ELEKTOR ELECTRONICS

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Special large Christmas issue

with more than sixty construction projects and informative/educative articles

Economy power supply

FSK/RTTY decoder for PCs

Programmable filter ICs

Temperature measurement techniques

Connect 4

6-digit a.c. power switch

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A MUSICAL CHRISTMAS PRESENT

Build this little circuit and surprise whoever you think eligible for a Christmas present that plays a short tune when opened.

MELODY ICs are now available in such a wide variety that it has become fairly easy to build an electronic music box from very few components. Here, we propose the use of an IC that contains eight popular Christmas tunes. The circuit starts to play a tune when triggered by a switch. The switch and the circuit should be carefully tucked away in the Christmas present. Remember, this time the electronics is less important—it is the appearance of the present that matters most. The nicer it looks, the better your chances of success.

The heart of the circuit shown in Fig. 1 is formed by an UM3481A melody generator IC from United Microelectronics Corp. (UMC). Although a series of similar ICs is available offering a wide variety of tunes, the UM3481A is used here because it plays eight 'evergreens' suited to the festive season. The chip contains an oscillator (tone generator), a modulator and an electronic memory. The information contained in the memory controls the tone generator and the modulator, so that a sequence of tones is produced to form a tune. All that is required additionally

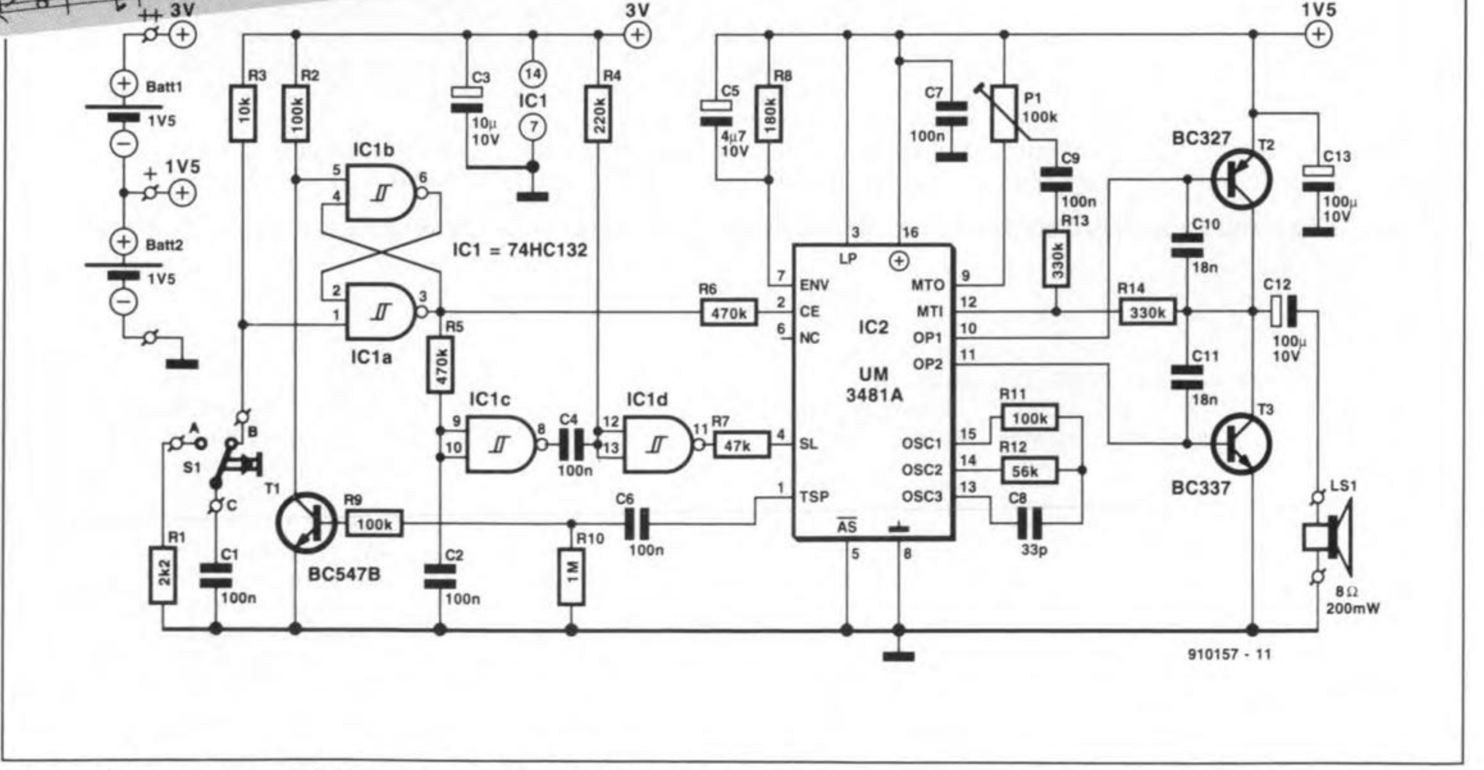

Fig. 1. A switch-triggered eight-melody generator for the festive season.

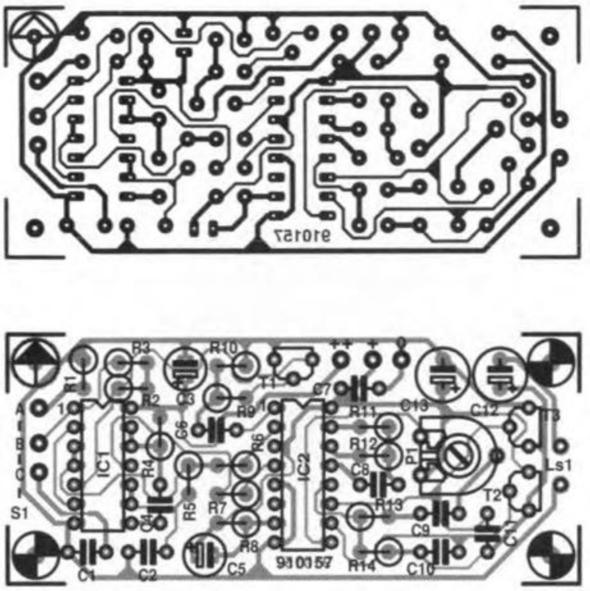

Fig. 2. Single-sided printed-circuit board for the melody generator.

to make the tune audible is a small power amplifier and a loudspeaker. The balanced power output stage is formed by transistors T_2 and T_3. The loudspeaker is connected to this amplifier via output capacitor C_{12}. The volume can be controlled by preset P_1 connected between the audio output, MTO (pin 2) of IC_2 and the input of the on-chip driver, MTI (pin 12). The power amplifier transistors are driven direct from the push-pull outputs of the IC, OP1 and OP2 (pins 10 and 11).

The frequency of operation of the on-chip oscillator is determined by components R_{11}, R_{12} and C_8. The tone frequency can be changed by altering the value of C_8. The timbre is determined by R_8 and C_5. For experiments with the timbre, change the value of C_5 to personal taste.

Table 1. UM3481A melodies

Jingle bells
Santa Claus is coming to town
Silent night, holy night
Joy to the world
Rudolph the red-nosed reindeer
We wish you a merry Christmas
O come, all ye faithful
Hark, the herald angels sing

The melody generator IC is switched on and off by a set-reset (S-R) bistable, IC_{1a}-IC_{1b}. A tune is started when the output of IC_{1a} supplies a logic high level to the CE (chip enable) input, pin 2, of the melody generator. When the CE input is held low, IC_2 is switched to the low-current (1 µA) standby-mode. This obviates an on/off switch.

Pin 5 of IC_{1b} is connected to a reset circuit based on transistor T_1. When the UM3481A has finished playing a tune, a '1' appears on the TSP output, pin 1. This signal causes T_1 to conduct briefly, and reset the bistable, so that the CE input of the melody generator is made low. When the present is opened, switch S_1 is set to position 'B'. Since C_1 is then not charged yet (it was previously connected to ground via R_1), pin 1 of the bistable is pulled low briefly, so that the output (pin 3) changes from low to high.

The two remaining gates in IC_1 ensure that a different tune is played every time S_1 is actuated. The eight available tunes are listed in Table 1. As soon as the output of IC_{1a} supplies a logic '1', C_2 is charged via R_5. When the 'high' trigger level of IC_{1c} is reached, this Schmitt-trigger NAND gate toggles and supplies IC_{1d} with a pulse via a differentiating network, C_4-R_4. This pulse is inverted and, on arrival at the SL input causes the melody generator to select the next tune from the memory. In this way, all eight tunes are played in succession, although this requires the preseent (a box?) to be closed and opened again eight times.

The circuit is powered by two series-connected 1.5-V penlight batteries. Given the low current drain of the circuit, the batteries should last through many 'recitals' of the IC's repertoire.

For ease of construction, a small printed-circuit board has been designed for the Christmas tune generator (see Fig. 2). Most passive components are fitted vertically. The two ICs may be fitted in sockets, but to reduce cost they may also be soldered direct on to the board.

Much of the effect achieved with your melodious Christmas present depends on your creativity in hiding the electronics, and, even more importantly, in finding the best way to fit the switch unobtrusively. When you use a box, you may want to fit a false bottom and install the electronics and the loudspeaker between it and the real bottom. A cigar box or a larger chocolate or sweets box will be sturdy enough for this purpose. Do not forget to drill a few holes where the loudspeaker is fitted, otherwise the sound will lack brightness. Next, the microswitch is fitted near the lid, such that it is switched to the rest position (position 'B' in the circuit diagram) when the lid is opened, or taken from the box.

If all is ready, assembled and tested, proceed with dressing up the box. Do not forget to put your Christmas present inside (the tunes are all very well, but She will probably not appreciate the electronics as much as you do), and use a large red ribbon to *wrap the whole thing up.* ■

COMPONENTS LIST

Resistors:		
1	2kΩ2	R1
3	100kΩ	R2;R9;R11
1	10kΩ	R3
1	220kΩ	R4
2	470kΩ	R5;R6
1	47kΩ	R7
1	180kΩ	R8
1	10MΩ	R10
1	56kΩ	R12
2	330kΩ	R13;R14
1	100kΩ preset H	P1
Capacitors:		
6	100nF pitch 5mm	C1;C2;C4;C6; C7;C9
1	10µF 10V radial	C3
1	4µF7 10V radial	C5
1	33pF	C8
2	18nF	C10;C11
2	100µF 10V radial	C12;C13
Semiconductors:		
1	BC547B	T1
1	BC327	T2
1	BC337	T2
1	74HC132	IC1
1	UM3481A*	IC2

* UMC distributors:

UK:

Manhattan Skyline Ltd. (0628) 75851

METL (0844) 278781

USA:

Unicorn Microelectronics Corp. (408) 727-9589

Miscellaneous:		
1	Microswitch with change-over contact	S1
1	Miniature loudspeaker 0.2W/8Ω	LS1
2	1.5-V penlight battery	
1	Holder for 2 penlight batteries	
1	Printed circuit board	910157

Merry Christmas!

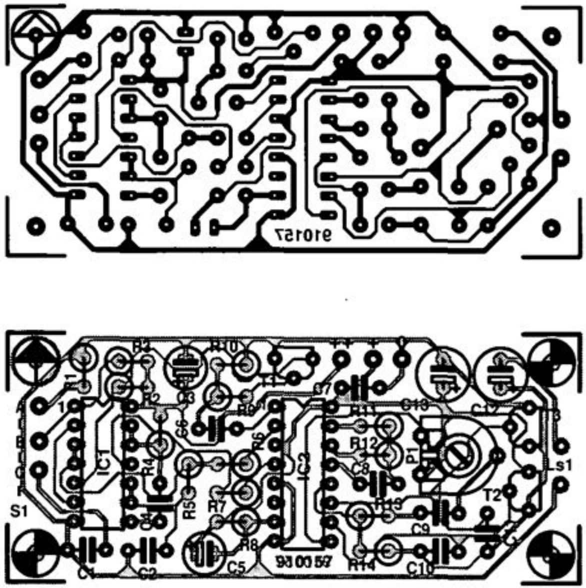

Fig. 2. Single-sided printed-circuit board for the melody generator.

COMPONENTS LIST

Resistors:

1	2kΩ2	R1
3	100kΩ	R2;R9;R11
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2	330kΩ	R13;R14
1	100kΩ preset H	P1

Capacitors:

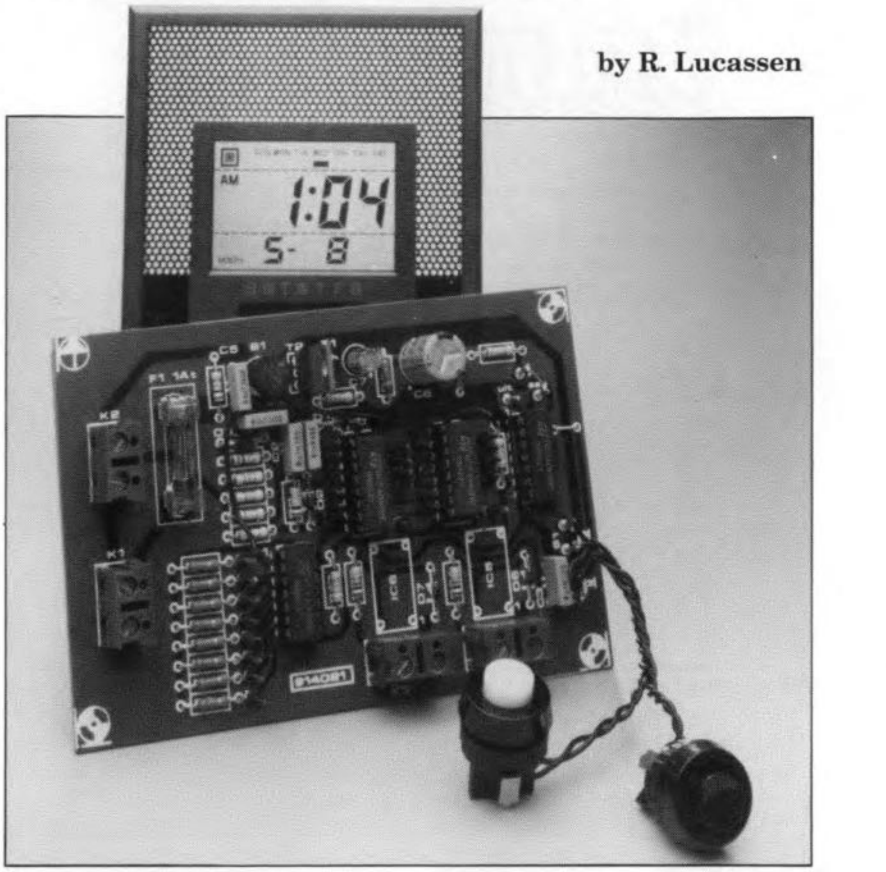
6	100nF pitch 5mm	C1;C2;C4;C6; C7;C9
1	10µF 10V radial	C3
1	4µF7 10V radial	C5
1	33pF	C8
2	18nF	C10;C11
2	100µF 10V radial	C12;C13

Semiconductors:

1	BC547B	T1
1	BC327	T2
1	BC337	T2

UNIVERSAL TIME SWITCH

by R. Lucassen



THIS circuit meets the requirement for a simple, low-cost timer with a timing range of a less than a second to several tens of hours, and a thyristor-based mains interface capable of controlling inductive loads.

The circuit consists basically of a timer section and a switching section. The timer derives its accuracy from the mains frequency: 50 Hz or 60 Hz. Components R4, R3, R2, C1 D1 and D2 convert the mains voltage into a clock signal for binary ripple counter IC1, a 4040. Counters IC1, IC3, and an 8-input AND gate, IC4, form a programmable divider. When the time set with the jumper wire(s) at the outputs of IC2 and IC3 has elapsed, the output of IC4 goes low and causes bistable IC2b-IC2c to toggle. As a result, the gate drive of thyristor Th1 is removed, and the load connected to K2 is switched off. To prevent mains pollution and switching noises, the load is switched during the zero crossing of the mains voltage. The timer can also be used to switch on a load after the preprogrammed time <197> this only requires wire jumper `Y' to be fitted instead of `Z'.

The time is set by fitting a maximum of eight wires between the 8-input AND gate and the counter outputs. The actual time is the sum of all selected times listed in the table.

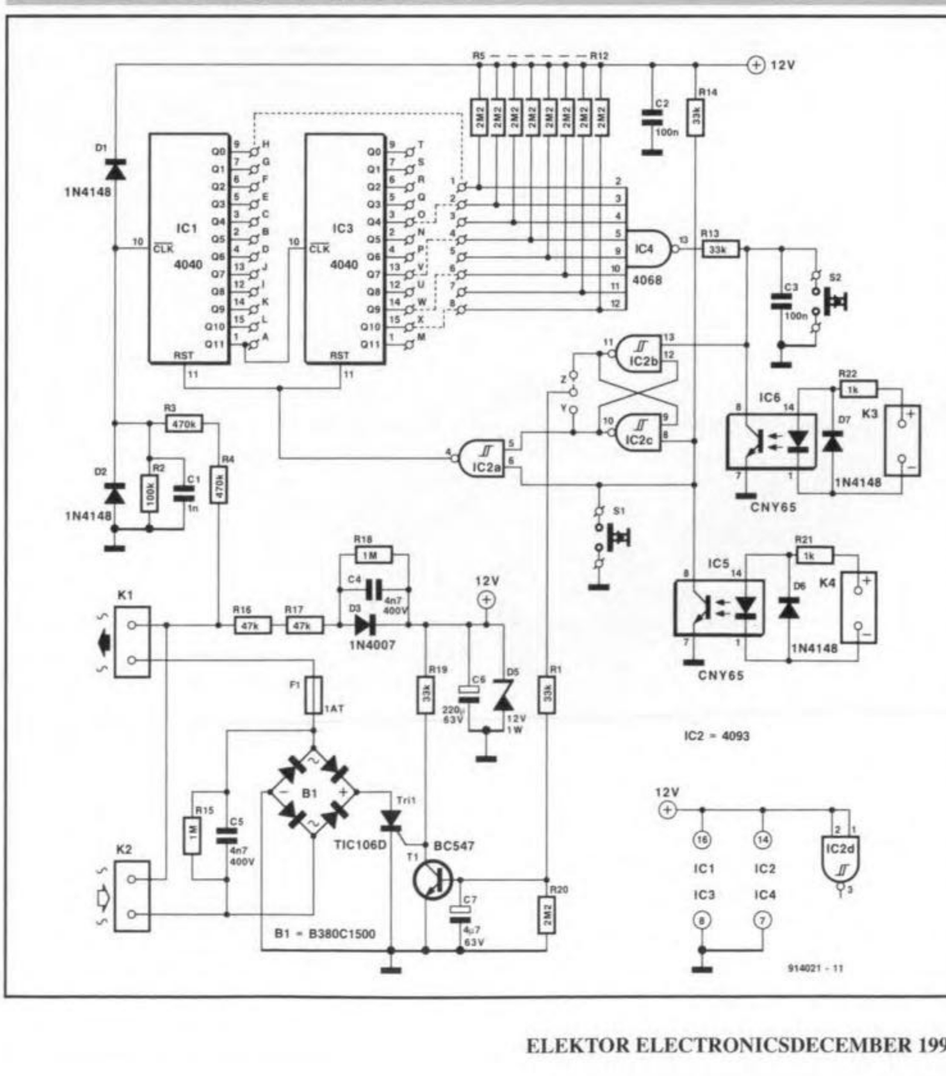
The 12-V supply voltage for the circuit is obtained from the mains with the aid of a single-phase rectifier, D3. The supply voltage is stabilized and smoothed by zener diode D5 and reservoir capacitor C6.

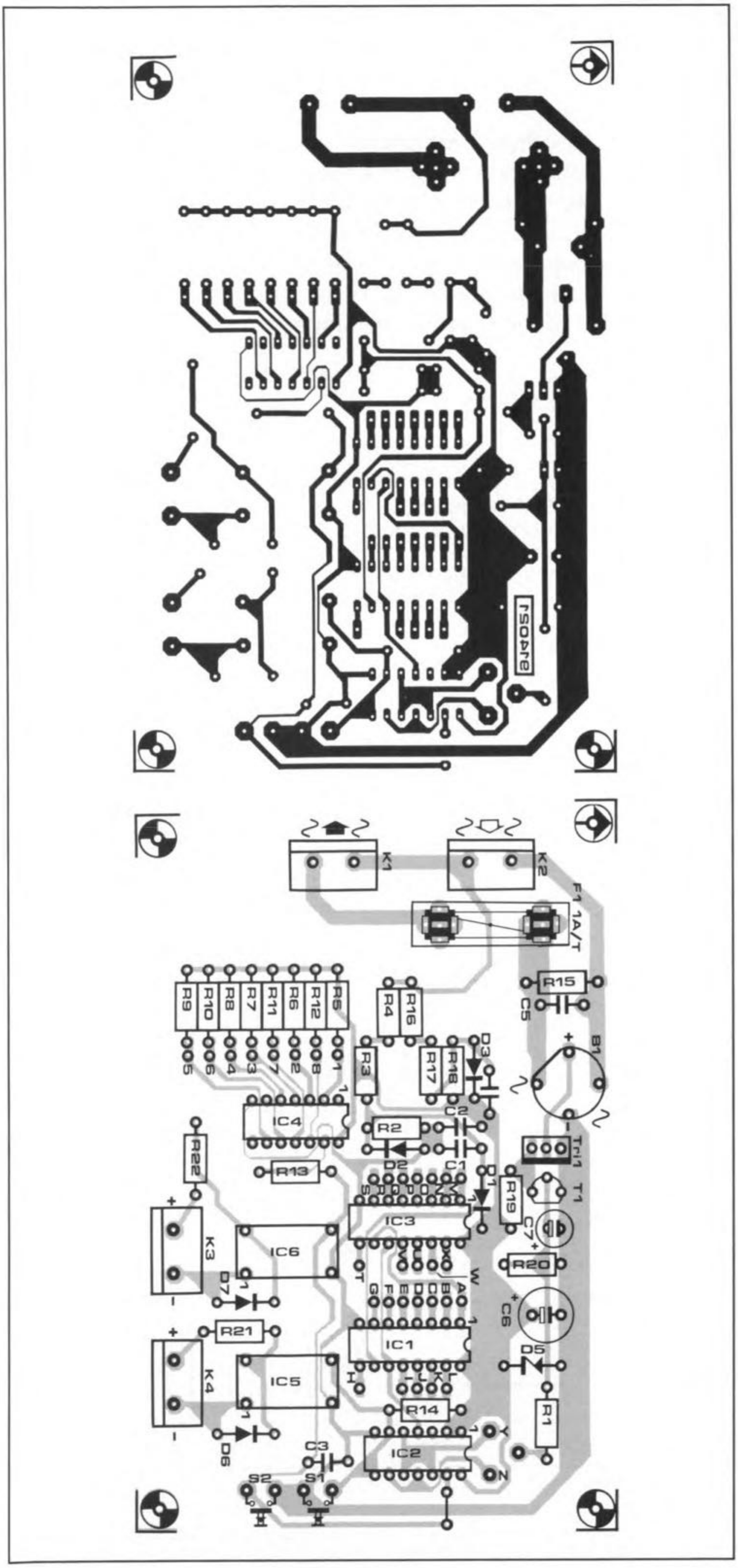
The two series resistors in the rectifier, R16 and R17, must not be replaced by a single 100-kΩ resistor. Remember, the total voltage drop across R16 and R17 is of the order of 220 V (at a mains voltage of 240 V), which is too much for a single resistor rated at 0.5 W. The same applies to resistors R3 and R4.

The timer is actuated by pressing push-button S2. Note that actuating the timer means that the load is switched on or off, depending on whether jumper Y or Z is fitted. During the timing cycle, the circuit can be reset by pressing S2 again. This starts a full timing cycle, irrespective of when the switch was pressed. The timing cycle can be stopped by pressing S1. Provision is made for electronic control of the start and stop functions. This is achieved with the aid of two optocouplers, IC5 and IC6. The electronic control inputs, K3 and K4, are electrically isolated from the timer, and can be driven with control voltages of 5 V.

The construction of the timer is straightforward. A minimum of wiring is required since all parts are contained on a single printed-circuit board. The start and stop switched must be rated at 250 V because they are at mains potential. The circuit must be fitted into an ABS enclosure with non-metallic screws. Take care to provide adequate strain reliefs and insulation of the mains input and output cables. ■

WARNING. Since the circuit carries dangerous voltages at a number of points, never work on the circuit when the mains is connected to it. Make sure that no part of the circuit can be touched when it is being set, adjusted or used.





SWITCHING TIMES		
IC_2 output	Time 50 Hz	Time 60 Hz
Q_1	0.02 s	0.02 s
Q_2	0.04 s	0.04 s
Q_3	0.08 s	0.07 s
Q_4	0.16 s	0.13 s
Q_5	0.32 s	0.27 s
Q_6	0.64 s	0.53 s
Q_7	1.28 s	1.07 s
Q_8	2.56 s	2.13 s
Q_9	5.12 s	4.27 s
Q_{10}	10.24 s	8.53 s
Q_{11}	20.48 s	17.07 s
Q_{12}	40.96 s	34.13 s
IC_3 output		
Q_1	1 m 22s	1 m 8 s
Q_2	2 m 44 s	2 m 16 s
Q_3	5 m 28 s	4 m 33 s
Q_4	10 m 55 s	9 m 6 s
Q_5	21 m 50 s	18 m 12 s
Q_6	43 m 41 s	36 m 24 s
Q_7	1 h 23 m	1 h 12 m
Q_8	2 h 55 m	2 h 25 m
Q_9	5 h 50 m	4 h 51 m
Q_{10}	11 h 39 m	9 h 43 m
Q_{11}	23 h 18 m	19 h 18 m
Q_{12}	46 h 36 m	38 h 50 m

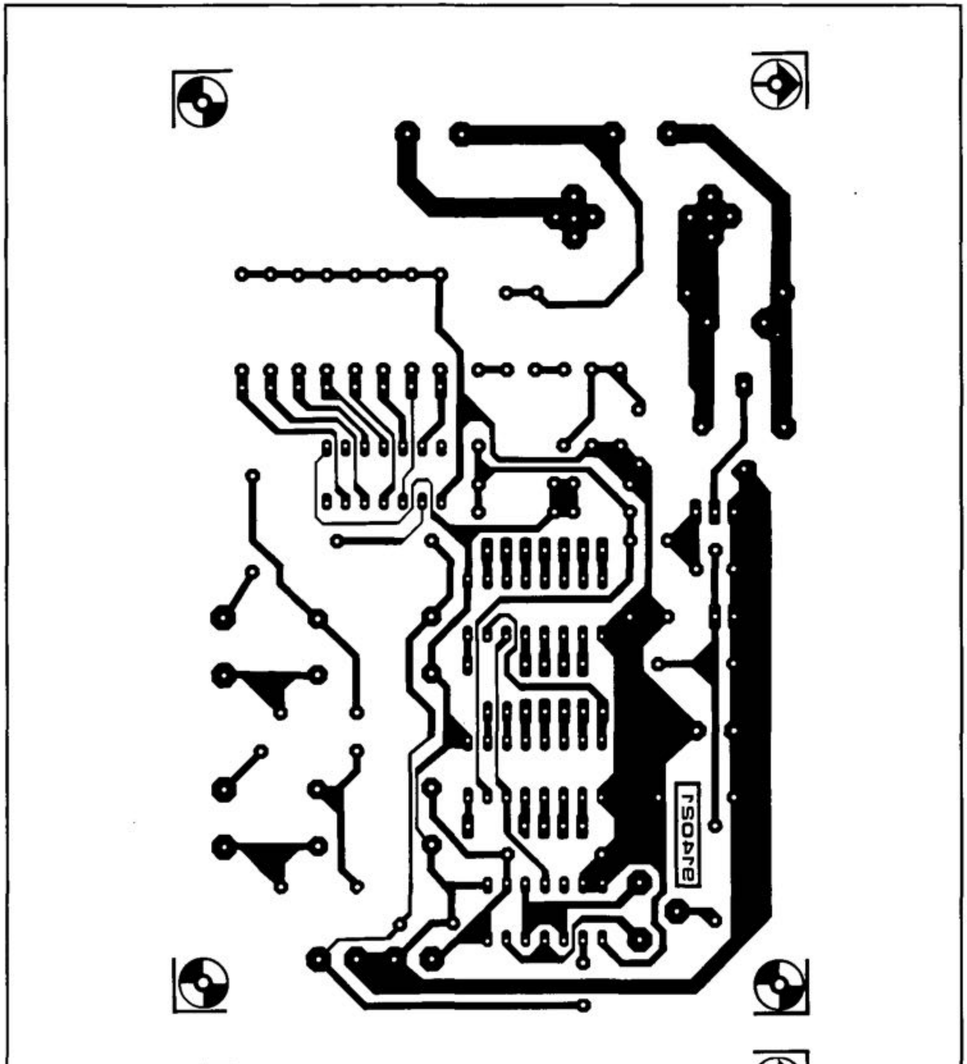
PARTS LIST

Resistors:
R1, R13, R14, R19 = 33 kΩ
R2 = 100 kΩ
E3, R4 = 470 kΩ
R5–R12, R20 = 2.2 MΩ
R15, R18 = 1 MΩ
R16, R17 = 47 kΩ
R21, R22 = 1 kΩ

Capacitors:
C1 = 1 nF
C2, C3 = 100 nF
C4, C5 = 4.7 nF, 400 V
C6 = 220 µF, 63 V, radial
C7 = 4.7 µF, 63 V, radial

Semiconductors:
D1, D2, D6, D7 = 1N4148
D3 = 1N4007
D4 = not used
D5 = zener diode, 12 V, 1.3 W
B1 = B380C1500 (round type)
T1 = BC547B
Tri1 = TIC106 D
IC1, IC3 = 4040
IC2 = 4093
IC4 = 4068
IC5, IC6 = CNY65

Miscellaneous:
K1–K4 = 2-way PCB terminal block, 7.5 mm pitch
S1, S2 = push-button switch for 250 VAC
F1 = fuse, 1 A, delayed action, with holder for PCB mounting
Enclosure, e.g., Bopla E430



SWITCHING TIMES

IC_2 output	Time 50 Hz	Time 60 Hz
Q_1	0.02 s	0.02 s
Q_2	0.04 s	0.04 s
Q_3	0.08 s	0.07 s
Q_4	0.16 s	0.13 s
Q_5	0.32 s	0.27 s
Q_6	0.64 s	0.53 s
Q_7	1.28 s	1.07 s
Q_8	2.56 s	2.13 s
Q_9	5.12 s	4.27 s
Q_{10}	10.24 s	8.53 s
Q_{11}	20.48 s	17.07 s
Q_{12}	40.96 s	34.13 s
IC_3 output		
Q_1	1 m 22s	1 m 8 s
Q_2	2 m 44 s	2 m 16 s
Q_3	5 m 28 s	4 m 33 s
Q_4	10 m 55 s	9 m 6 s
Q_5	21 m 50 s	18 m 12 s
Q_6	43 m 41 s	36 m 24 s
Q_7	1 h 23 m	1 h 12 m
Q_8	2 h 55 m	2 h 25 m
Q_9	5 h 50 m	4 h 51 m
Q_{10}	11 h 39 m	9 h 43 m
Q_{11}	23 h 18 m	19 h 18 m
Q_{12}	46 h 36 m	38 h 50 m

PARTS LIST

Resistors:

R1, R13, R14, R19 = 33 kΩ

FSK/RTTY DECODER FOR PCs

The circuit and the software described here are aimed at those of you who have so far dreaded the complexity of a full-blown FSK decoder and the well-presented objections of the Miss or Missus about the weight, size and noise of a good-as-new teleprinter machine (no matter how cheaply you may have acquired this wonderful equipment), when all you want to do is receive RTTY (telex) transmissions in the short-wave bands.

by Roger Collins

KEEPING the peace at home and still be able to intercept FSK (frequency-shift keying) transmissions requires some hardware to be built or purchased that changes the output of a short-wave receiver into a form that is suitable for processing by a personal computer (PC). The decoder presented here does everything to achieve just that. In combination with a simple BASIC program (Fig. 2), it turns your IBM PC (or compatible) into an RTTY decoder capable of handling different types of FSK, different baud rates, and different mark/space tone conventions. The method used to accomplish this is fairly rudimentary, and intended as a guide for further experimenting.

FSK techniques

Much transmission of data, whether news broadcasts, weather information or amateur traffic, over a radio network employs the principle of frequency shift keying (FSK). The data to be sent is in the form of logic 1s and 0s. This stream of data is used to shift the frequency of the transmitter, resulting in two discrete frequencies being radiated just like an SSB signal modulated by two (alternate) tones. A high transmit frequency denotes a 1 (or mark), and a low transmit frequency a 0 (or space). The two tones and the difference in frequency shift vary depending on the standard used.

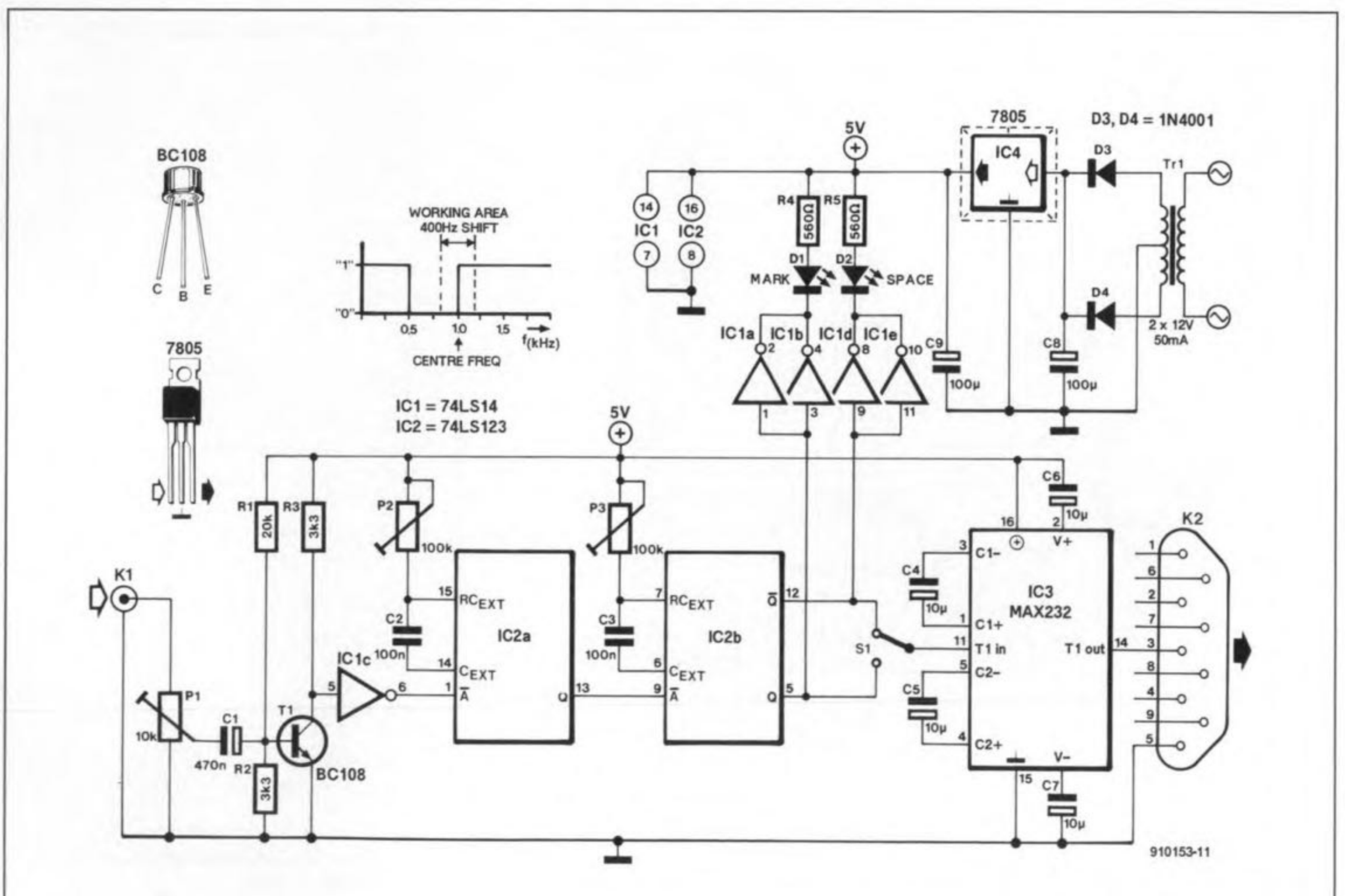


Fig. 1. Circuit diagram of the FSK decoder. A MAX232 is used to ensure the correct signal levels for the PC's serial port, COM2:.

A databyte can be sent asynchronously if it is preceded by a start bit to enable the terminal equipment to get ready to receive it. Likewise, one or two stop bits are used to enable the terminal equipment to shift the newly received databyte out, and prepare for the next start bit, which signals the arrival of a new databyte.

Since a byte is eight bits, a complete dataword would produce a packet of 10 or 11 bits. To reduce the number of bits, and with it the bandwidth occupied by the transmitter, the length of the dataword is reduced to seven and a half bits — five databits, one start bit, and a one and a half stop bit. However, five bits of data will only produce 32 (2^5) combinations. Assuming that plain language is used for the transmission, the 32 codes available allow the complete alphabet to be sent. In the RTTY (radioteletype) system, one of the codes is reserved to indicate 'figure shift', which offers another set of 32 codes that may be used for numbers and punctuation marks. In this set, there is a 'letter shift' code that returns the equipment to the alphabet. The code used is based on the Murry, or more frequently, the Baudot, convention.

To keep the bandwidth of the transmission in the short-wave band as small as possible, the transmission (data-) rate must be kept within limits. The normal speed in terms of bits transmitted per second (baud rate) is 45 to 75. At 50 baud, one bit of data has a length of 20 ms. Using a tone of 1 kHz to indicate a 1 would mean 20 cycles of the tone being transmitted.

At the receiver, a BFO (beat frequency oscillator) enables the two tones to be converted to any frequency within the audio pass-band, i.e., they may not necessarily be the exact original two tones. In the FSK demodulator, filters and phase-locked loop techniques are used to convert these two tones into the marks and spaces (1s and 0s) of the original transmitted data.

FSK decoding on a PC

MS-DOS as well as most communication and terminal emulation programs developed for PCs will allow the baud rate of a serial port (COM1: to COM4:) to be set only as low as 110 baud, and the data format to 7 or 8 bits, with 1 or 2 stop bits. For the reception of FSK data we require to set the baud rate as low as 45, with 5 databits and 1½ stop bit. Quite an unusual format for the average PC user!

Most PCs use a 8250 UART or similar IC in the serial interfaces COM1: and COM2:. The COM1: and COM2: base addresses are 03FB and 02FB respectively. The register functions of the 8250 are listed in Table 1.

For the present application, COM2: is used, and the BASIC program has been written to use this port for the RTTY decoder. The baud rate is sent to the UART as two bytes (high and low). Testing LSR bit 0 will indicate if data has been received in the RDR. Next, the RDR is read, the content is converted to ASCII, a check is made on letter shift or figure shift, and the converted char-

Table 1. 8250 UART register functions

address	LCR bit 7	Function
base + 0	0	Tx holding reg. (THR) (write) Rx data reg. (RDR) (read)
base + 0	1	baud rate divisor low (BRDL)
base + 1	1	baud rate divisor high (BRDH)
base + 1	0	interrupt enable reg. (IER)
base + 2	x	interupt ID reg. (IIR)
base + 3	x	line control reg. (LCR)
base + 4	x	modem control reg. (MCR)
base + 5	x	line status reg. (LSR)
base + 6	x	modem status reg. (MSR)

x = don't care.

Table 2. Teletypewriter codes

CHARACTER			CODE SIGNALS							ASCII	
LTRS	FIGS	START	1	2	3	4	5	STOP	CODE	LTRS	FIGS
A	–		1	1	0	0	0		3	65	45
B	?		1	0	0	1	1		25	66	63
C	:		0	1	1	1	0		14	67	58
D	$		1	0	0	1	0		9	68	36
E	3		1	0	0	0	0		1	69	51
F	>		1	0	1	1	0		13	70	62
G	*		0	1	0	1	1		26	71	42
H	<		0	0	1	0	1		20	72	60
I	8		0	1	1	0	0		6	73	56
J	bell		1	1	0	1	0		11	74	07
K	(		1	1	1	1	0		15	75	40
L	)		0	1	0	0	1		18	76	41
M	.		0	0	1	1	1		28	77	46
N	,		0	0	1	1	0		12	78	44
O	9		0	0	0	1	1		24	79	57
P	0		0	1	1	0	1		22	80	48
Q	1		1	1	1	0	1		23	81	49
R	4		0	1	0	1	0		10	82	52
S	'		1	0	1	0	0		5	83	39
T	5		0	0	0	0	1		16	84	53
U	7		1	1	1	0	0		7	85	55
V	=		0	1	1	1	1		30	86	61
W	2		1	1	0	0	1		19	87	50
X	/		1	0	1	1	1		29	88	47
Y	6		1	0	1	0	1		21	89	54
Z	+		1	0	0	0	1		17	90	43
BLANK			0	0	0	0	0		0	00	00
SPACE			0	0	1	0	0		4	32	32
CR			0	0	0	1	0		8	13	13
LF			0	1	0	0	0		2	10	10
FIGS			1	1	0	1	1		27	00	00
LTRS			1	1	1	1	1		31	00	00

```
10   '   *********************************************
20   '   *                                           *
30   '   *           FSK DECODER PROGRAM             *
40   '   *                                           *
50   '   *         L - LTRS ARRAY                    *
60   '   *         F - FIGS ARRAY                    *
70   '   *         BRD - BAUD RATE DIVISOR           *
80   '   *         G - 1/0 FIGS/LTRS                 *
90   '   *         &H2F8 - COMM 2 RDR/BRDL           *
100  '   *         &H2F9 - COMM 2 IER/BRDH           *
110  '   *         &H2FB - COMM 2 LCR                *
120  '   *         &H2FD - COMM 2 LSR                *
130  '   *********************************************
140  '
150  CLS
160  PRINT
170  PRINT "   FREQ              BAUD RATE "
180  PRINT "   ----              --------- "
190  PRINT
195  PRINT "  20.967                 50            TASS "
200  PRINT "  18.404                 50            TASS "
210  PRINT "  18.194                 50            TASS "
220  PRINT "  18.439                 50                 "
230  PRINT "  18.049                 50            FRENCH "
240  PRINT "  15.937                 50                   "
250  PRINT "  13.490                 50            FRENCH "
260  PRINT "   8.064                 50            FRENCH "
270  PRINT "   7.594                 50            BELGRADE "
280  PRINT
290  PRINT
300       INPUT "Enter baud rate  ",B
310       BRD=1843200!/(16*B)
320       BDRL=BRD AND &HFF
330       BRDH=(BRD AND &HFF00)/256
340  CLS
350  DIM L(31),F(31)
360  FOR J=0 TO 31
370  READ L(J)
380  NEXT J
390  FOR J=0 TO 31
400  READ F(J)
410  NEXT J
420  OUT &H2FB,&H84
430  OUT &H2F8,BRDL
440  OUT &H2F9,BRDH
450  OUT &H2FB,&H4
460  S=INP (&H2FD)
470    K=S AND 1
480    IF K=0 THEN GOTO 460
490  A=INP (&H2F8)
500  IF A=27 THEN G=1
510  IF A=31 THEN G=0
520  IF G=0 THEN PRINT CHR$(L(A)); ELSE PRINT CHR$(F(A));
530         OUT &H2FD,0
540  GOTO 460
550  DATA 00,69,10,65,32,83,73,85,13,68,82,74,78,70,67,75,84,90,76,87,72,89,
80,81,79,66,71,00,77,88,86,00
560  DATA 00,51,10,45,32,39,56,55,13,36,52,07,44,62,58,40,53,43,41,50,60,54,
48,49,57,63,42,00,46,47,61,00
```

910153-12

Fig. 2. Listing of the control program written in BASIC.

acter is sent to the video adapter. LSR bit 0 is then cleared, and the software waits for the next character by testing this bit.

A simple FSK decoder

The circuit diagram of the FSK decoder hardware is given in Fig. 1. The audio output of the receiver is applied to connector K1, and the preset level of P1 is adjusted to give a squared-up signal at the collector of T1. Provided the receiver has been tuned correctly to the FSK signal, the rectangular signal supplied by T1 will be the digital version of the two tones.

The two signal frequencies are fed to IC2a via a Schmitt trigger, IC1c. IC2a is a retriggerable monostable multivibrator set to a mono time of about 1 ms with preset P2. This means that signals higher than 1 kHz will cause this mono to be permanently set. Any frequency lower than 1 kHz, for instance, the lower FSK tone, will cause the mono to set and clear. This signal is fed to a second monostable, IC2b, set to 2 ms with P3. This monostable will be set for the periods of the signals, supplied by IC2a, shorter than 2 ms, i.e., for frequencies higher than 500 Hz. The result is that frequencies between 500 Hz and 1 kHz will produce a logic 0, and frequencies higher than 1 kHz a logic 1, with a sharp transition at this centre frequency.

Table 3. Decoder to PC connections

Decoder (D9)	PC (D9)	PC (D25)	Signal
5	5	7	ground
3	2	3	RxD

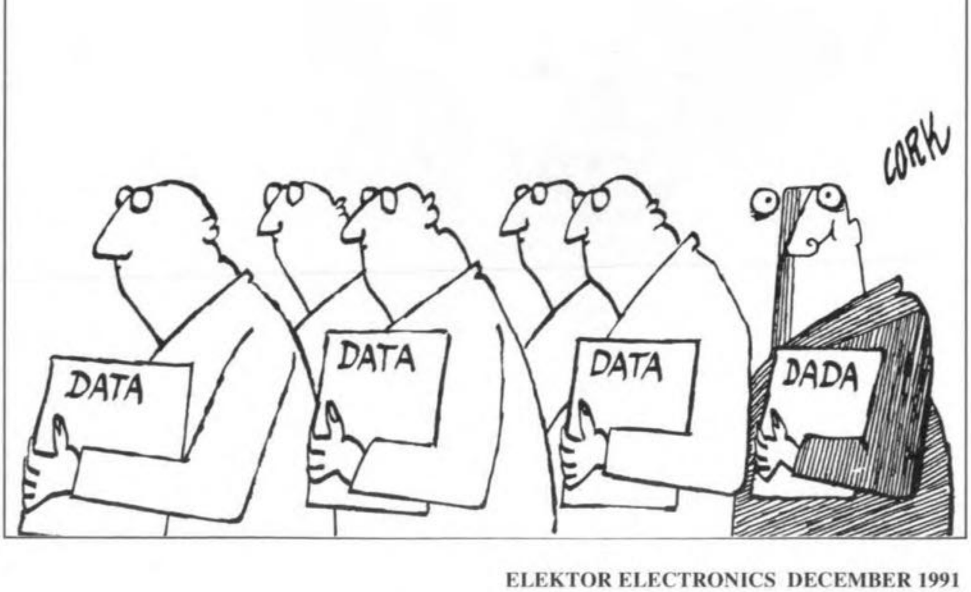
If the receiver is tuned so that the high tone and the low tone (mark and space) are equidistant around the centre frequency, the mark and space signals will produce 1s and 0s, depending on the received transmission.

The Q and $\overline{Q}$ signals are used to drive the mark and space LEDs to assist tuning to the FSK transmission. As there are as many marks as spaces, the two LEDs will flash at the same rate when the tuning is correct. These signals are also fed to the phase reversing switch, S1, and from there to a Type MAX-232 RS232 driver, IC3. This IC has an on-board DC-DC converter providing +10 V and −10 V rails to ensure the correct swing of the RS232 signal required by the serial port of the PC.

Correct setting-up of the serial port, the baud rate, the number of databits and stop bits will result in the interception of the RTTY transmission, which will de displayed on your computer monitor. Converting the 5-bit code into ASCII will enable the characters to be displayed.

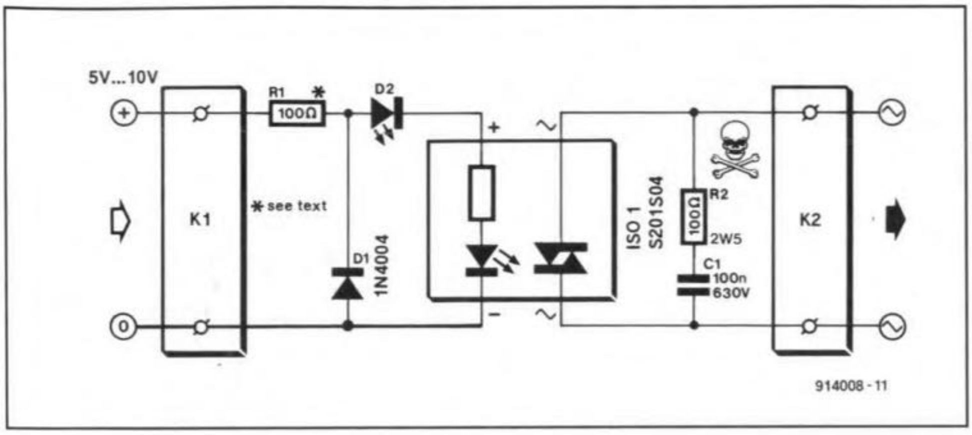
Presets are sufficient here since the final adjustment of the audio signal can be done at the receiver. The phase switch, S1, will be called upon occasionally when the marks and spaces are swapped as a result of tuning the receiver above or below the tones (USB or LSB).

Finally, the decoder is powered by a simple 5-V supply connected to the mains. Although its current drain is small, no attempt should be made at powering the decoder from the modem signals on the PC serial port lines. ■



SAFE SOLID-STATE RELAY

by J. Ruffell



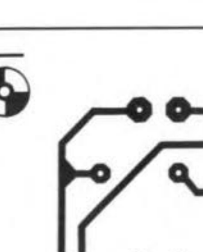
PARTS LIST

Resistors:
R1 = 100 Ω
R2 = 100 Ω, 2.5 W

Capacitors:
C1 = 100 nF, 630 V

Semiconductors:
D1 = 1N4004
D2 = LED, red
ISO1 = S201SO4 (Sharp)

Miscellaneous:
K1 = PCB terminal block, 5 mm pitch
K2 = PCB terminal block, 10 mm pitch



ALTHOUGH the S202DS2 solid-state relay (SSR) from Sharp is a useful and interesting electronic component, it fails to meet the minimum requirements for electrical safety in many countries where the mains voltage is 220 V or 240 V. This is mainly because the breakdown voltage of the optocoupler in the S202DS is too low, and the pin spacing of the device is too small.

For the many applications where electrical safety is a primary concern, Sharp have developed another SSR, the S201S04. The small SIL enclosure (shown in the photograph) contains an optocoupler complete with a series resistor, a zero-crossing switch and a power triac. The presence of the zero-crossing switch implies that the SSR is suitable for non-reactive loads only. Furthermore, since the value of the series resistor is only 130 Ω, an additional, external, resistor will often be required to prevent too high a current through the LED in the internal optocoupler.

For reasons of safety, the solid-state switch is best built on the printed-circuit board shown here (this board is not available ready-made). The value of the external series resistor, R_1, depends on the control voltage and the trigger current. The trigger current, in turn, depends to some degree on the current to be switched, and will typically lie between 5 mA and 20 mA. The optimum value is best determined empirically, observing a maximum current of 40 mA. The minimum value of the series resistor, R_1min, in Ω, is calculated from

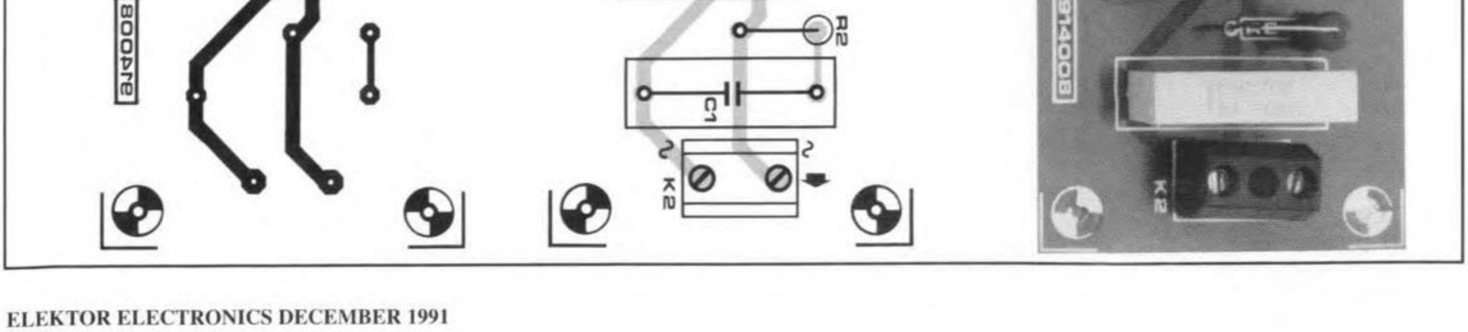
$$R_1\text{min} = 25\,(U_s - 2.4) - 130$$

where Us is the control voltage applied to connector K_1.

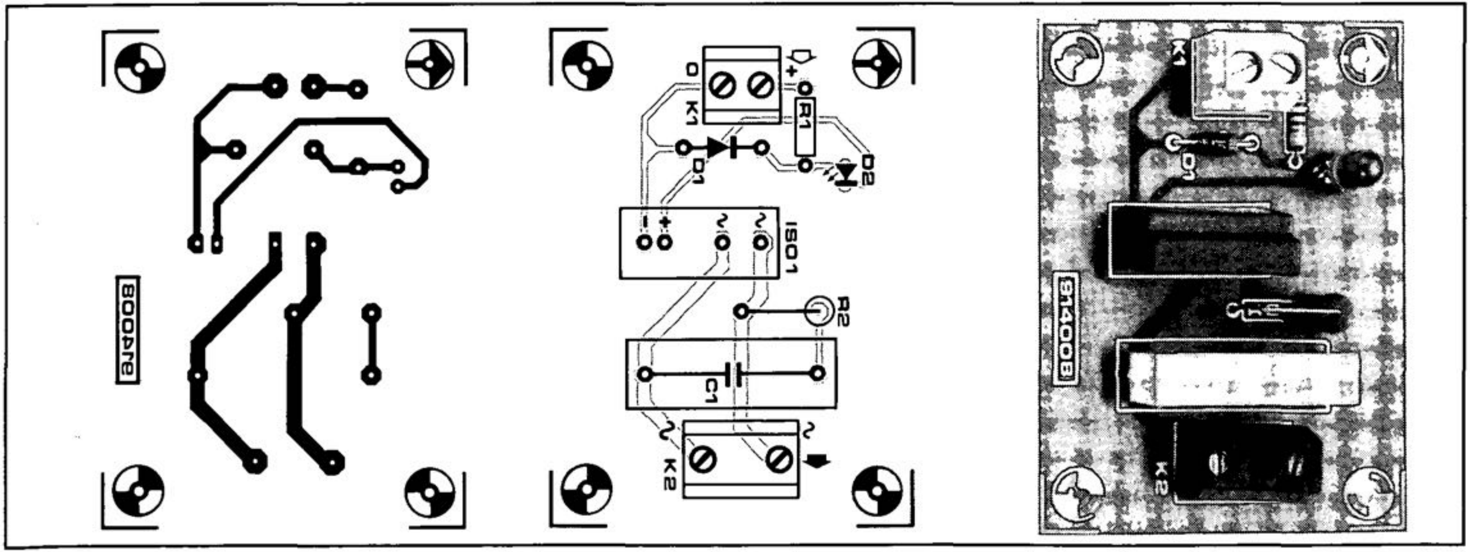
Diode D_1 protects the SSR against reverse control voltages, and D_2 indicates whether the SSR is supplied with a control current. Network R_2-C_1 is connected across the SSR output to protect the device against voltage surges on the mains.

When connected to a mains supply of 220 V or 240 V, the circuit may be used with non-reactive loads up to 330 W, which corresponds roughly to the maximum permissible effective load current of 1.5 A.

WARNING. Since the circuit carries dangerous voltages at a number of points, it is essential that proper electrical insulation is applied. Never work on the circuit when the mains is connected to it. Make sure that no part of the circuit can be touched when it is being set, adjusted or used. Good guidance on safety precautions may be obtained from the IEEE Wiring Regulations, a copy of which is available in most Public Libraries in the UK. ■

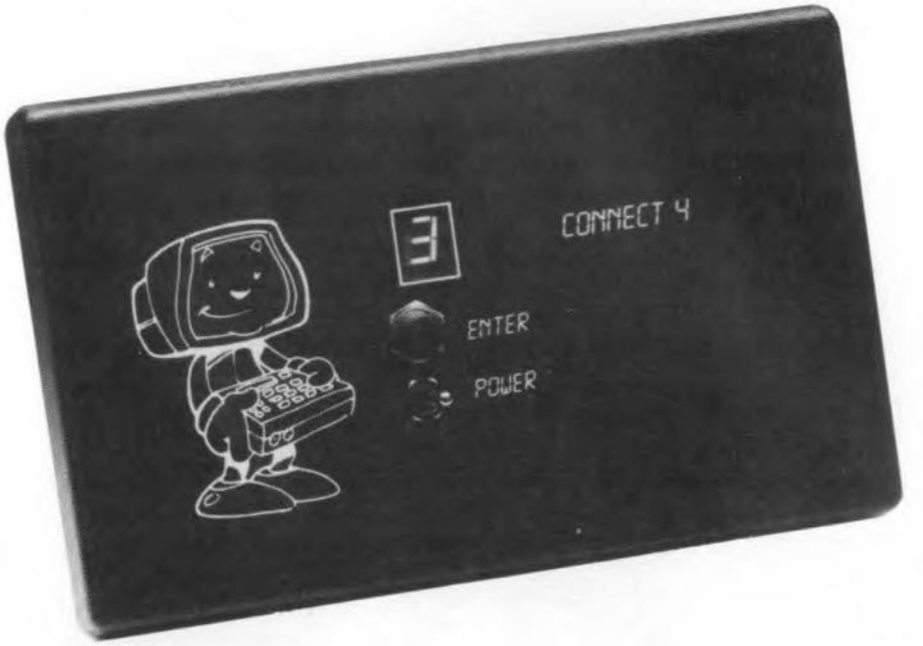


ger current. The trigger current, in turn, de-



CONNECT - 4

This article describes a battery-powered little circuit that allows you to play Connect-4 against a computerized opponent.



by Richard D. Bell

ALTHOUGH most of you will know how to play Connect-4, here are the rules. The game is played on a 7-by-7 vertical board. Players take it in turns to drop their counters down the columns. The counters stop falling when they hit the bottom of the column or another counter. The aim is to get your counters in a line of four either horizontally, vertically or diagonally. The first to get a line wins.

I have always enjoyed playing Connect-4 as long as I can remember. It is a game that is not as taxing to play as chess, but it does provide enough mental stimulation when played against a fairly competent opponent. With this in mind I set about designing a small pocket-sized circuit so that I could play sitting in lectures, or when I was on the train. The result is a 80×60 mm board with remarkably few components that plays a pretty mean game of Connect-4.

Circuit description

At the heart of the circuit (Fig. 1) is a microprocessor Type 6802. This was chosen because it has 128 bytes of in-built RAM, which suited my requirements perfectly.

The microprocessor runs a program stored in a 27C64 8-KByte EPROM. The program is all machine code, and about 6.5 KBytes long. It takes care of everything: user input, deciding where the computer should move, displaying the computer's moves, etc. More information on the software can be found further on.

The two four-input AND gates contained in IC3 (a 74HC20) serve to decode the address space of the microprocessor, so that it can read the EPROM, and write and latch data to the display.

For the display it was decided to use a single 7-segment LED type. The idea of using 49 bi-coloured LEDs was toyed with (the board is 7×7), but this was rejected for a number of reasons: cost, circuit complexity and current. Being a poor student at the time, the cost of 49 LEDs was found a bit excessive, while the current drain was also something to worry about (thinking about it now, this was not really a problem because only one column of 7 LEDs could be lit at any one time. The software would have cycled through the columns at a fast enough rate so that it appeared as if all 7 columns were being displayed simultaneously). Additional components would also be required: at least two more ICs, 7 transistors and some resistors. Coupled with the LEDs, the PCB size would have at least doubled. For all of these reasons, I decided against using 49 LEDs, and instead to use a single 7-segment LED display.

The use of a 7-segment LED display means that the player has to keep track of the state of the play manually. That is, you have to draw the board (or buy one of those pocket Connect-4 games).

The circuit has an RS423 interface, which allows the game to be connected to a (dumb) terminal, a computer running a communications program, or a printer with a serial input. The serial link enables the game board to be printed out automatically. The software provides two data transfer rates, selectable by the user, of 300 baud and 9,600 baud. The RS423 standard is similar to the more common RS232, except that the voltage swing is only ±5 V as opposed to ±12 V. Most equipment will receive RS423 signals just as well as it does RS232 signals.

The driver for the RS423 link consists of two transistors and a couple of resistors. It is only an output — no handshaking lines are received from the external equipment. It is assumed that at 300 baud the equipment will be able to handle displaying the received characters without the need of handshaking. At 9,600 baud, it is assumed that the equipment buffers all received data, making handshaking also unnecessary.

Construction

Construction of the game is relatively easy when the printed circuit board shown in Fig. 2 is used. Provided a soldering iron with a fine tip is used, no problems should be encountered.

It is best to start with the lowest profile components. The following order is recommended: wire links, resistors, IC sockets, capacitors, transistors, jack socket (use short pieces of solid wire to mount it a little above the board), crystal and then the regulator (IC5).

A 4-MHz crystal must be used because all timing for the RS423 link is derived from it. If the serial interface is not required, any crystal up to the maximum frequency of 4 MHz could be used. For example, the commonly found 3.58 MHz NTSC colour burst crystal.

Next, fit the two switches. Depending on the height of the enclosure you intend to use, these may be fitted direct on to the board, or connected to it via short wires. The same goes for the display, which may have to be fitted into a wire-wrap socket to allow it to reach up to the front panel of the enclosure. Alternatively, stack up a couple of regular IC sockets. In any case, fit a regular 14-pin IC socket in position LD1 on the board. The voltage regulator must be fitted with a small heatsink, making sure that this can not touch any of the component wires near IC5.

Finally, connect the battery leads to the board. The red lead goes to the hole marked '+', and the black lead to the hole marked '–'. If you do not intend running the circuit from a battery, a suitable DC input may be used instead. If you power the circuit from the mains, do not use the RS423 link, or else the 'ground' on the jack connector will be shorted to 0 V (it is normally at around 4 V). Any DC voltage from 7 V to 15 V can be used to power the circuit.

If the RS423 link is not required, the following components can be left out: R3, R4, R5, R6, R14, R15, T1, T2 and K1.

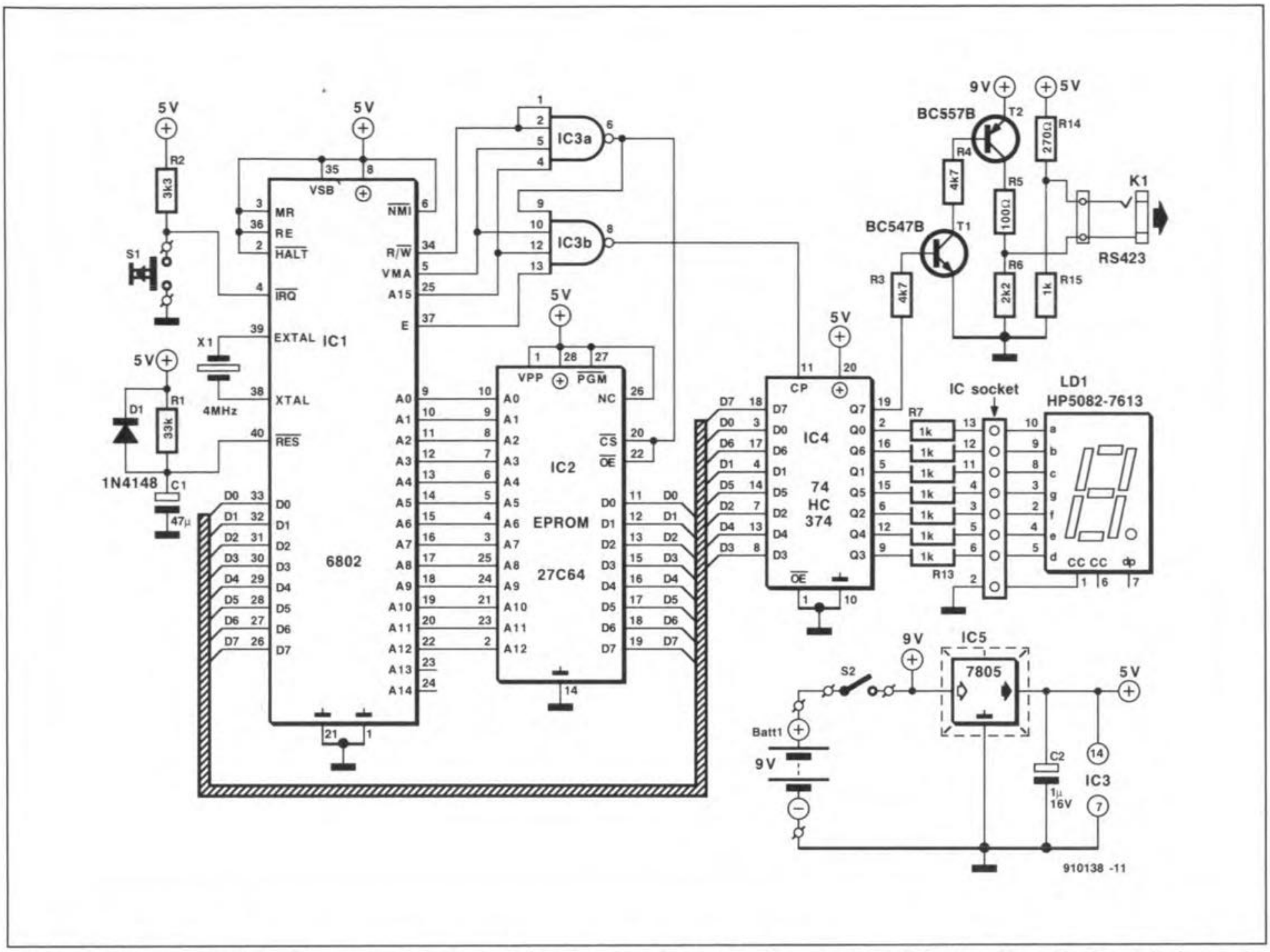


Fig. 1. Circuit diagram of the Connect-4 game. Remarkably, the game is played with a single push-button, S1, as the input device, and a 7-segment display as the output device.

Testing

Inspect your solder work carefully before testing the board. Also check the orientation of the polarized components and the IC sockets. Do not fit the ICs yet, except the voltage regulator. Connect a 9-V (PP3) battery, and switch on S2. Check that +5 V can be found on all the pins that it should be on (refer to the circuit diagram), and that it does not appear on any that it should not. If everything seems all right, you may proceed.

If you have fitted the parts for the RS423 interface, check the voltage on the common ('ground') connection of the jack socket. This voltage should be about 4 V with respect to the circuit ground. If it is not, there is a problem with R14 and/or R15. Next, with a piece of wire short pins 1 and 19 of the socket for IC4. Measure the voltage on the 'signal' (plug tip) connection of the jack socket. It should be about 0 V. Next, remove the shorting wire, and short pins 19 and 20 together on the same socket. This time the voltage on the signal connection should be about 8.5 V.

If everything is all right so far, switch off the power, and insert all ICs and the display into their sockets, making sure to observe the orientation. Note that the microprocessor, IC1, is the other way around from the three other ICs. The display is a 10-pin device which must be mounted centrally in the 14-way IC socket, that is, **pin 1 of the display goes to socket pin 2**.

Switch on, and hopefully you should see the letters 'c o n 4' cycle through on the display. If nothing at all appears on the display, or if the display remains steady or shows constantly changing garbage, there may be a problem with either the crystal, the reset circuitry or your solder work. All that can be done is to check the supply voltage, change the value of C1, and check the PCB meticulously for any open or short circuits. The EPROM must, of course, contain the right program.

Serial connection

The serial link on the board sends data at 300 bits/s or 9,600 bits/s. The format is 8 databits, no parity, and 1 stop bit.

Figure 4 shows the connection to the serial port on the BBC microcomputer, and Fig. 3 the connection to the RS232 (or RS423) port of a terminal, printer or an IBM PC or compatible. In all cases, an RTS-CTS connection is fitted to simulate handshaking.

Get ready to play!

You are ready to play the game as soon as you see the message 'c o n 4' cycle through on the display.

If you have the game connected up to a printer or terminal, press the button any time during the 'c o n 4' display to actuate the serial link. The letter 'P' will appear on the display indicating that printout (serial output) is enabled. Release the button, whereupon the display will switch between a '3' and a '9'. Press the button on the '3' to select 300 baud, or on the '9' for 9,600 baud. The game will restart, and this time data will be sent to the terminal.

You will now be asked to specify the board size (serial link only). See the examples in Figs. 6 and 7 for the difference between the two sizes. Stop the display on the 'S' for the small board, or on the 'L' for the large board.

