Interfacing COMPUKIT

Part 4 D.E.Graham

THIS MONTH we introduce a second companion board to the Decoding Module, and examine the implementation of analogue output from the Compukit.

ANALOGUE, TIMING AND AUDIO BOARD

This is a double sided p.c.b. of the same dimensions as the Decoding Module, which connects directly to it via a single edge connector to provide the Compukit with a range of facilities. The board is powered by the Decoding Module's dual 5 volt power supply, and, as may be seen from Fig. 4.1, contains four separate sections: A D/A converter and operational amplifier taken out to SK7; an 8 channel A/D converter accessed through SK6; an AY-3-8910 Programmable Sound Generator and audio amplifier whose output is taken to a number of pads at the edge of the board, and whose two 8 bit ports are accessed through SK2 and 3; and a 6522 Versatile Interface Adaptor providing a number of counting and timing facilities, as well as a further 16 bits of parallel port. Connections to the 6522 are made via SK4 and 5. Sockets SK2, 3, 4, 5, 6 and 7 are all of the 16-pin d.i.l. variety.

CONSTRUCTION

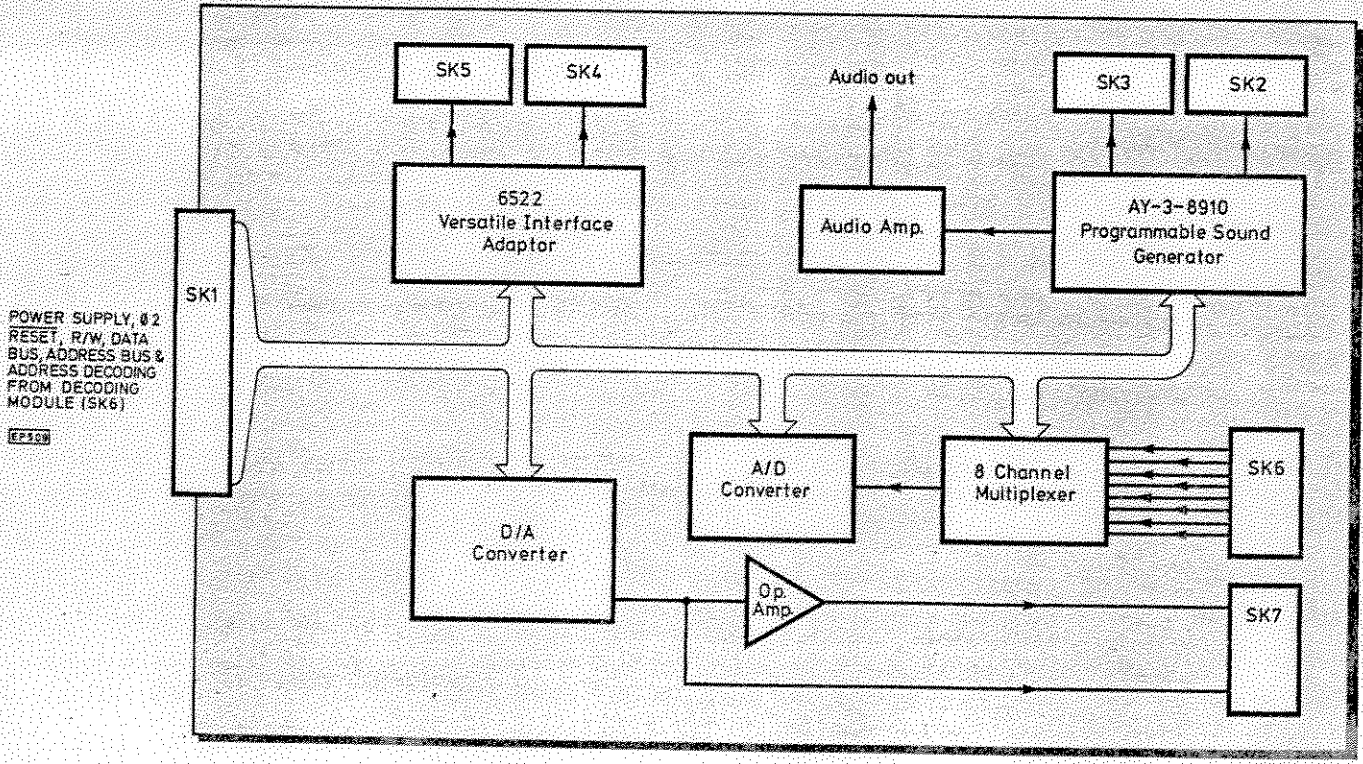
This should prove to be fairly straightforward. It is probably easiest to solder in i.c. sockets first, followed by discrete components, and finally the through-pins (as indicated on the component overlay in Fig. 4.4). Before inserting the i.c.s, test that the correct supply voltage appears at the appropriate pins of all i.c. sockets. The Analogue Board connects to the Decoding Module via a 2 × 25-pin 0·1 inch edge connector SK1. This is wired to SK6 on the Decoding Module as shown in Table 4.1. This wiring should be kept to a few inches in length. Precautions against static damage must be exercised when dealing with i.c.s 1, 2, 6, 8 and 10 since these devices may be easily damaged by static charges.

