
170 GOSUB 350
180 IF (ACK.OR.OUT)>0 THEN 220
190 PRINT "Read back:",BYTEIN
200 NEXT
210 GOTO 130
220 REM +++ I2C Transmission error +++++
230 GOSUB 810 : REM Stop condition
240 IF ACK>0 THEN PRINT "ACK failed!"
250 IF OUT>0 THEN PRINT "Time out!"
260 GOTO 150
270 REM *** Send Data to I2C *****
280 GOSUB 730 : REM Start condition
290 BOUT=ADDR.AND.0FEH : REM Set write mode
300 GOSUB 420 : REM Send address out
310 BOUT=BYTEOUT
320 GOSUB 420 : REM Send byte out
330 GOSUB 810 : REM Stop condition
340 RETURN
350 REM *** Read Data from I2C *****
360 GOSUB 730 : REM Start condition
370 BOUT=ADDR.OR.1 : REM Set read mode
380 GOSUB 420 : REM Send address out
390 GOSUB 580 : REM read byte in
400 GOSUB 810 : REM Stop condition
410 RETURN
420 REM === I2C Send Byte =====

```



```

430 BIT=80H : WERT=0.5
440 FOR I=1 TO 8
450 SDA=(BOU.T.AN.D.BIT)*WERT : REM Set data to bit of byte
460 BIT=BIT/2 : WERT=WERT+WERT : REM Set pointer to next bit
470 GOSUB 860 : REM Make clock low
480 PT1=PORT1.AN.D.ATL : PORT1=PT1.OR.SDA : REM Send bit out
490 GOSUB 890 : REM Make clock high
500 NEXT
510 REM -- Get ACK -----
520 GOSUB 860 : REM Make clock low
530 GOSUB 950 : REM Make data high
540 GOSUB 890 : REM Make clock high
550 ACK=PORT1.AN.D.ATH : REM If data is high ACK failed
560 GOSUB 860 : REM Make clock low
570 RETURN
580 REM === I2C Get Byte =====
590 BYTEIN=0 : WERT=0.5
600 FOR I=1 TO 8
610 GOSUB 860 : REM Make clock low
620 GOSUB 950 : REM Make data high
630 GOSUB 890 : REM Make clock high
640 SDA=(PORT1.AN.D.ATH)/WERT : REM Read data...
650 BYTEIN=BYTEIN.OR.SDA : REM ...to bit of byte
660 WERT=WERT+WERT : REM Set pointer to next bit
670 NEXT
680 REM -- Do ACK -----
690 GOSUB 860 : REM Make clock low
700 GOSUB 920 : REM Make data low to set ACK oK
710 GOSUB 890 : REM Make clock high
720 RETURN
730 REM === I2C Start condition =====
740 OUT=0 : REM Reset time out counter
750 GOSUB 950 : REM Make data high
760 GOSUB 890 : REM Make clock high
770 IF OUT=3 THEN 800 : REM Wait 3 times for clock and data
high
780 IF (PORT1.AN.D.60H)<>60H THEN OUT=OUT+1 : GOTO 770
790 GOSUB 920 : REM Make data low (start condition)
800 RETURN
810 REM === I2C Stop condition =====
820 GOSUB 920 : REM Make data low
830 GOSUB 890 : REM Make clock high
840 GOSUB 950 : REM Make data high
850 RETURN
860 REM -- Set Port 1.5 (SCL) to Low -----
870 PT1=PORT1.AN.D.CLKL : PORT1=PT1
880 RETURN
890 REM -- Set Port 1.5 (SCL) to High -----
900 PT1=PORT1.OR.CLKH : PORT1=PT1
910 RETURN
920 REM -- Set Port 1.6 (SDA) to Low -----
930 PT1=PORT1.AN.D.ATL : PORT1=PT1
940 RETURN
950 REM -- Set Port 1.6 (SDA) to High -----
960 PT1=PORT1.OR.ATH : PORT1=PT1
970 RETURN

```

Listing 1. I<sup>2</sup>C with MCS-51-BASIC.

Listing 2. Application example using the four new commands.

```

10 REM *****
20 REM * I2C Communication Test *
30 REM * (C) H.-J. Boehling 08.29.99 *
40 REM *****
50 ADDR=40H
60 FOR I=0 TO 255
70 PRINT I,
80 REM ===== I2C Write =====
90 I2CSTART
100 IF DBY(18H)=0 I2CPUT (ADDR) ELSE 260
110 IF DBY(18H)=0 I2CPUT (I) ELSE 260
120 I2CSTOP
130 REM ===== I2C Read =====
140 I2CSTART
150 IF DBY(18H)=0 I2CPUT (ADDR.OR.1) ELSE 260
160 IF DBY(18H)=0 I2CGET B ELSE 260
170 PRINT B
180 I2CSTOP
190 NEXT
200 REM ===== Wait for key =====
210 K=GET : IF K>0 THEN 210
220 PRINT "Continue?"
230 K=GET : IF K=0 THEN 230
240 GOTO 60
250 REM ===== I2C Error =====
260 STATUS=DBY(18H)
270 FOR J=1 TO 3 : I2CSTOP : NEXT
280 IF STATUS.AN.D.2=2 THEN PRINT "Time out error!"
290 IF STATUS.AN.D.4=4 THEN PRINT "Busy error!"
300 IF STATUS.AN.D.8=8 THEN PRINT "No acknowledge error!"
310 GOTO 90

```

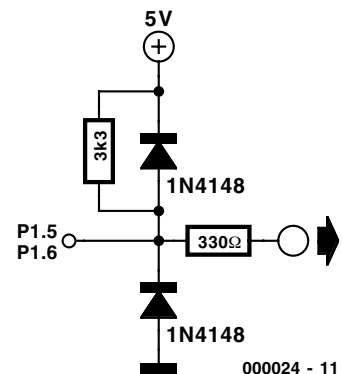
child's play, as can be seen from the program 'I2C Communication Test' shown in Listing 2. This program demonstrates communication with a PCF8574 at address 40H. It writes the values 0 through 255 to the I/O IC and reads them back via the I<sup>2</sup>C bus.

The source listing of the supplementary instructions is available on diskette from Readers Services (order number 006006-1) or from the download area of the Elektor Internet site ([www.elektor-electronics.co.uk](http://www.elektor-electronics.co.uk)). It must be assembled into a hex file using a suitable cross-assembler. This can then be burned into a 16 kB EPROM, along with the original BASIC interpreter. A recommended cross-assembler is the freeware program ASEM-51 from W. W. Heinz. The EPROM can also be burned 'on board', if the hardware of your MCS-51-BASIC system allows this. For this, all you need is the program EPROMMER.LIS. Both of these programs are available free of charge from the 80C32-BASIC control computer Internet site [www.isis.de/members/~boehling](http://www.isis.de/members/~boehling). If you have absolutely no interest in burning your own EPROM, you can obtain a ready-programmed version of the extended BASIC interpreter (in a 27C128 or 27C256) from our Readers Services under order number 006505-1.

(000024-1)

Text (German original): R. Gerstendorf

Literature: I<sup>2</sup>C Bus, Elektor Electronics (Publishing), ISBN 0 905705 47 5



000024 - 11

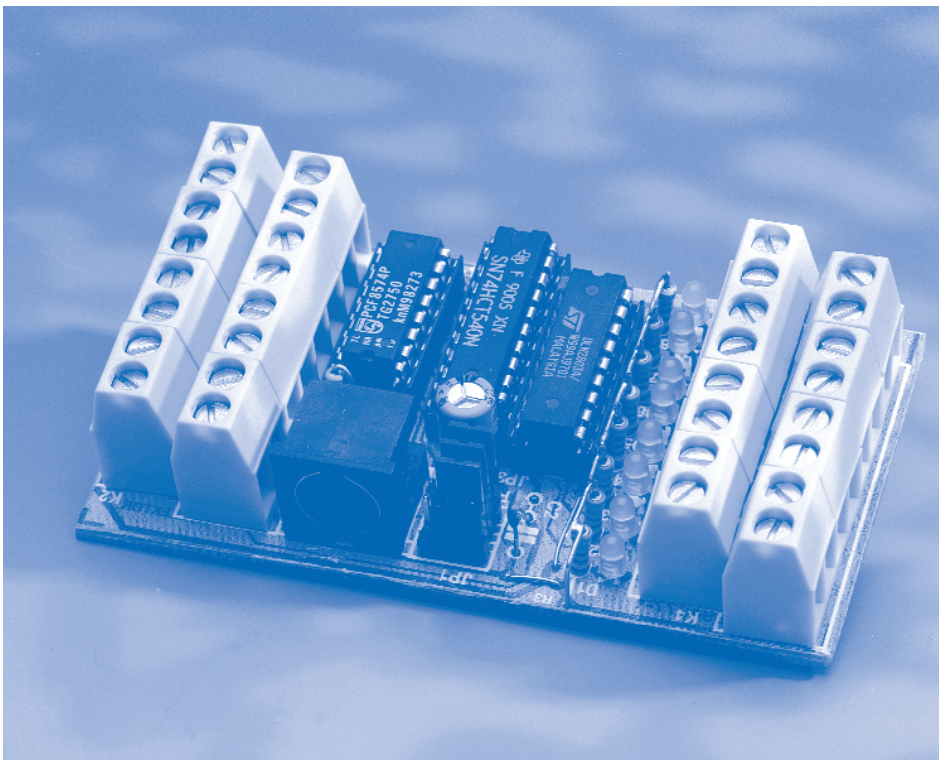
Figure 1. The external components needed for an I<sup>2</sup>C interface.

# 8-bit I/O port

control via the I<sup>2</sup>C™ interface

Design by H Böhling

I/O interfaces are published regularly in this magazine. Yet, each and every of them has its own special properties which makes it almost unique. The 8-bit port described in this article provides eight buffered outputs, eight inputs at TTL level, and communicates with the PC via the popular I<sup>2</sup>C interface. In spite of all these facilities, the circuit has been kept surprisingly compact.



Using an I<sup>2</sup>C interface has a number of important advantages: all communications take place via a 2-wire arrangement; the interface is reliable, fairly fast, and well documented; and many I/O components are obtainable at reasonable prices. The only drawback is that the control computer or microcontroller needs an I<sup>2</sup>C interface. Over the past few years, several I<sup>2</sup>C interfaces have been published in this magazine: the latest one in this

year's March issue. That interface was intended for connection to the printer port. It is supported by DDLs that may be used in a Windows environment. Great attention has also been paid to its use in microcontroller systems. Up to 16 interfaces may be connected in parallel, which affords the user access to as many as 128 bidirectional I/O lines.

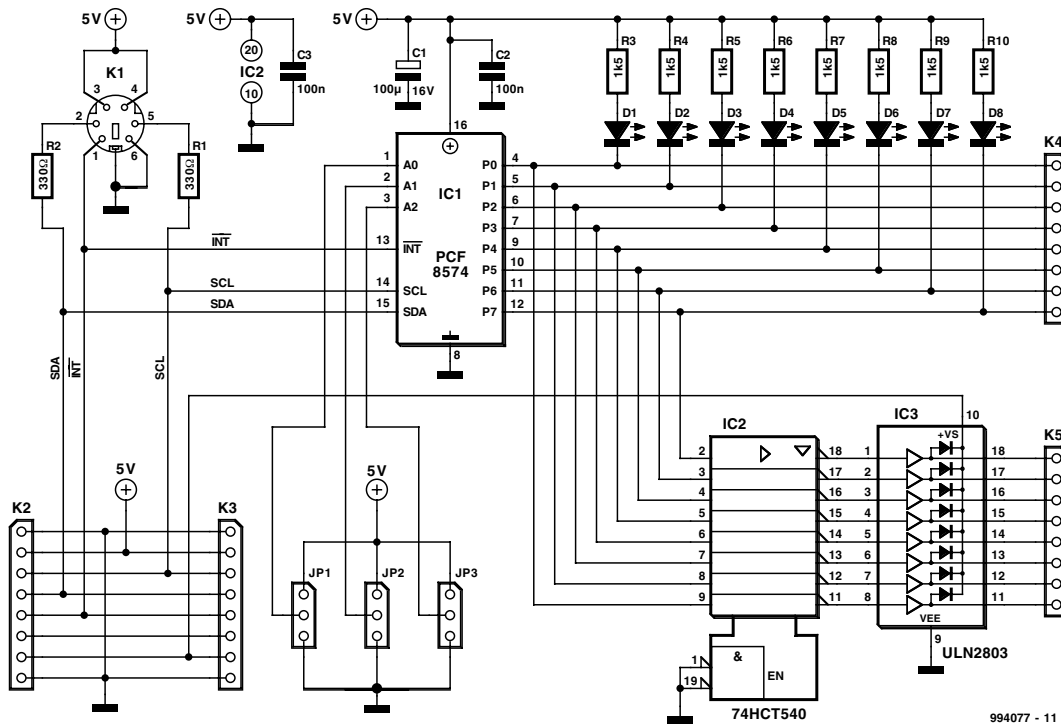
## Circuit description

The circuit of the I/O interface shown in **Figure 1** is based on a Philips Type PCF8574(A) circuit that has proved very popular in several projects published in this magazine. More details of this IC are given in the box later on in the article.

The PCF8574 is linked to the outside world via a miniature DIN socket and via a connecting strip. The DIN connector carries the SCL and SDA control signals, the (optional) INT (interrupt) line, the supply voltage, and the earth line.

If several interfaces are used in parallel, the connecting strip becomes significant. Connectors K<sub>2</sub> and K<sub>3</sub> are so arranged that the interfaces may be interlinked simply by short lengths of circuit wire. Apart from the I<sup>2</sup>C signals, the connecting strip also carries the supply line and the earth line. It also contains the common cathode connection for the freewheeling diodes in IC<sub>3</sub> (more about this later).

The base address of the PCF8574(A) may be adapted with jumpers Jp<sub>1</sub>–Jp<sub>3</sub>. If the PCF8574 is used, the base address is \$0100xxx (40 Hex), but if the PCF8574(a) is used, the base address is \$0111xxx (70 Hex). The base address is followed by the three bits set with the jumpers. Two base addresses and eight bit combinations give a total of 16 different addresses. This is why up to 16 modules



994077 - 11

Figure 1. Circuit diagram of the I/O port which is intended to be controlled via an I2C interface.

may be connected to a single I<sup>2</sup>C bus. The three variable bits are followed by a final bit, which determines the data direction (reading or writing).

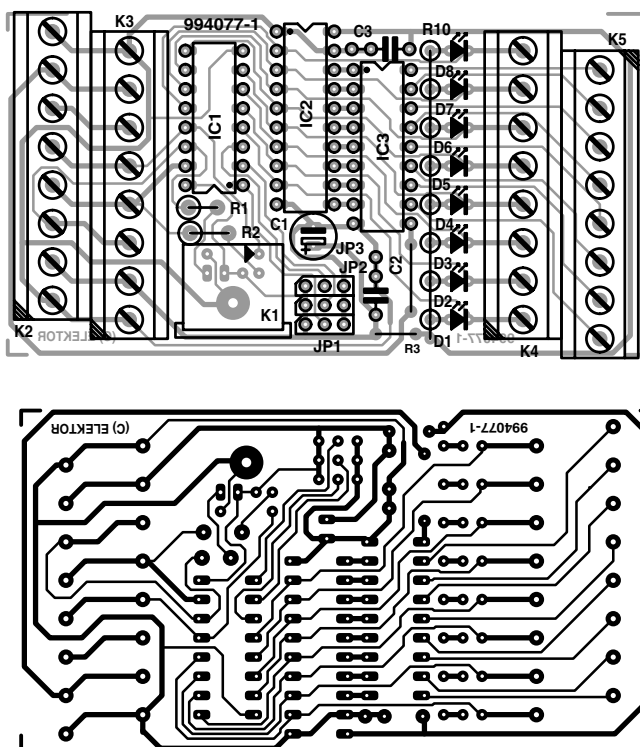
The PCF8574(A) has eight bidirec-

tional outputs: P<sub>0</sub>–P<sub>7</sub>. Each I/O line is provided with a pull-up resistor in series with an LED. When an I/O pin is arranged as an output, the associated LED shows the inverted output level.

When the output is low, the associated LED is on, and when it is high, the LED is off.

When an input is not used, it can remain open thanks to the pull-up resistor.

An I/O pin is used as an output with the aid of



### Parts list

#### Resistors:

R<sub>1</sub>, R<sub>2</sub> = 330 Ω  
R<sub>3</sub>–R<sub>10</sub> = 1.5 kΩ

#### Capacitors:

C<sub>1</sub> = 100 μF, 16 V, radial  
C<sub>2</sub>, C<sub>3</sub> = 0.1 μF

#### Semiconductors:

D<sub>1</sub>–D<sub>8</sub> = LED, high efficiency

#### Integrated circuits:

IC<sub>1</sub> = PCF8574AP or PCF8574P  
IC<sub>2</sub> = 74HCT540  
IC<sub>3</sub> = ULN2803

#### Miscellaneous:

Jp<sub>1</sub>–Jp<sub>3</sub> = 3-way PCB mount SIL socket with jump lead  
K<sub>1</sub> = 6-way miniature DIN connector for PCB mounting  
K<sub>2</sub>–K<sub>5</sub> = 8-way PCB terminal strip, pitch 5 mm  
Printed-circuit board Order No. 994077 (see Readers Services towards the end of this issue)

Figure 2. Printed-circuit board for the I/O port.

# The PCF8574

The PCF8574 is a CMOS device that may be used to provide microcontrollers with additional I/O functions via an I<sup>2</sup>C bus. Its circuit diagram is shown in Figure 3. The device contains a quasi-bidirectional port and an I<sup>2</sup>C interface. A quasi-bidirectional port is one that may be used as input or output. Use as input requires that the port is made logic high via the software.

When the port is high, it may be used to register logic levels at the port connection. When the output is later read via a read command, it can be seen what logic level was put on the input.

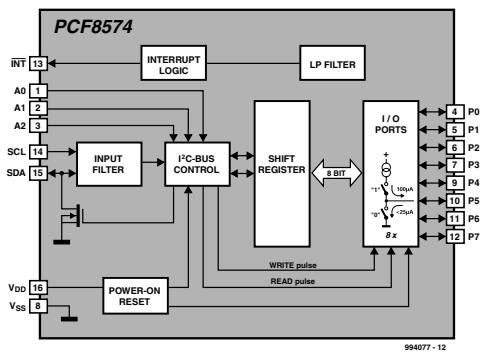
A port used as input may be reverted to use as an output by making it logic low, which requires an external current of at least 100  $\mu$ A to flow from it to earth.

The power at the output ports is sufficient for driving LEDs direct—see Figure 3. The current drawn from a port cannot exceed 100  $\mu$ A. The port can switch currents to earth of up to 25 mA.

There is a facility for generating an interrupt. When a port is arranged as an input, each change, negative or positive, will cause an interrupt. The interrupt is cancelled when its cause disappears, that is, when the port regains its original value, or after a read or write process has taken place from the port via the I<sup>2</sup>C interface.

After a hardware reset, the outputs of all ports are made high, which makes it possible for them to be used as input or as output.

Figures 4a and 4b show the signals that must be applied to the I<sup>2</sup>C bus to send data to, and receive data from, the microcontroller.



IC<sub>2</sub> and IC<sub>3</sub>. The former is a bus-driver that contains eight inverting buffers operating at TTL level. The buffers are used to control power driver IC<sub>3</sub>. This circuit contains eight transistor-drivers with open-collector output. All outputs are provided with a freewheeling diode, the cathodes of which are all linked to pin 10.

Type ULN drivers like IC<sub>3</sub> are eminently suitable for switching small resistive and inductive loads (up to 50 V, 500 mA). This means that small lamps and relays can be driven directly. Bear in mind that the earth line of the supply used for the loads must be linked to the earth terminal (pins 1 and 8) of K<sub>2</sub> or K<sub>3</sub>. Pin 1 is identified on the circuit diagram

as well as on the board by a small triangle. When inductive loads are switched, the use of freewheeling diodes is essential. The cathodes of these diodes in IC<sub>3</sub> must be linked to the supply lines used. This means that the supply voltage must also be connected to pin 7 of K<sub>2</sub> and K<sub>3</sub>.

## Construction

The interface is readily built on the single-sided printed-circuit board shown in Figure 2. The electronic circuits are contained in the middle of the board, while, as stated earlier, the connections to the outside world are made via a 6-way DIN socket and 6-way PCB type terminal strips with screw or clamp terminals. Both types of terminal ensure a good, reliable electrical connection.

Since the terminals strips are positioned next to another, they must be mounted back-to-back.

When all elements have been mounted and their connections are soldered securely, check the finished board carefully. When all is found all right, choose the requisite address (es) with the aid of the jumpers, and connect them to a suitable interface.

The completed board fits nicely in a standard case that can be clipped on to a DIN rail.

There is, of course, software needed before the interface can be used. Normally, the interface is supported by a driver that can send the requisite data to, or retrieve from, the relevant address. This function is in most circumstances sufficient to obtain the desired results with the card.

Figure 3. Internal circuit diagram of the PCF8574(A). The circuit was developed specially to make the control of I/O ports via an I<sup>2</sup>C interface possible.

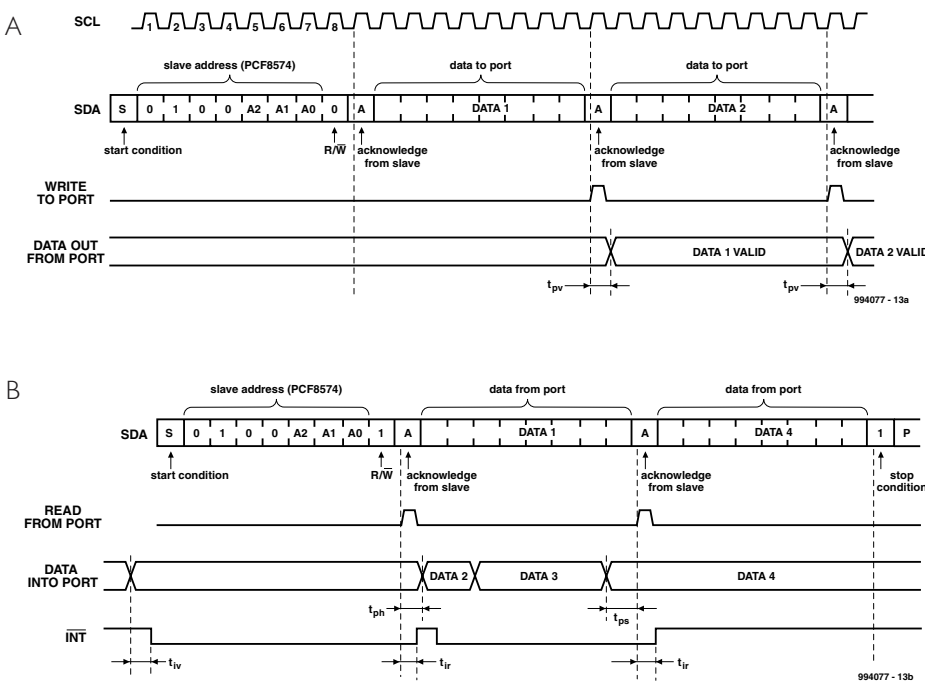


Figure 4. Timing diagram of a read and a write instruction executed by a PCF8574(A).

The content of this note is based on information received from manufacturers in the electrical and electronics industries or their representatives and does not imply practical experience by Elektor Electronics or its consultants.

# MCP120/130

## Microcontroller Supervisor

Most of today's microcontroller based applications need some protection against low power conditions that can cause many different system problems.

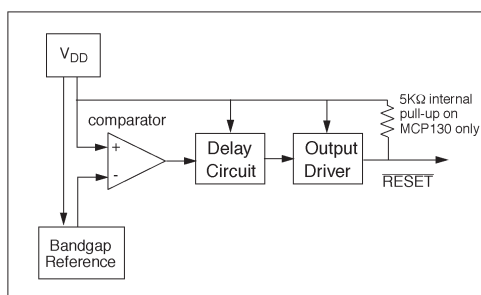


Figure 1. Block diagram of the MCP1x0.

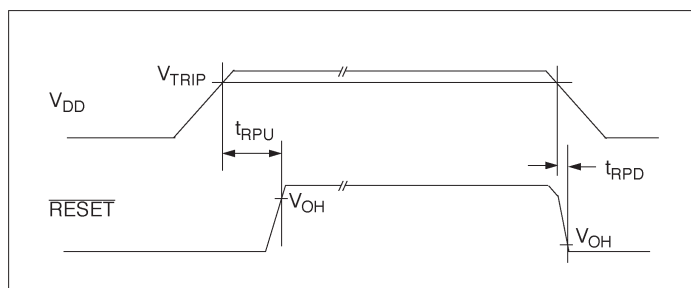


Figure 2. Timing diagram — reset at power up and power down.

Low voltage conditions on microcontroller systems can give problems in many situations. If for example the supply voltage to a system has a long time constant, the controller will at some point be storing and read-

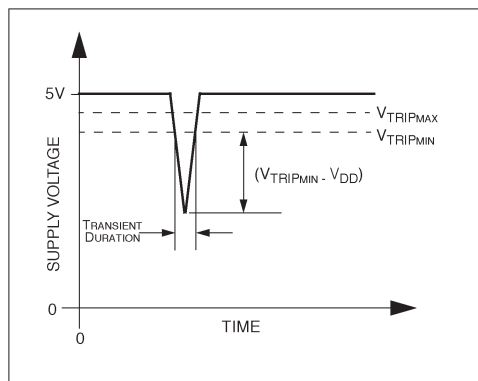


Figure 3. Typical transient response — short duration transients will not cause a reset.

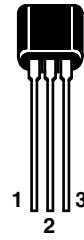
ing data from SRAM when there is insufficient supply voltage to sustain the SRAM data. This will produce indeterminate results and probable system failure. System brown-outs occur during operation and these supply voltage dips or glitches can be troublesome if, for instance they occur while the controller is writing to EEPROM. These failures are by their nature unpredictable and lead to an unreliable controller system.

Microcontroller voltage supervisory circuits have been developed to combat these problems. The MCP120/130 from Microchip Technology is just such a device. At system power-up it ensures that the microcontroller is held in its reset condition until the system voltage has reached its proper level and stabilised. If the supply voltage dips below the trip voltage during normal

operation, the  $\overline{\text{RESET}}$  output will go active Low to ensure a clean reset of the controller. The block diagram for this device is shown in **Figure 1**. The device is available with a choice of seven different trip voltages and many different package outlines. The  $\overline{\text{RESET}}$  output of this device is open drain and the MCP130 has a built in pull-up resistor of 5 kΩ. The MCP120 has no pull-up resistor but is otherwise identical, it should be used for controllers that already have an internal pull-up resistor on their reset input.

**Figure 2** shows the timing diagram of the MCP120/130  $\overline{\text{RESET}}$  signal at supply switch-on and power down. As the supply voltage rises above the trip voltage ( $V_{\text{TRIP}}$ ) the chip allows a time period  $t_{\text{RPU}}$  (typically 350 ms) before it will release the  $\overline{\text{RESET}}$  line. At power down,

Component identification: MCPI20/I30(T) - xxx b ml /pp				
<b>Part MCPI20/I30(T)</b>	MCPI20:	Open drain		
	MCPI20T:	Open drain, band and roll packaging		
	MCPI30:	Open drain & pullup		
	MCPI30T:	Open drain & pullup, band and roll packaging		
<b>Thresholds xxx</b>	270	$2.55 \leq V_{TRIP} \leq 2.70$		
	300	$2.85 \leq V_{TRIP} \leq 3.00$		
	315	$3.00 \leq V_{TRIP} \leq 3.15$		
	450	$4.25 \leq V_{TRIP} \leq 4.50$		
	460	$4.35 \leq V_{TRIP} \leq 4.60$		
	475	$4.50 \leq V_{TRIP} \leq 4.75$		
	485	$4.60 \leq V_{TRIP} \leq 4.85$		
<b>Pinout</b> (TO-92 only, front view, from top)	D	1: RST	2: V <sub>DD</sub>	3: V <sub>SS</sub>
	F	1: V <sub>SS</sub>	2: RST	3: V <sub>DD</sub>
	G	1: V <sub>DD</sub>	2: V <sub>SS</sub>	3: RST
	H	1: V <sub>DD</sub>	2: RST	3: V <sub>SS</sub>
<b>Temperature range I</b>	I -40 to +85 °C			
<b>Case/pp</b>	TO	TO-92, 3-pin	See pinout	
	TT	SOT-23, 3-pin	1: RST	1: V <sub>DD</sub> 1: V <sub>SS</sub>
	SN	SOIC, 8-pin	1: RST	2: V <sub>DD</sub> 4: V <sub>SS</sub>
			(all other pins not connected)	



when the supply voltage drops below  $V_{TRIP}$  a reset will be generated within typically 10  $\mu$ s.

An important consideration of Power On Reset circuits generally is the minimum pulse width of the transient required to cause a reset. **Figure 3** shows a typical voltage transient below the trip point vs. transient duration. You can see that the deeper the transient falls below the trip point the shorter it needs to be to generate a reset.

A 100 nF bypass capacitor mounted close to the V<sub>DD</sub> pin will assist in providing additional transient immunity.

(005057-1)

Typical data (V <sub>DD</sub> = 1.0 to 5.5 V), T = -40 to +85 °C, typical values for 5.0 V, 25 °C)						
Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Supply voltage	V <sub>DD</sub>		1.0		5.5	V
Supply current	I <sub>DD</sub>	V <sub>DD</sub> = 5.5 V, no load		45	60	$\mu$ A
Trip voltage	V <sub>TRIP</sub>	MCPIx0-270	2.55	2.625	2.70	V
		MCPIx0-300	2.85	2.925	3.00	
		MCPIx0-315	3.00	3.075	3.15	
		MCPIx0-450	4.25	4.375	4.50	
		MCPIx0-460	4.35	4.475	4.60	
		MCPIx0-475	4.50	4.625	4.75	
		MCPIx0-485	4.60	4.725	4.85	
RESET Low voltage	V <sub>OL</sub>	MCPIx0-...315, I <sub>OL</sub> = 3.2 mA, V <sub>DD</sub> = V <sub>TRIP,MIN</sub>			0.4	V
		MCPIx0-450..., I <sub>OL</sub> = 8.5 mA, V <sub>DD</sub> = V <sub>TRIP,MIN</sub>			0.6	V
RESET High voltage	V <sub>OH</sub>	MCPI30-xxx	V <sub>DD</sub> - 0.7		V	
Pull-up resistance		MCPI30-xxx		5		k $\Omega$
Output leakage current		MCPI20-xxx		1		$\mu$ A
Trip voltage hysteresis	V <sub>HYS</sub>			50		mV
V <sub>DD</sub> detection to $\overline{\text{RESET}}$ inactive	t <sub>RPU</sub>		150	350	700	ms
V <sub>DD</sub> detection to $\overline{\text{RESET}}$	t <sub>RPD</sub>	V <sub>DD</sub> from V <sub>TRIP,MAX</sub> + 250 mV to V <sub>TRIP,MIN</sub> - 250 mV		10		$\mu$ s
Absolute maximum values						
V <sub>DD</sub>	7.0 V					
All inputs and outputs	-0.6 V ... V <sub>DD</sub> + 1.0 V					
Operating temperature	-65... +125 °C					
ESD protection on all inputs	$\geq 2$ kV					

# Audio Attenuator

reduce signal levels — to spec

By Neville Frewin (design idea) and Sjef van Rooij (text)

It happens very often that there is a marked change in the sound level when you change the audio source. However, you can quickly put an end to this with a simple attenuator network.



Fortunately, with modern audio equipment this problem is not as bad as it used to be. Quite a few years ago, the differences between the usual output levels and input sensitivities were, to put it mildly, striking. Browsing through some old amplifier specification sheets from the 1970's, we see 'standard' input sensitivities for the tuner and tape inputs of 155 mV, 180 mV, 200 mV, 220 mV, 250 mV and 300 mV. Nowadays, the situation is not as bad, but there are still differences.

## Overdriving

Actually, there are two separate problems. In addition to the variation in the standard input and output levels (which fortunately is much

less than it used to be), there is also a risk of overdriving the amplifier. This is unfortunately still a serious problem.

If we have a quick look at the specifications of modern audio equipment, we see that the input sensitivity of the line inputs (tuner, tape and CD) is 200 mV for most amplifiers. Remarkably enough, receivers deviate from this value; most of them adhere to a standard sensitivity of 150 mV. It's not clear why there is this difference, but it is relatively small and essentially not all that important.

Much more important is the fact that the 'old-fashioned' level of 200 mV is a total mismatch with the standard output levels of modern CD, DVD and MD players. Without exception, these devices provide a maximum voltage of 2 V at the output. This is a factor of ten higher than the sensitivity of the input to which the signal is connected!

Of course, it is true that the average level of a CD recording is 12 dB below the maximum, which means that the average output level is only 500 mV. Although this is still a factor of  $2^{1/2}$  too high, it appears to be a bit less disastrous. However, this is an illusion, since even if the CD is properly recorded at the prescribed level, the signal peaks will still reach 2 volts. If the amplifier in question is already fully driven at 200 mV, such peaks will cause strong clipping, which has many undesirable consequences.

## Resistive divider

Fortunately, a signal source that delivers too much voltage, either in absolute terms or in comparison to other signal sources, can easily be brought back into line. A simple voltage divider, as shown in **Figure 1**, is all that you need. The degree of attenuation is determined by the ratio of resistors R1 and R2. In the example shown in **Figure 1**, the attenuation is 0.5, or a factor of 2. The attenuation can also be expressed in dBs; in this case it is -6 dB. The formula for calculating the attenuation in dBs is:

$$\text{attenuation} = 20 \log[R2/(R1+R2)].$$

For purposes of illustration, and in order to save practically oriented readers the trouble of making the calculations, we have prepared a number of examples that are shown in **Table 1**. These are based on standard E12-series resistance values. You will probably not need the 2.5 dB and 3.3 dB versions very often, but in light of the previously mentioned level differences, you will likely reach for the -6 dB and -12 dB attenuators fairly often.

## Matching

In addition to the ratio of R1 to R2, we also have to be concerned with the absolute values of these resistors. What are the guidelines? On the input side of the attenuator,

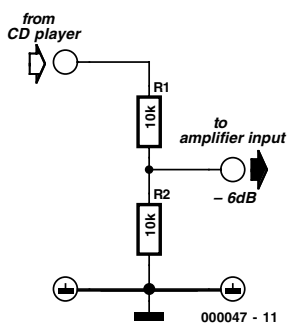


Figure 1. A simple resistive divider can be used to attenuate a signal to any desired degree.

we need to consider the output impedance of the signal source, while on the output side we have to consider the input impedance of the amplifier.

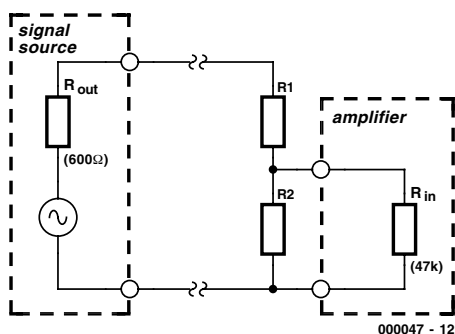


Figure 2. The source impedance must be taken into account when choosing the values of R1 and R2.

In high-frequency technology, the objective in this case is always to maximise the power transfer. This means that it is a good idea to ensure that the input impedance of the attenuator matches the output impedance of the signal source. In audio technology, completely different rules apply. Here the objective

is to load the signal source as little as possible, since overloading can cause frequency-dependent attenuation. This degrades the linearity of the signal source, which is naturally not allowed in a hi-fi installation. In addition, too much attenuation will increase the noise level.

With regard to all this, is there a rule that we should or must obey? The answer is yes, and the rule is that the load impedance should be at least ten times as high as the output impedance of the signal source. This situation is illustrated in **Figure 2**. The output impedance of most signal sources is usually between one hundred and several hundred ohms. If we keep the sum of R1 and R2 between 10 kΩ and 20 kΩ, we will thus always be on the safe side, and we need not be worried about overloading the signal source. This has

been taken into account in calculating the values listed in **Table 1**.

The input impedance of the amplifier is almost always 47 kΩ. This resistance stands in parallel with the resistance of R2, and that naturally affects the divider ratio of the network. In practice, however, the resulting deviations are not all that

serious. For example, if you make the precise calculations, you will find that the 9.9 dB attenuator actually yields an attenuation of 10.8 dB with a source impedance of 600 Ω and a load impedance of 47 kΩ. This is a truly negligible difference.

## Construction

In terms of construction, there are naturally various ways to achieve the same objective. The accompanying photographs show that you can very easily make an in-line attenuator using a Cinch plug and a Cinch cable socket. If you use 1/8-watt resistors, they will easily fit in the space between the plug and the socket. If you wish, you can then slide a piece of metal or plastic tubing over the assembly and finish it off with heat-shrink tubing. Mark the attenuation value on a sticker applied to the module, and you're done.