Next, the display will cycle through either 1, 2 or 3 horizontal bars (segments) being lit. This is the prompt for the level of difficulty. Stop the display on the desired level, 1 bar being easiest, 3 being the hardest.

Finally, you must tell the game who is to go first. Stop the display on the 'H' (for human) if you want to go first, or on the 'C' (for computer) if you want the 6802 to go first.

You are now playing the 6802 at Connect-4. Do not forget to have a ready-drawn board

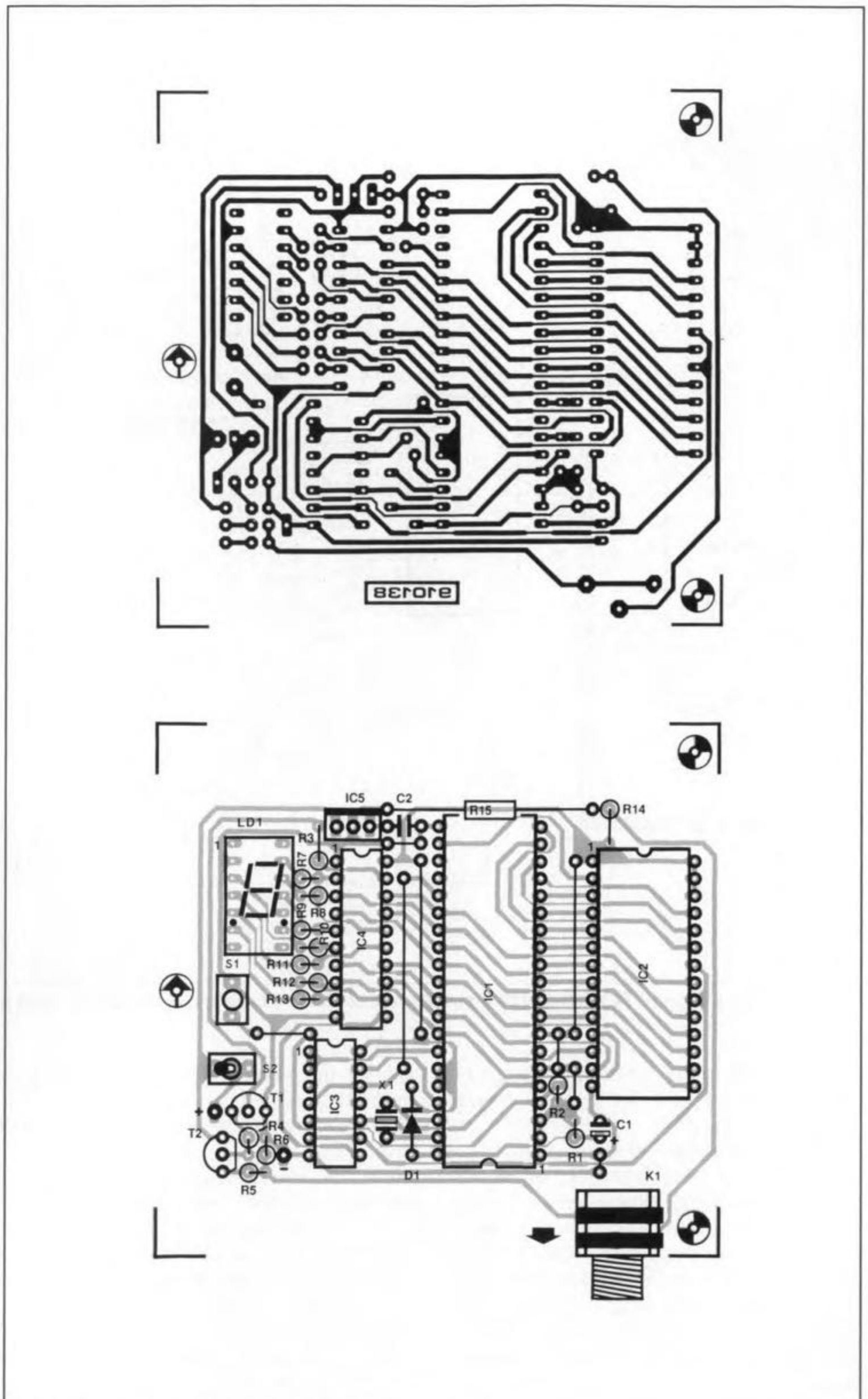


Fig. 2. Printed circuit board for the Connect-4 game.

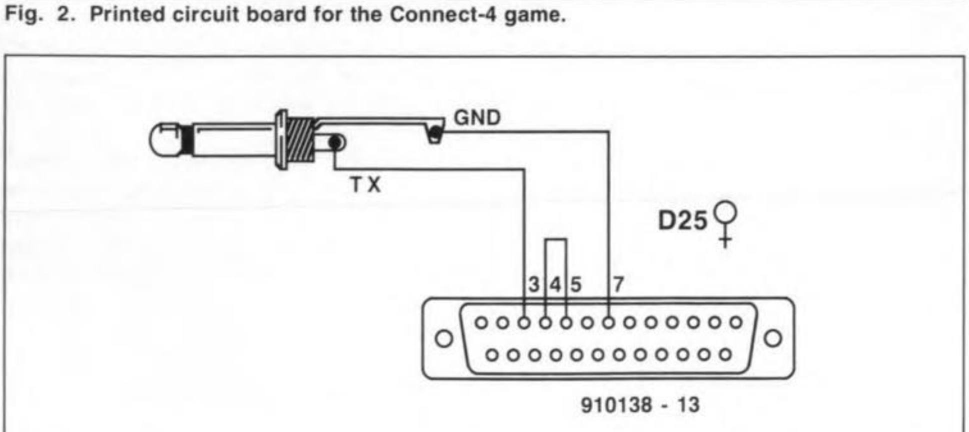


Fig. 3. Serial lead connection details for PCs, printers and terminals.

COMPONENTS LIST

Resistors:		
1	33kΩ	R1
1	3kΩ3	R2
2	4kΩ7	R3;R4
1	100Ω	R5
1	2kΩ2	R6
8	1kΩ	R7-R13;R15
1	270Ω	R14
Capacitors:		
1	47µF 25V radial	C1
1	1µF 16V tantalum	C2
Semiconductors:		
1	BC547B	T1
1	BC557B	T2
1	1N4148	D1
1	6802	IC1
1	27C64 (ESS6081)	IC2
1	74HC20	IC3
1	74HC374	IC4
1	7805	IC5
1	HP5082-7613	LD1
Miscellaneous:		
1	4.00 MHz quartz crystal	
1	PCB mount 3-mm jack socket	K1
1	miniature push-button	S1
1	miniature on/off switch	S2
1	PP3 (9V) battery clip	
1	heatsink for IC5	

handy if you are not connected up to a serial link.

When it is your turn, the display will cycle through the numbers '1' to '7', which correspond to the seven columns on the board. Press the button on the column you wish to play. In later stages of the game, some of the numbers will be missed out, indicating that the column is full. When you press the button, the falling graphic will be displayed, representing your counter dropping down the column.

When it is the computer's turn, the top segment of the display flashes, showing that the 6802 is 'thinking' about its move. When it has finished, it will display a number indicating which column it wishes to play.

If you wish to retire, just turn the game off and then on again.

If you win, a symbol which looks like a 'u' is displayed. If you lose (far more likely, even at level 1) an 'L' will be displayed. In the event of a draw, a 'd' will be displayed. Whichever indication appears, just press the button to start another game.

If you are using the serial link, you will be prompted for your response at each stage (see the examples in Figs. 5, 6 and 7).

Software

The machine code program contains a total of six search algorithms. Depending on the level of difficulty selected, either one, five or all six are used. The first search goes through each of the seven columns, and gives them a

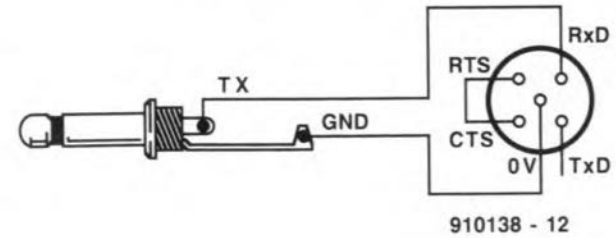


Fig. 4. Serial lead connection details for BBC-B micro.

```
CONNECT 4 - game (c) MB Ltd, code (c) R D Bell 1990-91, version 1.6

Instructions:

Try and outwit the computer by being the first to make a line of four, either
vertically, horizontally or diagonally.

The game is played on a 7 by 7 board. Play progresses with each player taking
turns to drop their counters down a column. The counters will fall until they
hit the bottom or another counter. The first to make a line of 4 wins.


Do you want a (S)mall or (L)arge board?

 ALT-F10  HELP | ANSI-BBS | HDX |  9600 N81 | LOG CLOSED | PRT OFF | CR    | CR

Instructions:

Try and outwit the computer by being the first to make a line of four, either
vertically, horizontally or diagonally.

The game is played on a 7 by 7 board. Play progresses with each player taking
turns to drop their counters down a column. The counters will fall until they
hit the bottom or another counter. The first to make a line of 4 wins.


Do you want a (S)mall or (L)arge board?
Large: You're  ##        I'm  /\
               ##             \/

Select the level of difficulty by pressing the button. (1-easy, 3-hard)
Easy: What a wimp!

If you want to go first stop the display on H, or if you wish the computer to
go first stop it on C.
Ok, I'll go first.

I'm thinking . . .
I'll go in column 4
```

910138-14

Fig. 5. Instruction screen displayed on the terminal when the serial link is used.

```
+----+----+----+----+----+----+----+
|    |    |    | /\ |    |    |    |
|    |    |    | \/ |    |    |    |
+----+----+----+----+----+----+----+
|    |    |    | /\ |    |    |    |
|    |    |    | \/ |    |    |    |
+----+----+----+----+----+----+----+
|    |    | /\ | /\ | /\ | /\ |    |
|    |    | \/ | \/ | \/ | \/ |    |
+----+----+----+----+----+----+----+
|    |    | ## | ## | /\ | ## |    |
|    |    | ## | ## | \/ | ## |    |
+----+----+----+----+----+----+----+
|    |    | ## | /\ | ## | /\ |    |
|    |    | ## | \/ | ## | \/ |    |
+----+----+----+----+----+----+----+
|    | ## | ## | /\ | ## | ## | /\ |
|    | ## | ## | \/ | ## | ## | \/ |
+----+----+----+----+----+----+----+
   1    2    3    4    5    6    7

I'm sorry, you've lost.
```

910138-15

Fig. 6. Example of the 'large board' option as displayed on the terminal.

rating. The column with the highest rating is then checked to see what effect it would have if it were played as the computer's go. If playing it would allow the human to win, it is ignored, and the next higher rated column is tried. If the level of difficulty is one, this is the only search used to pick up the computer's go.

If the level of difficulty is either two or three, a further four search techniques are used. These are far more complex, and involve searching forward by up to 12 moves in some instances. The microprocessor attempts to force the human into a losing situation, or create multiple win lines for itself, that the human will not be able to block.

For level three, only one more additional search is used. This compares the current board positions against stored ones in memory. If a match is found, the ideal response is read from memory. This search can be quite time consuming, but it does not mean that any moves that the micro rates as the best (but in the long run have proved not the best) can be avoided. It will be found that the 6802 plays a very good game of Connect-4 at level 3, when the maximum 'move' time is about 20 seconds.

The search algorithms are quite complicated, and their operation is not discussed further here. The author can supply the source listing (which is about 2,500 lines long) on paper or disk (BBC, Amiga or IBM format) for £8. ■

```
      . . . . . . .
      . . . . . . .
      . . . H C . .
      . . H C C . .
      . . C C H . .
      . . H C H . .
      . C H H H C H
      1 2 3 4 5 6 7

I'm thinking . . .
I'll go in column 2

      . . . . . . .
      . . . . . . .
      . . . H C . .
      . . H C C . .
      . . C C H . .
      . C H C H . .
      . C H H H C H
      1 2 3 4 5 6 7

I'm sorry, you've lost.
```

910138-16

Fig. 7. As Fig. 6, but showing the 'small board' option. As you can see, it is quite difficult to beat the 6802!

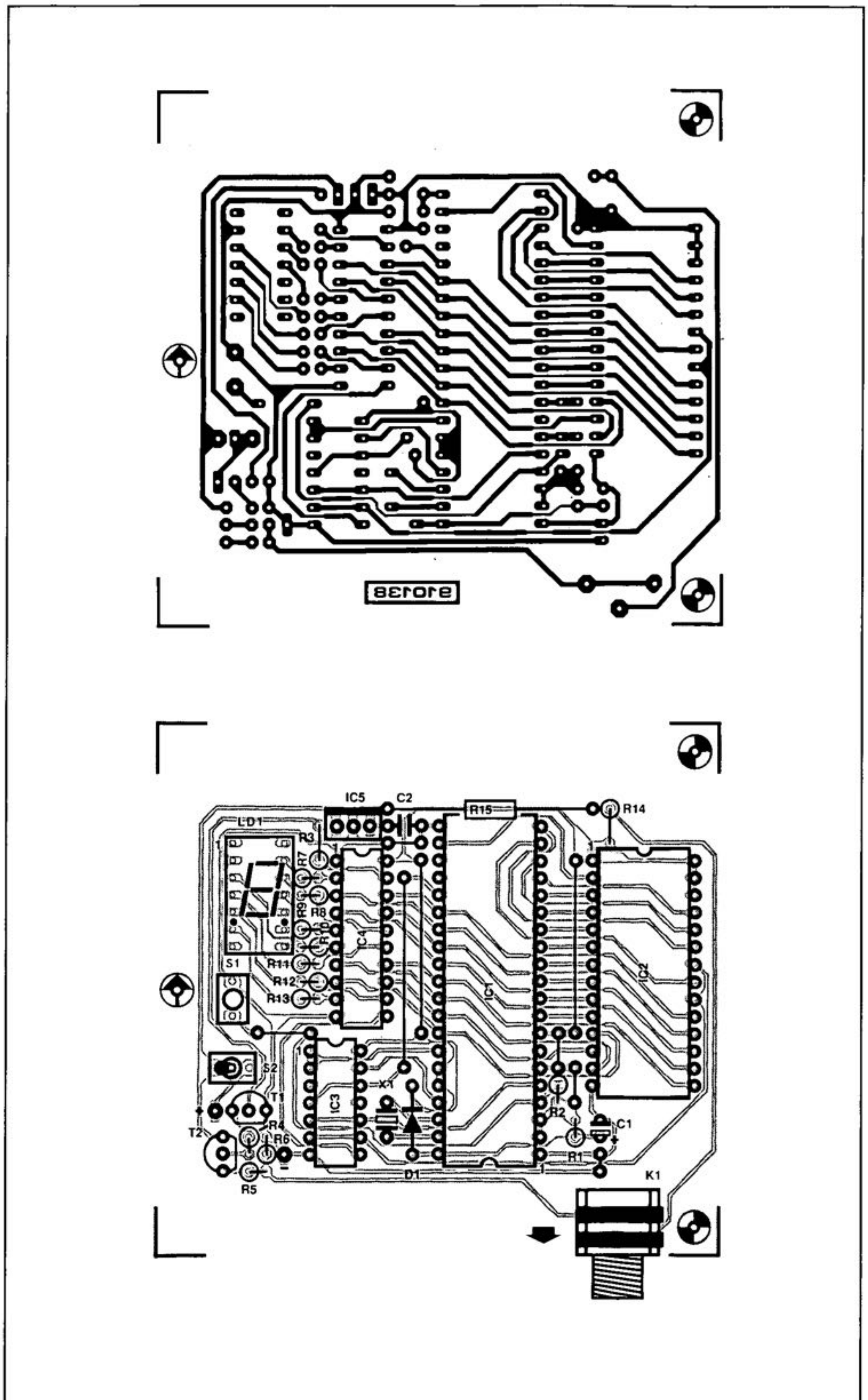


Fig. 2. Printed circuit board for the Connect-4 game.

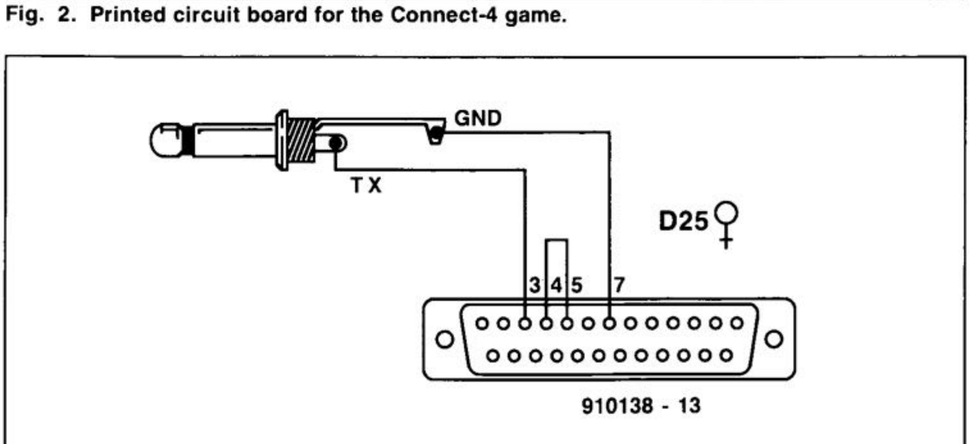


Fig. 3. Serial lead connection details for PCs, printers and terminals.

COMPONENTS LIST

Resistors:

1	33kΩ	R1
1	3kΩ3	R2
2	4kΩ7	R3;R4
1	100Ω	R5
1	2kΩ2	R6
8	1kΩ	R7-R13;R15
1	270Ω	R14

Capacitors:

1	47µF 25V radial	C1
1	1µF 16V tantalum	C2

Semiconductors:

1	BC547B	T1
1	BC557B	T2
1	1N4148	D1
1	6802	IC1
1	27C64 (ESS6081)	IC2
1	74HC20	IC3
1	74HC374	IC4
1	7805	IC5
1	HP5082-7613	LD1

Miscellaneous:

1	4.00 MHz quartz crystal	
1	PCB mount 3-mm jack socket	K1
1	miniature push-button	S1
1	miniature on/off switch	S2
1	PP3 (9V) battery clip	
1	heatsink for IC5	

handy if you are not connected up to a serial link.

When it is your turn, the display will cycle through the numbers '1' to '7', which correspond to the seven columns on the board. Press the button on the column you wish to play. In later stages of the game, some of the numbers will be missed out, indicating that the column is full. When you press the button, the falling graphic will be displayed, representing your counter dropping down the column.

When it is the computer's turn, the top segment of the display flashes, showing that the 6802 is 'thinking' about its move. When it has finished, it will display a number indicating which column it wishes to play.

If you wish to retire, just turn the game off and then on again.

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If you are using the serial link, you will be prompted for your response at each stage (see the examples in Figs. 5, 6 and 7).

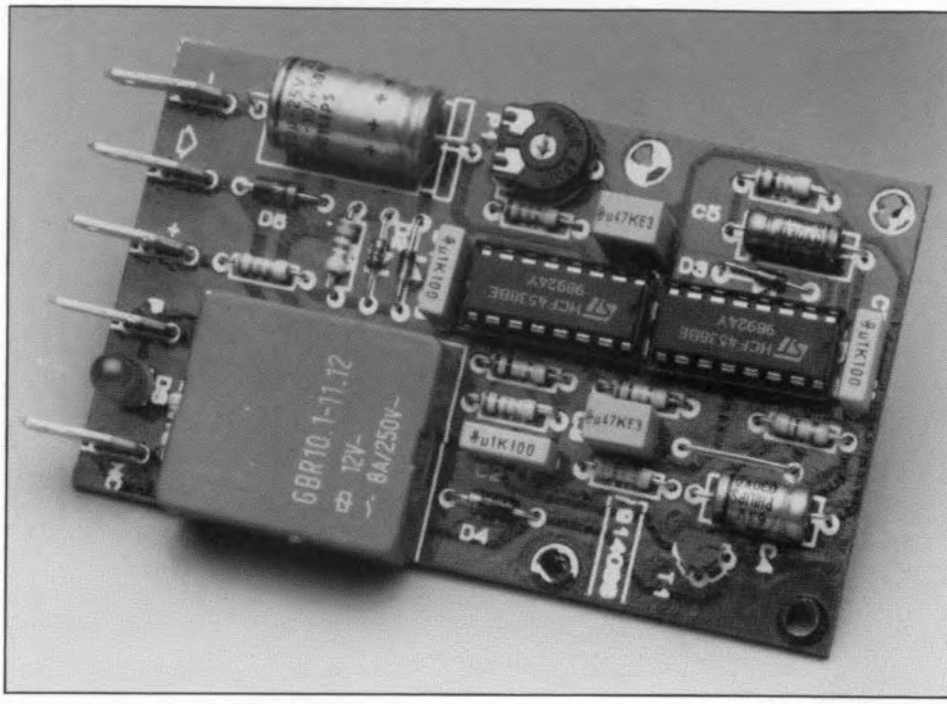
Software

The machine code program contains a total of six search algorithms. Depending on the level of difficulty selected, either one, five or all six are used. The first search goes through each of the seven columns, and gives them a

AUTOMATIC BLOWER FAN CONTROL FOR CARS

by J. Riecker

IN CASE you were not aware of it, the rush hour can affect your health. Stuck in a traffic jam or caught in the dense traffic in a big city, car drivers are often forced to switch off the fan to prevent being choked by the exhaust fumes produced by the vehicle in front of them. Switching the fan on and off every minute or so to keep the fumes out is a nuisance, and calls for an automatic switch controlled by the engine speed. Such switches exist, but unfortunately for most of you they are only found in top-of-the-range cars equipped with an airconditioning system.

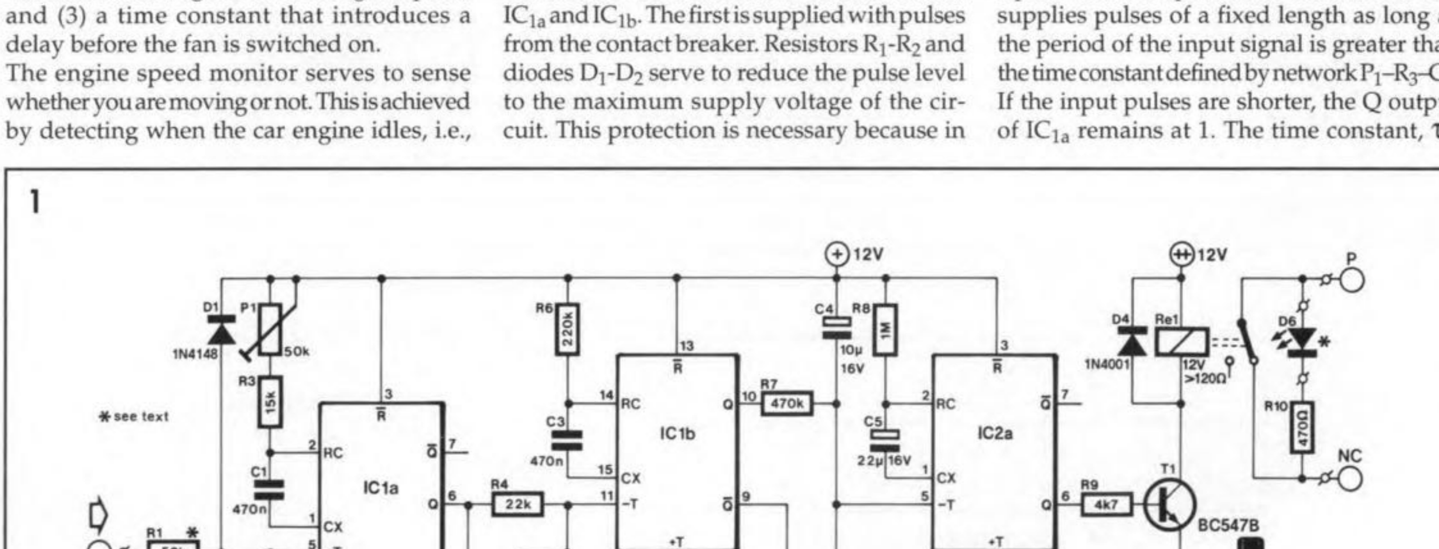


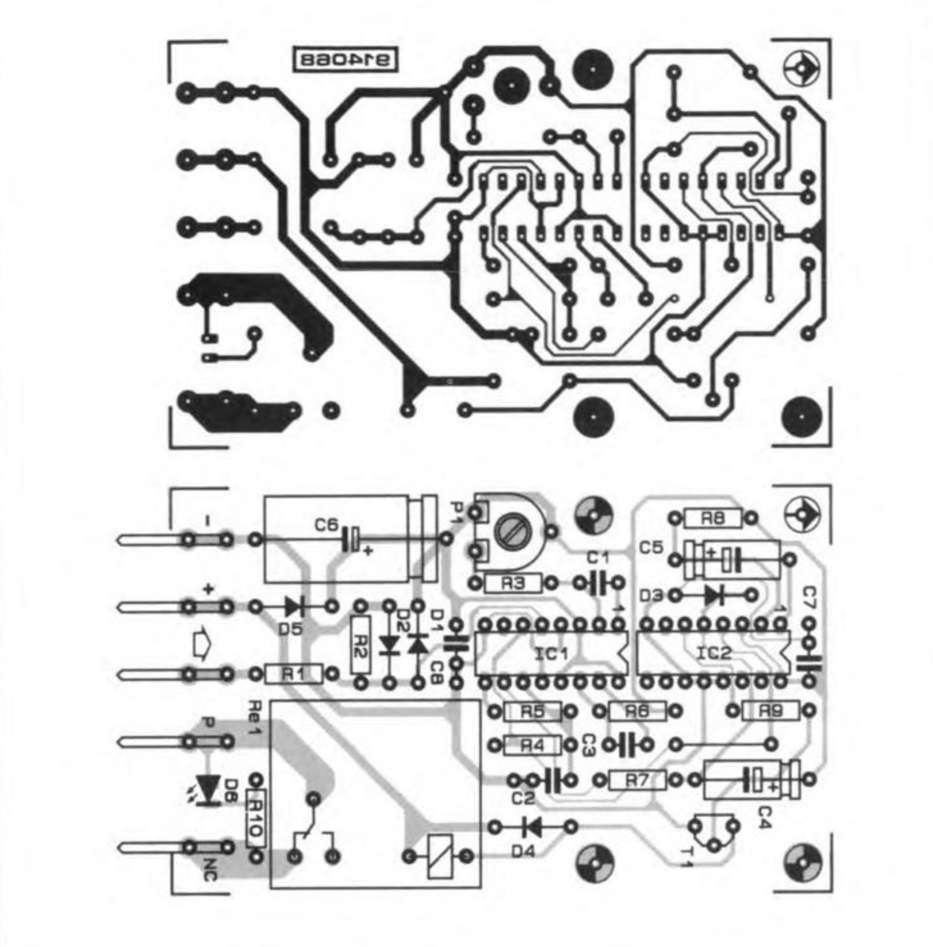
The circuit shown here will not set you back too much, yet puts you at a par with certain BMW 7xx drivers—well, at least as far as the fan control is concerned. The control automatically switches off the fan when the engine runs at a relatively low speed. After a short delay, the fan comes on again automatically when you are clear to drive after passing a congested spot or start moving again in a traffic jam.

The circuit consists essentially of (1) an engine speed monitor circuit set to a switching level of 1,800 rev/min; (2) an integrator to prevent fast switching around the engine speed; and (3) a time constant that introduces a delay before the fan is switched on.

The engine speed monitor serves to sense whether you are moving or not. This is achieved by detecting when the car engine idles, i.e., runs at a relatively low speed. The monitor consists of two monostable multivibrators, IC_{1a} and IC_{1b}. The first is supplied with pulses from the contact breaker. Resistors R_1-R_2 and diodes D_1-D_2 serve to reduce the pulse level to the maximum supply voltage of the circuit. This protection is necessary because in some cars the contact breaker pulses can have a peak value of up to 200 V. Monostable IC_{1a} supplies pulses of a fixed length as long as the period of the input signal is greater than the time constant defined by network P_1–R_3–C_1. If the input pulses are shorter, the Q output of IC_{1a} remains at 1. The time constant, τ_1,

1





2

PARTS LIST

Resistors:
R1 = 56 kΩ
R2 = 8.2 kΩ
R3 = 15 kΩ
R4 = 22 kΩ
R5 = 100 kΩ
R6 = 220 kΩ
R7 = 470 kΩ
R8 = 1 MΩ
R9 = 4.7 kΩ
R10 = 470 Ω
P1 = 47 kΩ preset

Capacitors:
C1, C3 = 470 nF
C2, C7, C8 = 100 nF
C4 = 10 μF, 16 V
C5 = 22 μF, 16 V
C6 = 220 μF, 16 V

Semiconductors:
D1, D2, D3 = 1N4148
D4, D5 = 1N4001
D6 = LED
T1 = BC547B
IC1, IC2 = 4538

Miscellaneous:
Re1 = 12 V/330 Ω PCB mount relay, contact rating about 8 A, e.g. Siemens V23127-A0002-A201
5 off angled 'fast-on' pin for PCB mounting

depends on the number of cylinders, N, in the engine:

$$\tau_1 = 120 \,/\, (\text{ engine speed} \times N\,)$$

For example, for a four-cylinder engine, and a switch-off speed of 1 800 rev/min:

$$\tau_1 = 120 \,/\, (\,1800 \times 4\,) = 16.67 \text{ ms.}$$

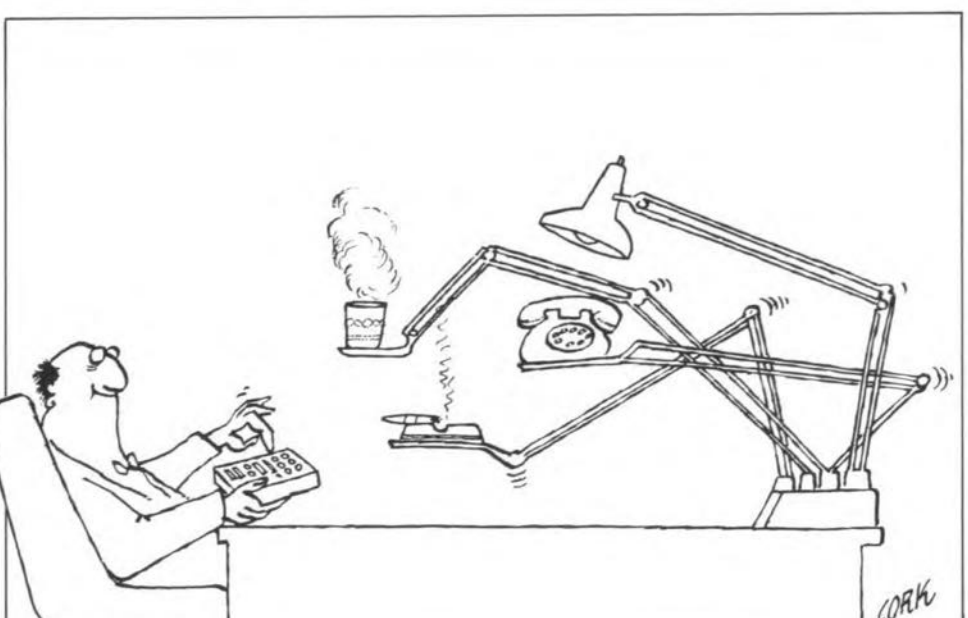
Similarly, for a 5-cylinder engine, τ_1=13.32 ms; for a 6-cylinder engine, τ_1=11.11 ms; and for an 8-cylinder engine, τ_1=8.32 ms.

The second monostable, IC_{1b}, is triggered as long as it receives input pulses from IC_{1a}. This results in pin 10 of IC_1 going high when the engine speed drops below 1 800 rev/min. To delay the response of the engine speed monitor, a small hysteresis is provided by R_5 and C_2. The monotime of IC_{1b}, τ_2, must be greater than the greatest value of τ_1. Here, τ_2 is set to about 100 ms.

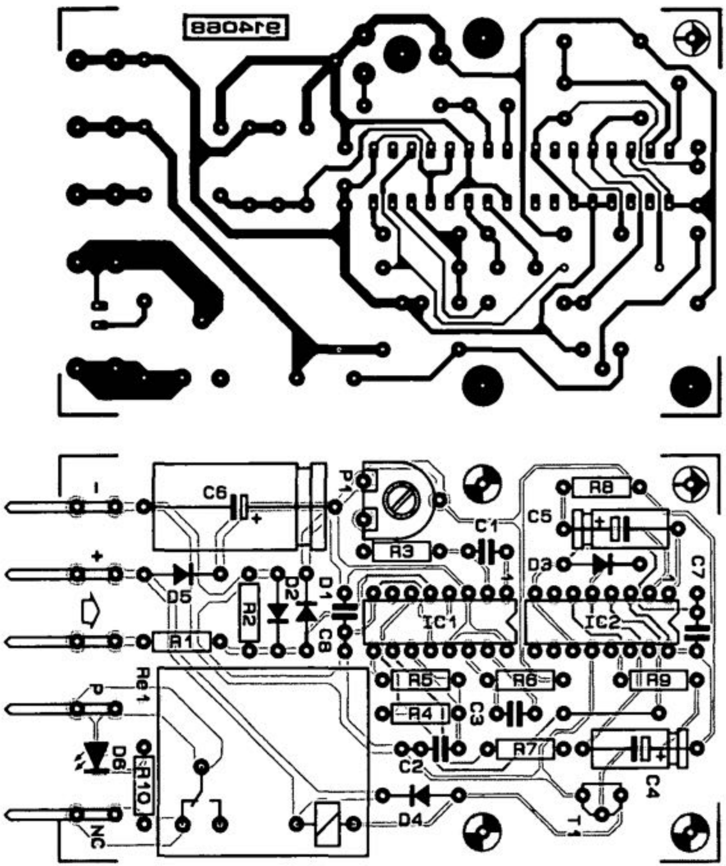
The integrator is formed by network R_7-C_4, whose time constant, τ_3, is set to about 3 s. Then follows a third monostable, IC_{2a}, which determines the on time, τ_4, set to about 20 s. A transistor driver, T_1, interfaces the control to a relay. Note that the fan is switched off when the relay is energized. This is done to enable the fan to be used when the control is not powered for whatever reason. Finally, the third monostable is connected to the first via the positive trigger input. This is done to prevent IC_2 being re-triggered every time the engine speed drops below 1 800 rev/min.

The circuit is best constructed on the printed-circuit board shown here. Keep an eye on the maximum fan current that flows via the board and the relay contacts—the connections between the fan and the board, 'P' and 'NC' (for normally closed) must be made in heavy-duty terminals and sockets as used in cars.

Test the circuit with the aid of a function generator connected to pin 5 of IC_1. Set a generator frequency that corresponds to the desired engine speed at which the fan control must operate. The generator frequency is $1/\tau_1$. Set the length of τ_1 by adjusting preset P_1 until the signal at pin 10 just toggles. Lower the frequency. The relay must be energized. Increase the frequency, and the relay must be de-energized after a delay of about 20 s. The circuit is now ready to install in the car. The current consumption is about 1 mA in the off state, and about 38 mA when the relay is energized. ■



2



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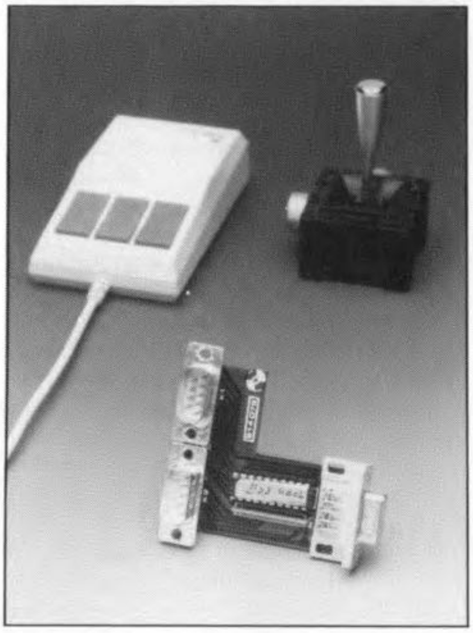
MOUSE/JOYSTICK SWITCH FOR AMIGA

by D. Gembris

HERE is an interesting circuit for all Amiga owners who object to having to disconnect the mouse every time a second joystick is required for a video game. The switch is all-electronic, and can be connected permanently to the joystick-1 port on the Amiga. Extremely simple to build from a minimum of components, the circuit detects automatically when the joystick or the mouse is used.



The mouse supplied with the Amiga computer supplies four signals, apart from the two button signals. Signals H and HQ (or V and VQ) indicate the direction, and X0 and X1 the speed (see Fig. 2). The joystick supplies similar signals, although it must be noted that joystick activity is simpler to detect than mouse activity. The joystick is active whenever one of the four direction signals goes low.

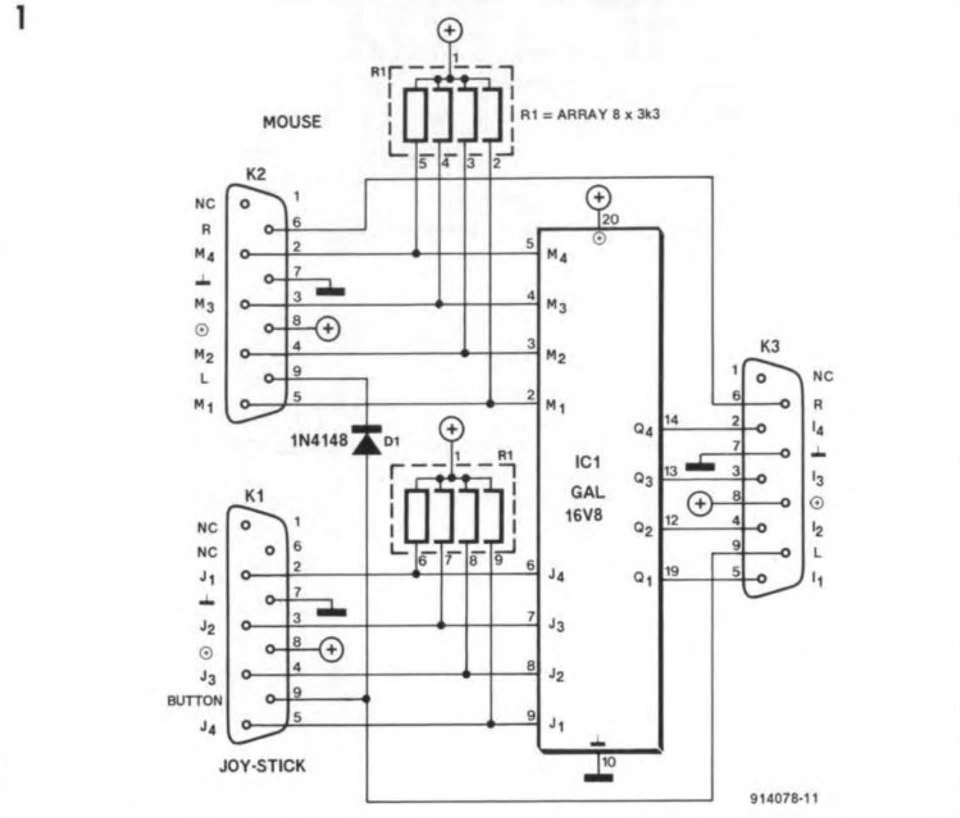
By contrast, mouse activity can only be detected by comparing the current state of the

3

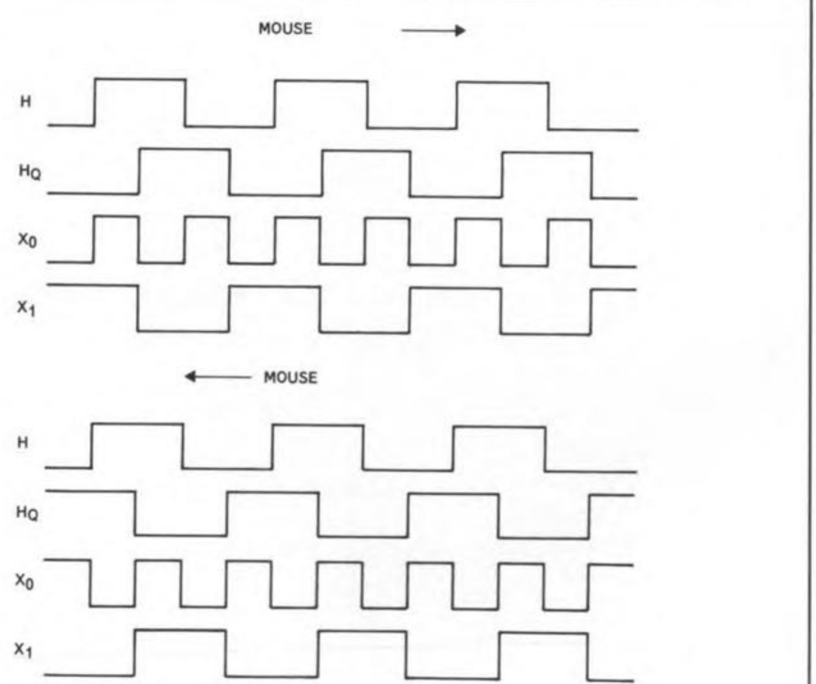
```
*IDENTIFICATION
ELEKTOR;
*TYPE GAL16V8;
*PINS
M1=2, M2=3, M3=4, M4=5, J1=9, J2=8, J3=7,
J4=6, Q2.T=12, Q3.T=13, Q4.T=14
HOUT.T=15, VOUT.T=16, SWM.T=17, DIF.T=18,
Q1.T=19;
*BOOLEAN EQUATIONS
SWM = /DIF & SWM & J1 & J2 & J3 & J4
     + DIF;
Q1 = SWM & M1
     + /SWM & J1;
Q2 = SWM & M2
     + /SWM & J2;
Q3 = SWM & M3
     + /SWM & J3;
Q4 = SWM & M4
     + /SWM & J4;
VOUT = M1;
HOUT = M2;
DIF = /VOUT & M1
     + /M1 & VOUT
     + /HOUT & M2
     + /M2 & HOUT;

*END
```

914078-13

1



2

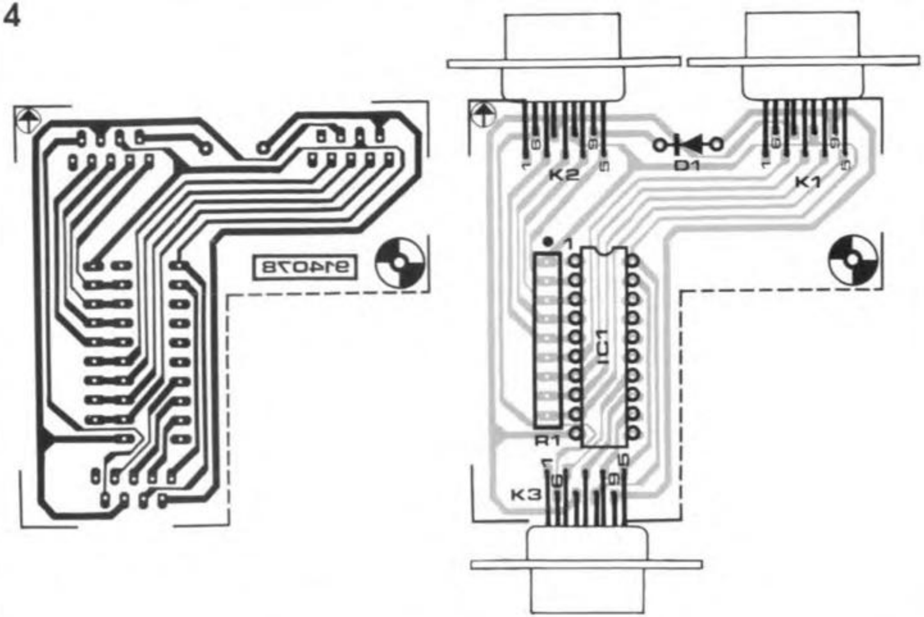


H	HQ	X0
0	0	0
0	1	1
1	0	1
1	1	0

HQ	X1
0	1
1	0

914078-12

4



PARTS LIST

Resistors:
R1 = array, 8×3.3 kΩ

Semiconductors:
D1 = 1N4148
IC1 = GAL 16V8 (ESS6003)

Miscellaneous:
K1, K2 = 9-way male sub-D connector, angled, for PCB mounting
K3 = 9-way, female sub-D connector, angled, for PCB mounting
PCB 914078

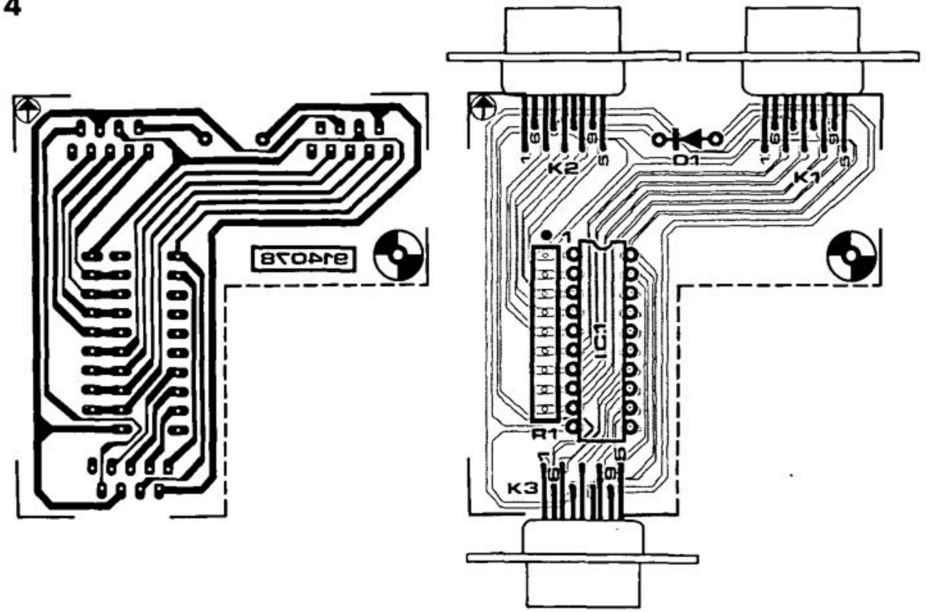
H and V lines with the previous state. The mouse is active when these states are different. Hence, a bistable and a clock would be required to implement an activity detector.

Here, a much simpler solution has been found by making use of the propagation delay of the logic functions contained in the GAL. In practice, the actual delay is uncritical, so that even the slowest GALs can be used—a few nanoseconds are sufficient for a reliable mouse activity detector.

The left-hand mouse button is combined with the button on the joystick via diode D_1. Pull-up resistors are fitted at the joystick and mouse inputs to prevent non-defined signals when one of these devices is not connected.

Those of you with access to a GAL programmer can use the source listing in Fig. 3 to produce a JEDEC file and program their own device. If you do not have a GAL programmer, you may like to know that IC_1 is available ready-programmed through our Readers Services. ■

4



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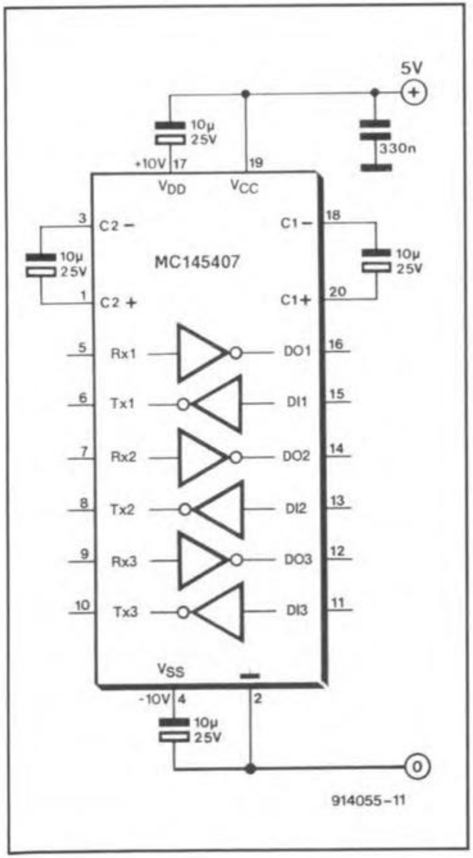
PCB 914078

RS232 WITH SINGLE POWER SUPPLY

by K. Walters



IN MOST personal computers, the power supply provides +5 V and ±12 V lines. The positive 12 V line is needed for the disk drives, and the ±12 V for the RS232 interface. Over the past few years, ICs have become available (such as the MAX232) that can drive serial channels (which need ±12 V) from a single +5 V line.

In the diagram, a Motorola MC145407 and four electrolytic capacitors provide ±10 V (the supply for RS232 connections may lie between ±5 V and ±15 V). The circuit also provides three input buffersand three output buffers (the MAX232 provides two of each). If more buffers are needed, the IC can supply a 145406 via its Vdd and Vss pins to give a total of six input buffers and six output buffers.

The 10-volt potentials are generated by an integral 20 kHz oscillator and two voltage doublers. When the supply is loaded, these voltages drop a little, but remain well within the RS232 requirement.

The open-circuit current drawn by the IC is only 1.5 mA, but this increases, of course, under load conditions.

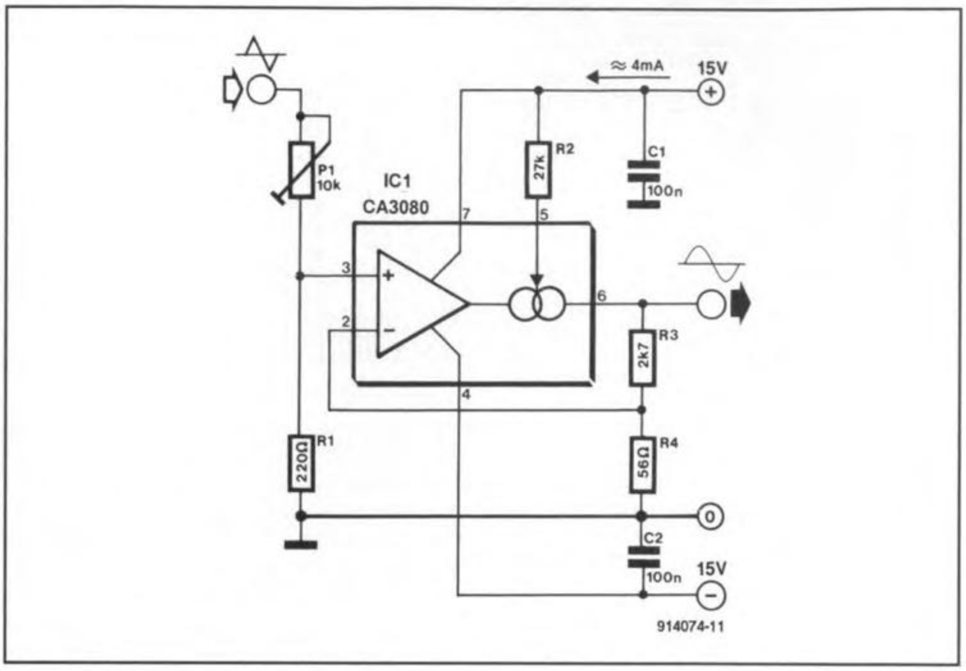
It is advisable to keep the construction as compact as possible and to locate the electrolytic capacitors very close to the relevant pins. The 330 nF decoupling capacitor must be soldered with the shortest possible leads between pins 2 and 19. Preferably, do not use an IC socket, because fairly high peak currents flow when the electrolytic capacitors are being charged. ■

SINE WAVE CONVERTER

by H. Kühne

THE converter, based on a Type CA3080 operational transconductance amplifier (OTA) converts a triangular voltage into a sinusoidal one with very low distortion. An OTA is a device whose amplification can be varied by a control current.

The circuit needs a stable, precisely symmetrical supply voltage, since the control is derived directly from this via resistor R_2. It also needs a symmetrical triangular voltage at a level of 350 mV p-p at pin 3 of IC_1. The output in those conditions is a sinusoidal voltage at a level of 2.85 V r.m.s. Provided the circuit is constructed carefully and P_1 is set correctly, the distortion does not exceed 1.2%. This figure deteriorates rapidly when the supply voltage is not accurate or precisely symmetrical. ■



POWER-ON DELAY

by G. Peltz

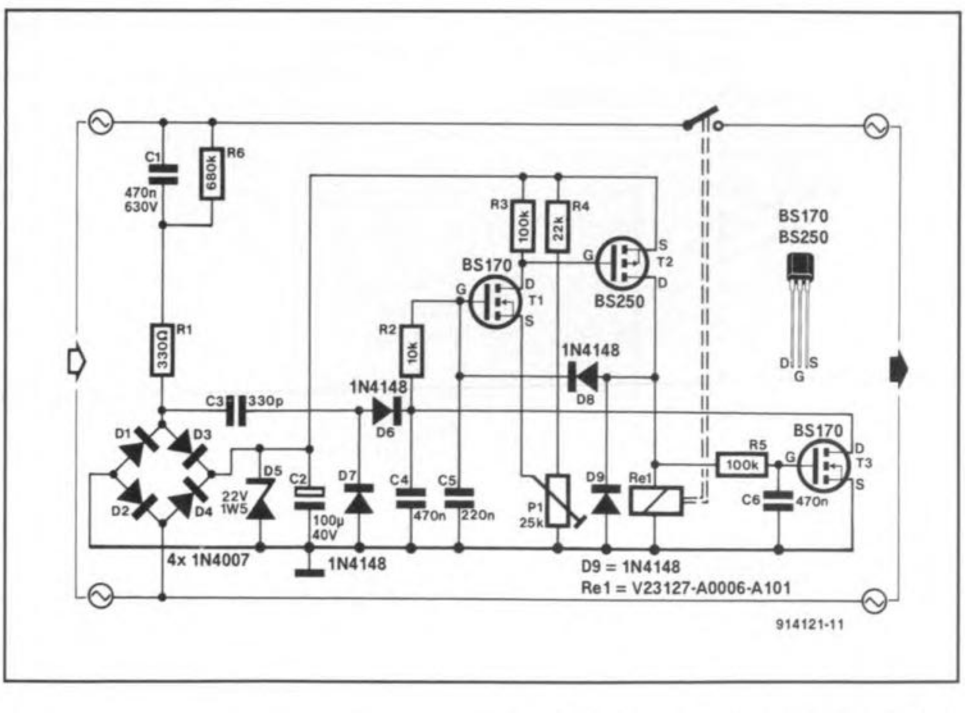
THE power supply for this analogue circuit that affords delays of 330 seconds is taken directly from the mains. The direct voltage at the output of the bridge rectifier is held at 22 V by zener diode D_5. Resistor R_6, which enables C_1 to discharge rapidly as soon as the mains is switched off, must be rated at 250 V a.c. or 400 V d.c.

The delay is provided primarily by C_4, which is charged via C_3, whose impedance at 50 Hz is about 10 MΩ, and half-wave rectifier D_6–D_7. After a given period, the potential across C_4 will be 12 V higher than the source voltage of T_1, which is set with P_1. The gate of T_1 has the same potential as C_4. Network R_2–C_5 serves to suppress any spurious voltage peaks.

When the potential across C_4 becomes higher than the source voltage of T_1, the FET begins to conduct and this will result in T_2 being switched on. Moreover, the voltage across the relay is fed back to the gate of T_1 via D_8. This feedback ensures that T_1 and T_2 are quickly driven into saturation.

Once the relay has been energized, transistor T_3 will be switched on via R_5–C_6. When this happens, C_4 will discharge through the transistor, so that the circuit is quickly back in its initial state. The delay on power-up is, therefore, not shortened by the residual charge in C_4. In spite of C_4 being discharged, the relay remains actuated because the gate voltage of T_1 is held via D_8. Only when the supply voltage is switched off will the relay be deenergized.

Note that the circuit is connected electrically to the mains so that great caution should be observed during any testing and operation. ■



TEMPERATURE MEASUREMENT TECHNIQUES

Whereas over the past few centuries temperature was measured by observing the expansion of a liquid (and later, a solid), nowadays many temperature measuring devices are based on electronic sensors. This article looks at the physical backgrounds and application areas of such sensors, as well as the methods of using them.

TEMPERATURE in the abstract is not easy to define, but it may be said of two bodies at different temperatures that one feels hotter to the touch than the other, or that when placed in contact, heat flows from the hotter to the colder. Temperature is thus a difference, which may be measured by the physical effects it produces in contact with a measuring instrument called a thermometer. Thermometers of whatever nature are devices for comparing temperature intervals with a standard temperature interval, that between two fixed points. The practical fixed points are the *ice point* (the equilibrium temperature between ice and air-saturated water at standard atmospheric pressure) and the *steam point* (the temperature of equilibrium between liquid water and its vapour at standard atmospheric pressure). The SI definition of temperature makes the fixed points *absolute zero* (0 K) and the *triple point of water* (273.16 K), that is, when the three phases liquid, solid and vapour exist together in equilibrium.

Scientifically speaking, temperature (symbol: T) is a measure of the kinetic energy of the molecules, atoms or ions of which a body or substance is composed. The faster the movement of these particles, the higher the temperature of the body or substance. Unfortunately, measuring the speed of molecules is hardly a practicable method to express temperature as a value. Fortunately, we can make use of some of the effects of temperature changes to measure the temperature proper. What effects can we observe?

- the volume increases (usually) with higher temperatures;
- the state of matter (usually) changes from the solid into the liquid and, finally, the gaseous phase.
- Many properties of matter, including heat capacity, sound propagation and electrical resistance, change.

The best known instrument to record the first type of change is the fluid thermometer. The length of the fluid column (mercury; alcohol) is a measure of temperature. The fluid is forced to expand in one direction by a small (glass) tube. A temperature change υ gives rise to a volume change, ΔV (V_1-V_2), of

$$\Delta V = V_0 \ \gamma \ \upsilon$$

where γ is the thermal expansion co-efficient per kelvin for the relevant matter.

A second example of temperature recording elements are thermometers and thermostats based on bimetallic strips. These are used, for example, in fuses. A bimetallic strip consists of two thin metal plates secured to one another, having different expansion coefficients. One end of the strip is securely fixed. Current flow through the strip causes a temperature increase, which in turn causes the strip to bend owing to unequal expansion of the components. The free end can thus serve to open or close an electrical circuit. The calculation of the change of length is similar to that for fluid expansion:

$$l = l_0 \ \alpha \ \upsilon$$

where α is the length expansion co-efficient for the relevant material. It should be noted that the co-efficients γ and α are constant within a certain temperature range only (generally, 0–40 °C for fluids, and 0–100 °C for solid matter).

The phase change from solid to liquid as a result of a temperature rise is exploited in a well-known electrical component: the fuse. The wire in a fuse melts when the current through it exceeds a certain limit.

Bimetallic elements and fuses are not,

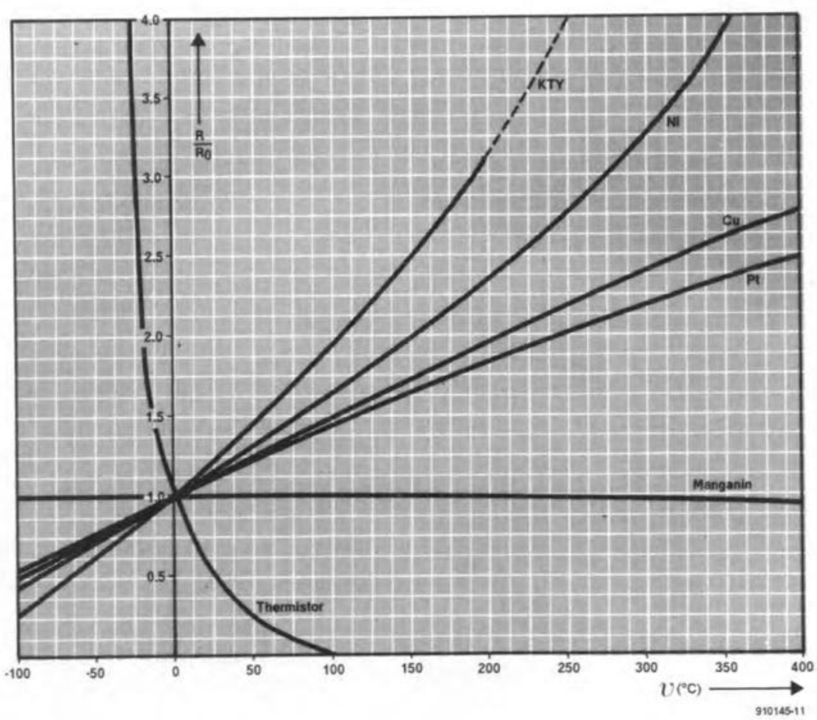


Fig. 1. Characteristic curves of some passive temperature sensors.

strictly speaking, direct temperature sensors. They are unsuitable for analogue temperature measurement, and merely serve to establish or break an electrical circuit permanently or temporarily by monitoring a current flow.

The resistance-based thermometer

One of the most important effects of temperature changes on physical properties is the change of resistance of conductors and semiconductors. There exist materials whose resistivity, ρ, (rho), rises with temperature. This is caused by an increase or decrease of charge carrier mobility, as a result of a greater charge carrier density. In the first case, the material has a positive thermal co-efficient, in the second, a negative thermal co-efficient.

Thermometers based on resistors are passive sensors that require auxiliary energy to enable the effect of a temperature change to be measured.

Conducting temperature sensors usually consist of a copper-nickel alloy (temperature range approx. –50 °C to +150 °C), or platinum (–250 °C to +1000 °C). The type marking of the sensor indicates the material resistance at 0 °C. A Type Pt100 sensor, for example, consists of platinum, and is produced to have a resistance of 100 Ω at 0 °C.

Apart from the metal-based sensors, there are also semiconductor sensors such as KTY sensors, PTC-cold, and NTC types. These sensors are inexpensive, and widely used in, for example, electric household utensils (washing machines, tumble dryers, etc.).

Figure 1 shows the temperature-resistance characteristic of a number of metals and semiconductors. The curves shown may be approximated mathematically by an exponential series. Since the curves are relatively straight, a sufficiently close mathematical description may be achieved for powers up to 3. Similarly, the resistance characteristic is described sufficiently accurately by

$$R = R_0\ [\,\alpha(\upsilon - \upsilon_0) + \beta\ (\upsilon - \upsilon_0) + \\ + \gamma\ (\upsilon - \upsilon_0)\,]$$

In this equation, υ is the current temperature and υ_0 the reference temperature of 0 °C, at which the resistance R_0 is valid.

The first power indicates the rate of rise of the curve (the temperature co-efficient), and the second its curvature. The sensitivity of the sensor may be obtained by differentiation:

$$S_r = \alpha + 2\beta\ (\upsilon - \upsilon_0) + 3\gamma\ (\upsilon - \upsilon_0)$$

Table 1. Temperature scale conversions

	Kelvin (K)	Centigrade (°C)	Fahrenheit (°F)
Absolute zero point	0	–273.15	–459.67
Triple point point of water *	273.15	0	32
Steam point	373.15	100	212

* For practical purposes, the ice point and the triple point of water may be taken as the same, but strictly speaking, the triple point of water is a little higher than 0 °C since, under the pressure of its own saturated vapour at that temperature, the melting point of ice is about 0.0075 °C.

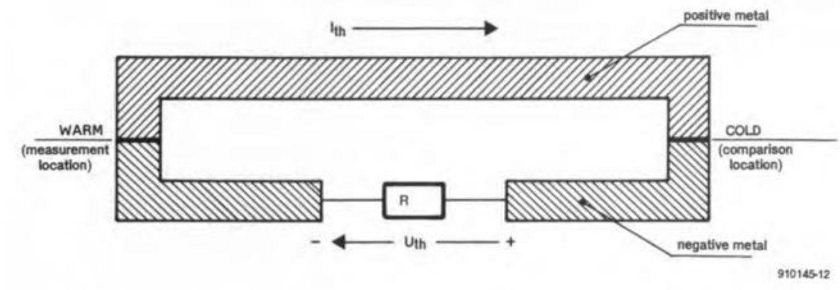


Fig. 2. Basic construction of a thermocouple.

Table 2 lists the values of the first two co-efficients for the materials indicated in Fig. 1. Note that

- metals are less sensitive to temperature changes than semiconductors (the curves are straighter);
- the curvature of the characteristics is significant at very high temperatures only, since the β co-efficient is 3 to 4 powers of ten smaller than the α-coefficient;
- the temperature/resistance characteristic of copper is linear;
- the non-linearity of semiconductor sensors is much greater than that of metal sensors;
- the resistance of manganin is virtually independent of temperature;
- the thermistor characteristic is so non-linear that it is better described by an *e* function than by series of powers. The resistance is described by

$$R = R_0\ e\,\mathrm{B}\ (1/T - 1/T_0)$$

where T is the absolute temperature, and T_0 equals υ_0 + 273.15 K, or the reference temperature at which R_0 is valid. The material constant, B, is found in the datasheets. It takes values of 2000 K to 5000 K at υ_0 = 20 °C, and causes a sensitivity that is ten times higher than that of metal film resistors, since

$$S_r = \beta / T_0^2.$$

Also note that PTC thermistors have a positive temperature coefficient within a certain temperature range only—outside this range, the co-efficient is negative.

Table 2. Co-efficients of temperature-dependent resistivity

	α (1/K)	β (1/K²)
Nickel	$+5.5\cdot10^{-3}$	$+7.4\cdot10^{-6}$
Platinum	$+3.9\cdot10^{-3}$	$-0.6\cdot10^{-6}$
Copper	$+4.3\cdot10^{-3}$	0
KTY	$+9\cdot10^{-3}$	$+11\cdot10^{-6}$
Manganin	$<0.04\cdot10^{-3}$	$-0.5\cdot10^{-6}$

Resistor-based thermometers come in many shapes and sizes. Thermistors, PTCs and NTCs are inexpensive, readily applicable and quite sensitive. Their non-linear behaviour, however, makes them hardly suitable for measurement applications. Their maximum usable temperature is usually 200 °C to 300 °C, although special (and much more expensive) types may be found with a rating of 1000 °C.

Integrated semiconductor sensors such as the LM35 series from National Semiconductor are cheap and tailored to temperature measurement. These sensors have the invaluable advantage of a high linearity within the operating temperature range. This linearity is ensured by internal compensation of the self heating caused by the current flow through the sensor. There also exist versions with an internal current source, which

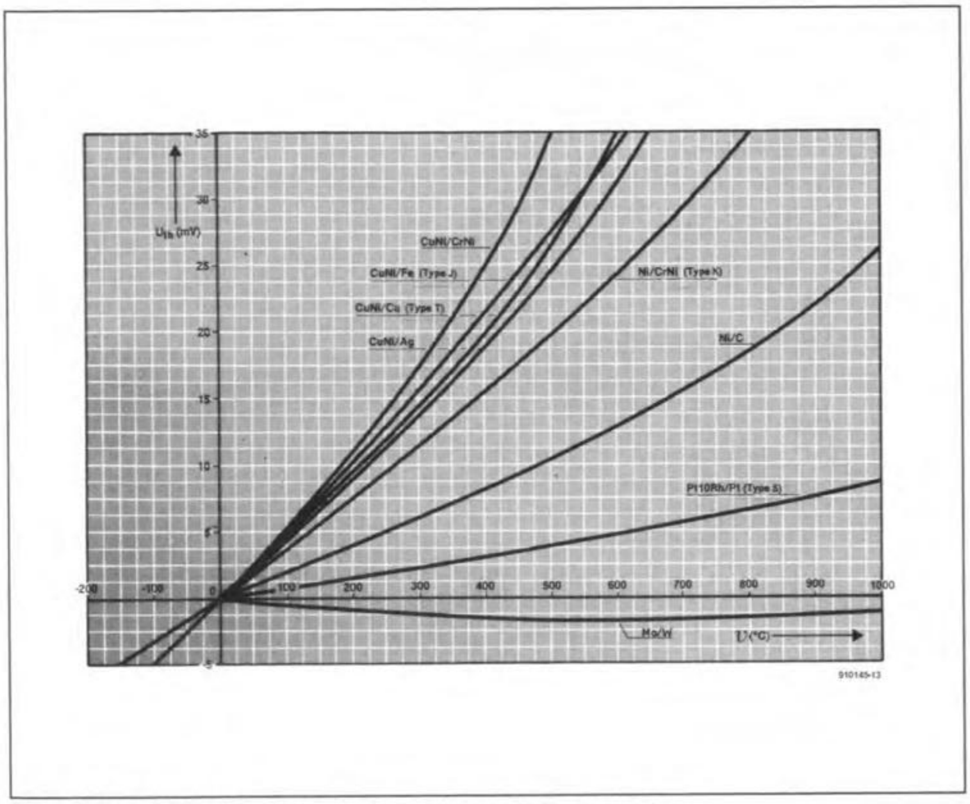


Fig. 3. Characteristic curves of commonly used thermocouples.

allows current-drive to be applied, avoiding errors caused by the resistance of long connecting wires. The main shortcoming of semiconductor temperature sensors is their restricted operating temperature range and maximum temperature, which is usually 150 °C or so.