We will cover the testing of the four parts of the board in the particular sections dealing with each functional unit. Details of the PSG 6522 and A/D converter will be given in forthcoming issues. Now we deal with D/A conversion.

D/A TECHNIQUES

In its simplest form a D/A converter may consist of a chain of resistors joined to a parallel output port. Fig. 4.5 shows a 4 bit D/A converter that could be connected directly to the

4.1. Block diagram of Analogue Board

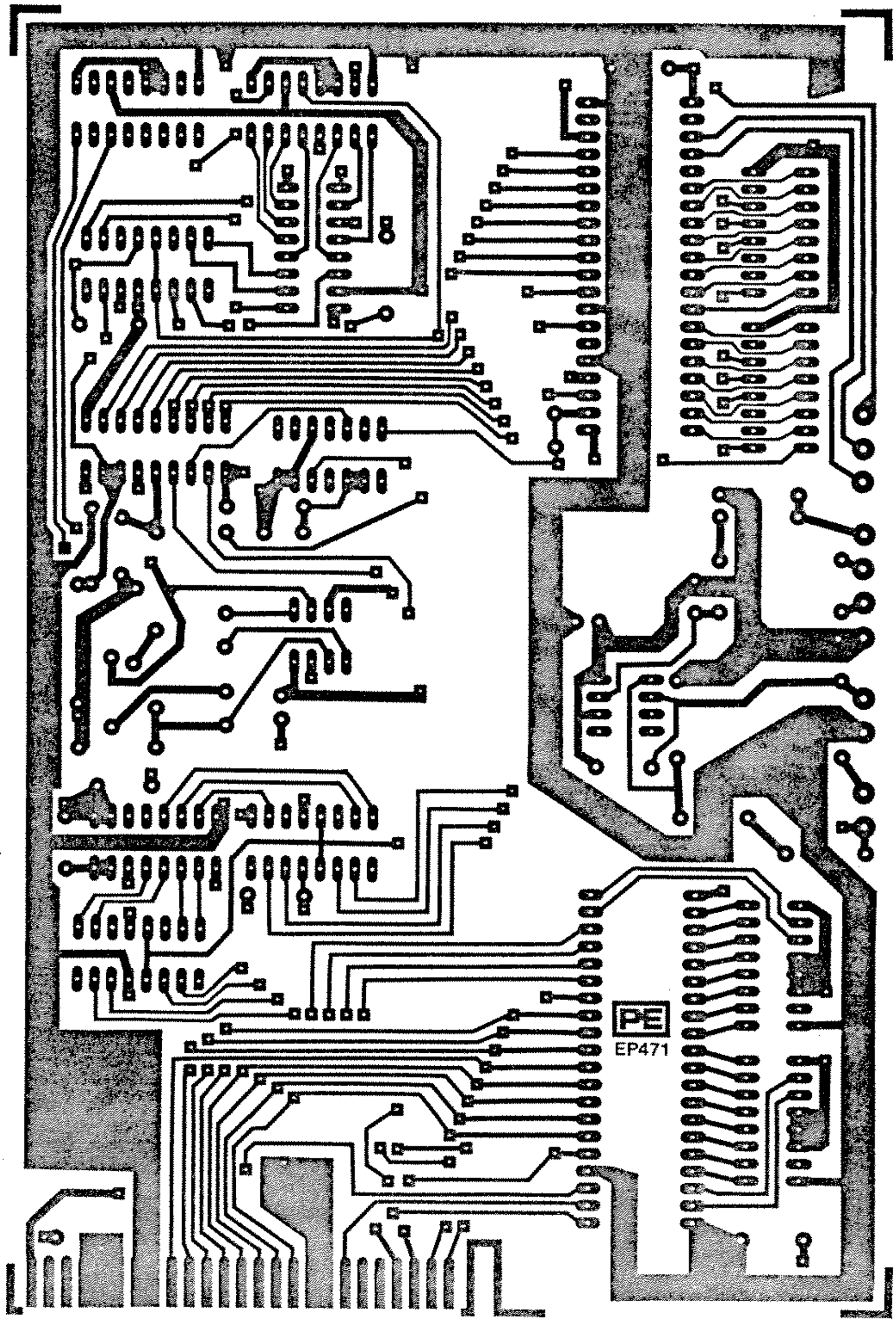


outputs of a 7475 quad latch. The output voltage would range from a fraction of a volt for zero data to about 4 volts for the decimal value 15. The resistors would need to be one per cent tolerance types to avoid abrupt changes in voltage occurring when different sections of the chain are brought into play, as in the major transition which occurs from 7 to 8 for example.

The configuration could be doubled up to produce an 8 bit converter, but resistor tolerances would become more critical. Also, if a PIA port was to be used with such a converter, higher value resistors would be required because of the relatively low drive capability of its output. This would further necessitate the use of a d.c. amplifier to produce a usable analogue output.