Note that the connection between such an 'attenuator plug' and the amplifier input should be either direct, or via a cable that is as short as possible. You may use a longer cable for the (low impedance) connection between the signal source and the attenuator.

If you frequently experiment with the various parts of your audio installation, you will probably find it handy to have a complete set of the attenuators listed in **Table 1**. For the active audio hobbyist, such a set is just about essential!

(000047-1)



Figure 3. A Cinch plug and cable jack can be used to make a handy in-line connector with a built-in attenuator.

**Table 1**

Attenuation	Attenuation in dB	R1	R2
0.75 ×	2.5	3.3 kΩ	10 kΩ
0.68 ×	3.3	4.7 kΩ	10 kΩ
0.50 ×	6.0	10 kΩ	10 kΩ
0.36 ×	8.9	10 kΩ	5.6 kΩ
0.32 ×	9.9	10 kΩ	4.7 kΩ
0.25 ×	12.1	10 kΩ	3.3 kΩ



# Car Burglar Alarm

employs battery voltage detection

Kit review by S. van Rooij

This time, Velleman have sent us a car burglar alarm construction kit for evaluation. This is a fairly simple but highly functional circuit, which is also offered at a very reasonable price.

We don't know Velleman's sales figures, but we know from our own experience that burglar alarms — and in particular car burglar alarms — are almost without exception guaranteed success numbers. This is due not so much to the quality or originality of whatever circuit may be used, but simply to the intended use of the circuit. Burglary has always been a serious problem, but a steadily rising level of criminal activity has unfortunately made good protection of valuable goods more and more of a bitter necessity.

This necessity applies to cars even more than to other goods. A car represents a significant amount of capital and it can easily be sold, and its owner is frequently forced to park in locations where the car is easy prey for persons with dubious intentions. A reliable alarm system is the only thing that can prevent such persons from carrying out their nefarious activities.

Overall, alarm systems can be divided into two categories. The first category consists of systems that make it impossible to start the engine or drive away without knowing the correct code. These systems are the most reliable, but they are also the most expensive and are especially difficult to install yourself. The second category consists of all types of alarms that generate a warning signal when there is an attempted burglary, with the objective of scaring off the would-be thief. This is somewhat less effective, since in principle you can still just drive away with the horn blowing. However, this is not all that likely, and alarms of this sort have the advantage that they are fairly easy to install yourself. The Velleman kit is an 'alarm signal generator' and thus belongs to the second category.



## Design

This circuit works without any separate sensors. It uses the battery voltage as its input information. Whenever someone enters the car, the interior light or the boot light will always go on, which causes the battery voltage to drop slightly. This voltage variation activates a control circuit, which in turn activates the horn (or an external siren) via a relay. The alarm can be enabled using the ignition switch or a separate remote control unit. Naturally, time delays are provided for entering and leaving the car, so that the rightful owner of the car has enough time to switch the alarm off or on.

Although the design of the alarm circuit has been kept extremely simple, it still has a couple of extra features. For example, a blinking LED indicates that the alarm is armed. If this LED is fitted so that it is visible

outside the car, it helps to discourage any would-be burglars. The circuit also has a built-in buzzer to remind you that the alarm is on when you get into the car, so you won't forget to switch it off.

The entry and exit delay times are both adjustable. The maximum entry delay is 30 seconds, while the maximum exit delay is 3 minutes. The length of time that the alarm signal sounds is limited to the legally specified value of 60 seconds. After this time, however, the alarm automatically rearms itself, so that the horn will start blowing again if the burglar has not stopped his nasty work in the mean time.

## Three timers

The schematic diagram of the car burglar alarm is shown in **Figure 1**. Three components — M1, M2 and IC4 — stand out in this diagram. All three are timers that are wired as

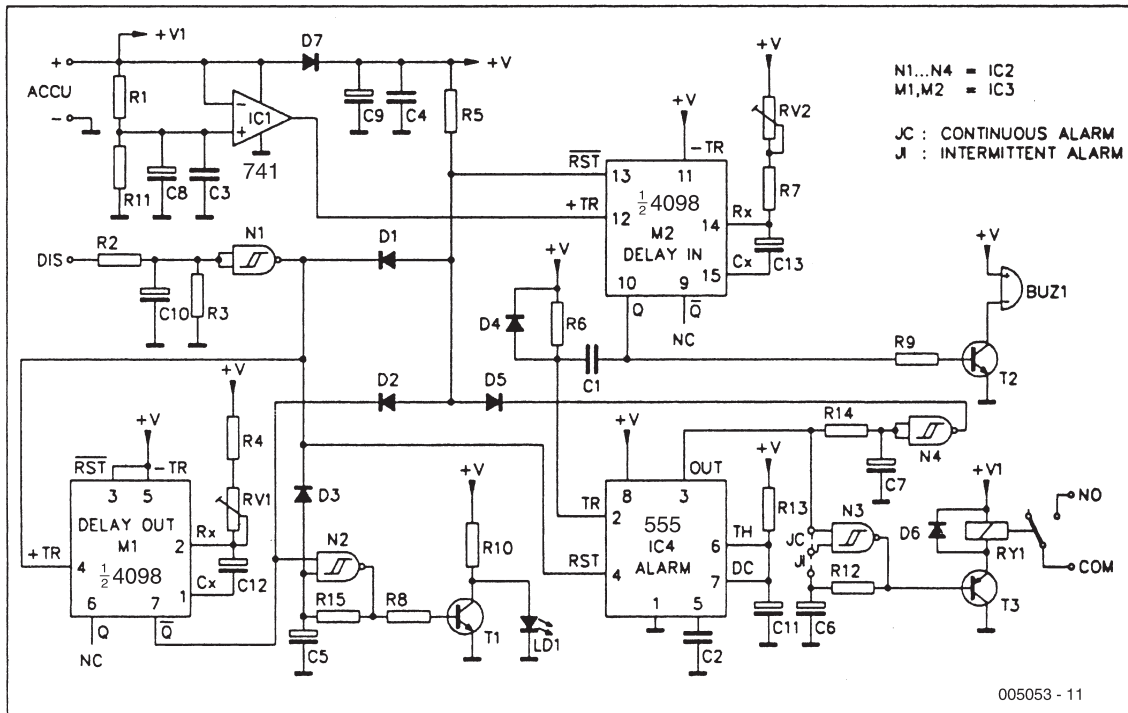


Figure 1. Schematic diagram of the car alarm. It primarily consists of several timers that provide the necessary time delays.

monostable multivibrators. They effectively form the heart of the circuit. Other essential components are opamp IC1, the warning LED LD1, buzzer BUZ1 and finally relay RY1, which activates the horn or siren.

The connections marked 'ACCU' serve as the sensor input. They are connected directly to the car battery. The DIS input is used to enable the alarm. This input is connected to a 'positive' lead after the ignition switch, possibly via a secret switch. If you omit the secret switch, the alarm is armed by the ignition switch itself. The alarm is enabled when DIS is 'low', which means when the ignition switch is off.

Now let's have a brief look at how it all works. As long as the car is being driven, the DIS input will be held 'positive' by the ignition switch. This means that timer M2 is held reset via N1 and D2, so that nothing happens.

As soon as you stop the car and switch off the ignition, DIS goes 'low'. This causes a positive trigger pulse to be sent from the output of N1 to monoflop M1, which is responsible for the exit delay. During this delay time, which can be adjusted using RV1, the /Q output of M1 takes over the job of blocking monoflop M2 (which was previously done via D1).

As soon as the delay time is expired, the reset signal is no longer applied to M2, and the alarm is armed. At the same time, the astable multivibrator built around N2 is enabled, and LED LD1 starts to emit warning blinks.

If one of the car doors is opened while the alarm is armed, the battery voltage drops slightly, due to the fact that the interior light goes on. This change in the battery voltage is detected by a comparator circuit built around IC1. This produces a trigger pulse for M2, which is the monoflop that is responsible for the entry delay. When the entry delay timer starts, buzzer BUZ1 is activated from the Q output of M2 via transistor T2. If the ignition is switched on during the entry delay time, which can be adjusted using RV2, M2 is reset and the buzzer is muted. However, if DIS does not go 'positive' within at most 30 seconds, a negative trigger pulse is generated when the monostable time expires. This pulse is applied to the trigger input of the third monostable, IC4. The relay is activated via T3, and it in turn activates the horn or siren. At the same time, a reset pulse is sent to M2 via N4 to rearm the alarm.

An astable multivibrator can also be switched into the circuit using a

jumper. This provides a choice between a continuous or intermittent alarm signal.

### Construction and fitting

The kit is accompanied by a clear set of instructions, which should avoid any problems in the construction of the circuit. We had a problem with mounting C8 and C9, since the types supplied with the kit were too large and did not fit on the circuit board. A bit of rummaging around in our own components drawer quickly solved this problem.

The instructions also provide clear information regarding connecting the circuit board in the car and installing the necessary wiring, complete with a few schematic diagrams. The possibility of using an infrared code lock instead of the ignition switch to enable and disable the alarm is also discussed.

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*A complete construction kit for the Car Alarm can be obtained from Velleman, Belgium. The kit, part number K3504, is priced at US\$19.95 and available from electronics retail shops. In the UK, a selection of Velleman kits is stocked by Maplin.*

*Velleman contact information:  
Velleman Components, Legen Heirweg 33,  
B-9890 Gavere, Belgium.  
Fax: (+32) 9 384 6702.  
Email: order@velleman.be  
Internet: http://www.velleman.be*

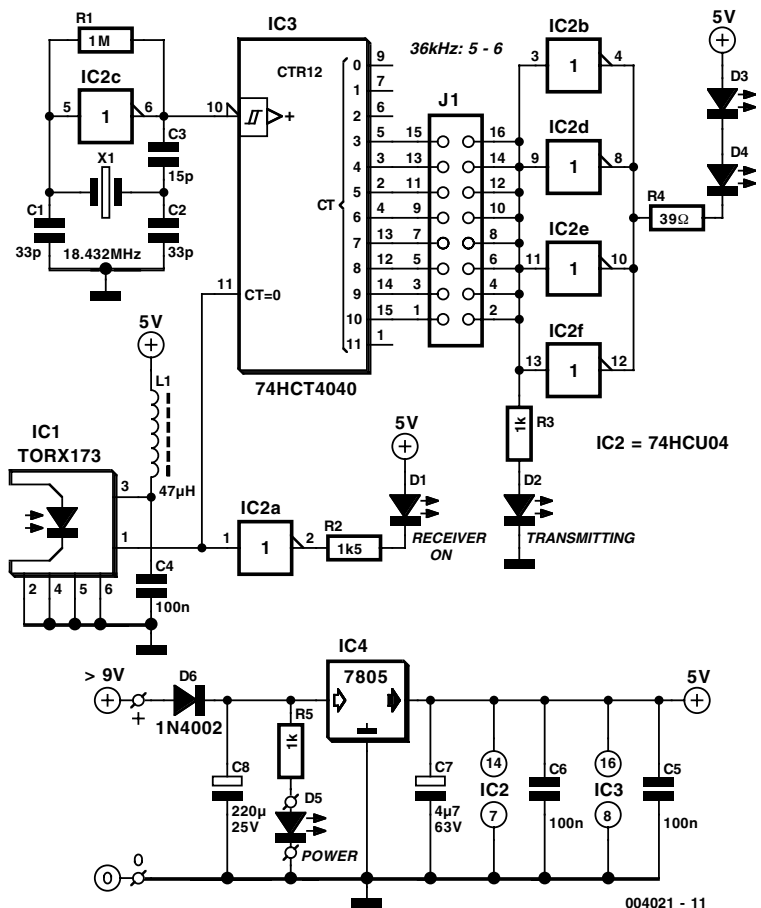
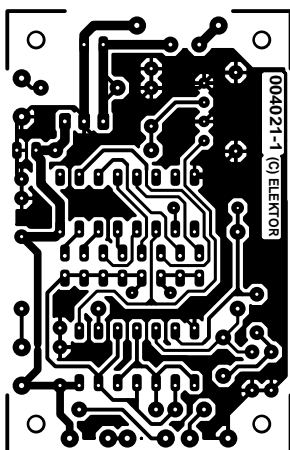
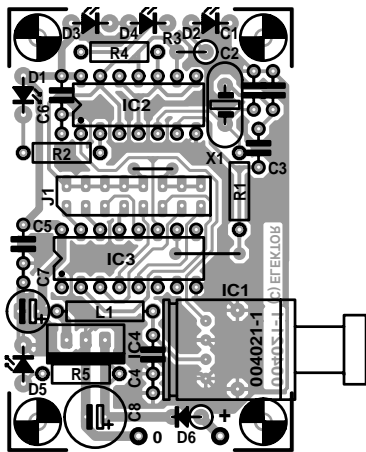
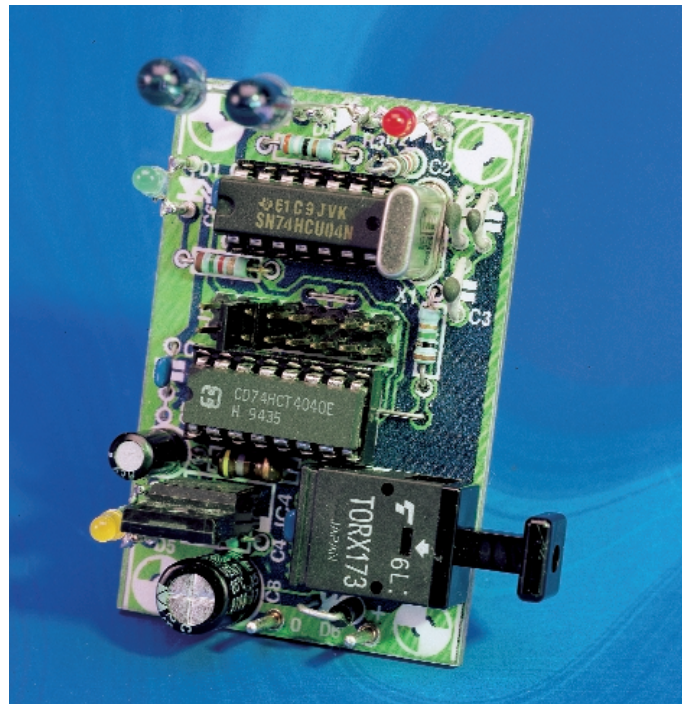
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# Transmitter for Fibre-Optic IR Extender

T. Giesberts

This circuit restores the original modulation of the signal received from the remote-control unit, which was demodulated by the receiver unit at the other end of the extender (see 'Receiver for fibre-optic IR extender').

If no signal is received, the Toslink transmitter in the receiver is active, so a High level is present at the output of the Toslink receiver in this circuit. Buffer IC2a then indicates via LED D1 that the receiver unit is active. The received data are re-modulated using counter IC3, which is a 74HCT4040 since the Toslink module has a TTL output. In the idle state, IC3 is held continuously reset by IC1. The oscillator built around IC2c runs free. When the output of the Toslink receiver goes Low, the counter is allowed to count and a carrier frequency is generated. This frequency is determined by the oscillator frequency and the selected division factor. Here, as with the receiver, we assume the use of RC5 coding, so a combination has been chosen that yields exactly 36 kHz. The oscillator frequency is divided by  $2^9$  on pin 12 of the counter, and  $18.432 \text{ MHz} \div 2^9 = 36 \text{ kHz}$ . The circuit board layout has a double row of contacts to allow various division factors to be selected, in order to make the circuit universal. You can thus select a suitable combination for other standards, possibly along with using a different crystal frequency. The selected output is connected to four inverters wired in parallel, which together deliver the



drive current for the IR LEDs D3 and D4 (around 50 mA). A signal from the counter is also indicate that data are being transmitted, via LED D2. This has essentially the opposite function of LED D1, which goes out when D2 is blinking.

In the oscillator, capacitor C3 is used instead of the usual resistor to compensate for the delay in IC2c. As a rule, this capacitor is needed above 6 MHz. It should have the same value as  $C_{load}$  of the crystal, or in other words  $0.5C1$  (where  $C1 = C2$ ). At lower frequencies, a  $1k\Omega$  to  $2k\Omega$  resistor can be used in place of C3.

A yellow LED is used for the power-on indicator D5. The current through this LED is somewhat higher than that of the other LEDs. If you use a red high-efficiency LED instead, R5 can be increased to around  $3k\Omega$ .

The circuit draws approximately 41 mA in the idle state when the receiver is on. If the receiver is switched off, the transmitter emits light continuously, and the current consumption rises to around 67 mA.

The PCB shown here is unfortunately not available ready-made through the Publishers' Readers Services.

## COMPONENTS LIST

### Resistors:

R1 =  $1M\Omega$   
 R2 =  $1k\Omega$   
 R3,R5 =  $1k\Omega$   
 R4 =  $39\Omega$

### Capacitors:

C1,C2 = 33pF  
 C3 = 15pF  
 C4,C5,C6 = 100nF ceramic  
 C7 =  $4\mu F$  63V radial  
 C8 =  $220\mu F$  25V radial

### Inductors:

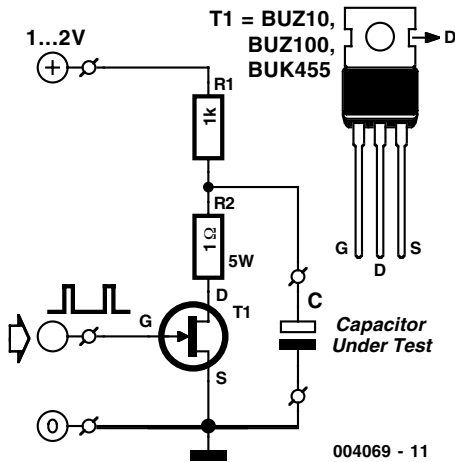
L1 =  $47\mu H$

### Semiconductors:

D1 = high-efficiency LED, green  
 D2 = high-efficiency LED, red  
 D3,D4 = LD271  
 D5 = high-efficiency LED, yellow  
 D6 = 1N4002  
 IC1 = TORX173 (Toshiba)  
 IC2 = 74HCU04  
 IC3 = 74HCT4040  
 IC4 = 7805

### Miscellaneous:

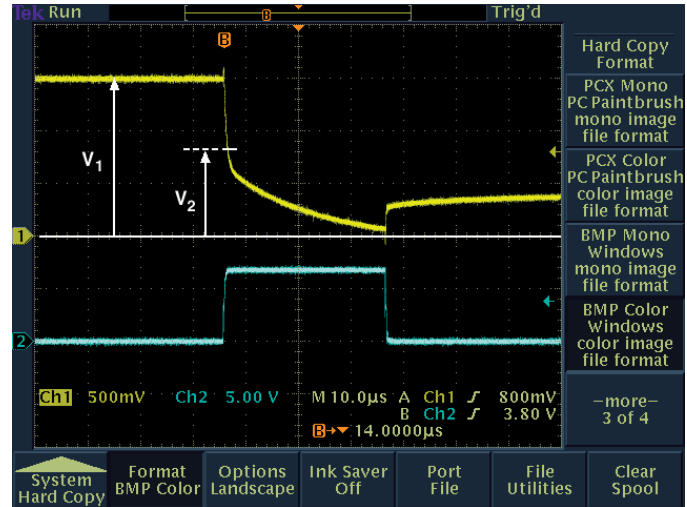
J1 = 16-way double contact row,  
 plus jumper  
 X1 = 18.432MHz quartz crystal



### K. Walraven

In a switch-mode power supply, the quality of the output voltage depends strongly on the quality of the electrolytic capacitors that are used. Here the effective series resistance (ESR), which is the internal 'ohmic' impedance of the capacitor, is one of the most important factors, since large currents are involved. It is rather difficult to *exactly* measure the ESR, but if you only want a quick idea, or you want to compare different families of capacitors, the illustrated simple measurement setup is very suitable.

The capacitor under test is charged via the 1-kΩ resistor (R1) until its voltage is the same as the applied supply voltage. You can then calculate the ESR using the formula  $(U_1/U_2) - 1$  (see trace 1 of the oscillogram). This formula is very simple, since we have chosen a value of 1 Ω for R2. The values of the supply voltage and R1 are not critical, since the measurement is relative (as shown by the formula). The capacitor is discharged via a 1-Ω resistor and a power FET. You would expect the discharge to occur according to the well-known exponential for-



mula, but as you can see from the oscillogram, the voltage first drops quickly, after which the expected exponential curve appears. This fast initial drop is due to the ESR of the capacitor, which produces a voltage drop equal to the product of the resistance and the discharge current. The greater the voltage drop, the poorer the capacitor.

If the initial voltage drop is approximately equal to half of the charge voltage, as in this case, then we can deduce that the ESR is approximately equal to the discharge resistance of 1 Ω. This is actually a relatively good value for a small, inexpensive 10-μF electrolytic capacitor. As a general rule, you can assume that the ESR decreases proportionally as the capacitance increases, and that it also decreases slightly as the voltage on the capacitor increases.

You can drive the FET directly from a pulse waveform generator, if it can deliver a short positive pulse to the gate with an amplitude of at least 6 V (see trace 2). The repetition interval must be 100 to 1000 times as long as the width of the positive pulse, since the capacitor will otherwise not have enough time

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to recharge. In most cases, you will only be able to obtain a stable image on the oscilloscope if it has a storage function. Almost any type of FET can be used, as long as the total dis-

charge resistance (the sum of  $R_2$  and  $R_{ds}$  of the FET) is as close as possible to  $1 \Omega$ .

(004069-1)

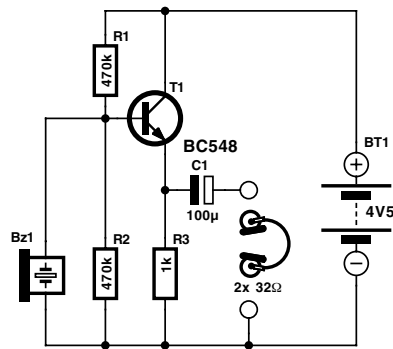
## 003

# Electronic Stethoscope

## B. Kainka

In order to listen to your heartbeat you would normally use a listening tube or stethoscope. This circuit uses a piezo sounder from a musical greetings card or melody generator, as a microphone. This transducer has an output signal in the order of 100 mV and its low frequency response is governed by the input impedance of the amplifier. For this reason we have chosen to use an emitter follower transistor amplifier. This has a high input impedance and ensures that the transducer will have a very low frequency response. At the output you just need to connect a set of low impedance headphones to be able to listen to your heartbeat.

Replacing the emitter follower with a Darlington transistor configuration will further increase the input impedance of the amplifier.



004038- 11

## K. Walraven

Making heatsink calculations has always been a bit of a nuisance. This sample spreadsheet makes life easier. Its main advantage is that you can see at a glance which heatsink you need and how hot it will become.

First you have to enter a certain amount of data. Reasonable default values are already present, so you can simply keep what is already present for anything that you don't know.

Let's have a look at the various fields. You start with the power that the transistor must handle, in watts. You can calculate this by multiplying the voltage across the transistor by the current through the transistor. Next comes the thermal resistance. This differs for each type of transistor and package, so you will have to look it up on the manufacturer's data sheet under  $R_{thjc}$  (junction to case). A 7805 in a TO220 package, for example, has a value of 4, while a 2N3055 in a TO3 package has a value of 1.5. A modern component, such as the Siemens BUZ100 in a TO220 package, has the unbelievably low value of only 0.6! After this, you need to know the thermal resistance value for the insulator (if one is used). If no insulator is used, enter a zero. A few typical values are: flexible plastic: 0.4; aluminium oxide (hard, white, 1 to 2 mm thick): 0.3; mica: 0.4. In addition, it makes a difference whether or not heat-conducting paste is used. Here you can only select between yes (1) and no (0). The spreadsheet will then automatically fill in either 0.1 or 0.5, respectively.

Next, enter the desired maximum temperature. For example, the internal temperature of the transistor may not be allowed to be higher than 125, 150 or 175 degrees. You can find this value on the data sheet of the component in question (maximum junction temperature). If you don't know the value, 150

Heatsink	
Input	
Power to be dissipated (watts)	30
Thermal resistance of transistor (degrees per watt)	1.5
Thermal resistance of washer (degrees per watt)	0.5
Heat conducting paste (1=yes, 0=no)	1
Max. heatsink temperature (degrees)	60
Max. temperature inside transistor	150
Result	
Heatsink (degrees per watt)	1.2
Transistor temperature (degrees celcius)	123
Heatsink temperature (degrees celcius)	60
Suggested heatsink type (Fischer)	SK95 75 SK42 100

degrees is usually the maximum allowed value (175 is only for the most recent components), and 125 is a safer value that is always acceptable.

However, you may want to avoid having the heatsink become too hot. According to safety regulations, any heatsink that is exposed to touch must not be hotter than 60 degrees. A heatsink that becomes hotter than this must be protected against being touched. If you don't care about this, you can enter a higher value here.

The program now displays a result consisting of four values. The first is the required heatsink specification in degrees per watt. This represents the larger of the two heatsinks required



to maintain the maximum transistor temperature and to remain below the maximum heatsink temperature. In addition, you will see the internal temperature of the transistor, the temperature of the heatsink and a suggestion for a suitable heatsink (type and length), such as 'SK85, 75 mm'. Several different suggestions may be displayed in a row, as in the illustration. This is only a very limited suggestion, but it does give you a quick impression. Furthermore, you are always dependent on what your dealer has in stock, and he can work with the calculated value of degrees per watt. You will see that it's fun to play around with various input values, and this will give

you insight into the relationship between the heatsink and the temperature of the transistor.

The spreadsheet is available from the Download section of the *Elektor Electronics* website at

<http://www.elektor-electronics.co.uk>

If you want to modify the program, you will first have to disable the protection and make the invisible columns visible. We (and other readers) would enjoy hearing about any improvements you make.

## P. Lay

This circuit can precisely measure electrostatic charge. The charge to be measured is stored on C1 (a high quality MKT capacitor with a value of 1-2  $\mu\text{F}$ ). The voltage ( $U$ ) across the capacitor (C1) is related to its charge ( $Q$ ) by the equation  $U = Q/C1$ . Operational amplifier IC2 buffers this very high impedance source. An input lead is connected to one side of capacitor C1 and terminated with a test probe. The other side is connected to an earth lead and to a convenient earth point. IC3 amplifies the low voltage level at the output of IC2 and drives the moving coil meter M1 ( $\pm 100 \mu\text{A}$  to  $\pm 1 \text{ mA}$  centre zero). Switch S2 allows selection between two measurement ranges. With S2 closed the amplification factor is 5 and when open the amplification factor is 10. The internal impedance of P1 is 2.2 k $\Omega$ . Alternatively a digital multimeter can be used in place of P1, in this case resistor R7 (2-20 K $\Omega$ ) can be omitted. Low Current LED D2 indicates that the electroscope is on.

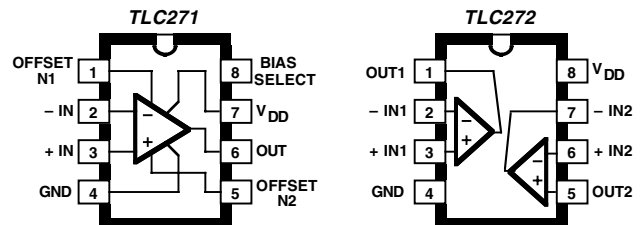
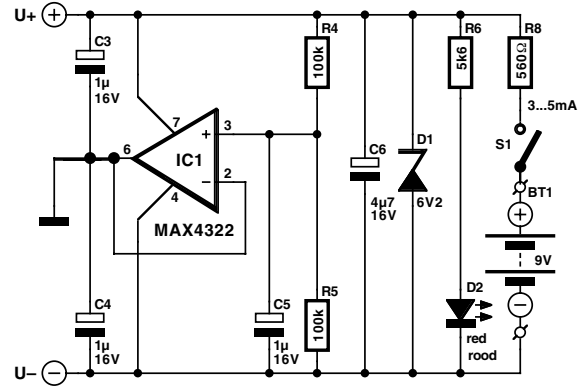
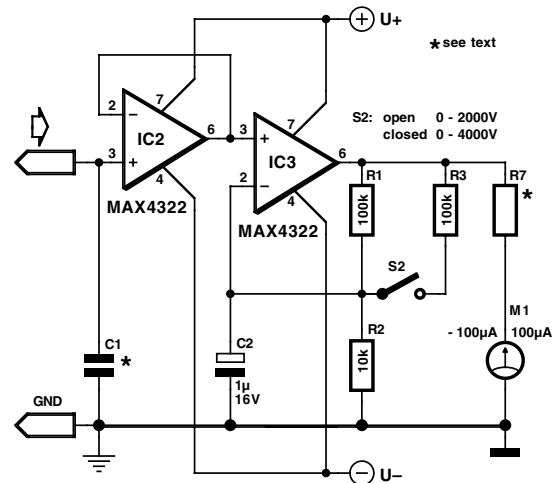
The operational amplifiers used here are MAX4322 from Maxim. The common mode input voltage for these devices can go to the supply rails; likewise the outputs will drive from rail to rail. The maximum supply voltage is 6.2 V, hence the need for zener diode D1 to limit the supply voltage. A full data sheet can be obtained from [www.maxim-ic.com](http://www.maxim-ic.com).

The operational amplifier IC1 produces a symmetrical supply with a centre rail (earth) from the 9-V battery. The supply current for the electroscope is in the order of 5 mA, most of which is used by the zener diode D1. Alternatively, the operational amplifiers can be replaced by a type that can operate at a higher supply voltage. For example IC2 and IC3 can be replaced by a single (dual op-amp) TLC272 (see the DIL outline for this device to assign the new pins). IC1 can be replaced by a TLC271 (pin 8 should in this case be connected to earth and pins 1 & 5 left unconnected). The maximum supply voltage for these IC's is 16 V so zener diode D1 can be omitted which will bring the supply current down to 3 mA.

Operation of the precision electroscope is simple:

1. Switch on S1, LED D2 lights.
2. The test probe is touched to the earth lead to discharge capacitor C1 before a measurement is made. Alternatively a small push button switch can be wired in parallel to C1 to discharge it.
3. The test probe is now touched onto the charged part.
4. The meter will show any charge, its polarity and its value.
5. After use, turn off to save the batteries.

(004011)

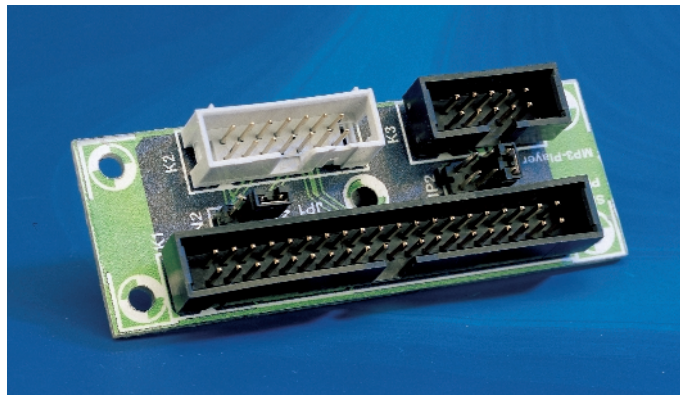


006

# Adapter for SB Live! Player 1024

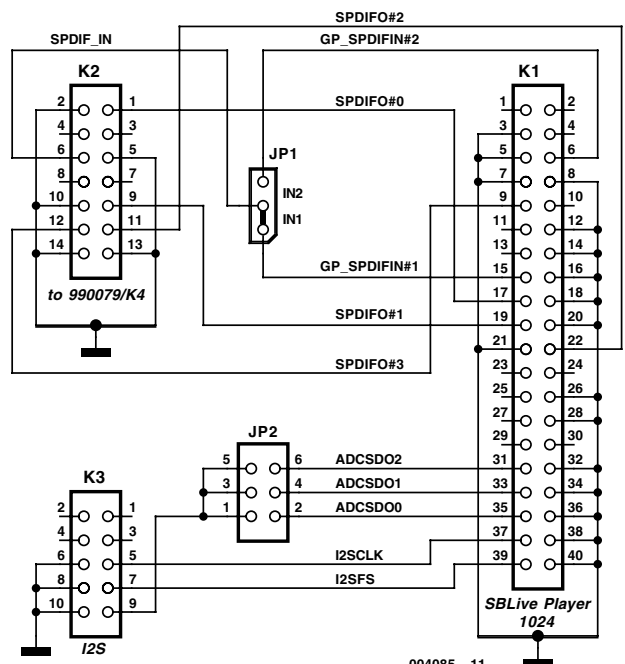
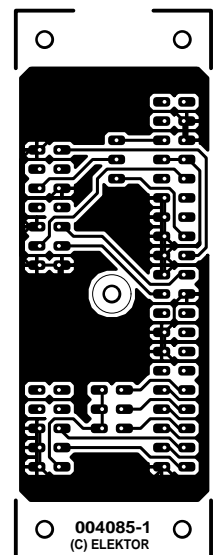
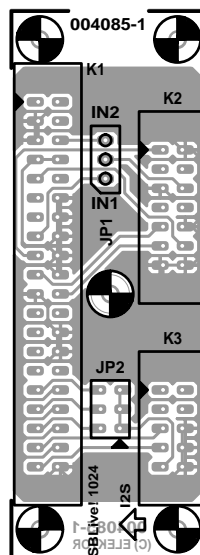
T. Giesberts

In the December 1999 issue, we published a design for a digital extension for the Sound Blaster Live! Value Player (circuit board #990079-1). This sound card has a 12-pin Audio Extension connector. The successor to this card is the Live! Player 1024, which has a 40-pin connector that includes the same inputs and outputs (plus others), but in different positions. To allow the extension to be used with the new sound card as well, we have developed an adapter card that makes the connections easy. The necessary signals from the 40-pin connector are passed through to a 14-pin connector whose pin assignments match those of the extension card. The accompanying table describes the available inputs and outputs on



**Table 1.**  
AUD\_EXT connector pin assignments for the SB Live! Player 1024.

Pin	Name	Description
1	VCC	Supply+5 V
2	VCC	Supply+5 V
3	GND	Earth
4	AC97CLK	Clock output 4.5 MHz
5	GND	Earth
6	GP_SPDIFIN#2	S/PDIF input 2
7	GND	Earth
8	GND	Earth
9	SPDIFO#3	S/PDIF output 3
10	GPO1	Output 1 (general purpose)
11	GPO2	Output 2 (general purpose)
12	GND	Earth
13	GPO0	Output 0 (general purpose)
14	GND	Earth
15	GP_SPDIFIN#1	S/PDIF input 1
16	GND	Earth
17	SPDIFO#0	S/PDIF output 0
18	GND	Earth
19	SPDIFO#1	S/PDIF output 1
20	GND	Earth
21	GND	Earth
22	SPDIFO#2	SPDIF output 2
23	GPI0	Digital general-purpose input 0 (reserved)
24	GPI1	Digital general-purpose input 1 (reserved)
25	OUTMIDI	MIDI output
26	GND	Earth
27	INMIDI	MIDI input
28	GND	Earth
29	KEY	
30	KEY	
31	ADCSDO2	I2S input 2 for audio data
32	GND	Earth
33	ADCSDO1	I2S input 1 for audio data
34	GND	Earth
35	ADCSDO0	I2S input 0 for audio data
36	GND	Earth
37	I2SCLK	Serial bit clock for I2S
38	GND	Earth
39	I2SFSS	Frame sync
40	GND	Earth



004085 - 11

## COMPONENTS LIST

### Miscellaneous:

JP1 = 3-way SIL header with jumper

JP2 = 2x3- way SIL header with jumper

K1 = 40-pin boxheader

K2 = 14- pin boxheader

K3 = 10- pin boxheader

the 40 pins (see also the help menu of the software for the new sound card). The 40-pin connector has two inputs, one of which can be selected using JP1. Apparently, only the first of these inputs is supported in the SB Live!Ware 3.0 software.

With regard to the four outputs, output 0 provides the S/PDIF signal for normal two-channel information. The other outputs also provide signals when (for example) AC3-encoded DVDs (5.1-channel Dolby Digital) are played back, if this is supported by the hardware/software player. In this case, output 1 provides a non-decoded data stream. As an extra feature, the I<sup>2</sup>S inputs can also be connected through to the ten-pin connector K3, but it appears that this is not supported by Live!Ware 3.0 for the 1024 card. JP2 can be used to select which of the three data inputs is connected to K3, but we have not been able to determine what if any benefit this may provide.