High temperatures are the exclusive domain of passive and metal sensors. Inexpensive and accurate, these devices are used at temperatures up to 1000 °C. Their non-linearity is fairly easy to compensate. On the down side, passive and metal sensors offer a low sensitivity, and are relatively expensive. Fortunately, metal film sensors are now available that can be produced economically whilst offering the same accuracy and stability as the traditional types.

Thermoelements

The group of active thermoelements is quite different from that of the passive resistance thermometers. While the latter require a current flow to operate, thermoelements produce a voltage proportional to temperature by virtue of the Seebeck-effect: if two different metals are joined, and the two junctions are kept at different temperatures, an electromotive force (e.m.f.) is developed in the circuit. The e.m.f. is caused by electron shifts inside a conductor of which the ends are at different temperatures. A metal is called 'positive' if it has a surplus of electrons at the 'hot' end, and 'negative' if the 'cold' end is negative with respect to the 'hot' end. When a positive and a negative metal are joined as shown in Fig. 2, the resultant thermocurrent, I_{th}, causes a thermovoltage, U_{th}, across the resistor.

The thermovoltage is proportional to the difference, ϑ between the temperature at the measurement location, ϑ_m, and that at the comparison location, ϑ_c:

$$\vartheta_m = \vartheta_c + \vartheta$$

In practice, an electronic circuit is used to relate the temperature of the comparison location to a virtual reference of 0 °C. The degree of electron shift is a material constant. Some values are given below in order of thermoelectrical voltage:

Material	Symbol	U_{th} (μV/K)
Antimony	Sb	+35
Iron	Fe	+16
Zinc	Zn	+3
Copper	Cu	+2.8
Lead	Pb	0
Aluminium	Al	–0.5
Platinum	Pt	–3.1
Nickel	Ni	–19
Bismuth	Bi	–70

Figure 3 shows the characteristic curves of some commonly used thermocouples. It is seen that some of these exhibit a virtually linear thermovoltage characteristic, for instance, the nickel/chromium-nickel, copper/constantan and iron/constantan combinations (constantan is a copper/nickel alloy). The curves of the high-temperature thermoelements with a range of up to 2650 °C are relatively non-linear, which is indicative of a low sensitivity.

The most commonly used thermoelements are classified according to the DIN-IEC 584 standard:

Mark	Combination	Symbols
T	copper/constantan	Cu/CuNi
E	chromium-nickel/constantan	NiCr/CuNi
J	iron/constantan	Fe/CuNi
K	chromium-nickel/aluminium-nickel	NiCr/NiAl
R	platinum + 13% rhodium/platinum	Pt13Rh/Pt
S	platinum + 10% rhodium/platinum	Pt10Rh/Pt

In addition to these elements, thermocouples are available based on gold, silver, rhenium, cobalt, molybdenum and wolfram.

Thermoelements are coupled to the measurement electronics either by welding or bolting. One alternative is a connector whose contacts must be made of the same materials as the thermoelement.

Pyrometers

Pyrometers are instruments for measuring very high temperatures. Their main application is in the metal industry (steel works; melting ovens), but also in meteorology. A principle is used that has not been discussed so far. Each body with a temperature higher than the absolute zero emits electromagnetic waves of a length between 800 nm and 1 mm. The power of this so called *radiant exitance* depends on the temperature and on the shape and colour of the object: black and rough objects have a higher radiant flux than smooth, bright ones. The relation between the emission constant, the radiant flux, the surface and the temperature is given by Stefan's law (Stefan's law, often called the Fourth Power law, is properly called the Stefan-Bolzmann Law, since while Stefan deduced it empirically, Bolzmann later gave a theoretical proof of it).

The radiant flux is distributed over a wide spectral range, i.e., it is not of a single wavelength. It has been found that the short-wavelength components in this spectrum become more prominent as the temperature rises (Wien displacement law). This effect may be observed when iron is heated: red glowing iron is 'colder' than white glowing iron.

The *optical pyrometer* depends for its action on the Wien displacement law, and the *total radiation pyrometer* on Stefan's law. Most pyrometers have optics complete with a diaphragm and an interference lens. The application is governed by the 'visible' area, the frequency range of the optics, and the absolute absorbtion capacity of the receiving surface, which is usually a small black area. This area absorbs the radiation energy, and consequently heats up, allowing the above mentioned types of sensor to be used for the actual temperature measurement. ■

VOX ACTUATOR FOR BABY ALARM

by R.G. Evans

HAVING a recent arrival in the family meant that some form of baby alarm or monitor was required if 'junior' was not to 'wah' unduly in his cot when left unattended. The circuit published in Ref. 1 seemed suitable, and was duly built. However, having dealt with single-transistor RF oscillators before, I was suspicious about the long-term stability of the transmitter, and did not want to sit thinking all was well when 'junior' was actually 'wahhing away' a few tens of kHz further up or down in the FM band.

The circuit shown in Fig. 1 was developed to enable the VOX (voice-operated switch) at a user-determined interval (1 to 10 minutes), and to emit a recognizable sound, such that the correct operation of the device could be verified. Well, in actual fact the single-transistor oscillator in the FM transmitter proved to be more stable than the receiver used to monitor it!

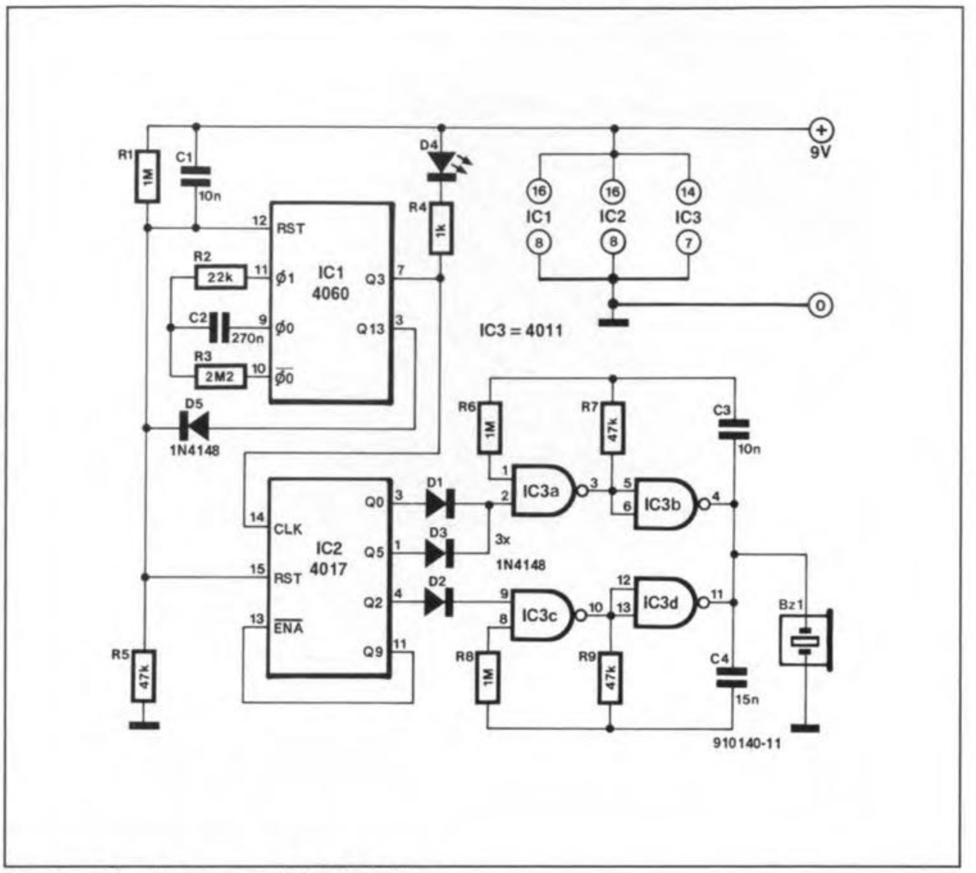


Fig. 1. Circuit diagram of the VOX timer.

The circuit

The circuit (Fig. 1) comprises three sections: an oscillator and counter, a digital pulse generator, and two tone generators. Referring to the circuit diagram, R1, R2 and C1 are connected to the oscillator pins of a 4060 oscillator/divider, IC1. Resistor R3 and capacitor C2 serve to reset both counters when the circuit is switched on. Resistor R4 and LED D1 form a counting indicator that provides evidence that the circuit is actually working — ideal for anxious parents! Pin 7 on IC1 supplies the clock pulse that steps the 4017 decade counter, IC2. If a slower progression through the counts is required, simply use subsequent outputs, for example, Q5 available on pin 5 of the 4060). Since the 4060 is a binary counter, each successive output will take twice as long to step through the tone sequence selected. Similarly, if a shorter time between bleep sequences is needed, take lower Q outputs to reset both counters (as drawn, this is done by the highest counter output, Q14). The decade counter, IC2, makes each output high in succession, until Q9 is reached. This is connected directly to the ENABLE to disable counting when high. Before this happens, each successive 'high' is fed through a diode to the required oscillator enable input. Gaps of one or more counts have been left between successive tones. By using various combinations of diodes and IC2 outputs, a variety of effects can be achieved. In this application, all that was required was a distinctive note, although a morse-code-like sequence could easily be programmed.

Circuit IC3 contains four NAND gates, allowing two gated oscillators to be realized. Note that each oscillator drives a single piezo resonator direct. On the prototype, this caused no problems with overloading of the NAND gate outputs. Changing the value of C3 or C4 will change the tone frequency as required.

Current consumption of the circuit should average about 5 mA, most of which goes to the 'counting' LED. Removing this on the prototype reduced current consumption to 0.8 mA except when tones were sounding, when the current drawn was 6 mA. At this low level, an Alkaline PP3 9-V battery should give about 500 hours service. ■

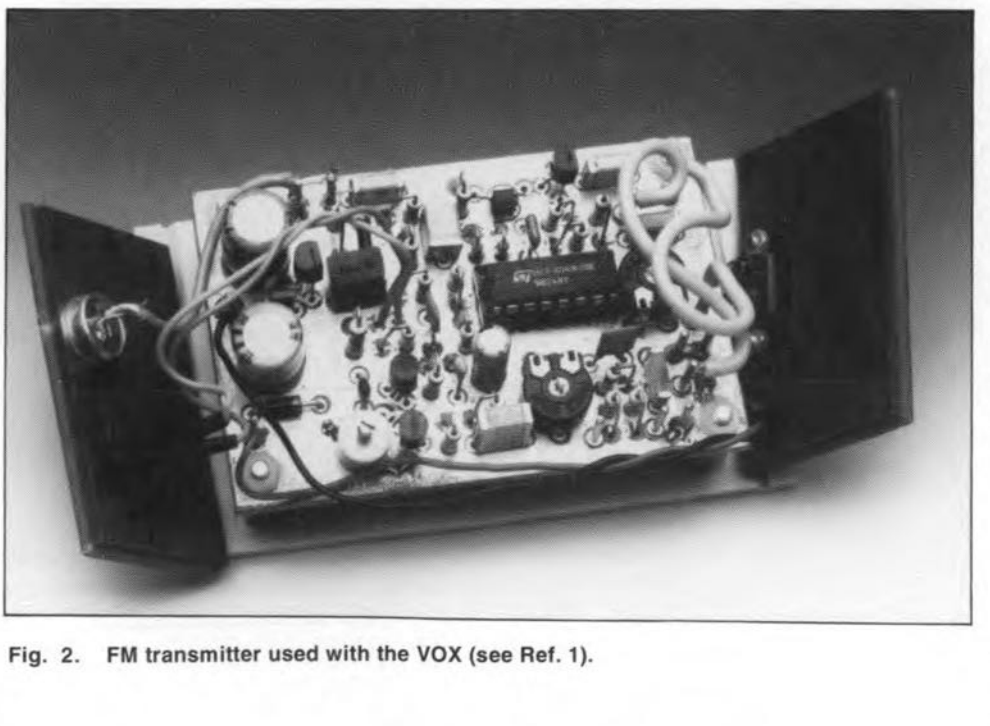


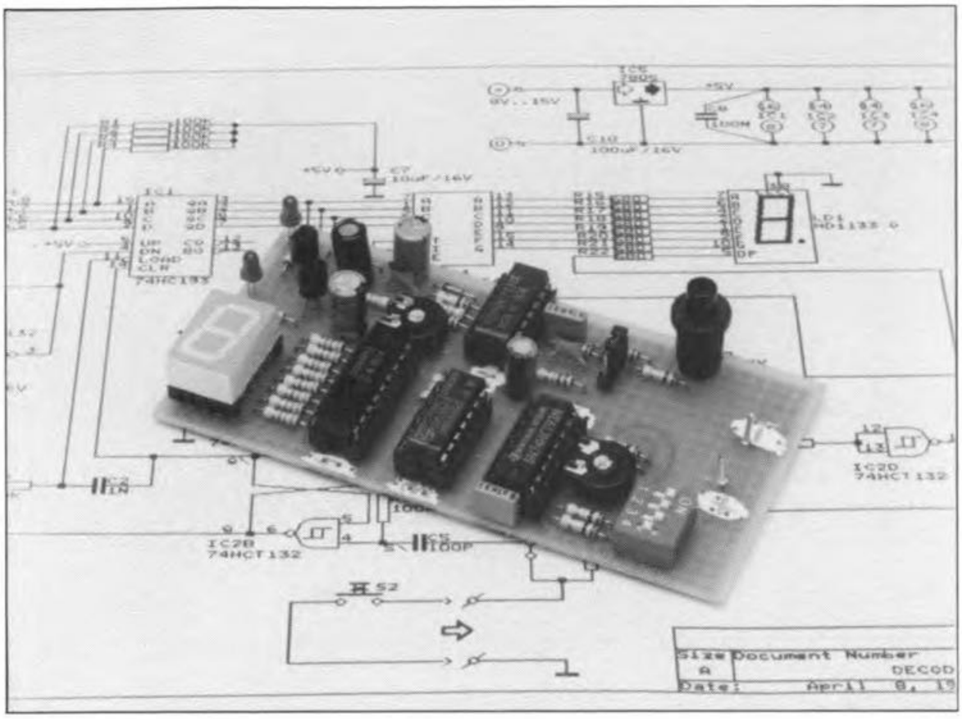
Fig. 2. FM transmitter used with the VOX (see Ref. 1).

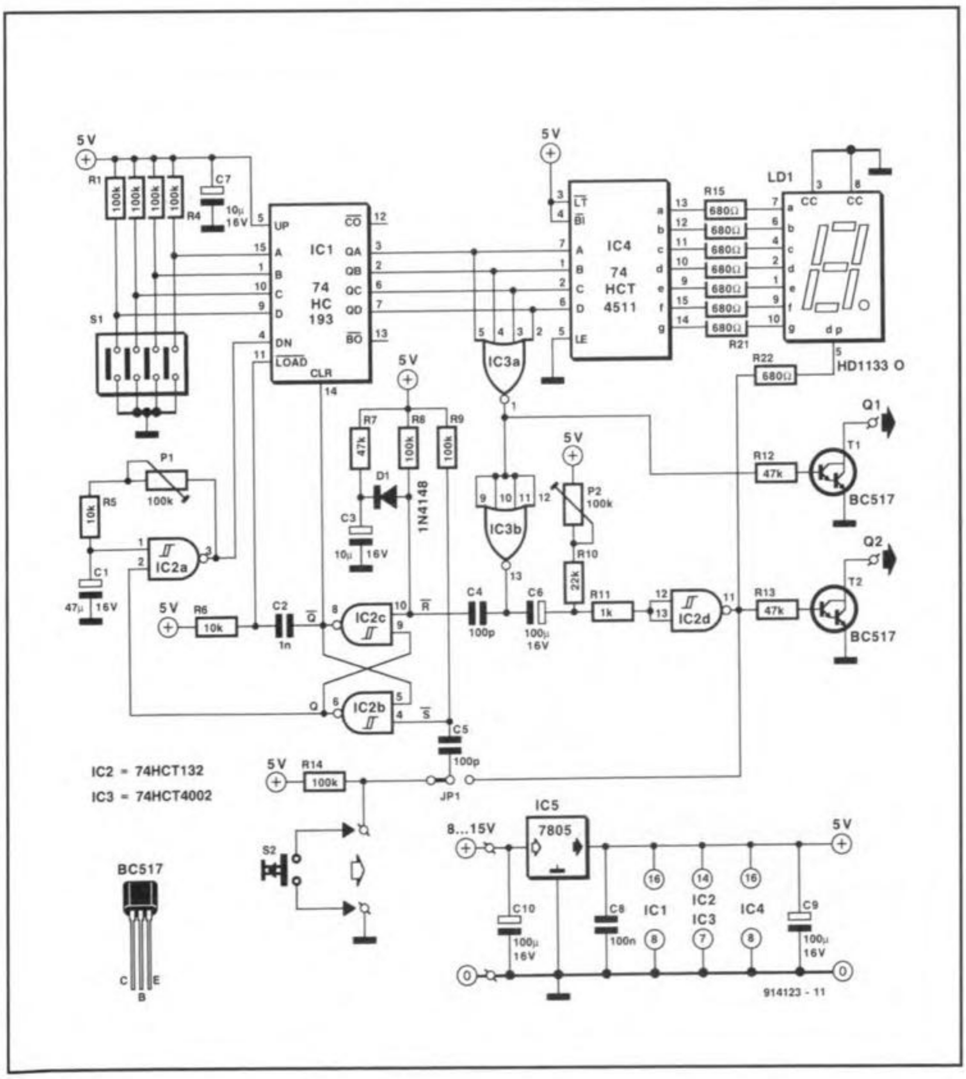
Reference:

1. "Mini FM transmitter". *Elektor Electronics* July/August 1991.

UNIVERSAL POWER-ON DELAY

by J. Ruffell





OUTPUT Q1 of this delay circuit becomes active after the switch-on period has elapsed and remains so until the next cycle is begun. Output Q2, on the other hand, also functions as a monostable; after its mono period has elapsed, Q2 automatically becomes inactive. The mono period can be set between 1 second and 4 seconds with P_2. The power-on delay can be set accurately between 1 second and 1 minute with P_1 and DIP switch S_1.

The circuit is also provided with a count-down indicator: the digit display on LD1 gives continuous information on the remaining switch-on time. The 7-segment display is driven by IC_4, a decoder chip that makes only the normal digits (1–9) visible.

When the end of the delay period has been reached, counter IC_1 has come to position 0. As a result, the output of IC_{3a} goes high and T_1 is switched on. Since at the same time the output of IC_{3b} toggles from high to low, monostable IC_{2d} is started. The output of the monostable then goes high and switches on T_2, indicated by the lighting of the decimal point of the display. Also, start/stop bistable IC_{2b}–IC_{2c} is reset, which disables the counter and the oscillator. To start the next time-out cycle, the bistable must be set afresh, for which, with link JP1 in the position shown in the diagram, a last transition (trailing edge) is required at the input. This is arranged most simply by pressing S_2, but the transition may also come from another circuit or from a sensor.

When JP1 is in the other position, the output of the monostable is linked to the input of the start/stop bistable (flip-flop). This results in the time-out cycle being started anew at the end of the mono time. The circuit then operates as an oscillator.

The circuit requires a power supply of 8–15 V. It draws a current of about 40 mA, most of which by the display. Transistors T_1 and T_2 can switch up to 400 mA. ■

BCD ROTARY SWITCH

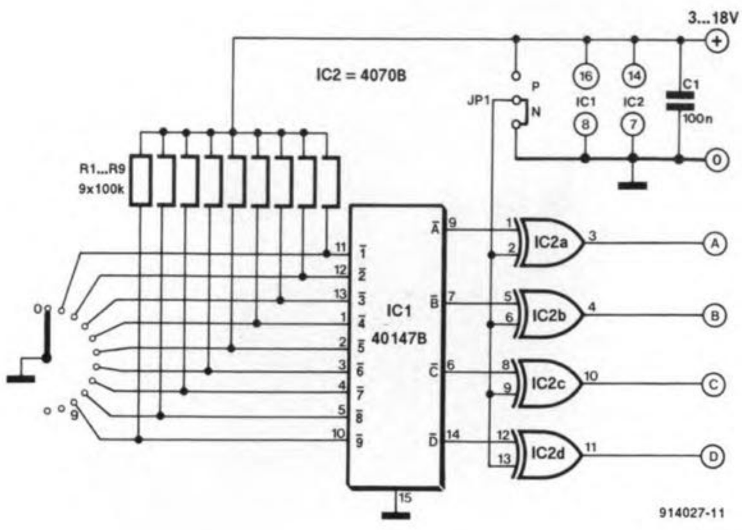
by J. Ruffell

BINARY-coded-decimal (thumb-wheel) switches are not only relatively expensive, but are also often not available to the wanted specification. A good alternative is shown in the present circuit that uses generally easily available components and a 12-position rotary switch (the most popular type) of which two positions are disabled.

The terminals of the switch are connected to the inputs of a prority encoder, IC_1. When an input goes low, the IC puts the number of that input as an inverted BCD code at the output. The four XOR gates enable the inverted code to be inverted again into a standard BCD code. This operation is effected with link JP1: in position P, the output carries the standard BCD code, and in position N, the inverted BCD code.

The circuit is powered by 3–18 V (because CMOS ICs are used). The use of a 5 V source enables LS, TTL, HC and HCT inputs also to be connected to the switch.

The circuit draws a current of only about 200 μA. ■

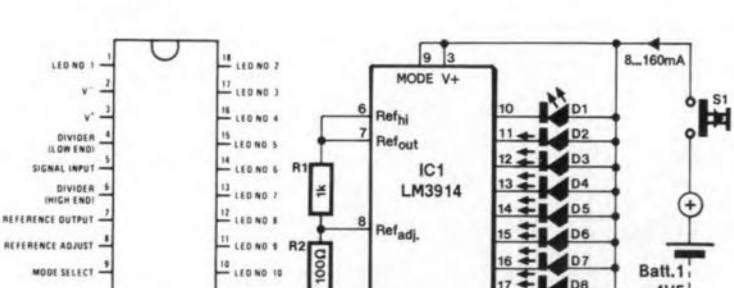


BATTERY TESTER

by A.B. Tiwana

VARIOUS types of dry and rechargeable battery (with an e.m.f. of ≤2.7 V) can be tested with the circuit shown in the diagram. It is based on the well-known Type LM3914 LED-display driver from National Semiconductor. The circuit compares the e.m.f. of the battery with a reference voltage that is derived from an internal source. The reference potential (pin 8) can be set between 1.5 V and 2.7 V by R_1-R_2-P_1. The voltage at pin 8 refers to the maximum scale value of the LED series. That is, if that voltage is 1.5 V, each LED represents 150 mV. It is recommended to set it to 1.5 V for NiCd batteries, and to 2.0 V for dry batteries. Resistor R_1 arranges a current of 12.5 mA for each LED.

It is advisable to test dry batteries on load, since the terminal voltage depends on the residual capacity. And, of course, the e.m.f. of even an almost flat battery is still close to its specified value. Rechargeable batteries retain their specified e.m.f. until they are virtually discharged, when it drops fairly rapidly. It is, therefore, of not much use to check the residual capacity of these batteries on the basis of their e.m.f.: the test is limited to an indication of whether the battery is fully charged or (nearly) flat. ■



GENTLE HALOGEN-LIGHT SWITCH

by H. Moser

THE switch circuit, intended for low-voltage halogen lights, extends the life of the lamps, because it ensures that the filament current is increased gradually, thus obviating the high peak currents that flow through the lamp with normal switches. The addition of a timer would enable the circuit to switch the lamp off again after a preset period of time.

The lamp is switched via T_1, a MOSFET that has a channel resistance of only 0.08 Ω, which ensures that losses are low (in the prototype ≤250 mW). Control is by means of pulse-width modulation, which also tends to minimize losses.

The circuit is switched on and off with S_1. Bistable IC_{2b} is a debounce circuit that clocks binary scaler IC_{2a}. When the Q output of the scaler is high, the lamp is on or is coming on; when the Q output is low, the lamp is out or going out. The lamp may be switched off automatically by IC_3 after a preset time. The time, *t*, in seconds, is calculated from $t = 32768 \times 2.3 \times R_4 \times C_7$, where R_4 is in ohms and C_7 in farads. With values as shown, the time is 700 s (11 min).

When the reset input of IC_{2a} is earthed, the lamp can be controlled only via S_1; timer IC_3 and the associated *RC* network can then be omitted.

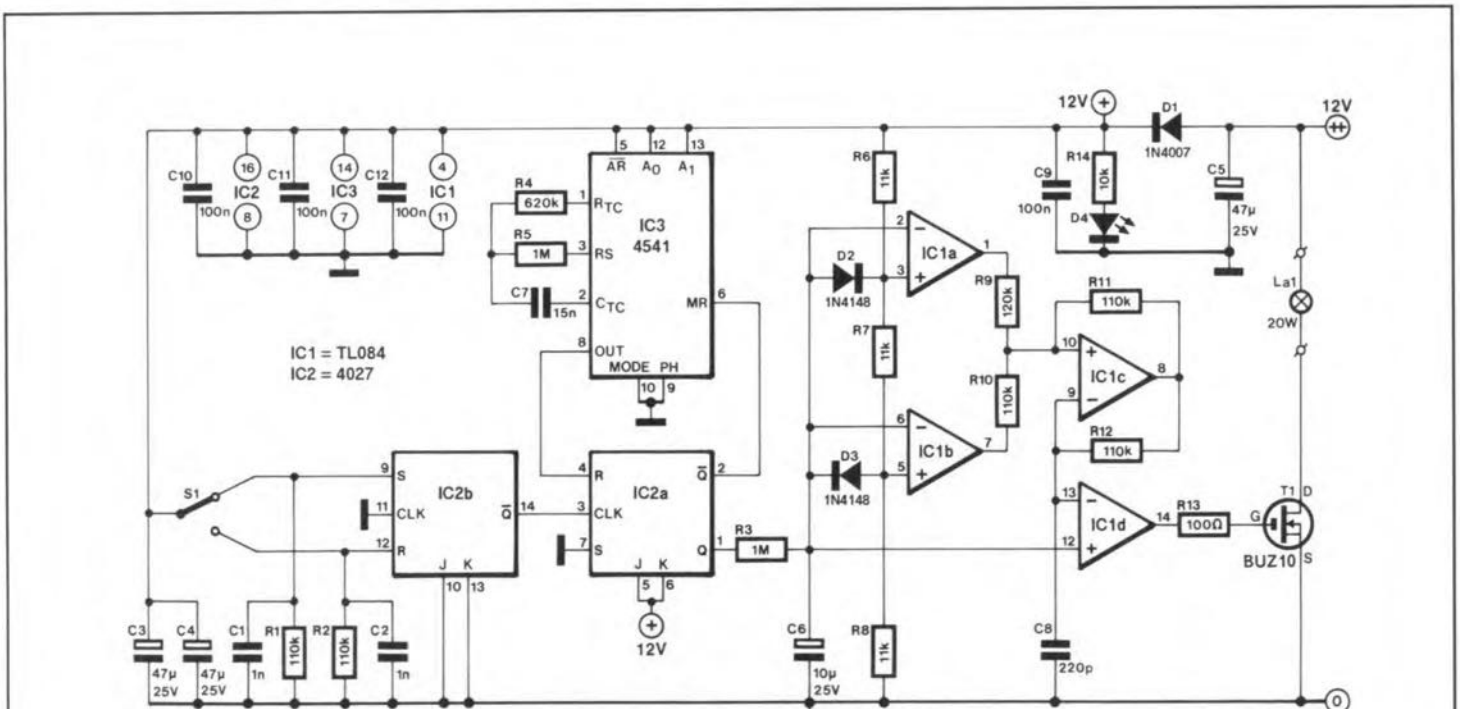
When the lamp is switched on with S_1, the voltage across C_6 rises slowly. Because of D_3, even at standby there is a potential across C_6 at a level just below that necessary to toggle comparator IC_{1b}. As soon as C_6 is being charged, the comparator will, therefore, toggle almost immediately. This starts rectangular-wave generator IC_{1c}. However, it is not the rectangular signal that is used here, but the triangular signal across C_8. That signal is compared with the voltage across C_6. This results in a 25 kHz rectangular signal at the output of IC_{1d}, whose pulse width increases slowly. That signal is used to drive T_1, and thus the lamp, which will gradually begon to light.

The voltage across C_6 continues to rise until the toggle level of comparator IC_{1a} is reached. That circuit then toggles, which stops generator IC_{1c}, but T_1 is kept conducting by IC_{1d}. The potential across C_6 is kept just above the toggle level of IC_{1a} by D_2. This arrangement makes it possible, if required, for the lamp to be turned down almost immediately after S_1 is pressed or the time set for IC_3 has elapsed.

When IC_{1a} toggles again, the triangular voltage is compared with the falling potential across C_6, so that the pulse width of the output signal from IC_{1d} decreases. When the voltage across C_6 has reached the level at which IC_{1b} toggles, the generator is switched off again, but this time T_1, and thus the lamp, remains off.

Finding switch S_1 in the dark is facilitated by using a switch with integral LED (D_4).

The power supply consists of a suitable mains transformer (which is probably already present for the lamp) and a bridge rectifier rated at 3 A. The current is drawn primarily by the lamp: with a 20 W lamp, it amounts to 1.6 A. ■



HCT CRYSTAL OSCILLATOR

by J. Bareford

THE wide frequency range, low power consumption and well-defined switching levels of HCMOS inverters make these devices eminently suited to building quartz crystal oscillators with TTL compatible outputs. Here, the six gates in a 74HCT04 package are used to build three crystal oscillators. The only difference between the 2 MHz, 16 MHz and 24 MHz oscillators is the capacitance around the quartz crystal, which in all cases must be a type that resonates at the fundamental frequency; overtone crystals cannot be used here.

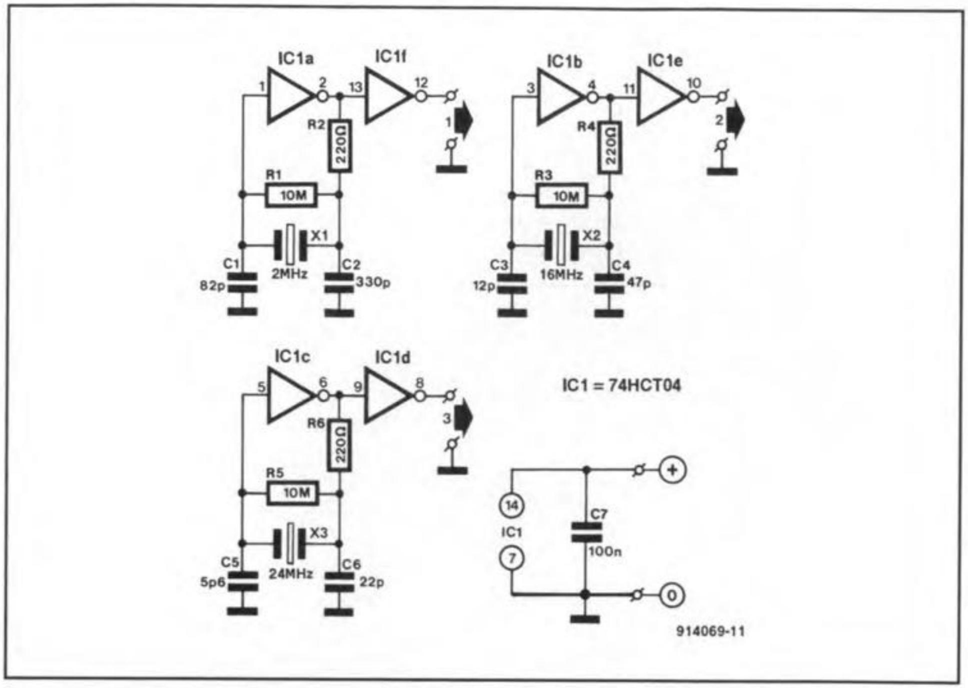
For output frequencies, f_o, other than the ones used here, use the following design data:

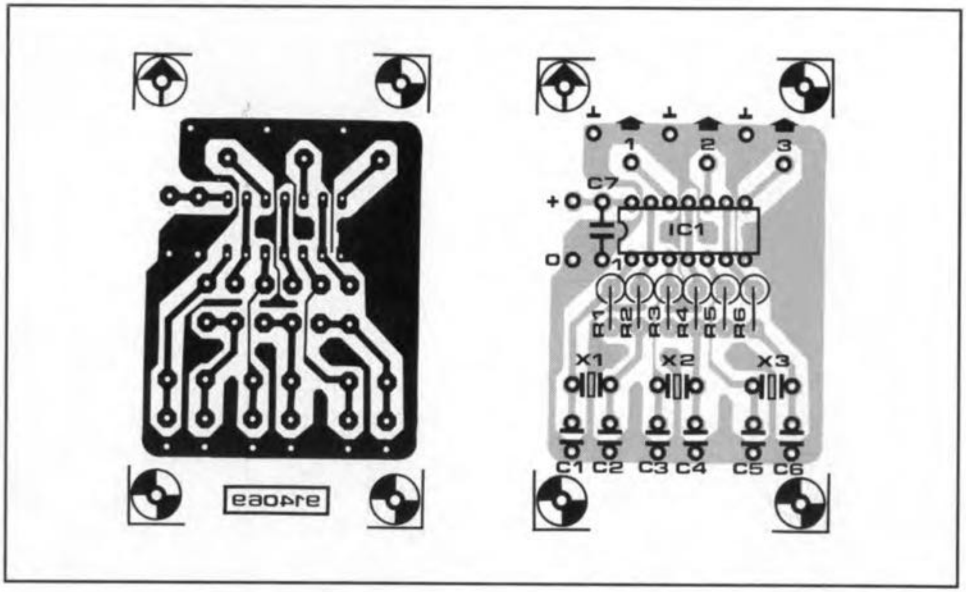
$$C_2 = 723 / f_o;$$
$$C_1 = C_2 / 4.$$

where f_o is in MHz and C_1, C_2 in pF. For 1–MHz crystals with a high impedance:

$$C_1 = C_2 / 10.$$

When one of the oscillators is not built, make sure to fit a wire link in PCB position C1, C3 or C5. This ensures a low level at the input of the first oscillator gate, preventing high current consumption and spurious oscillation of the HCT04. ■





PARTS LIST

Resistors:
R1, R3, R5 = 10 MΩ
R2, R4, R6 = 220 Ω

Capacitors:
C1 = 82 pF
C2 = 330 pF
C3 = 12 pF
C4 = 47 pF
C5 = 5.6 pF
C6 = 22 pF
C7 = 100 nF

Semiconductors:
IC1 = 74HCT04

Miscellaneous:
X1 = crystal 2 MHz
X2 = crystal 16 MHz
X3 = crystal 24 MHz

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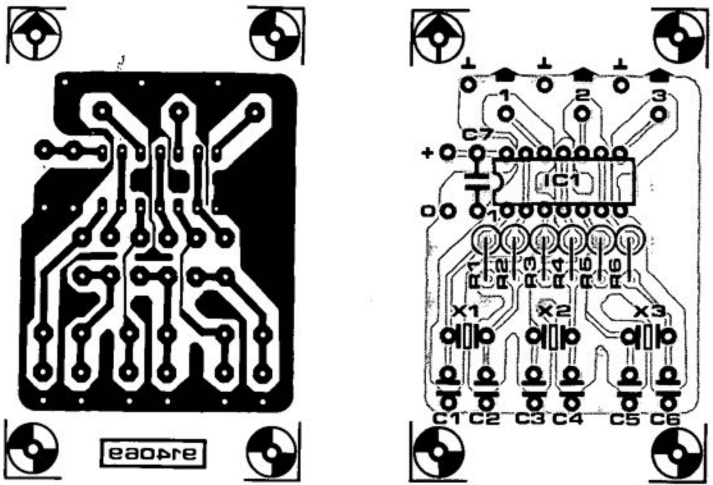
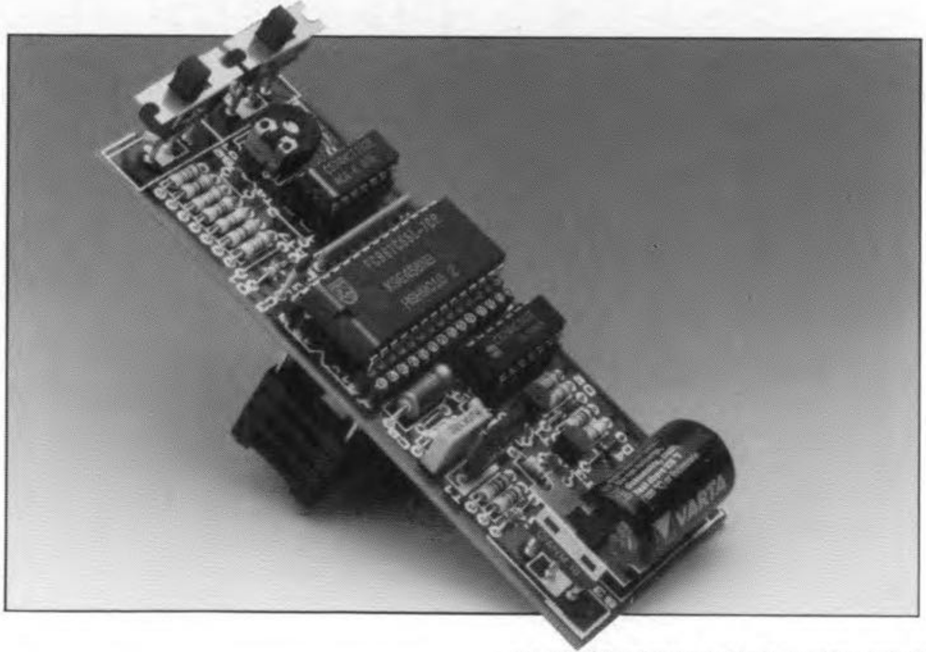


2764 EPROM EMULATOR

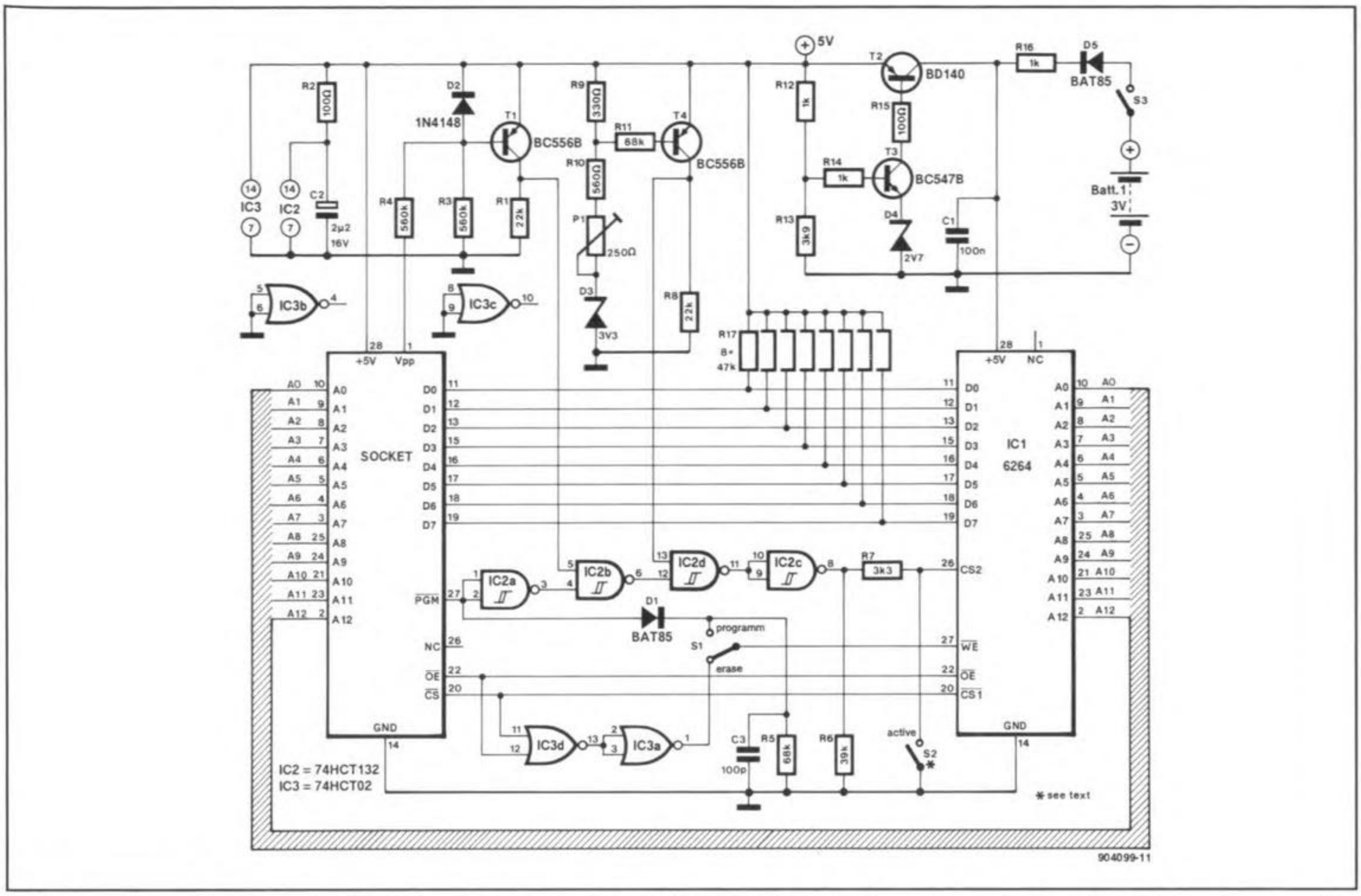
by I & H.J. Ehlers



THE emulator enables a Type 2764 EPROM in an existing circuit to be replaced by a static RAM. It is a very compact circuit: together with the stand-by power supply, it fits on a 105x40 mm ($4\ ^1/_8 \times 1\ ^9/_{16}$ in) board.

To all intents and purposes, the action of the circuit is indistinguishable from that of an actual 2764 EPROM. The programming voltage may be 12.5 V or 21 V. An additional advantage of the emulator is that programming and erasing during a development phase are not necessary, thus saving much time.

The position of switch S_2 determines whether the circuit is actuated or inactive. When it is closed, the circuit is inactive and the memory cannot be influenced externally: it is then



in the stand-by mode. This mode should be selected when it is expected that the circuit will not be used for some time or when it is removed from, or placed into, another circuit.

When S_2 is open, the content of the memory is protected by IC_2, T_4 and T_1. The only way the memory can be erased is by placing it in an EPROM programmer, setting switch S_1 to 'erase', and actuating the function 'Blank Check' or 'Read Out' on the programmer. When this routine has been completed, the entire content of the emulator is set to FF-H. Switch S_1 must then be set to position 'program' again, whereupon the emulator can be programmed in the traditional manner.

When programming has been completed, S_2 must be closed and the emulator can then be inserted into its proper place in the circuit. Before that circuit can be operated, S_2 must be opened again.

The battery supply is switched on and off with switch S_3: when it is switched off, the content of the RAM is lost, of course.

As can be seen in the photo, two PCB terminal strips with extra long pins are used to replace the EPROM pins. ■

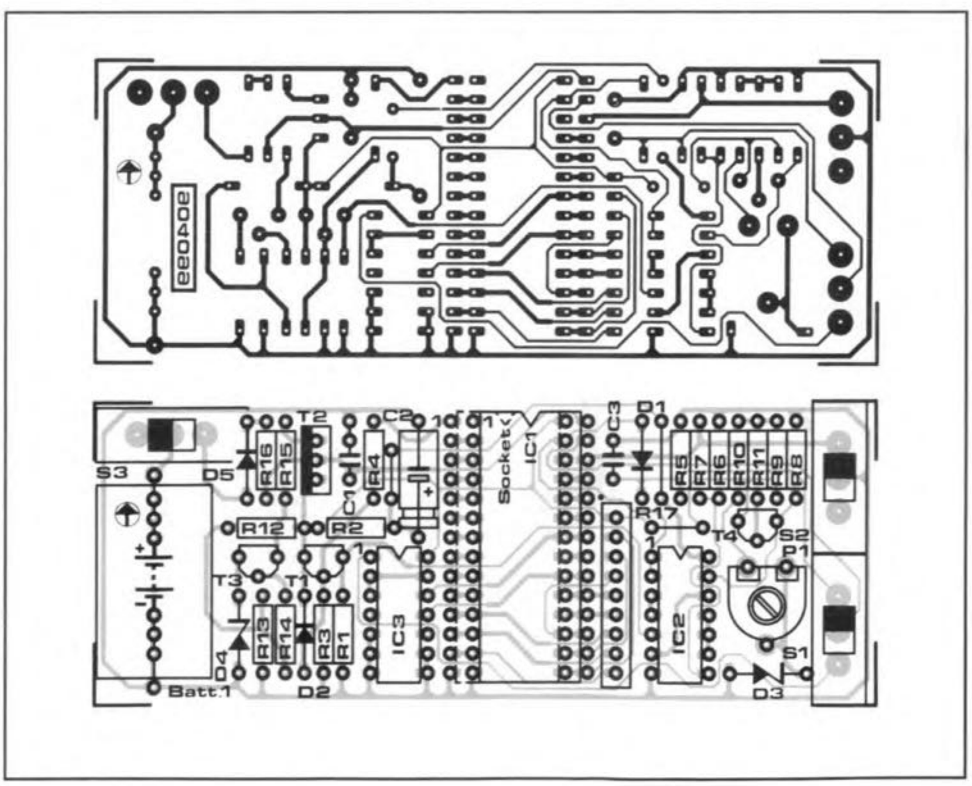
PARTS LIST

Resistors:
R1, R8 = 22 kΩ
R2, R15 = 100 Ω
R3, R4 = 560 kΩ
R5, R11 = 68 kΩ
R6 = 39 kΩ
R7 = 3.3 kΩ
R9 = 330 Ω
R10 = 560 Ω
R12, R14, R16 = 1 kΩ
R13 = 3.9 kΩ
R17 = array 8×47 kΩ
P1 = 250 kΩ preset

Capacitors:
C1 = 100 nF
C2 = 2.2 μF, 16 V
C3 = 100 pF

Semiconductors:
D1, D5 = BAT85
D2 = 1N4148
D3 = zener diode 3.3 V, 400 mW
D4 = zener diode 2.7 V, 400 mW
T1, T4 = BC556B
T2 = BD140
T3 = BC547B
IC1 = 6264
IC2 = 74HCT132
IC3 = 74HCT02

Miscellaneous:
S1–S3 = PCB slide switch;change-over contact
Batt1 = 3 V lithium battery



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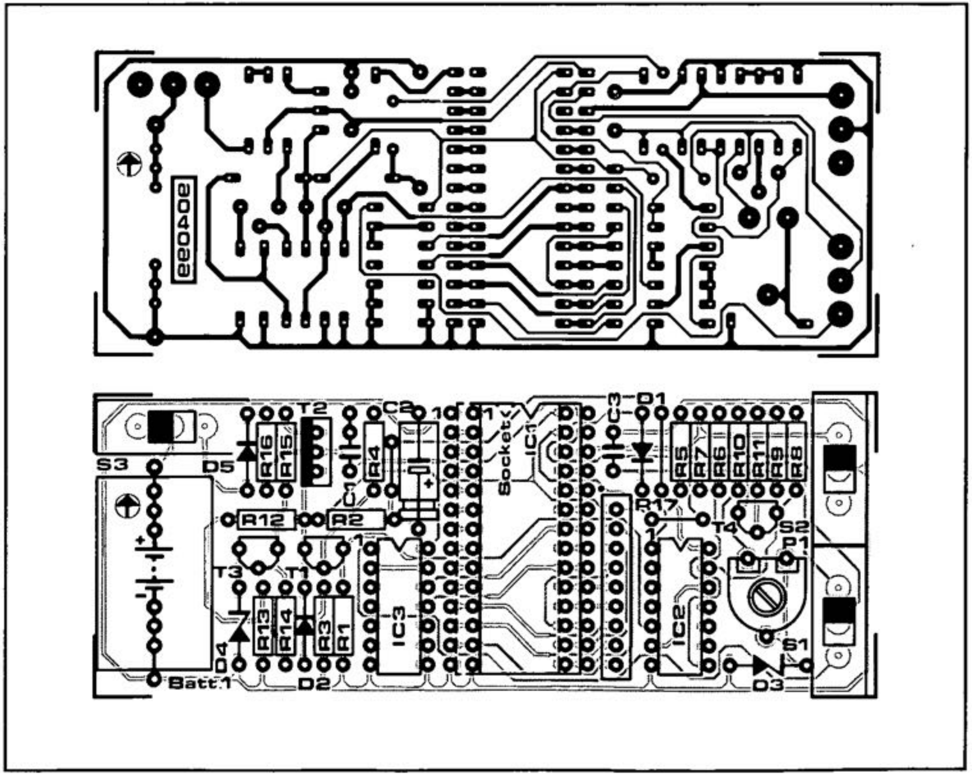


CLASS A POWER AMPLIFIER – PART 2

by T. Giffard

THE voltage amplifier and current amplifier are housed on separate printed-circuit boards—see Fig. 3 and 4 (Part 1). The current-amplifier board is fitted just above the heat sink as shown in Fig. 1, while the drivers, current control transistor and output transistors are screwed underneath (or beside) the board on to the heat sink. The terminals of the transistors are bent upwards at 90° about 3 mm from their housing and then soldered directly to the board. All other components are fitted at the *track side* of the board a few millimetres above the surface.

Protection circuit

The protection circuit serves to:

- delay the energizing of the output relay by a few seconds from power-on;
- monitor the d.c. resistance of the loudspeaker on switch-on: if this is lower than 2.2 Ω (nearing short-circuit), the output relay is not energized;
- deactuate the relay if the direct voltage across the output terminals of the amplifier rises above 0.6 V (indicating a defect in the amplifier);
- deactuate the relay if one, or both, of the secondary a.c. voltages fails—this also ensures that the loudspeakers are disconnected from the output when the amplifier is switched off.

Although the amplifier is not protected against short-circuits during operation, the output transistors can cope with such large currents that a short-circuit has disastrous results only when it happens at full drive. Such conditions are, however, not envisaged. After all, this is a quality design, not a foolproof public-address amplifier.

The circuit diagram of the protection section is given in Fig. 5. Note that the relay is not shown here, because it is located on the current amplifier board—see Fig. 4 (Part 1). The relay is controlled by Schmitt trigger T_{43} and T_{41}. The hysteresis in these stages, determined by R_{99}–R_{100}, ensures that the relay is energized when the potential across C_{47} is not less than 11 V and de-energized when that potential drops below 8.5 V. Inverter T_{42} in the collector circuit of T_{41} conducts when the relay is energized and this causes D_{29} to light.

When the power is switched on, and everything is in good order, C_{47} is charged slowly via R_{97}. Once the potential across the capacitor has reached a level of 11 V, T_{43} is switched on and the output relay is energized.

Capacitor C_{47} is shunted by T_{40}, which enables it to discharge very rapidly if a fault arises. The base of T_{40} is connected to the

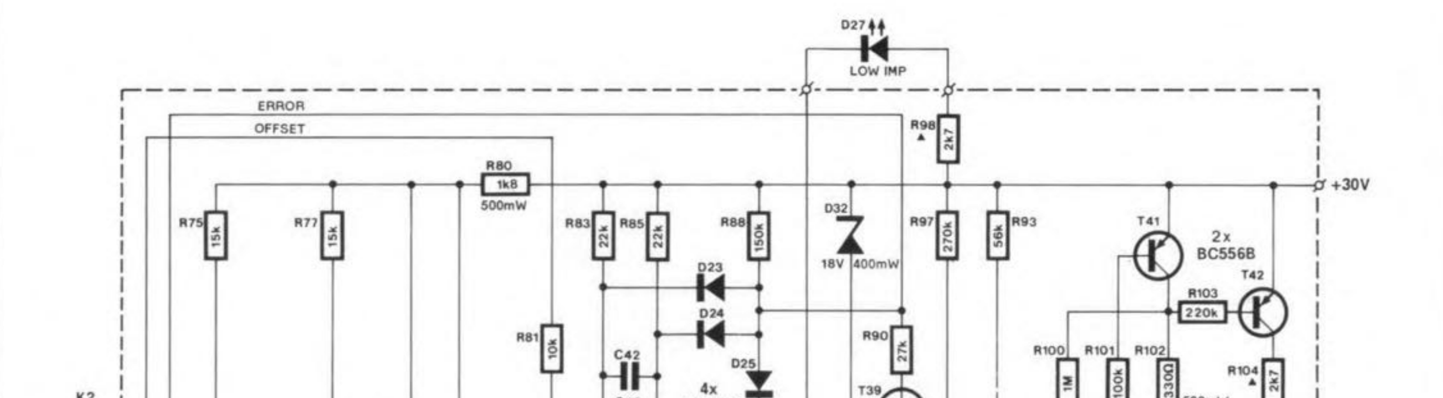


Fig. 5. Circuit diagram of the protection unit.

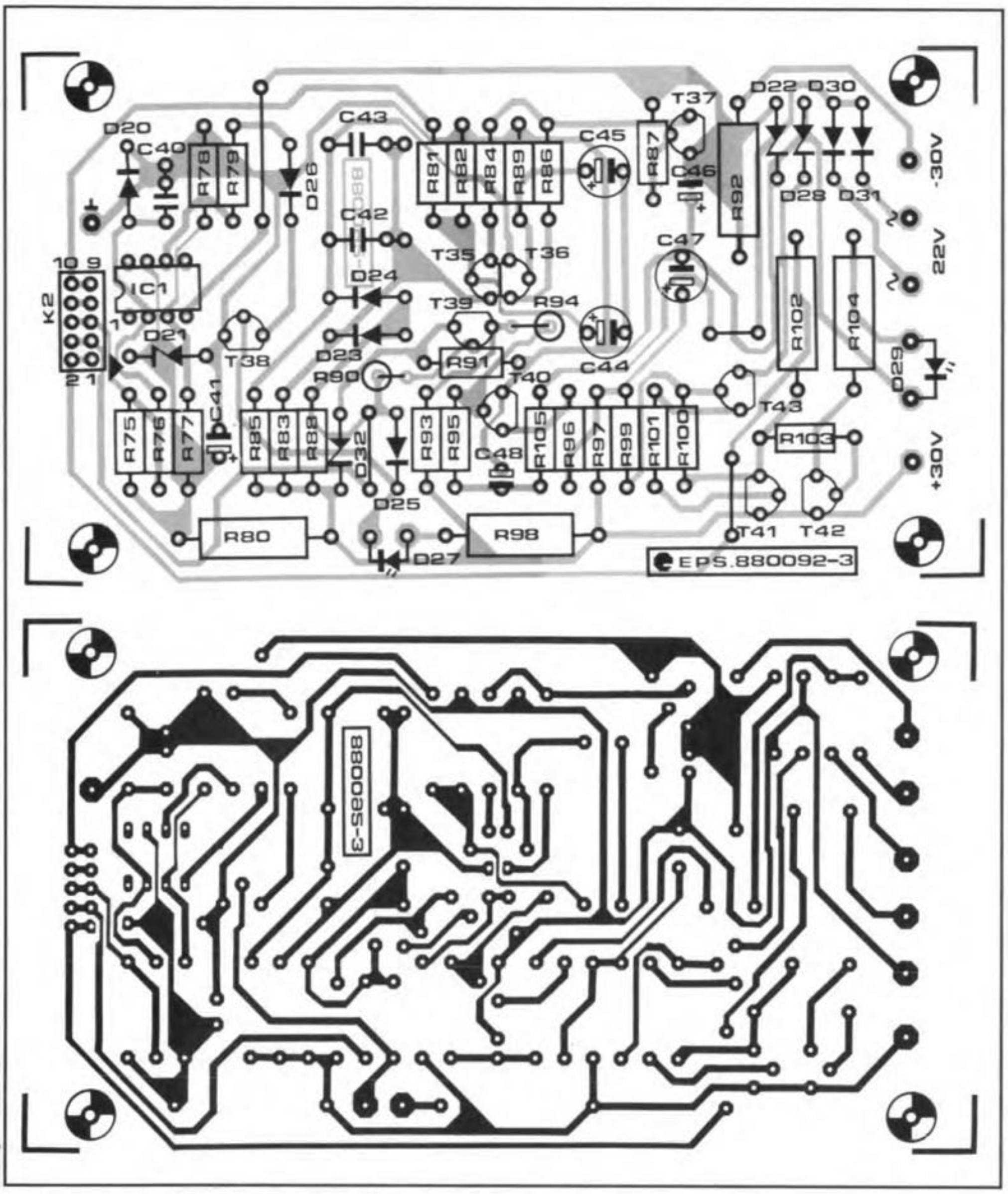


Fig. 6. Printed-circuit board for the protection unit.

secondary winding of the transformer via R_{95}–C_{48}–R_{105}–D_{30}–D_{31}. This rectifier circuit provides a negative direct voltage at a level which ensures that T_{40} is switched on as soon as the secondary voltage fails.

All other protection sections make use of T_{40} via a comparator based on T_{39}. When the base potential of T_{39} drops below about 12 V, that transistor conducts, and this causes C_{47} to discharge via T_{40}.

The value of the loudspeaker resistance is monitored by IC_1 immediately after the power is switched on, but just before the relay is energized. The inputs of the IC are connected to a Wheatstone bridge, one arm of which consists of R_{75} and the loudspeaker resistance, and the other of R_{77} and R_{78}. If the loudspeaker resistance is smaller than 2.2 Ω, the output of the opamp goes high so that T_{38} is switched on and LOW IMP indicator D_{27} lights. At the same time, T_{39} switches on T_{40}, so that the relay cannot be energized.

When the loudspeaker resistance is higher than 2.2 Ω, the relay is energized a few seconds after power-on. The voice coil is then no longer connected to the inverting input of IC_1 via pins 5 and 6 of K_2 and the IC can no longer monitor its resistance. During normal operation, the output of IC_1 is kept low via diode D_{20}.

The direct voltage at the output of the amplifier is measured by the differential amplifier formed by T_{35} and T_{36}. The output signal is fed to T_{35} direct and to T_{36} via C_{44} and C_{45}. If the direct-voltage difference is greater than 0.6 V, the collector voltage of either T_{35} or T_{36} drops to such an extent that T_{39} is switched on via D_{23} or D_{24}, depending on the polarity of the direct voltage.

Transistors T_{27} and T_{30} in the current amplifier—see Fig. 2 in Part 1—measure the current through the emitter resistor of one of the output transistors in the positive and negative half of the output signal respectively. When the peak value of that current exceeds 15 A, T_{39} is switched on via the ERROR line, so that the relay is de-energized.

Power supply

The power supply is designed as a dual mono configuration to ensure complete isolation between the two output stages. Its circuit is contained in Fig. 2 (Part 1). It also needs an additional board—see Fig. 7—to house the auxiliary transformer, Tr_1, rectifiers D_{35}–D_{38}, and smoothing capacitors C_{54} and C_{55}. The board is designed to be fitted with a number of terminal blocks to facilitate the inter-wiring of the amplifier sections.

Construction

The construction details are given for a mono amplifier; two such amplifiers are needed, of course, for a stereo installation.

The prototype is built in a fairly expensive enclosure with integral heat sinks; a suitable box and separate heat sinks may, of course, also be used. It is best to begin by drilling (and, preferably, tapping) holes in the heat sinks for the fastening screws of the boards and tran-

PARTS LIST

Resistors:
R75, R77 = 15 kΩ
R76, R99, R101 = 100 kΩ
R78 = 2.2 Ω
R79, R81 = 10 kΩ
R80 = 1.8 kΩ, 0.5 W
R82, R89, R105 = 2.2 kΩ
R83, R85 = 22 kΩ
R84, R86 = 100 Ω
R87 = 1 kΩ
R88 = 150 kΩ
R90 = 27 kΩ
R91 =5.6 kΩ
R92 = 2.2 kΩ, 0.5 W
R93, R95 = 56 kΩ
R94 = 12 kΩ
R96 = 150 Ω
R97 = 270 kΩ
R98, R104 = 2.7 kΩ, 1.5 W
R100 = 1 MΩ
R102 = 330 Ω, 0.5 W
R103 = 220 kΩ

Capacitors:
C40 = 150 nF
C41, C46 = 10 μF, 25 V
C42, C43 = 1 μF, 63 V
C44, C45 = 220 μF, 25 V
C47 = 100 μF, 40 V
C48 = 2.2 μF, 63 V

Semiconductors:
D20, D23–26 = 1N4148
D21, D22 = zener, 15 V, 400 mW
D27 = LED, orange
D28 = zener, 10 V, 400 mW
D29 = LED, red
D30, D31 = 1N4002
D32 = zener, 18 V, 400 mW
T35, T36, T40, T43 = BC546B
T37 = BF256A
T38 = BC639
T39, T41, T42 = BC556B
IC1 = LF411CN

Miscellaneous:
K2 = 10-way header for PCB mounting
IDC socket for mating with K2
PCB 880092-3 (see Readers' services)

sistors: a photocopy of Fig. 4 can be used as a template. Note that the board must be centred on the heat sink to ensure even heat distribution.

Next, build the voltage and current amplifier boards, followed by that for the protection unit. It is worth while to pair the transistors beforehand, particularly T_3–T_4, T_6–T_7, T_{21}–T_{22}, T_{23}+T_{24}–T_{25}+T_{26}, and, not so important, T_8–T_9 and T_{10}–T_{11}.

On the current amplifier board, fit all components at the track side, a few millimetres above the tracks. Note that inductor L_1 has fewer turns than its counterpart in the LFA150. Resistor R_{63} is located in the centre of the coil, thus 'floating' a good centimetre (about $^7/_{16}$ in) above the board.

Make certain that the type numbers of T_1 and T_2 in the voltage amplifier have the suffix 'V' (which indicates the amplification factor). Also ensure that the dot on the case of this dual FET is located above the corresponding dot on the board.

The pairs T_3–T_4 and T_6–T_7 must be juxtaposed with their smooth sides separated by heat conducting paste. Tighten the pairs together with a nylon cable tie.

Mount transistors T_8, T_9, T_{10} and T_{11}, insulated from one another, on a common L-shape aluminium heat sink measuring 55×20×15 mm ($2^1/_8$×$^3/_4$×$^9/_{16}$ in).

Note that the dimensions of a number of components on the print have become smaller (because their rating has been reduced) and that several of the indicated voltage levels on the board are no longer correct.

After the three boards have been completed, fit the drivers, output transistors and T_{20}–T_{26} to the heat sink: use heat conducting paste and insulating washers throughout. Cut about 1 mm off the washers for the output transistors to prevent their overlapping.

Bend the pins of T_{23}–T_{26} into a 'Z', so that their ends finish up about 1.2 mm ($^1/_{16}$ in) above the heat sink—see Fig. 8.

The pins of T_{21} and T_{22} must point straight up and those of the quiescent-current transistor, T_{20}, obliquely upwards. While bending the pins, check from time to time with the current amplifier board to make sure that everything fits nicely. If so, the board can be fitted on to the heat sink with the aid of 1 cm ($^3/_8$ in) long spacers. The transistor terminals should locate exactly in the appropriate holes in the board.

PARTS LIST

ANCILLARY POWER SUPPLY

Resistors:
R106 = 820 Ω

Capacitors:
C50–53 = 22 nF
C54, C55 = 1000 µF, 63 V
C56, C57 = 680 nF, 100 V
C58 = 22 µF, 25 V

Semiconductors:
D35–39 = 1N4002
D40 = LED, green

Miscellaneous:
Tr1 = mains transformer, 2×9 V, 3 VA for PCB mounting
F1 = fuse, 50 mA, delayed action, with PCB-mount holder
3× six-way PCB terminal block
PCB 880092-4 (see Readers' services)

MAIN POWER SUPPLY:
B1 = B100C35000
Tr2 = torroidal mains transformer, 2×22 V, 5 A
C31, C32 = 2×22,000 µF, 40 V
F2 = fuse, 2 A, delayed action
S1 = double-pole mains switch
Mains input socket with integral fuseholder
Heat sink: thermal resistance ≤0.4 K/W
Enclosure

SWITCH-ON DELAY SECTION

Resistors:
R1 = 220 Ω
R2 = 1 MΩ, ≥350 V
R3, R4 = 22 Ω, 10 W (4×12 Ω, 5 W)

Capacitors:
C1 = 1000 µF, 40 V
C2 = 330 nF, 630 V

Semiconductors:
D1–4 = 1N4007
D5 = zener, 24 V, 1.4 W

Miscellaneous:
Re1 = relay for PCB mounting, 24 V d.c., 20 mA, contact rating ≥5 A

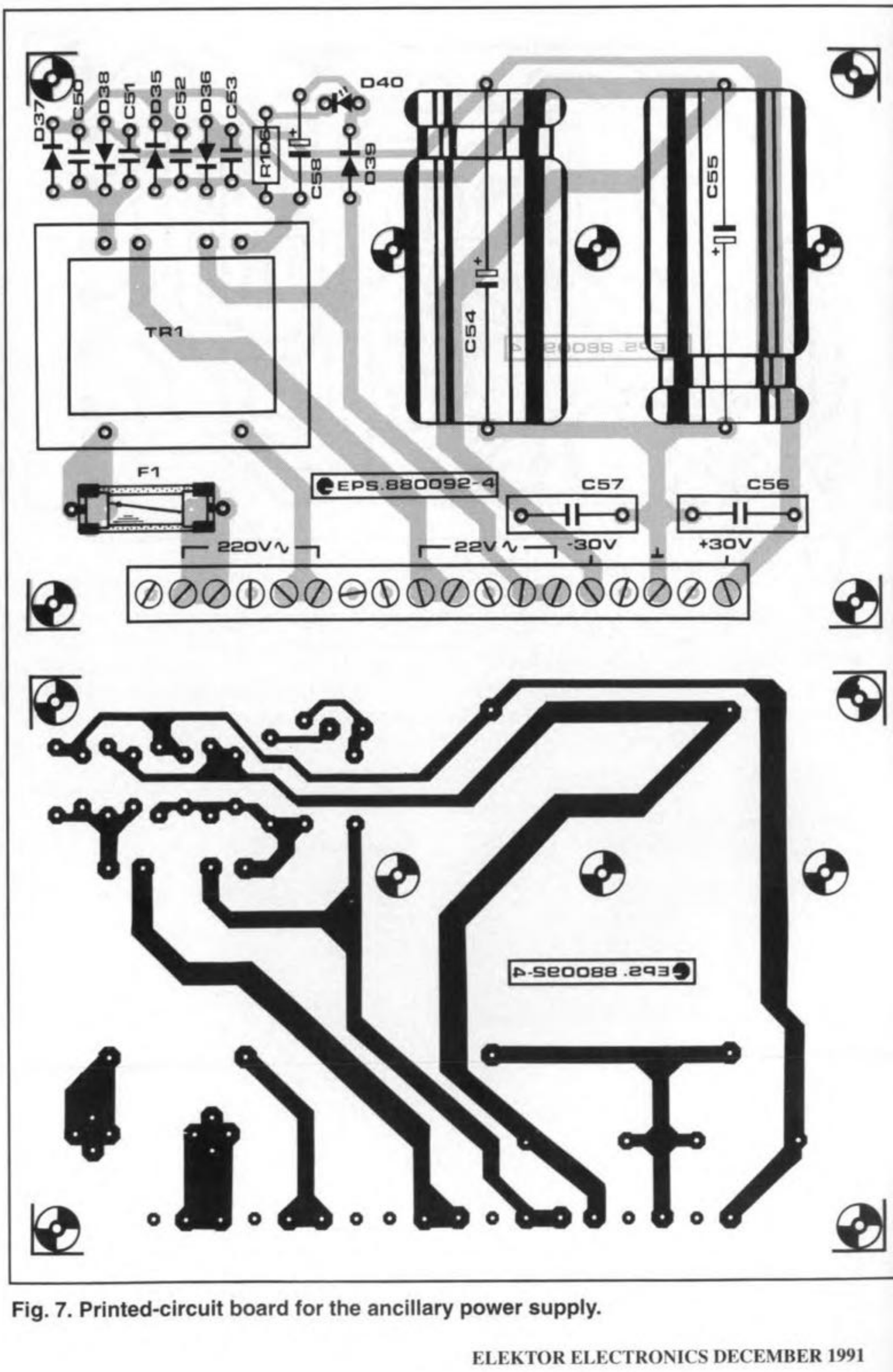


Fig. 7. Printed-circuit board for the ancillary power supply.

Bend the terminals of the output transistors so that they lie on the relevant solder pads over a length of a few millimetres, whereupon all transistors can be soldered in place.

Next, fit the voltage amplifier on to the current amplifier board on 30 mm ($1^3/_{16}$ in) spacers, and then the protection board on to the voltage amplifier board, again on 30 mm ($1^3/_{16}$ in) spacers. The length of the spacers, by the way, is dictated largely by the dimensions of the components.

Interconnect the 10-way connectors on the protection board and current-amplifier board by a length of suitably terminated 10-core flatcable. Interlink points A, B, C and FB on the current amplifier and voltage amplifier boards by short lengths of enamelled copper wire.

Provide a good number of ventilation holes in the top and bottom panels of the enclosure: the heat sinks get pretty hot and part of that heat is radiated into the case. Note that the ageing of most electrolytic capacitors (in the power supply) is accelerated at very high temperatures. It pays, therefore, to use electrolytic capacitors that are designed for operation in high temperatures.

The bottom panel also needs some holes for access to presets P_1.