ZN425 MONOLITHIC CONVERTER

It is of course possible to get around these problems, and particularly the problem of conversion accuracy, by using a



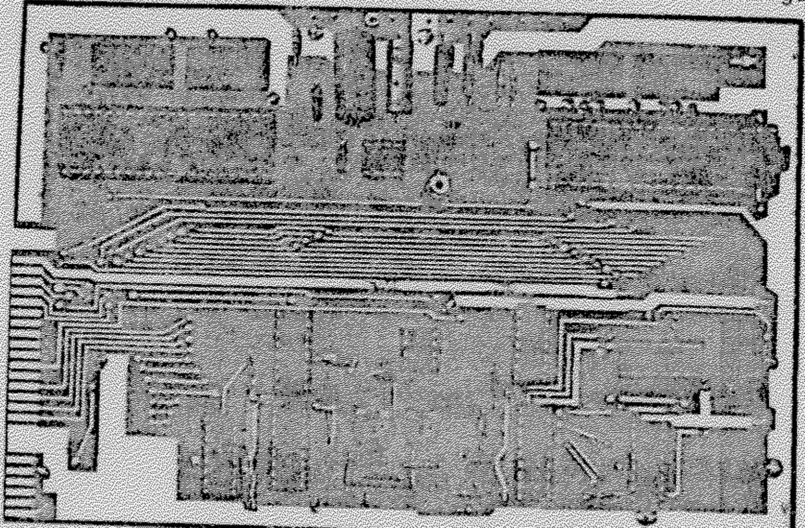
4.2. P.c.b. for Analogue Board (actual size)

Table 4.1 Connections Between SK1 of Analogue board and SK6 of Decoding Module.

	Upper		Lower	
SK1 pin number	SK6 pin number (upper)	Function	SK6 pin number (lower)	Function
1	1	Vgg(−5V)	1	RESET
2	2	Ø2	2	W7
3	3	1RQ	3	W8
4	4	BC1	4	R7
5	5	BDIR	—	NC
6	—	NC	—	NC
7	—	NC	7	R/W
8	—	NC	8	GND
9	—	NC	9	GND
10	—	NC	10	D7
11	11	W7	11	D6
12	—	NC	12	D5
13	13	A3	13	D4
14	14	A2	14	D0
15	15	A1	15	D1
16	16	A0	16	D2
17	17	GND	17	D3
18	18	GND	18	Vcc
19	19	GND	19	Vcc
20	—	NC	20	GND
21	—	NC	21	GND
22	—	NC	22	GND
23	—	NC	—	NC
24	—	NC	—	NC
25	25	NMI	25	BL2

monolithic D/A converter i.c. From the variety of such devices on the market we have chosen to use the Ferranti ZN425 for a number of reasons. In particular it is readily available at a reasonable price, and operates from a 5 volt supply.