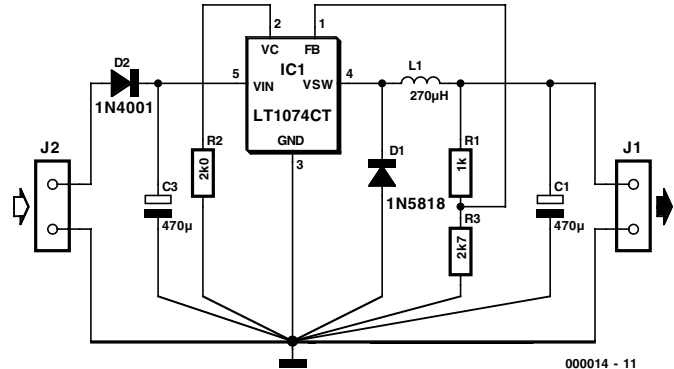
# 3-volts Car Adapter

A. Grace

This circuit is based on a standard LT1074CT switching regulator IC. For sure, *Application Note AN35* published by Linear Technology describes the design far more elegantly than the author could in this short article. Interested readers are therefore strongly advised to get a copy of AN35.

The schematic shows the LT1074CT used as a positive step-down or 'buck' converter. The 'switcher' is used to convert a +12-volt car battery voltage down to +3 volts for use with the personal hi-fi's and handheld games for the author's two boisterous children on long car journeys. Note at under ten years of age, children will rarely be hi-fi aficionados and are generally not concerned with any noise generated by the 'switcher' circuit.

The circuit is connected to the car +12-V system via the cigarette lighter socket — is advisable to use a fused version of the cigarette lighter plug. The +12-V arrives on the board via screw-terminal block J2. Diode D2 provides a reverse voltage protection, while C3 decouples the input to the switcher IC. The LT1074CT briskly switches the supply voltage on and off in response to the signal applied to its F/B input, to the extent that the average output voltage is at the required level. The values of potential divider resistors R1-R3 have been chosen to attenuate the output voltage so that there is 2.5 V at the F/B pin. The difference between the attenuated output voltage and the internal 2.5-V reference is used to control the modulation



effect of the switcher. Components R2 and C2 provide frequency stabilisation for the feedback loop. Inductor L1 along with the LT1074CT form the main switching components, while C1 provides decoupling for the output load. The 3-V output voltage is taken from screw terminal J1.

With this circuit built, boxed up and installed in your car, you can look forward to possibly your first 'quiet' long car journey.

# Noise-Driven Sound Generator

## G. Kleine

The sound generator shown here uses its built-in loudspeaker as a microphone when it is in the standby state. As soon as it detects a noise that exceeds an adjustable threshold level, it becomes active. This small, clever circuit can be used as an alarm generator that reacts to noises. You can also use it to help you locate an object in response to a loud sound, such as clapping your hands or whistling loudly.

The gate at the bottom of the schematic diagram acts as a linear low-frequency amplifier, due to the negative feedback resistor R3. It receives its input signal from loudspeaker LS1, which acts as a microphone when T1 is cut off. The amplified

output signal from this gate passes via C1 to a second 4011 gate, which triggers a monostable formed by the two gates located before and after C5 and R5. The DC threshold level is applied to pin 2 of IC1 via R2. This DC voltage is superimposed on the signal from C1. Retriggering of the monostable is prevented by the combination of R4, C4 and the first gate, in addition to which the sound generator (IC2) prevents the loudspeaker from acting as a microphone once it has been activated.

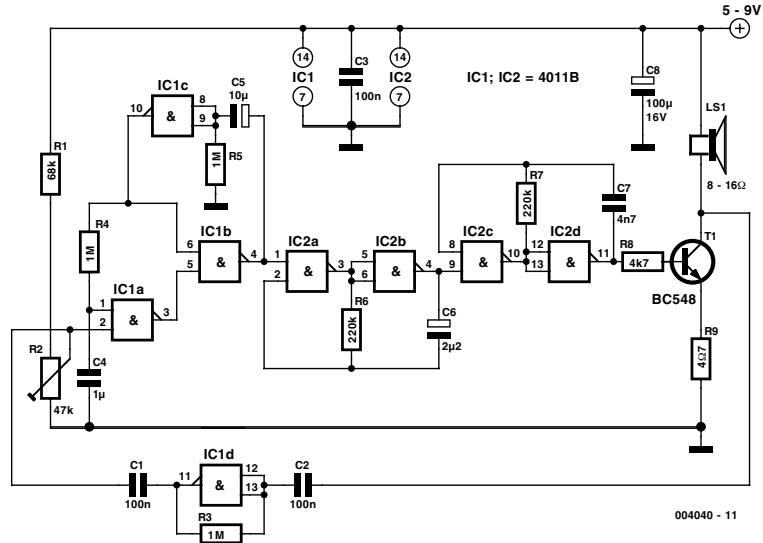
A High output signal from pin 4 of the monostable enables a pair of astable multivibrators in IC2. The first of these is a low-frequency generator, which modulates the audio-frequency

# SUMMER CIRCUITS COLLECTION

tone produced by the second multivibrator. The result is a 'siren' sound. Finally, T1 is driven via R8 to push the loudspeaker quite hard. The loudspeaker current is limited a little bit by R9.

The duration of the alarm signal is determined by the monostable time constant of R5 and C5. A Low level on pin 4 of IC1 blocks the sound generator. After the time delay determined by R4 and C4 has expired, the loudspeaker once again acts as a microphone. The circuit can be powered by a 5 V to 9 V battery.

(004040-1)



004040 - 11

## Using an inkjet printer and self- adhesive foil

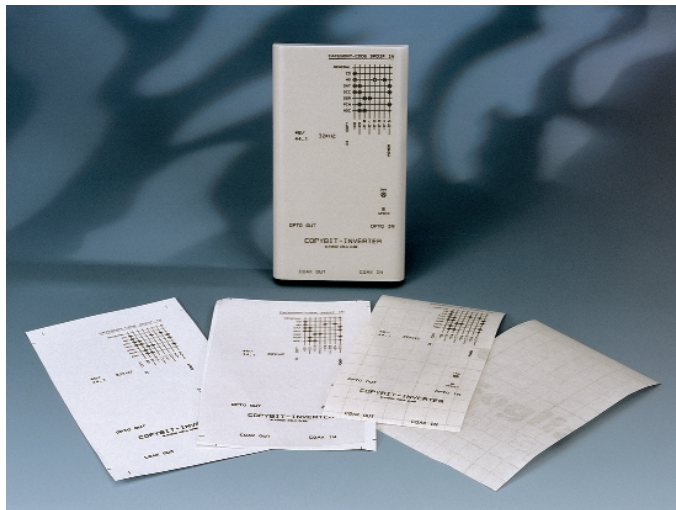
W. Foede

It is fairly easy to produce professionally looking, permanent front panel foils ('decals') for use on electronic equipment if you have a PC available along with an inkjet printer (Hewlett-Packard DeskJet or similar). Plus, of course, matt transparent sheet of the self-adhesive type as used, for instance, to protect book covers. This type of foil may be found in stationery shops or even the odd building market. One foil brand the author has used successfully goes by the name of Foglia Transparent. The production sequence is basically as follows:



1. The decal is designed at true size (1:1 or 100%) with a graphics program or a word processor, and then printed in black and white on a sheet of white paper (do not use the colour ink cartridge). Allow the ink to dry. Cut the foil as required, then pull the adhesive sheet from the paper carrier sheet. Keep the carrier paper handy, it will be used in the next phase.

2. Once the ink has dried, the transparent foil is placed on



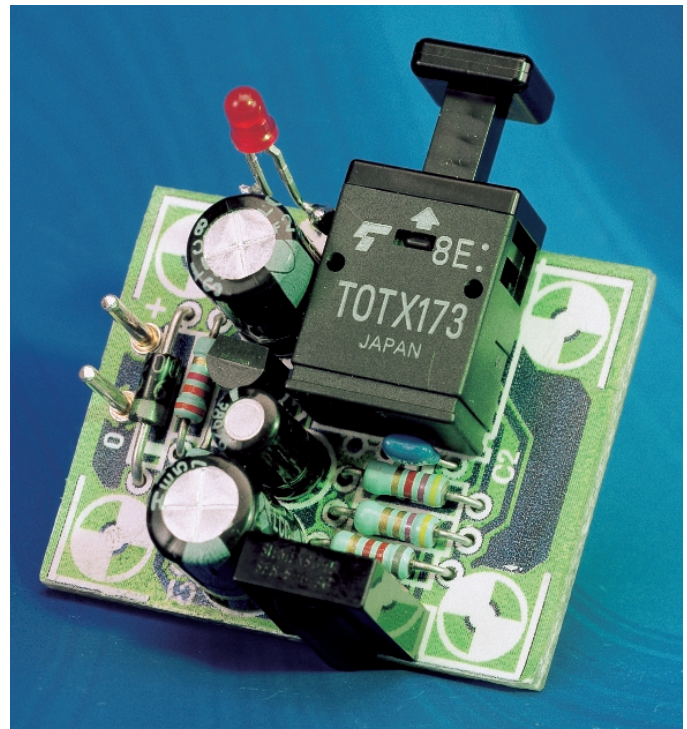
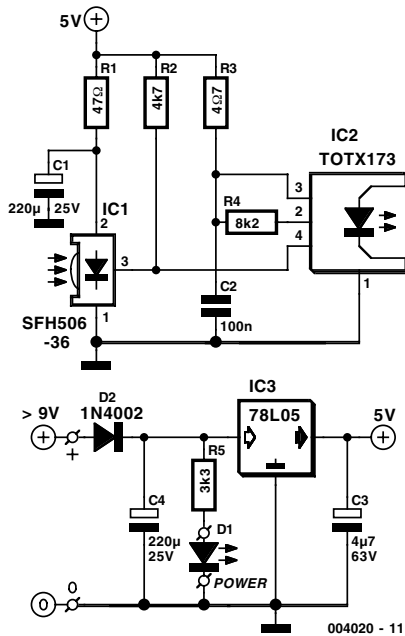
top of the decal. The foil is lightly pressed and then slowly pulled off the paper again (see photograph). Because the adhesive absorbs the ink to a certain extent, the mirror image of the decal artwork is transferred to the adhesive side of the foil.

3. For further processing, first secure the foil on the carrier paper again. Next, cut the decal to the exact size as required by the equipment front panel. Finally, pull off the carrier sheet again and apply the transparent foil on to the metal or plastic surface.



010

# Receiver for Fibre-Optic IR Extender



**T. Giesberts**

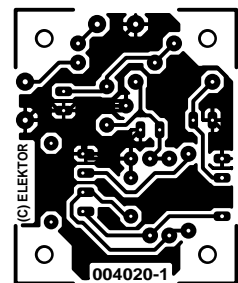
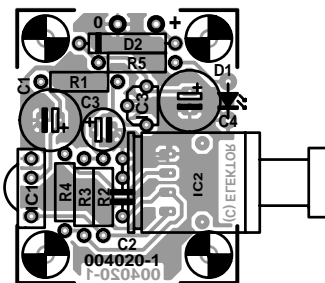
There are various types of remote-control extenders. Many of them use an electrical or electromagnetic link to carry the signal from one room to the next. Here we use a fibre-optic cable. The advantage of this is that the thin fibre-optic cable is easier to hide than a 75-Ω coaxial cable, for example. An optical link also does not generate any additional radiation or broadcast interference signals to the surroundings. We use Toslink modules for connecting the receiver to the transmitter. This is not the cheapest solution, but it does keep everything compact. You can use a few metres of inexpensive plastic fibre-optic cable, instead of standard optical cable for interconnecting digital audio equipment. The circuit has been tested using ten metres of inexpensive plastic fibre-optic cable between the receiver and the transmitter (which is described elsewhere in this issue).

The circuit is simplicity itself. A standard IR receiver/demodulator (IC1, an SFH506) directly drives the Toslink transmitter IC2. We have used the RC5 frequency of 36 kHz, but other standards and frequencies could also be used. Both ICs are well decoupled, in order to keep the interference to the receiver as low as possible. Since the Toslink transmitter draws a fairly large current (around 20 mA), a small mains adapter should be used as the power source.

There is a small printed circuit board layout for this circuit, which includes a standard 5-V supply with reverse polarity protection (D2). LED D1 is the power-on indicator. The supply voltage may lie between 9 and 30 V. In the absence of an IR signal, the output of IC1 is always High, and the LED in IC2 is always on. This makes it easy for the transmitter unit to detect whether the receiver unit is switched on.

The PCB shown here is unfortunately not available ready-made through the Publishers' Readers Services.

(004020-1)



**COMPONENTS LIST**

**Resistors:**

- R1 = 47Ω
- R2 = 4kΩ
- R3 = 4Ω
- R4 = 8kΩ
- R5 = 3kΩ

**Capacitors:**

- C1, C4 = 220µF 25V radial
- C2 = 100nF ceramic
- C3 = 4µF 63V radial

**Semiconductors:**

- D1 = high-efficiency LED
- D2 = 1N4002
- IC1 = SFH506-36 (Siemens)
- IC2 = TOTX173 (Toshiba)
- IC3 = 78L05

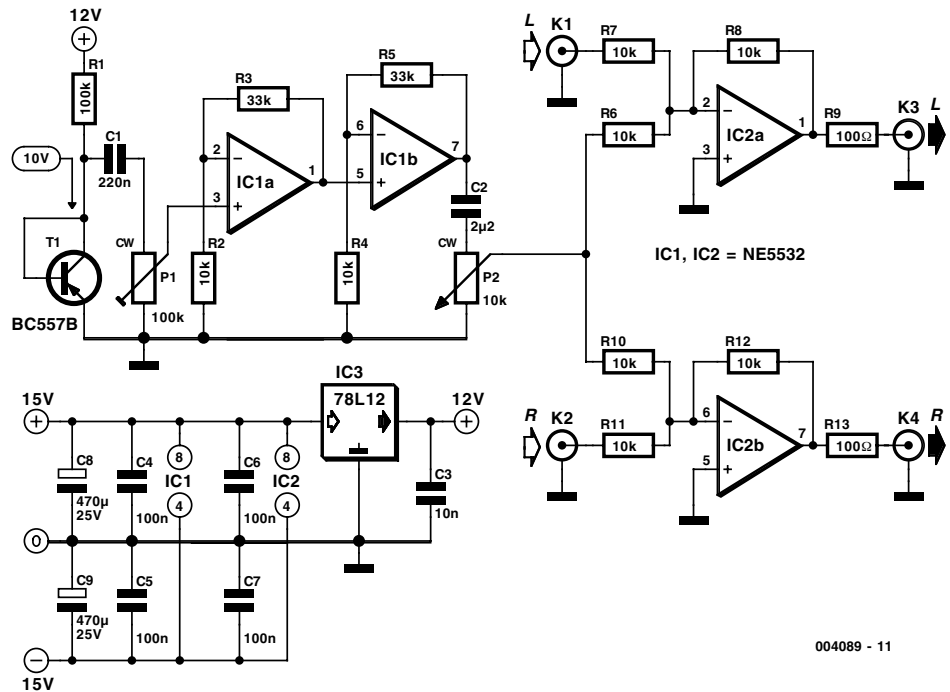
# 011 Noise Injector

T. Giesberts

This circuit is primarily intended to be used by persons who want to experiment with audio. For example, you can determine whether your own audible threshold for noise is different with and without music, or whether a particular CD sounds better with a little bit of noise. However, since this circuit produces white noise, it can also be used for test measurements, such as comparing the sounds of different loudspeakers, measuring filter characteristics and so on.

The measured characteristics, as shown in **Figure 2**, show a nearly flat amplitude distribution (averaged over 64 measurements). The effective value of the noise signal at the output is around 100 mV maximum (with both potentiometers set to maximum), measured over the frequency range of 22 Hz to 22 kHz.

The noise is generated by reverse-biasing the base-emitter junction of a PNP transistor (BC557B) so that it zeners. In our prototype, the voltage across T1 was approximately 10 V. P1 is used to set the level of the generated noise so that it is just audible, following which the output level can be adjusted using the logarithmic potentiometer P2. For making measurements, P1 can also be simply set to its maximum position. The noise is amplified by two opamp stages. Depending on the transistor manufacturer, or the type of transistor if you use a different type, the level of the generated noise can vary significantly. Using two amplification stages in series provides more options and considerably more bandwidth, and you can implement various filter characteristics around IC1a and IC1b according to your own taste. The gain of the two stages has been kept equal to ensure the maximum possible bandwidth. The amplified signal is then passed to a simple summing



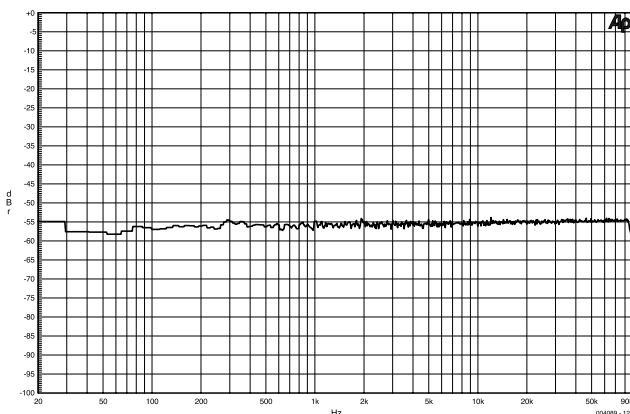
004089 - 11

amplifier (IC2). We have used a stereo arrangement, in which both channels receive the same noise signal. If you want to expand on the design, you can provide each channel with its own noise generator. In this case, you will have to use a dual potentiometer for P2.

The well-known NE5532 is used for the amplifiers, but any other good dual opamp would also be satisfactory. The opamps are fed from a standard, symmetrical  $\pm 15\text{-V}$  supply. In order to suppress possible positive feedback via the power supply, and to reduce the effects of power supply noise (since the opamps are non-inverting), the supply for the noise diode circuit (R1 and T1) is separately stabilised by IC3 (7812) and extra filtering for the  $\pm 15\text{-V}$  supply is provided by C8 and C9. IC3 must be located as close as possible to R1, T1 and IC1. The coupling capacitors C1 and C2 are necessary to prevent the DC component of the noise signal from appearing at the outputs.

The table lists some measured characteristics of the circuit, for a bandwidth B of 22 Hz to 22 kHz and a reference level of  $2 V_{\text{eff}}$ .

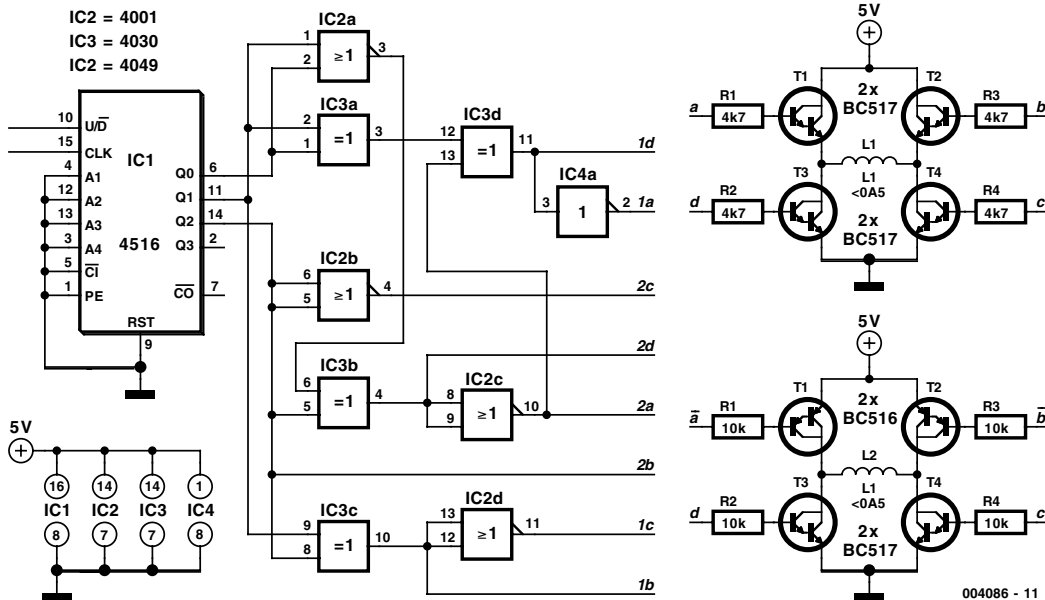
(004089-1)



THD + N (1 kHz, P2 min.)	< 0.0005 %
Noise level (P2 min.)	- 107 dB
Noise level (P1 min. / P2 max.)	- 88 dB
Noise level (P1 max. / P2 max.)	- 25 dB (112 mV <sub>eff</sub> )
Noise level (P1 max. / P2 max. / B > 500 kHz)	- 10.5 dB
Gain (K1/K3, K2/K4)	- 1 x
Current consumption	21 mA

012

# Bipolar Stepper Motor Control



004086 - 11

**K. Walraven (text) and  
R.T.J.M. van der Heijden (design)**

The subject of stepper motors is clearly very popular, with many reader responses to every published article. A design for a unipolar controller appeared in the May 1999 issue, and now we present a bipolar version. First, we want to explain how such a controller works and what's involved. A bipolar motor has two windings, and thus four leads. Each winding can carry a positive current, a negative current or no current. This is indicated in **Table 1** by a '+', a '-' or a blank.

A binary counter (IC1) receives clock pulses, in response to which it counts up or down (corresponding to the motor turning to the left or the right). The counter increments on the positive edge of the pulse applied to the clock input if the up/dwn input is at the supply level, and it decrements if the up/dwn input is at earth level. The state of the counter is decoded to produce the conditions listed in **Table 2**.

Since it must be possible to reverse the direction of the current in the winding, each winding must be wired into a bridge circuit. This means that four transistors must be driven for each winding. Only diagonally opposed transistors may be switched on at any given time, since otherwise short circuits would occur.

At first glance, **Table 2** appears incorrect, since there seem to always be four active intervals. However, you should consider that a current flows only when a and c are both active.

The proper signals are generated by the logic circuitry, and each winding can be driven by a bridge circuit consisting of four BC517 transistors. Two bridge circuits are needed, one for each winding. The disadvantage of this arrangement is that there is a large voltage drop across the upper transistors in particular (which are Darlingtontons in this case). This means that there is not much voltage left for the winding, especially with a 5-V supply. It is thus better to use a different type of bridge circuit, with PNP transistors in the upper arms. This of course means that the drive signals for the upper transistors

must be reversed. We thus need an inverted signal in place of 1a. Fortunately, this is available in the form of 1d. The same situation applies to 1b (1c), 2a (2d) and 2b (2c). In this case, IC4 is not necessary.

Stepper motors are often made to work with 12 V. The logic ICs can handle voltages up to 15 to 18 V, so that using a supply voltage of 12 V or a bit higher will not cause any problems. With a supply voltage at this level, the losses in the bridge circuits are also not as significant. However, you should increase the resistor values (to 22 kΩ, for example). You should preferably use the same power supply for the motor and the controller logic. This is because all branches of the bridge circuit will conduct at the same time in the absence of control signals, which yields short-circuits.

(004086-1)

**Table 1. Driving the windings.**

Phase 2	1	2	3	4	5	6	7	8
Winding 1	+	+		-	-	-		+
Winding 2		+	+	+		-	-	-

**Table 2. Decoded counter states.**

Phase	1	2	3	4	5	6	7	8
1a	+	+	+					+
1b			+	+	+	+		
1c	+	+					+	+
1d				+	+	+	+	
2a		+	+	+	+			
2b					+	+	+	+
2c	+	+	+	+				
2d	+					+	+	+

## 013

# Compact Switching Step-Down Converter

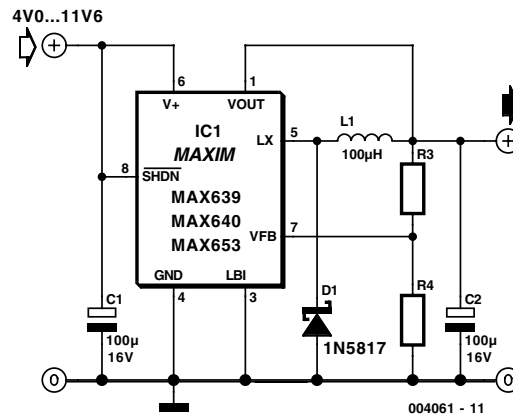
H. Steeman

Switch-mode power supplies are used in electronic circuits to increase (step up) or reduce (step down) voltage levels in the most efficient manner possible. Compared to linear voltage regulators, switch-mode supplies convert relatively little energy into heat. Their efficiency is thus high. This is a major advantage with compact power supplies in particular, since it sometimes makes forced-air cooling unnecessary.

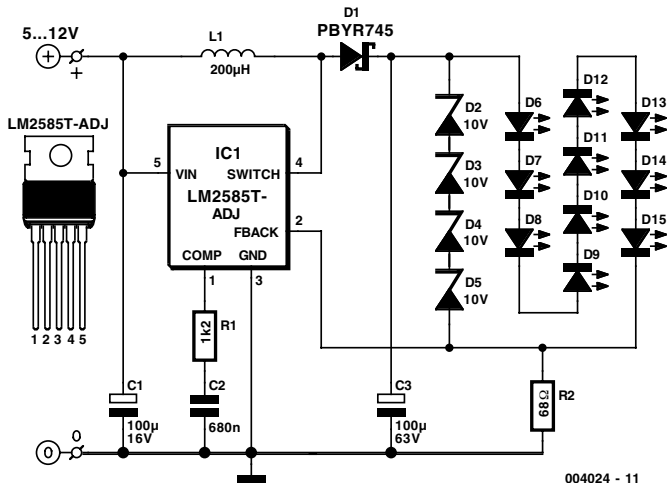
Building a switch-mode supply is considerably easier if you use components that have been specially developed for this application. One example of such an integrated step-down converter is the Maxim MAX639. This is designed for a fixed output voltage of +5 V, with an input voltage ranging between +5.5 and +11.5 V. Although this IC is primarily designed for a fixed output voltage, the output voltage can be tailored using a simple feedback network. With the given component values, resistors R3 and R4 determine the output voltage, with

$$R3 = R4 [(V_{out} / 1.28) - 1]$$

The value of R4 may lie between 10 kΩ and 10 MΩ, but a value of 100 kΩ is a good choice for most applications. The maximum



output current is 100 mA. If desired, a different type of Schottky diode with similar specifications can be used in place of D1 (a 1N5817). Inductor L1 must be suitable for a maximum current of 500 mA.



### K. Walraven

Nowadays you can buy white LEDs, which emit quite a bit of light. They are so bright that you shouldn't look directly at them. They are still expensive, but that is bound to change. You can make a very good solid-state pocket torch using a few of these white LEDs. The simplest approach is naturally to use a separate series resistor for each LED, which has an operating voltage of around 3.5 V at 20 mA. Depending on the value of the supply voltage, quite a bit of power will be lost in the resistors. The converter shown here generates a voltage that is high enough to allow ten LEDs to be connected in series. In addition,

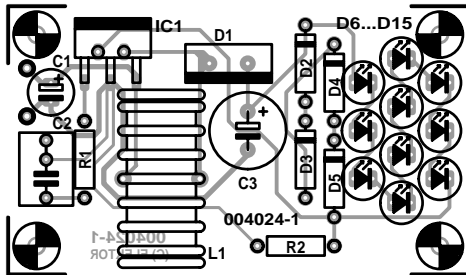
this converter supplies a constant current instead of a constant voltage. A resistor in series with the LEDs produces a voltage drop that depends on the current through the LEDs. This voltage is compared inside the IC to a 1.25-V reference value, and the current is held constant at 18.4 mA ( $1.25 \text{ V} \div 68 \Omega$ ).

The IC used here is one of a series of National Semiconductor 'simple switchers'. The value of the inductor is not critical; it can vary by plus or minus 50 percent. The black Newport coil, 220 µH at 3.5 A (1422435), is a good choice. Almost any type of Schottky diode can also be used, as long as it can handle at least 1 A at 50 V. The zener diodes are not actually necessary,

but they are added to protect the IC. If the LED chain is opened during experiments, the voltage can rise to a value that the IC will not appreciate.

The PCB shown here is unfortunately not available ready-made through the Publishers' Readers Services.

(004024-1)



## COMPONENTS LIST

### Resistors:

R1 = 1k $\Omega$

R2 = 68 $\Omega$

### Capacitors:

C1 = 100 $\mu$ F 16V radial

C2 = 680nF

C3 = 100 $\mu$ F 63V radial

### Inductors:

L1 = 200 $\mu$ H 1A

### Semiconductors:

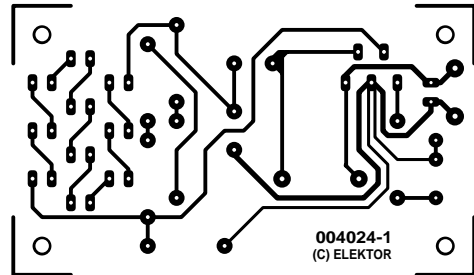
D1 = Schottky diode type  
PB7R745 or equivalent

D2-D5 = zener diode 10V, 0.4W

D6-D15 = white LED

IC1 = LM2585T-ADJ

(National Semiconductor)



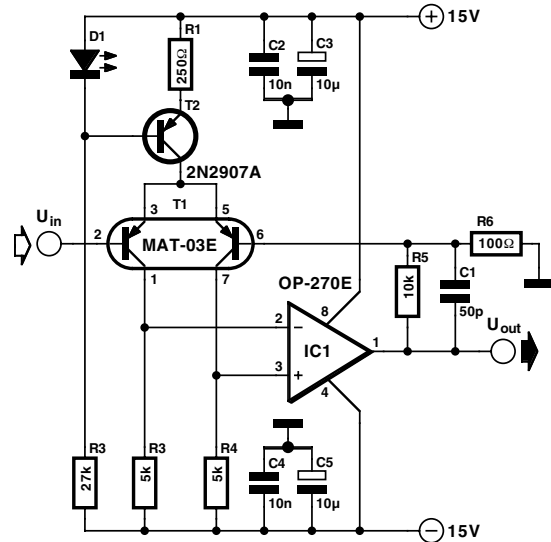
## 015

# Low-Noise Microphone Amplifier

**H. Steeman**

The signal from a microphone is too weak for a standard line input. This low-noise DC-coupled microphone amplifier provides a solution for anyone who wants to connect a microphone to his or her hi-fi installation. As can be seen from the schematic diagram, a good circuit does not have to be complex. A differential amplifier is built around T1 (MAT-03E), which is a low-noise dual transistor. The combination of T2 and LED D1 forms a constant-current source for the input stage. A low-noise opamp (OP-270E) amplifies the difference signal that appears at the collectors of the dual transistor. The result is an analogue signal at line level. The bandwidth of the amplifier ranges from 1 Hz to 20 kHz. Within the audio range (20 Hz to 20 kHz), the distortion is less than 0.005 percent. Since only half of the OP-270E is used, the remaining opamp could be used in the output stage of a stereo version.

The amplifier can be powered from a stabilised, symmetrical supply with a voltage between  $\pm 12$  V and  $\pm 15$  V. Such supply voltages are already present in many amplifiers.



# Power-On Sequencer

## A. Grace

This circuit was developed to turn on power supplies in sequence, and then turn them off again in the reverse sequence. This can be helpful for experimenting with equipment and circuits whose power has to be applied and removed in a particular order (like the PC/EPROM-Programmer combination used by Elektor's Software Service Department; *Ed.*)

The heart of the circuit is the venerable 4017 CMOS decade counter. Outputs Q1 to Q4 are used to set latches in the order

1-2-3-4, at which point the count is suspended. Pressing switch S1 allows the counting to continue. Counter outputs Q5 to Q8 are used to reset the latches in the reverse order, i.e., 4-3-2-1. The last output, Q9, is used to halt the counter.

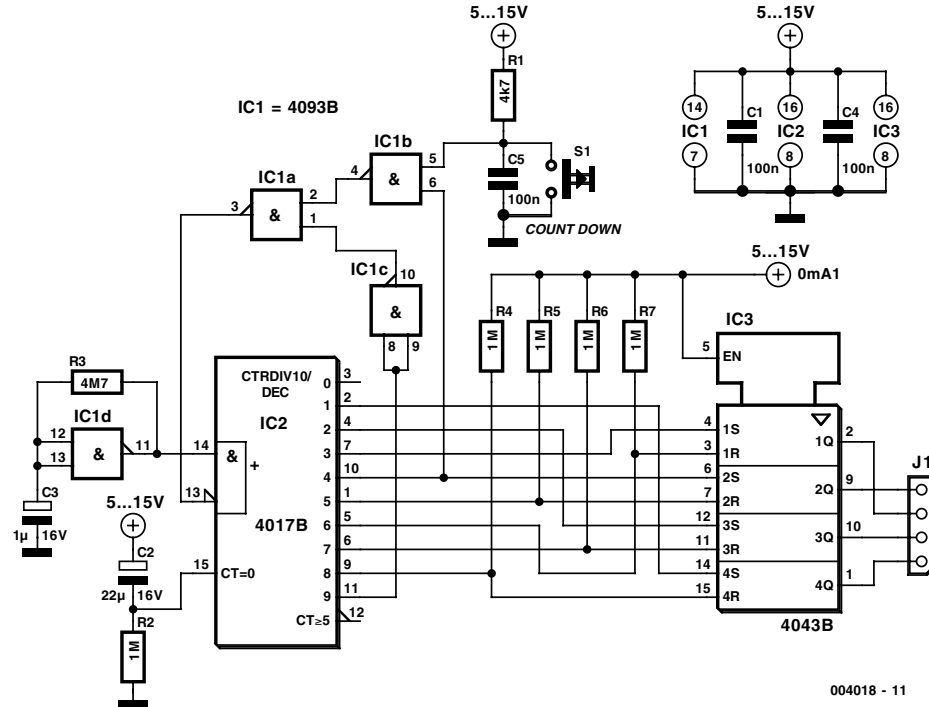
When power is applied, C2 and R2 initially keep the counter reset. When the power supply voltage is stable, the reset signal will go low and the 4017 will begin to count the 1-Hz clock signal supplied by an oscillator consisting of IC1d, R3 and C3. The outputs of the 4017 are actuated in sequence with each



# SUMMER CIRCUITS COLLECTION

rising edge of the clock pulse — but as the next clock pulse comes along the previous output is de-activated. The latches in the quad RS-latch type 4043 enable the outputs to stay active. IC2 stops counting at Q4 due to IC1b which removes the clock enable signal on pin 13 via IC1a. To enable the 4017 to continue counting and hence turn off the outputs, S1 has to be closed, thus restoring the clock enable on pin 13. Counter outputs Q5 to Q8 are connected to the reset inputs of the latches, so as IC2 increments, the latches are reset in the opposite sequence.

The count is finally halted at Q9 by IC1c, which again removes the clock enable signal. Weak pull-up resistors (R4-R7) are used on the latch 'reset' inputs to prevent undefined start conditions.



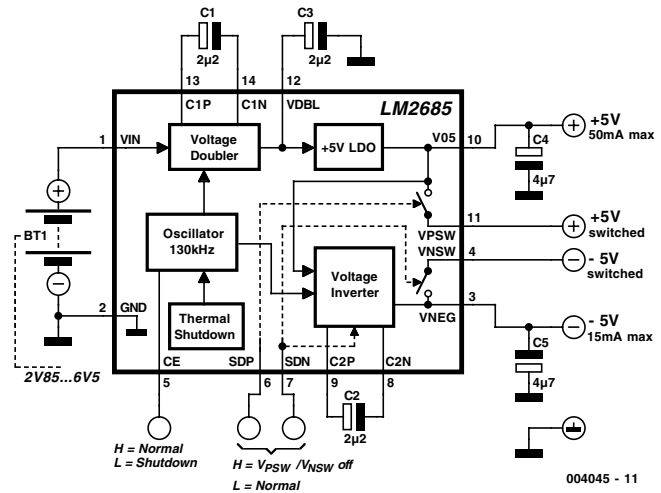
## G. Kleine

A symmetrical ±5 V power supply is often needed for small, battery-operated operational amplifier projects and analogue circuits. An IC that can easily be used for this purpose is the National Semiconductor LM 2685. It contains a switched-capacitor voltage doubler followed by a 5-V regulator. A voltage inverter integrated into the same IC, which also uses the switched-capacitor technique, runs from this output voltage. The external circuitry is limited to two pump capacitors and three electrolytic storage capacitors.

The IC can work with an input voltage between +2.85 V and +6.5 V, which makes it well suited for battery-operated equipment. The input voltage is first applied to a voltage doubler operating at 130 kHz. The external capacitor for this is connected to pins 13 and 14. The output voltage of this doubler is filtered by capacitor C3, which is connected to pin 12. If the input voltage lies between +5.4 and +6.5 V, the voltage doubler switches off and passes the input voltage through to the following +5-V low-dropout regulator, which can deliver up to 50 mA. C4 is used as the output filter capacitor.

All that is necessary to generate the -5-V output voltage is to invert the +5-V voltage. This is done by a clocked power-MOS circuit that first charges capacitor C2, which is connected between pins 8 and 9, and then reverses its polarity. This chopped voltage must be filtered by C5 at the output. The unregulated -5 V output can supply up to 15 mA.

The LM 2685 voltage converter IC also has a chip-enable input (CE) and two control inputs, SDP (shut down positive) and SDN (shut down negative). If CE is set Low, the entire IC is switched off (shut down), and its current consumption drops to typically 6 μA. The CE input can thus be used to switch the



connected circuit on or off, without having to disconnect the battery.