In the prototype, the two mains transformers were placed one above the other in the centre of the case. Fit each of the boards of the ancillary power supplies on two L-shaped pieces of aluminium, in such a way that the 6-way terminal blocks are accessible from above. Screw the bridge rectifier next to the transformers to the bottom panel with behind it the electrolytic capacitors—see Fig. 12. Keep a reasonable gap between the rectifier and the capacitors, because the rectifier gets pretty hot.

Figure 12 gives the wiring diagram of a mono amplifier: everything shown must be doubled for a stereo amplifier, except the mains entry, on/off switch and switch-on delay circuit.

The switch-on delay circuit prevents the fuses blowing when the amplifier is switched on (surge currents!). It consists of only a few components, so that it can easily be accommodated on a small piece of vero (prototyping) board.

The 'earth' side of the audio input connector must be connected to the metal case. If an insulated connector is used, fit a solder tag to its 'earth' side and solder this to the metal case. These are the only earth points that should be connected to the metal case. Note that the loudspeaker return line is not connected, as usual, to the central earthing point (between C_{31} and C_{32}), but to point C on the current-amplifier board. This arrangement ensures the least possible potential difference via the earth line between the input signal and the feedback signal at the gate of T_2 on the one hand, and the loudspeaker signal on the other, so that distortion is kept well below that in a traditionally wired amplifier. It was arrived at after extensive measurements with a number of earthing configurations.

Testing and setting up

After the wiring of the power supplies has been completed, it is wise to check it carefully before the amplifiers are connected to the power lines. Switch on the mains and measure the voltages across the buffer ca-

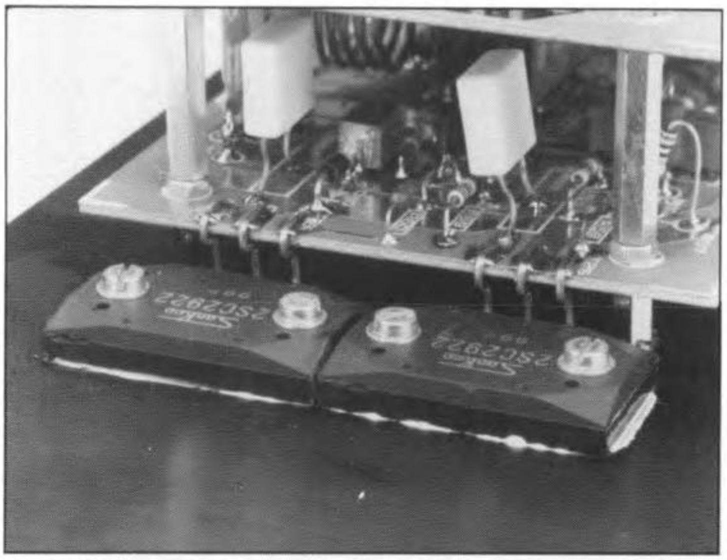


Fig. 8. This photo shows how the output transistors should be mounted; their terminals are bent into an 'Z' shape.

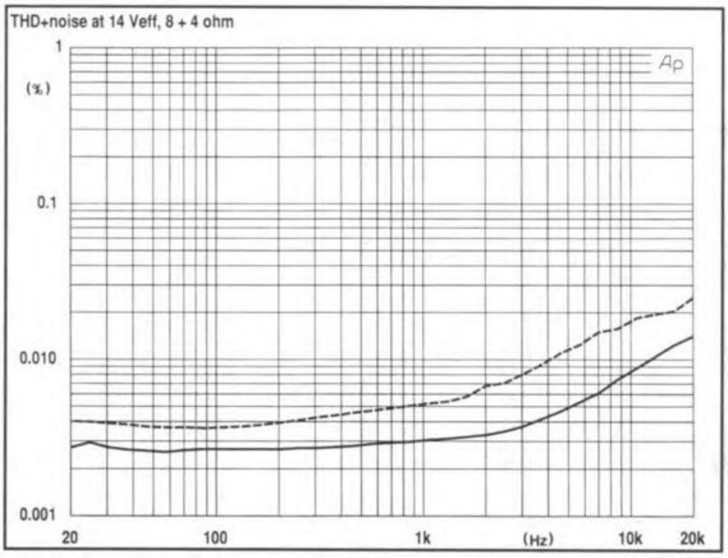


Fig. 9. Harmonic distortion over frequency range 20 Hz to 20 kHz at an output power of 25 W.

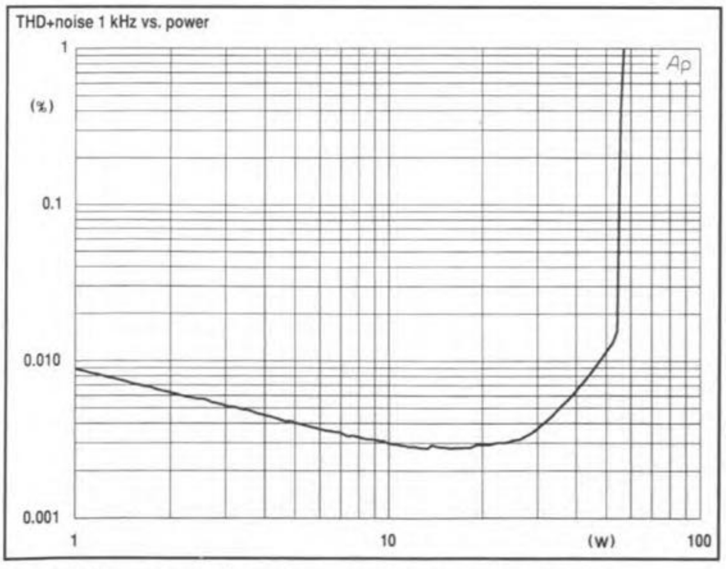


Fig. 10. Harmonic distortion as a function of output power into 8 Ω at a frequency of 1 kHz.

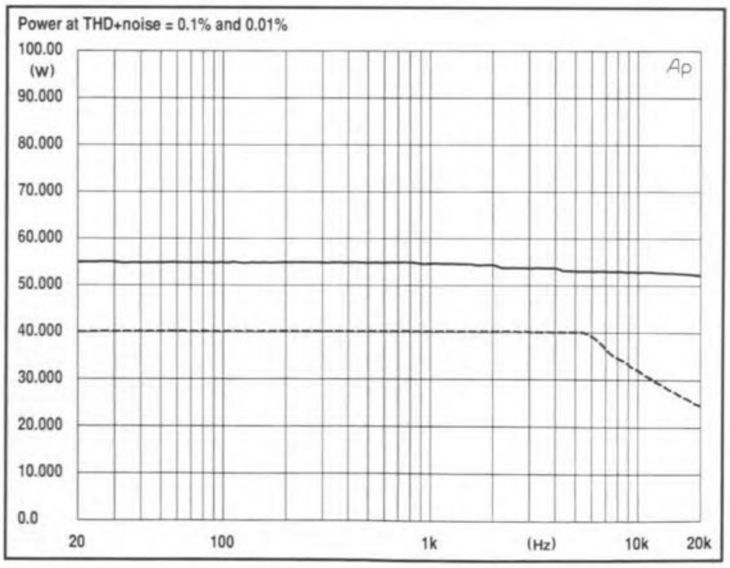


Fig. 11. Maximum output power into 8 Ω with harmonic distortion at 0.1% (solid line) and 0.01% (dashed line).

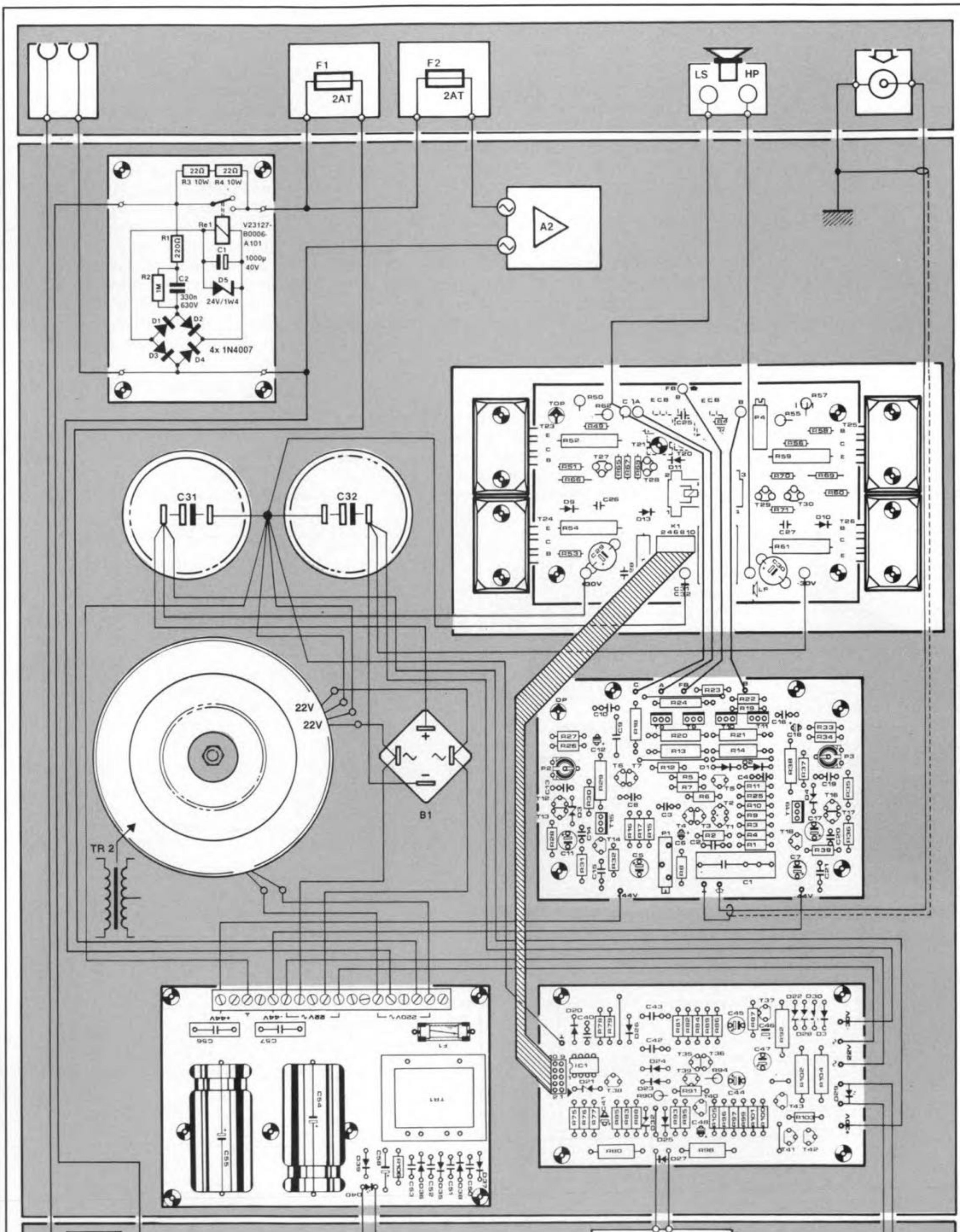


Fig. 12. Wiring diagram for a mono amplifier.

pacitors, which should be ±30 V, and those at the terminal blocks, marked ±70 V, on the ancillary supply boards, which should be ±44 V. If the last voltages are clearly lower than that value, the windings of the main transformer and of the ancillary transformer are not in series. That is remedied by interchanging the connections to the terminals marked 40 V~.

When all these levels are in order, run supply lines to the three boards, suitable lengths of screened cable to the audio inputs and heavy-duty wires to the loudspeaker terminals. For safety's sake, connect a 10 Ω, 5 W resistor in each of the supply lines to the current-amplifier boards.

Set P_4 to maximum resistance and switch on the mains. Next, with P_2 and P_3 respectively, set the supplies to the voltage amplifier to +38.5 V and –35 V. With a multimeter, measure the direct voltage at the output of the amplifier and set it to zero with P_1. Adjust the quiescent currents by varying P_4 until the voltage across the emitter resistors of the output transistors is 10 mV. When that is done, and the d.c. setting at the output remains virtually zero, the resistors in the supply lines to the current-amplifier boards can be removed after the mains has been switched off. Switch the mains on again, and measure the offset at the output afresh: readjust P_1 if necessary. Then, the quiescent current can be increased until the average direct voltage across each of the four 0.22 Ω emitter resistors is 138 mV. It is advisable to let the amplifier operate in that state for about an hour and then to measure the voltage across the emitter resistors again: readjust P_4 if required.

Committed Class A enthusiasts can adjust the quiescent current to 1.8 A, corresponding to 50 W into 8 Ω in Class A. However, much larger heat sinks (lower R_{th}) or forced cooling are then required. In the near future, we intend to publish an indicator circuit that shows when the –3 dB drive and the clipping point have been reached during music reproduction. In that way, it will be possible to check whether the amplifier operates in Class A or in Class B. ■

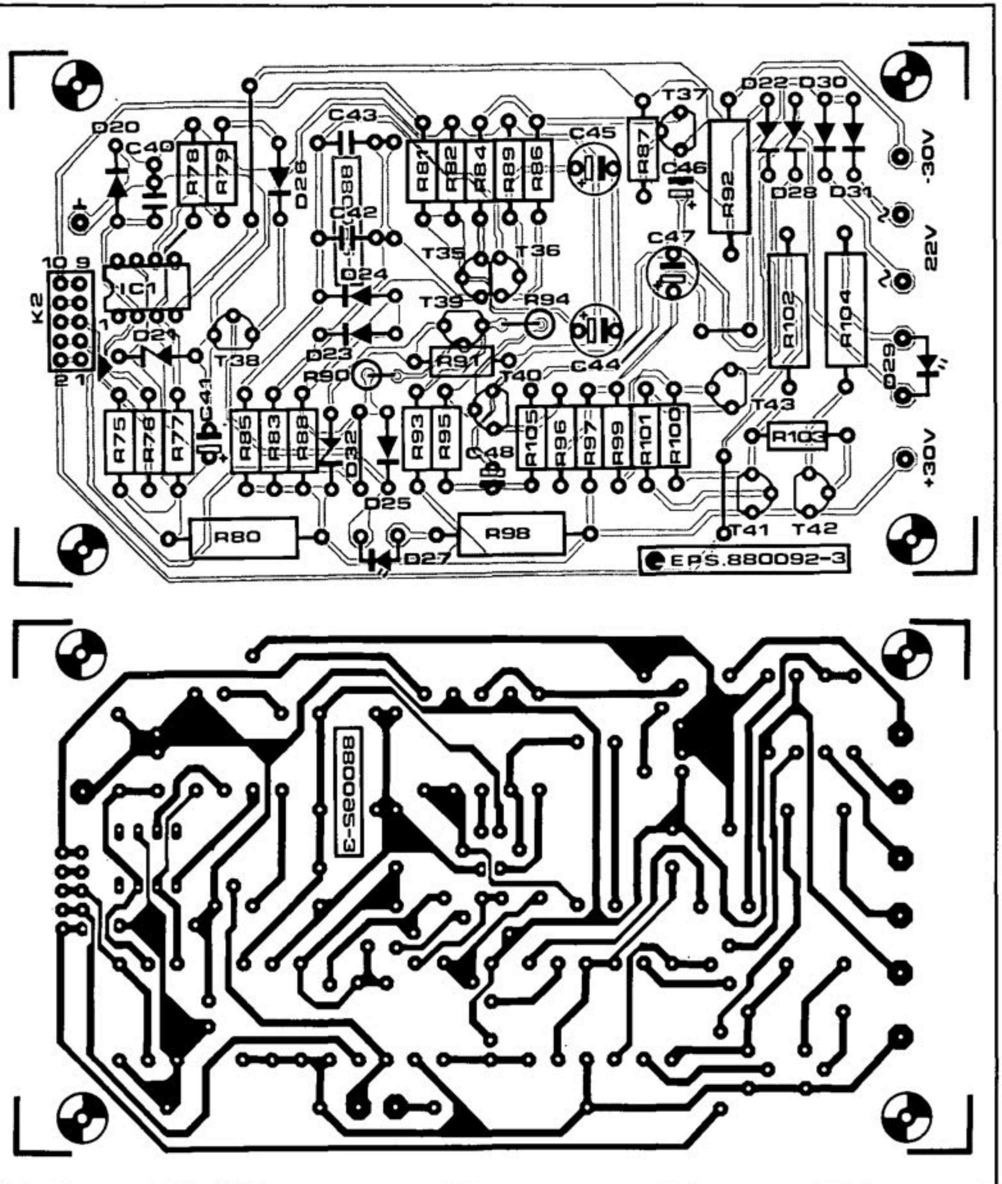


Fig. 6. Printed-circuit board for the protection unit.

secondary winding of the transformer via R_{95}–C_{48}–R_{105}–D_{30}–D_{31}. This rectifier circuit provides a negative direct voltage at a level which ensures that T_{40} is switched on as soon as the secondary voltage fails.

All other protection sections make use of T_{40} via a comparator based on T_{39}. When the base potential of T_{39} drops below about 12 V, that transistor conducts, and this causes C_{47} to discharge via T_{40}.

The value of the loudspeaker resistance is monitored by IC_1 immediately after the power is switched on, but just before the relay is energized. The inputs of the IC are connected to a Wheatstone bridge, one arm of which consists of R_{75} and the loudspeaker resistance, and the other of R_{77} and R_{78}. If the loudspeaker resistance is smaller than 2.2 Ω, the output of the opamp goes high so that T_{38} is switched on and LOW IMP indicator D_{27} lights. At the same time, T_{39} switches on T_{40}, so that the relay cannot be energized.

When the loudspeaker resistance is higher than 2.2 Ω, the relay is energized a few seconds after power-on. The voice coil is then no longer connected to the inverting input of IC_1 via pins 5 and 6 of K_2 and the IC can no longer monitor its resistance. During normal operation, the output of IC_1 is kept low via diode D_{20}.

The direct voltage at the output of the amplifier is measured by the differential amplifier formed by T_{35} and T_{36}. The output signal is fed to T_{35} direct and to T_{36} via C_{44} and C_{45}. If the direct-voltage difference is greater than 0.6 V, the collector voltage of either T_{35} or T_{36} drops to such an extent that T_{39} is switched on via D_{23} or D_{24}, depending on the polarity of the direct voltage.

Transistors T_{27} and T_{30} in the current amplifier—see Fig. 2 in Part 1—measure the current through the emitter resistor of one of the output transistors in the positive and

Resistors:
R106 = 820 Ω

Capacitors:
C50–53 = 22 nF
C54, C55 = 1000 µF, 63 V
C56, C57 = 680 nF, 100 V
C58 = 22 µF, 25 V

Semiconductors:
D35–39 =1N4002
D40 = LED, green

Miscellaneous:
Tr1 = mains transformer, 2×9 V, 3 VA for PCB mounting
F1 = fuse, 50 mA, delayed action, with PCB-mount holder
3× six-way PCB terminal block
PCB 880092-4 (see Readers' services)

MAIN POWER SUPPLY:
B1 = B100C35000
Tr2 = torroidal mains transformer, 2×22 V, 5 A
C31, C32 = 2×22,000 µF, 40 V
F2 = fuse, 2 A, delayed action
S1 = double-pole mains switch
Mains input socket with integral fuseholder
Heat sink: thermal resistance ≤0.4 K/W
Enclosure

SWITCH-ON DELAY SECTION
Resistors:
R1 = 220 Ω
R2 = 1 MΩ, ≥350 V
R3, R4 = 22 Ω, 10 W (4×12 Ω, 5 W)

Capacitors:
C1 = 1000 µF, 40 V
C2 = 330 nF, 630 V

Semiconductors:
D1–4 = 1N4007
D5 = zener, 24 V, 1.4 W

Miscellaneous:
Re1 = relay for PCB mounting, 24 V d.c., 20 mA, contact rating ≥5 A

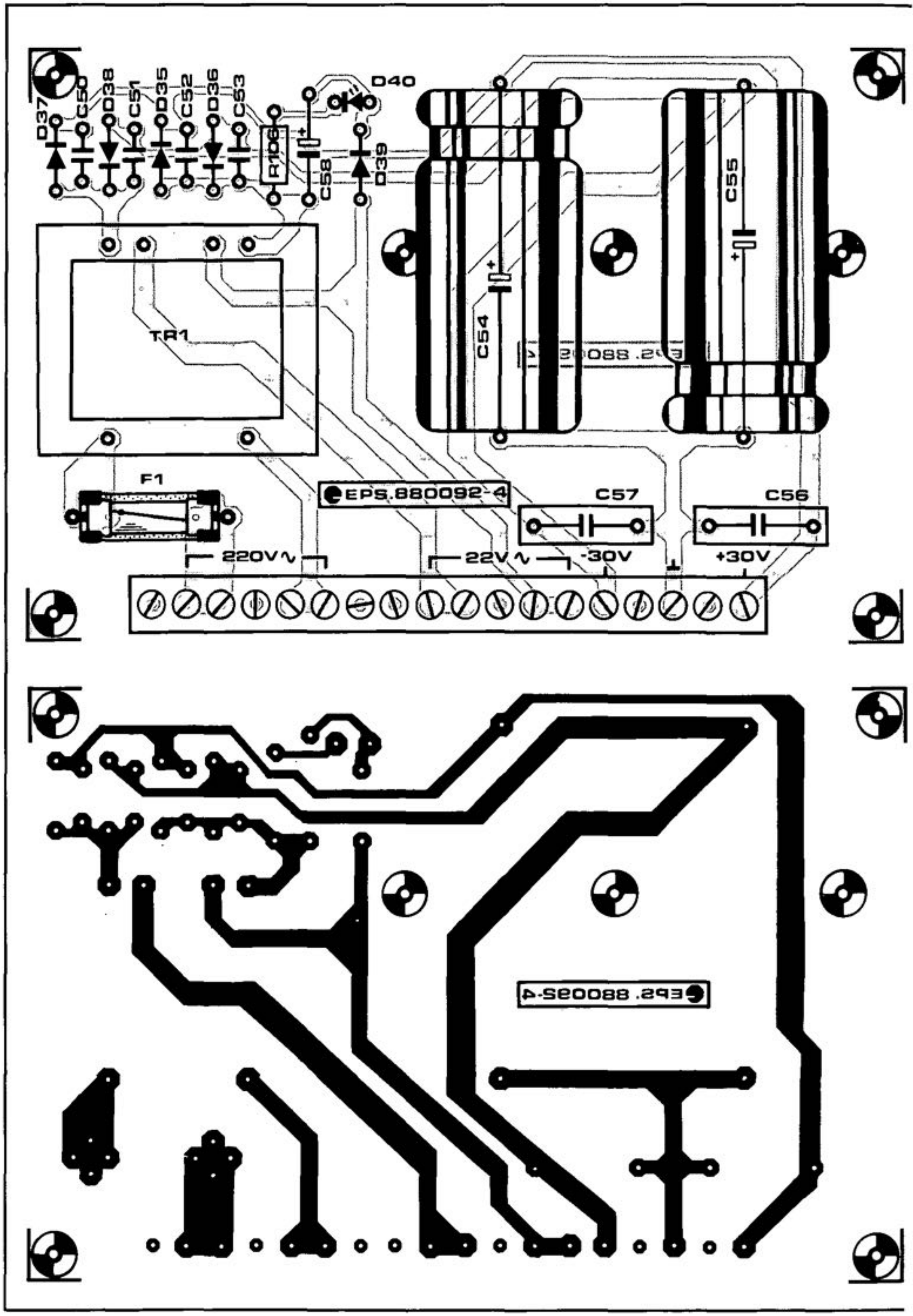
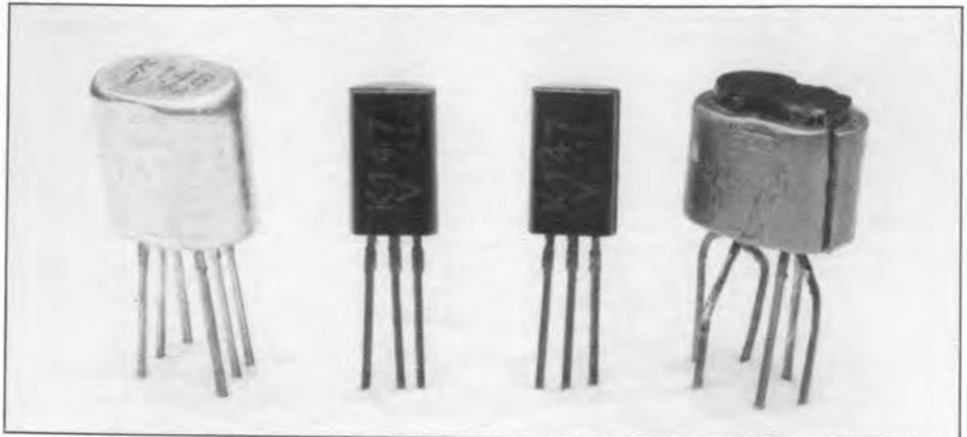


Fig. 7. Printed-circuit board for the ancillary power supply.

CORRECTIONS AND UPDATES

LFA150-A Class-A amplifier

November and December 1991
Replacement for 2SK146V.
We have recently been informed by Toshiba that the dual FET Type 2SK146V used in the LFA150-A design is no longer manufactured. The 2SK146V is not a dual FET in the true sense of the word, i.e., there are no two FETs on a single chip. Rather, it consists of two FETs, each in its own enclosure, which are held together by a metal ring. Such a construction is readily reproduced by clamping two 2SK147V FETs together, using a small piece of metal (e.g., copper or brass).



The photograph illustrates the construction of the replacement dual FET. In practice, the 'imitation' works perfectly. Note, however, that the pin connections of the replacement FET are different from the original 2SK146, which has facing identical pins. By contrast, the dual 2SK147V construction has identical pins in mirrored positions. Fortunately, this is simple to resolve by bending the outer pins (drain and source) of one FET such that the pin positions are swapped. (920163)

Sound sampler for Amiga

November 1991.
Capacitor C9 is mising from the parts list and the circuit diagram. C9 is a 100-nF decoupling capacitor fitted near IC7 (see component overlay).
LEDs D2 and D4 should be transposed, both in the circuit diagram and the parts list. D2 is the ERROR LED, and D4 the LEFT LED. (920074)

VARIABLE TIME SWITCH

by C. Mieslinger

THE SWITCH described has two time ranges that are selected with a push-button. In the prototype, the ranges were 5 minutes and 20 minutes, but these can be altered easily. Moreover, pressing the switch three times in succession switches off the load (here, a lamp).

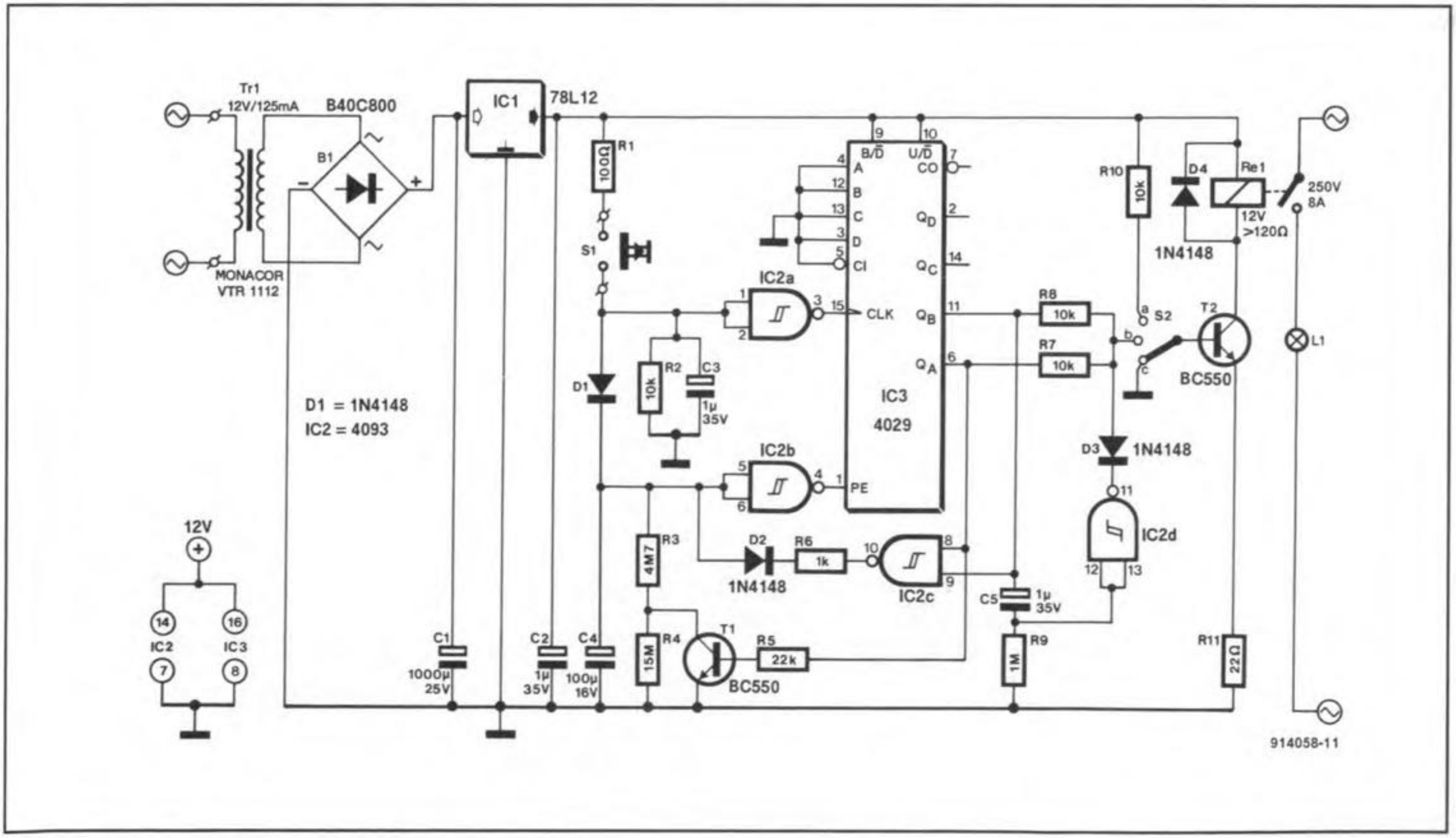
When S_1 is pressed, IC_3 is enabled via D_1 and NAND gate IC_{2b}; at the same time, capacitors C_3 and C_4 are charged. When the switch is released, IC_3 gets a clock pulse from IC_{2a} via R_2, so that its QA output goes high. This results in the relay being energized by T_2, so that its contact closes and the lamp comes on.

At the same time, the QA output switches on transistor T_1, so that R_4 is short-circuited. Capacitor C_4 is then discharged via R_3. After the potential across C_4 has dropped to the lower trigger level of IC_{2b}, which takes about 5 minutes, IC_3 is reset and the relay switches off the lamp.

When S_1 is pressed twice in succession, the counter gets two clock pulses and its QB output goes high. Transistor T_1 then remains off and C_4 discharges via R_3+R_4, which takes about 20 minutes. As an indication that the longer time has been selected, immediately after the second press on S_1, the lamp goes out briefly. This is effected by IC_{2d}, which is given a pulse by differentiating network R_9-C_5 when QB of IC_3 goes high.

When S_1 is pressed three times in succession, both QA and QB of IC_3 go high, which results in the output of IC_{2b} becoming 0 and C_4 discharging rapidly. The lamp is then switched off instantly.

Rotary switch S_2 enables switching the lamp on or off permanently. When this switch is in its centre position, the relay is controlled by the timing circuit. ■



AUTO POWER-ON/OFF FOR BICYCLE SPEEDOMETER

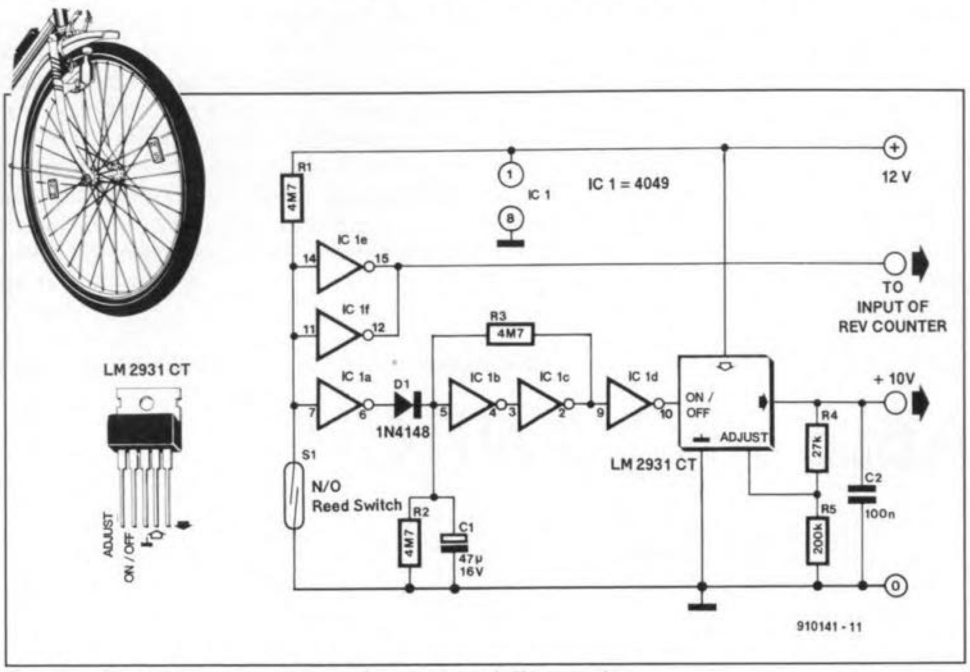


Fig. 1. Circuit diagram of the auto power-on/off extension.

by R.G. Evans

When a bicycle speedometer must be rugged, accurate and, above all, novel and a little unusual, the 'high-tech' computerized LCD units found in the shops are not really what you are looking for. The author found a circuit published in this magazine far more attractive, and set out to design an automatic on/off control for it.

Digital revolution counters (or 'speedos') are all very well, but although satisfactory in practical use, are unlikely to create much interest from other cycling enthusiasts. The same applies to a conventional moving-coil meter display, which is no alternative because it requires scale lighting, and its wavering needle is difficult to read in the first place. So, what is needed is a combination of a LED-based readout and yet some novel feature such as a line of lights. Fortunately, such a circuit was found in Ref. 1: a LED revolution counter with the LEDs arranged in a circle, just like a conventional rev counter or speedo. The circuit is based on Telefunken's U1096B 30-LED bar driver.

Some quick calculations on the likely rpm (and therefore speed) of a bicycle wheel led to substantially lower input pulse rates than would be encountered in the original application. Referring to the original article made redimensioning the monostable period simple, and the use of four trigger pulses per revolution helped iron out low-speed flicker whilst retaining a reasonable 'reaction time' to changes in speed (although not many people ride a bike at 1-2 mph).

In the present application, it was required to display a maximum speed of 30 mph (it was an off-road bike), which meant that each LED would represent 1 mph — easy to read, and novel in its appearance.

Automatic on/off control

Building the circuit to the original *Elektor Electronics* article was easy. However, a problem arose with the voltage regulator specified, an 48L10 low-drop 10-V stabilizer IC. This proved difficult to obtain, so an alternative was sought, and located in the RS (ElectroMail) catalogue. The LM2931CT from National Semiconductor has the facility to adjust the output voltage, and offers an on/off function coupled with low standby current drain. The idea was born to implement an automatic on/off control for the bicycle speedo. It had already been decided to (a) make the device quickly removable to prevent theft, and (b) to make it rechargeable to reduce running costs, and (c) to cut down on the fiddling about when installing the device.

Basically what was needed was a low current drain monitoring device that would sense the front wheel's movement, and switch the voltage regulator in the speedo on and off. The circuit to accomplish this is shown in Fig. 1. Based on a single CMOS IC, its standby current is under 1 μA, while its output capability is sufficient to switch the regulator on. Also, there are two inverter gates left, which are used here to provide the count signal to the rev counter circuit. A simple high/low input was obtained from a cheap reed switch mounted on the front fork, triggered by four passing magnets attached to the spokes of the front wheel. This signal is processed to suit both the rev counter input and the on/off circuit.

Pull-up resistor R1 ensures that the input to gate IC1a is low most of the time (the chances of the bike being left in a position where the reed switch and magnet coincide are much smaller than them being separate, and so allow the circuit to turn off, e.g., when you leave the bike for a short while). When the bike is ridden, the reed switch is closed by a passing magnet, when the input of IC1a is taken low, and the output of the gate goes high. The resultant pulse train charges capacitor C1 via diode D1. Resistor R2 determines the 'on' time, and the value shown provides a 30-second delay. The voltage across C1 is applied to the input of gate IC1b, which, along with IC1c and feedback resistor R3, forms a pulse shaper that provides a well-defined high or low output used to control the voltage regulator via one further inverter, IC1d. The regulator control voltage is low for 'on' and high for 'off'. The two remaining inverters are connected in parallel, and also take the reed contact signal. Their outputs are, therefore, high when a magnet passes the reed switch, just what the rev counter needs for correct operation.

Battery considerations and connection

The stand-by current of the prototype was a mere 0.8 mA, which goes mainly on account of the regulator. Since the circuit was being powered from a 12-V 800-mAH lead-acid gel battery, this would provide at least a week between recharges. Incidentally, recharging is accomplished by using two contacts on the base of the cycle lamp holder, so that the battery need not be removed for recharging. A suitable battery charger may be found in Ref. 2.

The current consumption of the active circuit is about 30 mA on average, giving at least 24 hours use in a week. This was deemed more than sufficient (after all, who has the time to cycle more than three hours a day).

Connections to the reed switch (a normally-open type) are made via a miniature plug and socket combination mounted on the back of the lamp holder, which, with careful modification, provided a ready-made housing for the battery and the circuit board. Using such a ready-made housing was felt reasonable in this case, as someone else had already spent time designing an anti-slip and anti-jolt bracketry to suit a bicycle environment, thereby solving what could be a major problem for some constructors. ■

References:

1. 'LED revolution counter'. *303 Circuits*, circuit no. 045.

2. 'Lead-acid battery charger'. *303 Circuits*, circuit no. 250.

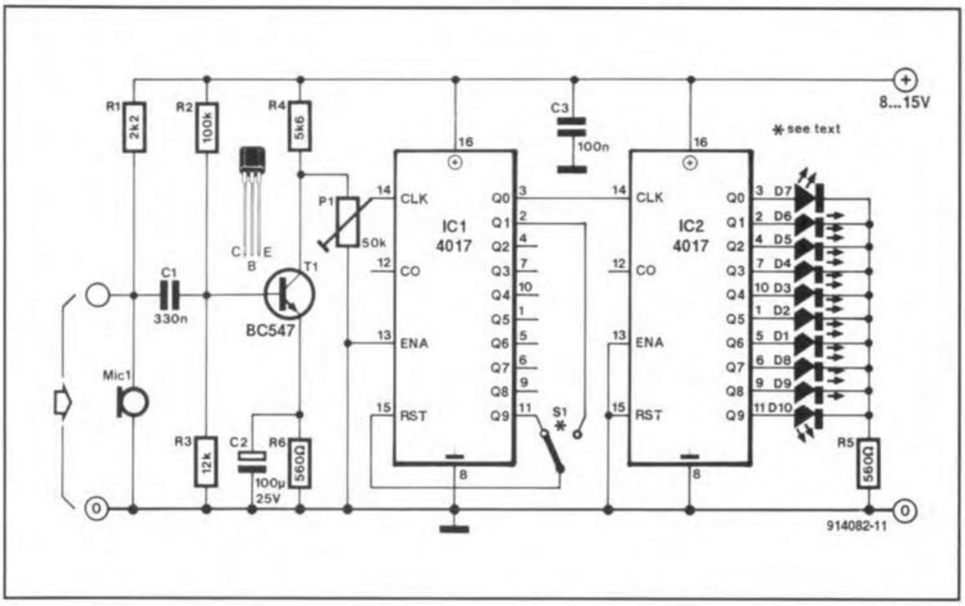
DISCO RUNNING LIGHTS

by A.B. Tiwana

POP MUSIC and light effects are inseparable. The circuits that make the effects possible vary from simple to complex. The circuit presented here is a simple one and is a sort of running light whose rate of change depends on the frequency and intensity of the sound.

The signal is applied to the clock input of counter IC_1 via a single-transistor amplifier, T_1. Its (amplified) level must be high enough to overcome the switching threshold of the counter, while its frequency determines how often the counter is clocked.

The input may be fed with the signal of a preamplifier, but it is also possible, as shown in the diagram, to connect an electret microphone across it, when it functions entirely contact-less. After amplification, the signal is applied to IC_1 via P_1, which controls the sensitivity of the circuit.



Since audio frequencies are too high for making a good visual effect, the signal frequency is scaled down by IC_1 when S_1 connects pin 11 with pin 15. When the switch is in the other position, pin 2 is connected with pin 15: the counter then divides by 1 and the effect assumes a completely different character that no longer resembles a running light.

The actual running light is provided by IC_2, a counter with integral 1-from-10 decoder, which is clocked by the Q0 output of IC_1. Of the ten outputs of IC_2, each of which is connected to an LED, there is always one 'high'. The ten LEDs have a common bias resistor, R_5, an arrangement that is perfectly feasible, since only one LED lights at a time (although it often seems as if more do so).

The circuit may be expanded by adding an LED at pin 12 (carry out) of IC_1. This LED must have its own bias resistor (560 Ω).

The power supply must be able to provide a current of up to 100 mA: at low frequencies the current is appreciably lower.

The colours of the LEDs can be chosen to individual taste. ■

TELEPHONE BUZZER AS SWITCH

by A. Rigby

RECTIFYING the buzzer signal on a telephone line results in a voltage that may be used to switch one or more loads, for instance, a light to show the deaf or hard-of-hearing that the telephone is ringing.

In the present circuit, the buzzer signal is rectified by D_1–D_4; the rectified voltage is smoothed by C_2 and held at 15 V by zener diode D_5. The voltage is used to drive the LED in optoisolator IC_1 via R_3. The optoisolator provides safe isolation between the telephone line and the present circuit and its load. Note, however, that in spite in this, the telephone authorities in some countries may not permit the use of the present circuit: it is always best to seek the advice of your local telephone manager.

As soon as a call signal appears on the telephone line, the LED in the optoisolator ensures that the integral transistor is switched on. This in turn switches on T_1, whereupon relay Re_1 is energized.

Capacitor C_3 is charged as long as the transistor in the optoisolator conducts, but discharges via R_4-R_5-T_1 when the call signal fails: this prevents T_1 being switched off during the intervals between the various pulses of the call signal. When that signal fails, the relay will be denergized after a short delay.

The circuit can be supplied by a 12 V mains adapter. The current it draws depends on the type of relay used, but should not exceed 100 mA. Make sure that the relay can handle the switched voltages and currents. ■

ON/OFF DELAY FOR VALVE AMPLIFIERS

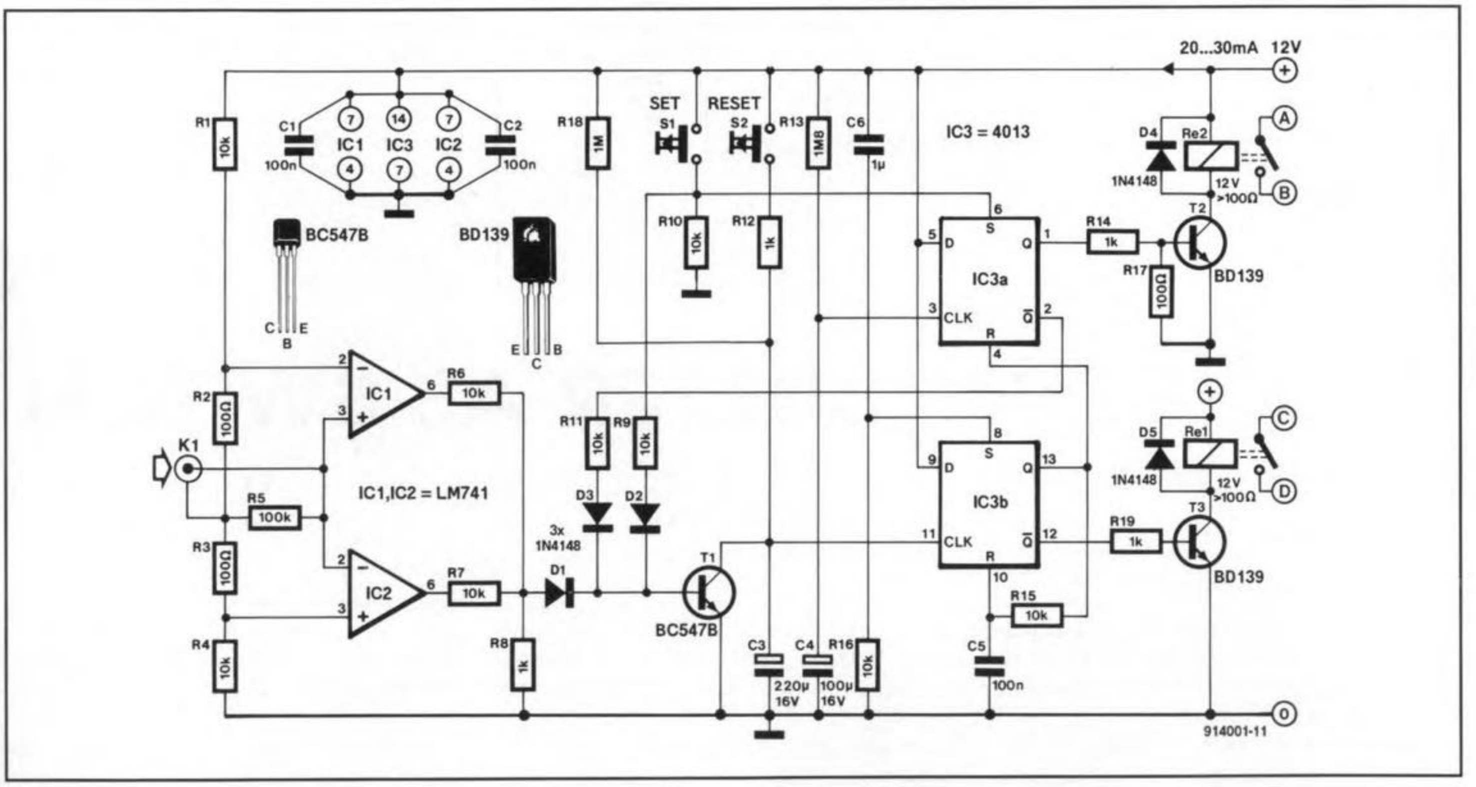
by A. Rigby

THIS circuit has been designed primarily for use with valve amplifiers. When the amplifier is switched on, filament voltage is supplied first and the anode potential a few minutes later. When there has been no input signal for a while, the anode voltage is switched off again automatically.

When the mains is switched on, a set pulse is supplied to bistable (flip-flop) IC_{3b} via R_{16}–C_6. The Q output (pin 13) then goes high and the bistable resets itself via R_5-C_{15}, whereupon relay Re_1 is energized via T_3 and the valves are provided with heater voltage. After a delay, dependent on time constant R_{13}-C_4, the potential at the clock input of IC_{3a} reaches a level that causes the bistable to toggle so that its Q output (pin 1) goes high. Relay Re_2 is then energized and switches the high voltage to the valves.

During operation of the amplifier, the inverting input of IC_1 and the non-inverting input of IC_2, both of which circuits are connected as comparator, are provided with a voltage of about 6 V by potential divider R_1-R_2-R_3-R_4. The audio signal from the preamplifier or output amplifier (one channel suffices) is fed to both ICs. The earth of this signal is connected to the potential divider, which means that the supply and earth lines of the amplifier and the delay circuit must be well isolated from one another. When the signal level is about 60 mV or greater, the output of either IC_1 or IC_2 will go high, depending on the polarity of the signal. Transistor T_1 is then switched on via R_6 or R_7, which results in C_3 discharging. When T_1 is off, C_3 is charged slowly via R_{18}. When there has been no signal input for a few minutes, the voltage across C_3 rises to a level where IC_{3b} gets a clock pulse. This results in IC_{3a} being reset, whereupon T_2 is switched off, so that relay Re_2 is deenergized and the high voltage is removed from the valves. Transistor T_1 is provided with base current via R_{11} and D_3, so that the clock input of IC_{3b} remains low. This bistable resets itself almost immediately, however, via R_{15}-C_5. The interval between clock pulse and reset is so short that Re_1 remains energized: heater voltage to the valves is, therefore, maintained.

There are two keys for user operation: S_1 resets IC_{3a} whereupon the high voltage is reapplied to the valves; S_2, when pressed, causes a clock pulse to be generated that switches the amplifier to standby. ■



BEDSIDE LIGHT TIMER

by H. Moser

MANY young children will insist on keeping the bedside light on for a couple of minutes after the storybook has been closed and father or mother has gone downstairs. They are also prone to fall asleep with the light on, which is a waste of energy, and a problem for the parent because the light has to be switched off without waking the child.

The timer shown here is an elegant solution to this little domestic problem. Simple to build from a handful of inexpensive components, it lets you determine how long the bedside light remains on after you have said goodnight and actuated the timer.

Pressing switch S_1 causes bistable IC_{1b} to toggle, and produces a debounced clock pulse at the input of the second bistable, IC_{1a}, whose Q output goes high, triggering a low-power thyristor, Th_1. The complementary bistable output, $\overline{Q}$, goes low and enables timer IC_2. The load, a small bulb (max. 60 W) is switched on, and remains on until counter IC_2 resets IC_{1a}.

The counter, a Type CD4541, has an on-board oscillator that operates at a frequency, *f*, given in Hz by

$$f = 1/2.3\, R_{TC}\, C_{TC}\,,$$

where R_{TC} and C_{TC} are the resistor and capacitor connected to pin 1 and 2 respectively. The resistor connected to the RS input, pin 3, has a value of about $2R_{TC}$.

The scale factor of the 4541 is set to 65 536 (2^{16}) here by tying its A and B control pins to the positive supply rail. This means that the OUT pin changes state after 32 768 clock pulses. The logic levels defined at pins 5, 10 and 9 select a logic low level at the OUT pin when the RESET pin is logic high. Hence, the delay, τ, in seconds, introduced by the circuit can be calculated from

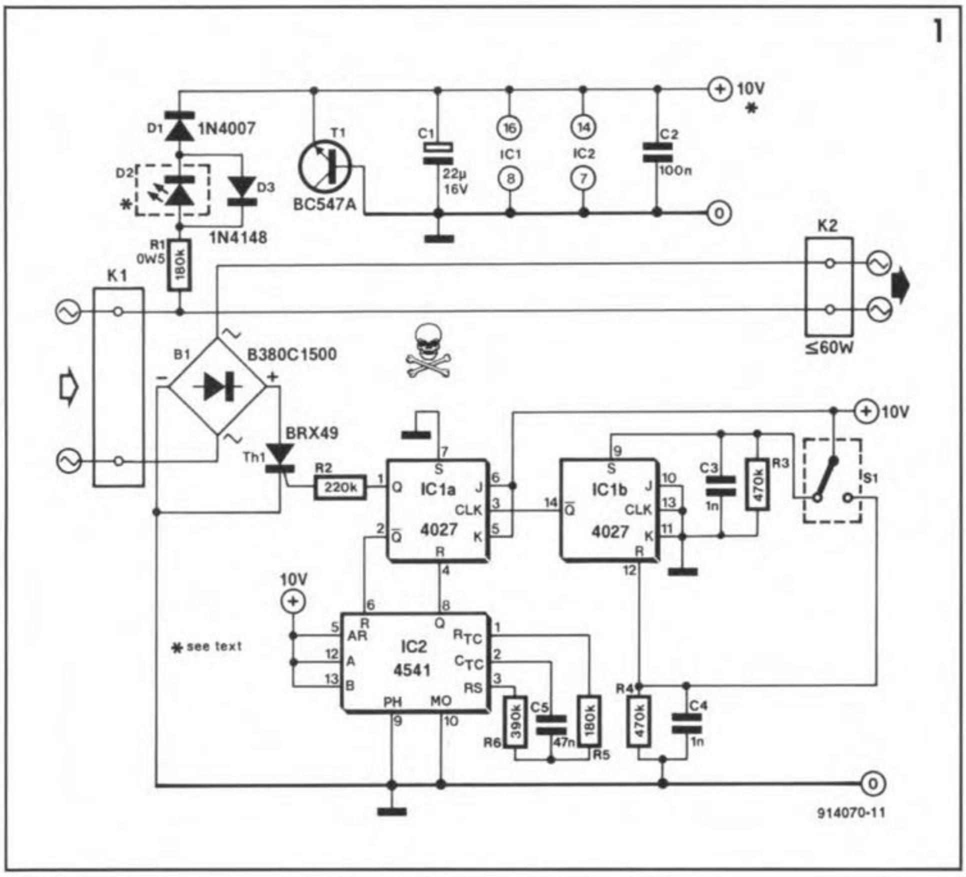
$$\tau = 2.3 \times 32768 \times R_5 \times C_5.$$

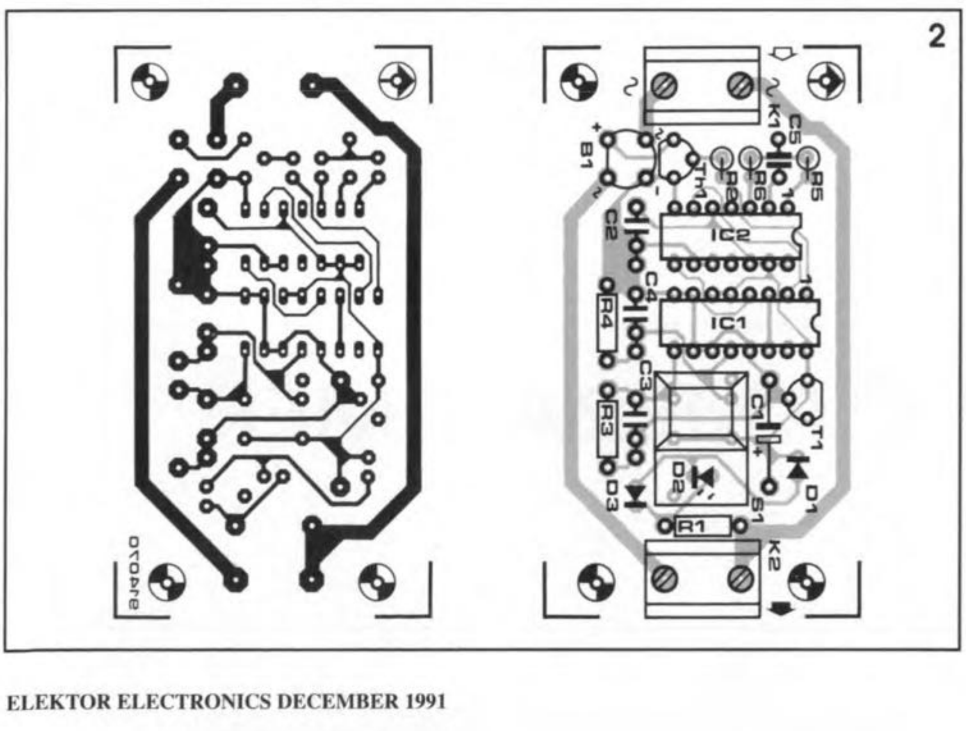
The circuit is powered direct by the mains. Transistor T_1 forms a 10-V zener diode. A LED, D_2, is used as an orientation aid for the child. The LED forms part of the ITW (Digitast) push-button, S_1.

It should be noted that the actual supply voltage of the circuit may lie between 6 V and 12 V, depending on the characteristics of T_1. The actual value is of little importance, however, as long as IC_{1a} is capable of supplying a trigger current of about 200 µA to the thyristor.

The circuit is constructed on the printed-circuit board shown in Fig. 2, and fitted in a suitable ABS enclosure. In the interest of safety, make sure the input and output cable are properly insulated and secured with strain reliefs. The clearance for the keytop in the top panel of the enclosure must be made as small as possible to prevent any risk of the circuit being touched.

WARNING. Since the circuit carries dangerous voltages at a number of points, it is essential that proper electrical insulation is applied. Never work on the circuit when the mains is connected to it. Make sure that no part of the circuit can be touched when it is being set, adjusted or used. ■





PARTS LIST

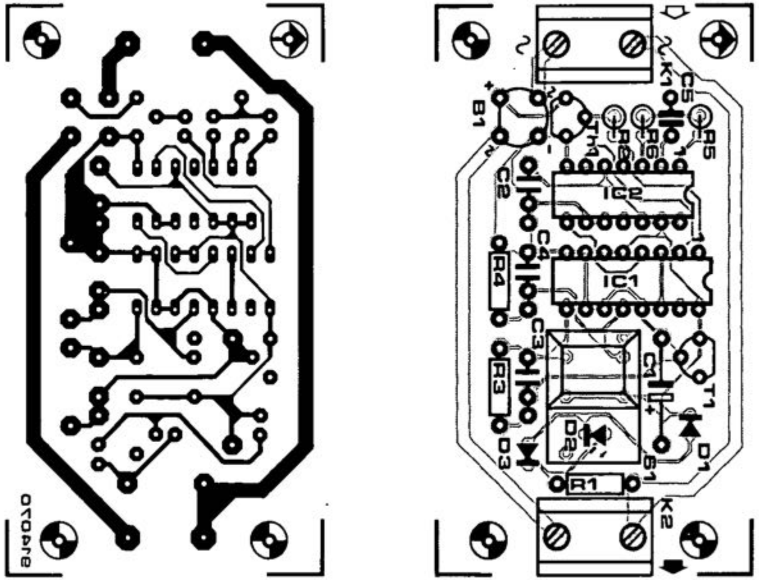
Resistors:
R1 = 180 kΩ, 0.5 W
R2 = 220 kΩ
R3, R4 = 470 kΩ
R5 = 180 kΩ
R6 = 390 kΩ

Capacitors:
C1 = 22 µF, 16 V
C2 = 100 nF
C3, C4 = 1 nF
C5 = 47 nF

Semiconductors:
D1 = 1N4007
D2 = LED, high-efficiency (see S1)
D3 = 1N4148
B1 = B380C1500
T1 = BC547A
Th1 = BRX49
IC1 = 4027
IC2 = 4541

Miscellaneous:
S1 = digitast push-button switch with integral LED
K1, K2 = PCB-mount terminal block, pin spacing 10 mm
ABS enclosure about 100×50×25 mm

2



D2 = LED, high-efficiency (see S1)
D3 = 1N4148
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Miscellaneous:
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ABS enclosure about 100×50×25 mm

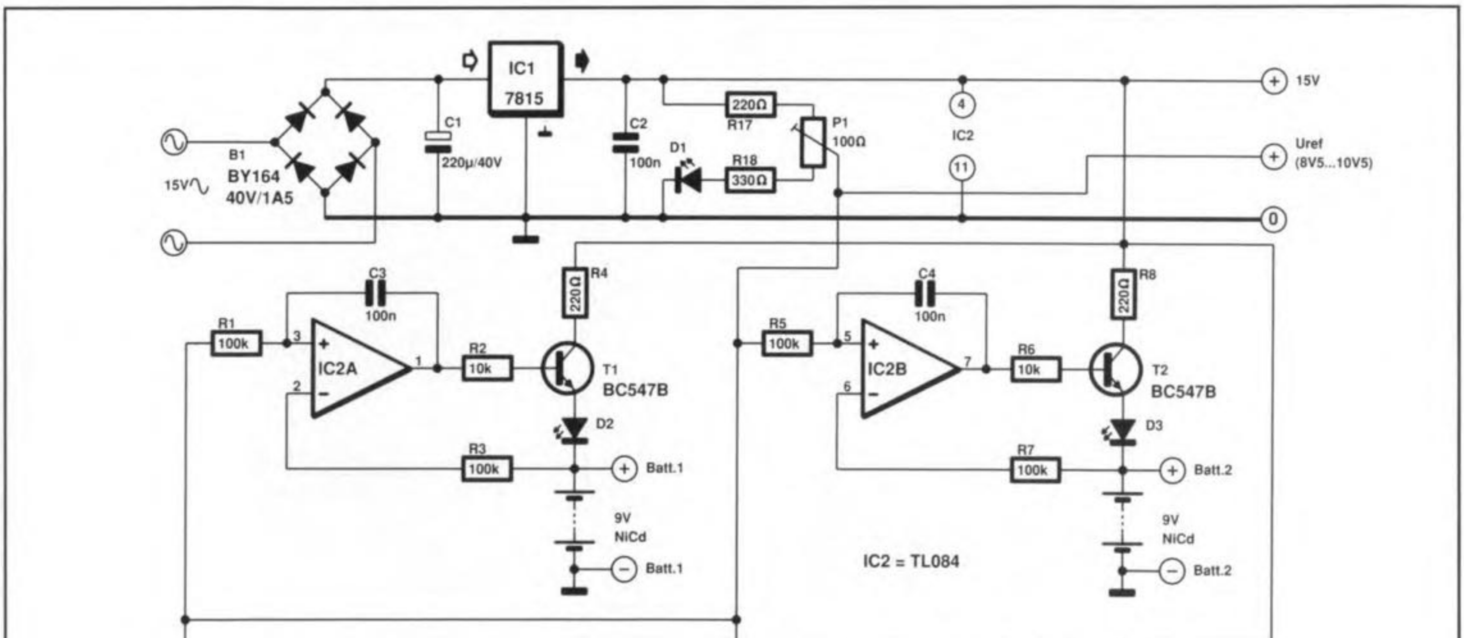
9-VOLT NiCd BATTERY CHARGER

by H. Moser

THE regulated power supply and four identical current sources shown in the diagram enable the simultaneous charging of four 9-volt NiCd batteries. The potential at the wiper of P_1 determines to what voltage the batteries will be charged: an unusual, but effective method. The voltage at the wiper is also applied to the non-inverting inputs of four comparators, IC_{2a}-IC_{2d}, via 100 kΩ resistors. When the battery voltage is too low, the relevant comparator toggles, which results in the associated transistor being switched on, whereupon the battery is charged. The rate at which the comparators can toggle is slowed down by a capacitor shunting the opamps (when a battery is being charged, its e.m.f. rises). The charging voltage, resulting from the current through the battery or batteries can rise to the level set with P_1. When that level is reached, the relevant circuit is switched off, and the e.m.f. of the battery drops almost instantly. This might cause the charging current to be switched on again, resulting in a charging voltage rising to the level set with P_1. To prevent this oscillatory action, the capacitor across the opamps enables the battery to stabilize. If, after a short delay, the battery voltage proves to be too low, the current is switched on again. The capacitor then ensures that the current will flow for a while, irrespective of the battery e.m.f. (after all, the battery was found not to be fully charged).

LEDs in the emitter circuits of the transistors give a visual indication of the on and off switching of the charging current. When the battery is nearly flat, the LED will be on continuously; when it is about fully charged, the charging current will be interrupted more and more frequently, so that the LED begins to flicker. The more nearly the battery is charged, the faster the LED will flicker; when the rate is about 1 Hz, the battery is fully charged.

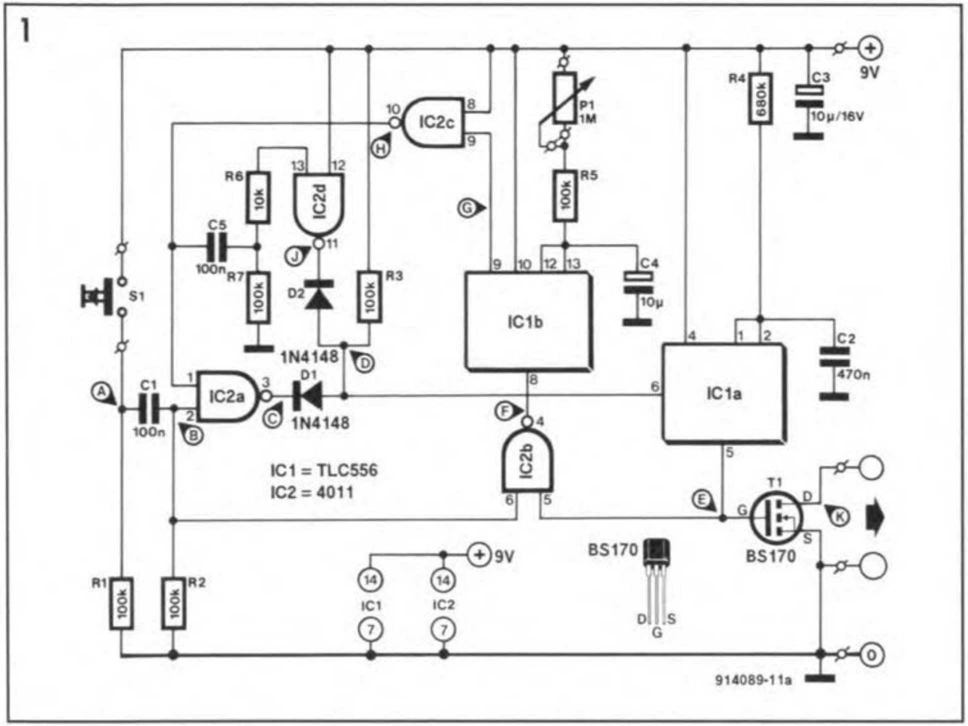
The circuit requires an alternating voltage of 15–18 V; it draws a current of about 150 mA. ■

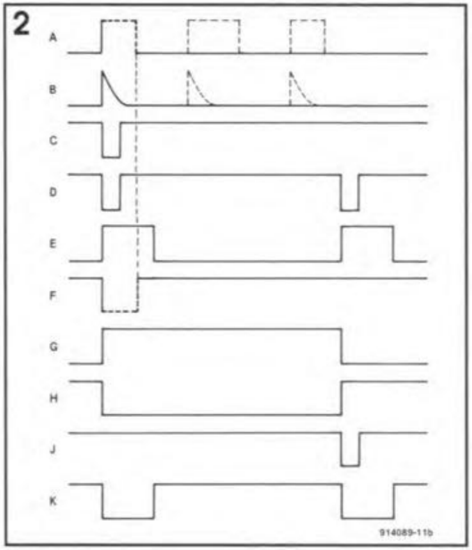


VIDEO CAMERA TIMER

by C. Hagl

SOME video cameras have a socket for a remote control unit. It appears, however, that it is not always easy to connect an interval-control to this socket. For instance, the Blaupunkt 8010 camcorder is not switched on or off in the traditional manner, but with a





40–60 ms long pulse. One pulse switches the camera on, the next one switches it off. Manual operation with a switch is virtually impossible to achieve. However, the timer described here offers a solution.

The timer generates the pulses automatically; the interval between two pulses can be set between about 1 s and 10 s. It operates from a 9V (PP3 or 6F22) battery: the current drain is only 330 µA.

When switch S1 is closed (signal A—see Fig. 2), differentiating network R_2-C_1 ensures that IC_{2a} gets only a short pulse (signal B), even if S_1 remains closed for some time. Assuming that the circuit was quiescent before S_1 was closed, pin 1 of IC_{2a} is high, so that the output of the IC (signal C) goes low as a result of signal B.

The output signal of IC_{2a} triggers monostable IC_{1a} via AND gate D_2-D_3-R_3, whereupon the output of IC_{1a} (signal E) switches on transistor T_1. This transistor serves as the stop/start switch of the camcorder; its drain and source are connected to the camera.

At the same time that IC_{1a} generates the start pulse, IC_{1b} is triggered to commence measuring the time interval between the start and stop pulses. This interval can be preset with P_1. During the interval, signal H is kept low and this disables switch S_1. Once the mono time of IC_{1b} has elapsed, signal H goes high via IC_{2d}, so that IC_{1a} is triggered anew and sends a stop pulse to the camera. The circuit then returns to the quiescent state, until S_1 is closed afresh.

As drawn, the circuit is particularly suitable for adding titles to the filmed material. One touch of S_1 and the title in front of the camera lens is recorded within a few seconds.

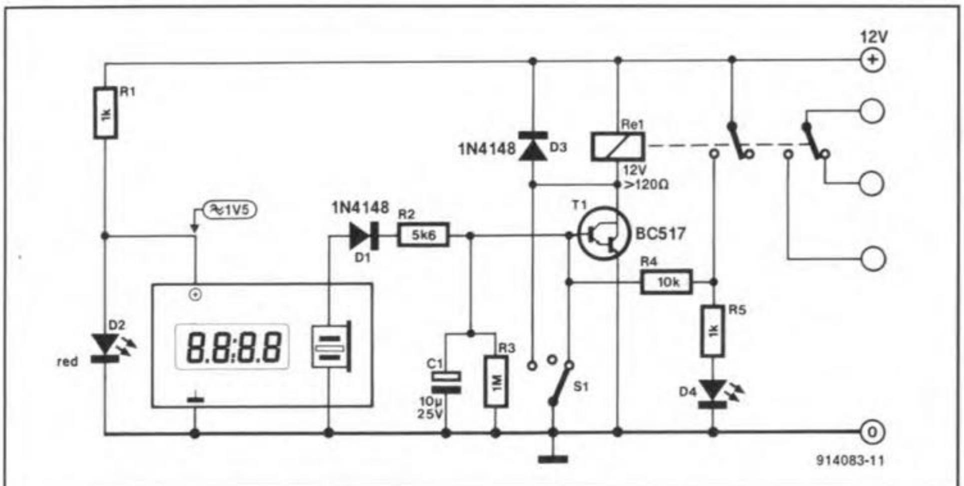
Switch S_1 may be replaced by an interval timer for making speeded-up recordings. ■

SWITCHING CLOCK FROM PARKING TIMER

by W. Zeiller

OVERCHARGING of batteries is prevented by the timely switching off of the charger. A timer that can be set to within a minute can be built fairly easily from an inexpensive parking timer and a simple switching circuit as shown in the diagram.