Fig. 4.6 gives a block diagram of the sections of the 425 used in D/A conversion. Essentially it consists of 8 data switches which are activated by an external port or latches. These switch a precision R-2R network to an on-chip 2·5 volt reference source to produce an analogue output on pin 14. This is typically 2·555 volts for all bits on, and 3mV for all bits off.



PRACTICAL D/A CIRCUIT

Fig. 4.7 gives the full circuit of the D/A section of the Analogue Board. This consists of a pair of 74LS75s wired to form an 8 bit data latch. The latch enables are taken to the W line on the Decoding Module, which corresponds to an address of 61320. The 8 parallel outputs of the latch are connected directly to the ZN425, which performs the conversion of the latched data within 1μ sec. The analogue output (DA) appears at pin 14 of the 425, and is fed to the non-inverting input of IC11, a 741 operational amplifier. Both DA, and the output of the op. amp. (DAA) are taken out to SK7, which also carries both polarity supply connections and ground.

The op. amp. circuit has two associated variable resistors. VR1 is used for zeroing, and has been given an extended offset capability, and VR2, which controls the gain between about 1 and 2.

To test the converter, connect a voltmeter between pin 14 of SK7 and earth (pins 1, 5 or 6 of SK7). Execute the command **POKE 61320, 0,** and adjust VR1 to give zero volts on the meter. Now execute **POKE 61320, 255.** This should cause the meter to read somewhere between 2·5 and 4 volts, depending on the setting of VR2. The system is now operational, and POKEing intermediate values to 61320 should yield intermediate voltage readings with a linear correspondence (providing the gain has not been set too high).

If the voltage does not vary with differing data, a voltage check should be made on the DA output of the converter (pin 14 of IC6, or pin 16 of SK7). If this does not alter when data is POKEd to 61320, then checks should be made on the outputs of the two latches IC4 and 5. These should also change when different values are POKEd to 61320.

APPLICATIONS OF THE D/A CONVERTER

The DAA output of the converter unit at pin 14 of SK7 may be used in a wide variety of different applications. It could be used for example to feed a servo amplifier controlling a d.c. motor which could variously drive a graph plotter, a steering mechanism, or a robot's left leg.

More simply it may be used to drive power controllers of one kind or another. For low power d.c. operation, a simple current amplifier of the type shown in Fig. 4·8 may be connected to the DAA output of the converter unit. This will vary the brightness of a 2·5V lamp according to the data POKEd to 61320. To set this up, first execute POKE 61320, 0, and adjust the zero offset (VR1) so that the bulb is just extinguished. Then execute POKE 61320, 255. This should

CONSTRUCTOR'S NOTE: NEW MONITOR IN EPROM

During the development of this series the screen editor written by Nigel Climpson and published in PE was found to be extremely useful. This editor is now available as the CE1 monitor in a 2716 EPROM for £12·50 + VAT and p&p. from **Technomatic Ltd.** It replaces the UK101 2K monitor ROM, and also contains useful routines such as a rapid screen clear.

illuminate the lamp brightly, and VR2 may then be adjusted to achieve best control over the full range of data.

A program of the type listed below will be found useful in setting up the converter for the above, and for other applications:

```
80 REM TEST ROUTINE FOR A/D CONVERTER
100 A=61320
120 INPUTX
140 POKEA,X
160 GOTO100
```

It simply requests a number, which should be an integer between zero and 255, and POKEs this to the converter.

TRIAC CONTROLLER

If a.c. or pulsed d.c. control is required, then the converter may be used to drive a Triac or Thyristor. There are many ways in which this may be achieved, but perhaps the most straightforward is to use the DAA output of the converter to vary the brightness of a l.e.d. indicator, which itself illuminates a light dependent resistor placed at a strategic