The SDP and SDN inputs can be used to switch the  $V_{PSW}$  and  $V_{NSW}$  outputs, respectively. These two pins are connected to the voltage outputs via two low-resistance CMOS switches. This allows the negative output to be separately switched off, whereby the voltage inverter is also switched off. Switching off with SDP not only opens the output switch but also stops the oscillator. There is thus no longer any input voltage for the -5 V inverter, so the -5 V output also drops out. The SDP and SDN inputs are set Low (< 0.8 V) for normal operation and High (> 2.4 V) for switching off the associated voltage(s).

## SUMMER CIRCUITS COLLECTION

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The positive output of the LM 2865 is short-circuit proof. However, a short circuit between the positive and negative outputs must always be avoided. The IC is protected against thermal destruction by an overtemperature monitor. It switches off automatically at a chip temperature of around 150 °C.

The full type number of the IC is LM 2685MTC. It comes in a TSSOP14 SMD package. National Semiconductor can be found on the Internet under *www.national.com*.

(004045-1)

## W. van Ooijen

JAL stands for 'Just Another Language', and it is a programming language similar to Pascal for the PIC 16C84, PIC 16F84, Scenix SX18 and Scenix SX28. The author is not a fan of C. He found it easier to write his own programming language, which meets his needs and preferences, and which in addition better matches the features (or lack thereof) of the microprocessors in question. You can read more about this language in the summary and examples in the on-line manual. There is also a FAQ section. Anyone who does not have experience working with a compiler for the PIC family will find good advice under '16x84 assignments'. You can find all of this, as well as compilers for DOS, Windows and Linux (all gratis), at the Internet site [www.xs4all.nl/~wf/wouter/pic/jal/](http://www.xs4all.nl/~wf/wouter/pic/jal/).

A small sample program that causes a LED to blink gives an impression of the language:

```
[1] - flash a LED on pin A0
[2] include 16f84_10
[3] include jlib
[4] pin_a0_direction = output
[5] forever loop
[6] pin_a0 = on
[7] delay_1s
[8] pin_a0 = off
[9] delay_1s
[10] end loop
```

The line numbers are not necessary; they have only been added for reference. In addition, there are a number of libraries available with routines such as pic I/O, delays, i2c, asych, random, hd44780 (LC display), I/O extensions, math and so on.

(004096-1)

The screenshot shows a Netscape browser window titled "JAL manual - contents - Netscape". The address bar contains the URL "http://www.xs4all.nl/~wf/wouter/pic/jal/doc/manual.html". The main content area displays the title "JAL manual - contents" and a list of links for navigation: "previous up next". Below this is a table of contents with the following items:

- [introduction](#)
- [language](#)
  - [basics](#)
  - [types](#)
  - [literals](#)
  - [constants](#)
  - [variables](#)
  - [expressions](#)
  - [statements](#)
  - [subprograms](#)
  - [pragmas](#)
- [compiler](#)
- [code generation](#)
- [libraries](#)
  - [target specification files](#)
  - [jlib \( jpic, jascii, jdelay, jseven, jstepper, jprint \)](#)
  - [interval](#)
  - [hd447804, hd447808](#)
  - [i2c](#)
  - [lm75](#)
  - [serial](#)
  - [random3](#)
  - [cio](#)
- [summary](#)
- [examples](#)
- [quick reference](#)
- [16x84](#)
- [SX](#)
- [release notes](#)

At the bottom of the page, there are more navigation links: "previous up next". The browser's status bar at the bottom shows "Document: Done".

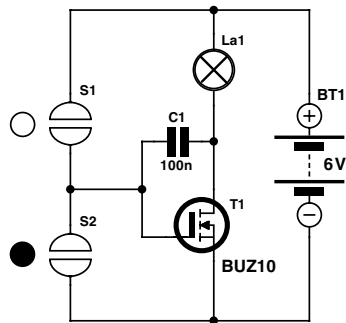
## 019

# Simple Touch Pad Dimmer

**B. Kainka**

Using a Power-FET it is possible to build a very simple touch dimmer for low voltage lamps. Two drawing pins are used here as the touch contacts. The electrical resistance of your skin is in the order of 100 k $\Omega$  to 1 M $\Omega$ . The circuit operates as an integrator with a capacitor in its negative feedback path. This configuration gives a relatively linear control characteristic. Once you have selected a brightness level, it will be maintained for hours if you use a low leakage (foil) capacitor. Another feature of this circuit is that the harder you press on the contacts, the quicker the lamp brightness changes.

(004037)



004037 - 11

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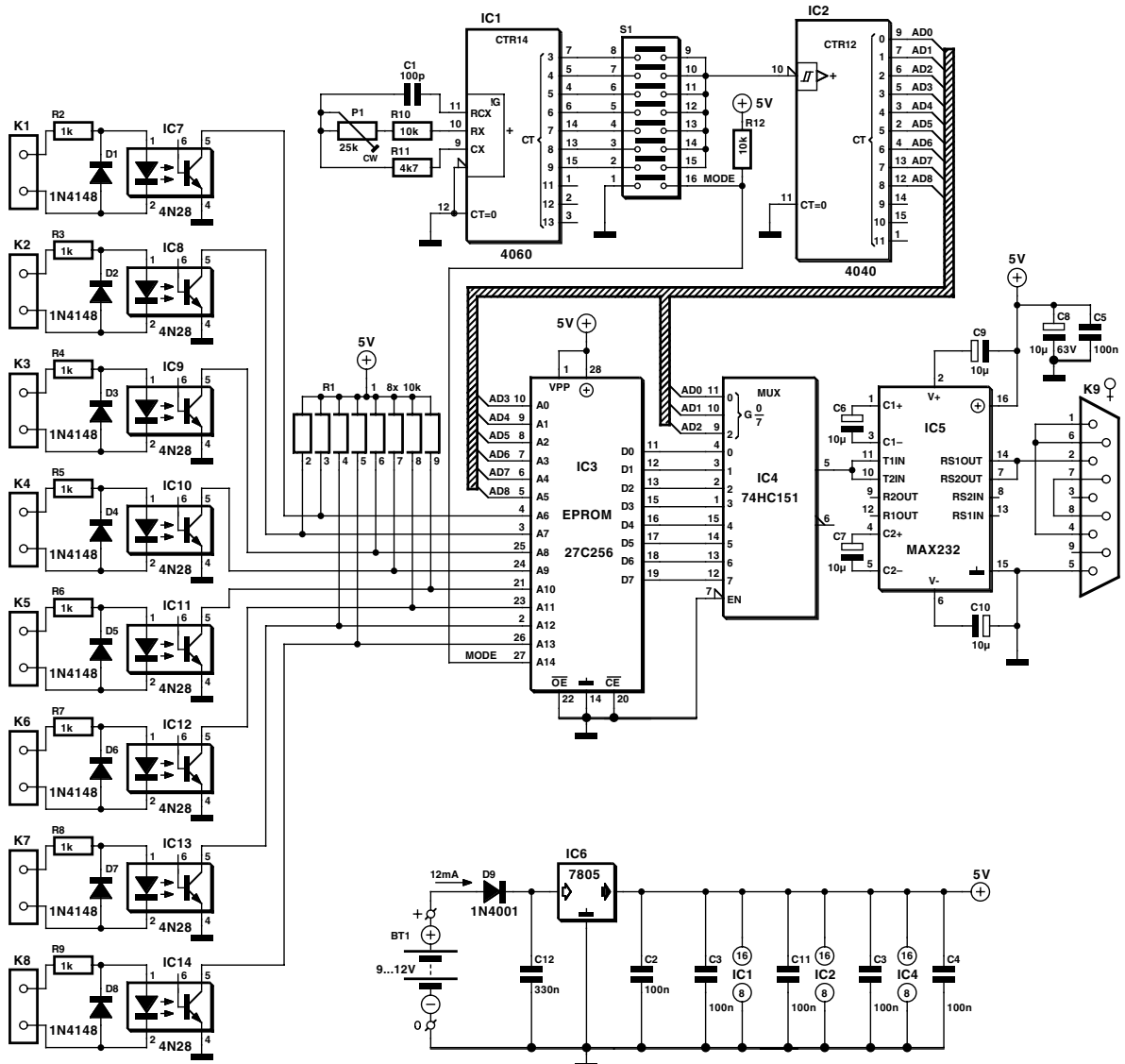
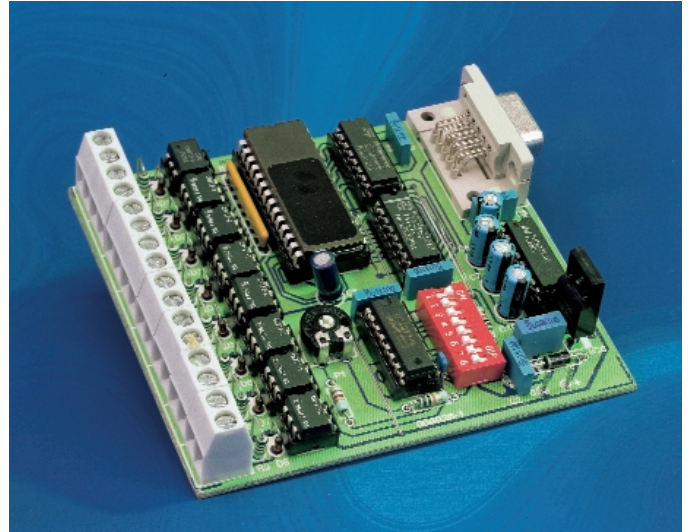
# 8 Channel D/I Card for RS232

G. Vastianos

The author is a student at the Electronics Department, Technological Educational Institute of Piraeus, Greece.

This project is a card with eight optically isolated TTL-compatible inputs for external connection to the serial port, which communicates through the RS-232 protocol. On this card you will look in vain for a UART or microcontroller chip because the design is based on a 27C256 EPROM.

Each digital input is connected to an optocoupler (IC7-IC14) through a resistor (R2-R9), and drives it with a current of 5 mA when the input voltage is 5 Vdc. A diode (D1-D8) is connected in parallel with each optocoupler input to protect against the ill effects of reversed signal polarity. The collectors of the internal optocoupler transistors drive EPROM address lines A6 to A13. The logic states of A6 to A13 are inverted (because the optocouplers work as inverters) and for this reason a second inversion is performed in software (EPROM) to cancel the total inver-



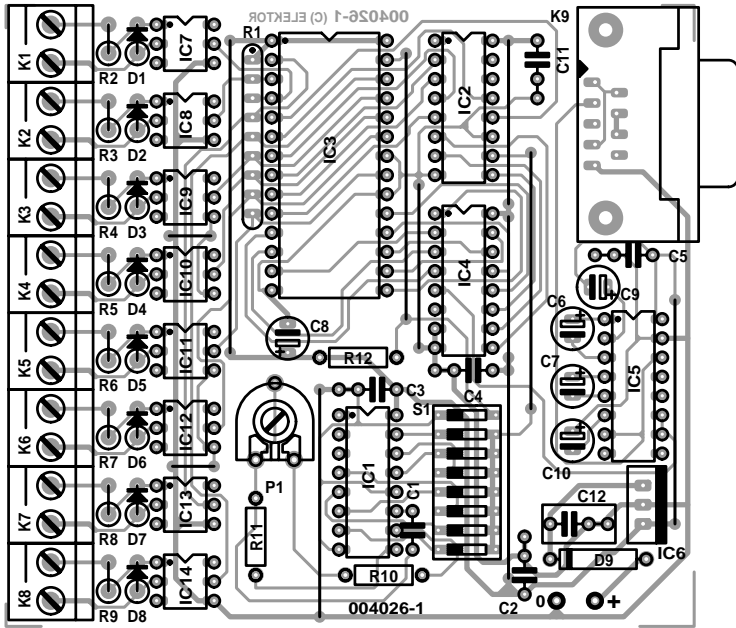
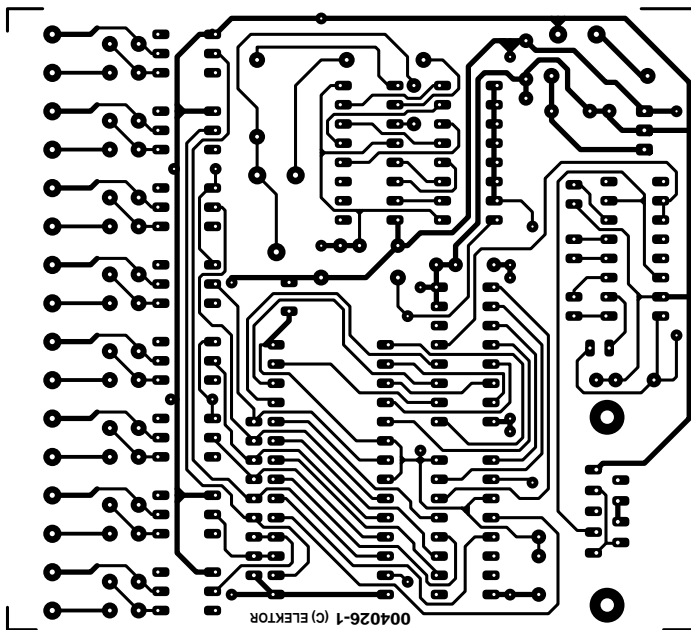


Table 1. ASCII Codes & bit values

CHAR	ASCII	D7	D6	D5	D4	D3	D2	D1	D0
CR	13	0	0	0	0	1	1	0	1
LF	10	0	0	0	0	1	0	1	0
'C'	67	0	1	0	0	0	0	1	1
'H'	72	0	1	0	0	1	0	0	0
'0'	48	0	0	1	1	0	0	0	0
'1'	49	0	0	1	1	0	0	0	1
'2'	50	0	0	1	1	0	0	1	0
'3'	51	0	0	1	1	0	0	1	1
'4'	52	0	0	1	1	0	1	0	0
'5'	53	0	0	1	1	0	1	0	1
'6'	54	0	0	1	1	0	1	1	0
'7'	55	0	0	1	1	0	1	1	1
':'	58	0	0	1	1	1	0	1	0
SP	32	0	0	1	0	0	0	0	0
SYNC	255	1	1	1	1	1	1	1	1



## COMPONENTS LIST

### Resistors:

R1 = 10kΩ 8-way SIL array  
 R2-R9 = 1kΩ  
 R10,R12 = 10kΩ  
 R11 = 4kΩ  
 P1 = 25kΩ preset H

### Capacitors:

C1 = 100pF  
 C2-C5,C11 = 100nF  
 C6-C10 = 10 μF radial  
 C12 = 330nF

### Semiconductors:

D1-D8 = 1N4148  
 D9 = 1N4001  
 IC1 = 4060  
 IC2 = 4040  
 IC3 = 27C256 (see text for programming)  
 IC4 = 74HC151  
 IC5 = MAX232  
 IC6 = 7805  
 IC7-IC14 = 4N28 of CNY17-2

### Miscellaneous:

K1-K8 = 2-way PCB terminal block, raster 5mm  
 K9 = 9-way sub-D socket (female), PCB mount  
 S1 = 8-way DIP switch

sion effect. In this way the 8 inputs become TTL compatible.

IC1, a CD4060, with the help of C1, P1, R11 and R10, forms a bitrate generator for 150, 300, 600, 1200, 2400, 4800 or 9600 bps. Preset P1 needs to be adjusted to the desired baudrate — an accuracy of 1-2% is required! The bitrate is selected using DIP switch S1. The CD4040 works as a 9-bit binary counter. The three LS bits of the counter outputs (AD0, AD1, AD2) drive the selection inputs of multiplexer IC4 (74HC151). The other counter bits (AD3-AD8) drive the LS address bits of the EPROM (A0-A5). The highest EPROM address line, A14, is connected to one of the DIP switches in S1 which defines the data transmission mode (TTY or BIN). With the above connections counter IC2 sweeps a range of 512 bits (64 bytes) of the total of 256 kBits (32 Kbytes) contained in the EPROM.

The number of 512-bit blocks (packets) equals the number of different combinations of CH0 to CH7 and MODE, and can be calculated from the following formula :

$$\begin{aligned} \text{Memory}_{\text{size}} &= 512 \text{ packets} * 512 \text{ bits/packet} \\ &= 256 \text{ Kbits} = 32 \text{ Kbytes} \end{aligned}$$

The data encoding unit consisting of IC1- IC4 transmits 512-bits packets (coming from the multiplexer output). The data in the transmitted packet depends directly on the logic states of lines CH0 to CH7 and MODE.

The power supply includes a 7805 regulator so that the card will not need a separate regulated power supply. Circuit IC5 (a MAX232) works as an RS232 Driver/Receiver, converting the multiplexer' s output data from TTL to RS232 compatible.

With the EPROM programmed with the right data, the circuit will produce messages (packets), through the RS-232 protocol, that will inform us for the logic states of the card's inputs. The transmission used by this card is **8 data bits, 1 stop bit and no parity**. Assuming an 'A' is to be sent, and that your PC runs a terminal simulation program receiving (via the RXD pin of its serial port) the following 10 bits '0100000101', then it will print on its screen the character 'A'.

This card transmits the logic states of its inputs in one of two modes, TTY (teletype) or BIN (binary).

In **TTY Mode**, the card transmits the following message to the computer:

```
<SYNC>,<SYNC>,<CR>,<LF>,'CH0:X',<SP>,'CH1:X',
<SP>,'CH2:X',<SP>,'CH3:X',<SP>,
'CH4:X',<SP>,'CH5:X',<SP>,'CH6:X',<SP>,'CH7:X'
```

Where <SYNC> is the character with ASCII code 255, used to synchronize the computer. Reception of this character (from the computer) causes a space to appear on the screen. <CR> and <LF> are 'carriage return' and 'line feed' with ASCII codes 13 and 10 respectively, and <SP> is the 'space' character with ASCII code 32. Reception of this character (from the computer) causes a space to appear on the screen. Finally, X is the logic state of each input, which will cause a '1' or a '0' to appear on the screen.

In **BIN Mode**, the card transmits the following message to the computer:

```
<SYNC>,<SYNC>,<DATA BYTE>
```

Where <SYNC> is as above and <DATA BYTE> is the character with an ASCII code equal to the numerical value of the byte built from the logic states of the inputs (with the MS Bit

representing CH7, and LS Bit, CH0).

These two modes are used in different cases. In cases where we want just to see the logic states of the input we just set the card in TTY mode and we use a terminal program as Telix, Procomm Plus, Hyper Terminal etc. In cases where we want to do some data logging or to compose a data acquisition & control system with other DAQ & control cards then we just set the card in BIN mode (because the decoding of the data is easier done by dedicated software).

The characters, their ASCII codes and their bit values, as used in the two modes are shown in **Table 1**. The bitstreams that must be transmitted for each character appear in **Table 2**.

The contents of the EPROM are created by a program (EPROMFMP.BAS) developed in Quick Basic, which is available from the author's website. The program first makes a temporary file that contains all data to be written in the EPROM in bit format (08DICARD.TMP). Next, it converts this file into byte format (08DICARD.BIN) and deletes the temporary file. Finally, it runs an external program (BIN2HEX.EXE) and adapts the file from Binary to IntelHex format (08DICARD.HEX). To program your own EPROM, you may use 08DICARD.BIN or 08DICARD.HEX file.

Finally, the mode and bit rate selection on S1 is shown in **Table 3**. The PCB designed for this project is unfortunately not available ready-made through the Publishers' Readers Services.

All software you will need to complete this project may be downloaded free of charge from the author's website at <http://members.xoom.com/robofreak/download/08dicard.htm> Also, for other projects developed by Mr. Vastianos, visit this address:

<http://members.xoom.com/robofreak/>

(004026-1)

**Table 2. Character composition**

CHAR	START BIT	D0	D1	D2	D3	D4	D5	D6	D7	STOP BIT
CR	0	1	0	1	1	0	0	0	0	1
LF	0	0	1	0	1	0	0	0	0	1
'C'	0	1	1	0	0	0	0	1	0	1
'H'	0	0	0	0	1	0	0	1	0	1
'0'	0	0	0	0	0	1	1	0	0	1
'1'	0	1	0	0	0	1	1	0	0	1
'2'	0	0	1	0	0	1	1	0	0	1
'3'	0	1	1	0	0	1	1	0	0	1
'4'	0	0	0	1	0	1	1	0	0	1
'5'	0	1	0	1	0	1	1	0	0	1
'6'	0	0	1	1	0	1	1	0	0	1
'7'	0	1	1	1	0	1	1	0	0	1
':'	0	0	1	0	1	1	1	0	0	1
SP	0	0	0	0	0	0	1	0	0	1
SYNC	0	1	1	1	1	1	1	1	1	1

**Table 3. DIP switch settings**

		SW 1								USAGE
#1	#2	#3	#4	#5	#6	#7	#8	MODE		
OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	"150, 8, 1, N : BIN"		
OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	"300, 8, 1, N : BIN"		
OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	"600, 8, 1, N : BIN"		
OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	"1200, 8, 1, N : BIN"		
OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	"2400, 8, 1, N : BIN"		
OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	"4800, 8, 1, N : BIN"		
OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	"9600, 8, 1, N : BIN"		
ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	"150, 8, 1, N : TTY"		
ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	"300, 8, 1, N : TTY"		
ON	OFF	OFF	ON	OFF	OFF	OFF	OFF	"600, 8, 1, N : TTY"		
ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	"1200, 8, 1, N : TTY"		
ON	OFF	OFF	OFF	OFF	ON	OFF	OFF	"2400, 8, 1, N : TTY"		
ON	OFF	OFF	OFF	OFF	OFF	ON	OFF	"4800, 8, 1, N : TTY"		
ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	"9600, 8, 1, N : TTY"		



021

# PC 12-V Adapter

T. Giesberts

This circuit can replace small mains adapters in the vicinity of the computer. This is particularly handy for devices that need a 12-V supply, such as active PC loudspeakers. The necessary 12-V supply voltage is taken directly from the PC power supply. In order to protect the PC supply against possible short circuits, and especially to prevent the PC from being crashed, a current limiting circuit is connected in series with the 12-V supply. This regulator consists of only four resistors, two transistors and HF decoupling.

The circuit works very simply. MOSFET T2 is normally driven fully on via R4, so that the 12-V potential from the PC power supply appears at the output. The current through R1 produces a voltage drop, which at a certain current level will cause T1 to start to conduct. This in turn 'pinches off' T2 somewhat, so that less output current is supplied. In order to minimise the voltage drop across R1, a bias voltage is applied to the base-emitter junction of T1 via R2 and R3. The current limiting value can thus be easily set by adjusting the value of R2. With the given component values, the maximum output current is more than 2.5 A (see Table 1). The circuit itself draws at least 1 mA, which rises to over 3 mA with a short circuit (excluding the load current). An IRF9540 is used for the P-channel MOSFET T2, due to its low  $R_{DS(on)}$  of 0.15  $\Omega$  (typical). Any desired type of power MOSFET can be used, as long as it can handle the maximum dissipation of 30 W.

For your convenience, we have also made a circuit board layout for the regulator. The outputs are a row of three adapter plugs. Everything fits behind the punchout for a 25-pin sub-D connector, which is present in nearly every PC. The mounting holes of the circuit board have the same separation as the mounting holes for a 25-pin sub-D connector. The board can easily be fixed in place using two small angle brackets.

The dissipation of FET T2 can easily be quite significant – around 30 W in case of a short circuit! This means that a heat sink must be used for T2. In theory, a heat sink with a thermal coefficient of around 2 K/W is needed for a continuous short circuit, but in practice you can manage with a thick piece of aluminium angle stock (3 to 4 mm thick) fixed to the PC enclosure. Don't forget that T2 must be well insulated electrically, since its case is connected to the drain and thus to 12 V!

The PCB shown here is not available ready-made through the Publishers Readers Services.

(004017-1)

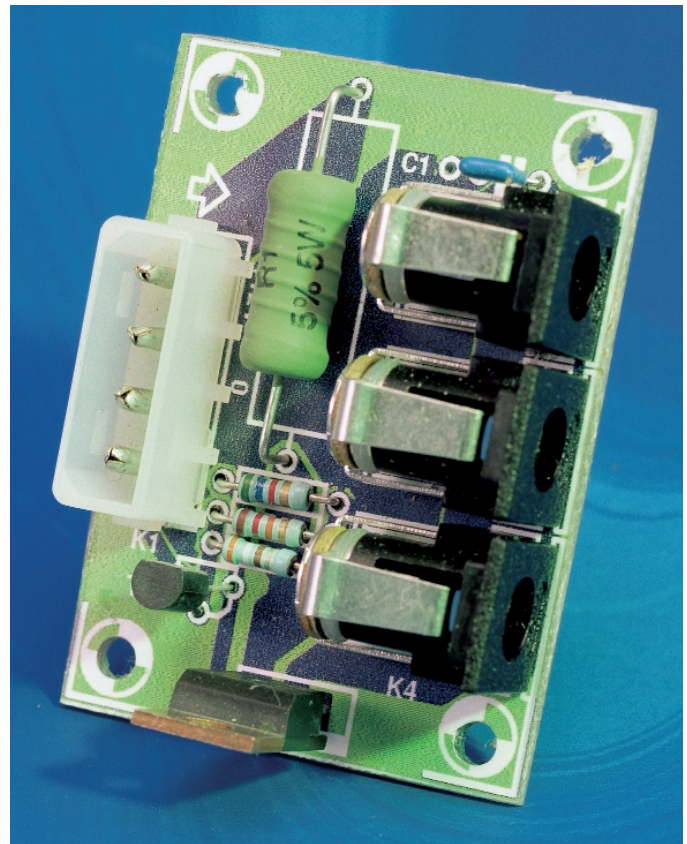
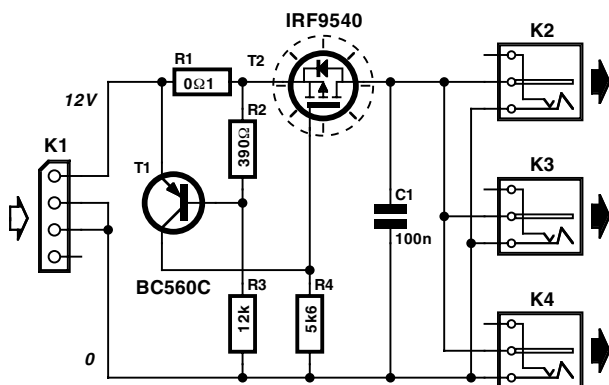


Table 1. Output voltage vs output current

Output load (W)	Voltage (V)	Current (A)
open	12	0
22	11.8	0.54
6.8	11.4	1.68
4.7	11.0	2.34
3.3	8.6	2.6
2.2	5.7	2.6
0	0	2.6



004017 - 11

COMPONENTS LIST

Resistors:

- R1 = 0 $\Omega$ 1 5W
- R2 = 390  $\Omega$
- R3 = 12k $\Omega$
- R4 = 5k6

Capacitors:

- C1 = 100nF ceramic

Semiconductors:

- T1 = BC560C
- T2 = IRF9540 (see text)

Miscellaneous:

- K1 = 4-way PC-supply plug, PCB mount (Farnell)
- K2,K3,K4 = mains adaptor plug, PCB mount

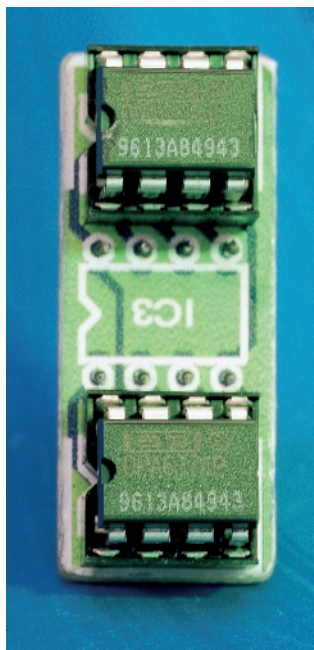
022

# 2 × single = 1 × dual

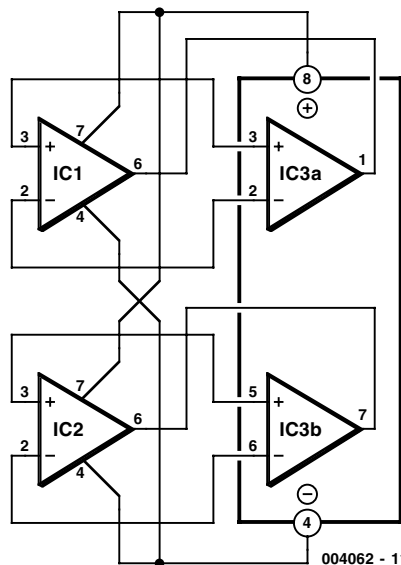
**T. Giesberts**

There are many more types of single opamps available than dual or quad versions. Not only can it sometimes be interesting to replace a dual opamp by two equivalent single opamps, it also allows the use of two completely different types of opamp, depending on the application. One example is the combination of the DAC and output filter of a CD player. A dual opamp is sometimes used here, although a fast linear amplifier is needed for the current-to-voltage converter, while a good low-noise opamp is more suitable for the output filter.

It's fairly easy to replace a dual opamp if you use one of the accompanying printed circuit boards. The schematic

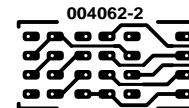
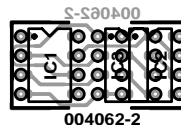
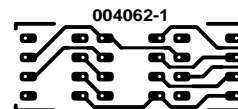
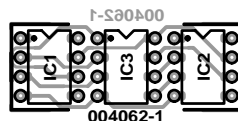


shows the connections between the two single opamps and the pin locations of the dual package. First solder eight short pieces of wire to the circuit board in the dual package location. After you have fitted the single opamps (with sockets if desired), solder these wires in place of the dual opamp. Pay careful attention to the orientation. Two layout versions are shown here. The larger one has better channel separation but takes up more space, while the other one is a lot more compact. With the larger board, the leads will probably have to be reasonably long, depending on the height of the surrounding components. This slightly increases the likelihood of interference. A third version is possible, using two small, separate printed circuit boards, with the ICs mounted back-to-back. In this case, however, the power supply leads would have to be connected between the two boards using wire bridges.

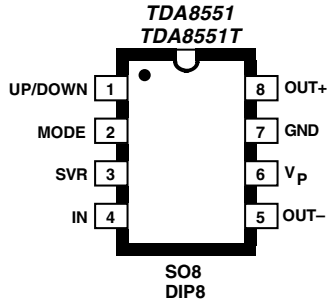


The PCB shown here is unfortunately not available ready-made through the Publishers' Readers Services.

(004062-1)



# AF Amplifier with Up/Down Volume Setting



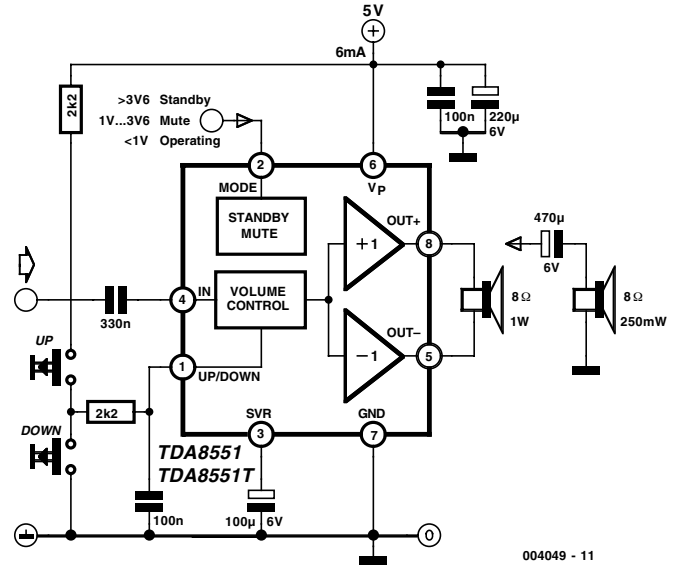
## G. Kleine

The Philips Semiconductors TDA8551 is a small audio amplifier with an integrated volume control. When operated from +5 V, it delivers a nominal output power of more than one watt into 8 ohms. It can also be used over a supply voltage range of +2.7 to +5.5 V, with correspondingly reduced output power. The output volume can be adjusted from -60 dB to +20 dB in 64 steps, using a set of up and down pushbuttons. The shared UP/DOWN input for the up and down switches has three states. If it is 'floating', which means that both of the switches are open, the volume remains unchanged. A pulse to earth decreases the volume by 1.25 dB, while a positive pulse increases the volume by 1.25 dB. When the power is switched on, the internal counter takes on the -20 dB setting.

An additional input (MODE) allows the amplifier to be switched from the operating state to the mute or standby state. If this input is held at the earth level, the amplifier is operational. If +5 V is applied to this pin, the TDA8551 enters the Standby mode, in which the current consumption drops from the typical operational level of 6 mA to less than 10  $\mu\text{A}$ . Finally, the MODE input can be used as a mute input by applying a voltage of 1 to 3.6 V to this input. This voltage can be provided by a connection to the SCR pin, which lies at half of the operating voltage and to which a filter capacitor is connected.

The loudspeaker is connected in a floating configuration between the two outputs of the bridge amplifier in the TDA8551. This provides the desired output power level, in spite of the low supply voltage. For headphone applications, which do not need as much output power, you can connect the headphone between earth and one of the outputs, via an electrolytic coupling capacitor. You can make a stereo headphone amplifier in this way, using two TDA8551 ICs.

The TDA8551 is housed in a DIP8 package. The SMD version is the TDA8551T, in an SO8 package. The datasheet can be obtained from [www.semiconductors.philips.com](http://www.semiconductors.philips.com).



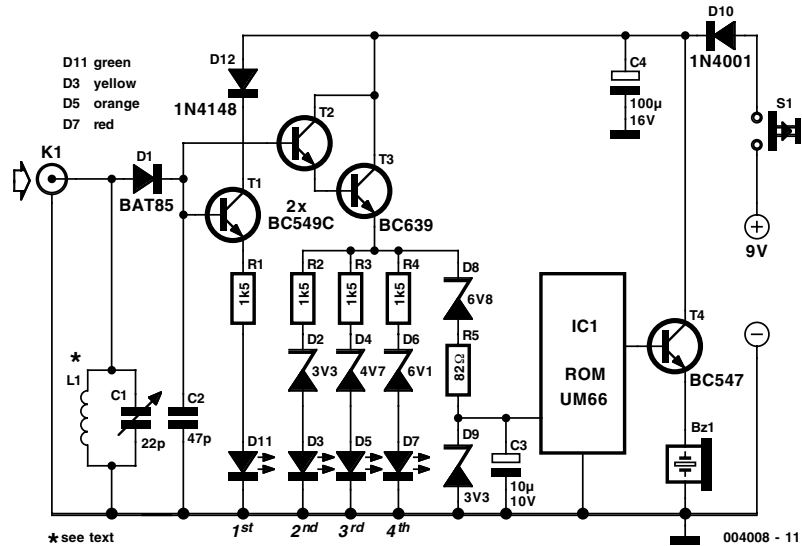
## N.S. Harisankar VU3NSH

This simple circuit helps you sniff out RF radiation leaking from your transmitter, improper joints, a broken cable or equipment with poor RF shielding. The tester is designed for the 2-m amateur radio band (144-146 MHz in Europe).

The instrument has a 4-step LED readout and an audible alarm for high radiation voltages. The RF signal is picked up by an antenna and made to resonate by C1-L1. After rectifying by diode D1, the signal is fed to a two-transistor high-gain Darlington amplifier, T2-T3. Assuming that a 10-inch telescopic antenna is used, the RF level scale set up for the LEDs is as follows:

When all LEDs light, the (optional) UM66 sound/melody generator chip (IC1) is also actuated and supplies an audible alarm. By changing the values of zener diodes D2, D4, D6 and D8, the step size and span of the instrument may be changed as required. For operation in other ham or PMR bands, simply change the resonant network C1-L1.

As an example, a 5-watt handheld transceiver fitted with a



LED	approx. RF e.m.f.
D1	>1 V
D3	>2 V
D5	>3 V
D7	>4 V
All	>7 V

half-wave telescopic antenna ( $G = 3.5$  dBd), will produce an ERP (effective radiated power) of almost 10 watts and an e.m.f. of more than 8 volts close to your head.

Inductor L1 consists of 2.5 turns of 20 SWG (approx. 1 mm dia) enamelled copper wire. The inside diameter is about 7 mm and no core is used. The associated trimmer capacitor C1 is tuned for the highest number of LEDs to light at a relatively low fieldstrength put up by a 2-m transceiver transmitting at 145 MHz.

The tester is powered by a 9-V battery and draws about 15 mA when all LEDs are on. It should be enclosed in a metal case.