The button cell is removed from the timer and the connections remade as shown. Diode D_2 serves as on/off indicator and as voltage stabilizer for the timer. The voltage across the buzzer is used as the output signal. Check that the buzzer in the timer you are using is connected as suggested here.



When the buzzer comes into action, its output is rectified by D_2 and then used to charge C_1. When the capacitor is charged to a certain level, the potential across it is sufficient to switch on T_1, whereupon relay Re_1 is energized and its contacts change over. One of these holds T_1 in conduction; the other can be used to make or break contact. The load can also be switched manually with S_1.

The connecting wires between the timer and the rest of the circuit pass via a small hole drilled in the back of the timer and a hole in the case that houses the other components. When that is done, the timer is glued to the front of the case so that its operating controls remain within easy reach. ■

SCIENCE & TECHNOLOGY

A simple and adaptable logic

a simplest logic of all

by M. Soper, MA

A PROBLEM with standard logic as implemented in the 7400 series of integrated circuits is that, since the approach is functional, there is a natural tendency to organize any system into levels—a kind of nested hierarchical structure results. But suppose the requirement is more unilevel and free-wheeling—suppose true statements are chasing each other round in a loop in a system intended to have a use as associative memory in artificial intelligence applications, some expressed positively: 'all ships are intended for use in water' and some negatively: 'no normally conducting useful circuits are short circuits', then any hierarchical approach to analysing what can follow from statements like these will confound the flexibility of the system by deciding the functional pattern of logical analysis at the outset. The logic suggested in this article, being relational, not functional, gets round this.

Building the new system

The system used here is very simple

EVEN is true ODD is false

and the relation is, for three integers a,b,c:

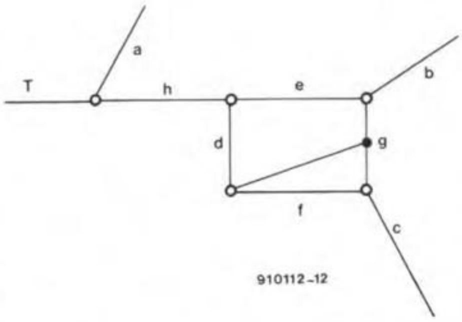
$a+b+c$ is odd abc is even.

Here, addition and multiplication are carried out as usual.

To show that this simplest logic is what is claimed, we must show that all logic can be done by this relation. Consider the notation $((a,b,c))$ used to indicate that numbers a,b,c obey this rule: $a+b+c$ is odd and abc is even. We must show that this relation is adequate for all logic and this can be done if the existence of the functions (relations) NOT and OR (first of all NOT) must be shown to exist:

- $((a,b,2))$ is equivalent to $a=$NOT b, since one of a,b is even and the other is odd. In fact, the relation is exactly two of a,b,c are even numbers.
- to show we can make OR: consider $((a,h,2))$, $((h,d,e))$, $((e,b,g))$, $((g,f,d))$, $((f,g,c))$—these entail that a OR $b=c$ is TRUE.

Here is a diagram of this logic circuit, where circles denote the relation:



The proof is thus:

Let a,b be odd: then h is even and, since b is odd, from $((e,b,g))$ we have e and g is even; then $((h,d,e))$ implies d is odd so that from $((f,g,d))$, f and g are even and, since f and g are even, from $((f,g,c))$, c is odd.

Let a be even and b odd, then as before, e and g are even, but in this case h is odd since a is NOTh. Since h is odd, from $((h,d,e))$, d and e are even now since d,g are even, f is odd so that $((f,g,c))$ implies c is even.

Let a be odd and b be even, then h is even: $((h,d,e))$, $((e,b,g))$ imply e is even and d,g odd; OR e is odd and d,g are even in either case because $((g,f,d))$, f is odd. Moreover f is odd and $((f,g,c))$ implies c is even.

Let a be even and b be even, then h is odd and from $((h,d,e))$, d and e are even; from $((e,b,g))$ and e,b even, we have g odd, then from $((f,g,c))$, c is even.

From all this we now have the table

a	b	c
odd	odd	odd
odd	even	even
even	odd	even
even	even	even

which is the correct pattern for the logic function OR with even meaning true, and odd, false.

Why should this logic be preferred?

There are two reasons for this logic to be preferred: the first is that no easy logic could be simpler, and the second is the fact that a relation is not hierarchical and can thus operate on converging data streams to create new true and false statements without any hierarchical structure being necessary. One can imagine triples of related strings, each one of which represents a 'proposition', moving through a data network like 'trains with three carriages' and interacting with other trains at junctions to produce more trains of statements on the data lines. Each junction can become a source of proliferation and segments on the 'lines', when triples of propositions are formed in this way, can 'float about' on the communication lines of a distributed processing system preceded by a special symbol or token (like three carriage trains running freely through a number of junctions). Thus, for an artificial intelligence system, each triple can be compared at each junction according to interference rules like these:

$((A,D,E))$, $((A,B,C))$, $((B,C,D))$ implies $((B,C,\overline{E}))$ and E false;

$((A,D,T))$, $((B,D,X))$, NOT$((A,D,B))$ implies $((A,\overline{B},T))$;

$((B,C,E))$, $((A,B,C))$, $((C,D,E))$, $((A,D,F))$ implies $((B,E,F))$;

$((A,B,C))$, $((C,D,E))$, $((A,D,F))$, NOT$((B,C,E))$ implies $((\overline{B},E,\overline{F}))$

$((A,B,C))$, $((B,C,D))$, $((B,C,E))$ implies NOT$((A,D,E))$

Liberation from standard binary functional logic

The most useful rules for generating a few of the many possible relations are:

$((A,D,T))$, $((B,D,X))$ iff A v B is true, where X has any possible value, and

$((A,B,C))$, $((B,C,D))$ iff $A=D$.

Note that $((A,B,T))$ iff $A=\overline{B}$, and

$((A,B,X))$ implies A or B true.

These relations, therefore, can generate all standard logic. But we need, perhaps, to generate from any propositions ones that are true and false. Here is one such method:

$((A,B,C)), ((B,C,D)), ((A,D,E))$ implies E is false, and

$((A,B,C)), ((B,C,D)), ((A,D,E)), ((U,V,E))$ implies U,V true.

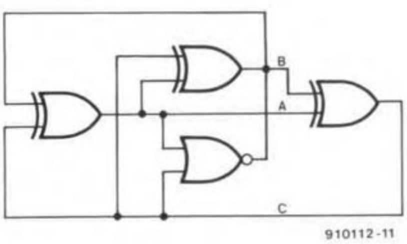
Thus, the hierarchical structure caused by functional approaches is not necessary.

Continuity with the old system

Stripped down to bare essentials, the new system of logic expressed as a table looks like this

a	*b*	*c*
F	F	*
F	T	T
T	F	T
T	T	F

which is the function table for exclusive OR (XOR) with one line deleted. This can be implemented by the following logic circuit:



This is cumbersome, but it shows that the simplest logic we are dealing with here can actually be built. In practical terms, the reason for using relational logic, and for perhaps building such units as available ICs, is the fact that one relational logic circuit can easily perform more than one task, because lines are not specifically inputs and outputs.

All lines can be connected as outputs—impossible or paradoxical networks simply result in unstable or partially competing output circuits, so that the units built for this purpose should be output protected. In practice, lines to have a use as inputs should be fed by high impedance buffers (non-inverting) or, more simply, fed by some impedance. Thus, all logic functions, and naturally also oscillators (three-phase) and other derived circuits, can be implemented with the use of buffers and our symmetric logic element. Hence, continuity with the old system is established.

Some higher versions of the logic

There are infinitely many relational logics, of which ours is the simplest. The next interesting logic is a six-logic, where the consecutive lines coming out have this cyclic pattern of true and false values: (TTFTFF), and a 10-logic, where the consecutive lines are (TTTFFFTFTF) in a cyclic pattern. In the six-logic, for readers with the patience to work this out, $(CDABMN)(MNFCGH)$ is equivalent to $C=A$ NAND B and in the 10-logic, the pattern $(T.A.B..C..)$ forms $C=A$ NOR B. These ten lines form a kind of device (or insect) with ten radially disposed legs. They are based on what is know as the *Theory of Quadratic Residues.*

Transformation model of the relation

For some purposes, a transformational model is preferable. When this is the case, the following model can be used—thus

$$\begin{bmatrix} 1 & 1 \\ 1 & 0 \end{bmatrix}\begin{bmatrix} c \\ a \end{bmatrix}=\begin{bmatrix} b \\ c \end{bmatrix}$$

$$\begin{bmatrix} 1 & 1 \\ 1 & 0 \end{bmatrix}\begin{bmatrix} b \\ c \end{bmatrix}=\begin{bmatrix} a \\ b \end{bmatrix}$$

$$\begin{bmatrix} 1 & 1 \\ 1 & 0 \end{bmatrix}\begin{bmatrix} a \\ b \end{bmatrix}=\begin{bmatrix} c \\ a \end{bmatrix}$$

where all the numbers are modulo 2—that is, throwing out 2s and taking only the remainders, 0 or 1.

Note the fact that a,b,c here are not allowed all to be zero; we could remove this condition by adding one more row and column to the three matrices, but instead we merely note $abc <> 0$. One interesting fact is that this matrix can be square-rooted; the square root is

$$\begin{bmatrix} 0 & 1 \\ 1 & 1 \end{bmatrix}$$

The original matrix could generate the Fibonacci series from $(1,1)^T$ and so can this one, but inverted. This square-root property suggests that our Δ of transformations can be turned into a Y of transformations and, indeed, this is possible—let all transformations operate from the same vector at the middle $(a,b,c)^T$. The three matrices need three rows and three columns since they are distinct in the three directions. These

$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix}\begin{bmatrix} 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix}\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

can do this, each operating in turn.

Buffer stages

The logic outlined above does require in the practical implementation the use of buffer stages, but these are used anyway. From the point of view of logic rather than electronics, these are not easily modelled in a system without time. They can be called compellers and merely *insist* that output equals input. Logically (without a sense of evolution), these are simple equalities.

Is there any reason for relational logic to dominate? The systems, being equivalent, can coexist, but note that relational logic is very highly suited to the continuous ordering and relation of isolated facts, whereas a more functional approach cannot do this naturally.

For example, the system associating propositions with numbers can link each proposition with a multiple of three, and add 0 or 1, depending on truth or falseness; adding 2 could be used, when the truth of a statement has not yet been decided, if required.

Adaptation

The strange feature of this logic system is that a 'cubic' network is used. For example: define $[xyz]$ by $((x,s,t)), ((y,t,u)), ((z,s,u)), ((t,s,u))$ for some s,t,u; then this network: $((a,c,n)), ((a,c,1)), ((b,q,n)), ((n,c,p)), [qdp]$ performs $d=a$ iff b when a,b are inputs and in this case c is NOT a. Using c,d, as inputs results in b iff c XOR d.

This is a strange feature to adapt to—instead of rank upon rank of ordered functional logic, we have what appears as a graph with two sorts of vertice or node and a rank of buffers (one way round or another). This utilization of flexibility of options is difficult for people, but very easy for computers, which can quickly print out all available uses of a net, whethere they can be used immediately or not.

Here, then, is a logic based merely on arithmetic. ■

ECONOMY POWER SUPPLY

One instrument no electronics hobbyist can do without is a regulated power supply. This month we present a no-frills design that should be affordable for many.

by L. Lemon

FRONT COVER PROJECT

UNDOUBTEDLY the most popular class of regulated, variable power supplies is that with a voltage rage of up to 30 V or so, and an output current of 2 to 3 ampères. The present supply belongs in this ever popular class. The fact that we have baptized it 'economy power supply' does not mean that it is a very basic design with marginal specifications. Most of you will know that the greater part of the money spent on a regulated power supply is invested in the power transformer and the smoothing capacitors — little to be done about that! However, while this cost consideration holds true for the present supply, it was our aim to achieve the best possible specifications from inexpensive components.

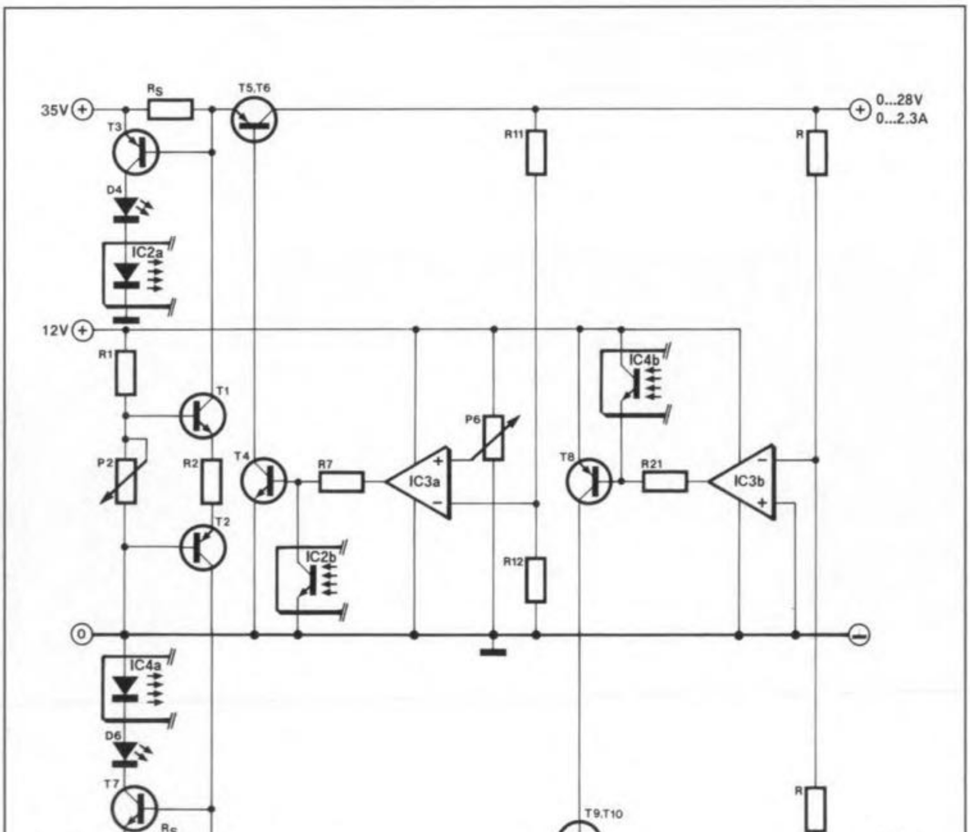


Fig. 1. Block schematic diagram of the power supply. Conventional? Well, not quite...

Basic operation

The operation of the power supply is illustrated in Fig. 1. What is shown is a classic series-regulated power supply. The heart of the circuit is formed by a positive voltage regulator based on IC3a, T4, T5 and T6. This is a classic voltage regulator. The negative input of the opamp is supplied with a sample of the output voltage via a voltage divider. The opamp compares the voltage at the negative input with that at the positive input, which is held at a voltage adjustable with P6. The opamp acts as an error amplifier, that is, it will attempt to counter voltage differences between its inputs by driving the power transistors via T4. In this way, it ensures a stable output voltage at all load currents below the maximum.

The base-emitter junction of T4 is shunted by the phototransistor of an optocoupler. As soon as the current limit is actuated, the phototransistor starts to conduct, withdrawing so much base current from T4 as is necessary to keep T5 and T6 from supplying the maximum permissible output current.

The current limit circuit measures the output current with the aid of resistors R_s inserted in the two supply rails. In the positive half of the supply, T3 monitors the voltage across R_s in the positive rail. When this voltage is high enough for T3 to conduct, the 'current limit' LED, D4, lights, just as the LED in the optocoupler. The latter causes the associated phototransistor to conduct, and the output current to be limited.

The actuation level of the current limit is made adjustable by a current source based on T1 and T2. Transistor T1 supplies a current set by potentiometer P2 to the current limit circuit in the positive half of the supply. T2 supplies the same current to the negative half. This provides the current monitoring

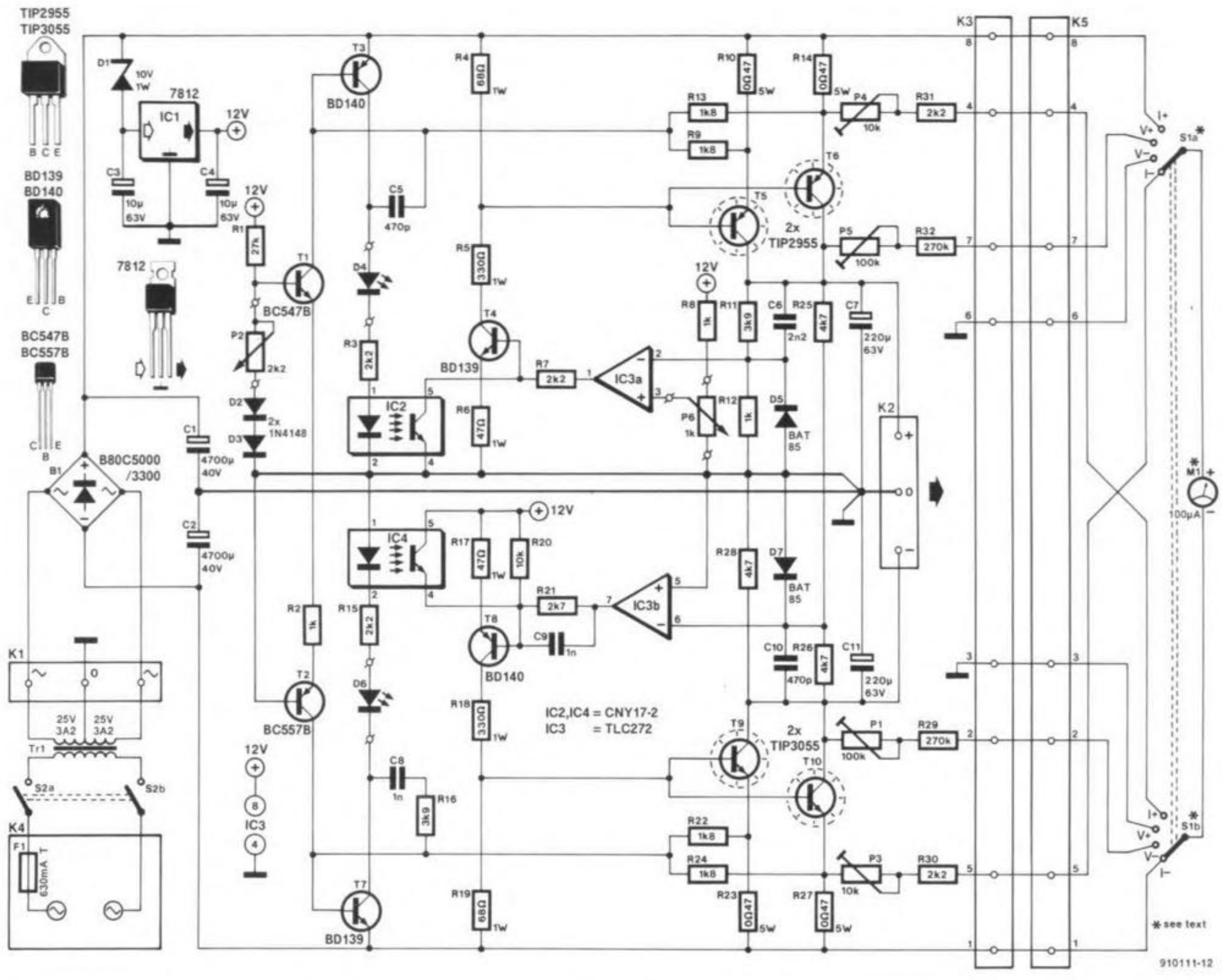


Fig. 2. Circuit diagram of the economy power supply, a conventional symmetrical design based on series regulators and error amplifiers.

transistors, T3 and T4, with a bias, which gives the current limit circuit a greater sensitivity, that is, it can be actuated by relatively small currents.

The operation of the current limit circuit in the negative supply is identical to that in the positive supply. Potentiometer P1 acts as a common control for both current limiters. Transistor T7 monitors the negative output current, and controls the voltage regulator accordingly via an optocoupler. The voltage regulator is basically the same as in the positive supply. Note, however, that the driver transistor, T8, and the optocoupler are connected to +12 V instead of to ground. This is necessary because the negative voltage regulator is powered by a positive supply voltage. This unusual arrangement obviates positive and negative auxiliary supply voltages, but does raise the problem of regulating the output voltage between 0 V and about −28 V with the aid of an opamp that works with input voltages between 0 V and +12 V. At the output of the opamp, this is solved by operating the driver with respect to +12 V. The opamp input voltages are held

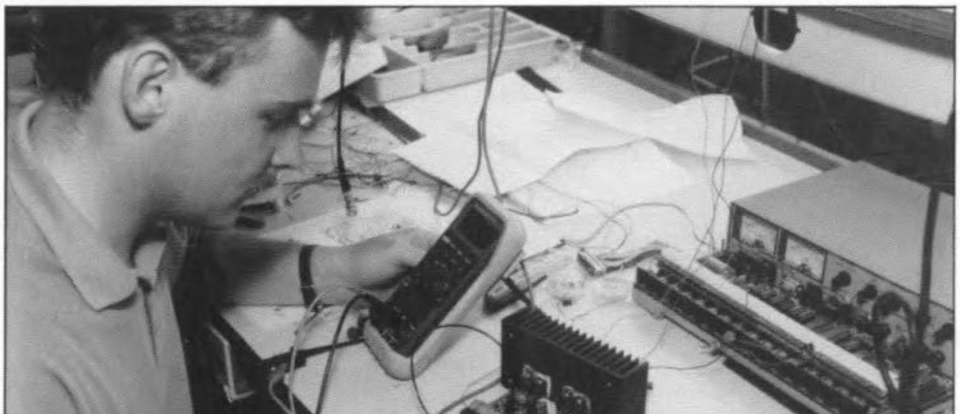


Fig. 3. Initial test on the assembled board.

at virtually nought volts. The positive input (the reference of the regulator) is simply tied to ground. This means that the regulator must keep the negative input at 0 V via the feedback of the negative output voltage. Since the feedback is realized with two identical resistors *R* connected between the positive and the negative output, the regulator will adjust itself such that the positive and negative output voltages are equal, and adjustable with a single control, P6.

Circuit description

The circuit diagram of the power supply, Fig. 2, is a not more than a 'dressed up' version of the block diagram discussed above.

The mains voltage is connected to the supply via a mains entrance socket, K4 (note that this has an integral fuseholder), and from there goes to the on/off switch, S2, and the primary of the mains transformer, Tr1. The secondary voltages (2×25 V) are rectified by a bridge rectifier, B1, and smoothed by reservoir capacitors C1 and C2. This results in an unregulated voltage of about ±35 V.

The unregulated voltage is reduced by about 10 V by zener diode D1. This is done to keep the input voltage of regulator IC1 (a 7812) within safe limits. The regulator output voltage, 12 V, is used to power the auxiliary supply.

In the current limit circuit, P2 has two diodes connected in series. This is done to prevent a 'dead range' on P2, when the threshold voltage of the base-emitter junction of T1 and T2 has to be overcome.

The power stages of the supply consist of two parallel connected transistors, T5-T6 and T9-T10. Strictly speaking, one transistor would have sufficed in each power stage, since the second breakdown point is just not reached when the dissipation is maximum (maximum output current at minimum output voltage). However, the additional transistor affords peace of mind both in regard of safe maximum ratings and the ability of the heatsink to maintain a reasonably low temperature.

The emitter resistors with the power transistors have two tasks: first, they distribute the current between the transistors; and second, they function as current sensors R_s (refer back to Fig. 1). Since the current limiting circuit is to monitor the total current through both power transistors, the emitters are connected to the base of T3 and T7 respectively via summing resistors.

Diodes D5 and D7 do not appear in the block diagram. Their function is to protect the negative opamp inputs against negative voltages that could cause destruction, or switching to undefined states. The diodes limit the negative input voltage to about 0.6 V, a value that is safely withstood by almost any modern IC. Normally, the opamp inputs will not go negative. This may happen briefly, however, when the supply is switched on, or when it acts on sudden, large, load variations. In these cases, the difference between the output voltage can give rise to a negative voltage at the negative input of the opamps. Diodes D5 and D7 clamp these negative voltages to safe levels.

To keep the cost of the instrument low, a single meter is used for the voltage and current read-out. The meter ranges are created by switch S1, whose contacts are connected to several points in the circuit. Your budget allowing you are, of course, free to fit as many meters as you like, with a choice between analogue and digital.

COMPONENTS LIST

Resistors:

1	27kΩ	R1
3	1kΩ	R2;R8;R12
3	4kΩ7	R25;R26;R28
2	68Ω 1W	R4;R19
2	330Ω 1W	R5;R18
2	47Ω 1W	R6;R17
5	2kΩ2	R3;R7;R15;R30; R31
4	1kΩ8	R9;R13;R22;R24
4	0.47Ω 5W	R10;R14;R23;R27
2	3kΩ9	R11;R16
1	10kΩ	R20
1	2kΩ7	R21
2	270kΩ	R29;R32
2	100kΩ preset H	P1;P5
2	10kΩ preset H	P3;P4
1	1kΩ lin. potentiometer	P6

Capacitors:

2	4700µF 40V	C1;C2
2	10µF 63V radial	C3;C4
2	470pF	C5;C10
1	2nF2	C6
2	220µF 63V radial	C7;C11
2	1nF	C8;C9

Semiconductors:

1	10V 1W zener diode	D1
2	1N4148	D2;D3
2	LED 3mm red	D4;D6
2	BAT85	D5;D7
1	B80C5000/3300 (80V piv, 5A peak bridge rectifier)	B1
1	BC547B	T1
1	BC557B	T2
2	BD140	T3;T8
2	BD139	T4;T7
2	TIP2955	T5;T6
2	TIP3055	T9;T10
1	7812	IC1
2	CNY17-2	IC2;IC4
1	TLC272	IC3

Miscellaneous:

2	3-way PCB-mount terminal block; pitch 5mm	K1;K2
1	10-way male box header	K3
1	Mains appliance socket with integral fuseholder; fuse: 1.25A slow (240/220 V mains) or 1.25 A slow (110/117 V mains)	K4;F1
1	10-way female IDC header plus flatcable	K5
1	2-pole, 4-contact rotary switch	S1
1	2-pole mains on/off switch with indicator lamp	S2
1	100-µA moving-coil meter or digital meter module	M1,
1	Printed-circuit board	910111
1	Front-panel foil	910111-F
1	Toroidal mains transformer 2×25V @ 3.2A , e.g., 510116 (220V) or 530116 (240V) from ILP (Jaytee Electronic Services)	Tr1
1	Heat sink 0.6K/W, e.g., Fischer SK90; h=100mm	
4	insulating set for T5, T6, T9 and T10	
1	Metal case 100×300×180mm (Telet LC970; supplier: C-I Electronics)	

Fig. 4. Preparing the enclosure and the front panel before the PCB is fitted.

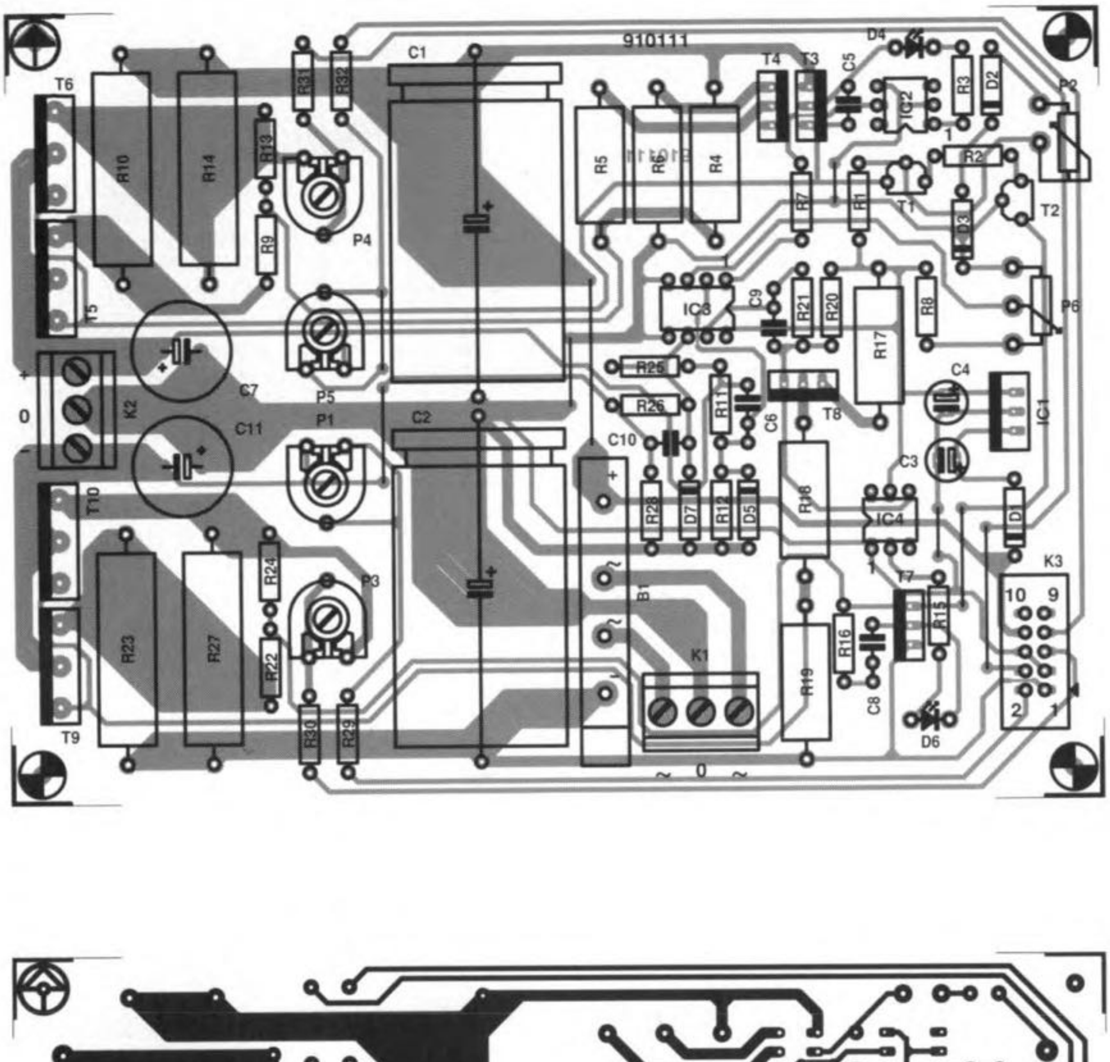


Fig. 5. Single-sided printed circuit board for the economy power supply.

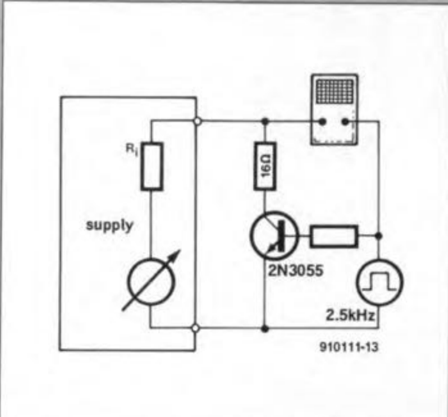
TESTING A POWER SUPPLY — *THE DYNAMIC WAY* —

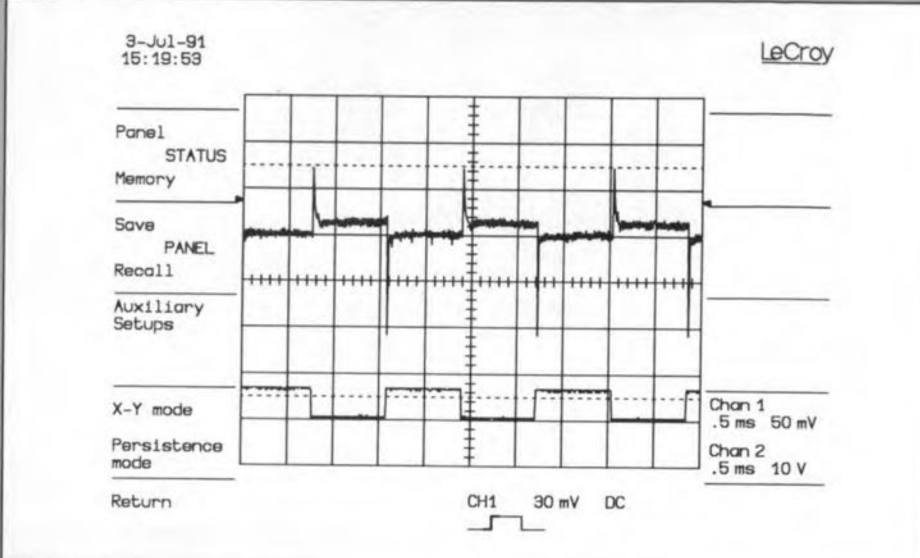
The most important feature of a regulated power supply is its ability to keep the output voltage constant in spite of load variations. Unfortunately, this can never be done perfectly. The main stumbling blocks we encounter in practice are the internal resistance of the supply, and the speed of the voltage regulator. To establish the effect of these parameters, the supply may be subjected to the fairly gruesome test described here.

A 16-Ω load is switched on an off by a rectangular control signal via a power transistor. The power supply is set to an output voltage of 16 V, so that the output current is switched between 0 A and 1 A. The test set-up is shown in the circuit diagram. The oscilloscope plot shows the response of the supply to these sudden, heavy, load variations. Because a rectangular control signal is used, we can find a point where the voltage regulator loses track of the load variations.

When the load is switched on, the voltage will first drop considerably, and not rise to the previously set level until the voltage regulator provides the necessary drive to the power transistors. Similarly, when the load is switched off, the voltage regulator maintains the drive for the transistors a little too long, so that the output voltage rises considerably. The length of the voltage peaks (approx. 100 µs), enables us to deduce that the regulator functions properly up to about 10 kHz (above 10 kHz, the response may be improved by adding buffer capacitors).

Apart from the peaks, the scope plot also shows a small variation of the output voltage when the load is stable. This change is caused by the internal resistance of the power supply. Here, the variation is about 15 mV. Since this voltage drop is caused by a current of 1 A, the internal resistance of the supply is 15 mΩ.





Construction and adjustment

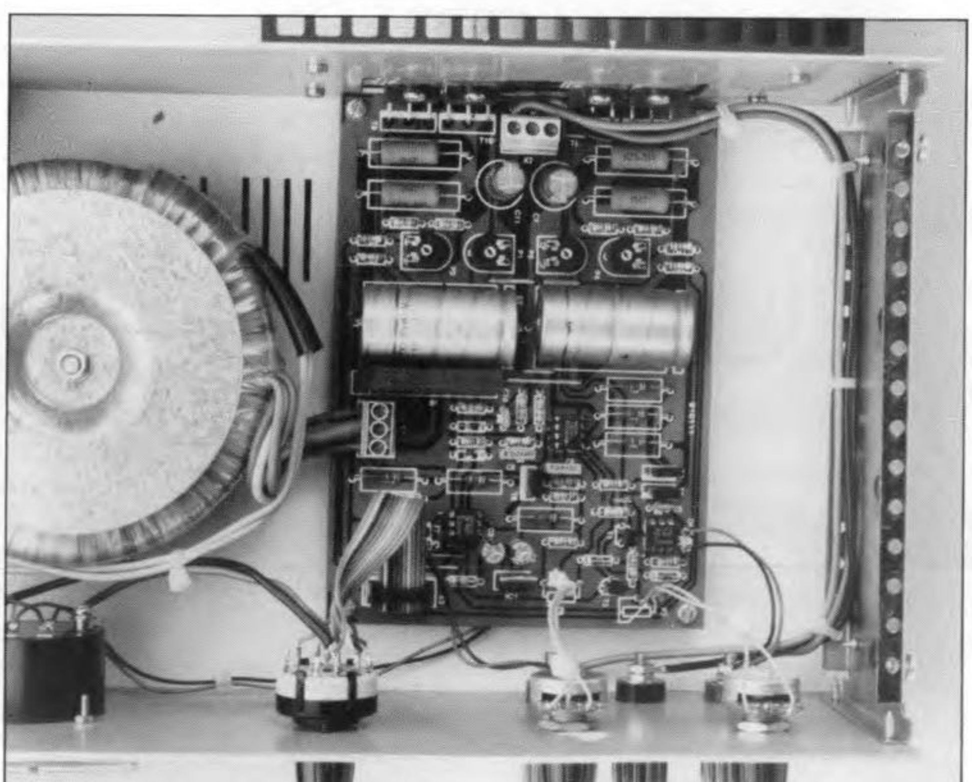


Fig. 6. Internal view of the economy power supply.

The construction is best carried out on the single-sided printed-circuit board shown in Fig. 5. There is no fixed order in which the components are mounted on to the board, as long as you start with the eight wire links. Keep the power transistors, T5-T6, and T9-T10, and connector K2 to the last.

The case and the heatsink must be drilled before the power transistors are soldered to the board. When it is time to solder, have all mounting hardware, i.e., mounting pillars, bolts, nuts, washers and the like handy to enable the transistor terminals to be given the required Z-shape and inserted into the PCB holes. At this stage it is also possible to determine the best way of mounting the terminal block connector, K2, which is fairly close to the edge of the PCB and, therefore, to the heat sink. In some cases, you may want to fit K2 such that the connecting wires can be inserted from the side of C7/C11. On the component mounting plan there seems to be little space to do this, but in most cases capacitors C7 and C11 will be smaller than drawn.

The wiring between the mains entrance socket, mains switch S2 and the primary of the transformer must be installed in accordance with safety regulations.

The wiring between connector K3 and

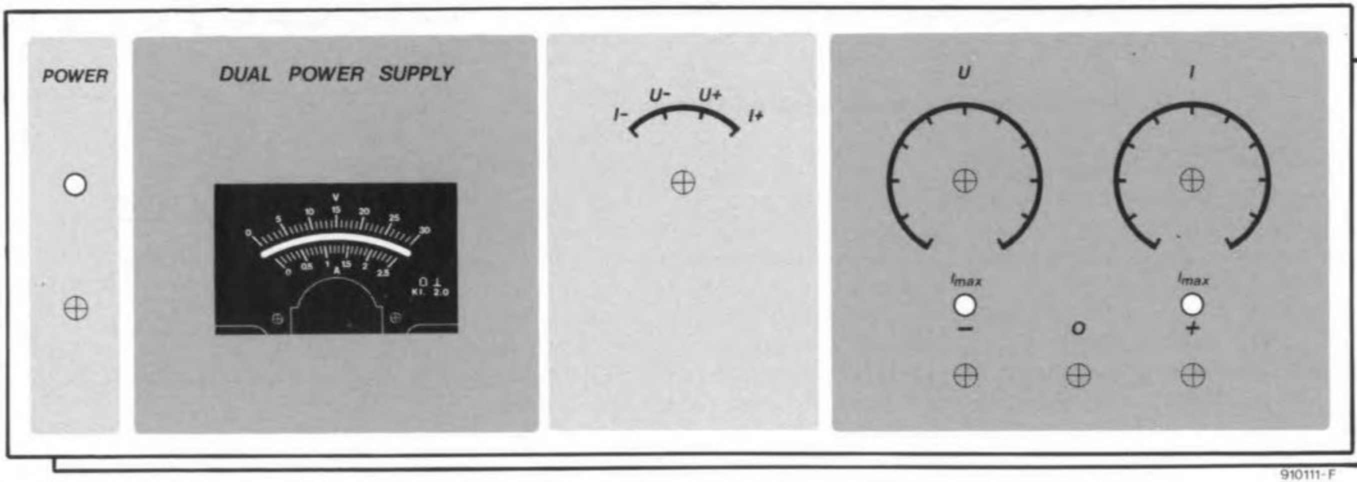


Fig. 7. Front panel layout.

switch S1 consists of connector K5 and a length of flatcable. The connector pinning is such that the flatcable wires can be connected to the switch contacts in the right order. If a digital meter is used, a 3-pole type must be used for S1. The third switch section is then used to switch the decimal point and the 'V' and 'A' indications on the display. In addition, you will require a shunt resistor at the input of the digital meter. When a meter is used with a sensitivity of 200 mV, this shunt resistor takes a value of 270 Ω. Also note that the power supply of the digital meter unit must float with respect to the supply. In most cases, this means that a battery or a separate supply is required.

The power supply proper has no adjustment points; only the meter needs to be calibrated against an accurate multimeter. Set the supply to the maximum output voltage and maximum output current. Connect the multimeter as a voltmeter to the outputs. Take the multimeter reading, and adjust P1 and P3 to give corresponding meter indications for the positive and the negative output voltage respectively. Next, short-circuit the positive output with the multimeter set to the current range. Adjust P4 until the indication of the meter on the supply equals that of the multimeter. Do the same for the negative output and preset P5.

Finally, note that the space reserved for the meter on the front panel foil (Fig. 7) allows analogue as well as digital meters to be fitted. The analogue meter scale printed on the foil may be cut out and stuck over the existing meter scale. ■

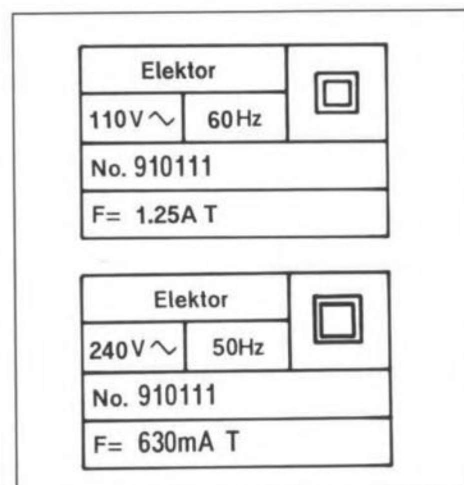


Fig. 8. Suggested rear panel labels for the power supply.

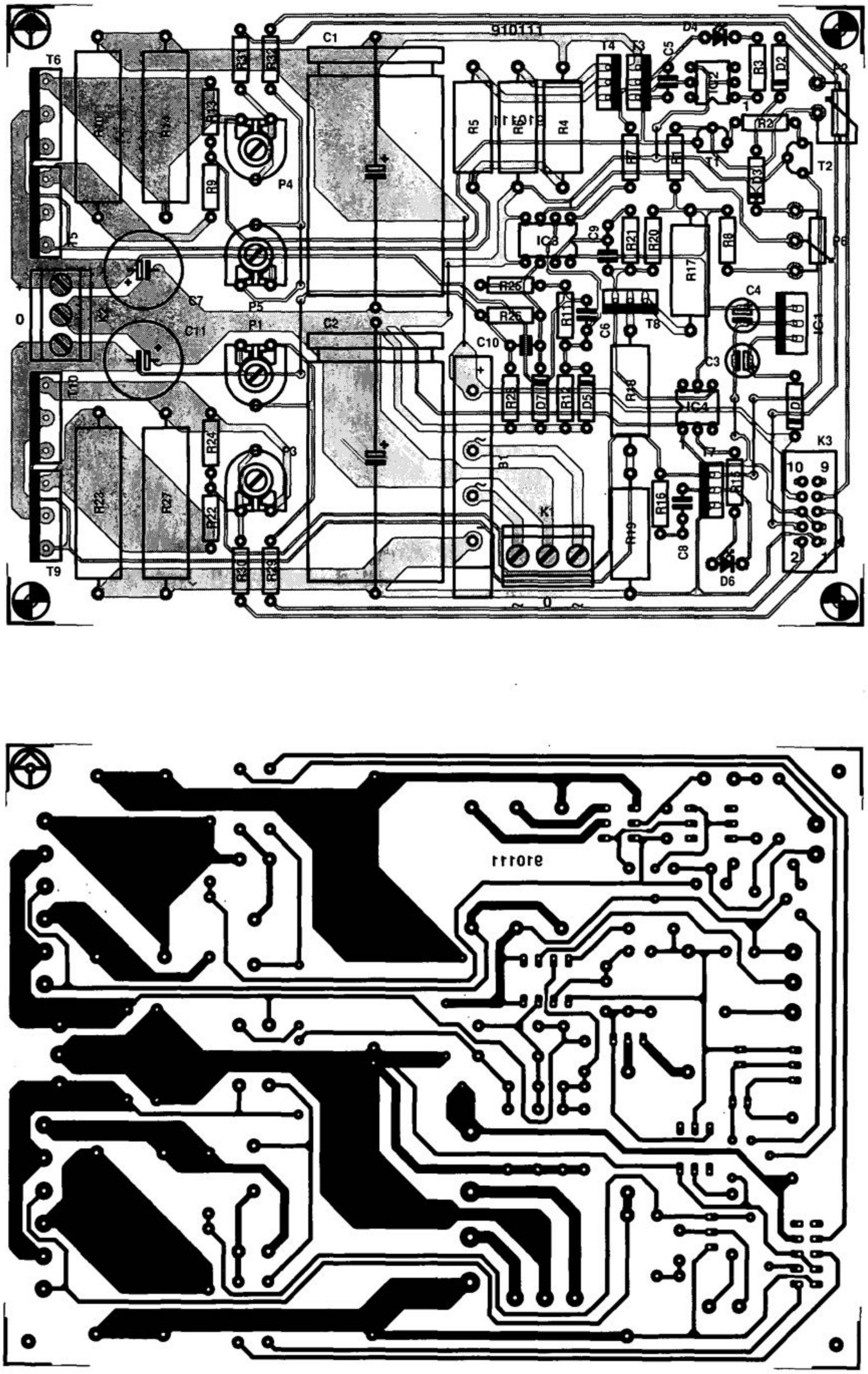
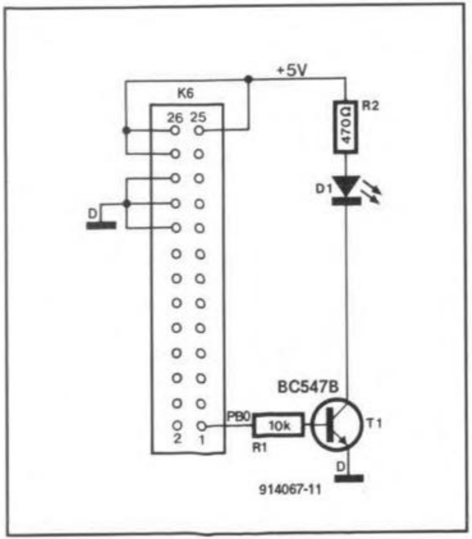


Fig. 5. Single-sided printed circuit board for the economy power supply.

LED INDICATOR FOR TEMPERATURE LOGGER



by J. Ruffell

THE measurement card for the indoor/outdoor thermometer* may be provided with the additional LED indicator shown in the diagram to check the operation of the software.

Every fifteen seconds, a pulse is placed via the background program TLOGGER on to line PBO, which is taken outside via connector K_6. The level on this line is, of course, not switched irrespective, but only at the instant that TLOGGER checks whether a temperature measurement is being carried out. If that is so, the level on the line remains high for about 1 s (depending on the speed of the computer). When no measurement is being carried out, this time is appreciably shorter: of the order of 80 ms. The line is also used by the software to signal an error condition outwards. If, for instance, TTRANS.CFG or TLOGGER.CFG is not found, or the path is not correct, or the disc is full, pulses at a frequency of 10 Hz are placed on it.

The diagram shows how the LED is connected to K_6 via a short length of flatcable. Power is supplied by the computer. ■

* *Elektor Electronics*, March 1991

AMPLIFICATION/ATTENUATION SELECTOR

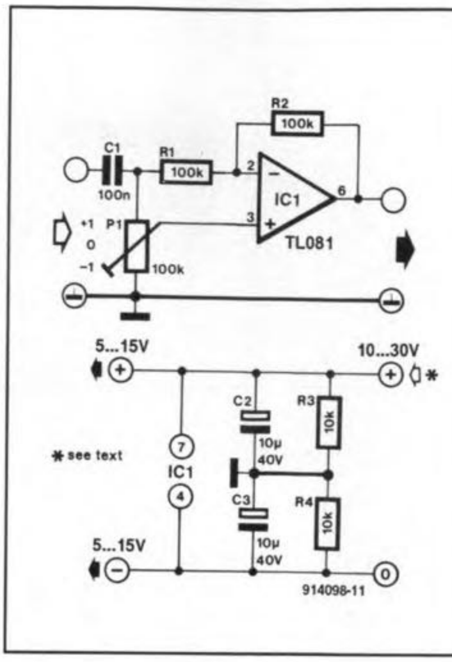
A National Semiconductor application

A TYPE TL081 opamp and some passive components are sufficient to construct a small amplifier whose amplification can be varied between +1 and –1 with a potentiometer—see the diagram.

The input signal is applied to both inputs of the opamp: to the inverting input via C_1 and R_1, and to the non-inverting input via C_1 and P_1. The amplification of the amplifier is R_2:R_1=1. However, the level of the signal at the +input is determined by the position of the wiper of P_1. When the wiper is at the centre of its travel, the two input signals cancel each other, so that there is no output. When the wiper is at the 'high' end of the potentiometer, the signal at the +input is larger than that at the inverting input and this is then available, amplified by 1, at the output. When the wiper is at earth potential, the opamp functions as a normal inverting amplifier with unity gain.

The input impedance of the circuit is about 50 kΩ. With a value of C_1 as shown, the amplifier can handle frequencies from 30 Hz upwards.

The circuit requires a power supply of ±5–15 V and draws a current of only a few mA. If such a supply is not available, it may be produced from a single 10–30 V supply as shown in the diagram. ■



SLAVE MAINS ON-OFF CONTROL

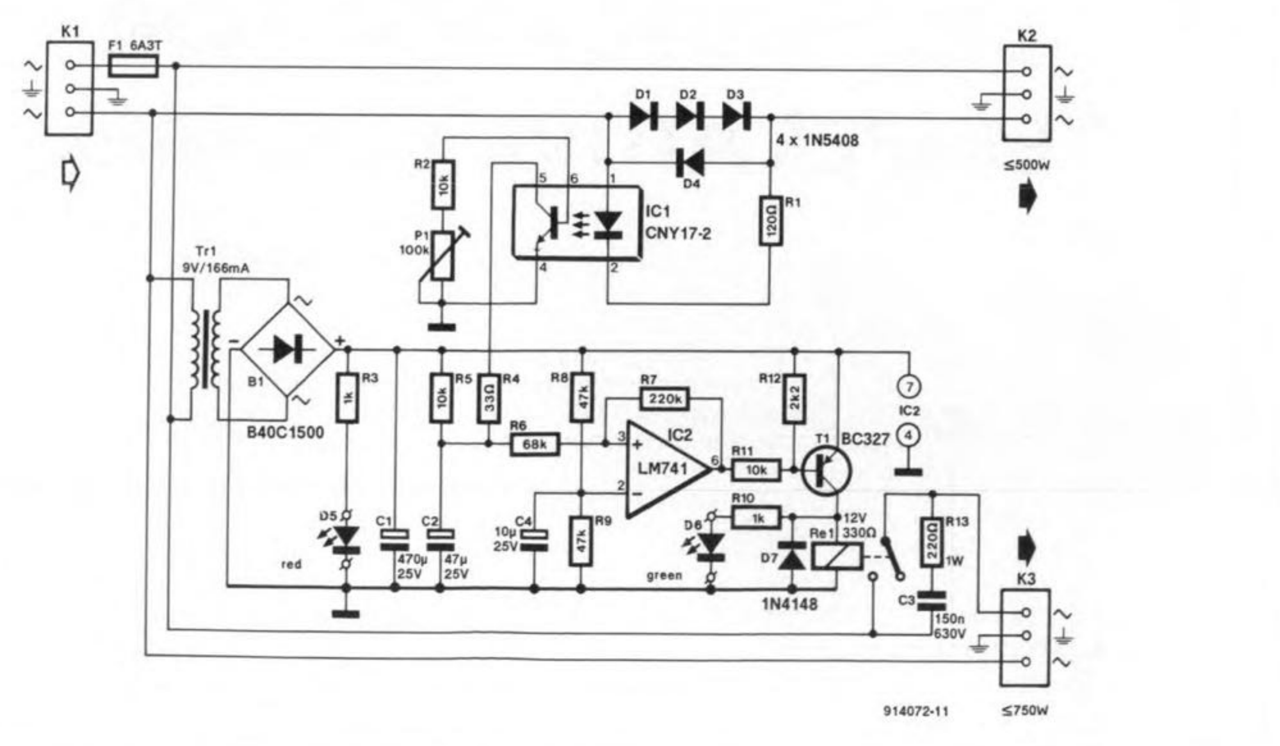
by J. Ruffell

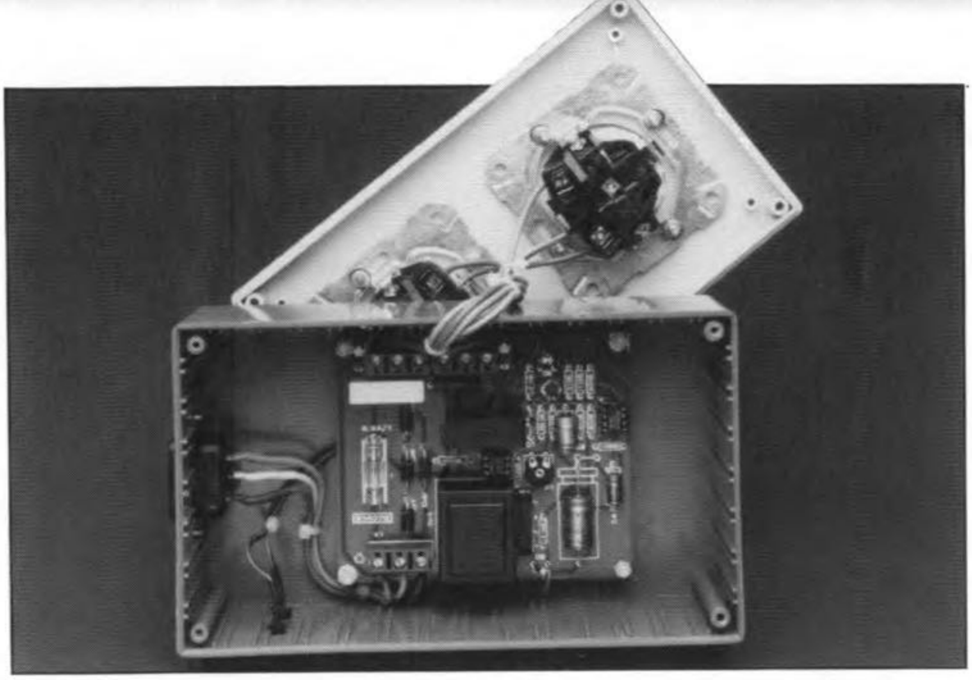
THIS is an improved version of the slave mains on-off control published in the July 1990 issue of *Elektor Electronics*. The circuit has been substantially changed and offers much better control of inductive loads.

The control switches mains-powered equipment on and off simultaneously with a master unit. One particularly useful application of the control is in audio racks where the signal sources (cassette deck, CD player, tape recorder, tuner, etc.) are switched on and off together with the power amplifier.

The circuit monitors the current consumption of the master unit (connected to K_2) with the aid of an optocoupler, IC_1. When P_1 is set to maximum sensitivity (corresponding to the highest resistance value), a few milliamperes are sufficient for the control to switch on the

1





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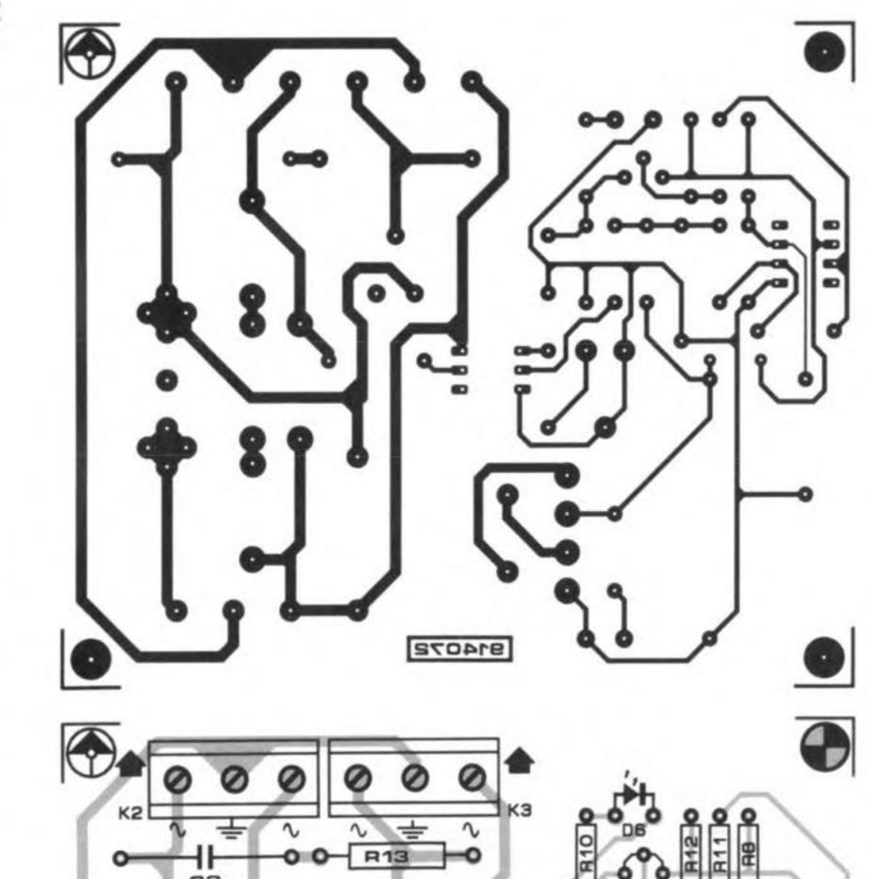


slave(s), which are connected to K_3. The maximum sensitivity will rarely be used, however, since allowance should be made for leakage and quiescent currents of the master unit.

When the current consumption of the master unit exceeds the preset trigger level, the transistor in IC_1 starts to conduct, causing the output of opamp IC_2 to go low. Consequently, transistor T_1 conducts and actuates the load (the 'slave') via relay Re_1.

After the master unit has been switched off, C_2 is charged via R_5. At a certain voltage on C_2, the comparator toggles and switches off the slave via T_1 and Re_1. This happens after 500 ms or so.

The state of the control is indicated by two LEDs, one, D_5, as an on/off indicator for the control proper, and another, D_6, for the on-off state of the slave. The maximum loads at the master and slave outputs are 500 W and 750 W respectively.

The control is best constructed on the printed circuit board shown in Fig. 2. The mains connections to the board are made with three 3-way PCB terminal blocks. For safety reasons the earth track on the board should be strengthened by a piece of copper wire of 2.5 mm² cross-sectional area or larger.

WARNING. Since the circuit carries dangerous voltages at a number of points, it is essential that proper electrical insulation is applied. Never work on the circuit when the mains is connected to it. Make sure that no part of the circuit can be touched when it is being adjusted or used. ■

PARTS LIST

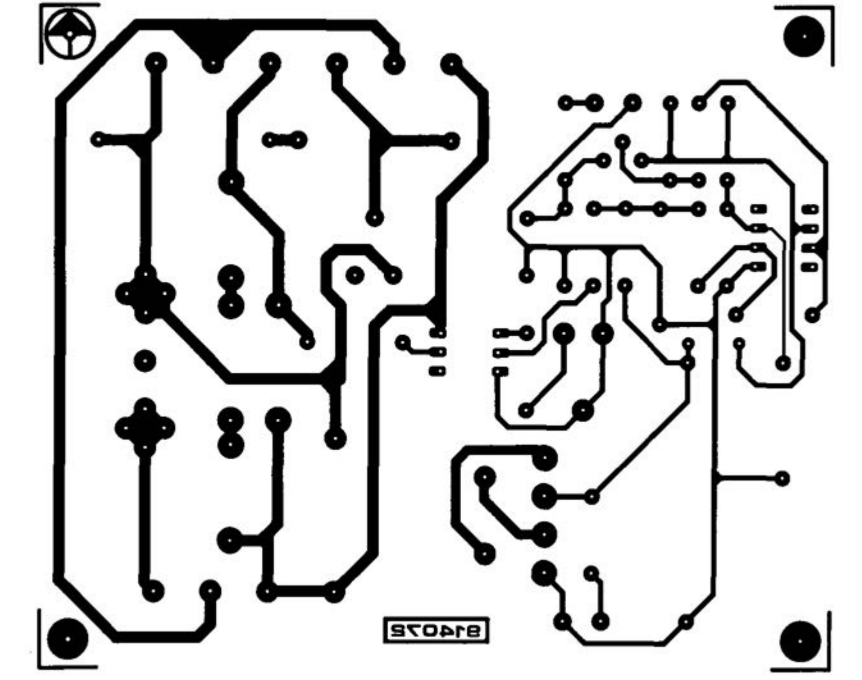
Resistors:
R1 = 120 Ω
R2, R5, R11 = 10 kΩ
R3, R10 = 1 kΩ
R4 = 33 Ω
R6 = 68 kΩ
R7 = 270 kΩ
R8, R9 = 47 kΩ
R12 = 2.2 kΩ
R13 = 220 Ω, 1 W

Capacitors:
C1 = 470 µF, 25 V
C2 = 47 µF, 25 V
C3 = 150 nF, 630 V
C4 = 10 µF, 25 V

Semiconductors:
D1–D4 = 1N5408
D5 = LED, red
D6 = LED, green
D7 = 1N4148
B1 = B40C1500
T1 = BC327
IC1 = CNY17-2
IC2 = LM741

Miscellaneous:
K1–K3 = 3-way PCB block, pitch 7.5 mm
F1 = 6.3 A fuse with holder
Tr1 = mains transformer 9 V, 160 mA sec.
Re1 = SPST relay, 12 V, 330 Ω, e.g. Siemens V23127-B2-A201
ABS enclosure 190×110×74 mm, e.g. Retex RG4

2



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R8, R9 = 47 kΩ
R12 = 2.2 kΩ
R13 = 220 Ω, 1 W

DIGITAL (TAPE) COUNTER

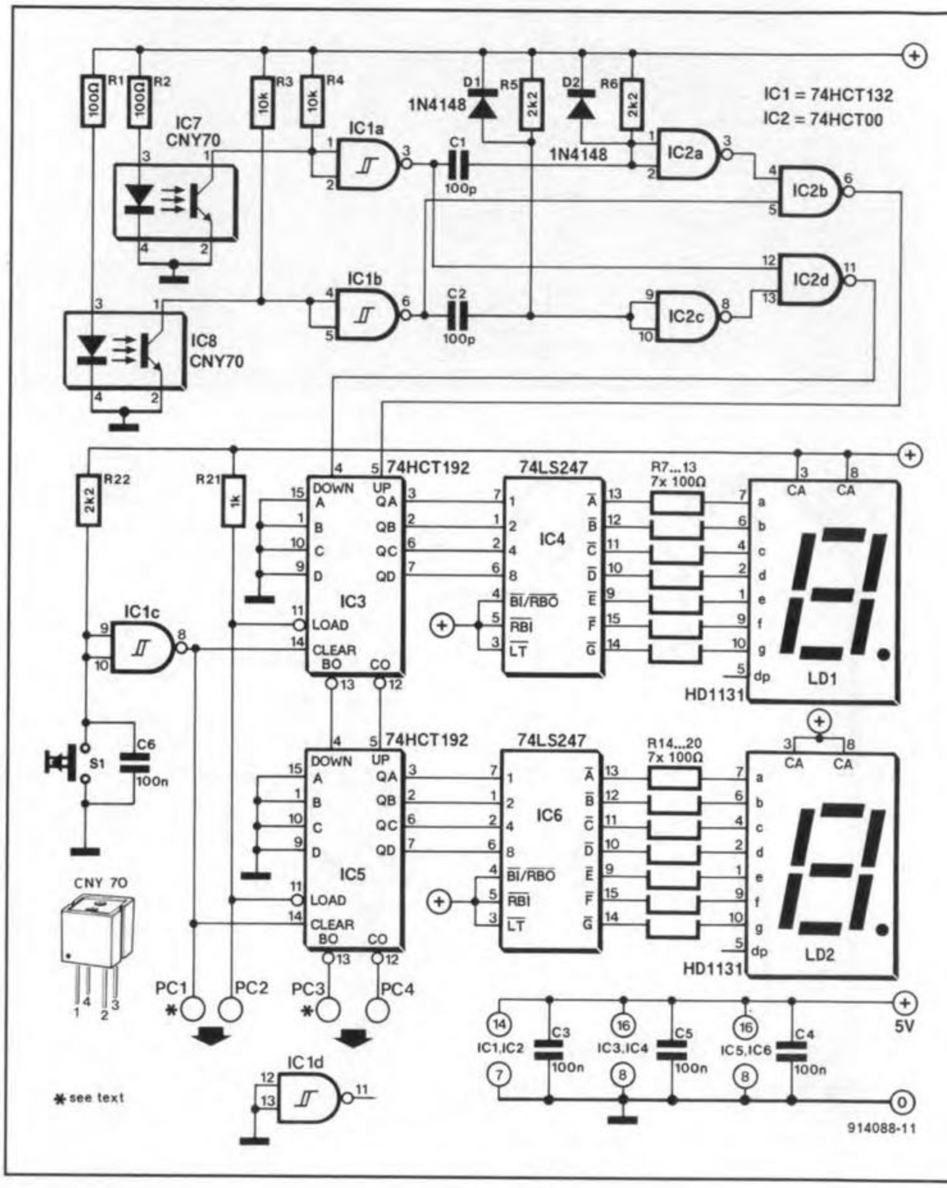
a Texas Instruments application

SINCE there are still tape recorders about that have no mechanical tape counter, the circuit shown here offers an excellent, electronic add-on for these. It can, of course, also be used to replace a mechanical counter. Furthermore, it can be used for other applications, for instance, as hoist-height indicator for a model building crane, or for indicating the position of a chisel on a lathe.

The input of the circuit is formed by two optoisolators. The sequence of the pulse signals provided by these isolators depends on the direction into which a coding disc turns. The NAND gates following the isolators produce from those signals an up pulse or a down pulse, which enables up/down counter IC_3 to register the position irrespective of the direction of rotation. That position is made visible via a decoder on a seven-segment display. The number of digits the counter provides can be extended by adding more counter/decoder/display stages to the extension terminals, PC_1–PC_4, in the same way that IC_5, IC_6, LD_2 are connected to IC_3.

The optical input signal is provided by a coding disc that is sub-divided into a number of alternate reflecting and non-reflecting segments. The two optoisolators are positioned above the disc in such a way that when one is directly above a segment, the other is exactly above the line dividing two segments. It is, of course, possible to use a light barrier and a coding disc that has alternate transparent and opaque segments. Two LEDs and a pair of phototransistors can also be used.

The power supply is a 5 V regulated type that can deliver 250 mA. For each additional counter stage, 100 mA should be added to that figure. ■



WATER LEVEL CONTROL

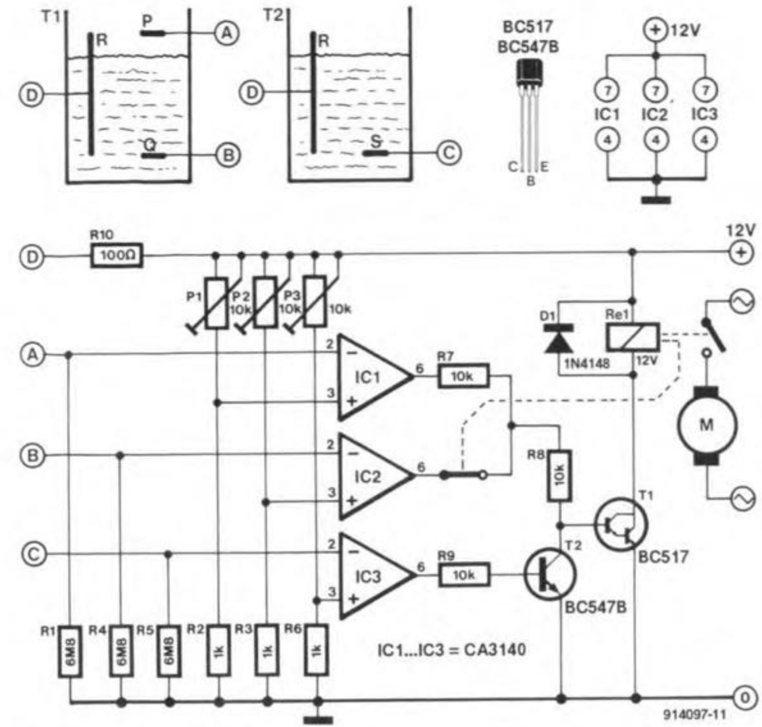
by S. Kokate

IN SOME countries, the water supply is irregular at most times; in many other countries at times of a drought. A means of making this less inconvenient is offered by the circuit described here. It needs two water tanks: one, T2, at ground level or even underground and the other, T1, in the loft or at least considerably higher than the first one. Tank 2 gets filled by a pump from tank 1 to ensure that there is sufficient water pressure. The circuit shown ensures that the water in tank 1 is kept at a given level; if the water drops below that level, the pump will be switched on. There is protection in case tank 2 is empty.