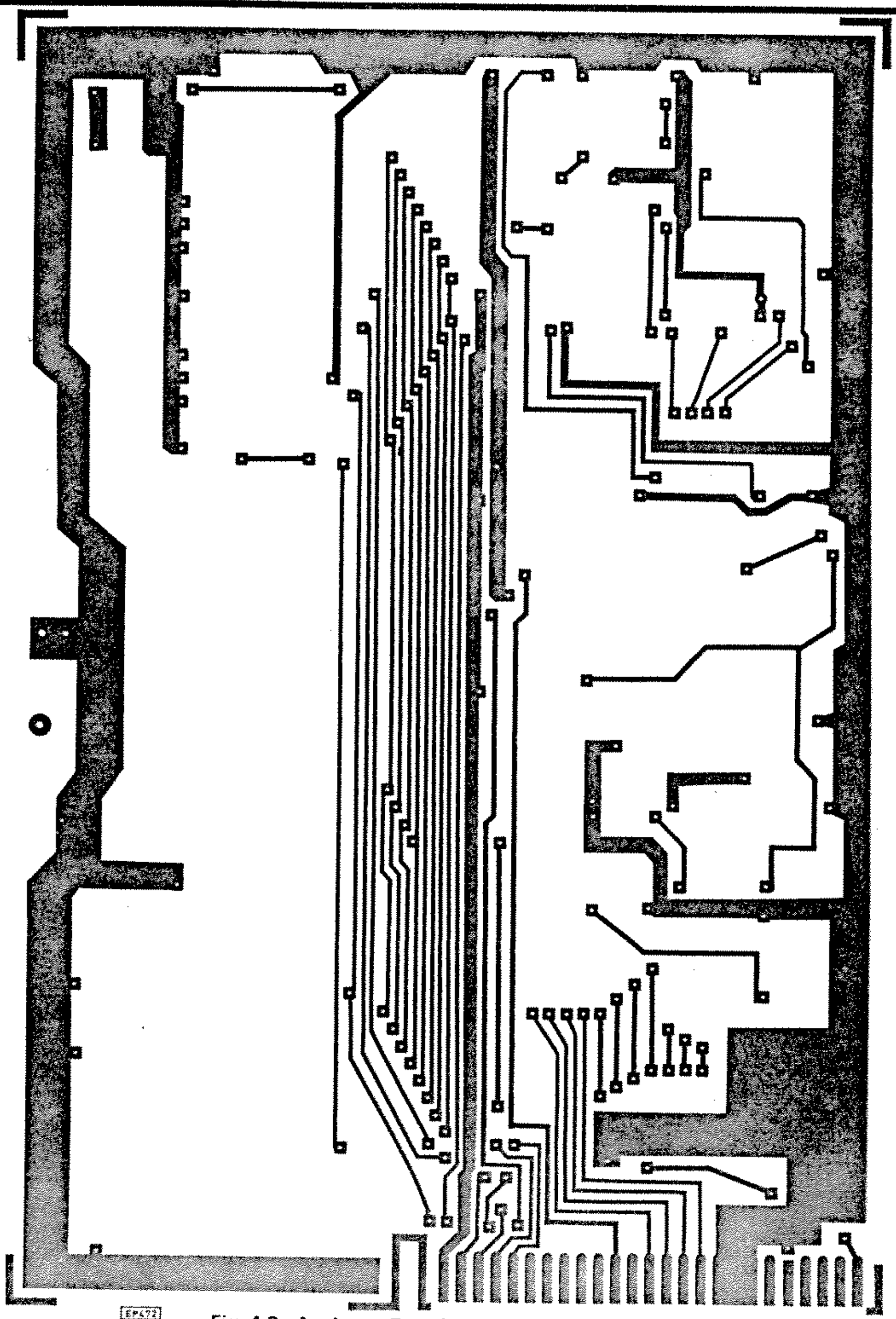


Fig. 4.3. Analogue Board p.c.b. component side

point in a triac or thyristor controller circuit. This has the great advantage of completely isolating the computer system from the mains. Alternatively, a patent opto-isolator such as the TIL112 may be used. In either case the l.e.d. may be directly driven by the DAA output of the converter as in Fig. 4.9.

Fig. 4.10 gives an experimental circuit for a power controller using the l.d.r. method. The phase shift for the triac is produced by the R1/C1 network, with the l.d.r. altering the charge time of C1. R2, R3, and C2 help to reduce hysteresis and flicker, common diseases of this type of controller, though the latter is *not* completely eliminated. L1 and L2 are inductors each formed by winding about 100 turns of wire of a half inch former. Perhaps the most vital part of the circuit is the R4/C3 network. This prevents spikes in the supply line from destroying the triac.