(004008-1)

025

# Max. Temp. Detector for Fan controller

T. Giesberts

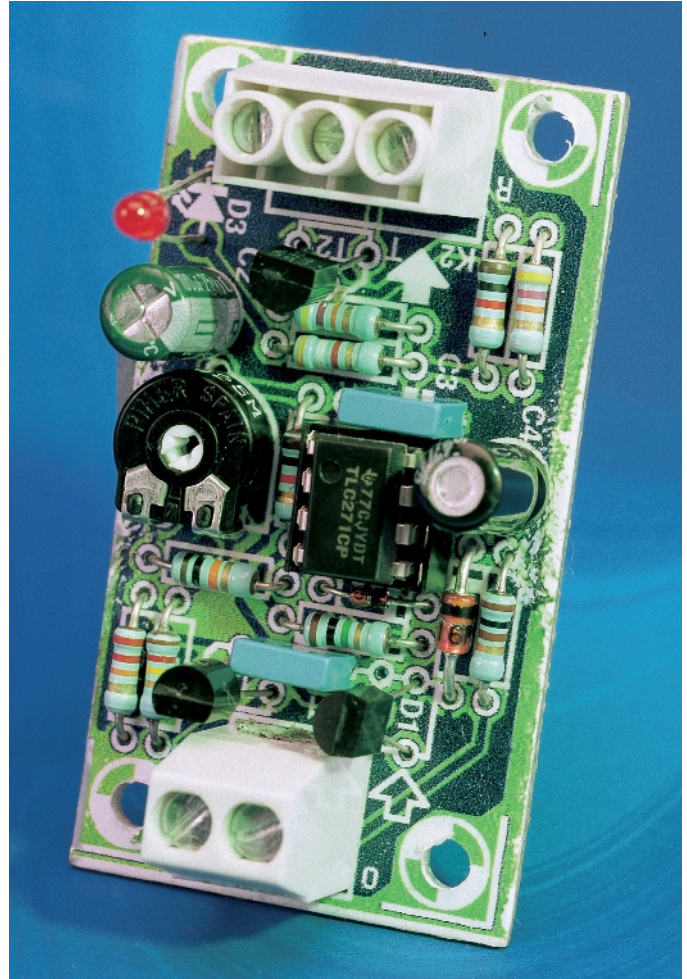
The fan controller circuit for the Titan 2000 and other AF heavy-duty power amplifiers, published in the May 1999 issue, has an output that sets a voltage if the fan controller reaches the end of its range. Since the controller responds to temperature, this signal is seen by the amplifier protection circuitry as an overtemperature indication. The disadvantage of this output is that the maximum voltage for the fans is not constant, but depends on the load (number of fans, defective fans) and the mains voltage. This variation is caused by the fact that the supply voltage for the output stage is taken directly from the filtered transformer voltage. If the fans should fail, for example, the maximum temperature limit would lie at a considerably higher level than the desired value. The accompanying circuit, which compares the magnitude of the fan voltage to a fixed reference value, has been developed to allow the maximum temperature to be reliably detected. This circuit is tailored for 12-V fans.

The reference voltage is generated by the 'micropower voltage reference' D1 and the FET T1, which is wired as a current source. These components are powered directly from the applied fan voltage. The current source is set up to deliver approximately 50  $\mu$ A. D1 can work with as little as 10  $\mu$ A. The supply voltage for the IC is decoupled by R10, C3 and C4, with D4 providing overvoltage protection. A maximum supply voltage of 16 V is specified for the TLC271. This opamp works with a supply voltage as low as 3 V and can handle a common-mode voltage up to approximately 1.5 V less than the positive supply voltage. Accordingly, 1.2 V has been chosen for the reference voltage. The fan voltage is reduced to the level of the reference voltage by the voltage divider R2-R3-P1. The limits now lie at 11.2 V and 16.7 V. If you find these values too high, you can reduce R2 to 100 k $\Omega$ , which will shift the limits to 9.5 V and 14.2 V.

The output of the voltage divider is well decoupled by C2. A relatively large time constant was selected here to prevent the circuit from reacting too quickly, and to hold the output active for a bit longer after the comparator switches states. A small amount of hysteresis (around 1 mV) is added by R4 and R5, to prevent instability when the comparator switches. D2 ensures that the magnitude of the hysteresis is independent of the supply voltage.

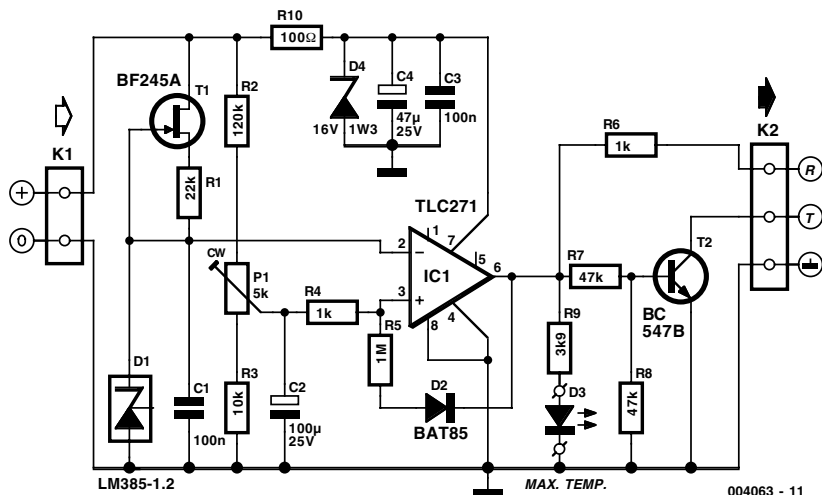
Two outputs have been provided to make the circuit more versatile. Output 'R' is intended to directly drive the LED of an optocoupler. In addition, transistor T2 is switched on by the output of the opamp via R7 and R8, so that a relay can be actuated or a protection circuit triggered using the 'T' output. The high-efficiency LED D3 indicates that IC1 has switched. It can be used as a new 'maximum' temperature' indicator when this circuit is added to the fan controller of the May 1999 issue.

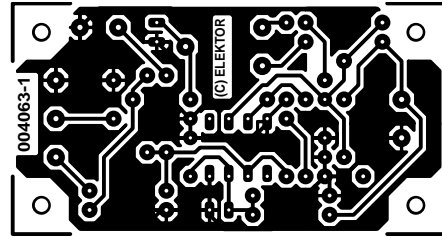
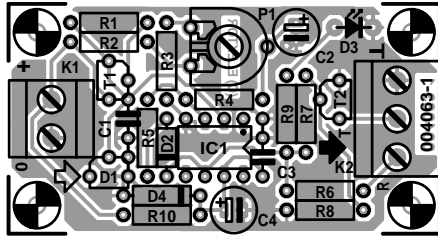
The circuit draws only 0.25 mA when the LED is out,



and the measured no-load current consumption (with a 12.5-V supply voltage) is 2.7 mA when the LED is on. The PCB shown here is unfortunately not available ready-made through the Publishers' Readers Services.

(004063-1)





## COMPONENTS LIST

### Resistors:

R1 = 22k $\Omega$   
 R2 = 120k $\Omega$   
 R3 = 10k $\Omega$   
 R4,R6 = 1k $\Omega$   
 R5 = 1M $\Omega$   
 R7,R8 = 47k $\Omega$

R9 = 3k $\Omega$   
 R10 = 100 $\Omega$   
 P1 = 5k $\Omega$  preset

### Capacitors:

C1,C3 = 100nF  
 C2 = 100 $\mu$ F 25V radial  
 C4 = 47 $\mu$ F 25V radial

### Semiconductors:

D1 = LM385-1.2  
 D2 = BAT85  
 D3 = high-efficiency-LED  
 D4 = zener diode 16V/1W3  
 T1 = BF245A  
 T2 = BC547B  
 IC1 = TLC271CP

### Miscellaneous:

K1 = 2-way PCB terminal block,  
 raster 5mm  
 K2 = 3-way PCB terminal block,  
 raster 5mm

**026**

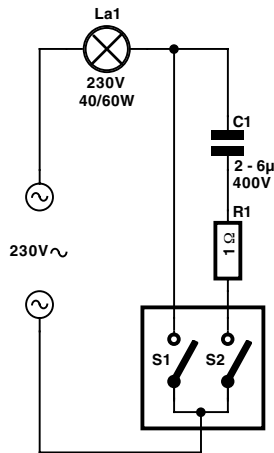
# Two-Position Dimmer

**G. Baars**

This super-simple dimmer consists of only two components, and it can easily be built into a mains switch. If you do this, don't forget to first switch off the associated branch circuit in the fuse box, since the mains voltage is always dangerous!

The circuit does not need much explanation. When S1 is closed, the lamp works at full strength, and the position of S2 does not matter. When S1 is open and S2 is closed, the capacitor causes a voltage drop, so the lamp is dimmed. The power dissipation of the capacitor is practically zero, so the circuit does not generate any heat. The resistor prevents sparking when S2 is closed while S1 is already closed. The value of the capacitor can be matched to the power of the lamp to be dimmed; it should be between 2 and 6  $\mu\text{F}$ .

Be sure to use a class X2 capacitor. Also, don't forget that this circuit works only with resistive (non-inductive) loads. Unpredictable things can happen with an inductive load!



004077 - 11

(004077-1)



# 10 to 1000 MHz Oscillator

## G. Kleine

Nowadays, it is no longer necessary to use discrete components to build oscillators. Instead, many manufacturers provide ready-made voltage-controlled oscillator (VCO) ICs that need only a few frequency-determining external components. One example is the RF Micro Devices RF2506. This IC operates with a supply voltage between 2.7 and 3.6 V (3.3 V nominal) and provides a low-noise oscillator transistor with integrated DC bias setting. In addition, it has an isolating buffer amplifier that strongly reduces the effects of load variations (load pulling) on the oscillator. If a voltage less than 0.7 V is applied to the power-down input (pin 8), the oscillator is shut down and the current consumption drops from 9 mA to less

than 1  $\mu\text{A}$ . The VCO is enabled when the voltage on pin 8 is at least +3.0 V.

Connecting the feedback capacitors C1 and C2 to pins 3 (FDBK) and 4 (VTUNE) transforms the internal transistor into a Colpitts oscillator. A resonator is also needed; here this consists of C4 and L1, and it is coupled via C3. Keep the Q factor of the coil as high as possible (by using an air-core coil, for example), to ensure a low level of phase noise. Since most applications require a tuneable oscillator, the varicap diode D1 (BBY40, BBY51, BB804 etc) can be used to adjust the resonant frequency. The tuning voltage  $U_{\text{Tune}}$  is applied via a high resistance. The value of the tuning voltage naturally depends on the desired frequency range and the variable-capacitance

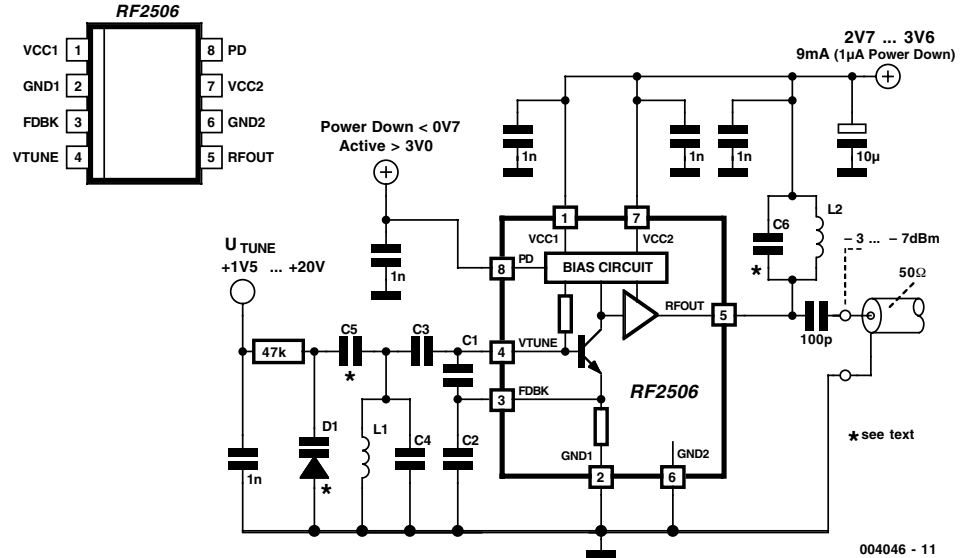
# SUMMER CIRCUITS COLLECTION

diode (D1) that is used. The table shows a number of suggestions for selecting the frequency-determining components.

If the frequency range is narrow, a parallel-resonant circuit should be connected between the output pin and  $+V_{CC}$ , to form the collector load for the output transistor. This can be built using the same components as the oscillator resonator. With a broadband VCO, use a HF choke instead, with a value of a few microhenries to a few nanohenries, depending on the frequency band. In this case C6 is not needed. The output level of this circuit is  $-3$  dBm with an LC load and  $-7$  dBm with a choke load.

The table that accompanies the schematic diagram provides rough indications of component values for various frequencies. It is intended to provide a starting point for experimentation. The coupling between the variable-capacitance diode and C5 determines the tuning range of the VCO. The manufacturer maintains an Internet site at [www.rfmd.com](http://www.rfmd.com), where you can find more information about this interesting oscillator IC.

(004046-1)



f in MHz	C1 in pF	C2 in pF	C3 in pF	C4, C6 in pF	L1, L2 in nH
50	47	47	1000	15	140
100	18	18	10	10	64
250	6.8	12	6.8	8.2	30
400	3.3	5.6	3.9	1.8	40

# 0 - 44 dB RF attenuator

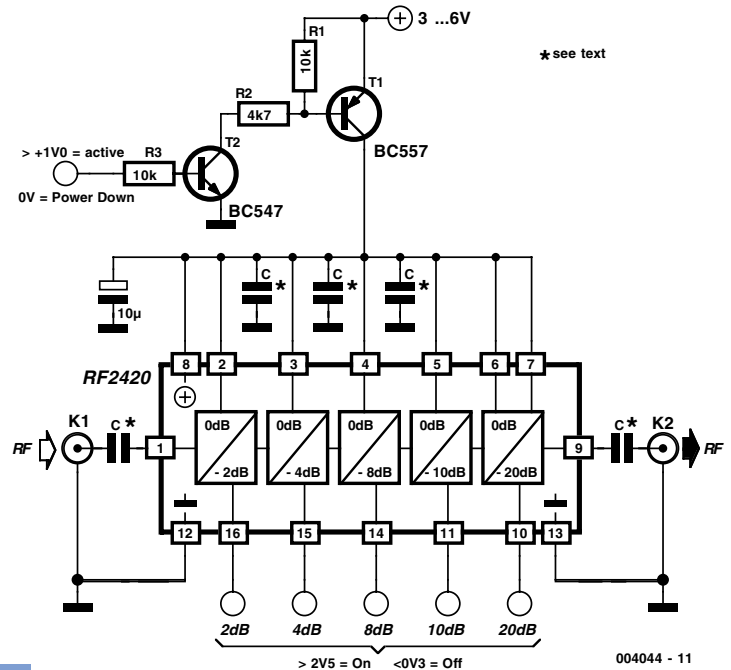
## G. Kleine

Anyone who has to reduce the amplitudes of RF signals in a controlled manner needs an attenuator. Linearly adjustable attenuation networks using special PIN diodes are available for this, but they require quite intricate control circuitry.

A simpler solution is to use an integrated attenuator that can be switched in steps. The RF 2420 is an IC built using gallium-arsenide (GaAs) technology, which works in the frequency range between 1 MHz and 950 MHz. It can thus be used as an attenuator for cable television signals, for example. The attenuation can be set between 0 and 44 dB in 2-dB steps. An insertion loss of 4 dB must also be taken into account. This base attenuation can be measured in the 0-dB setting, and it forms the reference point for switchable attenuation networks that provide 2, 4, 8, 10 and 20 dB of attenuation. These are all controlled by a set of 5 TTL inputs. The control signals must have Low levels below 0.3 V and High levels of at least +2.5 V. The RF 2420 works with a supply voltage between +3 V and +6 V, with a typical current consumption of 4 mA. A power-down mode, in which the current consumption drops to 0.8 mA, can be activated by removing power from the bussed  $V_{DD}$ -pins.

The sample circuit diagram for

f	C
≥ 1 MHz	10 nF
≥ 10 MHz	1 nF
≥ 100 MHz	100 pF



the RF 2420 shows that the only external components that are needed are decoupling capacitors. The coupling capacitors at the input and output determine the lower operating frequency

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limit. The table lists possible capacitor values. The input and output are matched to 50-ohm operation, but they can also be used with 75-ohm cables with a small increase in reflections.

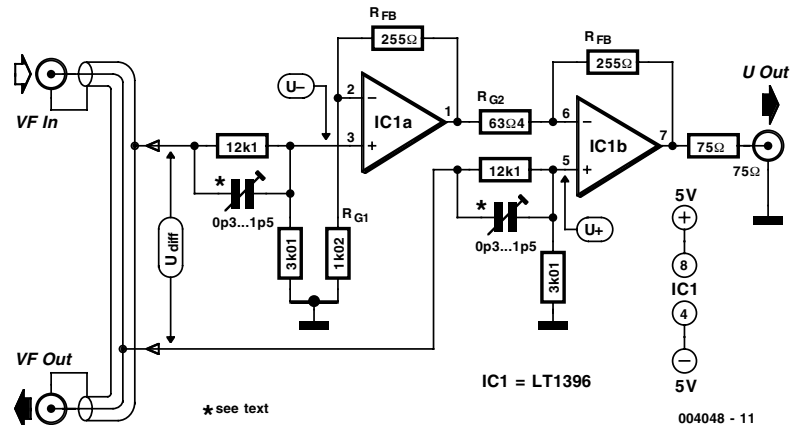
The RF 2420 is available in a 16-pin SOP-16 SMD package. Its data sheet can be found at [www.rfmd.com](http://www.rfmd.com).

(004044-1)

## G. Kleine

If you want to connect a video signal to several destinations, you need a distribution amplifier to match the 75-ohm video cable. A distribution amplifier terminates the incoming cable in 75 ohms and provides several outputs, each with 75-ohm output impedance. Since this is usually achieved by putting a 75-ohm series resistor in the output lead of each video opamp (current-feedback amplifier), the opamps must be set up for a gain of 2 in order to achieve an insertion gain of 1 (0 dB). The disadvantage of this arrangement is that if the amplifier or its power supply fails, no signal is available at any of the outputs.

This can be remedied by using a high input impedance amplifier, which can be tapped into a video line without having to have its own 75-ohm termination resistor. In order to eliminate hum interference and voltage differences between the cable screen and the circuit earth, the circuit exploits the common-mode rejection of the opamp. This can be optimised with resistor  $R_{G1}$ . With the indicated LT1396 video opamp, more than 40 dB of common-mode rejection can be achieved. The signal bandwidth of the circuit can be optimised using the trimpots. It reaches to more than 10 MHz, which is quite acceptable for



$$V_{OUT} = 1/2 \cdot G \cdot (V_{+} - K) = 1/10 \cdot G \cdot V_{DIFF}$$

$$R_{G1} = (G + 3)$$

$$R_{G2} = R_{FB} / (G + 3)$$

video signals.

Thanks to the high-impedance connection to the video line, the video signal is not affected when the power for the coupled amplifier is switched off. You can learn more about the LT1396 from its data sheet at <http://www.linear-tech.com>.

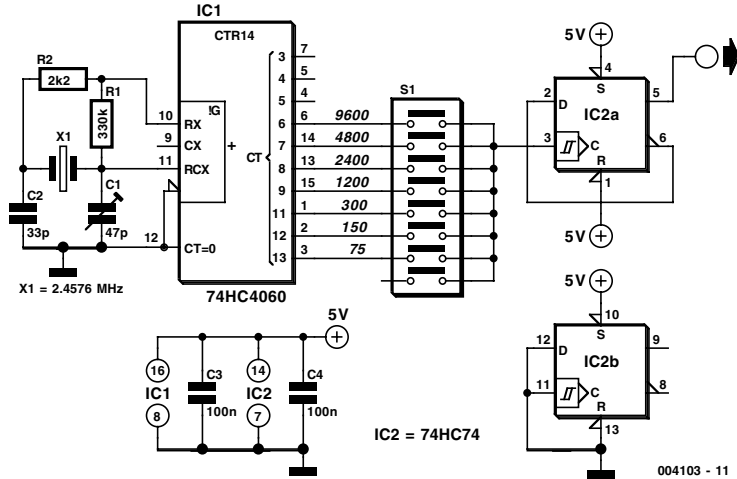
# 030

## Baud Rate Generator

**K. Walraven**

Elsewhere in this issue, an *RC* oscillator is used as a baud rate generator. If you can calibrate the frequency of such a circuit sufficiently accurately (within a few percent) using a frequency meter, it will work very well. However, it may well drift a bit after some time, and then.... Consequently, here we present a small crystal-controlled oscillator.

If you start with a crystal frequency of 2.45765 MHz and divide it by multiples of 2, you can very nicely obtain the



# SUMMER CIRCUITS COLLECTION

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well-known baud rates of 9600, 4800, 2400, 600, 300, 150 and 75. If you look closely at this series, you will see that 1200 baud is missing, since divider in the 4060 has no Q10 output! If you do not need 1200 baud, this is not a problem. However, seeing that 1200 baud is used in practice more often than 600 baud, we have put a divide-by-two stage in the circuit after the 4060, in the form of a 74HC74 flip-flop. This yields a similar series of

baud rates, in which 600 baud is missing. The trimmer is for the calibration purists; a 33 pF capacitor will usually provide sufficient accuracy.

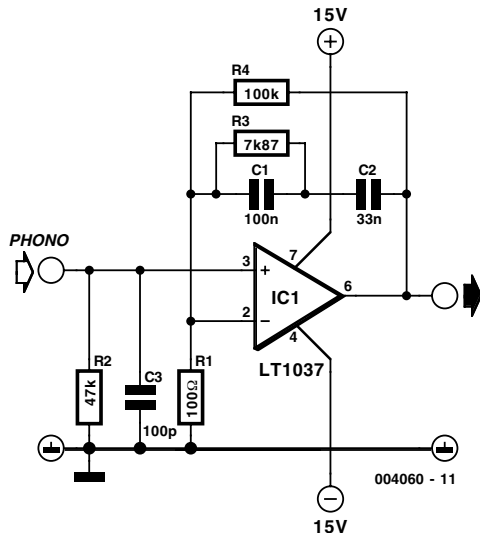
The current consumption of this circuit is very low (around 1 mA), thanks to the use of CMOS components.

(004103-1)

# Simple MD Cartridge Preamplifier

**H. Steeman**

Phonographs are gradually becoming a rarity. Most of them have had to yield to more advanced systems, such as CD players and recorders or (portable) MiniDisc player/recorders. This trend is recognised by manufacturers of audio installations, which means that the traditional phono input is missing on increasingly more systems. Hi-fi enthusiasts who want make digital versions of their existing collections of phonograph records on a CD or MD, discover that it is no longer possible to connect a phonograph to the system. However, with a limited amount of circuitry, it is possible to adapt the line input of a modern amplifier or recorder so that it can handle the low-level signals generated by the magnetodynamic cartridge of a phonograph. Of course, the circuit has to provide the well-known RIAA correction that must be used with these cartridges. The preamplifier shown here performs the job using only one opamp, four resistors and four capacitors. For a stereo version, you will naturally need two of everything. Any stabilised power supply that can deliver  $\pm 15\text{ V}$  can be used as a power source.





# High-Side Current Measurements

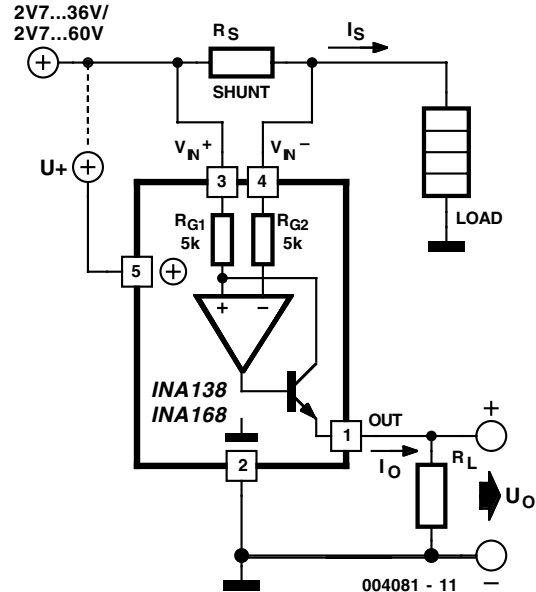
K. Walraven

(from a Burr-Brown application note)

It's always a bit difficult to measure the current in the positive lead of a power supply, such as a battery charger. Fortunately, special ICs have been developed for this purpose in the last few years, such as the Burr-Brown INA138 and INA168.

These ICs have special internal circuitry that allows their inputs to be connected directly to either end of a shunt resistor in the lead where the current is to be measured. The shunt is simply a low-value resistor, across which a voltage drop is measured whenever a current flows. This voltage is converted into an output current  $I_o$  by the IC. This current can be used directly, or it can be converted into a voltage by means of a load resistor  $R_L$ . In the latter case, the 'floating' measurement voltage across the shunt is converted into a voltage with respect to earth, which is easy to use.

The value of  $R_L$  determines the gain. A value of  $5\text{ k}\Omega$  gives  $1\times$ ,  $10\text{ k}\Omega$  gives  $2\times$ ,  $15\text{ k}\Omega$  gives  $3\times$  and so on. It all works as follows. Just like any opamp, this IC tries to maintain the same potential on its *internal* plus and minus inputs. The minus input is connected to the left-hand end of the shunt resistor via a  $5\text{-k}\Omega$  resistor. When a current flows through the shunt,



this voltage is thus lower than the voltage on the plus side. However, the voltage on the plus input can be reduced by allowing a small supplementary current to flow through T1. The IC thus allows T1 to conduct just enough to achieve the necessary lower voltage on the plus input. The current that is needed for this is equal to  $V_{\text{shunt}} / 5 \text{ k}\Omega$ . This transistor current leaves the IC via the output to which  $R_L$  is connected. If the value of  $R_L$  is  $5 \text{ k}\Omega$ , the resulting voltage is exactly the same as  $V_{\text{shunt}}$ .

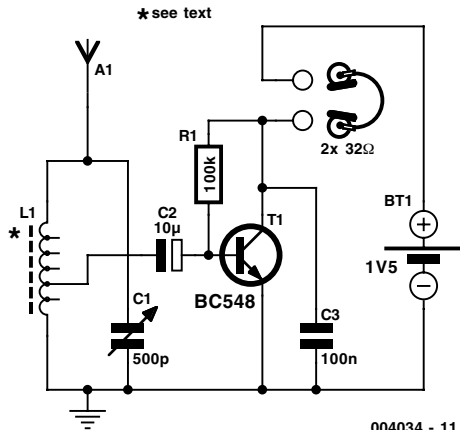
The IC is available in two versions. The INA138 can handle voltages between 2.7 and 36 V, while the INA168 can work up

to 60 V. The supply voltage on pin 5 may lie anywhere between these limits, regardless of the voltage on the inputs. This means that even with a supply voltage of only 5 V, you can make measurements with up to 60 V on the inputs! However, in most cases it is simplest to connect pin 5 directly to the voltage on pin 3. Bear in mind that the value of the supply voltage determines the maximum value of the output voltage. Also, don't forget the internal base-emitter junction voltage of T1 (0.7 V), and the voltage drop across the shunt also has to be subtracted.

# One Transistor Radio

## B. Kainka

Here is a simple circuit for a one transistor Audion type radio powered by a 1.5 V battery. It employs a set of standard low-impedance headphones with the headphone socket wired so that the two sides are connected in series thus giving an impedance of  $64 \Omega$ . The supply to the circuit also passes through the headphones so that unplugging the headphones turns off the supply. Using an Audion configuration means that the single transistor performs both demodulation and amplification of the signal. The sensitivity of this receiver is such that a 2 m length of wire is all that is needed as an antenna. The tap on the antenna coil is at  $1/5$ th of the total winding on the ferrite rod. For details of the antenna coil see the article *Diode Radio for Low Impedance Headphones*. This circuit is suitable for reception of all AM transmissions from longwave through to shortwave.



# Stepper Motor Generator

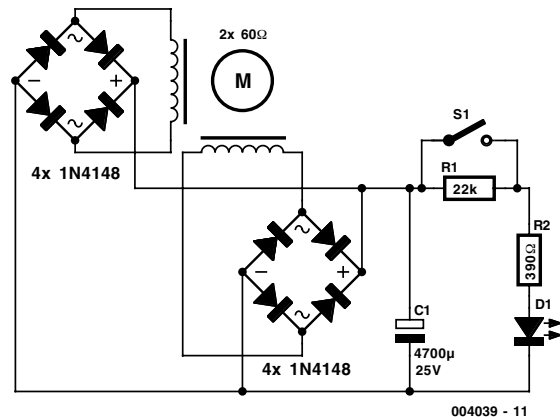
## B. Kainka

Any stepper motor can be used as a generator. In contrast to other generators, a stepper motor produces a large induced voltage even at low rotational speeds. The type used here, with a DC resistance of  $2 \times 60 \Omega$  per winding, can generate more than 20 V when turned by hand, without any gearing. The circuit diagram for a 'hand-cranked torch' shows how you can use a stepper motor as a generator.

A supplementary circuit stores the energy. Two bridge rectifiers, each made up of four 1N4148 diodes, charge the 4700- $\mu$ F capacitor. The super-bright (white) LED is driven either via a 390- $\Omega$  resistor (Power Light), or via 22 k $\Omega$  in series with 390  $\Omega$ . In the latter case, the LED is not as bright, but it stays on longer.

You must restrain yourself when cranking the dynamo, since in the 'bright' setting it is possible to exceed the rated LED current of 20 mA, while in the 'long' setting it is possible to exceed the rated capacitor voltage of 25 V. If necessary, adjust the value of the LED series resistor.

The lamp is bright enough for reading in complete darkness. The stepper motor generator is thus ideal for spies, thieves and children who want to read under the bedcovers. You could also keep it handy in your hobby room, in case of a short circuit.



(004039-1)

*From the workshop of the author:  
<http://home.t-online/home/B.Kainka>*

035

# Video Correction for Pinnacle Studio MP10

T. Giesberts

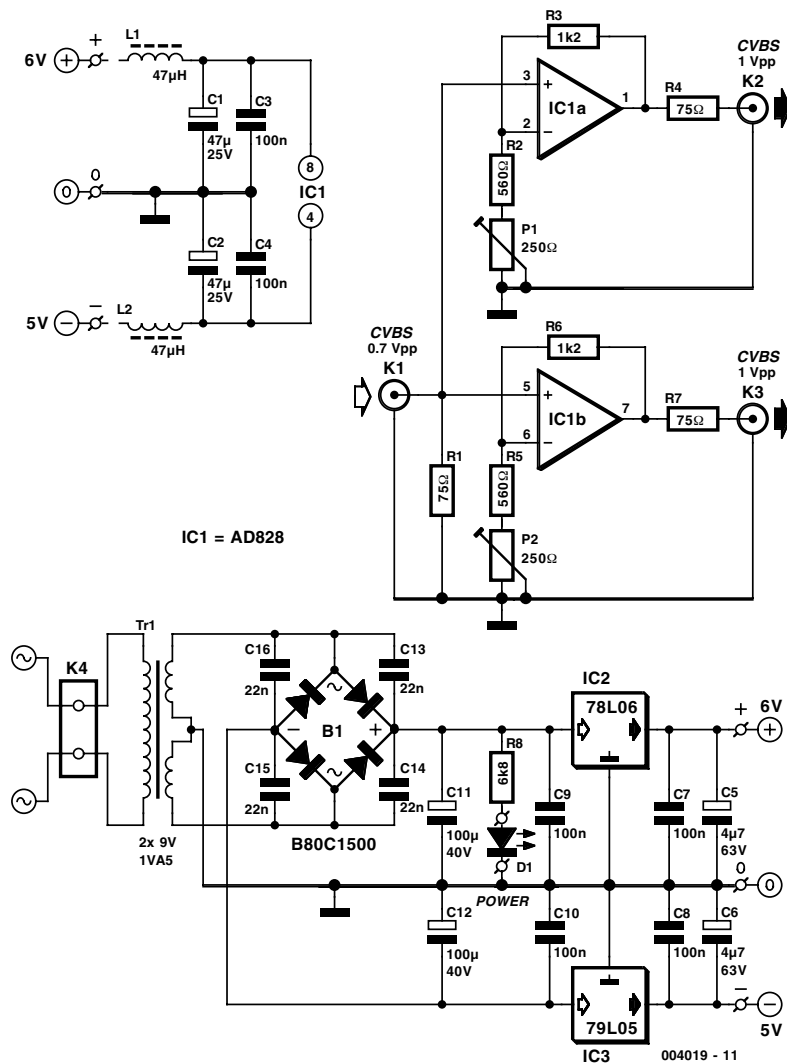
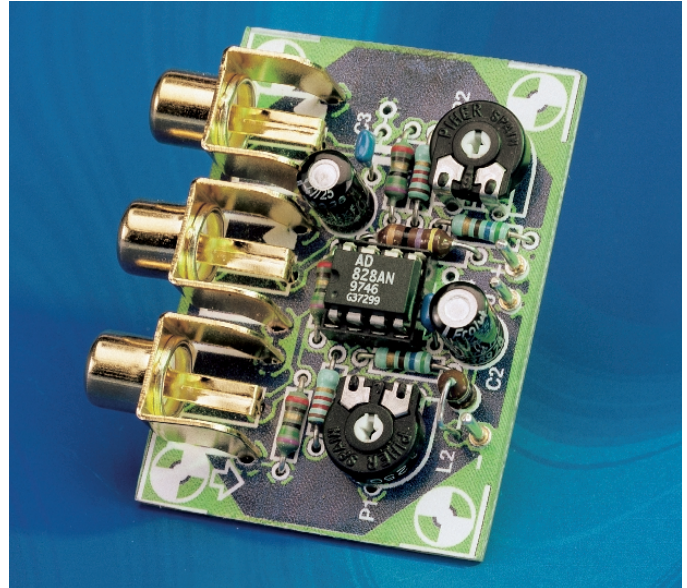
The Pinnacle Studio MP10 is an external real-time MPEG1 codec that includes composite video input and output. The output provides only 0.7 V, which is too low for most video equipment. Many video inputs are standardised for 1-V signals. The low output level of the MP10 can easily be corrected. The correction circuit, with its own small power supply, can also be used for many other applications.

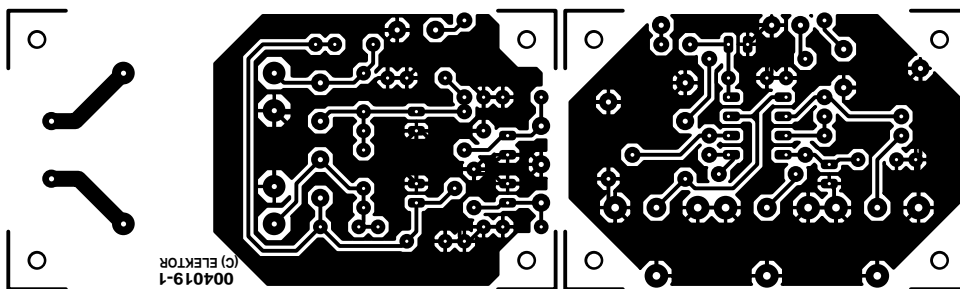
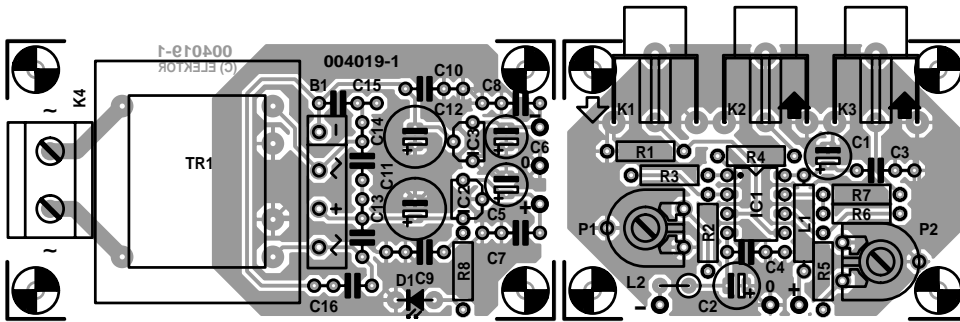
An Analog Devices AD828 dual low-power video opamp is used for the amplifier. Both opamps are connected to the output of the MP10, so two separate devices can be connected to the outputs of the correction circuit. The amplifier IC combines high bandwidth and a large slew rate with a relatively low no-load current consumption. The input and outputs of the circuit have the standard 75 Ω impedance. This means that the gain of the amplifiers must be a bit less than 3 ( $2 \div 0.7 = 2.86$ ). Two trimpots (P1 and P2) allow the output levels to be set to the standard value, and compensate for various component tolerances. The inputs and outputs are DC-coupled, since certain video inputs need a signal with a DC offset to maintain the proper black level. With VHF/UHF modulators or video capture cards for PCs, the syn-

chronisation may otherwise be unstable with bright pictures, since the sync pulses are weakened by the asymmetric supply voltage and the equipment in question evidently does not have clamp circuitry. According to the data sheet, the no-load bandwidth of the IC is 85 MHz at a gain of 2 with a  $\pm 5$  V supply. With a 75-Ω load (150 Ω in total), the measured bandwidth is roughly 45 MHz (1 V<sub>pp</sub> across 75 Ω). The supply voltages for the IC are well decoupled by L1, L2, and C1 through C4.