The circuit is operated by a number of sensors mounted in the tanks. Each tank contains a non-corrosive or insulated pin or straight piece of stout wire, *R*. Tank 1 has two sensors, *P* and *Q*, each consisting of a small, non-corrosive metal disc; tank 2 has one sensor, *S*, which is identical to those in tank 1. Sensor *P* indicates when tank 1 is full; *Q* signals when tank 1 is empty; *S* indicates when tank 2 is empty (no water at all).

Pins *R* are connected via a resistor to the positive supply line, while the sensors are linked to the inverting input of three opamps, IC_1–IC_3. The non-inverting inputs of these amplifiers are supplied with a reference voltage, derived from potential dividers. Sufficient water between a pin and a sensor causes a virtual short-circuit that results in a high level at the inverting input of the associated opamp. A relay is used to switch the pump and and off: its normally open contact operates the motor and its normally closed contact is linked to the output of IC_2.

When tank 1 is full, the inverting input of all three opamps is at a high level: the out-



puts of all three are then low and the relay is not energized. When the water level in tank 1 drops, the output of IC_1 goes high, but, since the output of IC_2 is low, the relay will remain inoperative. When, however, the water level drops to below sensor *Q*, the output of IC_2 will go high. Transistor T_1 is switched on and the relay is actuated, so that the pump is switched on and the output of IC_2 is open-circuited. The high level at pin 6 of IC_1 will ensure that T_1 remains switched on.

When tank 1 is filled to the level of sensor *P*, the resulting low level at the output of IC_1 will cause the relay to be deenergized, so that the pump is switched off.

When tank 2 is empty, the output of IC_3 becomes high, which switches on T_2 so that T_1 does not get any base current. Consequently, the relay cannot be energized.

The reference voltage for each of the opamps can be preset with P_1–P_3 to obtain the required switching pattern, which, of course, depends also on the sensors used and the composition of the water.

Since there is a direct voltage at the sensors, these must be inspected regularly. Some advice here: the carbon electrodes from an old battery do not dissolve in water and arte non-corrosive.

The current drawn by the circuit is determined chiefly by the relay coil: the BC517 can switch up to 400 mA. The opamps draw only a few milliamperes. ■

AUDIBLE TESTER

by L. Roerade

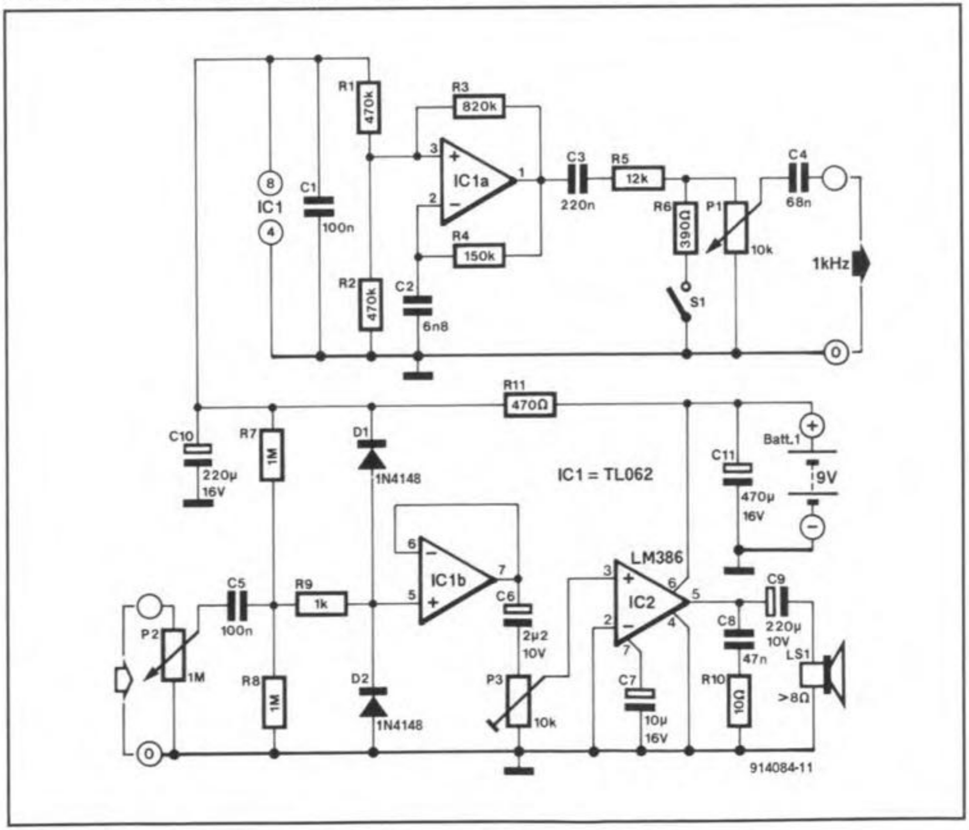
THE TESTER, which is very useful for testing parts of electronic circuits, consists of an oscillator that generates a 1 kHz test signal and a detector that amplifies the detected signal which is then made audible by a small loudspeaker or buzzer. The tester draws only a small current so that it can be powered by a 9 V (PP3 or 6F22) battery.

Circuit IC_{1a} functions as a rectangular-wave generator whose frequency is determined by the time constant R_4–C_2. With values as shown, the frequency is about 1 kHz and this is hardly affected by variations in the supply voltage.

The oscillator signal is fed to the circuit on test via C_3, R_5, potentiometer P_1 and C_4. With a 9 V supply, the maximum voltage at the wiper of P_1 is about 3.5 V p-p. When S_1 is closed, the voltage at the output terminals is reduced to $^1/_{14}$th.

The measurand is input to the detector via sensitivity control P_2. The circuit is protected against too high input voltages by R_9, D_1 and D_2. After the signal has been buffered by IC_{1b}, it is applied to power amplifier IC_2 via C_6 and P_3. The signal is raised to a level that enables its driving a small loudspeaker or buzzer.

The prototype drew a current of 7 mA in the absence of a signal, and this increased to nearly 200 mA with a strong input signal. The maximum drive level to the power amplifier, and thus the maximum current drain, is determined with P_3. ■



APPLICATION NOTES

The contents of this article are based on information obtained from manufacturers in the electrical and electronics industry and do not imply practical experience by *Elektor Electronics* or its consultants.

MICROPROCESSOR PROGRAMMABLE UNIVERSAL ACTIVE FILTERS
(Maxim Integrated Products Inc.)

Maxim's MAX260/261/262 series of ICs contain two double filter sections of which the response can be set for each section individually by means of a microprocessor output port or a microcomputer system. This brings the programming of roll-off frequencies and *Q* factors at the flick of a switch within easy reach. Handy, too, in the laboratory, such a computer-controlled filter bank!

FILTER ICs based on switched capacitors have been with us for quite some time. Their operating principle is fairly simple: each frequency determining capacitor is associated with an electronic switch that enables the charge transfer to the capacitor to be controlled by pulse-width modulation at a frequency much higher than the desired pass-band. Switched-capacitor filter ICs usually require the desired pass-band to be defined beforehand, which results in a certain internal configuration. Next, a potentiometer is added to give continuous control of the filter frequency over a certain range.

The new family of IC filters produced by Maxim takes this principle one step further. Each IC in the three-member family contains two second-order switched-capacitor active filters, whose parameters Q, f_c and f_0 can be set with the aid of a few datawords supplied by a computer system. Virtually everything required to do this efficiently is integrated in

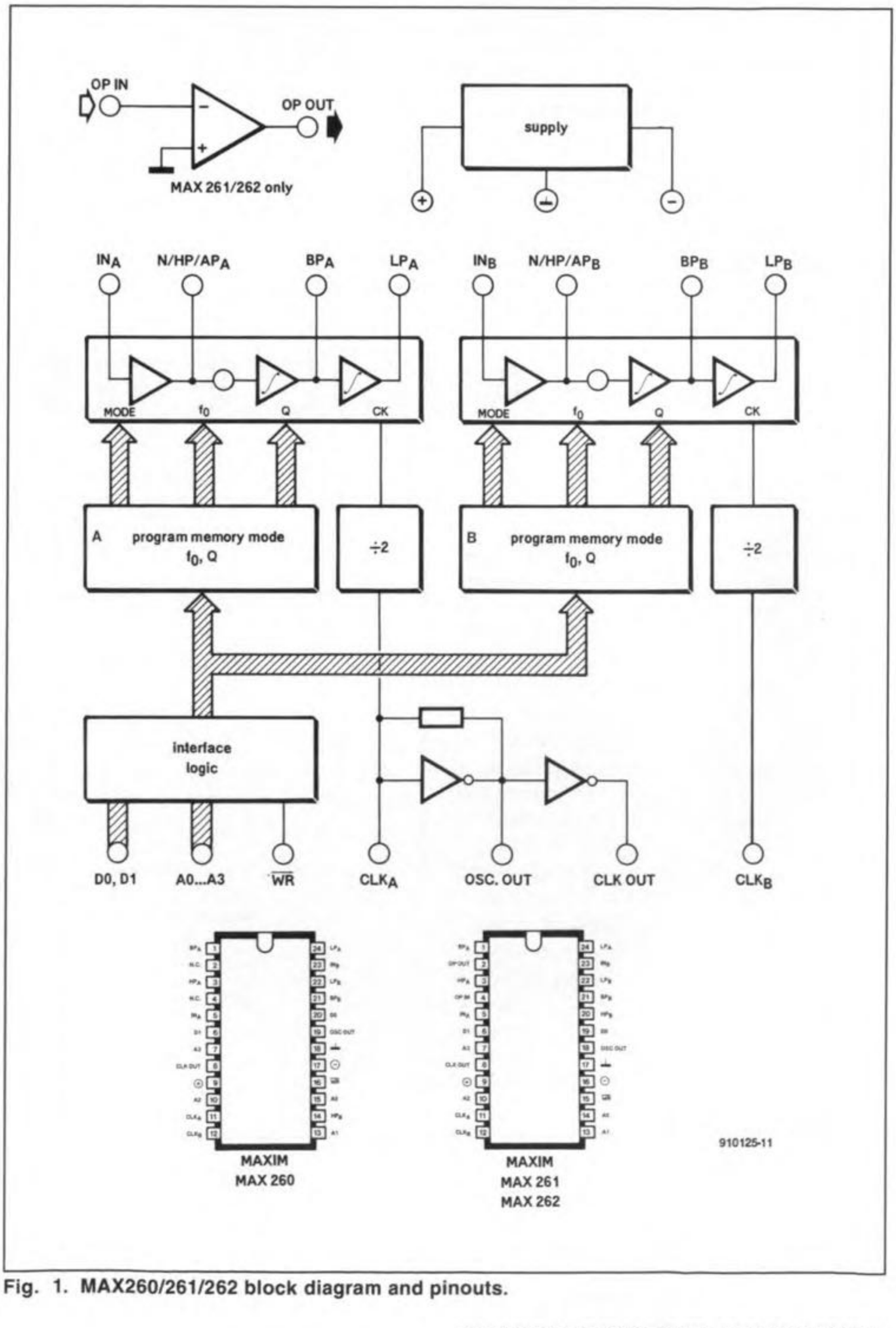


Fig. 1. MAX260/261/262 block diagram and pinouts.

the IC, including the capacitors. The filter configuration is flexible since each section has a low-pass, a high-pass and a band-pass output. Each filter section can be used on its own, but it is also possible to cascade sections to obtain higher-order filters (which have steeper roll-off characteristics).

IC topography

The block schematic diagram of the MAX260/262/262 is shown in Fig. 1. Each second-order filter section has its own clock input, and individual settings for the roll-off frequency and the *Q* factor. In this way, the sections can operate independently whilst allowing complex filter functions to be created. An on-board oscillator is available that may be connected to a quartz crystal or a suitable *R-C* combination. A binary scaler connected between each clock input and the filter section prevents the duty factor of the applied signal affecting the operation of the filters. The MAX261 and the MAX262 also contain an uncommitted opamp that may be used to create, for instance, a notch output.

Figure 2 gives the internal structure of a filter. What is shown is basically a state-variable filter consisting of two integrators and a summing amplifier. Four switched-capacitor networks enable the *Q* factor as well as the centre frequency, f_0, of each section to be programmed individually. The three switches controlled by the 'mode select' block allow the opamps and the summing amplifier to be interconnected in many different ways.

The ratio of the clock frequency to the set centre frequency is so large that the clock frequency is readily extracted from the output signal, which results in a nearly ideal second-order state-variable response. The ratio is not the same for all three ICs — for the MAX262, it is purposely set to a lower value to enable the IC to handle higher frequencies than the other two.

Filter mode selection

Mode 1 (Fig. 3a) is useful when implementing all-pole low-pass and band-pass filters such as Butterworth, Bessel and Chebyshev types. It can also be used for notch filters, but only second-order types because the relative pole and null locations are fixed. Mode 1, along with Mode 4, supports the highest clock frequencies because the input summing amplifier is outside the filter's resonant loop. The gain of the low-pass and notch outputs is 1, while the band-pass gain at the centre frequency, f_0, equals *Q*.

Mode 2 (Fig. 3b) is also used for all-pole low-pass and band-pass filters. The advantages compared to Mode 1 are higher available *Q* factors and lower output noise. However, the f_{clk}/f_0 ratios available in Mode 2 are $\sqrt{2}$ times lower than with Mode 1, so a wider overall range of section centre frequencies may be selected when a common clock is used.

Mode 3 (Fig. 3c) is the only mode which produces high-pass filters. The maximum clock

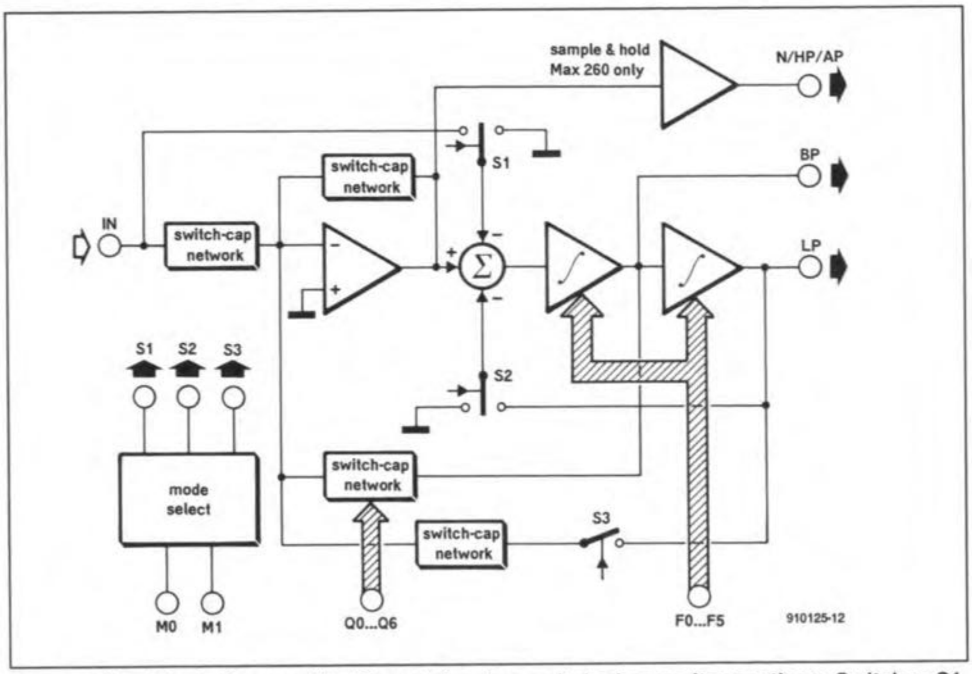


Fig. 2. Filter block diagram. The IC contains four switched-capacitor sections. Switches S1, S2 and S3 allow a certain filter configuration to be set (see Fig. 3)

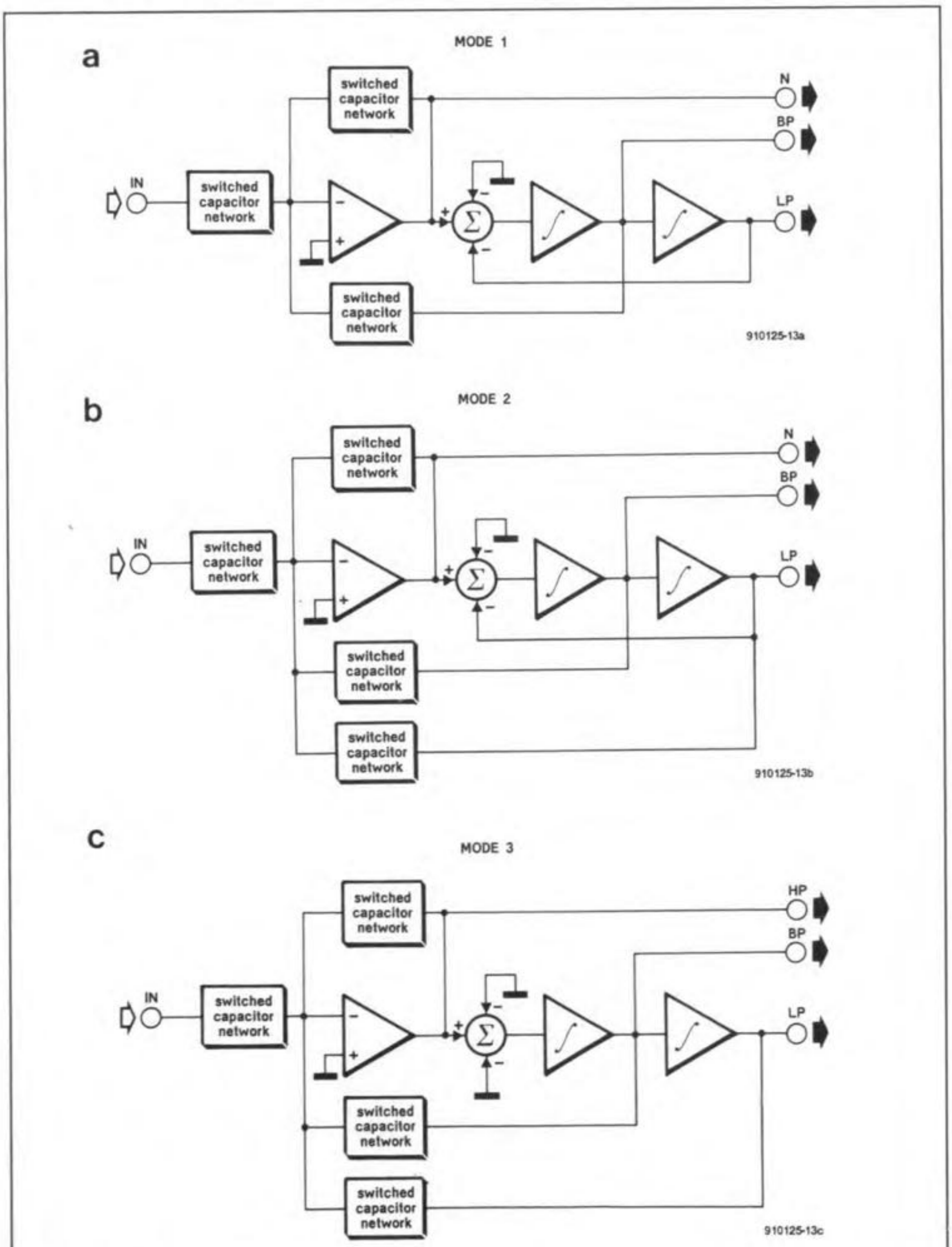


Fig. 3a, 3b, 3c. Filter modes selected by programming the IC.

frequency is slightly lower than with Mode 1.

Mode 3a (Fig. 3d) is an extension of Mode 3. The uncommitted opamp in the MAX261 and MAX262, or an external opamp, is used to create a separate notch output. This is achieved by summing the low-pass and high-pass outputs. Mode 3a is particularly suited to creating elliptical filters (with poles and nulls).

Mode 4 (Fig. 3e) is the only mode that provides an all-pass output. It also allows all-pole low-pass and band-pass filters to be created. Table 1 lists the main characteristics of the above modes.

Programming the filters

Very narrow filters can be created by cascading a number of filter sections. This, however, requires the central frequency, f_0, and the quality factor, Q, to be calculated with the aid of filter theory. Since the two filter sections in the MAX26x-based experimental circuit (to be described further on) are used independently, the discussion can be limited to a second-order filter, which will meet most experimental demands.

The filter IC has three address lines and two datalines. These are readily connected to, for instance, a Centronics port on a computer. To program a filter section, eight two-bit datawords must be written to it. The function of these bits is given in Table 2. After programming the IC, the connection to the computer may be broken. The filter IC will continue to function with the programmed settings until its supply voltage is removed.

Apart from the desired mode for a certain filter configuration, the computer must supply a corresponding value for the ratio f_{clk}/f_0, and another for the desired Q factor. The latter two parameters depend on the programmed mode, and can not be caught in a simple rule or equation. That is why Table 3 lists values for N, a number to be fed to the IC in order to obtain a certain frequency ratio given the selected mode. When using this information, do mind the 'notes' below the table.

The ratio f_{clk}/f_0 may be programmed between about 100 and 200 for the most frequently used modes of the MAX260/261. Consequently, at a clock of 200 kHz, f_0 can be set (via the computer) to a value between 1 kHz and 2 kHz. To obtain a somewhat larger control range, the oscillator frequency is made adjustable in our design. This is achieved with the aid of a potentiometer.

The Q factor is also programmed via a corresponding number, N, which may take a value between 0 and 127. This allows the actual Q to be set between 0.5 and 64 in Modes 1, 3 and 4. The set Q also determines the maximum clock frequency. The MAX261 in the present circuit is capable of operating up to 1.7 MHz in all modes at Q values smaller than 8 (with Q=1, 4 MHz is achieved). At higher Qs, the maximum frequency is reduced to about 1.2 MHz.

The filter IC may be put into a low-power

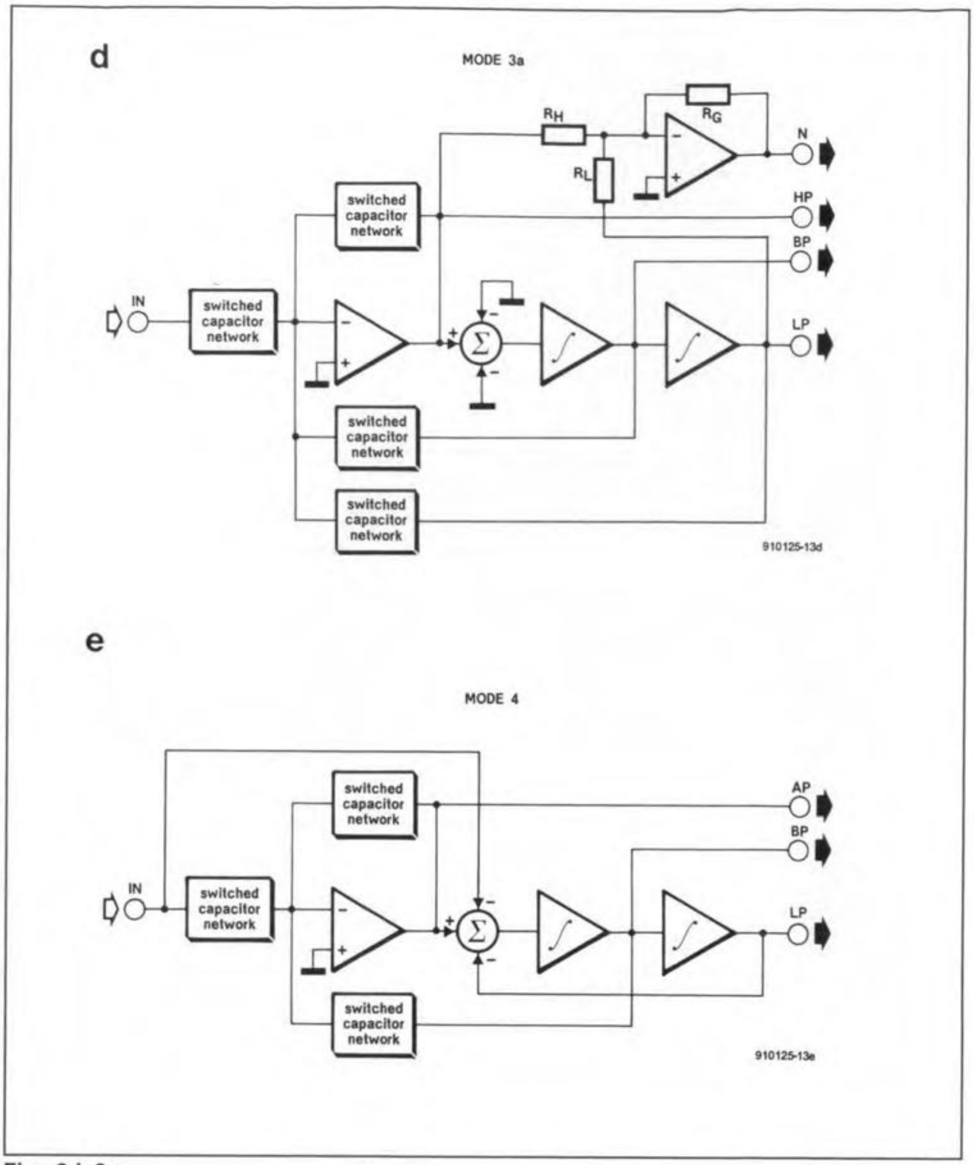


Fig. 3d, 3e.

MODE	M1, M0	FILTER FUNCTIONS	f_0	Q	f_N	H_{OLP}	H_{OBP}	H_{ON1} ($f \to 0$)	H_{ON2} ($f \to f_{CLK}/4$)	OTHER
1	0, 0	LP, BP, N	SEE TABLE 2	SEE TABLE 3	f_0	-1	-Q	-1	-1	
2	0, 1	LP, BP, N			$f_0\sqrt{2}$	-0.5	$-Q/\sqrt{2}$	-0.5	-1	
3	1, 0	LP, BP, HP				-1	-Q		-	$H_{OHP} = -1$
3A	1, 0	LP, BP, HP, N			$f_0\sqrt{\frac{R_H}{R_L}}$	-1	-Q	$+\frac{R_G}{R_L}$	$+\frac{R_G}{R_H}$	$H_{OHP} = -1$
4	1, 1	LP, BP, AP				-2	-2Q			$H_{OAP} = -1$ $f_Z = f_0$, $Q_Z = Q$

Notes:
f_0 = Center Frequency
f_N = Notch Frequency
H_{OLP} = Lowpass Gain at DC
H_{OBP} = Bandpass Gain at f_0
H_{OHP} = Highpass Gain as f approaches $f_{CLK}/4$
H_{ON1} = Notch Gain as f approaches DC
H_{ON2} = Notch Gain as f approaches $f_{CLK}/4$
H_{OAP} = Allpass Gain
f_Z, Q_Z = f and Q of Complex Pole Pair

Table 1. Main filter characteristics (Fig. 3)

shut-down mode by programming a Q of 0 in filter A. This reduces the current drain from 7 mA to about 0.35 mA.

A development circuit

Figure 4 shows the circuit diagram of an experimental programmable filter based on the MAX261. The circuit is eminently suited to quick design and testing of a certain filter response.

The inputs of the IC are fitted with two coupling capacitors, C_1 and C_2, and signal level controls, P_1 and P_2. Two clamp circuits, D_1-D_2-R_1 and D_3-D_4-R_2, protect the IC inputs against too large input signals.

The clock oscillator runs with an R-C combination, P_3-C_7. The potentiometer gives a clock frequency range of about 70 kHz to 1.5 MHz. If necessary, lower frequencies may be obtained by increasing the value of C_7.

The jumpers at the outputs of the filter sections allow you to select a particular filter function for feeding to output connectors K_4 and K_5. It is also possible to connect two filter sections in series by fitting a jumper (or a wire link) between points 'A' and 'B'.

The low-pass filters at the outputs of the circuit, R_5-C_8 and R_7-C_{10}, serve to suppress

DATA BIT		ADDRESS				LOCATION
D0	D1	A3	A2	A1	A0	
FILTER A						
$M0_A$	$M1_A$	0	0	0	0	0
$F0_A$	$F1_A$	0	0	0	1	1
$F2_A$	$F3_A$	0	0	1	0	2
$F4_A$	$F5_A$	0	0	1	1	3
$Q0_A$	$Q1_A$	0	1	0	0	4
$Q2_A$	$Q3_A$	0	1	0	1	5
$Q4_A$	$Q5_A$	0	1	1	0	6
$Q6_A$		0	1	1	1	7
FILTER B						
$M0_B$	$M1_B$	1	0	0	0	8
$F0_B$	$F1_B$	1	0	0	1	9
$F2_B$	$F3_B$	1	0	1	0	10
$F4_B$	$F5_B$	1	0	1	1	11
$Q0_B$	$Q1_B$	1	1	0	0	12
$Q2_B$	$Q3_B$	1	1	0	1	13
$Q4_B$	$Q5_B$	1	1	1	0	14
$Q6_B$		1	1	1	1	15

Note: Writing 0 into $Q0_A$-$Q6_A$ (address locations 4-7) on Filter A activates shutdown mode. BOTH filter sections deactivate.

Table 2. Filter parameter address locations.

f_{CLK}/f_0 RATIO				PROGRAM CODE						
MAX260/61		MAX262								
MODE 1,3,4	MODE 2	MODE 1,3,4	MODE 2	N	F5	F4	F3	F2	F1	F0
100.53	71.09	40.84	28.88	0	0	0	0	0	0	0
102.10	72.20	42.41	29.99	1	0	0	0	0	0	1
103.67	73.31	43.98	31.10	2	0	0	0	0	1	0
105.24	74.42	45.55	32.21	3	0	0	0	0	1	1
106.81	75.53	47.12	33.32	4	0	0	0	1	0	0
108.38	76.64	48.69	34.43	5	0	0	0	1	0	1
109.96	77.75	50.27	35.54	6	0	0	0	1	1	0
111.53	78.86	51.84	36.65	7	0	0	0	1	1	1
113.10	79.97	53.41	37.76	8	0	0	1	0	0	0
114.67	81.08	54.98	38.87	9	0	0	1	0	0	1
116.24	82.19	56.55	39.99	10	0	0	1	0	1	0
117.81	83.30	58.12	41.10	11	0	0	1	0	1	1
119.38	84.42	59.69	42.21	12	0	0	1	1	0	0
120.95	85.53	61.26	43.32	13	0	0	1	1	0	1
122.52	86.64	62.83	44.43	14	0	0	1	1	1	0
124.09	87.75	64.40	45.54	15	0	0	1	1	1	1
125.66	88.86	65.97	46.65	16	0	1	0	0	0	0
127.23	89.97	67.54	47.76	17	0	1	0	0	0	1
128.81	91.80	69.12	48.87	18	0	1	0	0	1	0
130.38	92.19	70.69	49.98	19	0	1	0	0	1	1
131.95	93.30	72.26	51.10	20	0	1	0	1	0	0
133.52	94.41	73.83	52.20	21	0	1	0	1	0	1
135.08	95.52	75.40	53.31	22	0	1	0	1	1	0
136.66	96.63	76.97	54.43	23	0	1	0	1	1	1
138.23	97.74	78.53	55.54	24	0	1	1	0	0	0
139.80	98.86	80.11	56.65	25	0	1	1	0	0	1
141.37	99.97	81.68	57.76	26	0	1	1	0	1	0
142.94	101.08	83.25	58.87	27	0	1	1	0	1	1
144.51	102.89	84.82	59.98	28	0	1	1	1	0	0
146.08	103.30	86.39	61.09	29	0	1	1	1	0	1
147.65	104.41	87.96	62.20	30	0	1	1	1	1	0
149.23	105.52	89.54	63.31	31	0	1	1	1	1	1
150.80	106.63	91.11	64.42	32	1	0	0	0	0	0
152.37	107.74	92.68	65.53	33	1	0	0	0	0	1
153.98	108.85	94.25	66.64	34	1	0	0	0	1	0
155.51	109.96	95.82	67.75	35	1	0	0	0	1	1
157.08	111.07	97.39	68.86	36	1	0	0	1	0	0
158.65	112.18	98.96	69.98	37	1	0	0	1	0	1
160.22	113.29	100.53	71.09	38	1	0	0	1	1	0
161.79	114.41	102.10	72.20	39	1	0	0	1	1	1
163.36	115.52	102.67	73.31	40	1	0	1	0	0	0
164.93	116.63	105.24	74.42	41	1	0	1	0	0	1
166.50	117.74	106.81	75.53	42	1	0	1	0	1	0
168.08	118.85	108.38	76.64	43	1	0	1	0	1	1
169.65	119.96	109.96	77.75	44	1	0	1	1	0	0
171.22	121.07	111.53	78.86	45	1	0	1	1	0	1
172.79	122.18	113.10	79.97	46	1	0	1	1	1	0
174.36	123.29	114.66	81.08	47	1	0	1	1	1	1
175.93	124.40	116.24	82.19	48	1	1	0	0	0	0
177.50	125.51	117.81	83.30	49	1	1	0	0	0	1
179.07	126.62	119.38	84.41	50	1	1	0	0	1	0
180.64	127.73	120.95	85.53	51	1	1	0	0	1	1
182.21	128.84	122.52	86.64	52	1	1	0	1	0	0
183.78	129.96	124.09	87.75	53	1	1	0	1	0	1
185.35	131.07	125.66	88.86	54	1	1	0	1	1	0
186.92	132.18	127.23	89.97	55	1	1	0	1	1	1
188.49	133.29	128.81	91.08	56	1	1	1	0	0	0
190.07	134.40	130.38	92.19	57	1	1	1	0	0	1
191.64	135.51	131.95	93.30	58	1	1	1	0	1	0
193.21	136.62	133.52	94.41	59	1	1	1	0	1	1
194.78	137.73	135.09	95.52	60	1	1	1	1	0	0
196.35	138.84	136.66	96.63	61	1	1	1	1	0	1
197.92	139.95	138.23	97.74	62	1	1	1	1	1	0
199.49	141.06	139.80	98.85	63	1	1	1	1	1	1

Notes: 1) For the MAX260/61, $f_{CLK}/f_0 = (64 + N)\pi/2$ in Mode 1, 3, and 4, where N varies from 0 to 63.
2) For the MAX262, $f_{CLK}/f_0 = (26 + N)\pi/2$ in Mode 1, 3, and 4, where N varies 0 to 63.
3) In Mode 2, all f_{CLK}/f_0 ratios are divided by $\sqrt{2}$. The functions are then:
MAX260/61 $f_{CLK}/f_0 = 1.11072\ (64 + N)$, MAX262 $f_{CLK}/f_0 = 1.11072\ (26 + N)$

Table 3. Central frequency programming.

the clock frequency. For best results, these filters should have a roll-off frequency which is geared to the set clock frequency. However, in view of the universal character of the present application, a fixed roll-off frequency of just higher than 20 kHz is used here.

The IC is linked to the computer via a Centronics connector. A resistor array is used to ensure fixed logic levels at the IC inputs when the computer is not connected. For simplicity's sake, the circuit is powered by an asymmetrical supply. This requires an additional potential of half the supply voltage to be created for the MAX261. This is achieved with components R_3, R_4 and C_5. The supply voltage is stabilized by a 5-V regulator Type 7805. The current drain of the circuit is smaller than 20 mA.

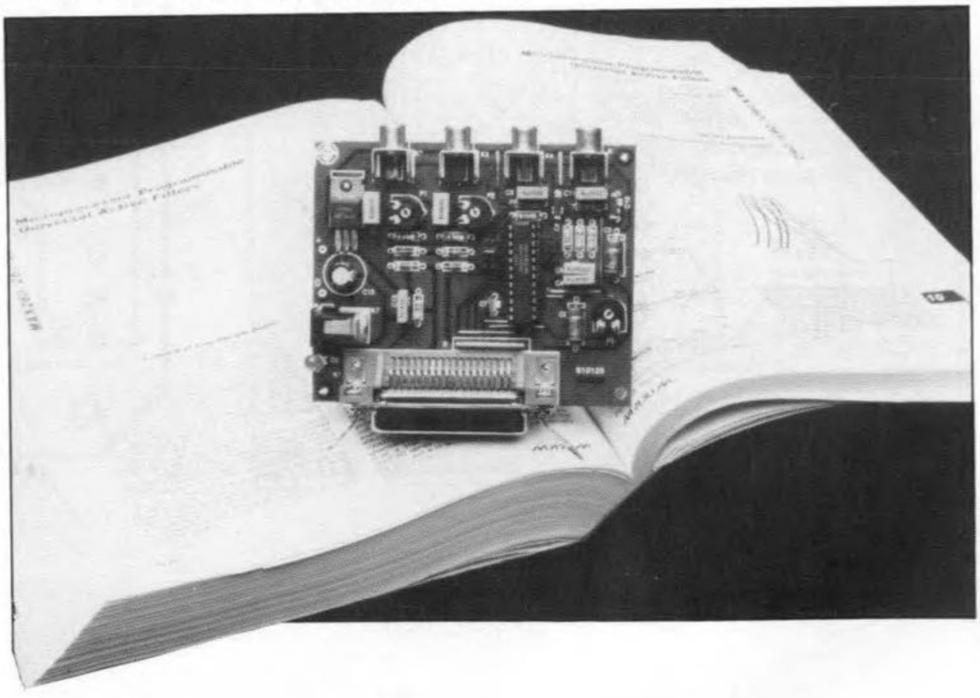
Practical use

The experimental programmable filter is best constructed on the printed circuit board shown in Fig. 5. The wiring is reduced to a minimum because all connectors are mounted on to the board. The completed PCB is fitted into a small ABS enclosure from Pactec of dimensions 146×92×27 mm (approx.). The input supply voltage is best furnished by a small mains adaptor with 9 V to 12 V d.c. output.

For an initial test, connect the control input of the filter to the Centronics output of a PC, and the input(s) to a signal generator. The output(s) is (are) connected to a measuring instrument, e.g., an oscilloscope. The maximum input voltage with the level controls fully open depends on the desired mode, the selected output, and the set *Q* factor (see Table 1). The maximum output voltage is about 1.5 V_{rms} at the supply voltage used here.

The short BASIC program listed in Fig. 6 gives ready control over the filter section settings. First, select the desired mode. In most cases, this will be Mode 1 if a low-pass or band-pass filter is desired, or Mode 3 if you want a high-pass filter.

Next, enter the corresponding number for f_0 (centre frequency) and *Q* (quality factor). Use Tables 3 and 4 to look up the num-



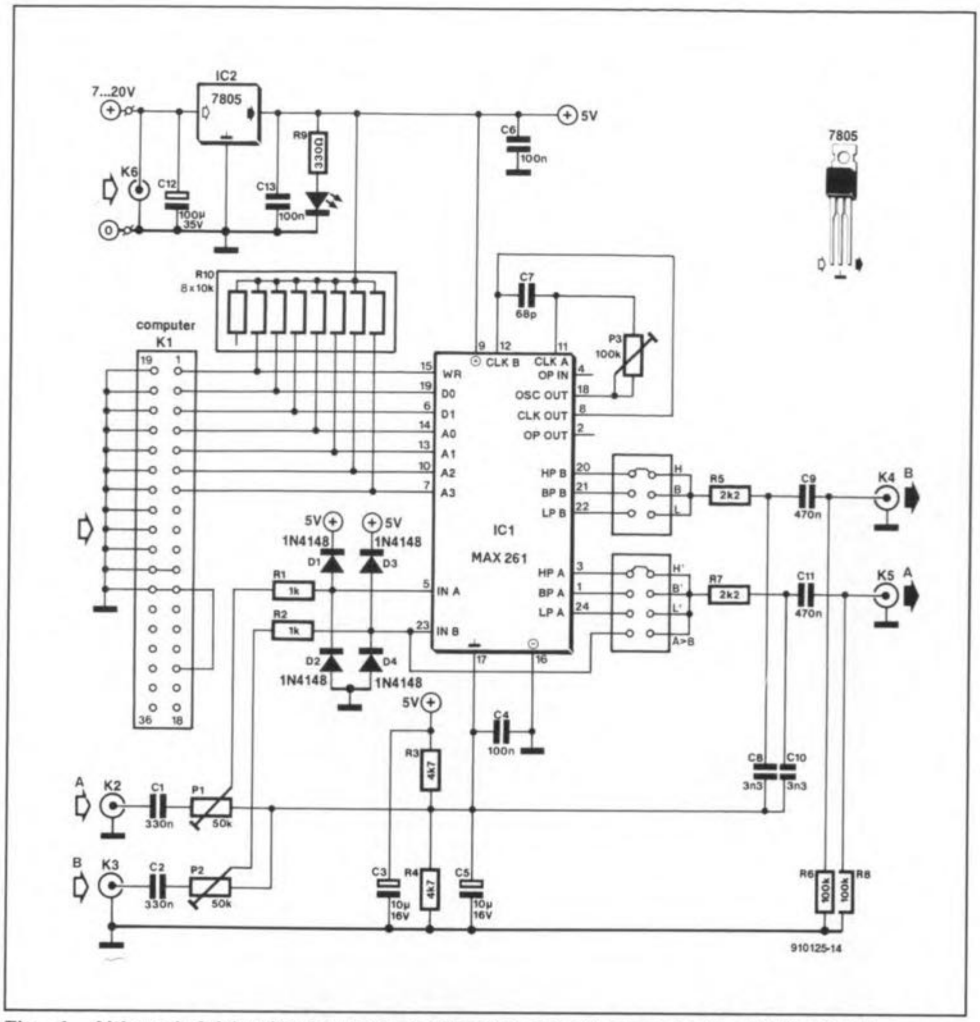


Fig. 4. Although fairly simple, the experimental circuit based on the MAX262 offers many interesting possibilities.

COMPONENTS LIST

Resistors:

2	1kΩ	R1;R2
2	4kΩ7	R3;R4
2	2kΩ2	R5;R7
2	100kΩ	R6;R8
1	330Ω	R9
1	10kΩ 8-way SIL	R10
2	50kΩ preset H	P1;P2
1	100kΩ preset H	P3

Capacitors:

2	330nF	C1;C2
2	10µF 16V	C3;C5
3	100nF	C4;C6;C13
1	68pF	C7
2	3nF3	C8;C10
2	470nF	C9;C11
1	100µF 35V radial	C12

Semiconductors:

4	1N4148	D1-D4
1	LED red 5mm	D5
1	MAX261	IC1
1	7805	IC2

Miscellaneous:

1	36-way PCB-mount angled Centronics socket	K1
4	PCB-mount RCA or phono socket	K2-K5
1	3-mm dia. PCB-mount adaptor socket	K6
1	Printed circuit board	910125

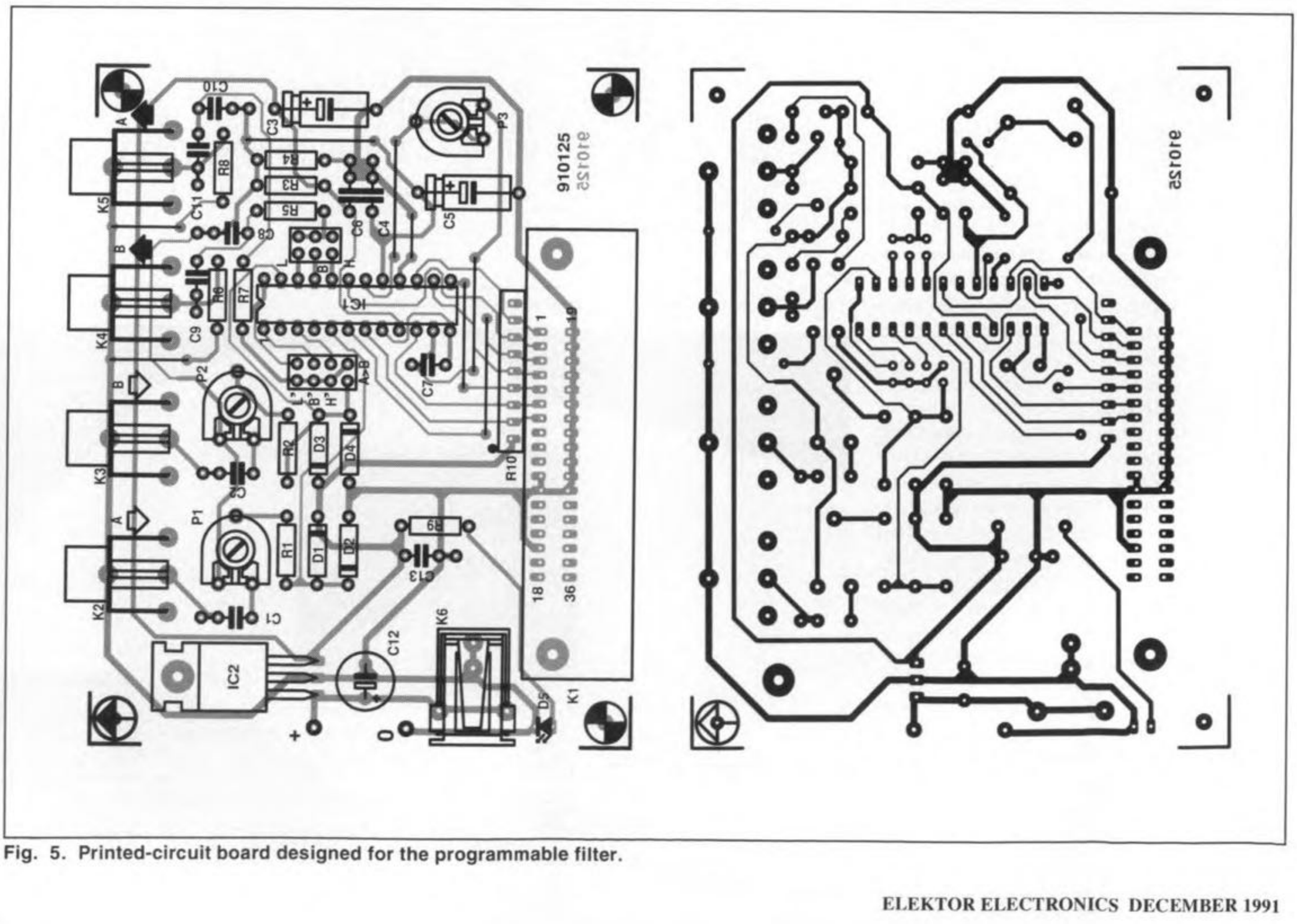


Fig. 5. Printed-circuit board designed for the programmable filter.

bers N that yield the desired parameter values, observing the available range (between 0 and 63 for $N(f_0)$, and between 0 and 127 for $N(Q)$). The computer builds the resulting datawords and sends them to the filter circuit. You may want to extend the program by incorporating the equations below Tables 3 and 4 in order to be able to work without the conversion (N-) tables, and program the frequency ratio and the quality factor direct.

Finally, a few programming hints for commonly used filter types. A Butterworth filter is implemented by programming a Q of 0.707, in which case the –3-dB roll-off frequency equals f_0. A Bessel characteristic is obtained with Q set to 0.5, when f_0 equals the –6-dB roll-off frequency. A Chebyshev-like response is possible by entering a Q of 1. In that case, f_0 is the resonance point of the small peak which occurs near the roll-off frequency with this type of filter. This peak becomes larger when higher Q values are programmed. However, the resultant filter characteristics are rarely used or required. ■

Source:

Maxim Integrated Circuits Data Book 1989, pages 10-1 to 10-24.

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UK distributors: Dialogue Distribution Ltd. (0276 682001); 2001 Electronic Components (0438 742001); Thame Components Ltd. (084 4214561).

PROGRAMMED Q		PROGRAM CODE							
MODE 1,3,4	MODE 2	N	Q6	Q5	Q4	Q3	Q2	Q1	Q0
0.500*	0.707*	0*	0	0	0	0	0	0	0
0.504	0.713	1	0	0	0	0	0	0	1
0.508	0.718	2	0	0	0	0	0	1	0
0.512	0.724	3	0	0	0	0	0	1	1
0.516	0.730	4	0	0	0	0	1	0	0
0.520	0.736	5	0	0	0	0	1	0	1
0.525	0.742	6	0	0	0	0	1	1	0
0.529	0.748	7	0	0	0	0	1	1	1
0.533	0.754	8	0	0	0	1	0	0	0
0.538	0.761	9	0	0	0	1	0	0	1
0.542	0.767	10	0	0	0	1	0	1	0
0.547	0.774	11	0	0	0	1	0	1	1
0.552	0.780	12	0	0	0	1	1	0	0
0.556	0.787	13	0	0	0	1	1	0	1
0.561	0.794	14	0	0	-0	1	1	1	0
0.566	0.801	15	0	0	0	1	1	1	1
0.571	0.808	16	0	0	1	0	0	0	0
0.577	0.815	17	0	0	1	0	0	0	1
0.582	0.823	18	0	0	1	0	0	1	0
0.587	0.830	19	0	0	1	0	0	1	1
0.593	0.838	20	0	0	1	0	1	0	0
0.598	0.846	21	0	0	1	0	1	0	1
0.604	0.854	22	0	0	1	0	1	1	0
0.609	0.862	23	0	0	1	0	1	1	1
0.615	0.870	24	0	0	1	1	0	0	0
0.621	0.879	25	0	0	1	1	0	0	1
0.627	0.887	26	0	0	1	1	0	1	0
0.634	0.896	27	0	0	1	1	0	1	1
0.640	0.905	28	0	0	1	1	1	0	0
0.646	0.914	29	0	0	1	1	1	0	1
0.653	0.924	30	0	0	1	1	1	1	0
0.660	0.933	31	0	0	1	1	1	1	1
0.667	0.943	32	0	1	0	0	0	0	0
0.674	0.953	33	0	1	0	0	0	0	1
0.681	0.963	34	0	1	0	0	0	1	0
0.688	0.973	35	0	1	0	0	0	1	1
0.696	0.984	36	0	1	0	0	1	0	0
0.703	0.995	37	0	1	0	0	1	0	1
0.711	1.01	38	0	1	0	0	1	1	0
0.719	1.02	39	0	1	0	0	1	1	1
0.727	1.03	40	0	1	0	1	0	0	0
0.736	1.04	41	0	1	0	1	0	0	1
0.744	1.05	42	0	1	0	1	0	1	0
0.753	1.06	43	0	1	0	1	0	1	1
0.762	1.08	44	0	1	0	1	1	0	0
0.771	1.09	45	0	1	0	1	1	0	1
0.780	1.10	46	0	1	0	1	1	1	0
0.790	1.12	47	0	1	0	1	1	1	1
0.800	1.13	48	0	1	1	0	0	0	0
0.810	1.15	49	0	1	1	0	0	0	1
0.821	1.16	50	0	1	1	0	0	1	0
0.831	1.18	51	0	1	1	0	0	1	1
0.842	1.19	52	0	1	1	0	1	0	0
0.853	1.21	53	0	1	1	0	1	0	1
0.865	1.22	54	0	1	1	0	1	1	0
0.877	1.24	55	0	1	1	0	1	1	1
0.889	1.26	56	0	1	1	1	0	0	0
0.901	1.27	57	0	1	1	1	0	0	1
0.914	1.29	58	0	1	1	1	0	1	0
0.928	1.31	59	0	1	1	1	0	1	1
0.941	1.33	60	0	1	1	1	1	0	0
0.955	1.35	61	0	1	1	1	1	0	1
0.969	1.37	62	0	1	1	1	1	1	0
0.985	1.39	63	0	1	1	1	1	1	1

PROGRAMMED Q		PROGRAM CODE							
MODE 1,3,4	MODE 2	N	Q6	Q5	Q4	Q3	Q2	Q1	Q0
1.00	1.41	64	1	0	0	0	0	0	0
1.02	1.44	65	1	0	0	0	0	0	1
1.03	1.46	66	1	0	0	0	0	1	0
1.05	1.48	67	1	0	0	0	0	1	1
1.07	1.51	68	1	0	0	0	1	0	0
1.08	1.53	69	1	0	0	0	1	0	1
1.10	1.56	70	1	0	0	0	1	1	0
1.12	1.59	71	1	0	0	0	1	1	1
1.14	1.62	72	1	0	0	1	0	0	0
1.16	1.65	73	1	0	0	1	0	0	1
1.19	1.68	74	1	0	0	1	0	1	0
1.21	1.71	75	1	0	0	1	0	1	1
1.23	1.74	76	1	0	0	1	1	0	0
1.25	1.77	77	1	0	0	1	1	0	1
1.28	1.81	78	1	0	0	1	1	1	0
1.31	1.85	79	1	0	0	1	1	1	1
1.33	1.89	80	1	0	1	0	0	0	0
1.36	1.93	81	1	0	1	0	0	0	1
1.39	1.97	82	1	0	1	0	0	1	0
1.42	2.01	83	1	0	1	0	0	1	1
1.45	2.06	84	1	0	1	0	1	0	0
1.49	2.10	85	1	0	1	0	1	0	1
1.52	2.16	86	1	0	1	0	1	1	0
1.56	2.21	87	1	0	1	0	1	1	1
1.60	2.26	88	1	0	1	1	0	0	0
1.64	2.32	89	1	0	1	1	0	0	1
1.68	2.40	90	1	0	1	1	0	1	0
1.73	2.45	91	1	0	1	1	0	1	1
1.78	2.51	92	1	0	1	1	1	0	0
1.83	2.59	93	1	0	1	1	1	0	1
1.88	2.66	94	1	0	1	1	1	1	0
1.94	2.74	95	1	0	1	1	1	1	1
2.00	2.83	96	1	1	0	0	0	0	0
2.06	2.92	97	1	1	0	0	0	0	1
2.13	3.02	98	1	1	0	0	0	1	0
2.21	3.12	99	1	1	0	0	0	1	1
2.29	3.23	100	1	1	0	0	1	0	0
2.37	3.35	101	1	1	0	0	1	0	1
2.46	3.48	102	1	1	0	0	1	1	0
2.56	3.62	103	1	1	0	0	1	1	1
2.67	3.77	104	1	1	0	1	0	0	0
2.78	3.96	105	1	1	0	1	0	0	1
2.91	4.11	106	1	1	0	1	0	1	0
3.05	4.31	107	1	1	0	1	0	1	1
3.20	4.53	108	1	1	0	1	1	0	0
3.37	4.76	109	1	1	0	1	1	0	1
3.56	5.03	110	1	1	0	1	1	1	0
3.76	5.32	111	1	1	0	1	1	1	1
4.00	5.66	112	1	1	1	0	0	0	0
4.27	6.03	113	1	1	1	0	0	0	1
4.57	6.46	114	1	1	1	0	0	1	0
4.92	6.96	115	1	1	1	0	0	1	1
5.33	7.54	116	1	1	1	0	1	0	0
5.82	8.23	117	1	1	1	0	1	0	1
6.40	9.05	118	1	1	1	0	1	1	0
7.11	10.1	119	1	1	1	0	1	1	1
8.00	11.3	120	1	1	1	1	0	0	0
9.14	12.9	121	1	1	1	1	0	0	1
10.7	15.1	122	1	1	1	1	0	1	0
12.8	18.1	123	1	1	1	1	0	1	1
16.0	22.6	124	1	1	1	1	1	0	0
21.3	30.2	125	1	1	1	1	1	0	1
32.0	45.3	126	1	1	1	1	1	1	0
64.0	90.5	127	1	1	1	1	1	1	1

Notes: 4) * Writing all 0s into Q0A-Q6A on Filter A activates a low power shutdown mode. BOTH filter sections are deactivated. Therefore this Q value is only achievable in filter B.
5) In Modes 1, 3, and 4: $Q = 64/(128\text{-}N)$
6) In Mode 2, the listed Q values are those of Mode 1 multiplied by $\sqrt{2}$. Then $Q = 90.51/(128\text{-}N)$

Table 4. *Q* factor programming.

```
100 AB$=" FILTER A " : GOSUB 150 : REM GET DATA FOR SECTION A
110 ADD = 0 : GOSUB 220 : REM WRITE DATA TO THE PRINTER PORT
120 AB$=" FILTER B " : GOSUB 150 : REM GET DATA FOR SECTION B
130 ADD = 32 : GOSUB 220 : REM WRITE DATA TO THE PRINTER PORT
135 PRINT
140 GOTO 100
150 PRINT " MODE (1..4; SEE TABLE 1) : "; AB$; : INPUT M
160 IF M<1 OR M>4 THEN 150
170 PRINT "CLOCK RATIO (0..63, N OF TABLE 3) "; AB$; : INPUT F
180 IF F<0 OR F>63 THEN 170
190 PRINT "Q (0..127, N OF TABLE 4) "; AB$; : INPUT Q
200 IF Q<0 OR Q>127 THEN 190 ELSE PRINT
210 RETURN
220 LPRINT CHR$(ADD+M-1); : ADD=ADD+4
230 FOR I=1 TO 3
240 X=(ADD + (F-4*INT(F/4))) : LPRINT CHR$(X);
250 F=INT (F/4) : ADD = ADD + 4
260 NEXT I
270 FOR I=1 TO 4
280 X=(ADD + (Q - 4*INT(Q/4))) : LPRINT CHR$(X);
290 Q=INT(Q/4) : ADD = ADD + 4
300 NEXT I
310 RETURN
```

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Fig. 6. Use this BASIC program along with the information in Tables 3 and 4 to program the filter sections. Note that the centre frequency and the *Q* factor are not programmed direct but as corresponding values of a variable, *N*.

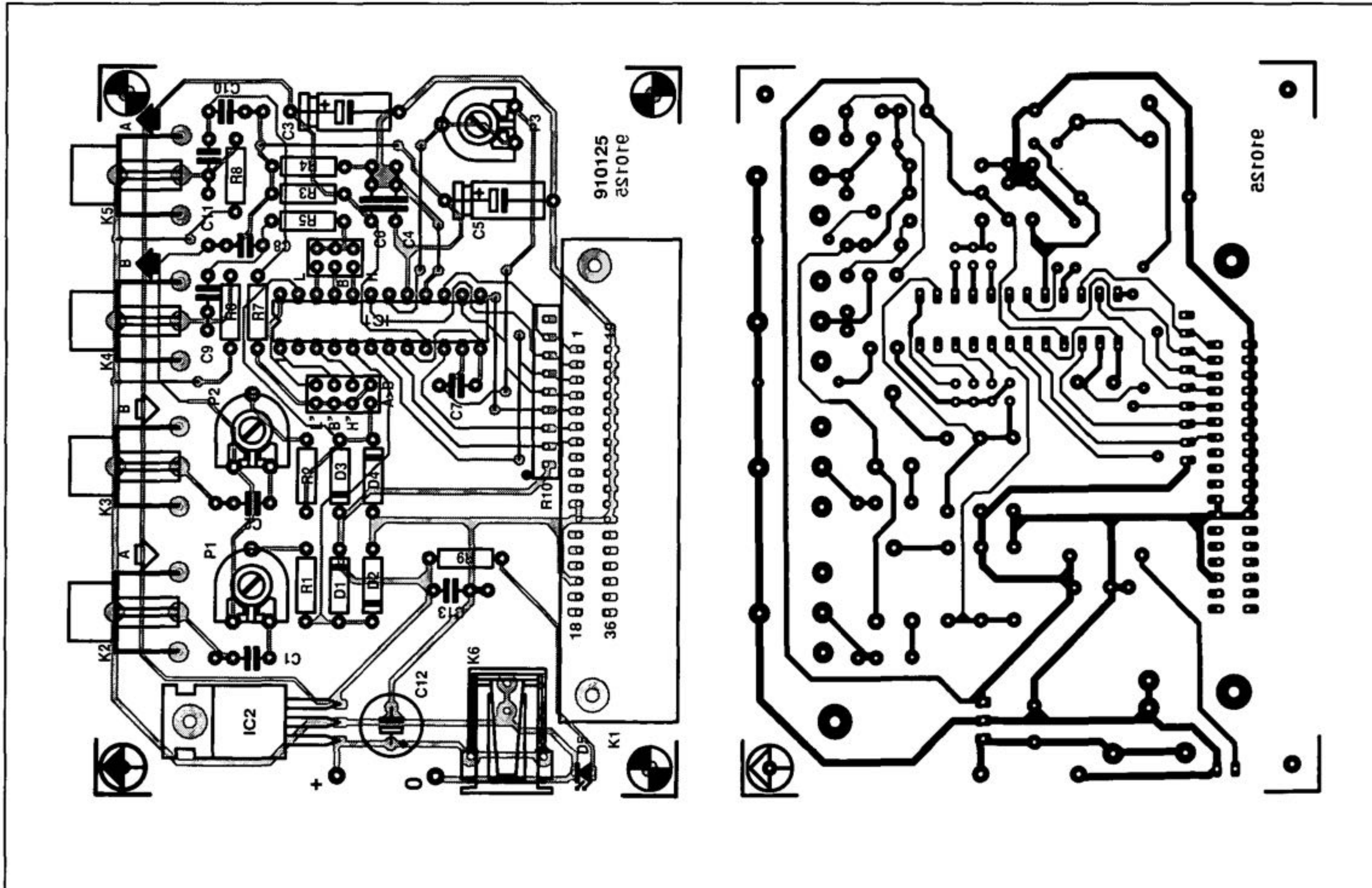


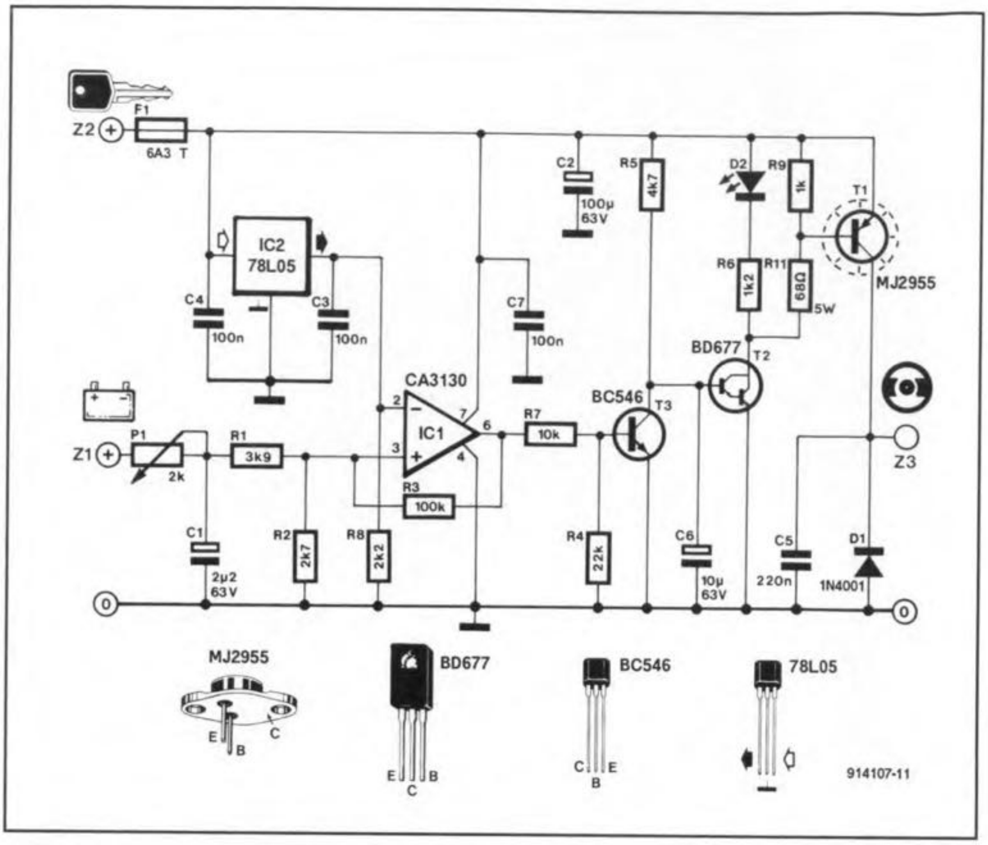
Fig. 5. Printed-circuit board designed for the programmable filter.

VOLTAGE REGULATOR FOR CARS

by R. Lucassen

IN OLDER cars, the battery charging voltage is controlled mechanically. The regulator consists of a relay that switches the stator windings of the alternator on and off. This arrangement is prone to breakdown, inaccurate regulation and sensitivity to load variations.

An electronic alternative as shown has the advantages of not containing any moving parts and of providing much more accurate regulation. Moreover, the voltage is measured at the battery terminals, so that losses in the wiring are not included in the measurement.



The regulator, IC_1, is essentially a device that continuously compares the battery voltage with a reference potential. This comparator drives a power transistor that switches the excitation of the alternator.

Terminal Z1 is connected to the + terminal of the battery; Z2 to the ignition switch; and Z3 to the stator winding of the alternator.

The battery voltage is reduced to about 5 V by potential divider R_1–R_2–P_1 and applied to the non-inverting input of Schmitt trigger IC_1. The inverting input of this opamp is at a reference potential of 5 V provided by regulator IC_2. Power transistor T_1 is switched by the output of IC_1 and transistors T_2 and T_3. Diode D_2 functions as an indicator, while D_1 is a free-wheeling diode. Capacitor C_6 attenuates the pulse generated when T_1 is switched on, so that far fewer harmonics are generated and interference on medium-wave radio is suppressed.

The regulator is calibrated by connecting a 12 V lamp or 15 Ω, 10 W resistor between Z3 and earth and a variable power supply and multimeter, set to 15 V, between Z1 and earth. Set the power supply output to 14.3 V and adjust P_1 until the lamp just goes out. When the power supply output is reduced slowly, the lamp should come on again at 13.9 V.

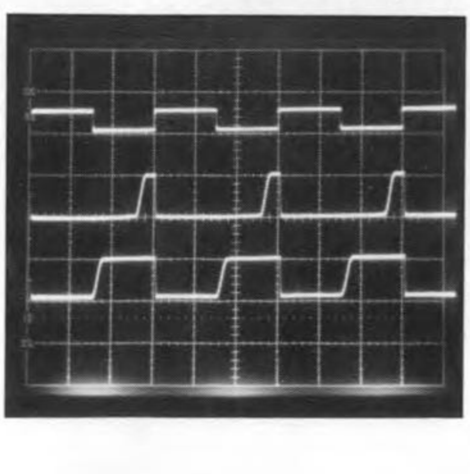
The regulator is best built in a small aluminium case that also serves as heat sink for T_1. The case can be made water-tight with a suitable (hardening) silicone paste. ■

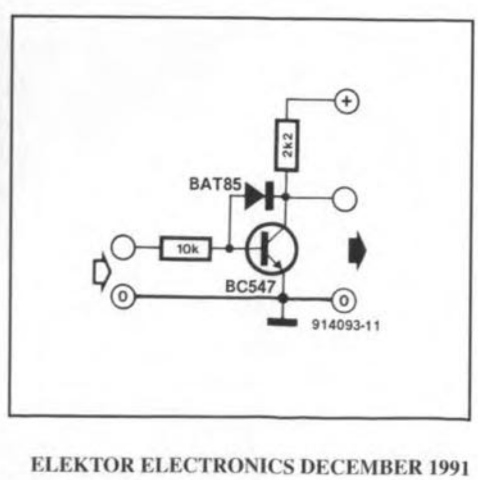
FAST SWITCHING GATE

by A. Rigby

SWITCHING transistors are usually driven into saturation, which has an adverse effect on the switching speed. This effect is eliminated, or nearly so, by the use of Schottky diodes at the inputs. It is equally possible to add a diode to a transistor (across its base-collector junction) as shown in the diagram to increase its switching speed.

When the transistor is driven into conduction, its base current will soon be limited because the diode has a lower transfer potential than the base-collector junction, so that part of the current will flow through the diode. When the transistor is switched off, it will therefore require less time to reach the non-conducting state. The effect is seen clearly in the photograph. Signal 1 is the input signal at a frequency of 166 kHz. Signal 2 is the (inverted) collector signal without diode, and signal 3 is the collector signal with the diode added. It is evident that, owing to the diode, the collector returns to the high-level state much more rapidly. ■





UNIVERSAL 64-BIT OUTPUT

by D. Lorenz

SINCE the proposed circuit makes use of the Centronics interface, it is suitable for virtually all types of computer: even older types with a seven-bit Centronics interface, although in their case the possibility of giving an overall reset is not available.

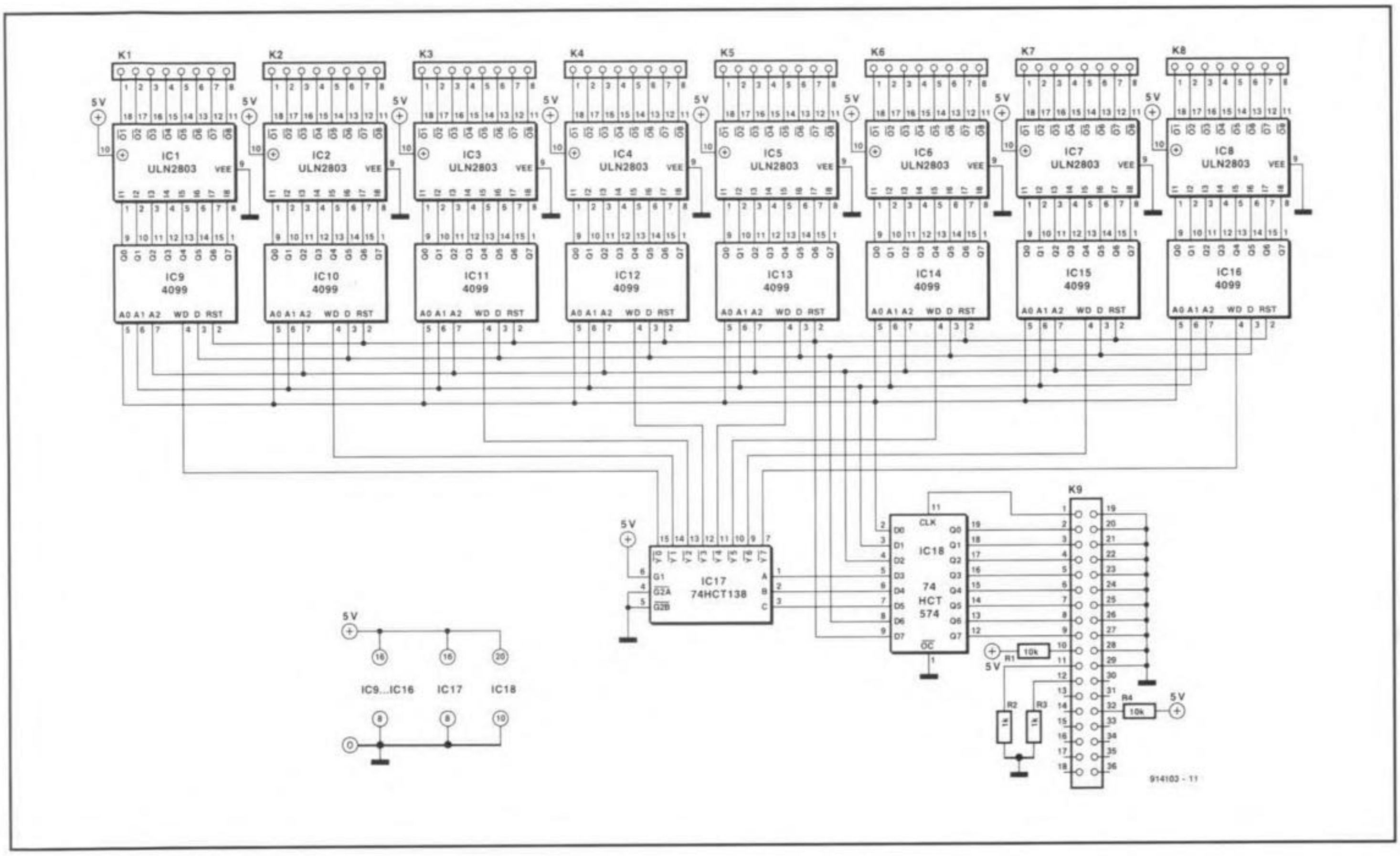
The data from the interface are clocked in IC_{18} with the strobe signal. The three least significant bits are applied directly to the three address inputs of eight-bit addressable latches IC_9–IC_{16}. These latches are addressed by the next three data bits via address decoder IC_{17}. In that way, the six least significant bits form the number of the output bit to be addressed (0–63).

Whether the addressed output is high or low depends on data bit 6. Since drivers IC_1–IC_8 invert, the logic level at the output is inverted with respect to bit 6. The driver ICs can switch up to 500 mA per output.

All outputs are reset (the open-collector outputs of the drivers become high-impedance) when data bit 7 is high and data bit 6 is low. The state of the three address bits is irrelevant.

When it is required to set one bit and reset the others rapidly (for instance, by a running light), data bits 6 and 7 can both be made high, whereupon the wanted bit is addressed with the other six bits.

Most loads can be driven directly by the driver ICs, as long as the levels at the output do not exceed 50 V and 500 mA. If it is required to switch the mains, the outputs can be expanded with a solid-state relay. ■



STATIC D.C.–D.C. CONVERTER

by A.B. Tiwana

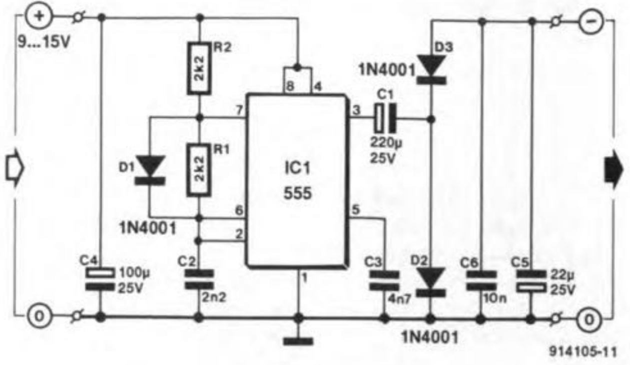
A TYPE 555 timer and some passive components can provide a small converter to provide a negative output of 12 V at a few milliamperes.

The 555 is connected as an astable with a rate of 125 kHz. Network C_1-D_2-C_5-D_3 forms a cascade circuit that supplies a negative direct voltage. Since in the design it was required that neither a transformer nor a coil was used, the efficiency of the converter is not high: not more than 16% at an output current of

Output data for U_{in} = 15 V				
Load (Ω)	U_{out} (V)	I_{out} (mA)	I_{in} (mA)	Efficiency (%)
—	14.3	—	15	0
15 k	12.7	0.85	17.8	4
1 k	10.5	10.5	53.8	14
680	10	14.7	65.5	15
400	9	22.5	85.4	16
330	7.5	22.7	105	11

20 mA. However, in battery-powered equipment requiring a negative supply at only a few mA, that is no hardship. Note, however, that even unloaded, the converter draws a current of about 15 mA.

The output voltage has a ripple of about 0.6 V p-p, which can be suppressed with the aid of a resistor-zener diode network or a low-drop regulator at the output. ■

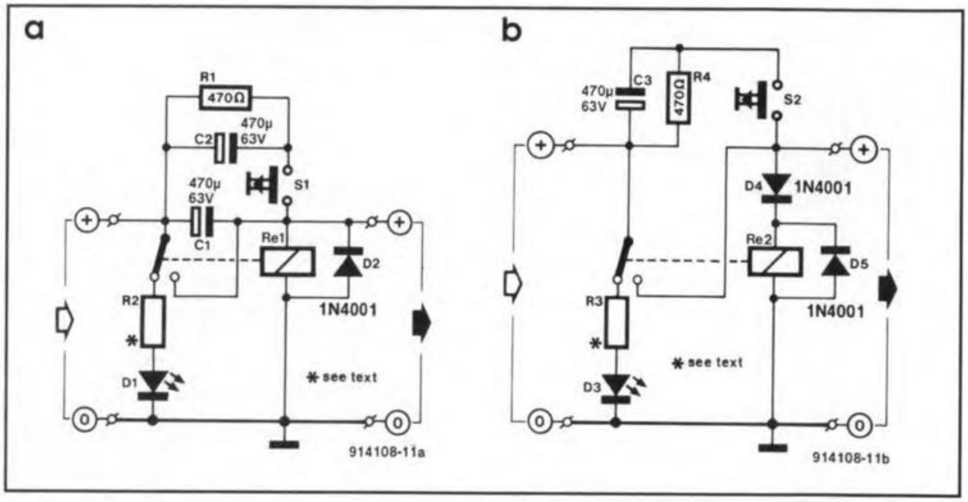


RELAY FUSE

by R. Kuhn

SIMPLE battery chargers and power supplies are not normally provided with a current limiter. In many cases, however, it would be advantageous if the unit were proof against short-circuits. An electro-mechanical fuse which serves that function and which can be added to the unit is shown in the diagram. There are two variations, one for power supplies (a) and the other for battery chargers (b). The circuit will be described on the basis of (a).

When power is switched on, the relay gets a short energizing pulse of current via C_1. Since the relay contact then changes over, the relay remains energized. When a short-circuit occurs at the output terminals of the power supply, the relay is deenergized and the connection between input and output is broken. The relay is re-energized by a new pulse of current via C_2 after the short-circuit has been removed and S1 is pressed briefly. Capacitor C_2 also prevents an overload if S_1 were pressed while the short-circuit persists. The capacitor is discharged via R_1 when S_1 is opened. Diode D_1 (biased via R_2) shows when the circuit is off.



The diagram for battery chargers differs in one respect from that described: on power-on, the relay is not energized via a capacitor, but by the battery on charge via D_4. In case the battery is so flat that it can no longer supply sufficient current to actuate the relay, the relay can be energized, via C_3-R_4, by-pressing S_2 briefly.

The value of bias resistors R_2 and R_3 depends on the LED used and the supply voltage. The relay voltage must, of course, also be in accord with the supply voltage. ■

OVERLOAD INDICATOR

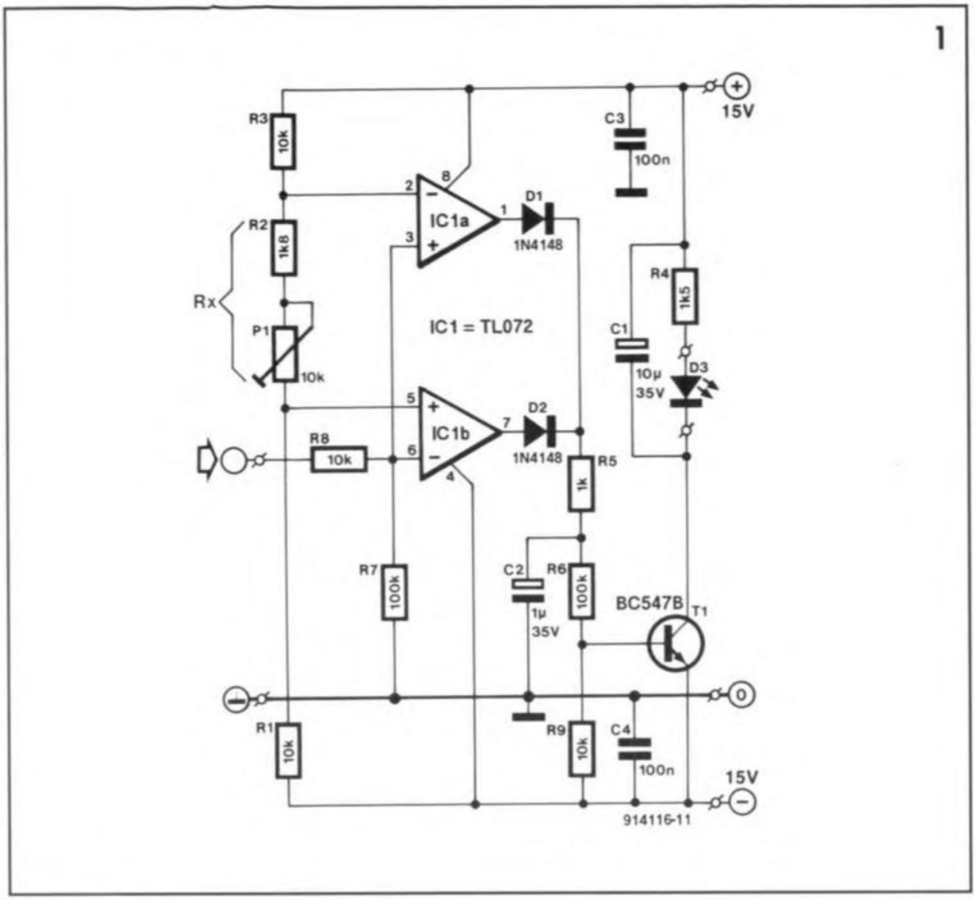
by W. Teder

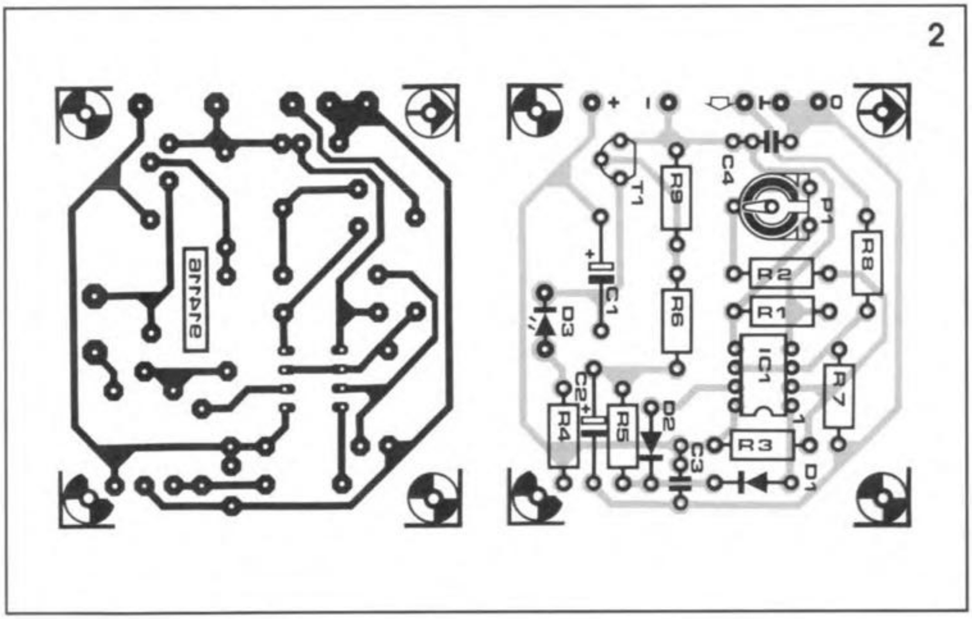
THE overload indicator consists of a window comparator that measures the magnitude of an a.f. signal. Two of the opamps contained in an TL072 are supplied with a reference voltage by potential divider R_1–R_2–R_3–P_1. The outputs of the opamps drive T_1 via diodes D_1 and D_2 (that function as half-wave rectifier), which in turn actuates D_3. Network R_5–R_6–C_2 ensures that the LED lights even during short signal peaks. Capacitor C_2 is charged fairly rapidly via D_1 (or D_2) and R_5, after which it discharges slowly via R_6, R_9 and the base-emitter junction of T_1. Capacitor C_1 also contributes to the longer lighting of the LED.

When the level of the signal at the input is high enough, IC_{1a} is toggled by the positive half periods of the signal and IC_{1b} by the negative halves. In this way, a peak above the maximum level will be indicated even when the signal is asymmetrical.

Because of the symmetrical power supply and design of the indicator, the reference voltage for both opamps can be set with one potentiometer.

The circuit draws a current of 5–6 mA when the LED is off. When an overload peak is indicated, the LED draws an additional 20 mA. With values as shown, the reference voltage can be set roughly between 0.9 V





and 5.5 V.

The circuit can be connected to the output of a power amplifier, but potential divider R_7–R_8 then needs to be adapted and protected by diodes to the supply lines. ■

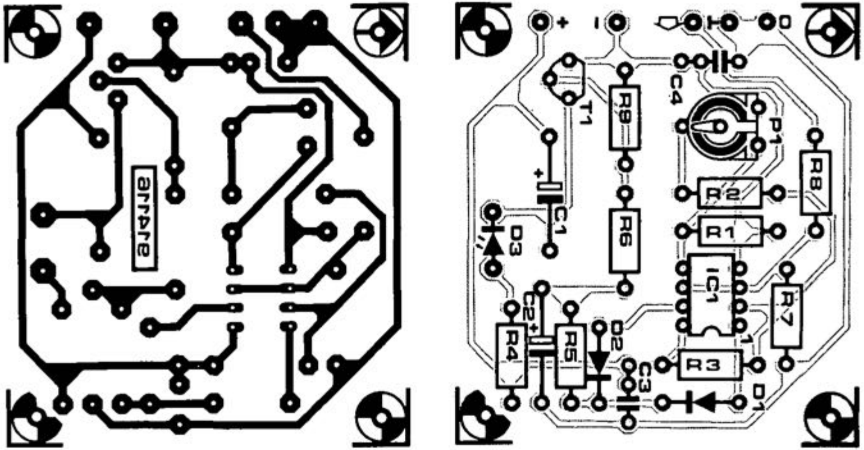
PARTS LIST

Resistors:
R1, R3, R8, R9 = 10 kΩ
R2 = 1.8 kΩ
R4 = 1.5 kΩ
R5 = 1 kΩ
R6, R7 = 100 kΩ
P1 = 10 kΩ preset

Capacitors:
C1 = 10 µF, 35 V
C2 = 1 µF, 35 V
C3, C4 = 100 nF

Semiconductors:
D1, D2 = 1N4148
D3 = LED, red
T1 = BC547B
IC1 = TL072 or TL082

2



HORSE SIMULATOR

by G. Lausches-Dress

HERE is a way of faithfully reproducing the movements of a horse: with a rotary switch that enables selection of step, trot, gallop to the right, gallop to the left, and backward. The manner in which the horse puts down its hoofs is indicated clearly by LEDs. The simulator forms, therefore, a versatile demonstration model for instructors and learner riders.

The patterns for driving the LEDs are provided by EPROM IC_4, whose hex dump in the table shows the relevant addresses and associated data. Addressing is carried out with S_{3a} and counter IC_1. Oscillator IC_{3c} ensures that successive addresses are generated automatically. The speed with which the horse moves can be set with P_1. The oscillator can also be switched off by closing S_1. If that is done, S_2 must be pressed briefly before the next pattern is supplied to the LEDs.

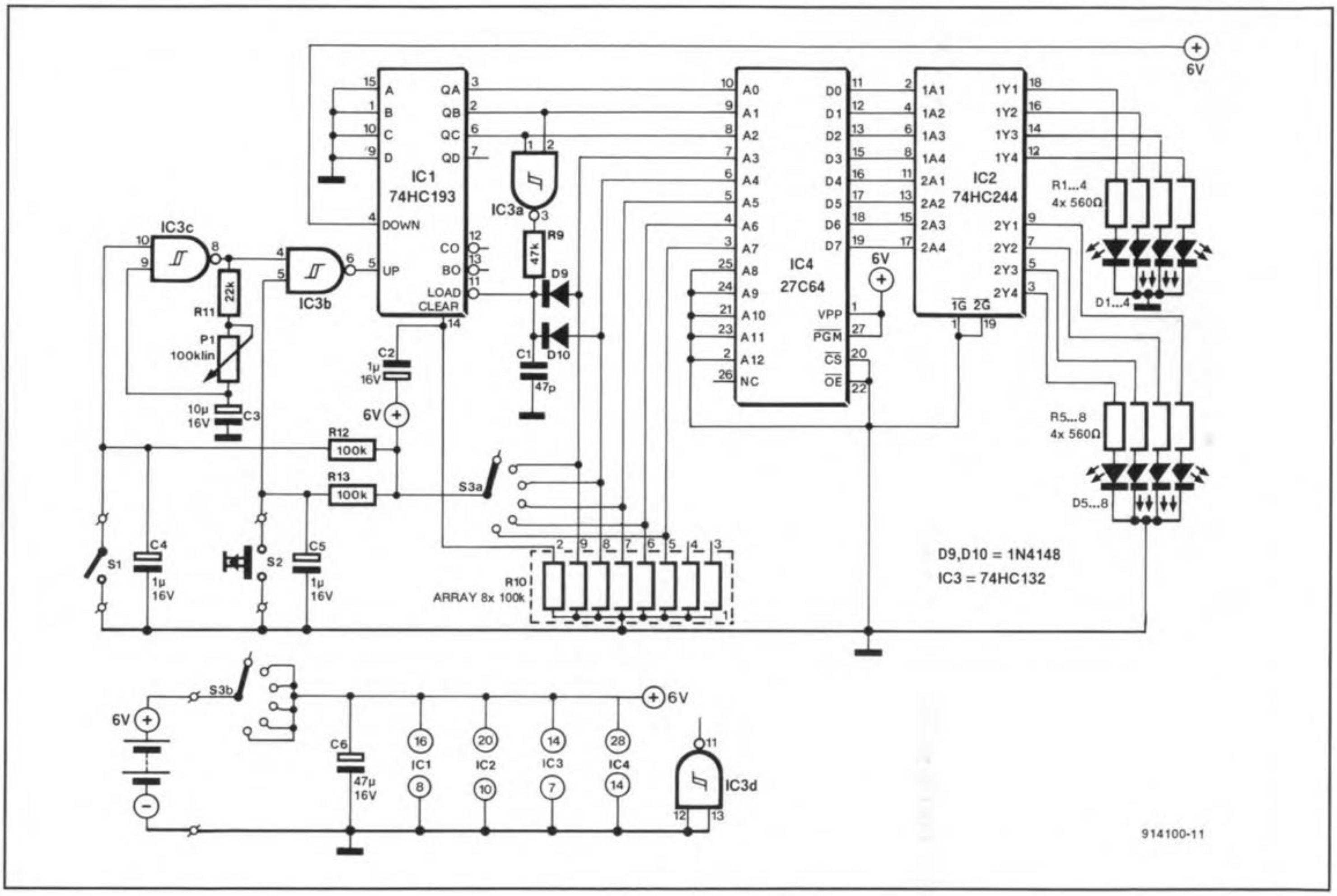
When correct addresses are generated, a reset pulse is passed to the counter by IC3a. The power-up reset is provided by C2 and one of the resistors of array R10.

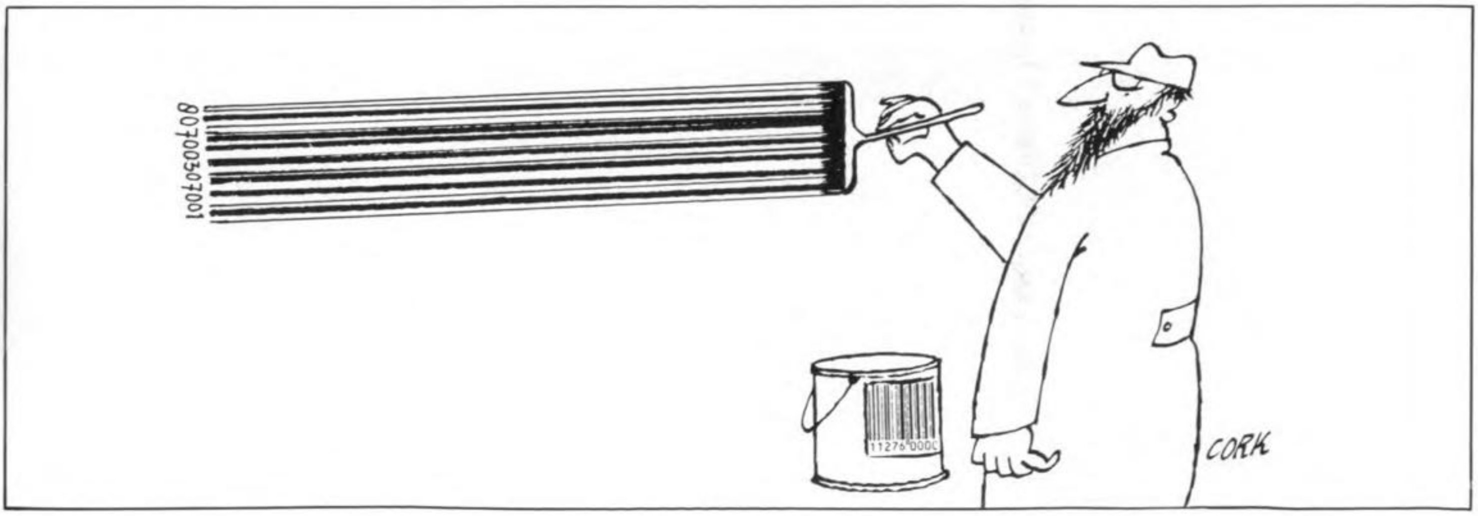
The circuit is operated by a 6 V battery. An separate on/off switch is not required because that function is already provided by S3b. In operation, the circuit draws a current of only 35 mA.

The simulator can be built on a piece of prototyping (vero) board. The only important thing during the construction is to ensure that the LEDs are configured as shown, that is, two rows of four LEDs each with D_1 at the top left and D_5 at the bottom left. The head of the horse is then at the right and its tail at the left. ■

Tabel 1. EPROM-Listing.

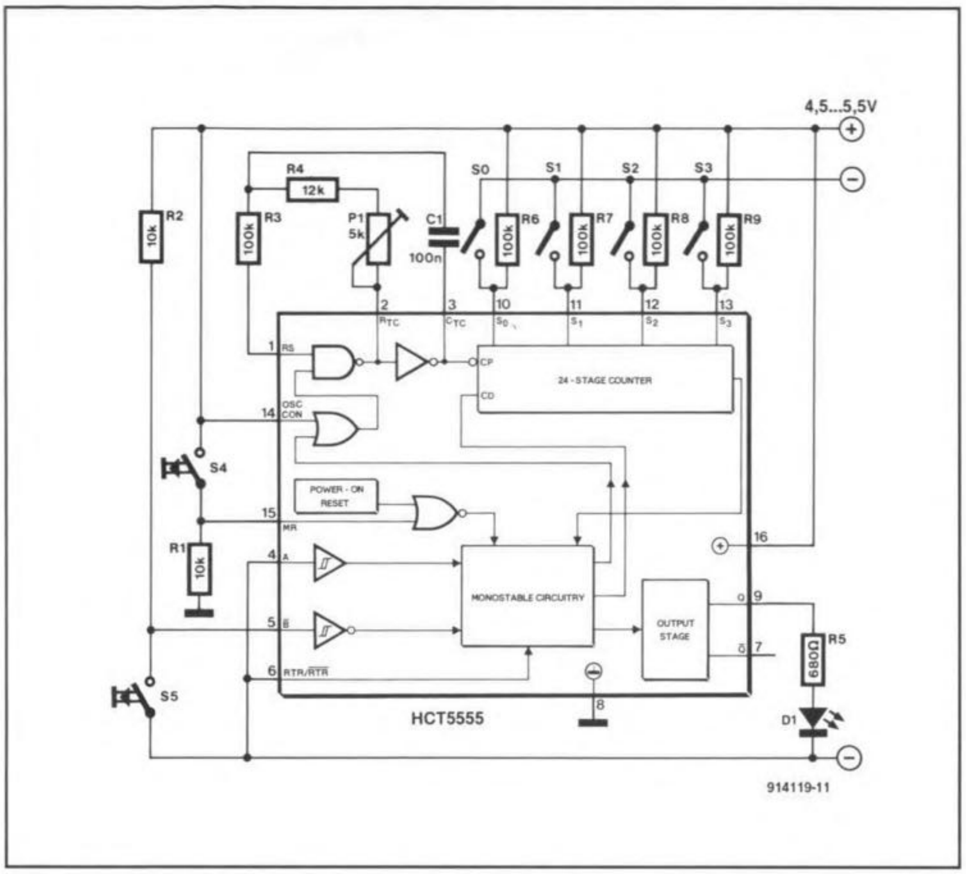
00000:	00 00 00 00 00 00 00 00	85 84 92 90 A2 22 2A 09
00010:	84 00 21 00 84 00 21 00	00 00 00 00 00 00 00 00
00020:	01 45 44 54 10 00 00 00	00 00 00 00 00 00 00 00
00030:	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
00040:	80 A2 22 2A 08 00 00 00	00 00 00 00 00 00 00 00
00050:	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
00060:	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
00070:	00 00 00 00 00 00 00 00	00 00 00 00 G0 00 00 00
00080:	5A 12 96 48 69 5A 00 00	00 00 00 00 00 00 00 00
00090:	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
000A0:	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
000B0:	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
000C0:	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
000D0:	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
000E0:	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
000F0:	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00





DIGITAL 555

by K. Walters



select inputs				divisors	
S3	S2	S1	S0	binary	decimal
L	L	L	L	2^1	2
L	L	L	H	2^2	4
L	L	H	L	2^3	8
L	L	H	H	2^4	16
L	H	L	L	2^5	32
L	H	L	H	2^6	64
L	H	H	L	2^7	128
L	H	H	H	2^8	256
.	.	.	.	.	.
H	L	L	L	2^{17}	131 072
H	L	L	H	2^{18}	262144
H	L	H	L	2^{19}	524 288
H	L	H	H	2^{20}	1 048 576
H	H	L	L	2^{21}	2 097 152
H	H	L	H	2^{22}	4 194 304
H	H	H	L	2^{23}	8 388 608
H	H	H	H	2^{24}	16 777 216

AFTER many years, there is finally a digital version of the well-known Type 555 timer IC: the HCT5555. The traditional 555 can be used as astable or monostable, with the timing determined by an *RC* network. Crystal control is not possible and when the time constant is long, accuracy goes by the way.

The HCT5555 is intended purely as a monostable; if operation as an astable is required, a number of external components must be added—see diagram. The timing is arranged, however, by a separate integral oscillator and programmable divider. Owing to the greater number of facilities, the new device is not housed in an 8-pin case like the 555, but in a 16-pin package.

The chip has two trigger inputs: one for first transitions (A) and one for last transitions (B). These inputs can be interlinked: the mono time, determined by the oscillator and the set scaling factor, then starts at each and every transition of the input signal. When one of the inputs is actuated, output Q goes high. There is a complementary output $\overline{Q}$.

Some of the new terminals are:

- MR (pin 15)is the Master Reset;
- retriggerable (pin 16), which determines whether the IC reacts to trigger pulses when the mono time has not yet lapsed;
- OSC(illator) CON(trol) (pin 14) via which the integral oscillatgor can be stopped.
- pins 1, 2, and 3, are used for the oscillator, while pins 10-13 determine the scaling factor—see table.

A possible application of the new device is the timer as shown in the diagram that indicates when, for instance, NiCd batteries have been on charge for 14 hours. The LED then goes out (or just comes on if the $\overline{Q}$ output is used). The oscillator is set to 333 Hz with P_1 (R=1.84 kΩ). Leave all switches open or omit them altogether.

The supply voltage depends on the type of IC used: the HCT version needs 4.5–5.5 V, whereas the HC version can operate from 2–6 V. The IC draws about 0.5 mA. ■

DIGITAL FUNCTION GENERATOR – PART 3

by T. Giffard

POPULATING the four boards should not present any problems. As usual, care must be taken to ensure that, where appropriate, the polarity of components is observed and that soldering is carried out neatly. IC sockets, when used, should be high-quality types with gold-plated contacts.

On the display board, the 7-segment display must be fitted in a suitable socket that is mounted a little above the board. The ICs should be soldered, not fitted in a socket. The connectors with protection collars must

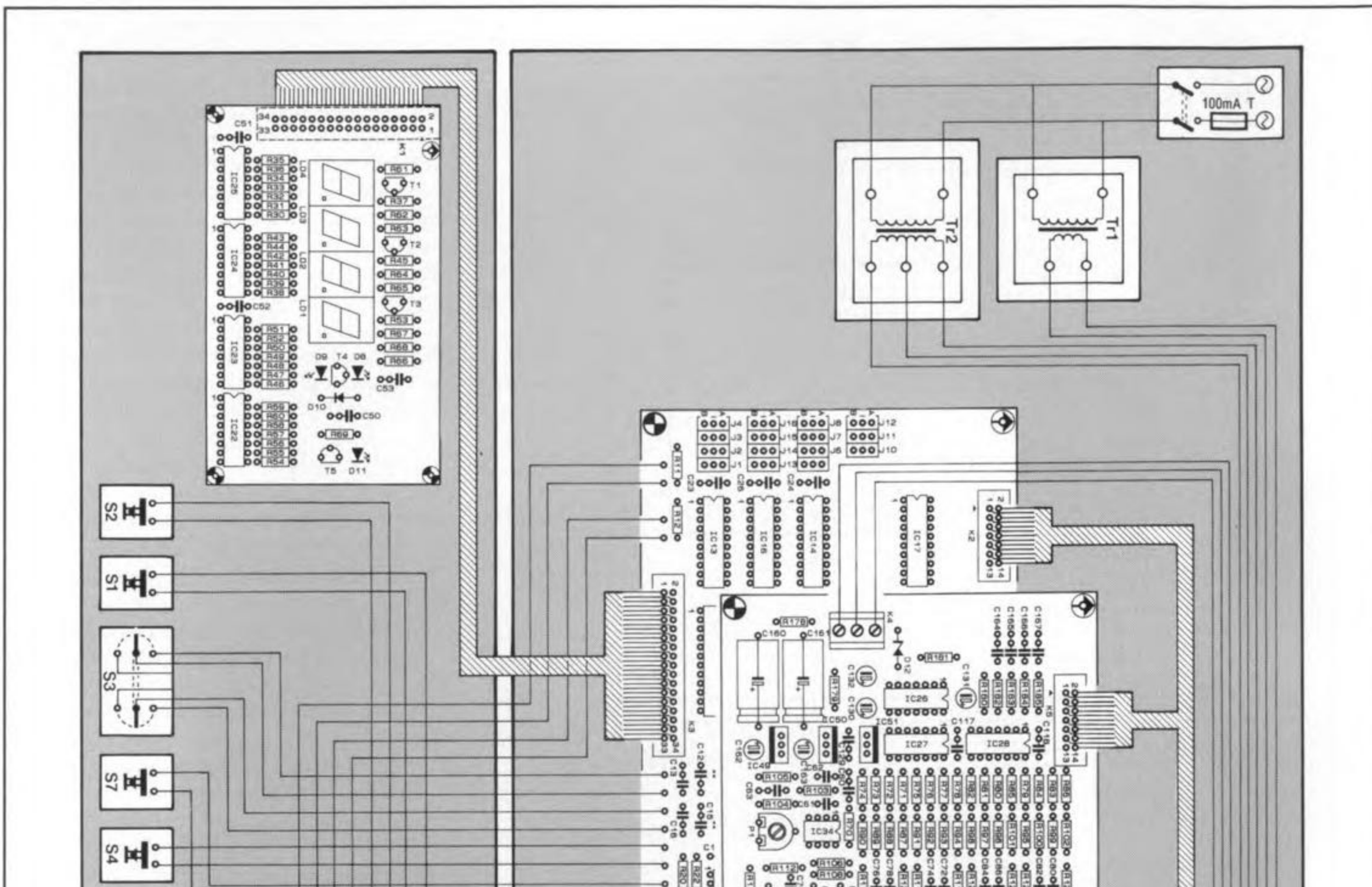


Fig. 24. Wiring diagram of the digital function generator.

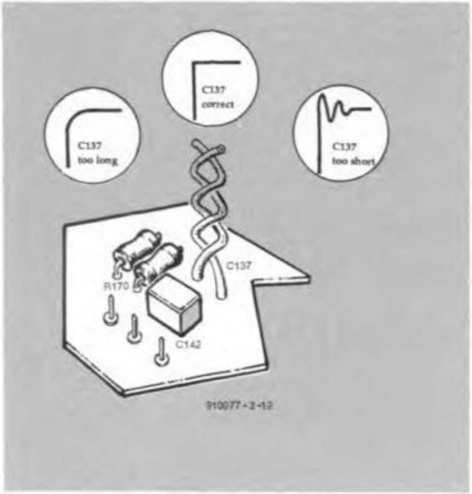


Fig. 25. Construction of C37.

be fitted at the track side of the board. Do not fit the three LEDs until the board has been fastened to the front panel of the case.

The printed-circuit boards for the digital section, the rectangular/triangular waveform converter, and the sine wave converter are inter-joined into a three-layer construction. Any connecting wires to the front panel controls should be soldered to the relevant pins on the boards before these are joined together. Use normal insulated circuit wire and make the connections rather longer than eventually required. This does not apply to the connections to output level control P_3 and to the BNC sockets, which should be in screened audio cable: the screen should be left unconnected at the front panel. This method of building is necessary, because functional tests will be carried out before the overall construction is begun.

Connect a suitable 9 V supply to the relevant points on the digital section board. Connect an oscilloscope to pin 6 of IC_{1d} and adjust C_2 until the oscillator in IC_1 generates a signal of 40 kHz. The frequency of the signal at pin 3 of IC_4 should then be 160 Hz. Next, adjust the core of L_1 so that the VCO operates correctly at both minimum and maximum drive voltage.

Connect the display board to the digital section board and press S_1 (DOWN) until the lowest display position (1000) has been reached. Then, with the oscilloscope connected at the VCO output, pin 6 of IC_5, adjust L_1 for a frequency on the oscilloscope of 2.56 MHz. The level at pin 13 of IC_4 should lie between 0.3 V and 5.7 V.

Check the function of the various switches and insert the jump leads as required in accordance with the instructions in Part 1.

Mechanical construction

The boards for the digital section, the rectangular/triangular converter and the sine wave converter must be screwed together with the aid of suitable spacers. Next, make the connections in flatcable between K_2, K_5 and K_8 and the power supply connection in suitable cirircuit wire to K_4 on the sine wave converter board and to K_9 on the rtectangular/triangular converter board.

Then, make the various holes in the enclosure: for the front panel, use a photocopy of the front panel foil as template (do not use Fig. 11, which is not the right size). Do not forget the four holes for fastening the display board: use a photocopy of Fig. 13 as template.

Fit the mains transformers on the bottom panel of the enclosure, and the mains entry and on/off switch to the rear panel.

Finally, make all electrical connections between the various boards and front panel controls: consult the overall wiring diagram in Fig. 24.

Calibration

Connect a multimeter at pin 6 of IC34, switch on the generator, leave if for a few minutes, set the frequency to 1000 Hz, and then adjust P_1 for zero reading on the multimeter.

Connect an oscilloscope to pin 7 of IC_{42} and adjust P_4 until the rectangular signal is symmetrical with respect to the base line on the oscilloscope.

Connect a multimeter across R_{163} and an oscilloscope to output socket K_7. Set S_8 to triangular wave, P_8 to maximum and P_7 to the centre of its travel. Next, P_6 (amplitude of the input signal to IC_{41}) and P_9 (regulating time) must be adjusted, but here a compromise must be made. The aim is to keep the time the generator requires to stabilize after a change of frequency short, yet long enough at low frequencies as mentioned earlier.

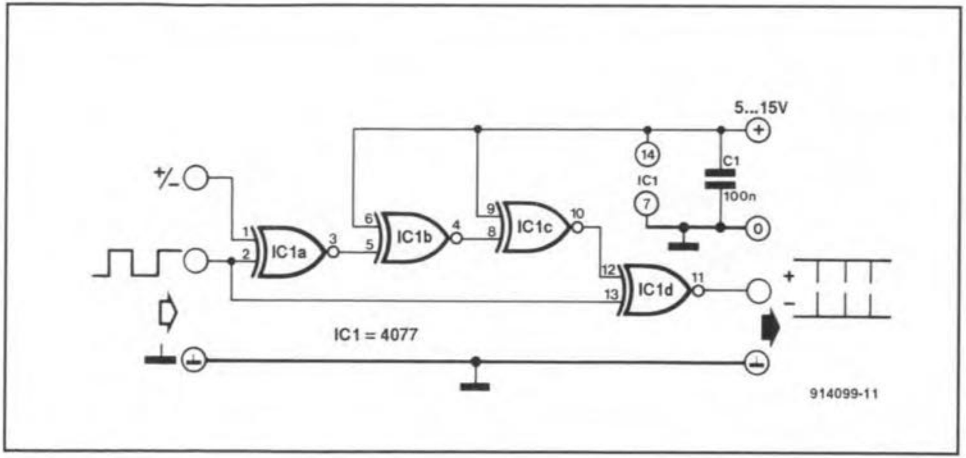
Connect a multimeter to pin 1 of IC_{42} and adjust P_5 till the multimeter reads zero.

Set S_8 to rectangular wave and connect an oscilloscope to output socket K_7. When the capacitance of C_{137} is correct, a true rectangular wave will appear on the screen. If the waveform has rounded corners, the capacitance is too large, whereas if it shows overshoot, the capacitance is too small. These effects are shown in Fig. 25. If the capacitance is too small, C_{137} must be remade; when it is too large, it may be shortened millimetre by millimetre with sharp side-cutting pliers until the waveform is correct. Take care not to damage the enamel insulation. In some cases, it may be found that the capacitance of the track on the board is sufficient and C_{137} is not required at all. ■

PULSE SHAPER

by T. Giffard

THE diagram shows how the four gates contained in a 4077 may be used to build a circuit that doubles the frequency of a signal applied to it. In other words, it generates a pulse for every edge of the input signal: the pulse width is determined by the internal delay of gates IC_{1a}–IC_{1c}. To that end, the original signal at pin 13 is compared with the delayed signal at pin 12. Because of the XNOR function of IC_{1d}, any level difference between the two is translated into a level change at the output of IC_{1d}.



The quiescent output level at pin 11 is set by connecting the ± input of IC_{1a} to ground or to the +ve supply rail. If it is taken to ground, IC_{1d} delivers a zero level followed by positive pulses for each of the edges of the input signal. If it is linked to the +ve supply rail, IC_{1d} outputs a high level followed by negative pulses for each of the edges of the input signal.

Instead of a 4077, a 4030 or 4070 may be used, in spite of the fact that these have XOR instead of XNOR gates. Only the pulse width of the output signal will be slightly different owing to the changed transfer time in the gates.

The current drawn by the circuit depends on the signal frequency: at very low frequencies, it is virtually nil. ■

DESIGN IDEAS

The contents of this column are based solely on information supplied by the author and do not imply practical experience by *Elektor Electronics*

6-digit coded a.c. power switch

by K.A. Nigim, B.Sc., Ph.D., MIEEE

DIGITALLY coded switches are useful and have many applications: for the individual who does not want to carry a heavy bundle of keys for his home or his business premises; in industry, remote or coded switched power devices are also appreciated.

The 6-digit coded power switch described in this article can be used to switch a.c. loads of up to 25 A ON and OFF *directly*. Moreover, the output signal from the electronic circuitry can be used to interface with many alarm and control systems.

The six digits are keyed in one at a time, in the correct sequence, on a standard 4×3 telephone-type keyboard. In case of a wrong code being input, a signal is available to actuate an alarm circuit or buzzer. When that happens, the system can be disarmed with a *secret* reset button that may be any number on the keyboard.

Assuming a correct code is input, a signal is transmitted to

- a latch circuit that commands the power switch to change its current state, and
- auto-reset the circuit in readiness for the second command.

The circuit, whose diagram is given in Fig. 1, is built around four Type 4013BE CMOS dual D-type bistable (flip-flop) ICs, a Type 4069B inverter IC, a Type MOC3063 optoisolator and a Type BTA 26-600B triac.

Coding section

The push-button keyboard is connected to the main circuit board via a 12-way PCB terminal connector, allowing an easy and quick way to change the proper number. After the wanted six digits have been chosen (here, 012457), the remainder, except the one for manual reset, are tied to the dummy switch terminal.

The circuit is powered by a 9–12 V regulated d.c.source. The common terminal of the keyboard is connected to the positive rail. Whenever a switch is pressed, a high level potential is applied rapidly to the appropriate input and charges the capacitor connected in series with it. The capacitor discharges slowly through the resistor shunting it every time the switch is released, thus eliminating switch bounce effects.

When the first digit has been entered correctly, a high level is applied to pins 10 and 11 of IC_1, which results in a change from low to high at pin 12 of this IC. That is the initializing pulse and the aim is to use this to command the power switch to change its state. Therefore, the pulse is fed directly to the data input (pin 5) of IC_2, waiting for the second digit to be entered to the clock input (pin 3).

The data is transferred to the output port (pin 1), which in turn is connected directly to the data input of IC_{2b} (pin 9) waiting for the third digit to be entered to pin 11.

This process continues until all six digits have been keyed in, one at a time, in the correct sequence. The pulse has then moved from the first bistable (flip-flop) to the latch part of IC_{4a}. It is possible to add as many digits

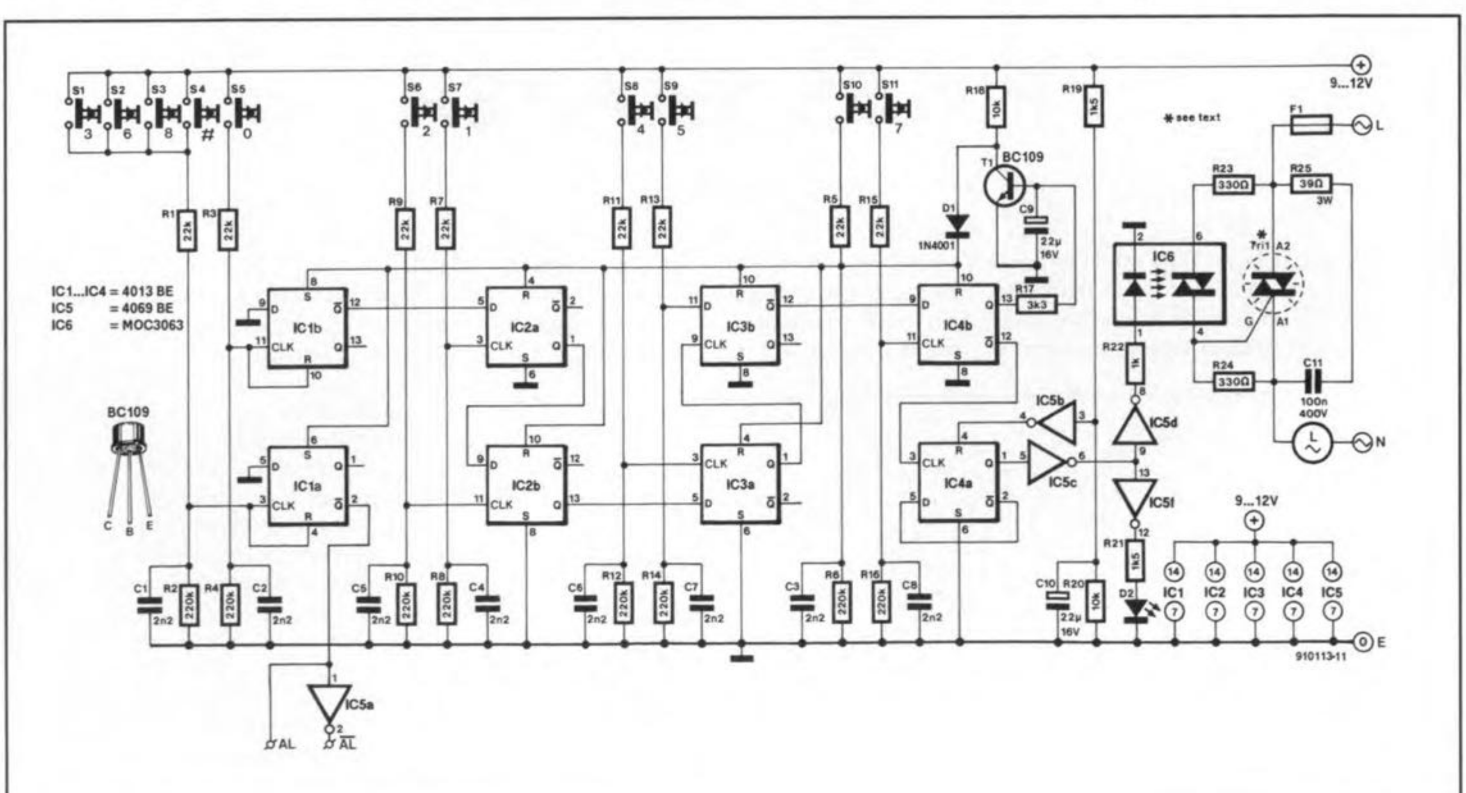


Fig. 1. Circuit diagram of the 6-digit coded a.c. power switch.

to the code as wanted merely by increasing the number of bistables: two digits per IC.

When a wrong digit is keyed in, the state of pin 2 of IC_1 is changed instantly and a high or low level output is available for use with an alarm circuit or a simple buzzer. The circuit is reset with the *secret* switch, here S_{10}.

To reset the circuit automatically every time the correct code is entered, the reset line is given a 20 ms delay pulse, generated by T_1; the delay is the time constant of network R_{18}–C_9.

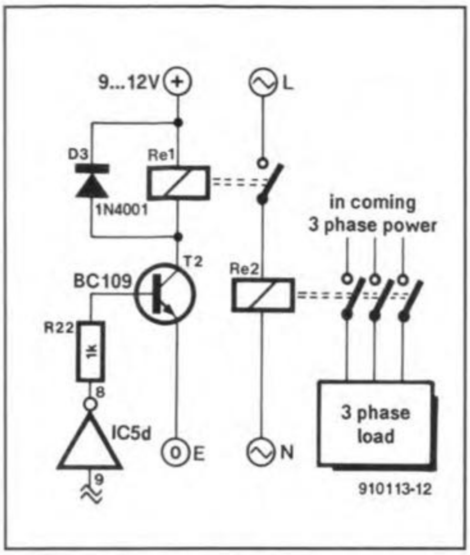


Fig. 2. Slave-master relay configuration for use with large industrial systems.

Latch and triac driver

After the correct code has been entered, the output pulse will disappear as soon as the auto-reset signal is applied. To drive the power switch, the output (pin 1) of a bistable or latch in IC_{4a} will stay on or off until a second signal is generated by the same code. A green LED, D_2, will light to indicate a successful entry and the latch state.

It was found that every time the power supply is switched on, a false trigger could be intiated by the latch and, therefore, the reset input (pin 4) of IC_{4a} is disabled for an instant by a delayed high signal via IC_{5b}. The delay is determined by R_{19}–C_{10}.

The output of the latch is buffered and connected to the zero-crossing optoisolator. The input current to IC_6 is limited to 15 mA by R_{22}. The use of a zero-crossing isolator minimizes the electromagnetic interference normally associated with switching power devices and isolates the electronics from the mains supply.

The a.c. load is connected to the mains via a suitable load-rated triac mounted on an appropriate heat sink. To drive a load of up to 25 A, a triac Type BTA 26-600B or equivalent can be used mounted on a 2.4–3.3 K/W heat sink. Suppressor network R_{25}–C_{11} is included for loads with a poor power factor ($\leq$0.6). The triac must be mounted well away from the main logic board to avoid potentially fatal electric shocks.

Although the circuit described has been designed primarily for driving single-phase a.c. loads, it can be modified by adding the slave-master relay configuration shown in Fig. 2 to make it suitable for use with large 3-phase powered industrial loads.

The slave relay, Re_1, is energized or de-energized depending on the state of the latch port (pin 1) of IC_{4a}. When the output signal is high, the relay coil is energized and power is supplied to the coil of master relay Re_2. The three contacts of that relay then close and supply power to the 3-phase load. When the output signal is low, the slave relay is deenergized and breaks the supply to the master relay, whose contacts thereupon open and remove the power from the load.

Construction

Construction of the switch unit is straightforward. Connect the common line of the keyboard to the positive supply rail. Set the required code, reset and dummy digits. Insert all resistors and capacitors. Insert IC_1 and test the operation of the reset, dummy inputs and the first digit. When any dummy switch is pressed, the output of pin 2 of IC_1 should change state. Proceed with inputting the correct first digit and examine the existence of the initializing pulse at pin 12 of IC_1. When all is well, insert the remainder of the ICs and follow the pulse every time the next digit is keyed in. An auto-resetting pulse must be initiated at the end of the process. Varying the value of R_{19} will change the reset time. The green LED (D_2) will change state after a successful entry.

Caution

Great care should be taken when wiring the power switch, since it carries mains voltage. During testing, connect a 40–100 W bulb in place of the load: this should change state every time the correct code is entered. ■

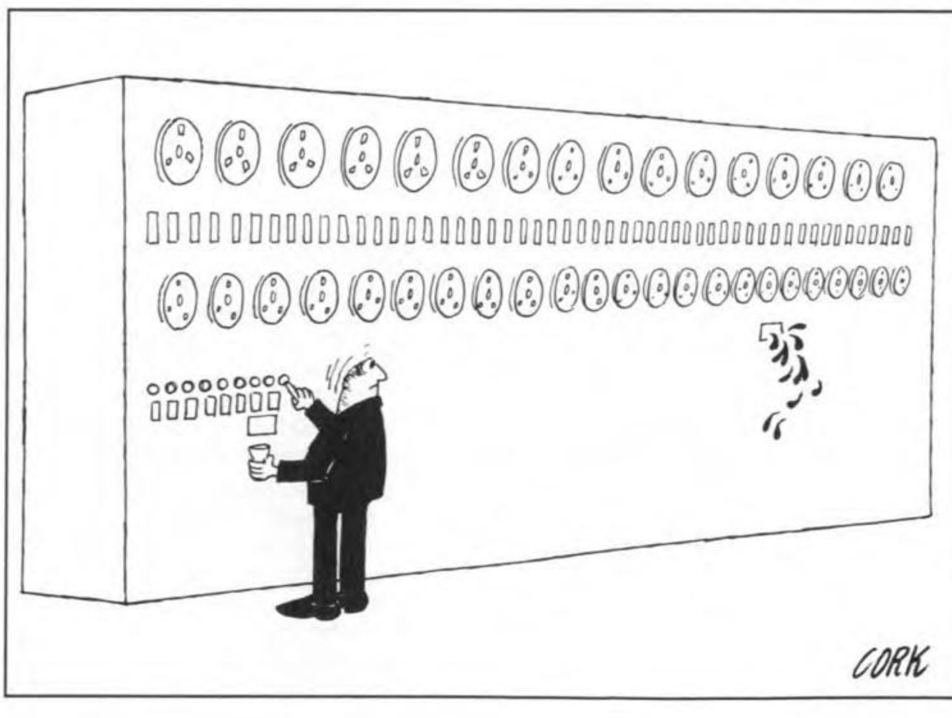
PARTS LIST

Resistors:
R1, R3, R5, R7, R9, R11, R13, R15 = 22 kΩ, 0.5 W
R2, R4, R6, R8, R10, R12, R14 R16 = 220 kΩ
R17, R26 = 3.3 kΩ
R18, R20 =10 kΩ
R19, R21 = 1.5 kΩ
R22 = 1 kΩ
R23, R24 = 330 Ω
R25 = 39 Ω, 3 W

Capacitors:
C1–C8 = 2.2 nF, ceramic
C9, C10 = 22 μF, 16 V, electrolytic
C11 = 0.1 μF, 400 V, metallized polypropylene

Semiconductors:
IC1–IC4 = 4013 BE
IC5 = 4069 BE
IC6 = MOC 3063
T1, T2 = BC109
D1, D3 = 1N4001
D2 = LED. green
Tri1 = BTA 26-600B

Miscellaneous:
Keyboard = standard 3×4
12-way PCB connector for keyboard
Re1 = miniature relay, 12 V, 400 Ω coil; 3 A contacts
Re2 = specified by the load



ALEXANDER GRAHAM BELL

by Douglas Clarkson

IT IS one thing to be remembered for a single clever invention, quite another to have made worthwhile contributions in a broad range of disciplines. The overwhelming importance of Bell's invention of the articulate telephone overshadows many of his other contributions to the education of the deaf, aeronautics, telegraphy and marine engineering. It is obvious that he was driven by strong humanitarian instincts to use the emerging technology for the benefits of society in general.

Events in his personal life highlighted his awareness of the problems created by physical handicaps. Bell was born in Edinburgh in 1847 and his mother suffered a severe hearing impairment that gave him an insight into the problems of communication thus created. His father, Andrew Melville Bell, was a prominent teacher of the deaf who, in 1862, published a progressive treatise on 'visible speech'—a method of teaching deaf individuals to vocalize and not use sign language.

In Scotland, Alexander Graham Bell's health had never been good and his younger brothers had died at an early age of respiratory problems. A subsequent move of his family in 1870 to Canada and then to Boston in the USA succeeded in restoring his wellbeing, though his health would from time to time suffer from excessive overwork.

Being the son and grandson of speech therapists, Bell was fascinated by all aspects of speech relating to education and training of the deaf. In 1874 he developed the 'photoautograph'—a device that incorporated a human ear and produced a visible indication of sounds on smoked glass. With this apparatus, sounds constructed by a teacher could be copied by a deaf pupil. Unfortunately, the device provided insufficiently sensitive for practical use. Modern technology has since implemented the idea in diverse ways with the use of, for example, frequency analysis and microprocessor-based displays.

Bell's most productive period dates from 1871 when he began teaching at Sarah Fuller's school in Boston by day and experimenting in the fields of electricity and acoustics by night. In 1873, he gained access to the research laboratories of the University of Boston following his appointment there as Professor of Vocal Physiology. Up to the emergence of the telephone in 1876, however, he had to supplement his small income by taking private classes as a teacher of the deaf.

It is quite clear that success with the telephone could have come much sooner if Bell had been allowed to follow his own intuition. His sponsors were more concerned with the 'harmonic telegraph', a system for loading a single telepgraph line with multiple channels of communications, where each channel had a harmonic frequency that could be sent independently over a single wire. While the commercial advantage of increasing the data throughput on existing telegraph lines was significant, it was left to Bell to pursue his vision of the usefulness of the telephone privately.

Bell first succeeded in transmitting oral sounds in Boston on 2 June 1875 after discovering that plucking reeds on the harmonic telegraph could induce an undulating current which would cause the receiving reeds to vibrate audibly. Bell refined this system in January 1876 when he wrote the patent application to include a variable resistance device (microphone) in the transmit section. The patents was filed on 14 February and the system was successfully demonstrated on 10 March. The world was then at his feet.

After the development of the telephone, Bell found much of his time taken up with protecting his series of patents. In all, around 600 challenges were made. By today's standards, Bell was fortunate to have won a series of legal arguments raised by major telegraph companies, such as Western Union, seeking to develop their own implementations of the telephone. No doubt, the respectful appearance of Bell helped in securing of what was in effect a monopoly of all telephone communication in North America.

The tale of the commercial exploitation of the telephone is at least as important as the technical development of the product, though this is seldom touched upon. The general principle that the financial guardians of the Bell system followed was that at each stage of its growth the company was not to be constrained, particularly as regards capitalization. It was determined, for instance, that the State of New York provided the most liberal policies for effective financing of the company.

At each stage in the rapid expansion of the Bell system, there was always the danger that its very success would bring about its downfall. Bell, however, was not a direct player in commercial wheeling and dealing and left that up to individuals like Gardiner Hubbard, his father-in-law. One of the main problems of insufficient capital funding arose from Hubbard's insistence that the telephone equipment should be rented and not purchased outright. This was characteristic of Hubbard's company that manufactured and leased sewing machines.

With his financial position now assured, Bell's role became one of a wealthy philanthropist who was able to to devote time to what interested him personally and provide help to deserving organizations and individuals. A large amount of funding, for example, was provided for educating the deaf.

Some of the most touching photographs in the Bell archives are those of Bell with Helen Keller, who was blind and deaf from an early age. This is where the humanity of the man can be most visibly discerned. In fact, reading of the intensity that such matters were given over 100 years ago, the question begs to be asked: "Are we doing enough today?". In all, funding of around $450,000 was channelled into the education of the deaf during his lifetime.

Another significant technical development was the audiometer, a device used for the assessment of hearing impairment. After winning the prestigious Volta Prize in 1880, Bell helped set up the Volta Laboratory, which succeeded in developing Edison's phonograph into a successful commercial product (called gramophone).

His interest in various fields was in some instances prompted by personal tragedy. Following the death of his infant son from a respiratory complaint, he developed an 'artificial lung', forerunner of the iron lung ventilator. He was also aware of the possibilities of the use of radium for the treatment of cancer as early as 1903. After the loss of the *Titanic*, he experimented with early forms of the sonar system.

Bell was later to return to Canada amid the rugged scenery of Cape Breton Island where at Baddeck he built his beloved house 'Beinn Breagh'. It was here that Bell undertook investigations into diverse fields, such as aeronautics, marine engineering and even the breeding of sheep. Bell's wife Mabel, whom he met as one of his deaf pupils in 1873, took an active interest in his various projects. Indeed, as a major shareholder in the Bell Telephone System, she was a major source of funding, especially for aviation projects.

Mabel, in fact, suggested the formation of the Aerial Experiment Association. Efforts in flight development were rewarded by the flight in 1909 of the *Silver Dart*—the first powered flight in Canada. Investigations of this group led to the independent development of the aileron—essential for stable, controlled flight. Marine engineering held his interest in later years, resulting in the development of the HD-4 hydrofoil, which in 1919 achieved a record speed of 70 m.p.h. in the Bay of Baddeck.

Bell was ever ready to give encouragement to others directly involved in scientific experimentation. He provided funds, for example, for the Michelson-Morley experiment to detect the presence of the *ether*.

Bell was also largely responsible for raising the esteem of the *National Geographic Magazine* to that of a global publication following the death of its founder, Gardiner Hubbard, in 1891.

Setting aside the hugely important invention of the telephone, Alexander Graham Bell should be remembered largely for demonstrating in his various activities that technology should be developed and implemented for the ultimate benefit and welfare of the individual. There can be no doubt, however, that the tremendous advances in world-wide communications that continue to develop, and which have their origin in his work, are a major factor in removing artificial barriers of nationality, culture and political systems. In this regard, therefore, Alexander Graham Bell is largely responsible for beginning the evolution of a 'global

Readers interested in the history of communications may find it intriguing to learn that A.G. Bell's patent application made it by *a few hours*, because later on 14 February 1876 a second patent for the telephone was lodged by Elisha Gray. The applications were virtually identical, describing the electrical transmission and reception of human speech by variations in the resistance of the transmitter (microphone).

Elisha Gray (1835-1901) was a professional inventor whose first patent (granted in 1867) was for a self-adjusting telegraph relay. This proved to be of interest to the Western Union Telegraph Company and so earned Gray enough money to become a partner in a Cleveland firm that manufactured telegraphic instruments.

Gray and his partner, Enos Barton, transformed the company into America's leading maker of electrical apparatus: the Western Electric Manufacturing Company, which eventually became Western Electric, the sole supplier of telegraphic equipment to Western Union.

It is a curious fact that most experts in telegraphy, including Gray, misjudged the importance of the telephone, whereas Bell had always believed that the telephone would eventually be of far greater importance than the telegraph. History has proved him right.

(*Editor*)

ELECTRONIC POWER-ON DELAY

by G. Peltz

THE power supply for the delay circuit is derived directly from the mains by a bridge rectifier, D_1–D_4. The rectifier must be able to handle a current of up to 1 A. For safety reasons, resistor R_1 ensures that capacitor C_1 is discharged rapidly when the mains is switched off. The resistor should, therefore, be rated at 250 V a.c. or 400 V d.c.

The direct voltage output of the rectifier is held steady at 24 V by zener diodes D_6 and D_7. The use of two zener diodes gives a stable voltage of 12 V for IC_1. The rectgifier output is smoothed by C_2 and C_3.

Timing of the circuit is based on the mains frequency: the clock signal is rectified by D_5 and then taken from the junction R_2–R_3 at a level of about 11 V from where it is applied to pin 10 of IC_1. After 2–10 clock pulses, output Q11 goes high. If contact 2 of DIP switch S_1 is closed, that high (12 V) signal is applied to the gate of T_1, an *n*-channel VMOS FET. This transistor then conducts, which causes the relay to be energized.

If, as shown in the diagram, all contacts of S_1 are open, the gate of T_1 is permanently connected to the positive supply rail. That means that as soon as the supply is switched on, the relay is energized.

When T_1 is on, the clock input of IC_1 is low via D_9, so that the counter is disabled.

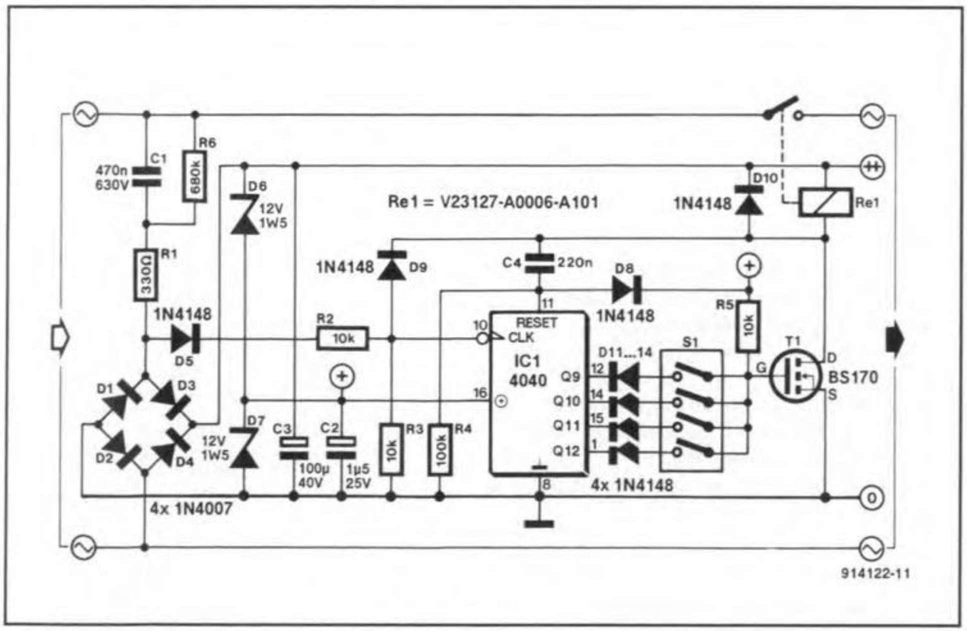
The delays that can be selected with the DIP switch are shown in the table. The DIP switch may for convenience's sake be replaced by a binary-coded decimal (thumbwheel) switch.

Immediately after the supply is switched on, assuming that T_1 does not begin to conduct, the IC is reset by a pulse generated by R_4–C_5. The level of the pulse is limited by D_8 to a safe value. When a new count cycle is started, the IC is, therefore, always in its zero state.

Diode D_{10} is a free-wheeling device to suppress voltage peaks that are caused by the relay coil when the current through it is switched off.

The current drawn by the circuit is determined mainly by the value of C_1: in the diagram it amounts to about 30 mA.

Caution must be exercised because the circuit is connected directly to the mains. The circuit must, therefore, be tested with the aid of an isolating transformer. Furthermore, it should be built into an enclosure that makes it impossible for mains-carrying parts to be touched. ■



DELAY TIMES				
Switches S_1				Time (s)
1	2	3	4	
0	0	0	0	0.0
0	0	0	1	5.1
0	0	1	0	10.2
0	0	1	1	15.4
0	1	0	0	20.5
0	1	0	1	25.6
0	1	1	0	30.7
0	1	1	1	35.8
1	0	0	0	41.0
1	0	0	1	46.1
1	0	1	0	51.2
1	0	1	1	56.3
1	1	0	0	61.4
1	1	0	1	66.6
1	1	1	0	71.7
1	1	1	1	76.8

A WORLD OF COMPUTERS

by C.C. Whitehead

IT MAY surprise many people to learn that computers have been with us since the dawn of history—or even before! It is, however, only in the second half of the present century that ordinary people have had them brought to their notice. Because of recent publicity (among others on BBC television), the name Babbage may stand out. But let us go back to the beginning.

Most people who have to do with computers would casually describe them as 'thinking machines', which would be good enough. That brings us to consider the term 'thinking'. Immediately comes to mind the term 'intelligence'. What is intelligence? This could lead to a great deal of controversy. Some people say that the term 'military intelligence' is a contradiction in terms. But in that connection, intelligence has a different meaning, best interpreted as 'information', upon which real intelligence can be brought to bear.

Now we are faced with the problem of defining intelligence. This again will cause controversy, but in this article it will have the broadest definition so as to cover all possible cases.

The definition might be 'the ability of an individual to react favourably to his/her environment—that is, from the point of view of the individual concerned'.

If we accept this definition, we realize that intelligence is inherent not only in human beings, but in all living creatures and even machines. And this is where the inorganic computer, of which we hear so much, comes in.

This brings us back to the matter of information, and how it is to be transmitted. Using technical terms, we say that it is usually transmitted in either or both of two forms: analogue and digital. Analogue is the form in which it is usually presented to our senses, whereas digital is the form in which it is normally employed in certain units in all computers.

As the computer machine has been developed, it has come more and more to resemble the living computer—particularly the human brain, but with one or two important differences—which we will discuss later.

From this, it may be realized that computers exist in a multitude of forms, from the simplest machine and living creature to the latest product of technology and the human machine.

Many people, particularly those with religious views, cannot accept the idea that physical laws appertain to living creatures. Although the inescapable fact is that they do, there are several aspects to be taken into account. To understand these, we have to consider the basic form of a computer—see Fig. 1. Although this is one of the many forms that a computer may take, the drawing shows all the essential elements. In the simplest form of computer, such as, for instance, a washing machine, the logic and the clock are inherent in the arrangement of its components.

There is a striking similarity between a fully developed inorganic computer, that is, machine, and a fully developed organic computer—the human brain. There are, however, also several important differences between them: some of these are clearly understood, but little is understood of others.

One of the well-understood differences is the 'clock rate' in terms of the number of pulses per second. In the human brain, that rate is about 16 pulses per second (although it varies in different individuals), but in the inorganic computer, it may be a million times faster. This enables calculations to be carried out that would be imposible in the human brain on account of the time involved. The clock controls the speed of operation.

The only thing we know with absolute certainty about the universe in which we live is that it changes.

Karl Marx

A little-understood difference is *emotion*, about which we do not know nearly as much as we would like, and only insofar as it appertains to the human brain. It probably also plays a large part in other organic brains.

Information processed in the basic computer may be in either analogue or digital form. In the 'logic unit', however, it is always dealt with in its digital form. There are only two answers to every question: yes or no, resembling a switch that is on or off as shown in Fig. 2. The problem represented by the switches in that illustration—which may be translated into analogue form at a later stage—exists in the memory and logic units in the form of a pattern as shown in Fig. 3.