To minimise power dissipation, the supply voltages are limited to +6 V and -5 V. The positive voltage is larger, since we assume that the signal is usually positive and that consequently more headroom is needed on the positive side. The power supply is a standard design, with generous RF decoupling. The 78L06 and 79L05 voltage regulators can adequately handle the low current demand. LED D1 is the required mains power indicator, which must be externally visible when the circuit is built into an enclosure.

The printed circuit board layout uses standard components and has been made as compact as possible. IC1 was mounted in a standard IC





**COMPONENTS LIST**

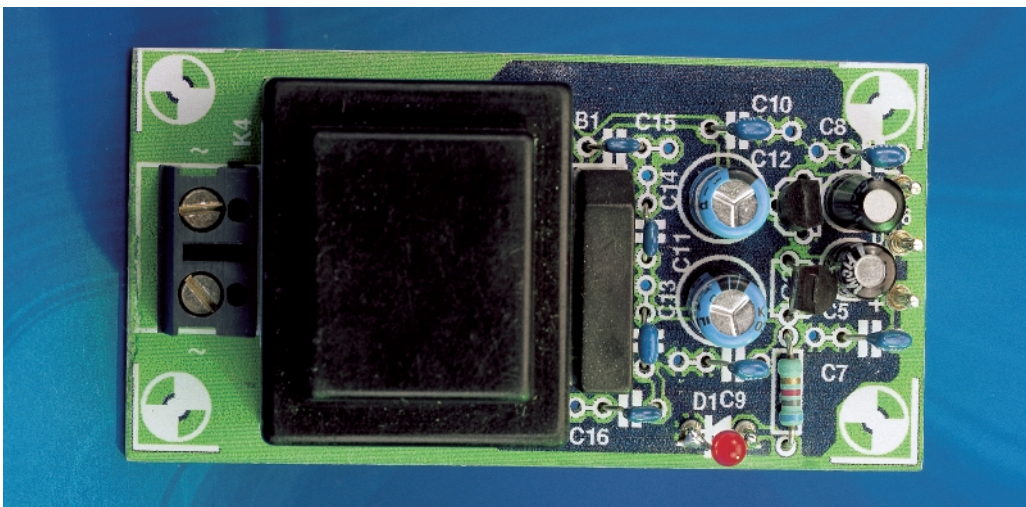
**Resistors:**  
 R1,R4,R7 = 75Ω  
 R2,R5 = 560Ω  
 R3,R6 = 1kΩ  
 R8 = 6kΩ  
 P1,P2 = 250Ω preset

**Capacitors:**  
 C1,C2 = 47μF 25V radial  
 C3,C4,C7-C10 = 100nF ceramic  
 C5,C6 = 4μF 63V radial  
 C11,C12 = 100μF 40V radial  
 C13-C16 = 22nF ceramic

**Inductors:**  
 L1,L2 = 47μH

**Semiconductors:**  
 D1 = high-efficiency LED  
 B1 = B80C1500 (80V piv, 1.5A peak) rectangular case  
 IC1 = AD828AN (Analog Devices) (Farnell)  
 IC2 = 78L06  
 IC3 = 79L05

**Miscellaneous:**  
 K1,K2,K3 = cinch sockets, PCB mount (e.g., Monacor/Monarch type T-709G)  
 K4 = 2-way PCB terminal block, raster 7.5 mm  
 Tr1 = mains transformer, PCB mount, secondary 2x9 V/1.5 VA (e.g. Monacor/Monarch type VTR-1209)



socket for the measurements, but it would be better to solder it directly to the board. The layout of the power supply and amplifier portion has been kept modest, so that you should not have any trouble finding a small enclosure to hold everything. The no-load current of the IC is around 13 mA with no input

signal. With both outputs loaded and driven, the current rises to around 16 mA. The PCB shown here is unfortunately not available ready-made through the Publishers' Readers Services.

(004019-1)

036

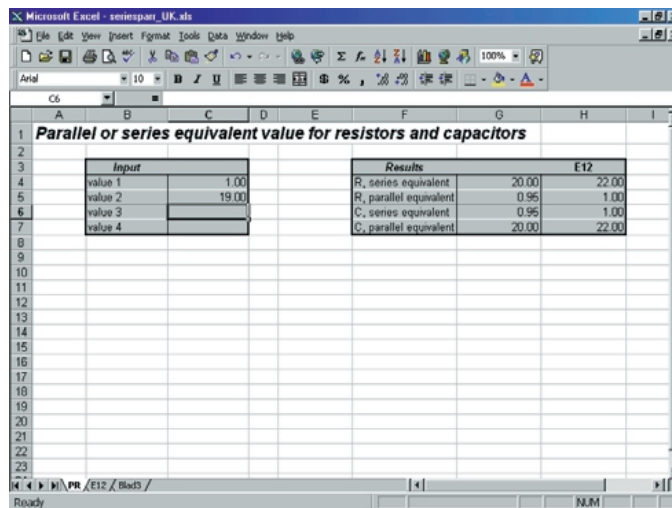
# Series/Parallel Equivalent Circuits in Excel

K. Walraven

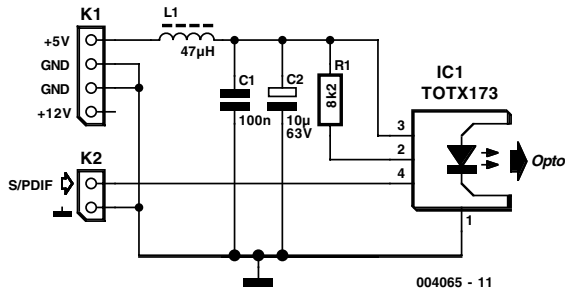
We all complain occasionally about Microsoft, but the advantage of their monopoly position is that everyone has the same programs. As a result, in spite of everything there is at least a sort of standardisation. The program described here runs under Excel and calculates the serial and parallel values of resistors and capacitors.

You can enter up to four values in the input section, and the output section displays the both the calculated value and the result rounded to the nearest value in the E12 series. Enter the values with all necessary zeros, thus '3400' instead of '3k4' and '4000000' instead of '4 M'. If you want to leave a cell empty, don't type a zero, since the program won't like this (due to divide-by-zero problems). Instead, type any arbitrary value and then delete it. You can also use decimal values, with a period as a separator. You don't have to enter commas to separate the thousands; Excel will generate them automatically. The formulas behind this program are not especially complex. A series circuit simply involves summing the values, and a parallel circuit is calculated by adding up the  $1/R_x$  values and then computing the inverse value of the sum.

You might enjoy having a look at the program and modifying it to suit your own taste. First unlock the worksheet via Tools → Protection → Unprotect Sheet. Now you can change anything that you want. For a brief description of the routine that



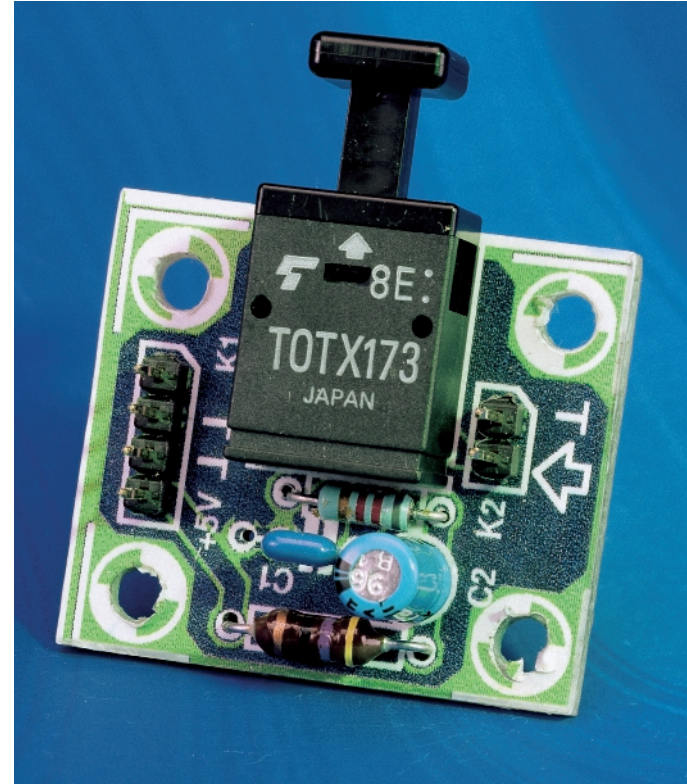
computes the E12 value, see the article 'E12 in Excel' elsewhere in this issue. You can find the spreadsheet on the *Elektor Electronics* website, <http://www.elektor-electronics.co.uk>.



### T. Giesberts

This little circuit is intended to be used to provide external access to an unused digital output of a CD or DVD drive in a PC. It provides an electrically isolated interface. In addition, this circuit is also handy for connecting a (portable) MD recorder, since these devices usually only have optical digital inputs.

The circuit is a standard application for the Toshiba Toslink transmitter module. On account of the large amount of interference present in the PC environment, extra decoupling for the transmitter module is provided by L1, C1 and C2. A small PC power connector can be attached to the pin header K1 (pay careful attention to the orientation; +5 V is red). The cable for the S/PDIF output of the CD or DVD player can be connected to K2. Make sure that the signal and earth leads are correctly





connected. A suitable screened cable is often provided with a player that has an S/PDIF output. Otherwise, you can make your own single-lead screened cable, with a two-pole connector for a pin header at each end.

Most drives provide a standard logic level at the digital audio output, and this signal can be connected directly to the input of the Toslink transmitter without any modifications. The circuit draws approximately 13 mA.

There is only one additional remark. It seems that certain CD

and DVD drives provide a signal at the S/PDIF output only when a CD is actually being played (there is not even a S/PDIF clock present if no disc is being played). This means that a recorder will miss a small part of the signal when an audio CD starts playing, since the PLL of the clock extraction circuit must re-lock to the clock signal.

The PCB shown here is unfortunately not available ready-made through the Publishers' Readers Services.

(004065-1)

## COMPONENTS LIST

### Resistor:

R1 = 8k $\Omega$ 2

### Capacitors:

C1 = 100nF ceramic

C2 = 10 $\mu$ F 63V radial

### Inductor:

L1 = 47 $\mu$ H

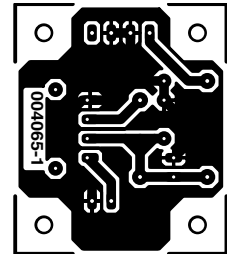
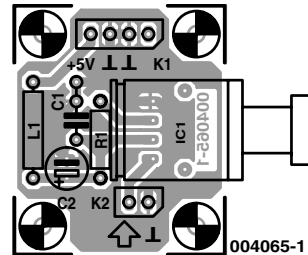
### Semiconductor:

IC1 = TOTX173 (Toshiba)  
(Eurodis)

### Miscellaneous:

K1 = 4-pin SIL-header

K2 = 2-pin SIL-header



## 038

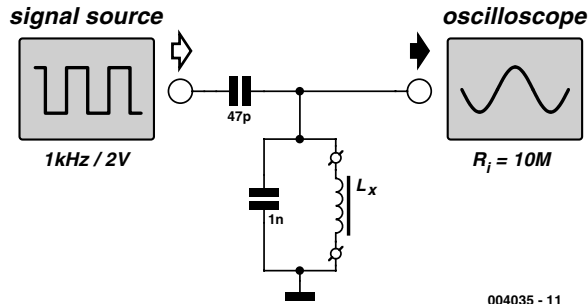
# Measuring Inductors

## B. Kainka

Often you find yourself in the position of needing to wind your own coil for a project, or maybe you come across an unmarked coil in the junkbox. How can you best find out its inductance? An oscilloscope is all you need. Construct a resonant circuit using the coil and a capacitor and connect it to a square wave generator (often part of the oscilloscope itself) Adjust the generator until you find the resonant frequency  $f$ . When  $C$  is known (1000 pF) the inductance  $L$  may be calculated from:

$$L = 1 / (4\pi^2 \cdot f^2 \cdot C)$$

If you are also interested how good the coil is i.e. what is its quality factor or  $Q$ , you can use the oscilloscope again. If the level of the damped oscillation drops to 0.37 ( $= 1/e$ ) of the maximum after about 30 periods, then the  $Q$  factor of the coil is about 30.



The  $Q$  factor should be measured at the intended operating frequency of the coil and with its intended capacitor. The coupling capacitor should by comparison be a much smaller value.

# Simple mV Source

## A. Grace

This design can be used to simulate millivolt (mV) sensor signals for industrial control systems.

Most of the new sensors used to day include some form of 'intelligence' at the measurement head, that is, the point at which the sensor comes into contact with what it is to measure. At this point, the sensor signal is conditioned/digitized and fed into a microcontroller that transmits a digital representation of the sensor value to the remote control system. However, there are still a number of 'elderly' control systems still in the field that have the intelligence remote from the sensor head. These systems rely on field wiring to convey the measured signal back to the control system.

During commissioning of these types of plant, it is useful to simulate the sensor signal to ensure amongst other things, that the sensor signal gets back to the correct terminals on the control system as they invariably pass through various junction boxes on the way. It can also be used to ensure that the control system operates correctly in response to the sensor signal.

The design shown here has been used by the author to 'bench test' a control system prior to being installed. Please note that the design is only suitable for simple simulation and is not accurate enough for calibration purposes.

Power from a 'plugtop' PSU (when bench testing) or a battery is fed to three current sources (diodes). Of these, I1 gen-

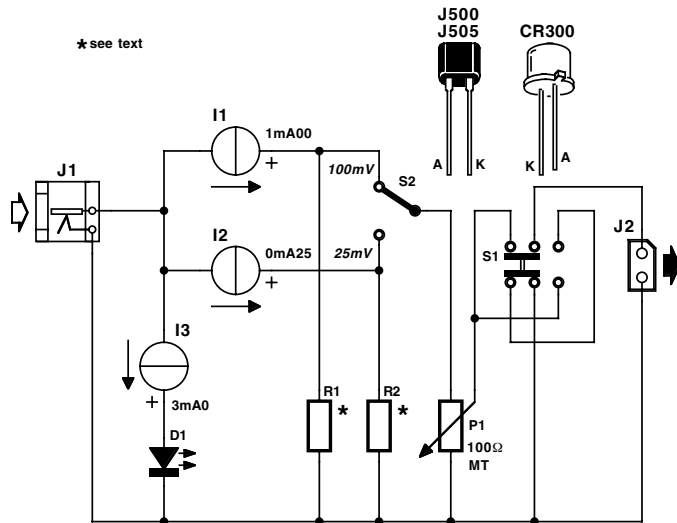
# SUMMER CIRCUITS COLLECTION

erates a 1.00 mA current signal, which when switched across the 100- $\Omega$  pot creates a 100-mV signal. Likewise, I2 generates a 0.25-mA signal which generates 25 mV across the pot. Current source I3 develops 3.0 mA and is used to illuminate the LED to give a power indication. The selected current source is switched via S2 to the 10-turn pot. Switch S1 is used to cleverly swap the polarity of the output signal. If the Type MTA206PA DPDT switch from Knitter is used, you get a centre-off position which actually shorts out the output signals (S1 pins 2 and 5) together, ensuring a zero output signal.

The current sources, despite being pretty expensive, are not very accurate — they have 10% tolerance! (hence the unsuitability for calibration use). If the output is too high, the tolerance can be ‘trimmed’ by fitting a bleed resistor (R1, R2) as shown in the diagram. The current sources are manufactured by Vishay/Siliconix and stocked by Farnell.

The circuit draws a current of about 4.25 mA.

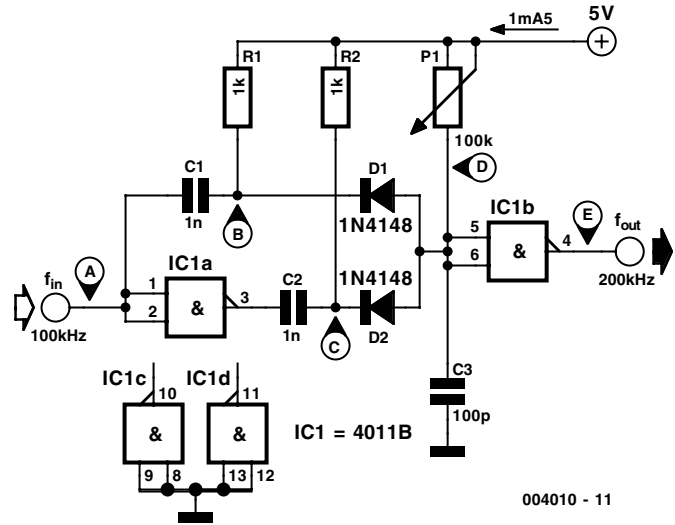
(004106-1)



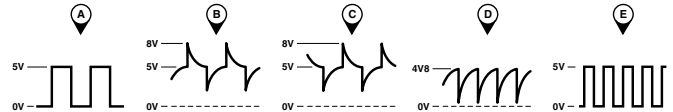
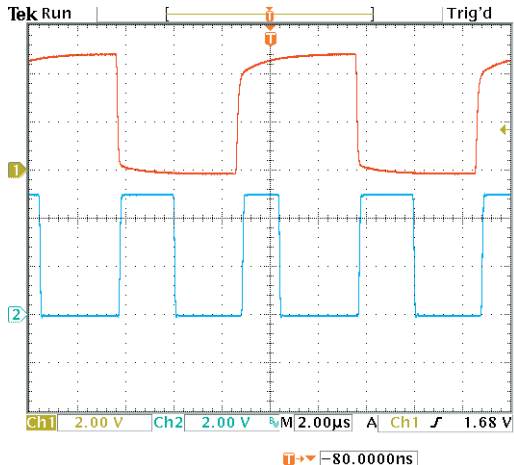
**K. Kraus**

Using just a few discrete components and two inverters, it is possible to build a simple TTL square wave frequency doubler for signals up to about 100 kHz. The input signal is applied to the differentiating circuit R1-C1. This converts the rising edge of the square wave into a positive pulse and the falling edge into a negative pulse. The inverter IC1a (you could use a NAND or NOR gate with the inputs tied together) inverts the input square wave and applies it to the differentiating circuit R2-C2. This differentiator performs the same function as R1-C1 i.e., producing positive pulses on rising edges and negative pulses on falling edges but in opposite phase to the output of R1/C1. The two diodes only pass the negative parts of the two signals, so at the anodes we get a series of negative pulses at a frequency of twice the input signal.

The output consists of a capacitor, which is charged up through preset R3. Each negative pulse stops the charging process and quickly discharges the capacitor. The resultant sawtooth waveform is applied to the input to IC1b (actually,



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the slopes of the waveform are not linear but exponential). The final inverter converts this signal back into a square wave but with twice the frequency of the input signal. The on/off ratio of the output square wave can be adjusted by preset R3, which will alter the time constant of R3-C3.

The current consumption of the frequency doubler is approximately 1.5 mA at 5 V. The low value of R1 means that the design has a low input impedance and the input current to IC1 is greater than the suggested maximum in the data sheet for this type of IC. It is therefore important that the supply voltage is not increased above +5 V.

(004010)

041

# Serial-to-Parallel Converter

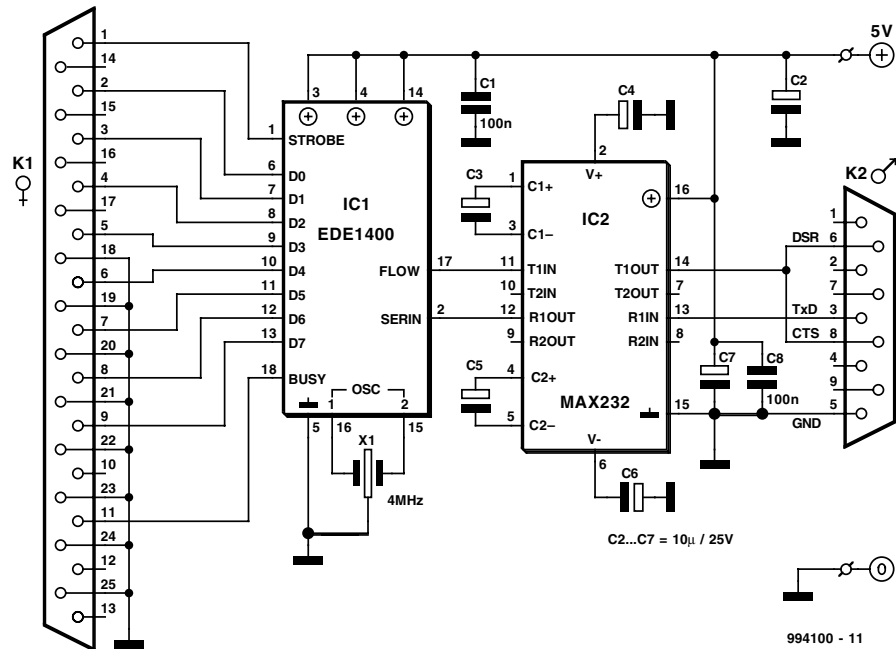
L. Lemmens

This converter may help if just the serial port on a personal computer is free, whereas the printer needs a parallel (Centronics) port. It converts a serial 2400 baud signal into a parallel signal.

The TxD line, pin 3, CTS line, pin 8 and the DSR line, pin 6, of the serial port are used — see diagram. The CTS and DSR signals enable handshaking to be implemented.

Since the computer needs real RS232 levels, an adaptation from TTL to RS232 is provided in the converter by a MAX232. This is an integrated level converter that transforms the single +5 V supply into a symmetrical  $\pm 12$  V one.

The serial-to-parallel conversion is effected by IC1. This is essentially a programmed PIC controller that produces a Centronics compatible signal from a 2400 baud serial signal (eight data bits, no parity, one stop bit). The IC also generates the requisite control signals. If there is a delay on the Centronics port, the RS232 bitstream from the computer may be stopped

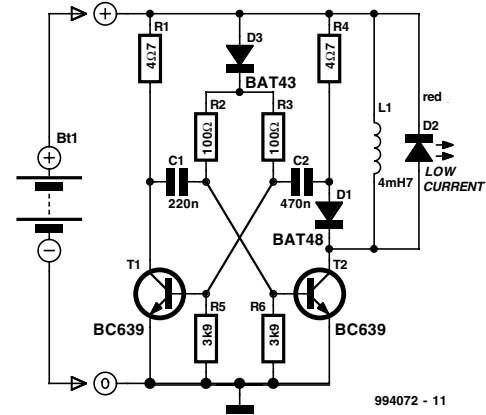


via the Flow signal (pin 17). This ensures that no data is lost. The controller needs a 4 MHz ceramic resonator, X1.

**J. Friker**

The battery discharger published in the June 1998 issue of this magazine may be improved by adding a Schottky diode ( $D_3$ ). This ensures that a NiCd cell is discharged not to 0.6–0.7 V, but to just under 1 V as recommended by the manufacturers. An additional effect is then that light-emitting diode  $D_2$  flashes when the battery connected to the terminals is flat.

The circuit in the diagram is based on an astable multivibrator operating at a frequency of about 25 kHz. When transistor  $T_2$  conducts, a current flows through inductor  $L_1$ , whereupon energy is stored in the resulting electromagnetic field. When  $T_2$  is cut off, the field collapses, whereupon a counter-emf is produced at a level that exceeds the forward voltage (about 1.6 V) of  $D_2$ . A current then flows through the diode so that this lights. Diode  $D_1$  prevents the current flowing through  $R_4$  and  $C_2$ . This process is halted only when the battery voltage no longer provides a sufficient base potential for the transistors. In the original circuit, this happened at about 0.65 V. The addition of the forward bias of  $D_3$  (about 0.3 V), the final discharge voltage of the battery is raised to 0.9–1.0 V. Additional resistors  $R_5$  and  $R_6$  ensure that sufficient current flows through  $D_3$ . When the battery is discharged to the recommended level, it must be removed from the discharger since, in contrast to the original circuit, a small current continues to flow through  $D_3$ ,  $R_2$ ,  $R_3$ , and  $R_5$ ,  $R_6$  until the battery is totally discharged



The flashing of  $D_2$  when the battery is nearing recommended discharge is caused by the increasing internal resistance of the battery lowering the terminal voltage to below the threshold level. If no current flows, the internal resistance is of no consequence since the terminal voltage rises to the threshold voltage by taking some energy from the battery. When the discharge is complete to the recommended level, the LED goes out. It should therefore be noted that the battery is discharged sufficiently when the LED begins to flash.

[994072]

043

# 8 Channel D/O Card for RS232

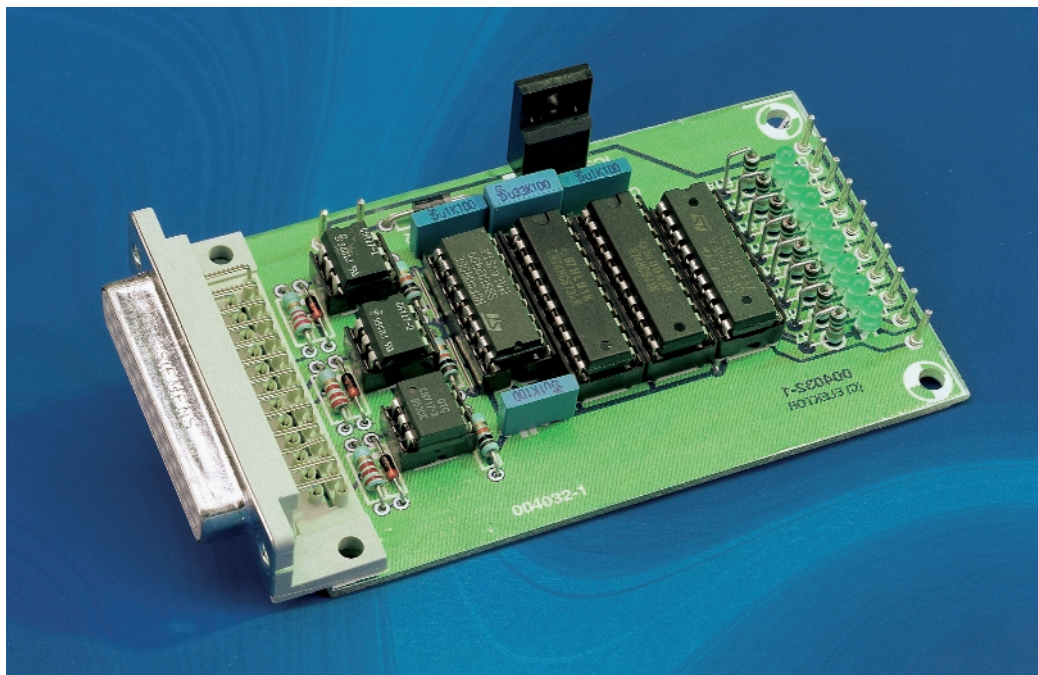
G. Vastianos

The author is a Student at the Electronics Department, Technological Educational Institute of Piraeus, Greece.

This article describes a card with 8 open-collector digital outputs for external connection to a PC serial port. The design of this card is based on direct accessing of the PC's UART registers to adapt the communication from serial to parallel.

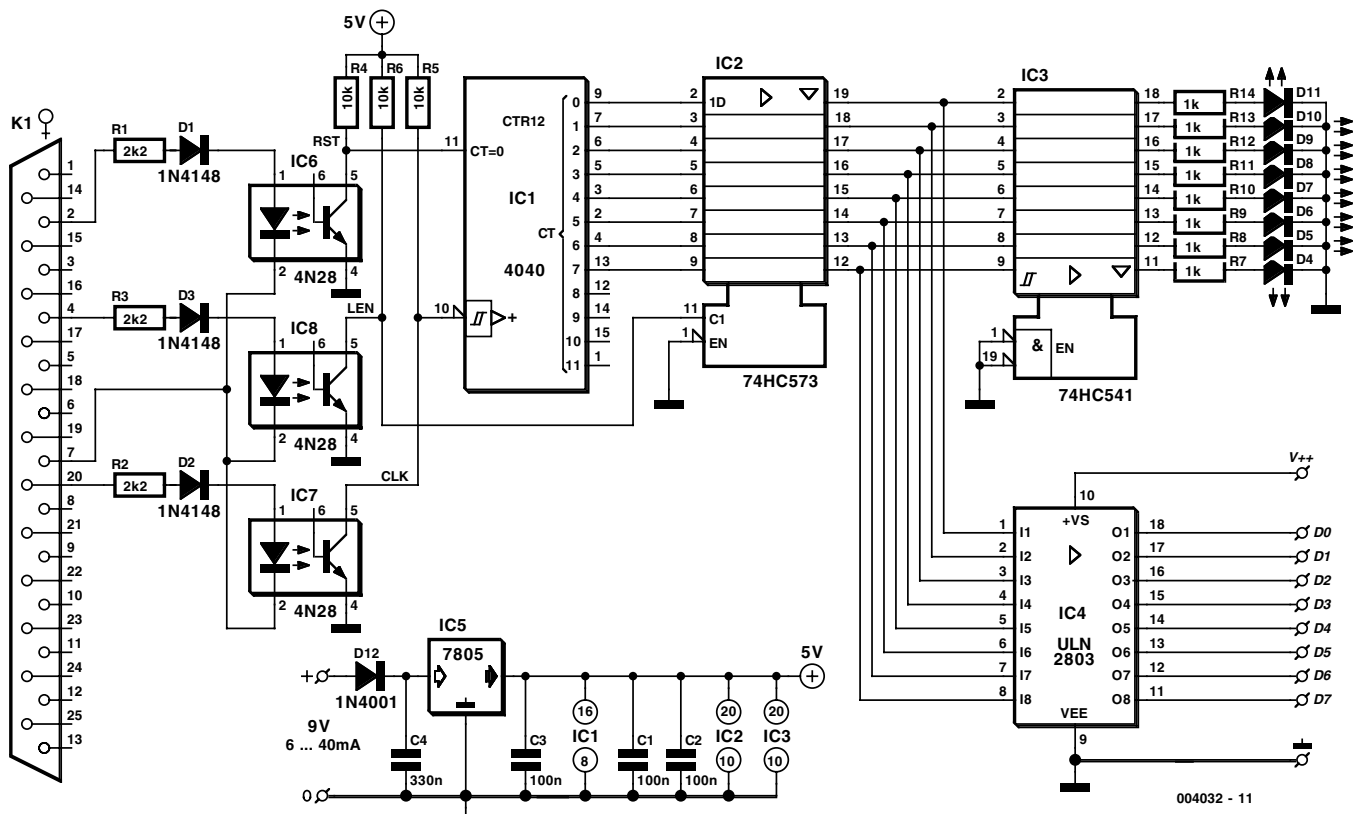
A computer may have one to four serial ports (COM1 to COM4) where each port occupies eight locations on its memory map as shown in **Table 1**.

The basic lines that a UART uses in serial communication for transmission and reception, are TXD and RXD. Also a group of extra lines (DCD, DSR, RTS, CTS, DTR, RI) is used to establish different types of serial communication. Some of these extra lines work as inputs and others as outputs, but each of them (except RXD) may be controlled through a bit in the UART register as shown in **Table 2**. The voltage levels on



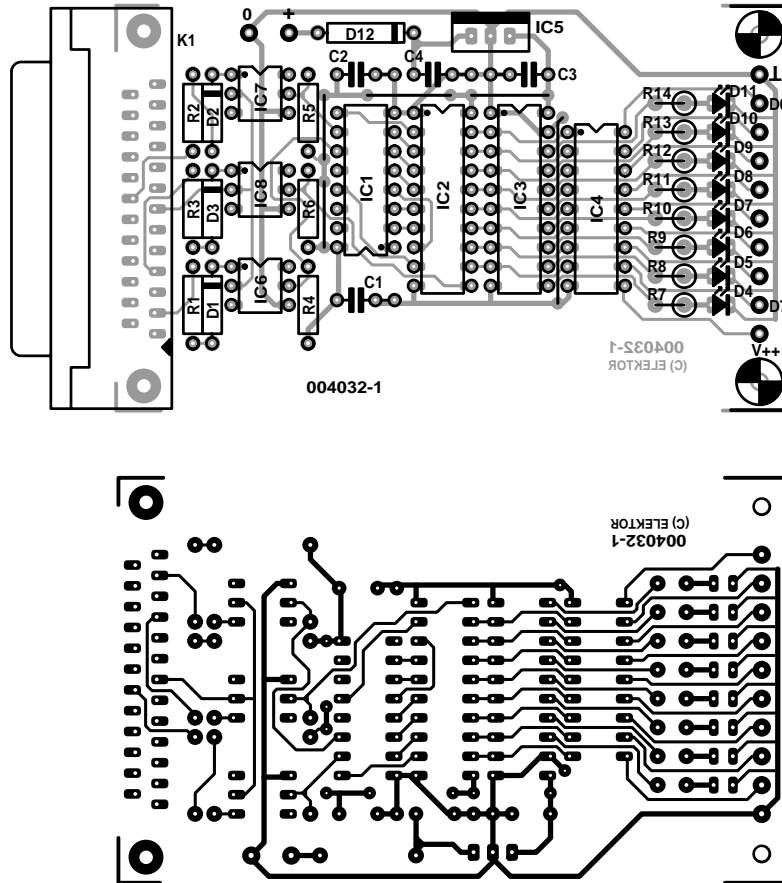
a serial port (RS232 levels) are officially -12V for logic 1 and +12 V for logic 0.

The computer's serial port is connected to the card through the connector K1. The three available outputs of the serial port (TXD, DTR, RTS) are applied to R1-D1, R2-D2, R3-D3 to ensure



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COMPONENTS LIST

Resistors:

- R1,R2,R3 = 2kΩ
- R4,R5,R6 = 10kΩ
- R7-R14 = 1kΩ

Capacitors:

- C1,C2,C3 = 100nF
- C4 = 330nF

Semiconductors:

- D1,D2,D3 = 1N4148
- D4-D11 = LED, high efficiency
- D12 = 1N4001
- IC1 = 4040
- IC2 = 74HC573
- IC3 = 74HC541
- IC4 = ULN2803
- IC5 = 7805
- IC6,IC7,IC8 = 4N28 or CNY17-2

Miscellaneous:

- K1 = 25-way sub-D socket (female), PCB mount
- 12 solder pins

Table 1. PC COM port addresses

Register Name	COM1	COM2	COM3	COM3
Transmit/Receive Buffer	3F8h	2F8h	3E8h	2E8h
Interrupt Enable Register	3F9h	2F9h	3E9h	2E9h
Interrupt Identification Register	3FAh	2FAh	3EAh	2EAh
Line Control Register	3FBh	2FBh	3EBh	2EBh
Modem Control Register	3FCh	2FCh	3ECh	2ECh
Line Status Register	3FDh	2FDh	3EDh	2EDh
Modem Status Register	3FEh	2FEh	3EEh	2EEh
Scratch Pad Register	3FFh	2FFh	3EFh	2EFh

safe driving of the optocouplers IC6, IC7 and IC8. So when a serial port output line is at +12 V, the internal transistor of the relevant optocoupler works is driven to saturation. Conversely, when this line is at -12V, the same transistor will be cut off. The logic equations between the TXD, DTR, RTS and the RST, CLK, LEN lines are the following :  $RST_{TTL} = NOT TXD_{RS232}$  ;  $CLK_{TTL} = NOT DTR_{RS232}$ ;  $LEN_{TTL} = NOT RTS_{RS232}$ .

Table 2. UART bit locations

Pin Name	25pin Connector	9pin Connector	COM1	COM2	COM3	COM3	Bit	I/O
TXD	#2	#3	3FBh	2FBh	3EBh	2EBh	6	O
DTR	#20	#4	3FCh	2FCh	3ECh	2ECh	0	O
RTS	#4	#7	3FCh	2FCh	3ECh	2ECh	1	O
CTS	#5	#8	3FEh	2FEh	3EEh	2EEh	4	I
DSR	#6	#6	3FEh	2FEh	3EEh	2EEh	5	I
RI	#22	#9	3FEh	2FEh	3EEh	2EEh	6	I
DCD	#8	#1	3FEh	2FEh	3EEh	2EEh	7	I

The RST and CLK lines drive 12-bit binary counter IC1 of which only 8 bits are used. The eight least significant outputs of the binary counter are applied to latch IC2, together with the LEN line.

The normal operating sequence is as follows. First an RST pulse is generated to reset the counter. Next, we produce the number of the CLK pulses needed to get the desired logic states on all counter outputs. Finally, we produce a LEN pulse to hold the logic states at the outputs of the latch.

Buffer IC3 (74HC541) drives LEDs D4-D11, which give a visual representation of the output logic states. Another buffer, IC4, this time a ULN2803A, is the actual output stage of the card. The eight open collector outputs of the ULN2803 are available as solder pins at the card edge. Note that the ULN2803 has open-collector outputs. Each of these is capable of switching up to 50 V, while the total load current on all outputs should not exceed 500 mA.

The card has its own voltage regulator and may be powered by any mains adapter rated at 9-15 V.

The software for the communication with the card has been developed in Turbo Pascal. The communication routine is called CARD08DO. Calling this routine (from any program written in Turbo Pascal) should comply with the following syntax:

CARD08DO (COMADDRESS, VALUE, DELTIME)

Where COMADDRESS: Word type variable, must contain

## SUMMER CIRCUITS COLLECTION

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(before calling) the base address of the serial port. Acceptable values of this variable are \$3F8 (for COM1), \$2F8 (for COM2), \$3E8 (for COM3), \$2E8 (for COM4).

VALUE: Byte type variable, must contain (before calling) the arithmetic value of the 8 channels group. The 8 logic states of the 8 channels make a Byte with LS Bit Ch0 and MS Bit Ch7. Acceptable values of this variable are 0 to 255.

DELTIME: Byte type variable, must contain (before calling) the value of 'delay time'. Acceptable values of this variable are 0 (for a slow 8086 computer at 8 MHz) to 4 (for a fast Pentium computer running at 266 MHz).

The source code of the communication routine (CARD08DO.SUB) and a demonstration program (08DOCARD.PAS), with an executable version of the demonstration program (08DOCARD.EXE) may be downloaded from the author's website at

*<http://members.xoom.com/robofreak/download/08docard.htm>*

The PCB shown here is unfortunately not available ready-made through the Publishers' Readers Services.

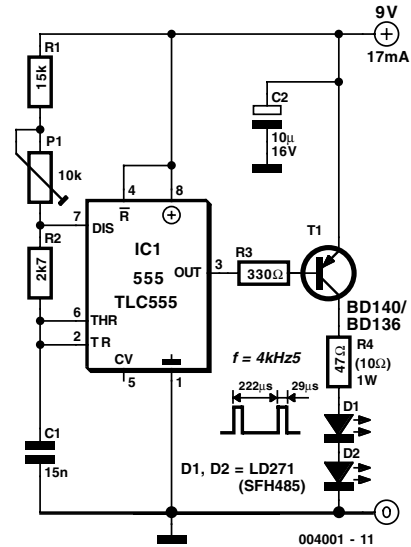
Pradeep G.

This is a short-range light barrier for use as an intruder alarm in doorposts, etc. The 555 in the transmitter (**Figure 1**) oscillates at about 4.5 kHz, supplying pulses with a duty cycle of about 13% to keep power consumption within reason. Just about any infra-red LED (also called IRED) may be used. Suggested, commonly available types are the LD271 and SFH485. The exact pulse frequency is adjusted with preset P1. The LEDs are pulsed at a peak current of about 100 mA, determined by the 47 Ω series resistor.

In the receiver (**Figure 2**), the maximum sensitivity of photodiode D2 should occur at the wavelength of the IREDs used in the transmitter. You should be okay if you use an SFH205F, BPW34 or BP104. Note that the photodiode is connected reverse-biased! So, if you measure about 0.45 V across this device, it is almost certainly fitted the wrong way around. The received pulses are first amplified by T1 and T2. Next comes a PLL (phase lock loop) built with the revered NE567 (or LM567). The PLL chip pulls its output, pin 8, Low when it is locked onto the 4.5 kHz 'tone' received from the transmitter. When the (normally invisible) light beam is interrupted (for example, by someone walking into the room), the received signal disappears and IC1 will pull its output pin High. This enables oscillator IC2 in the receiver, and an audible alarm is produced.

The two-transistor amplifier in the receiver is purposely over-driven to some extent to ensure that the duty cycle of the output pulses is roughly 50%. If the transmitter is too far away from the receiver, overdriving will no longer be guaranteed, hence IC1 will not be enabled by an alarm condition. If you want to get the most out of the circuit in respect of distance covered, start by modifying the value of R2 until the amplifier output signal again has a duty cycle of about 50%. The circuit is simple to adjust. Switch on the receiver, the buzzer should sound. Then switch on the transmitter. Point the transmitter LEDs to the receiver input. Use a relatively small distance, say, 30 cm. Adjust P1 on the transmitter until the buzzer is silenced.

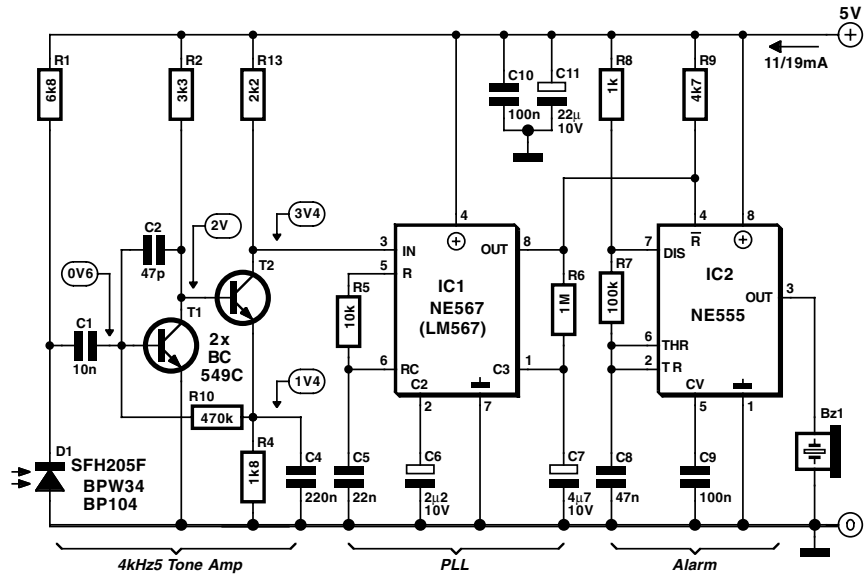
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Switch the receiver off and on again a few times to make sure it locks onto the transmitter carrier under all circumstances. If necessary, re-adjust P1, slowly increasing the distance between the transmitter and the receiver.

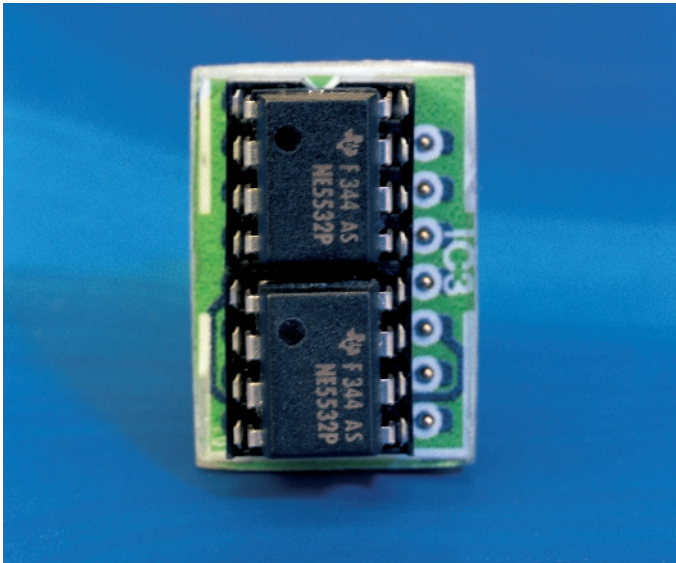
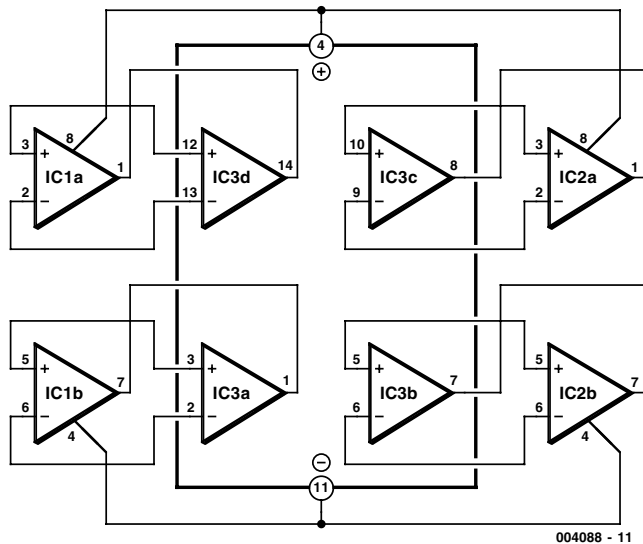
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2



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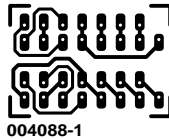
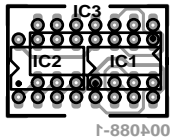
2 × Dual = 1 × Quad



T. Giesberts

This is a sort of sequel to the article '2 × single = 1 × dual'. In this case, two dual opamps are combined to make one new quad opamp. This allows many possible variations, and again it allows two completely different types of dual-opamps to be used.

It is very easy to replace a quad opamp if you use the printed circuit board shown here. The schematic diagram shows the interconnections between the two dual opamps and the pin locations of the quad opamp. The two dual opamps are soldered on top of the board, and two 7-pin contact strips are soldered to the bottom side. These can then be plugged into the socket of the original quad opamp. When selecting the opamps, carefully check their pinouts, as

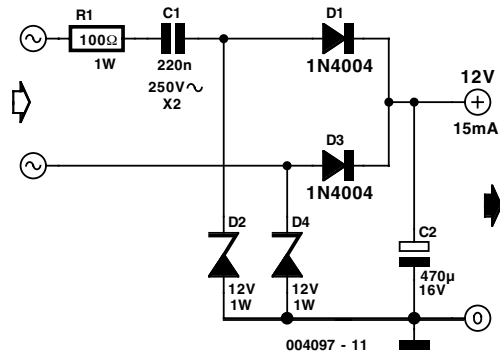


well as that of the quad opamp to be replaced. Nowadays, most types have 'standard' pinouts, but there are a few exotic types that do not conform to the standard. The PCB shown here is unfortunately not available ready-made through the Publishers' Readers Services.

## K. Walraven

Many circuits can be powered directly from the mains with the aid of a series capacitor (C1). The disadvantage of this approach is that usually only one half cycle of the mains waveform can be used to produce a DC voltage. An obvious solution is to use a bridge rectifier to perform full-wave rectification, which increases the amount of current that can be supplied and allows the filter capacitor to be smaller. The accompanying circuit in fact does this, but in a clever manner that uses fewer components. Here we take advantage of the fact that a Zener diode is also a normal diode that conducts current in the forward direction. During one half wave, the current flows via D1 through the load and back via D4, while during the other half wave it flows via D3 and D2.

Bear in mind that with this circuit (and with the bridge rectifier version), the zero voltage reference of the DC voltage is not directly connected to the neutral line of the 230-V circuit. This means that it is usually not possible to use this sort of supply



to drive a triac, which normally needs such a connection. However, circuits that employ relays can benefit from full-wave rectification.

The value of the supply voltage depends on the specifications of the Zener diodes that are used, which can be freely chosen. C2 must be able to handle at least this voltage. The amount of current that can be delivered depends on the capacitance of C1. With the given value of 220 nF, the current is approximately 15 mA.

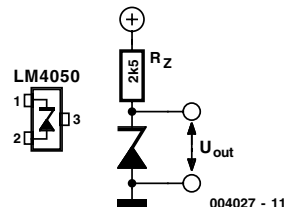
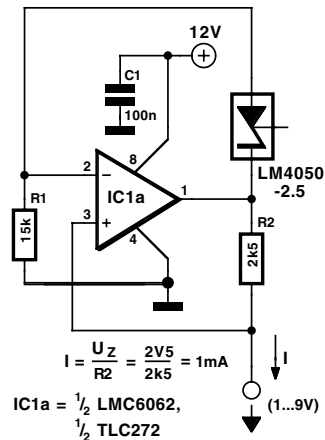
A final warning: this sort of circuit is directly connected to mains voltage, which can be lethal. You must never come in contact with this circuit! It is essential to house this circuit safely in a suitable enclosure (see the 'Safety Guidelines' page that appears occasionally in *Elektor Electronics*).

# Voltage Reference for Battery Powered Circuits

The LM4050 from National Semiconductor is a high precision micropower shunt voltage reference in a sub-miniature, surface-mount, three pin, SOT-23 package. The unit operates in the industrial temperature range of  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ . The design eliminates the need for an external stabilising capacitor and is at the same time stable when operated into any capacitive load. The unit is available in several different, fixed reverse breakdown voltages from 2.500 V, 4.096 V, 5.000 V, 8.192 V to 10.000 V. The minimum operating current ranges from  $60\ \mu\text{A}$  for the LM4050-2.5 to  $100\ \mu\text{A}$  for the LM4050-10.0 this, along with its tiny outline, makes it ideal for use in battery powered applications. The LM4050 is available in three different grades of accuracy of **0.1%**, **0.2%** and **0.5%**, all have a low temperature coefficient of less than  $50\ \text{ppm}/^{\circ}\text{C}$ .

During the manufacturing process, the use of fuse and zener-zap reverse breakdown voltage trimming ensure that the premium (or A grade) components have an accuracy of better than  $\pm 0.1\%$  at  $25^{\circ}\text{C}$ . Stable reverse breakdown accuracy over a wide range of temperatures and operating currents is achieved by bandgap reference temperature drift curvature correction and a low dynamic impedance. Altogether this is a versatile component with an impressive specification.

The full data sheet is available from the web site: [www.national.com](http://www.national.com)

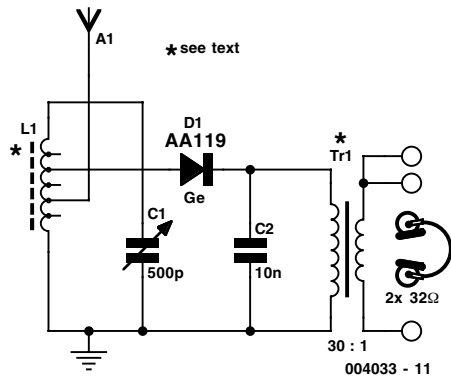


# Diode Radio for Low Impedance Headphones

## B. Kainka

If you ever look at construction notes for building old detector type radios the type of headphones specified always have an impedance of  $2 \times 2000 \Omega$ . Nowadays the most commonly available headphones have an impedance of  $2 \times 32 \Omega$ , this relatively low value makes them unsuitable for such a design. However, with a bit of crafty transformation these headphones can be used in just such a design. To adapt them, you will need a transformer taken from a mains adapter unit, the type that has a switchable output voltage (3/4.5/6/9/12 V) without the rectifying diodes and capacitor. Using the different taps of this type of transformer it is possible to optimise the impedance match.

For the diode radio (any germanium diode is suitable in this design) the key to success is correct impedance matching so that none of the received signal energy is lost. The antenna coil on the 10 mm diameter by 100 mm long ferrite rod is made up of 60 turns with a tap point at every 10 turns; this is suitable for medium wave reception. If a long external aerial is



used it should be connected to a lower tap point to reduce its damping effect on the circuit. You can experiment with all the available tapping points to find the best reception. With such a simple radio design, the external aerial will have a big influ-



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ence on its performance. Tip: If your house has metal guttering and rain water pipes, it will be possible to use these as an aerial, as long as they are not directly connected to earth. Those who live in the vicinity of a broadcast transmitter may be

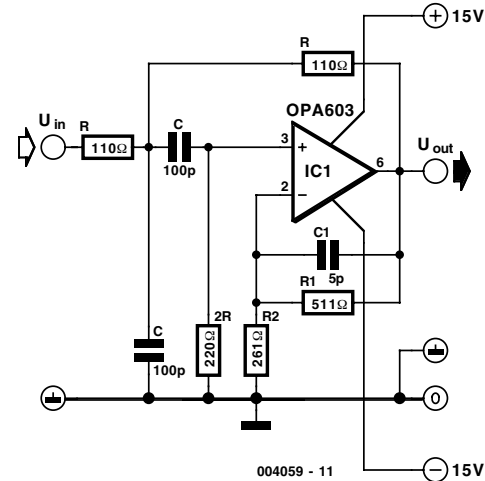
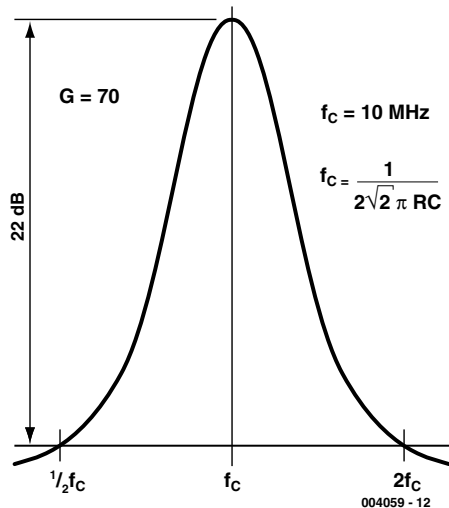
able to connect a loudspeaker directly to the output or if the volume is too low, why not try connecting the active speaker system from your PC?

(004033)

# Single-Opamp 10-MHz Bandpass Filter

H. Steeman

A bandpass filter is usually used to pass frequencies within a certain frequency range. If a high-performance opamp is used, such a filter can also be used at relatively high frequencies. As shown in the schematic diagram, here we have chosen an OPA603, which is a fast current-feedback opamp with a 100 MHz bandwidth for gain values between 1 and 10 (0 to 20 dB). If the circuit only has to handle a narrow range of frequencies, as in this case, the gain can be increased. With a current-feedback opamp, just as with an ordinary opamp, the



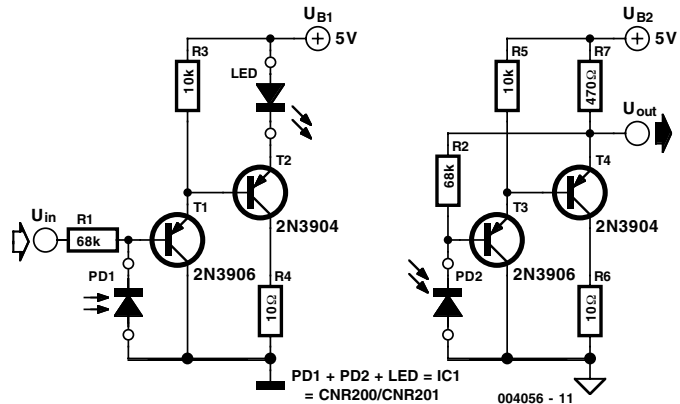
negative feedback between the output and the inverting input determines the gain. In addition, the impedance of the feedback network determines the open-loop gain and the frequency response. With the component values shown in the schematic diagram, signals outside the passband are attenuated by 22 dB. The centre frequency of the filter is 10 MHz. As indicated by the printed formula, the centre frequency can easily be altered. However, keep in mind that 10 MHz is roughly the maximum frequency at which this circuit can be used. The circuit can be powered by a supply voltage of  $\pm 15 \text{ V}$ .

# Analogue Optical Coupler

H. Steeman

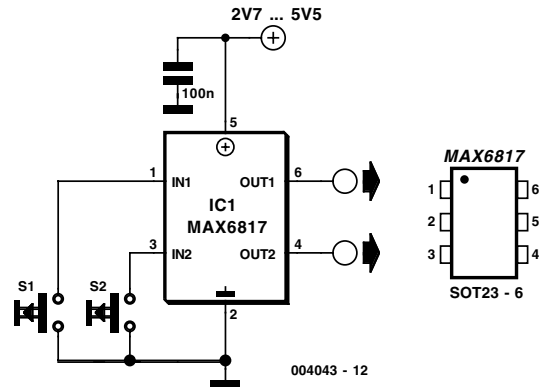
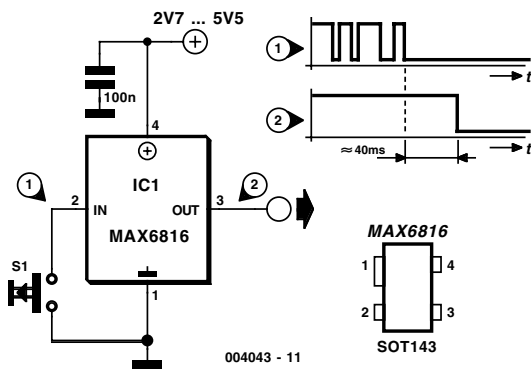
It is sometimes necessary to make an electrically isolated connection in a circuit. An optocoupler is usually the key component in such a situation. In most optocouplers, a single light-emitting diode (transmitter) and a single photodiode (receiver) are optically coupled inside the package. This solution is satisfactory for transferring digital levels (such as the control signals for a thyristor), since only two logical states (LED on or LED off) have to be transferred. An exact (analogue) coupling is thus not necessary.

If an analogue voltage must be transferred, then it is important that the voltages at the input and the output closely track each other. To make this possible, the transmitter and receiver must employ comparable components that are incorporated into an analogue circuit. The type CNR200 and CNR201 opto-



couplers that are available from Agilent (formerly Hewlett-Packard) contain all the essential components for such a function. There are two photodiodes and one LED in a single package, with an optical coupling between the LED and one of the photodiodes. The schematic diagram shows how the transmitter LED is optically coupled to the photodiode in the receiver. The remaining photodiode is incorporated into the transmitter and ensures that the characteristic of the trans-

mitter amplifier is the same as that of the receiver. Assuming a supply voltage of 5 V, analogue voltages in the range of 0 to 3 V can be readily transferred. The isolation voltage between the input and output of this optocoupler is 1000 V. The value that can be achieved in practice depends on the printed circuit board layout.



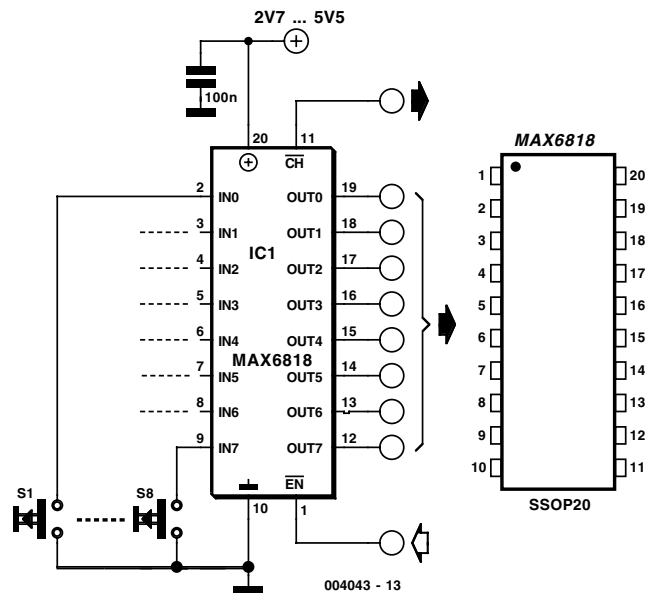
### G. Kleine

Contact bounce is an age-old problem with all types of push-button switches and keypads that are connected to digital components. The measures that are used to deal with the repeated closing of the contacts when the switch is first activated include RC networks, flip-flop circuits and software routines. Now there is a single IC that takes over this task and delivers clean digital pulses to the following circuitry.

The MAX 6816, MAX 6817 and MAX 6818 ICs are well-protected pushbutton switch debouncers with one, two and eight inputs, respectively. The wiring for these ICs is simple, as shown in **Figure 1**. No external components are needed. The switches connected to the inputs need only make contact to earth. Internal pull-up resistors are provided. These ICs work with supply voltages between 2.7 V and 5.5 V, with a current consumption of less than 20  $\mu\text{A}$ . The inputs can handle (fault) voltages up to  $\pm 25$  V and electrostatic discharges up to  $\pm 15$  kV.

Each MAX 681x IC works with an internal oscillator that clocks a counter. The counter is always reset whenever the input level changes within 40 ms. Only after the level applied to the input remains stable for longer than 40 ms will the counter increment to its final count and enable the output signal. This sort of debouncing is used for both closing and opening the switch.

The MAX 6818 can be connected directly to a data bus, since it has an enable input (/EN) that switches the outputs to a high-impedance (tri-state) condition when a High level is applied. There is also a Change output (/CH), which indicates a change of state of one of the pressed keys. The /CH output can be directly connected to the interrupt input of a micro-processor system. The pinout of the MAX 6818 corresponds to that of the well-known 74xx573 latch, so it can be directly sub-



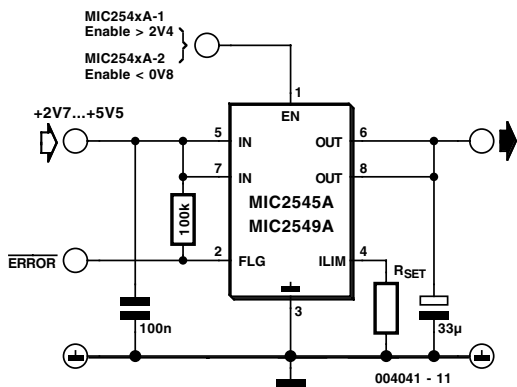
stituted for the latter IC.

The MAX 6816 comes in a tiny SOT-143-SMD package, while the MAX 6817 comes in a 6-pin SOT23 SMD package and the MAX 6818 in a SSOP20 package. Data sheets for these debouncer ICs can be obtained via the Internet from [www.maxim-ic.com](http://www.maxim-ic.com).

(004043-1)

052

# Switch ICs with Adjustable Current Limiting



G. Kleine

Transistors are often used for switching power supply voltages. MOSFETs are most often used, since they have low 'on' resistances, and they are also available for large currents. What a discrete transistor or MOSFET lacks are protective functions, such as current limiting and overtemperature protection.

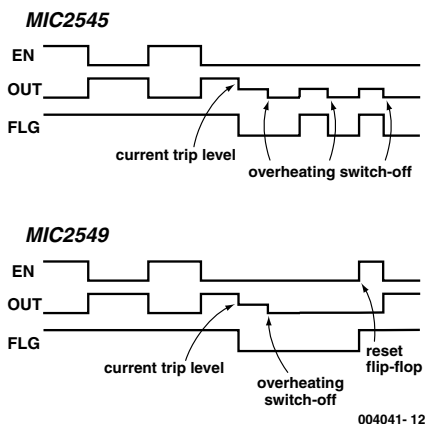
The MIC2545A from Micrel can provide a solution to this problem. This MOSFET switch has programmable current limiting, as well as undervoltage and overtemperature cutouts. It works with input voltages between +2.7 V and +5.5 V. With a typical 'on' resistance of only 35 mΩ, this IC can switch up to 2.5 A in a DIP8, SO8 or TSSOP14 package. It also includes a soft-start circuit, which limits the switch-on current for the first two milliseconds. An integrated charge pump generates the gate voltage needed for switching the MOSFET.

The current limiting level can easily be set by an external resistor between the ILIM pin and earth. The resistance value can be calculated using the following simple formula:

$$R_{set} = 230 / I_{lim}$$

where the current  $I_{lim}$  is in ampères and the resistance  $R_{set}$  is in ohms. For a maximum current between 0.5 and 2.5 A, the resistance thus lies between 460 Ω and 92 Ω. In case of a short circuit, the current is limited to around  $1.6I_{lim}$ .

The MIC2545A is controlled via an Enable input. In order to satisfy all possible applications, it is available in two versions.

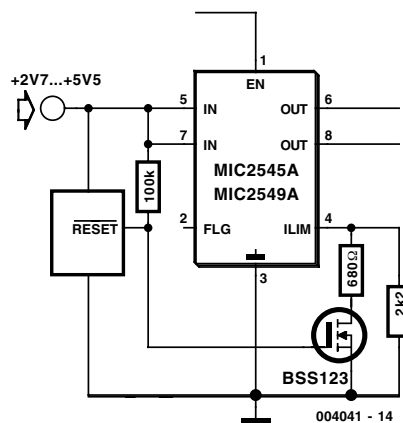
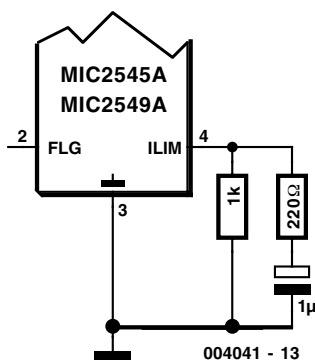


The MIC2545A-1 switches on the MOSFET when the Enable input is High ( $V_{in} > 2.4 V$ ), while the MIC2545A-2 version switches on the MOSFET when the Enable input is Low ( $V_{in} < 0.8 V$ ). The IC typically draws 90 µA when the switch is enabled, but it draws less than 1 µA in the switched-off state. This means that it can also be used for switching on battery-operated equipment. The low operating current consumption of the MIC2545A makes a mechanical battery switch unnecessary.

The operating state of this high-side switch is indicated by an open-gate flag output. An error condition (overcurrent, undervoltage or overtemperature) is signalled by a low resistance at this output, so that an external pull-up resistor is pulled to earth.

The MIC2545A switches on again after an overtemperature cutout as soon as the chip temperature has dropped sufficiently. However, in some cases it may be desirable to save the overtemperature state and prevent the output from automatically being switched on again after an overtemperature excursion. In such cases, the derivative type MIC2549A can be used. It contains a flip-flop, which must be reset by deactivating the Enable signal before the switch can be re-enabled. The MIC2549A is also available in two versions, namely the MIC2549-1 with active high Enable and the MIC2549-2 with active low Enable.

The overtemperature cutout is triggered at a chip temperature of approximately 130 °C. The switch can be re-enabled after the temperature drops below 120 °C.



The MIC2545A has an interesting feature that allows the switch-on current for a following assembly to be increased. If a series RC combination is connected in parallel with  $R_{set}$ , the effective resistance connected to the ILIM pin is reduced for a short time immediately after switch-on. During the charging time for the capacitor (corresponding to the time constant of the RC combination,  $t = RC$ ), the two resistors are connected in parallel, and the current limit value is thus increased. Once the capacitor is charged, only the normal resistor is effective. An additional interesting possibility is to switch the current limiting level to a different value by means of a transistor, which can for example be driven by a reset IC or a supply voltage monitoring IC. This allows the switch-on current to be limited to a lower level. As long as the input voltage is not high enough, the current limiting level is switched to a low value, since  $\overline{RESET}$  is Low and the FET is cut off, so that only one of the two resistors is effective. As soon as the input voltage is

$$R_{SET} = 230 \text{ V} / I_{LIM}$$

$$0.5 \text{ A} \leq I_{LIM} \leq 2.5 \text{ A}$$

$$I_{LIM} \mid_{t < RC} = 230 \text{ V} / (1 \text{ k}\Omega \parallel 220 \Omega) \approx 1.3 \text{ A}$$

$$I_{LIM} \mid_{t > RC} = 230 \text{ V} / 1 \text{ k}\Omega \approx 0.23 \text{ A}$$

$$RC = 220 \Omega \cdot 1 \mu\text{F} = 220 \mu\text{s}$$

$$I_{LIM} = 230 \text{ V} / 2.2 \text{ k}\Omega \approx 100 \text{ mA}$$

$$I_{LIM} = 230 \text{ V} / (680 \Omega \parallel 2.2 \text{ k}\Omega) \approx 440 \text{ mA}$$

OK, the  $\overline{RESET}$  signal goes High and switches on the FET. Both resistors are now connected in parallel, and the current limiting level lies at a higher value. You can obtain more information at [www.micrel.com](http://www.micrel.com).

## A. Grace

This design is for a simple half-duplex optically isolated interface that converts a 20 mA current loop (connected to J2) into an RS232 signal (on J1) which can be monitored by, say, a laptop PC. In the author's case, the system operates at 1200 baud. The signal to be monitored should be a fully digital on-off communications signal, rather than the usual 4/20 mA (industrial) analogue transmission standard.

The overall action of the interface is of double inversion. The current in the comms signal is normally present when no data is being sent, and the current is switched off to represent data. Consequently the transistor in the opto-isolator is normally switched on, giving a low at the input to IC1c. This is inverted to give a high (+12 V) on the RS232 input, which is the default condition for no data.

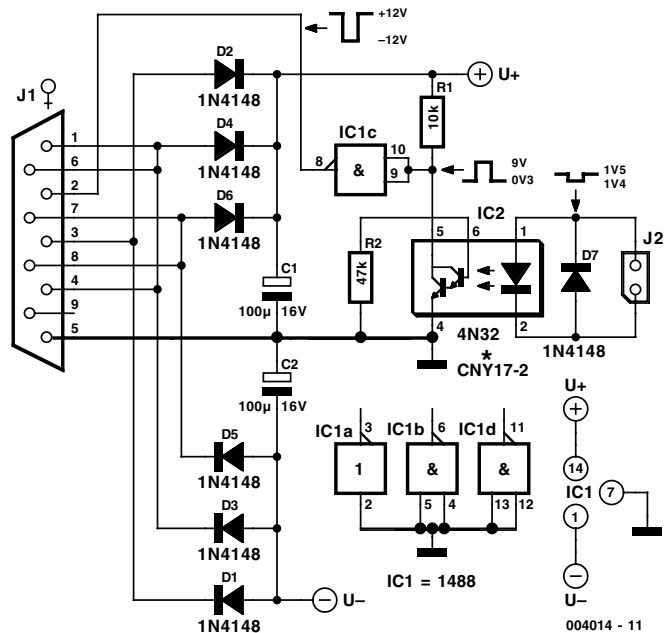
The interface itself is powered by the serial (RS232) port used to monitor the signal. This is achieved by stealing power from unused RS232 signal lines. The standard RS232 connector is a 9-way male 'D' type whose connections are shown in the table.

The positive and negative supply rails for IC1 are set up by rectifying the unused RS232 potentials via diodes D1 through D6, with C1 and C2 acting as reservoir capacitors.

Opto-isolator devices normally switch on reasonably fast but are relatively slow to switch off. Resistor R2 speeds up turn-off time. Diode D7 has been included to protect the opto-isolator against excessive reverse voltages — these may occur when the interface is accidentally wired back to front.

If voltage drive is used instead of 0/20 mA pure current

Pin no.	Signal	In/Out
1	DCD	In
2	RxD	In
3	TxD	Out
4	DTR	Out
5	Common	
6	DSR	In
7	RTS	Out
8	CTS	In
9	RI	In



drive, a current limiting resistor is required at the opto-isolator input. This resistor will typically be between 330 Ω and 1 kΩ, and the LED current should always be kept well below 50 mA to prevent damage to the opto-isolator.

The circuit may be modified for compatibility with 4/20 mA industrial current-loop systems by carefully matching the value of R2 to the opto-isolator used. In general, the lower the value, the less sensitive the interface will become. Almost any opto-isolator device may be used provided its transfer is close to 100% (or '1' — check datasheets). Good results were obtained with, among others, the Siemens CNY17-2. This device boasting a breakdown voltage specification of 5,300 V, it is Class-2 compliant provided the distance between the pins is greater than 6 mm. This however will require some bending. For Class-1 safety requirements, the normal pin distance governed by an 8-way DIL socket is adequate.

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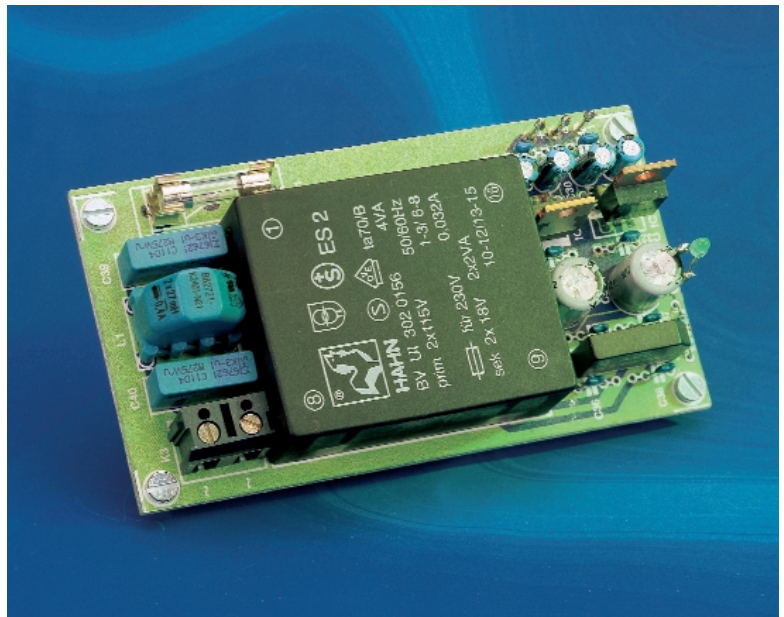
# Universal Symmetric Power Supply

T. Giesberts

This power supply has been specially designed for the 20<sup>th</sup>-order filter described elsewhere in this issue, but it can also be used for a legion of other opamp circuits. The supply voltage is set to  $\pm 17.5$  V, in light of the maximum output level of the filter. This benefits the signal to noise ratio. The specified absolute maximum supply voltage for most opamps is  $\pm 18$  V, and we have intentionally kept a bit below this limit.