It is here that the similarity between the living and non-living computer stands out. In the living human brain, there are untold millions of these tiny switches, as neurologists will testify, very probably more than exist in any inorganic computer. In the most highly developed computers, they exist not only in the logic unit but in the memory as well, and this, of course, applies to the living brain.

There is another important fact about *all* computers, and that is that *they have to be programmed*, that is, told what problem they have to solve and how they must proceed in doing so. How this is done is well known to anyone who uses an inorganic computer. But how does it apply to the living brain? The answer is that it lies in what we call 'education', which is said to derive from the Latin for 'bringing out', although it is quite obviously a process of 'putting in'. *Now you see why governments*

The organic computer generally has the ability to select its inputs from the environment. In the case of an organic computer, the inputs are nerve-trunks.

Information may be stored in many memories in the case of an inorganic computer, but the human brain has only two memories.

The output wiring of circuitry in an inorganic computer is analogous to nerve-trunks in the organic computer.

Bodily functions in the organic computer are equivalent to machine and chemical processes in an inorganic computer.

In an organic computer, the clock rate is generally 16 pulses per second, but in inorganic computers it may be many millions of pulses per second.

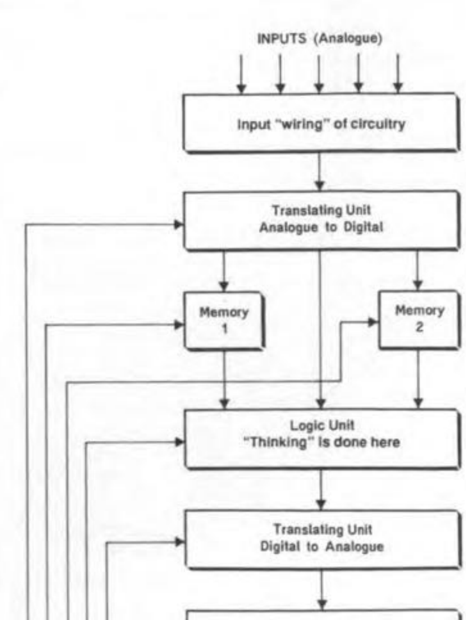


Fig.1. Basic form of a computer.

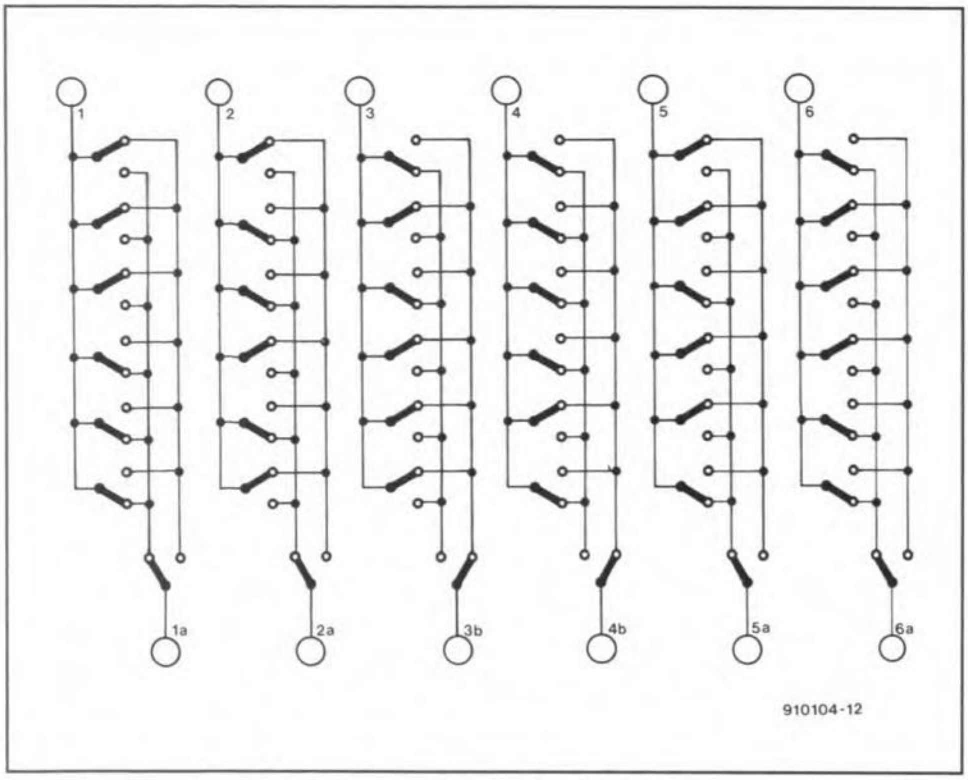


Fig. 2. Computers are, basically, assemblies of switches, each of which represents a 'yes' or 'no'. In this drawing there are 84 switch contacts, whose pattern is shown in Fig. 3. It does not require much mathematical insight to see that even 84 contacts provide an astronomical number of possible patterns. Imagine then the complexity of the human brain that has millions of switch contacts.

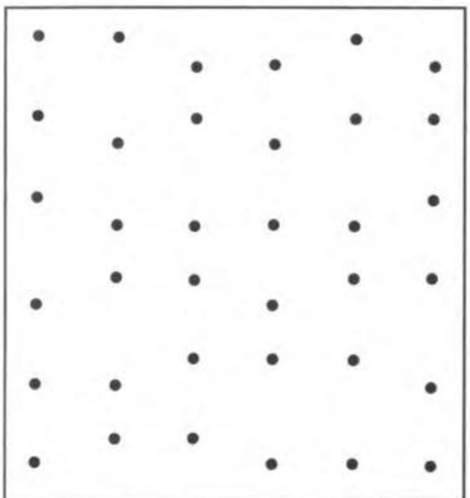


Fig. 3. See caption of figure 2.

are so concerned with 'education'!

Another well-developed form of inorganic computer is the 'automatic factory', where the total output of the computer is translated into analogue terms to make the machine work. In living creatures, there are numerous analogue units. For example, in the human organism, the process of translating the output of the logic unit into analogue terms would appear to take place in the cerebellum and the independent nervous system to control such functions as digestion, excretion, and the supply of hormones.

Now, let's look at it from another angle, that which directly concerns human consciousness and the nature of human thinking. It is important to think carefully about the *real* world in which we are living. Did the dominant animals in the past become extinct owing to the fact that they didn't have enough intelligence to survive or did they have intelligence and did not use it?

The dominant creature in the world today—man—is in imminent danger of extinction if he does not use *his* intelligence. To use that intelligence, we must look at the world as it is *today*.

The comment of Karl Marx quoted above is apposite. In the world as we see it today, that change is very rapid. Changes that in the not too distant past would have taken a hundred years to come about now happen in a period of less than ten years.

It is the economic system brought about by politics that decides what sort of life we shall live or, in simple terms, how we will gain our livelihood.

In today's technology, the computer plays an important role. It is more than just a machine. The highest state of development of the computer shows a startling analogy with the human brain, at least insofar as brain function is known.

There are two basic principles used in the design of a computer. Any computer may employ either or both principles. In the earliest automatic machines and computers, the 'analogue' principle was used.

A source of electrical power is applied to a machine to perform a certain task. The resulting output in terms of electrical power is reversed in phase and applied to the input in common with the original input—negative feedback—as illustrated in Fig. 4. This device is know as a servo system. In the case of an inorganic system, its design involves a high standard of mathematical ability.

The organic system, for instance, the human body, has a multitude of such servo systems that control the movement of muscles and other body functions.

An important difference between the inorganic computer and the human brain is, as stated before, emotion, about which, apart from its overt effects, we know little. It involves self-consciousness, which is most apparent in human beings and the higher-order apes.

The science that embraces computers, calculators and robots is called cybernetics, which means 'steermanship'. Thus, machines that can steer themselves towards a desired goal. Many such machines have been invented over the past two centuries at least, but only to perform one, or at most a few, simple tasks, like many of our household gadgets.

One section of a complete computer, the one that that is most analogous to the thinking part of the human brain—the cerebral cortex—works on the digital principle. This is the *logic unit.*

Other sections of the computer work on the analogue principle and still others use both. In the organic computer, these would appear to be located in the hypothalamus, cerebellum and autonomous nervous system. It appears that the memories use the digital system located in the hypothalamus, since they obviously exist even in lowly forms of animal life.

The hormone system, controlling the chem

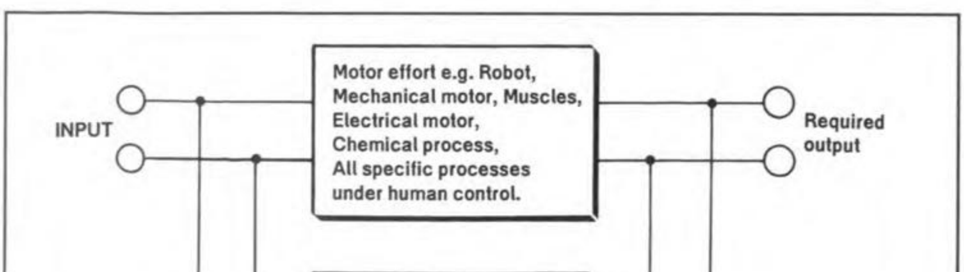


Fig. 4. In some processes, such as the performing of simple tasks by a machine, the 'feedback' control is exercised by a human being: this is called 'management'.

istry of the blood and the beating of the heart (which has its own servo-system) appears to be controlled by the pituitary gland in the hypothalamus. The digestive and excretary systems are controlled by the autonomous nervous system in the trunk; it is separate from the main nervous system, but partly under its control.

The most important part of both the organic and inorganic computer is the memories—the vital core of the whole system. There may be many memories in an inorganic computer system, but the human brain appears to have two: the long-term memory and the short-term memory. They perform separate functions. An older person, whose short-term memory may be failing, can normally recall with some clarity incidents that happened in his or her childhood, but cannot remember something that occurred yesterday.

In order that it can function, the computer must be fed with information and instructions, for which it has a number of 'inputs'. The human brain is fed by the five senses: sight, hearing, touch, smell and kinæsthesia. These inputs enable both types of computer to keep in touch with their environment. The organic computer has the ability to select some of its inputs from the environment; the inorganic computer, however, must be programmed by human beings.

Now, 'programming' is the tricky part of this dialogue, since this is where the different points of view come in. Since programming involves instructions in regard to the task to be performed and the way in which it is to be performed, the religious person will aver that the programming is carried out by God or his counterpart, the Devil, with the connivance of family and acquaintances. The agnostic or atheist will insist that programming is nothing more than the effect of the environment—physical, political and economic. The physical facts are obvious and not necessarily antagonistic to the religious point of view. The political fact is that governments are keenly concerned with the programming, that is, education. And the process always concerns the economy.

If this article makes it appear that the whole universe is a computer, the question arises: "Who is the programmer?" ■

RS232 FOR SHARP POCKET COMPUTERS

by S. Schmid

PROGRAMMING pocket computers is normally a tricky job, owing to the small keys and the small memory. The pocket computers from Sharp, which can be programmed in BASIC, have an interface that can be connected to a special cassette interface. The signals at that interface are very similar to those of an RS232 interface, but they are inverted and have different logic levels. It would, of course, be tremendous if the pocket computer could be linked to larger computer via this interface, because the writing, changing and storing of the software could then be done much more conveniently.

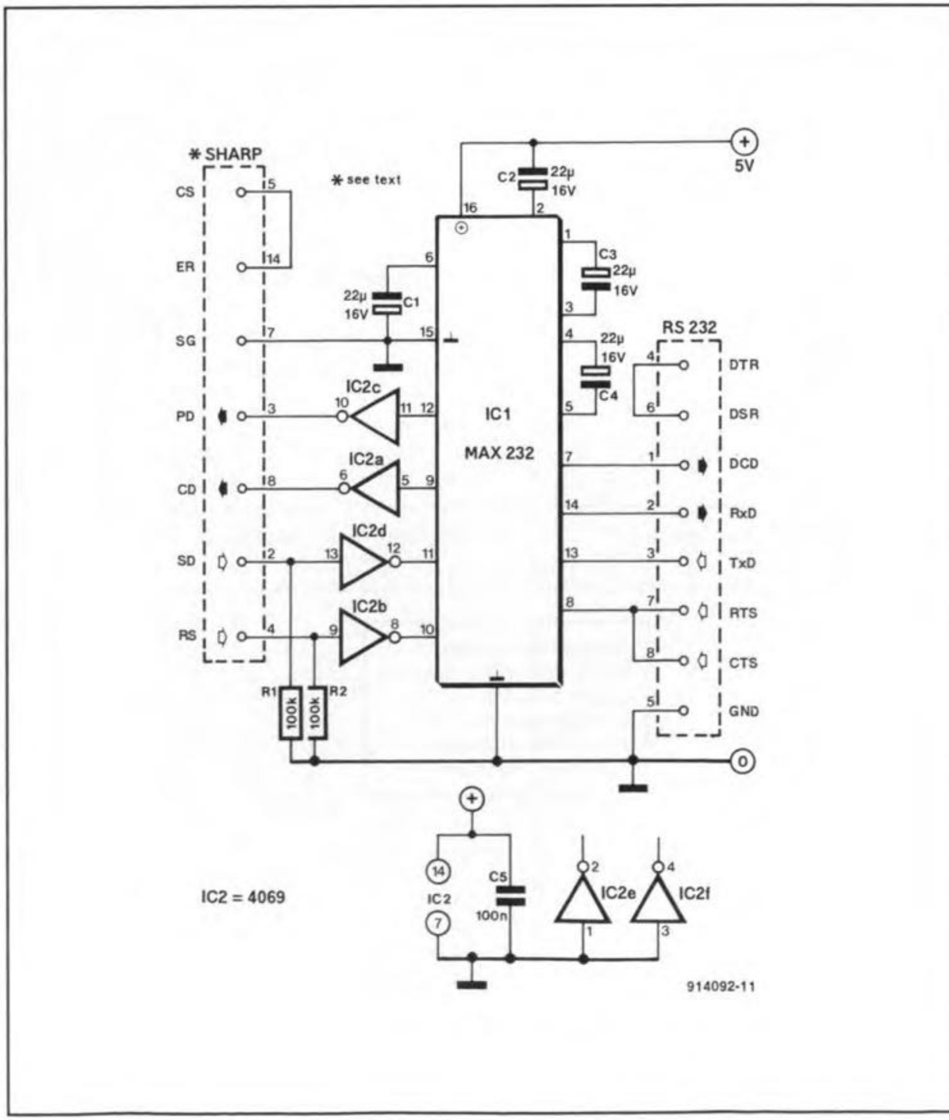
It only requires a small circuit—see diagram—to make that possible. The single 5V supply voltage is converted into ±10 V in IC_1. With these voltages, the buffers in IC_1 can convert the logic signals of the pocket computer into RS232 levels. Inversion of the levels is effected by four inverters in IC_1.

The circuit draws a current of only 30 mA, so that it can be supplied from the larger computer.

The connector to link the interface to the pocket computer presents a little inconvenience, because its pitch (1.27) is rather unusual. Connectors with that pitch are normally too long for this application: the only solution is to cut one to size!

The circuit has been tested with a XON/XOFF protocol, 2400 baud, even parity, 8 data bits and a stop bit. At higher speeds, small problems arose, but that need not always be the case, depending on the software.

The interface of the Sharp pocket computer is set with
OPEN" COM:2400, E, 8,1, A, L, &H1A, X, N": CLOSE. ■



PROTECTION AGAINST DIRECT VOLTAGE

by W. Teder

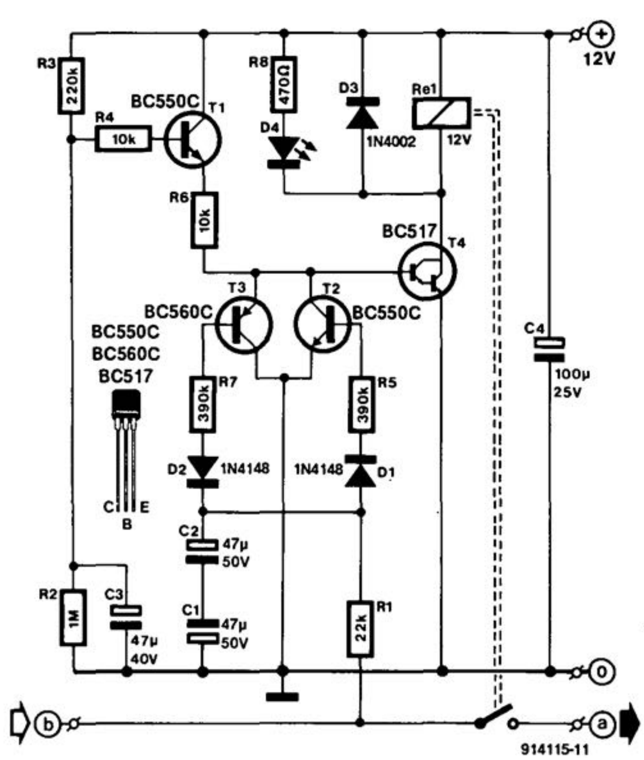
AMPLIFIERS that have no capacitor at their output may, in case of a defect, apply a direct voltage to the loudspeakers and this can destroy the drive units. The circuit shown can prevent such a catastrophy.

It is best to give the circuit a separate power supply: this minimizes any work on the amplifier(s). This supply must, however, be switched synchronously with that to the amplifier(s), since on power-on, T_1 ensures that the relay (which switches the loudspeaker inputs) is energized after some delay. The delay is determined by the time-constant R_3C_3.

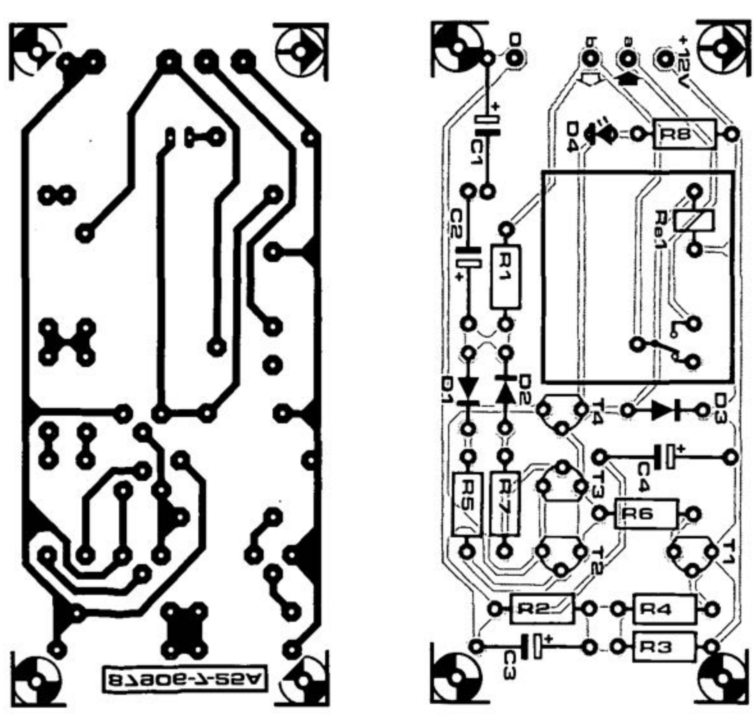
Assuming that the amplifier operates correctly, its output signal at point b is linked to point a, and thence to the loudspeaker(s), via the relay contact. Owing to the time constant R_3–C_3, bipolar capacitor C_1-C_2 cannot be charged by the a.c. signal at point b. If, however, a defect causes a direct voltage at that point, the capacitors will be charged via R_2. Depending on the polarity of the direct voltage, either T_2 or T_3 will be switched on, which removes the base current from T_4 and this results in the deenergizing of the relay: the amplifier output is then removed from the loudspeaker(s).

The supply to the protection circuit must be neither regulated nor smoothed. True, C_4 provides some smoothing, but the important thing is that after the amplifier has been switched off, this capacitor is discharged more rapidly than the smoothing capacitors in the amplifier power supply. This ensures that the relay is deenergized before the amplifier can produce a click in the loudspeaker(s). Depending on the relay, the current drawn by the circuit is about 50 mA. ■

1



2



PARTS LIST

Resistors:
R1 = 22 kΩ
R2 = 1 MΩ
R3 = 220 kΩ
R4, R6 = 10 kΩ
R5, R7 = 390 kΩ
R8 = 470 Ω

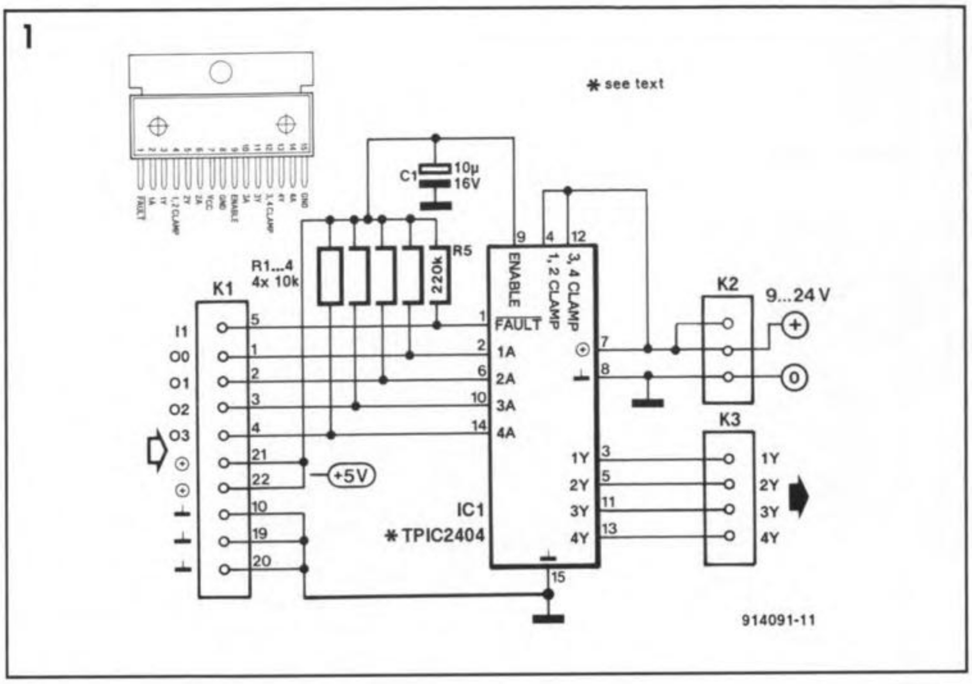
Capacitors:
C1, C2 = 47 µF, 50 V
C3 = 47 µF, 40 V
C4 = 100 µF, 25 V

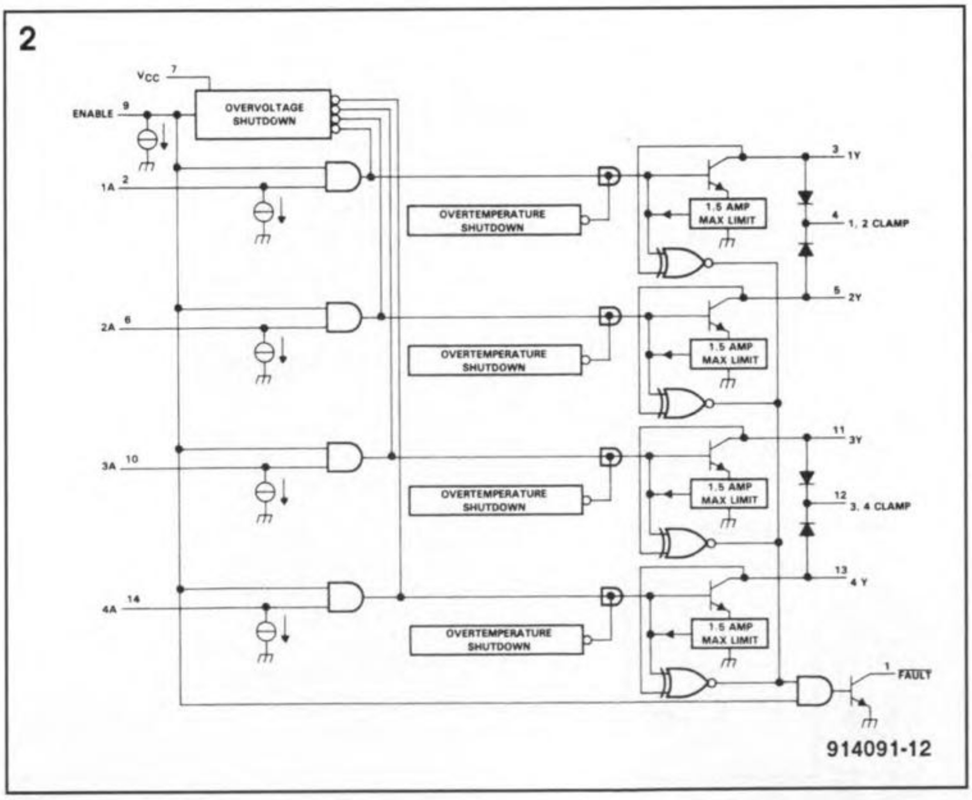
Semiconductors:
D1, D2 = 1N4148
D3 = 1N4001
D4 = LED
T1, T2 = BC550C
T3 = BC560C
T4 = BC517

Miscellaneous:
Re1 = 12 V relay, e.g.
Siemens V23217-A0002-A101

INTELLIGENT POWER SWITCH

by J. Ruffell





TEXAS Instruments' TPIC2404 is a monolithic, high-voltage, high-current, quadruple switch especially designed for driving peripheral loads, such as relays, solenoids, motors, lamps, and other high-voltage, high-current loads from low-level logic. It can switch currents of up to 1 A without any problem; the current may be increased to 4 A by connecting four outputs in parallel. As shown in Fig. 2, the outputs are of the open-collector type.

Connected in a circuit as shown in Fig. 1, the chip may conveniently be used to increase the power handling of the Centronics analogue-to-digital and digital-to-analogue converter published in the May 1990 issue of *Elektor Electronics*. Note that the FAULT output of the IC is connected to input I1 of the converter. This enables the TPIC2404 to indicate the following fault conditions.

- Too high supply voltage (>25.5 V).
- Thermal overload.
- Output short circuit.
- Loads not connected (only if outputs are inactive).

The software regularly monitors the level on line I1 and will indicate a fault condition.

The TPIC2404 must be fitted on to a small heat sink: 8 cm^2 (1.5 in^2). When the chip is used with the converter, R_{31} on the converter board must be disconnected.

The switch draws a current of about 100 mA when all outputs are active. ■

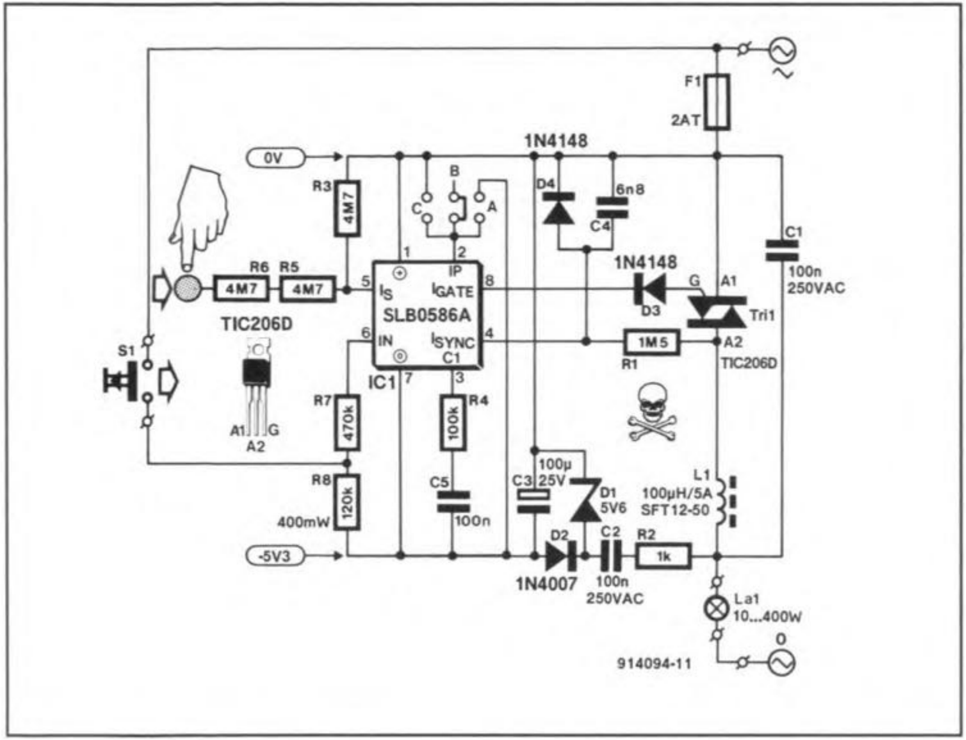
CMOS DIMMER

A Siemens application

SIEMENs' Type SLB0586A IC enables the simple construction of a dimmer with touch control. Used in conjunction with a Type TIC206D triac, it allows the dimming of light bulbs of 10–400 without any problem. A 100 µH, 5 A inductor is needed to suppress the switching noise.

Synchronizing pulses are derived from the mains voltage via R_{11}, C_4 and D_4 and these are applied to pin 4 of the IC.

The supply voltage is obtained by means of R_2, C_2, D_1, D_2 and C_3, and lies about 5.3 V



below the mains voltage. The touch key used to operate the IC is connected to pin 5 via two 4.7 MΩ resistors, R_5 and R_6, to guarantee the safety of the user.

Since dimmers are often built into an existing circuit, there is frequently a need for operation from two different locations. Consequently, the diagram shows an additional push-button switch that may be situated well away from the touch key.

The diagram also shows three jump leads, which are intended for selecting one of three modes in which the IC can work. When jump lead B is used, the light is always switched on at the last used level, whereas when A or C are used, the light comes on at minimum brightness. When B or C are used, the dimming direction reverses every time dimming is used; this is not the case when jump lead A is used.

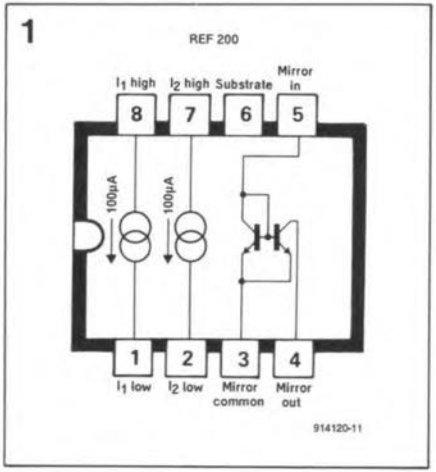
When the touch key is touched briefly, that is, for 50–400 ms, the light is switched on or off; if it is touched for a longer period, the dimming cycle is started. ■

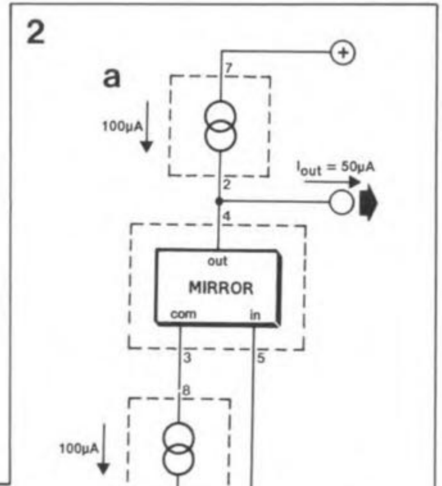
REF 200

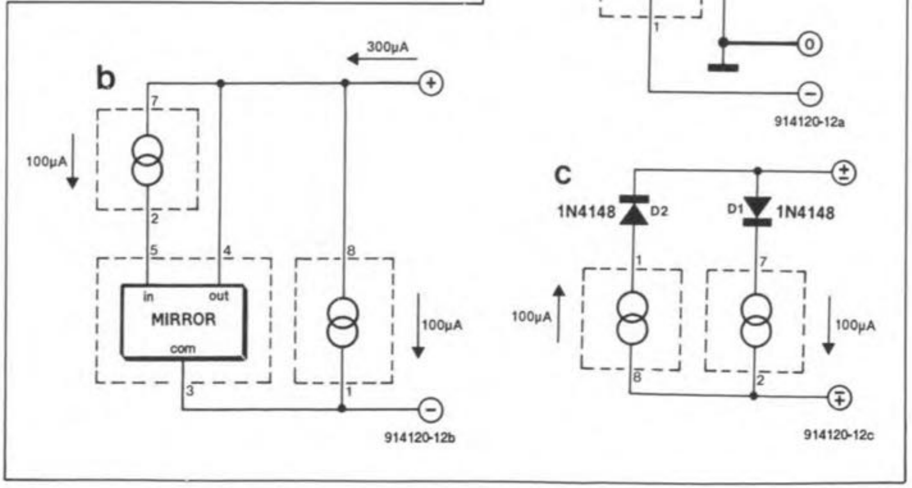
A Burr-Brown application

BURR-BROWN's REF200 provides in one 8-pin DIL package two independent current sources, either of which can supply 100 µA, and a 1:1 current mirror. The pinout of the device is shown in Fig. 1. Note that there are no pins for connecting a supply voltage. The correct operation of the current sources is, however, guaranteed when the potential across the source is not less than 2.5 V. The average drift with temperature is only 25 p.p.m./K. The output impedance is not less than 100 MΩ. The operating voltage must not exceed 40 V.

The two sources and the mirror make possible a number of configurations, some of which are shown in Fig. 2. That in Fig. 2a is a 50 µA current source whose output voltage may vary between 0 and the positive supply voltage minus 2.5 V. In Fig. 2b, all parts of the IC form a floating 300 µA current source. Finally, Fig. 2c shows a bidirectional 100 µA source. ■







WIDEBAND ANTENNA AMPLIFIER

This simple to build antenna booster offers a gain of some 20 dB over a frequency range that covers the VHF FM radio band and the whole of the UHF TV band.

an ELV design

AN antenna amplifier is useful in cases where reception of a VHF or UHF station is marginal, or where several radios or TV sets share a single antenna. In the latter case, the loss introduced by a 'splitter' has to be overcome with some additional gain. Since an antenna amplifier raises noise as well as signals within its pass-band, it is essential that it be mounted as close as possible to the antenna, where its beneficial effect is greatest.

The antenna amplifier described here is designed such that it can be connected to the antenna via a very short cable, without the need of a separate power supply being fitted close by on the roof top.

The amplifier is powered via the output coax cable. This arrangement is called a phantom supply. Figure 1 gives an indication of the RF performance that may be expected from the amplifier. It is seen that a gain of about 20 dB is achieved at frequencies between 40 MHz and 860 MHz.

Use and function

The antenna amplifier is inserted between two coax connectors in the existing cable near the antenna. The connection is broken, and the coax plug at the side of the antenna is inserted into the input socket of the antenna amplifier. The amplifier output socket is connected to the plug fitted on the downlead cable, i.e., the coax cable that leads to the TV set. That is all there is to the basic installation of the amplifier.

Once installed, the amplifier provides a gain of 20 dB, which is ample to prevent a fairly long downlead cable or other attenuating devices (including splitter boxes and connectors) degrading the signal-to-noise that exists at the antenna terminals — the upshot is that you have a better signal/noise ratio at the end of the downlead cable, i.e., at the input of your TV set.

The amplifier is phantom-powered, that is, it receives its supply voltage via the downlead cable, obviating the need of separate (low-power d.c.) wiring. The phantom supply for the amplifier is inserted into the cable at the antenna input of the TV set. The antenna plug is pulled out of the TV antenna input, and plugged into the input of the phantom supply unit. Next, the output plug of the phantom supply unit is plugged into the antenna socket on the TV set. The supply

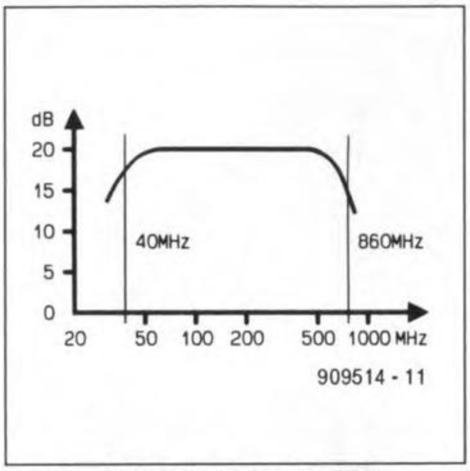


Fig. 1. Pass-band of the amplifier.

voltage for the phantom unit must lie between 5 V and 8 V d.c., and is best provided by a small mains adaptor. When an unregulated adaptor is used, care should be taken to keep the output voltage below 7 V. Given that the current consumption of the antenna amplifier is a few milliamps only, this may mean that the output voltage switch must be set to 4.5 V, which usually gives a no-load output voltage of between 6.5 V and 7 V. Make sure that the tip of the 3.5-mm jack plug is the **positive** supply. The 3.5-mm jack plug of the mains adaptor is inserted into the socket on the phantom supply unit, which takes care of the d.c. decoupling at the input of the TV set.

The circuit

The circuit diagram of the antenna amplifier is given in Fig. 2. The RF signal supplied by the antenna arrives at the input of a Type NE5205 RF integrated amplifier via input socket BU4 and coupling capacitor C3. The NE5205 raises the signal ten times, which corresponds to a voltage gain of 20 dB. The output signal of the IC is fed to the input of the TV set via capacitor C4, socket BU5, the downlead cable and the phantom supply unit. Inductor L2 blocks the RF signal, and so provides a d.c. path for the positive supply voltage on the signal connection of BU5. Likewise, capacitor C4 blocks the d.c. supply voltage at the output of the amplifier IC. The IC supply voltage is decoupled for RF as well as lower frequencies by a parallel combination of an SMA (surface-mount assembly) capacitor, C6, and an electrolytic capacitor, C5.

The operation of the phantom supply unit is apparent from Fig. 3. The output signal of the antenna amplifier arrives at socket BU2, and is fed through to BU3 via coupling

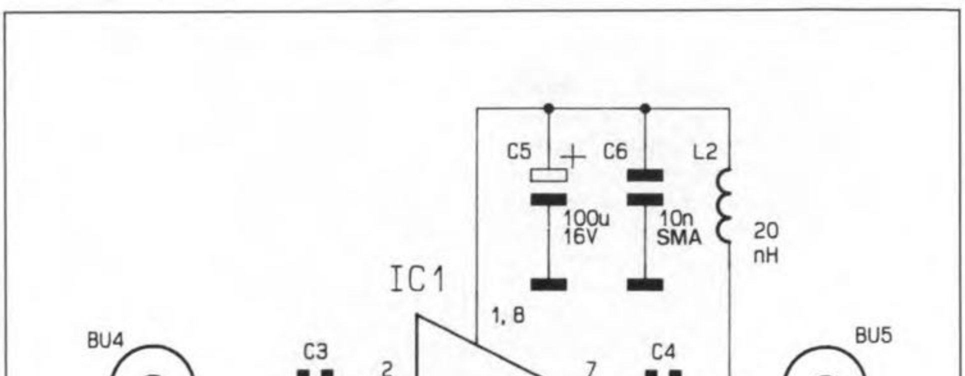


Fig. 2. Circuit diagram of the masthead amplifier.

capacitor C2. The output connector, BU3, is plugged into the antenna input on the TV set. Inductor L1 prevents RF signals being short-circuited by the power supply, and feeds the direct voltage applied to BU1 (the supply input socket) to the core of the coax cable. In this way, the RF signal is superimposed on the direct supply voltage of the amplifier. This supply voltage can not arrive at the antenna input of the TV set because it is blocked by capacitor C8.

Construction

Provided you have some experience in working with miniature circuits, the construction of the antenna amplifier is straightforward.

Start the construction by positioning and soldering the three SMA capacitors at the track side of the amplifier board. Next, mount IC1 at the component side, and solder its terminals at the track side. Finally, mount inductor L2 at the component side, taking care not to create short-circuits.

The strip of sheet metal supplied with the kit is bent around the PCB edges to form the amplifier case. Next, the input socket and the output plug are fitted to the short sides, and soldered at the inside of the 'case'.

Push the amplifier PCB into the case, such that the side with the IC on it rests against the pins of the coax connectors. Align the PCB, and solder one of the long sides to the metal case, at about 4 mm from the underside of the case. Next, clamp the case into its final shape, and solder the ends of the metal plate where they join. Secure the PCB in the case by soldering it all around to the metal plate. Likewise seal the input and output connector by soldering at the outside of the enclosure. The 6-mm hole in one of the long sides of the enclosure must also be sealed by soldering.

Connect the centre pins of the coax connectors on the amplifier to the copper tracks at the other side of the board by inserting short pieces of silver-plated wire (supplied with the kit) into the respective holes, and soldering at the track side and the connector pin.

The phantom supply does not require a separate circuit board. The input and output coax connectors are fitted on to the metal sheet enclosure as with the amplifier. Here, however, the 6-mm hole in one of the long sides is used to mount the 3.5-mm jack socket for the d.c. supply voltage. The centre pins of the coax connector are connected by capacitor C2. The centre pin of the input coax connector is connected to the centre pin of the supply socket via inductor L1. Next, solder the ground connection of the supply socket to the inside of the enclosure. Finally, fit decoupling capacitor C1 across the supply socket terminals.

Carefully check the construction of the amplifier and the phantom supply unit before you run a short test on them. Next, seal the enclosures completely by fitting the cover plates, and soldering these securely to the enclosures. ■

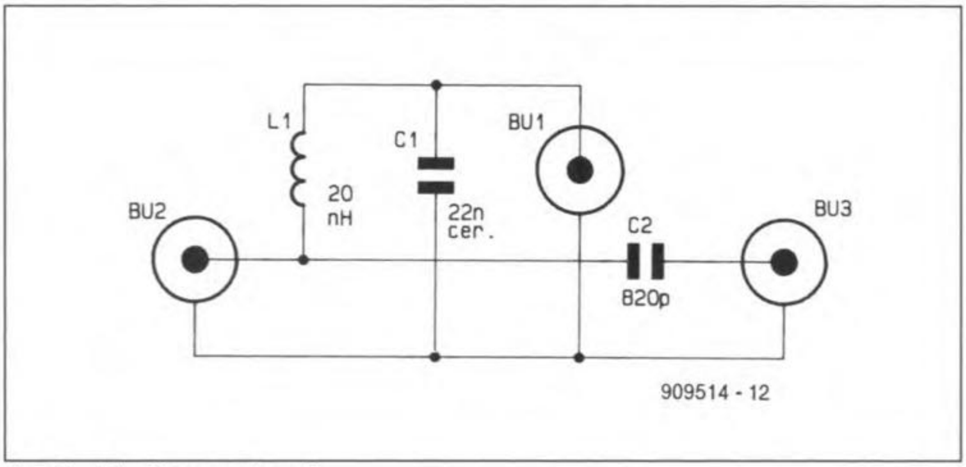


Fig. 3. **Phantom supply unit.**

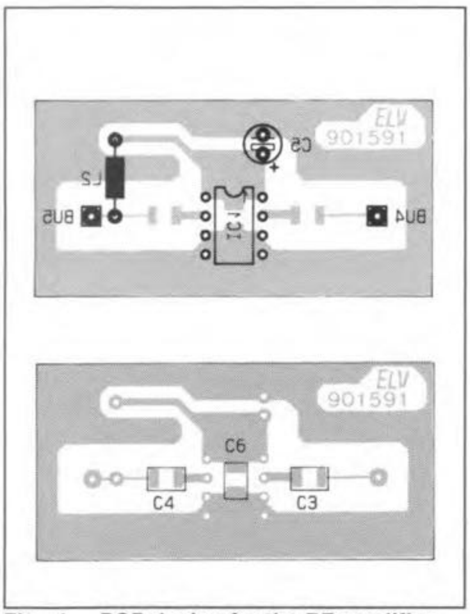


Fig. 4. **PCB design for the RF amplifier.**

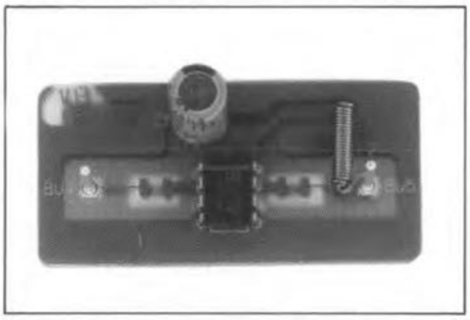


Fig. 5. **Component side view of the completed amplifier board.**

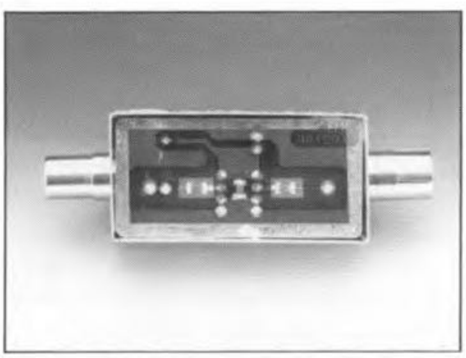


Fig. 6. **Track side view of the amplifier board before it is soldered to the inside of the enclosure.**

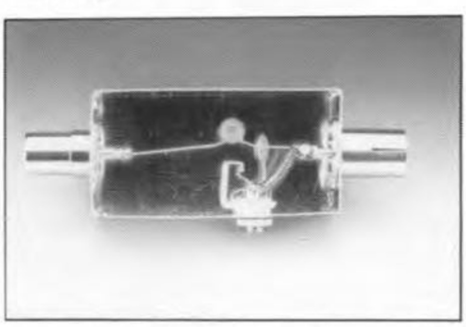


Fig. 7. **Completed phantom supply unit.**

COMPONENTS LIST

Content of kit supplied by ELV

Capacitors:

1	820pF	C2
3	10nF SMA	C3;C4;C6
1	22nF ceramic	C1
1	100µF 16V radial	C5

Semiconductors:

1	NE5205	IC1

Miscellaneous:

2	20nH inductor	L1;L2
1	3.5-mm jack socket	BU1
2	Coax socket, chassis mount	BU2;BU4
2	Coax plug, chassis mount	BU3;BU5
2	sheet metal enclosure	
	70mm silver-plated wire	
1	Printed circuit board	

A complete kit of parts for the wideband antenna amplifier described here is available from the designers' head office and worldwide distribution centre:

ELV GmbH
P.O. Box 1000
D-2950 Leer
GERMANY

Telephone: +49 491-60080
Facsimile: +49 491-72030

EASY-PC — A REVIEW

910121

by Mike Wooding G6IQM

AN important aspect of any electronic designer or constructor's work is to produce circuit diagrams and printed circuit board layouts for their designs or projects. Having done a little of this type of work myself over the years, I can say with confidence that, even for the most adept, it is not the easiest of subjects to tackle. For many, having to design a circuit, or produce a printed circuit board for a given circuit schematic, is a daunting task, even for the simplest of circuits.

However, there are now available for owners of computers of all types, quite a profusion of Computer Aided Design (CAD) software packages, to assist in such areas. The most popular home computer for the more serious user is now becoming the ubiquitous PC (personal computer), or one of its various clones. So, having looked around at what CAD packages are available for the PC, I decided to have a look at what appeared to be, from the advertising literature, one of the better ones — EASY-PC, from Number One Systems Limited.

EASY-PC

EASY-PC is a CAD package for IBM PC/XT/AT/386 computers, or true compatible clones, running under MS-DOS version 2.0 or later. The basic requirements for running the software are a minimum of 512k of memory, with a CGA, EGA or VGA graphics adaptor, preferably with a colour monitor (especially pertinent if multi-layered printed circuit boards are to be designed). The latest release of the software also supports Hercules graphics adaptors.

To enable the software to be used with greatest ease a Microsoft Mouse, or equivalent, is a useful addition. To obtain hard copies of designs an IBM Graphics compatible 9 or 24-pin dot matrix printer is required, or with the now upgraded version of EASY-PC, a Hewlett-Packard LaserJet II or equivalent laser printer can be used. Unlike some of the rival CAD packages available, a maths co-processor is not required to run this software successfully.

User manual and configuration

The package is very well presented. An A4 sized ring-binder contains the instruction manual, thus allowing for the easy inser-

tion of updates, etc. into the instructions. The software itself is supplied on two 360k 5.25-inch disks or one 720k 3.5-inch disk, both formats being supplied with the package.

The initial pages of the instruction manual deal with the copyright license agreement and any 'Stop Press' information that has not been included in the manual. There is also a READ.ME file on the disks that contains any later information concerning changes, etc., to the software. After these initial pages the instruction manual proper is entered. The first section deals with the computer requirements and how to load and configure the software and/or install it onto a hard disc.

The configuration is simplicity itself. Unless you are using a CGA display adaptor, there is no user configuration to be done. If you are using a CGA adaptor, the only configuration to be carried out is to copy and overwrite the main EASYPC.EXE program previously loaded with the ECGA.EXE one provided on the disc. That completes the configuration. A function-key command prompt strip is also supplied in the manual for copying or cutting out and placing above the keyboard.

The next and main section of the user manual is a very full and detailed description of how the software is used. The 'training' method is extremely easy to follow and is based on a tutorial, taking you through the various stages and features using a printed circuit board design supplied as a file on the disks. I have never used such a complex CAD package before, but after only a couple of hours going through this tutorial, I was becoming quite conversant with the very user-friendly package.

Getting started

After running EASY-PC you are presented with the opening title screen for a few seconds, and then the main menu with the following options:

1 ... Design Layout.
2 ... Design Schematic.
3 ... Create Layout Symbol.
4 ... Create Schematic Symbol.
5 ... Exit to DOS.

Printed circuit board layouts ... Option 1

Selecting option 1 presents the user with the main drawing screen, which consists of a rectangle in the centre of the screen enclosing a cross-shaped cursor. At the bottom of the screen is a status line, giving, amongst other information, the X and Y coordinates of the present cursor position. Along the top of the screen are located three small shaded squares, which indicate the cursor access points for three drop-down menus.

Moving around the screen is accomplished using either the cursor control keys on the keyboard (either the 2,4,6 & 8 keys on the numeric keypad, or the separate cursor-control keys if fitted to your keyboard) or the mouse.

As with all software packages utilising a mouse, the mouse driver utility must be loaded in before EASY-PC. This is usually done automatically by the AUTOEXEC.BAT and or the CONFIG.SYS files, which are run by the operating system of the computer on switch-on.

The drop-down menus are actuated by positioning the cursor over the shaded area, at which the menu appears. Menu items are selected simply by moving the highlighted bar over the desired function and pressing the ENTER key. Alongside each menu item is also given the alternative function key command, which will select the item without using the drop-down menu. These function key commands are also given on the function key command prompt strip mentioned earlier.

Once a layout is loaded it is displayed within the rectangle enclosing the centre area of the screen. This rectangle represents the maximum size of circuit board that can be accommodated in one go, that is 17 inches square. The cursor position, as mentioned earlier, is given by the X and Y coordinates shown on the status line at the bottom of the screen. The coordinates reference point is the bottom left-hand corner of the rectangle, and they vary numerically from 0 to 17.

Initially, the drawing area is shown at lowest magnification, and as such would be very difficult to work in. However, by positioning the cursor within the drawing area and pressing Z on the keyboard, the display is magnified by a factor of two, with the position marked by the cursor located at the centre of the screen area. Pressing Z again magnifies it further again by a factor of 2. This can be repeated until the maximum magnification factor of 12 times is reached, at which the entire screen area represents an actual board area of approximately 1/2-inch square. There are two other ways of actuating the zoom which are dealt with in the manual.

For fast movement around the display at high zoom levels a panning facility is available, whereby positioning the cursor at the edge of the display beyond which the view is required and pressing the P key, the view is moved across the layout such that the cursor position is now at the centre of the screen. Again, there are other methods of selecting this facility, a useful one of which is the ability to use the centre button on some three-button mice (mouses?!).

There are various other facilities available to help the user get around the screen, such as a grid over the entire screen, a scale around the edge of the screen and a full-screen cross-wire cursor instead of the small default version. I found that the large cross-wire and the outer edge scale was my preference. There is also a feature which allows you to reference the current cursor coordinates, and then all distances as indicated by the cursor X and Y coordinates on the status line are measured from the reference point, rather than the default bottom left-hand corner of the layout.

That covers very basically the facilities available for moving around the screen. However, the package needs must be used to realise just how powerful these apparently simple-sounding features really are.

Loading and saving layouts is also a simple function key or mouse operation, and directories of the various libraries can be easily displayed on-screen without disturbing the layout.

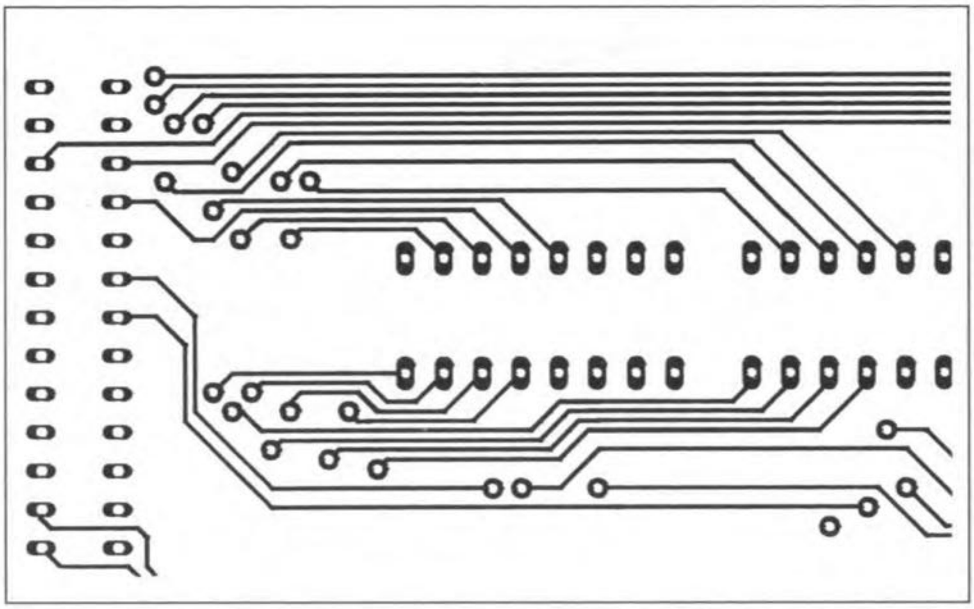


Fig. 1. A section of the demonstration board (design file) included with Easy PC. This artwork was produced as a HPGL file and plotted at a scale of 200% on a Roland DPX-2200 flat-bed plotter.

Having familiarised oneself with the basics above, the powerful intricacies of the package can be explored. The tutorial in the user manual takes you through a guided tour of these, demonstrating by means of using the circuit board layout included on the disk. You are instructed how to lay down tracks, change track widths, lay down solder pads, vary the size, shape and orientation of them and select which of the eight board conductor layers to put them on or, in the case of tracks, route them to.

Included within the package is a library of pre-drawn symbols, such as single-in-line and dual-in-line IC pad patterns, various transistor pad patterns, etc. These symbols can be loaded into the layout, repeated, moved, re-orientated, etc., which saves a lot of time for the designer not having to draw his/her own.

As well as the ability to design circuit board layouts for boards with up to eight conductor layers, the top and bottom silk screen layers and etch-resist layers can also be designed.

It would be wholly inadvisable of me to try and emulate the instructions by explaining, even in the briefest terms, how all the design functions are utilised and accomplished. Suffice it to say that all the features available will allow highly complex printed circuit boards to be designed with the minimum of difficulty. A full list of the main features is included at the end of this review.

Circuit schematics ... Option-2

Option 2 on the main menu leads us into the other main function of the software package, drawing circuit diagrams (schematics). Upon selecting this option, as before, the user is presented with the main drawing screen at minimum zoom factor. Moving around the drawing screen, zooming, panning, etc., are all facilitated in exactly the same way as for the layout section described above.

The only main difference is that, whereas in the layout option the user has a choice of up to eight board layers, obviously in the schematic drawing mode only one layer is permitted.

As before, a library of pre-drawn symbols is available on the disks, which includes the basic symbols for resistors, capacitors, inductors, transistors, basic gates, etc. Again, these allow for much quicker designing and drawing of circuit diagrams, and help the user to produce neater and repetitively reproducible drawings.

Very powerful editing facilities are available in the package which apply to both this mode and the layout drawing one. These facilities allow previously drawn circuits/layouts to be modified, added to, sections deleted, or other circuits/layouts to be merged into them. Block editing features allow areas of circuits/layouts to be saved, deleted and moved. Symbols within the circuits/layouts can be changed or modified, either singly or on a global basis.

Create layout symbol and Create schematic symbol ... Options 3 & 4

These options are self-explanatory — they allow the user to modify existing or create his/her own symbols and save them into the libraries. The rules to be observed when designing/altering symbols are simple to

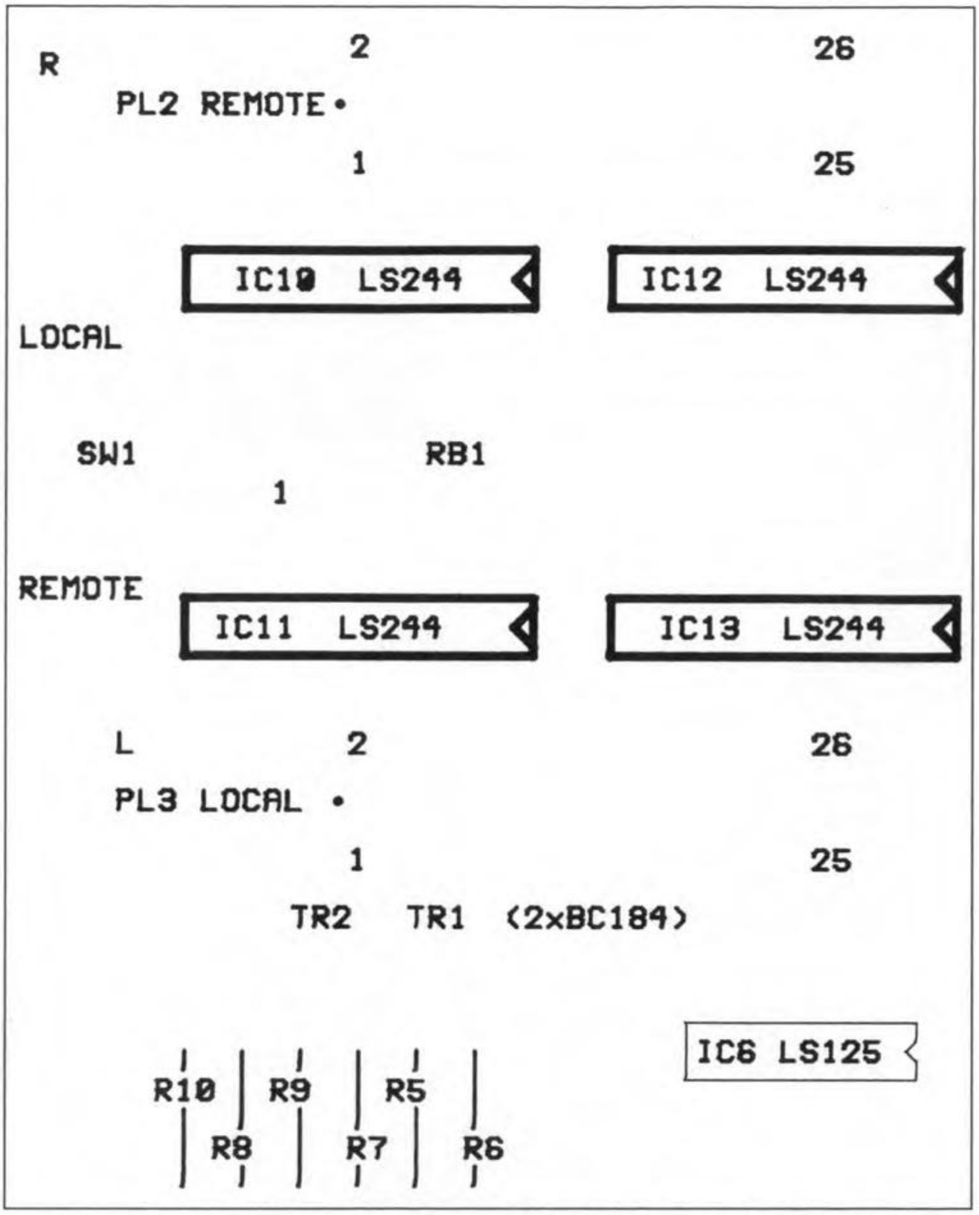


Fig. 2. Example of a component mounting plan produced by Easy-PC. Scale: 200%, HPGL file output sent to Roland DPX-2200 plotter.

follow, essentially symbols for circuit schematics must not contain solder pads as connection dots. Symbols for board layouts can be designed for all layers, lines included in the symbol are restricted to layers 0 and 9 (top and bottom silk screen layers) as is any text, and solder pads can be on all layers or just layer 1.

Printing your design

As mentioned earlier, layout and circuit designs can be saved and loaded to and from disk. For hard copies of the designs an IBM graphics compatible 9 or 24-pin dot matrix printer is required (for users of HP LaserJet II or compatible laser printers see the EASY-LASE section below).

To obtain a printed output, the BLOCK mode is selected from the left-hand drop-down menu (or by pressing the appropriate function key). The user can then 'rubber-band' a box around the desired section to be printed (or all of the circuit/layout if required) by positioning the cursor at the lower left-hand corner of the section required, clicking the left mouse button and drawing a box around the section. When the required section is enclosed in this box a further press of the left mouse button 'fixes' it in place.

Once the box has been defined, selecting the middle drop-down menu reveals a selection of actions that can be performed on the box, including draft, normal and bold printing. Selection of one of these options presents the user with the options screen for setting the printer defaults, after setting these as necessary (or if necessary) the selected layout can be printed.

The main features of EASY-PC

- High speed operation. Zoom and pan at typically 1-2 seconds (Eurocard board) on 8086-based PCs, much faster on 286 and 386 based machines. (On my 386-based machine this was timed at virtually instantaneous).
- Permanent What You See Is What You Get (WYSIWYG) display — tracks and pads always appear on screen full width and solid.
- Multilayer boards with up to 8 conductor layers, top and bottom silk screens and solder resist layers.
- Up to 17 × 17 inch (430 × 430 mm) board size.
- Surface-mount technology supported.
- Up to 1,500 ICs, up to 5,000 tracks (with up to 12,000 segments), up to 4,000 solder pads (in addition to those used in ICs), up to 100 different symbols per board, and up to 6,000 text characters per circuit diagram.
- 128 different track widths from 0.002 to over 0.5 inches (0.05 to 13 mm). Maximum of eighth widths per board.
- 128 different solder pad sizes from 0.002 to over 0.5 inches (0.05 to 13mm). Maximum of sixteen sizes per board.
- Solder resist artworks with suitable pad clearances can be produced automatically.
- Grid, 0.1 inch (2.54 mm) with snap to 0.1, 0.05 or 0.025 inch (2.54, 1.27, 0.63 mm). Pads and tracks, etc. can also be located off grid to a resolution of approximately 0.002 inches (0.05 mm).
- Auto-via facility for interconnections between layers.
- Pad shapes include edge connector fingers, circular, oval, square and rectangular pads, with or without holes.
- Over 400 library symbols included with the package.
- Repeat, Move, Rotate, Mirror and Erase Block and Feature
- operations. Complex track areas, pads and symbols can be repeated at a single key stroke.
- Tracks and angles can be fixed at 45° or 90°, or run at any angle.

That completes my look at the main program. However, there are various other utilities included in the package, EASY-PLOT, EASY-GERB, EASY-DRILL and EASY-LASE, and I shall briefly describe these and their uses.

EASY-PLOT

EASY-PLOT is the utility program which takes files created by EASY-PC and converts them into HPGL format, for output either direct to a pen plotter or to a disc file for downloading at a later date.

Its main features include:

- Choice of various draft modes for speed.
- Selection of a wide range of pen sizes

and pen writing speeds.
- Selection of ×0.25, ×0.5, ×1, ×2, ×3 or ×4 output scale.
- The ability to plot a section of a layout or schematic.
- A0, A1, A2, A3 or A4 output.
- The ability to position the plot anywhere on the paper.
- The ability to select various pens on multi-pen plotters.

EASY-GERB

EASY-GERB is a utility program which takes printed circuit board files created by EASY-PC and converts them into Gerber photo-plot format, for downloading to a photo-plotter.

Its main features include:
- Selection of which layers are to be plotted.
- Selection of whether or not an etch-resist solder mask is required and selection of the required clearances.
- Change the current work file.
- Start plot, which automatically detects which layers have been used in the layout design and creates the appropriate files.

EASY-DRILL

EASY-DRILL is a utility which takes printed circuit board files created by EASY-PC and converts them into NC DRILL format to drive an automatic numerically controlled drill.

Its main features include:
- The option to change the current work file.
- Generate a drill file.
- The ability to adjust drill sizes without having to alter the pad sizes in the original EASY-PC board layout file. Drill sizes can be selected in either imperial or metric values.

EASY-LASE

EASY-LASE is a utility program which takes printed circuit board and schematic files created by EASY-PC and converts them into HP-PCL format to drive a Hewlett-Packard LaserJet II or compatible laser printer.

Upon loading EASY-LASE you are first prompted for the file name of the layout/circuit to be printed. Once that has been entered and found the program reads the file, scans the layout/circuit and presents the main menu.

Listed on the menu screen are all the details of the layout/circuit, including the number of tracks, solder pads, symbols, holes and the amount of text. Also given is the actual board size for layouts and whether the layout or circuit will fit on the selected paper size at the selected scale.

A full range of user-selectable options are available and are:
- Direction of output to a choice of ports, i.e., COM1, LPT1, etc.
- Resolution, i.e: 300 dpi, etc.
- Number of copies (maximum 99).
- The facility to print layers separately or together.
- The ability to scale the layout/circuit so that it will fit the selected paper size. This is automatically calculated and prompted on-screen.
- Avoid or Fill in the holes in the centres of the solder pads.
- Print out the solder pads only.
- Select the paper size, i.e: A4, Legal, etc.
- Printer offset (defaults to 0.5 inches in from the bottom left-hand corner of the paper).
- Selection of a rectangular area of the layout/circuit to be printed.
- Automatically centre the output on the paper.
- Save new setup or restore previous setup.
- Enter a compensation factor for the printer in use, which is determined by closely examining a special test file to be printed out from the disc with 0 compensation values (the initial default setting).
- Change the input file.

Finally in this review I must mention that an extra library of pre-drawn schematic symbols is available called EASY-PC Library, which contains more than 1,000 extra circuit diagram and layout symbols, covering eight IC logic families and a range of popular microprocessors, memories and support chips. An additional PCB layout library contains a selection of widely used board outlines, including eurocards (16 × 10 cm) and PC bus extension adaptors.

Conclusions

I found the package very well presented and extremely user- friendly. After a couple of hours I was able to move around within the main program with ease, using both the drop-down menus and function keys with relative ease. The seemingly complex drawing and editing facilities are, in fact, very simple to use, once the key strokes and mouse commands have been practised and experimented with a few times. Manipulation of the library symbols is also simple and very time saving, compared with drawing your own.

The user instruction manual is very detailed and concise. I particularly liked the tutorial section, which I found to be most instructive, especially when compared with other commercial software packages that I use, where the user is expected to be a mind-reader and miracle worker!

All-in-all I could not find anything I did not like with the package. Again, I found it very user-friendly and, within the constraints of my limited experience and knowledge of layout and circuit drawing and design, I could find nothing untoward, or nothing that the package seemed unable to cope with. Highly recommended for both full commercial and amateur use.

I wish to thank Mr. Espin of Number One Systems Limited for his help and advice, and for the review software. ■

EASY-PC is priced at £98.00 + £4.75 p&p + VAT for the U.K. Europe: £98.00 + £10.00 p&p & Airmail. U.S.A.: $195 including p&p and Airmail. All other countries: £110 complete including Airmail.

EASY-PC Library is priced at £38.00 + £4.75 p&p + VAT for the U.K. Europe: £38.00 + £10.00 p&p & Airmail. U.S.A.: $75.00 including p&p and Airmail.

Both packages are available from: **Number One Systems Limited, Harding Way, St.Ives, Huntingdon, Cambridgeshire PE17 4WR, England. Telephone: (0480) 61778. International: +44 480 61778. Fax: (0480) 494042.**

SINGLE-CHIP MAINS SUPPLY

A Harris application

HARRIS's Type HV-2405E IC, connected with a few external components as shown in the diagram, enables the direct derivation of a regulated 5–24 V d.c. supply from a 100–260 V a.c. mains supply. The peak output current of the device is 50 mA.

The chip contains a pre-regulator that arranges the charging of C_2, a fairly large capacitance, at the onset of each period of the mains voltage. The charging continues until the potential across the capacitor has reached a level that is roughly the wanted output plus 6 V.

When that state is reached, C_2 provides the voltage necessary for the series regulator also contained in the IC. The output of this regulator can be set between 5 V and 24 V with P_1, and is available at pin 6.

The load current will discharge C_2 to some extent, but the pre-regulator ensures that adequate recharging takes place during every period of the mains supply.

WARNING. Since the circuit and its output is connected electrically to the mains, any apparatus connected to the circuit is, therefore, also at mains potential. Great care should thus be exercised when working on it: touching certain parts is potentially lethal! ■