The transformer is one of a series made by Hahn (model UI 30), so the circuit can be easily adapted for higher power levels by using a different transformer. All transformers in this series have the same footprint (53 × 44 mm), with only the height changing according to the power capacity. The series consists of 3, 4, 6, 10 and 16-VA models, which are respectively 16.3, 18.3, 21.8, 27.7 and 37.6 mm high. There are two secondary windings, with standard voltages of 2 × 6, 2 × 9, 2 × 12, 2 × 15 and 2 × 18 V. We chose a 4 VA transformer with 2 × 18 V secondaries for this application. Certain models are also available from other manufacturers, but the locations of the secondary connections are different. The circuit board layout can accommodate two different types.

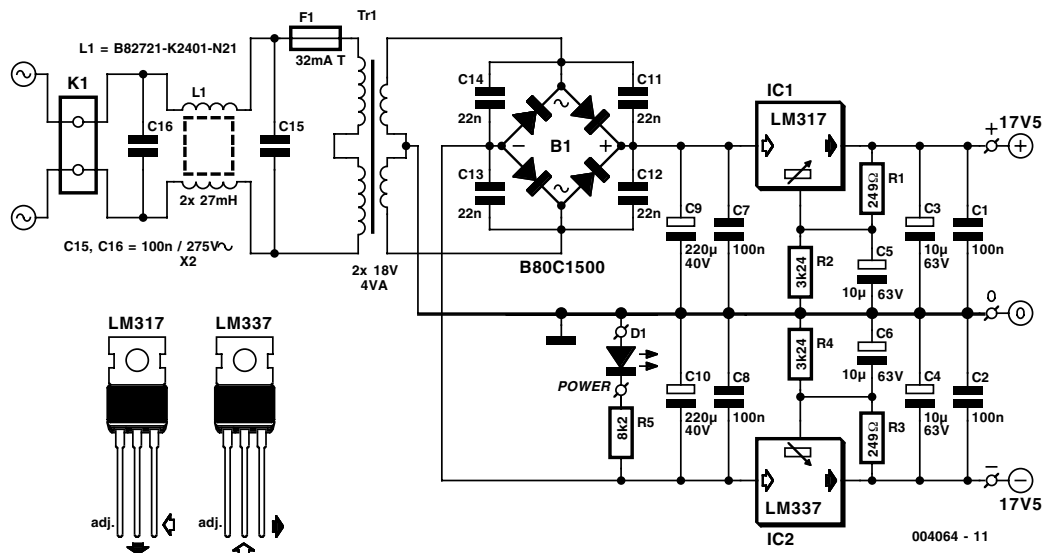
The circuit is based on the well-known LM317 and LM337 voltage regulators. Since the output voltages are set by voltage dividers, any voltage between 1.25 V and 40 V is possible. In case you don't already know, the formula for the positive out-



put voltage (LM317) is

$$V_{out} = 1.25 \cdot (1 + R2/R1) + I_{adj} \cdot R2$$

The same formula applies to the negative regulator, using R3



COMPONENTS LIST

Resistors:

- R1, R3 = 249Ω 1%
- R2, R4 = 3kΩ 24 1%
- R5 = 8kΩ 2

Capacitors:

- C1, C2, C7, C8 = 100nF ceramic
- C3...C6 = 10µF 63V radial

- C9, C10 = 220µF 40V radial
- C11-C14 = 22nF ceramic
- C15, C16 = 100nF 275V<sub>AC</sub> class X2

Inductors:

- L1 = 2x27 mH (e.g., Siemens type B82721-K2401-N21) (Electrovalue)

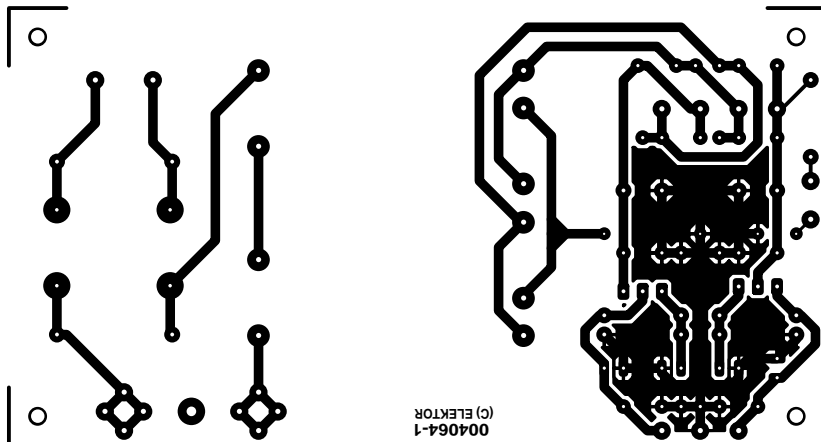
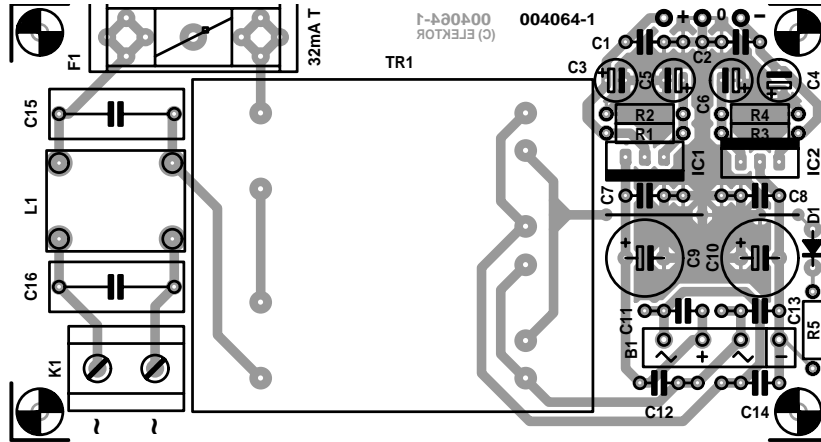
Semiconductors:

- D1 = high-efficiency LED
- IC1 = LM317T (TO220 case)
- IC2 = LM337T (TO220 case)

Miscellaneous:

- K1 = 2-way PCB terminal block, raster 7.5mm
- B1 = B80C1500, rectangular case

- (80V piv, 1.5A peak)
- F1 = fuse, 32mA slow, with PCB mount holder and cap
- Tr1 = mains transformer, PCB mount, secondary 2x18 V/4VA (e.g., Hahn type BV UI 302 0156)
- PCB, order code 004064-1



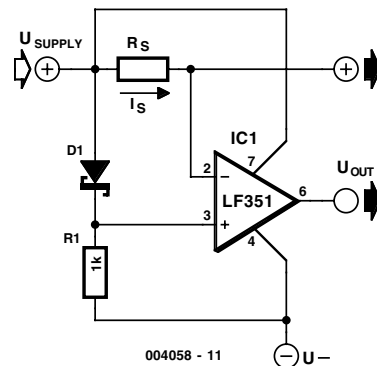
and R4 instead. Capacitors C5 and C6 increase the ripple suppression to 80 dB. Depending on the application and the output power, it may be necessary to use heat sinks for the regulator ICs.

The power supply has a simple mains filter to suppress common-mode interference. This is primarily needed if the supply is used to power sensitive circuits. The coil is a Siemens type that has been used in many other *Elektor Electronics* projects. D1 acts as a mains voltage indicator. The indicated value of the fuse, both in the diagram and on the circuit board, is 32 mA (slow). This value will have to be modified for higher power levels (as will the label on the circuit board!). With lower output voltages and larger output currents, the filter capacitors C9 and C10 must be made larger. The working voltage can then be reduced, so the physical dimensions will probably remain the same.

The PCB shown here is available ready-made through the Publishers' Readers Services.

## H. Steeman

The best way to measure the current in a circuit is to place a sense resistor in the current path. The higher the resistance, the more exact the measurement will be. However, the drawback of a high resistance is that it affects the operation of the circuit in which the measurement is being made. If an active sort of sensor is used, the sense resistance can be kept small. The circuit diagram shows how a sensitive overload indicator can be built using a simple opamp (such as an LF351) and a sense resistor in the current path. A voltage difference is generated between the plus and minus inputs of the opamp with the help of a diode. Usually, the voltage drop across D1 (a Schottky diode) will be 0.2 to 0.3 V. This value can be influenced somewhat by R1, which affects the amount of current that flows through the diode. The larger the value of R1, the smaller the voltage drop across the diode. The inverting input of the opamp is connected to the positive supply voltage following the sense resistor  $R_S$ . Consequently, the voltage level at the output of the opamp will be equal to the negative supply voltage, for example  $-5$  V. As the current that flows through the sense resistor  $R_S$  increases, the voltage on the inverting input of the opamp decreases. As soon as the voltage drop across  $R_S$  ( $= I_S \times R_S$ ) becomes slightly greater than the volt-



age drop across D1, the output of the opamp will switch to the positive supply voltage level. An indicator lamp or relay can be connected to the opamp output. The maximum supply voltage for the opamp is  $\pm 15$  V, so the circuit can readily be used to monitor symmetric power supplies with voltages between 5 and 15 V.

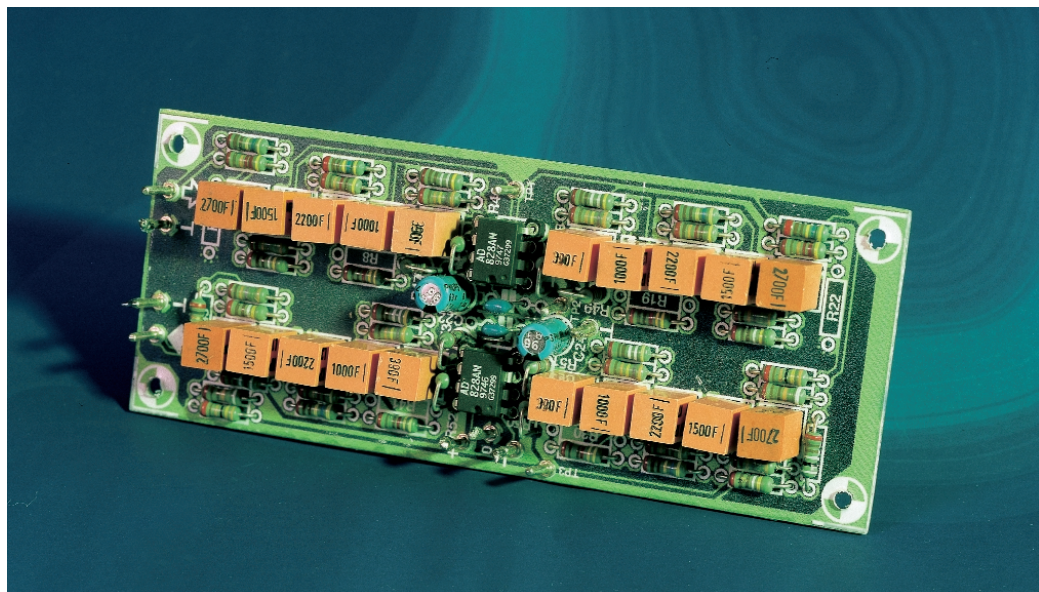
(004058-1)

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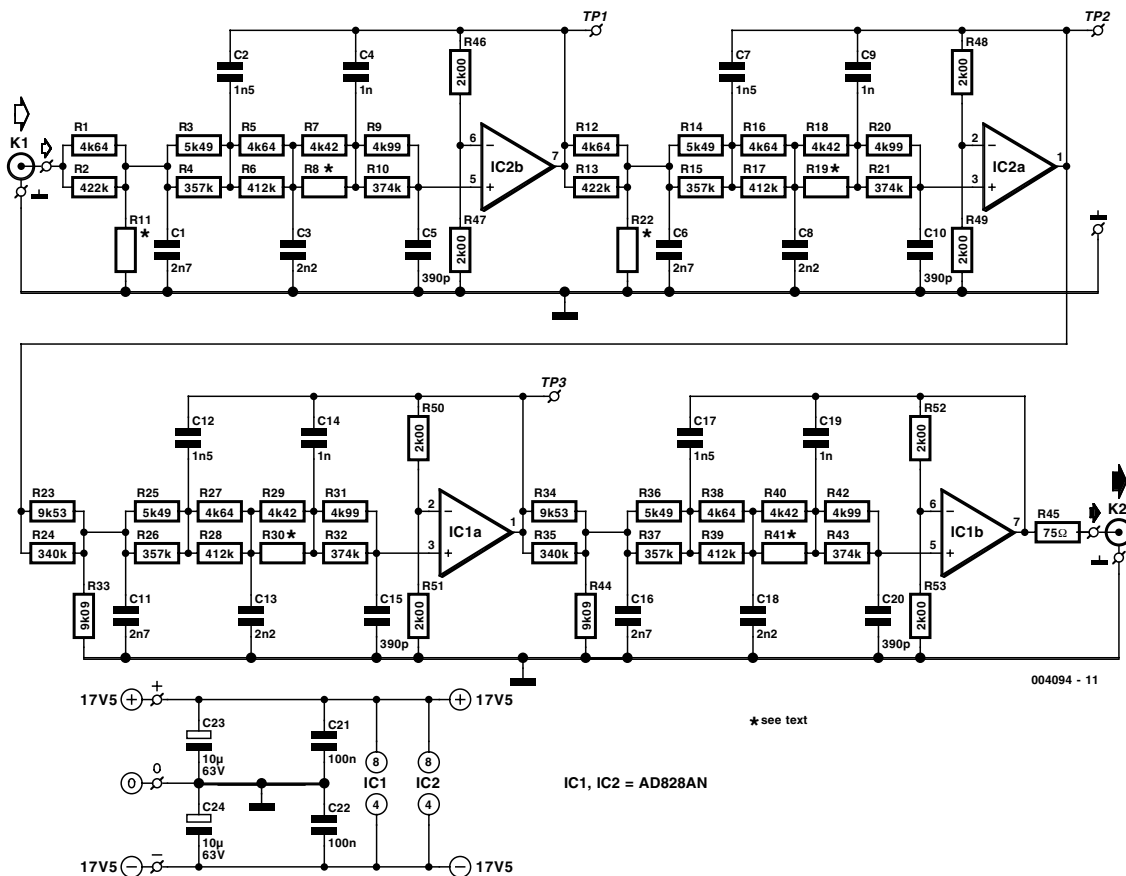
# 20<sup>th</sup>-Order Measurement Filter

T. Giesberts

This circuit is based on the configuration of a fifth-order Butterworth filter using only one opamp (see p 116 of the 1995 Summer Circuits issue). Here we achieve a 20<sup>th</sup>-order filter by connecting four fifth-order sections in series. The first three sections are tapped off at TP1, TP2 and TP3. As you will see, the transfer characteristic is not a pure 20<sup>th</sup>-order Butterworth, but it does have the steepness of such a filter. The desired bandwidth for the whole filter is achieved by adjusting the turnover point of each section to a higher value. The -3 dB bandwidth of the total filter is theoretically set to 22 kHz, which means that a value of 26 kHz must be used for each section. The measured total bandwidth of the prototype is 20.9 kHz. In this regard, we have to point out that all components must be selected with a tolerance of less than 0.1 percent, since it is otherwise pointless to try to copy the circuit. Excessive tolerances in the component values will degrade the characteris-



tics of the filter. There are 12 components per section that must be selected within this tolerance (with each parallel network counting as one component)! Even with selected components, the practical implementation will always vary a bit from the theoretical behaviour (with a somewhat lower turnover point, for example).



The filter calculations employ exact E12 values for the capacitors, which produces rather 'strange' values for the resistors. It is necessary to connect resistors with E96 values in parallel to achieve the necessary resistance values. **Table 1** summarises the resistor values.

The choice of opamp is even more critical than the precision of the components. The opamps must have a very large bandwidth and low distortion in the audio band, and they must be able to supply enough current. This last factor comes from the fact that the dimensions of the filter components represent a compromise between the amount of noise generated by the impedance of the filter network itself, the load on the opamp due to the negative feedback and the load of any following network. In practice, a video amplifier must be used to avoid affecting the filter characteristics. The chosen opamp, an Analog Devices AD828AN, does not however have the desired distortion specifications. It is only possible to achieve better specifications by using a discrete amplifier specially designed for this application. With such an amplifier, it is possible to significantly reduce the impedance of the filter network and increase the maximum current, in order to improve the specifications.

This circuit was originally intended to be used to measure codecs, for example. Their specifications are often given only for the audio band, for which a steep measurement filter is used. The mixer products with the sampling frequency, which lie outside the audio band, are often not attenuated by any more than 50 to 70 dB by digital filtering.

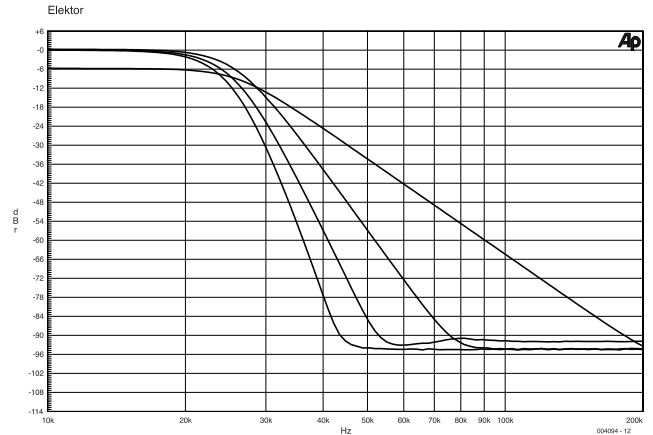
In order to produce a 5<sup>th</sup>-order filter using the illustrated arrangement, each section must have a gain of 2. In order to prevent the amplification of the overall filter from becoming too large, extra attenuators have been added to the last two sections. We chose  $2 V_{eff}$  as the maximum allowable signal level. The attenuators form the first resistances of the filter sections, which means that the parallel impedance of R23, R24 and R33 is equal to that of R1 and R2. The printed circuit board layout allows such networks to be used for all four sections (with positions R11 and R22 open). If the measured values of R7, R18, R29 and R40 match the desired theoretical value (which falls within the tolerance range of a 1% 4k42-Ω resistor), no parallel resistors are necessary in these positions. Make sure that the signal source has DC coupling. It is recommended to use a very good audio opamp in series with the input, to provide a well-defined input impedance.

The brief specifications of the filter are as follows:

supply voltage	±17.5 V
bandwidth (-3 dB)	20.9 kHz
suppression (40 kHz, 2 $V_{eff}$ in)	78 dB
THD+N (1 kHz, 1 $V_{eff}$ in)	0.005 %
THD+N (1 kHz, 2 $V_{eff}$ in)	0.009 %
S/N (2 $V_{eff}$ in)	94 dB
gain (10 kΩ load)	7.75
output impedance	75 Ω
current consumption	28 mA

**Figure 3** shows the measured characteristics of each of the cumulative sections. The ultimate suppression is around 94 dB before the signal disappears below the noise level. The gain of the first section is naturally 6 dB lower.

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**Table 1**

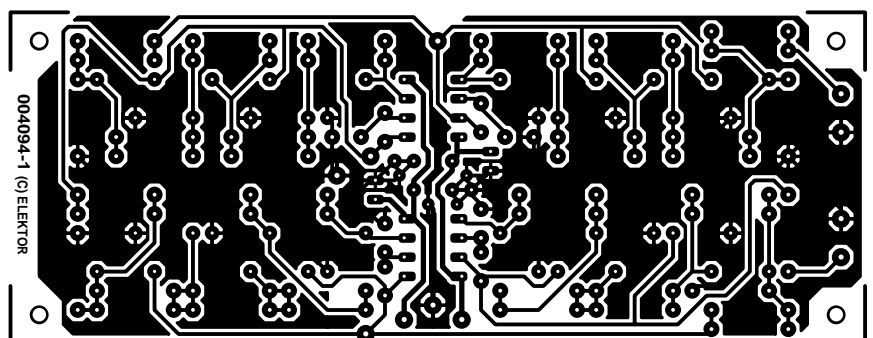
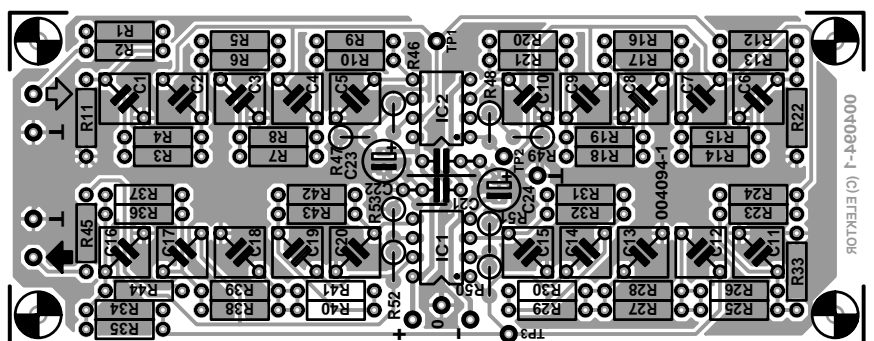
Resistors (A = 2 x)		Parallel	Theoretical
R1, R12	= 4k64		
R2, R13	= 422 k	4k5895	(4k58974)
R3, R14, R25, R36	= 5k49		
R4, R15, R26, R37	= 357 k	5k4069	(5k40684)
R5, R16, R27, R38	= 4k64		
R6, R17, R28, R39	= 412 k	4k5883	(4k58787)
R7, R18, R29, R40	= 4k42		
R8, R19, R30, R41	= (5M62)	4k4200	(4k41649)
R9, R20, R31, R42	= 4k99		
R10, R21, R32, R43	= 374 k	4k9243	(4k92361)
R11, R22	= open		

**Alternative values:**

R7, R18, R29, R40	= 4k53		
R8, R19, R30, R41	= 178 k	4k4176	(4k41649)

**Extra 6 dB attenuation:**

R23, R34	= 9k53		
R24, R35	= 340 k		
R33, R44	= 9k09	4k5896	(4k58974)



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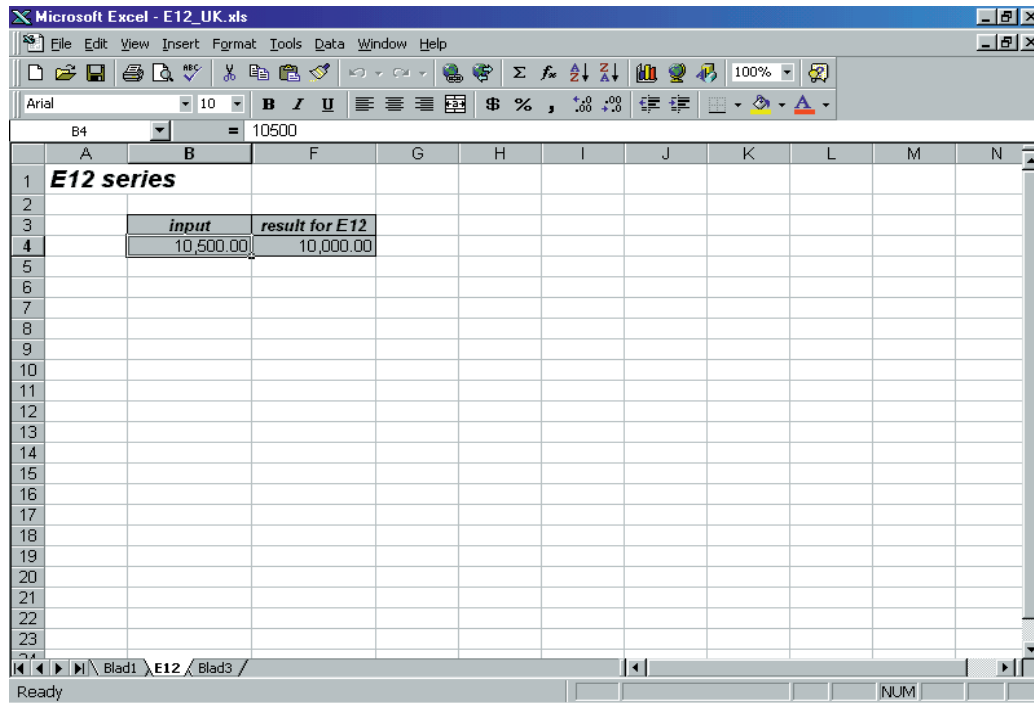
# E12 Series in Excel

**K. Walraven**

You can do all sorts of neat things with Excel, such as computing the nearest E12 value. Select the cell under 'Input' and enter the value that you want to have rounded off. Type the value with all necessary zeros, thus '6800' instead of '6k8' and '1200000' instead of '1M2'. The nearest E12 value will appear in the cell just to the right. It's handy to permanently install this program on your computer, so that it's always available when you need it.

The program also works with values less than 1 Ω; all you have to do is to enter a leading period as a separator. The result will be displayed to two decimal places, but Excel naturally works internally with more decimal places. If you want to see them, select the cell and click on 'Increase Decimal'. Since the worksheet is protected, you will first have to delete the protection via Tools → Protection → Unprotect Sheet.

Maybe you have another nice application that might interest other readers, or you may just want to modify the worksheet. After you have deleted the protection, you can start to work. First make the hidden columns visible by selecting columns B and F and then selecting Format → Column → Unhide. The log-



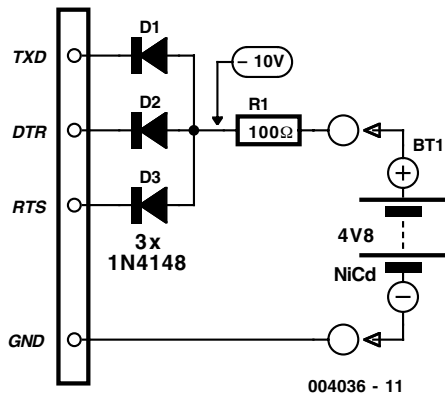
arithm of the entered value is taken to determine the power of ten that it contains, and the entered value is then divided by this number to yield a value between 1 and 10. Next, this value is looked up in a normalised E12 table. The result is then multiplied by the power of ten, to produce a value with the proper number of zeros. Of course, we could have just made a big E12 table containing all possible values, but that is not such an elegant solution.

**B. Kainka**

Some workbenches can't help ending up looking like a rats nest of cables and equipment, so its always an advantage if a piece of mains equipment can be removed from somewhere to free up an extra mains socket. Here we are using the ubiquitous PC as a battery charger. An unused serial interface port can supply enough current to charge (or trickle charge) low-capacity Nickel Cadmium (NiCd) batteries. You could for example, use the batteries in a radio and charge them during use.

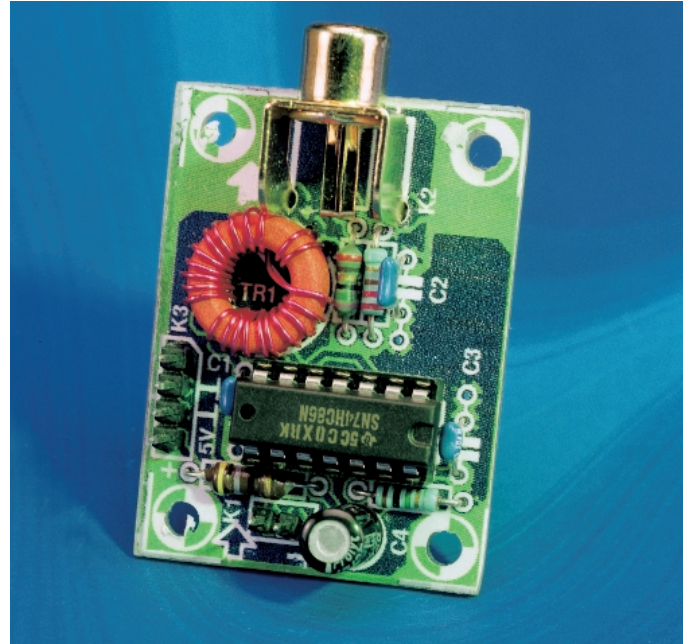
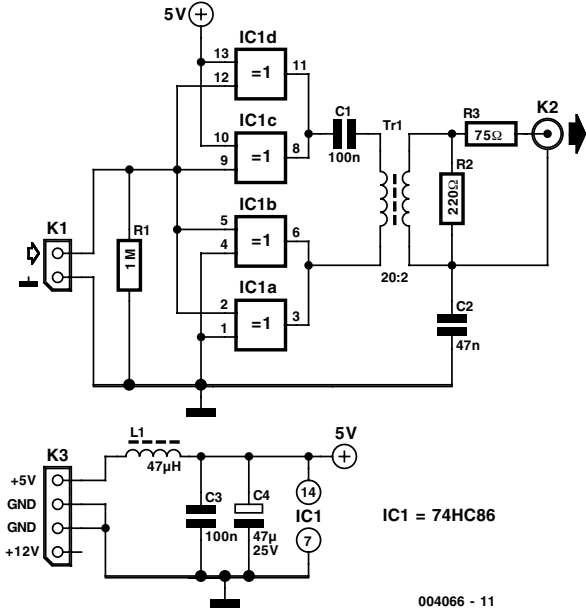
The three serial port connections TxD, DTR, and RTS, when not in use, are at  $-10\text{ V}$  and can supply a current of around 10 to 20 mA (they are short-circuit protected). The circuit shown supplies a charging current of approximately 30 mA. If it is necessary to alter the polarity of the charging circuit then it is a simple job to reverse the diodes and using software, switch the port signals  $+10\text{ V}$ . Those interested could also write a software routine to automatically recharge the batteries.

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# Coaxial S/PDIF Output



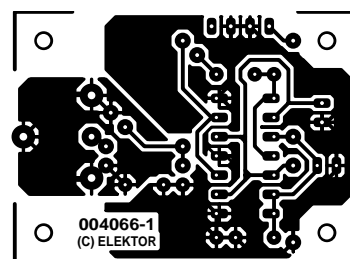
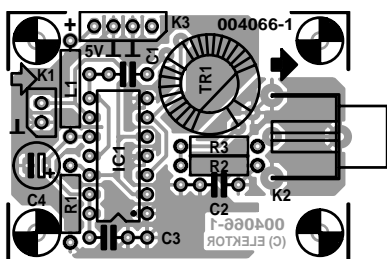
The PCB shown here is unfortunately not available ready-made through the Publishers' Readers Services.

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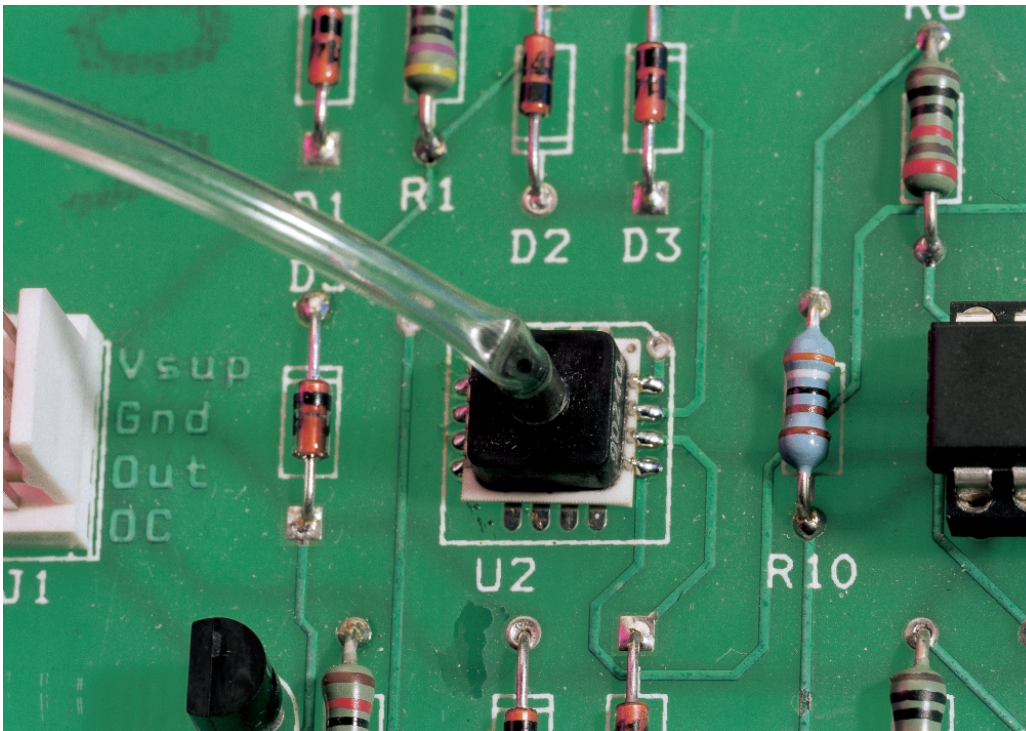
**T. Giesberts**

This circuit is an alternative to the optical S/PDIF output described elsewhere in this issue. The quality of the connection provided by this link is usually better than that of an optical link (less jitter). In order to avoid earth loops, a small output transformer is normally used for digital audio signals. The construction of such a transformer has been described several times in *Elektor Electronics*. It is based on a Philips toroidal core, with 20 turns on the primary and 2 turns on the secondary, both using 0.5-mm varnished copper wire. An output signal of 0.5 V<sub>pp</sub> across 75 Ω must be delivered, which means that 10 V<sub>pp</sub> is necessary on the primary. This signal is provided by a quad EXOR gate (74HC86). A clean symmetrical buffer stage is created by wiring two EXORs as inverters (IC1c and IC1d) and letting the other two work without inversion (IC1a and IC1b). Using EXOR gates makes the delay times of the two buffers the same, and using two gates in parallel on each side allows more current to be delivered. R1 ensures that the gates have a defined level if there is no connection to the signal source. In the absence of an S/PDIF signal, C1 prevents a short-circuit current from flowing. R2 damps any overshoots (which mainly occur if there is no load). C2 provides an HF earth connection for the screen of the interconnecting cable. The power supply is well decoupled by L1, C3 and C4. The current consumption with a signal and load is around 4 mA, but with no S/PDIF signal it drops to zero.

COMPONENTS LIST	
<b>Resistors:</b> R1 = 1MΩ R2 = 220Ω R3 = 75Ω	<b>Semiconductor:</b> IC1 = 74HC86
<b>Capacitors:</b> C1, C3 = 100nF ceramic C2 = 47nF ceramic C4 = 47μF 25V radial	<b>Miscellaneous:</b> K1 = 2-pin SIL header K2 = cinch socket, PCB mount (e.g., Monacor/Monarch T-709G) K3 = 4-pin SIL header Tr1 = ferrite ring core Philips type TN13/7,5/5-3E25. Primary 20 turns, secondary 2 turns
<b>Inductor:</b> L1 = 47μH	







**J. Schuurmans**

A simple pressure switch with a range of 50 to 350 mbar can be made using a pressure sensor. If you can accept somewhat reduced linearity, the sensor can even be used up to 500 mbar. As shown in the schematic diagram, the circuit contains very few components other than the sensor. D1, R1, C1 and D5 form a simple voltage stabiliser that holds the supply voltage for the sensor and opamps at 5 V. The three diodes in series with the sensor provide temperature compensation (more on this later). The differential output signal from the sensor is amplified 30× by an instrumentation amplifier composed of opamps IC1a, IC1b and IC1c. The amplification factor can be adjusted if necessary by modifying the value of R10. The amplified output signal is compared to the voltage on the wiper of P1. If the voltage that results from the pressure being measured is less than the value set by P1, the output of comparator IC1d is High and LED D4 is on. An external load can be switched via the open-collector output of T2. We used a Melexis MLX90240 sensor ([www.melexis.com](http://www.melexis.com)), but unless you work in the automotive industry, you won't be able to obtain this sensor. An Exar sensor (such as the SM5310-005-G-P; see [www.exar.com](http://www.exar.com)) or a Motorola type can be used instead. If necessary, the circuit can be

modified as described below. Start with the sensor sensitivity specification from the data sheet (approximately 60 mV/bar/volt in our case). Since the supply voltage of the sensor is 5 V minus 3 diode drops, or around 3 V, the net sensitivity is thus 180 mV/bar. The range of the sensor is 0 to 350 mbar, so the maximum output voltage is 63 mV. The following amplifier has a gain of approximately 30, so the output signal ranges between 0 and 1.89 V. This voltage is compared to the voltage on the wiper of P1, which can be varied between 0 and 2.5 V. If the sensitivity differs from the nominal value, the amplification can be adjusted as necessary using R10. Finally, a remark on the temperature compensation. The sensor used here has a temperature coefficient of 2100 ppm/degree. Other types of sensor will have somewhat different values (consult the data sheet). The supply voltage should thus increase by 2100 ppm of 3 V for every degree, which is 6.3 mV per degree. The voltage across a silicon diode drops approximately 2 mV per degree, so the supply voltage of the sensor increases as the temperature increases. This compensates for its decreased sensitivity. With the indicated sensor, three diodes in series are needed to just about fully compensate for its temperature coefficient. Two diodes are sufficient for the previously mentioned Exar sensor.

(004070-1)