The l.e.d. and series resistor are connected between the DAA output of the converter and Vcc. The l.e.d. should be

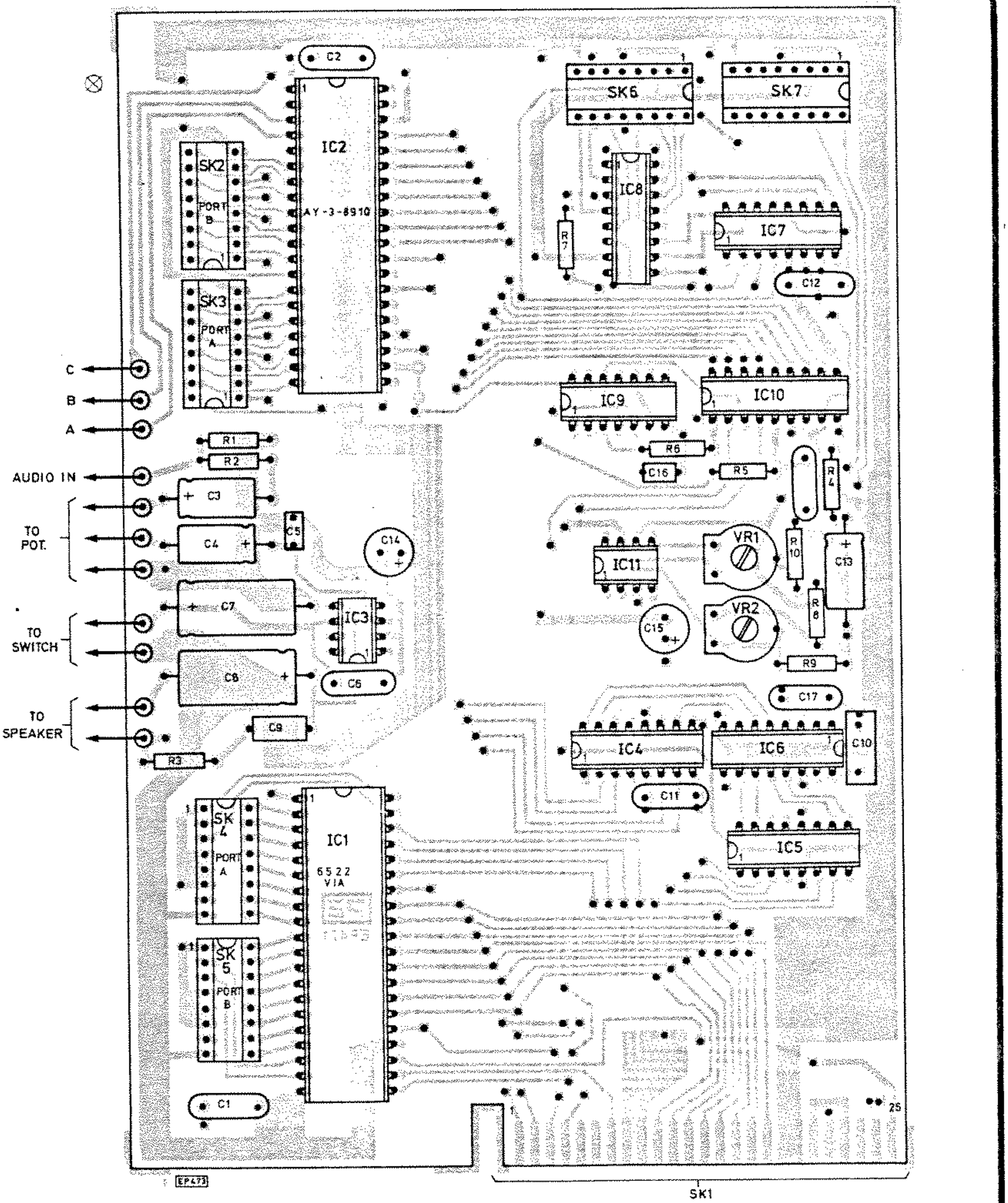


Fig. 4.4. Component overlay for Analogue Board

taped to the l.d.r., and the pair mounted in a *completely* light-tight container.

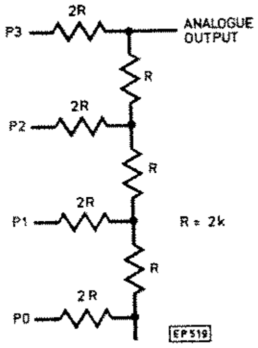
To set up the circuit, VR1 of the converter should be set to give zero volts between DAA and ground on execution of POKE 61320, 0. VR2 should then be adjusted to give a smooth range of control. Some adjustment of R1, 2 and 3 may be necessary to effect this.

THYRISTOR CONTROLLER

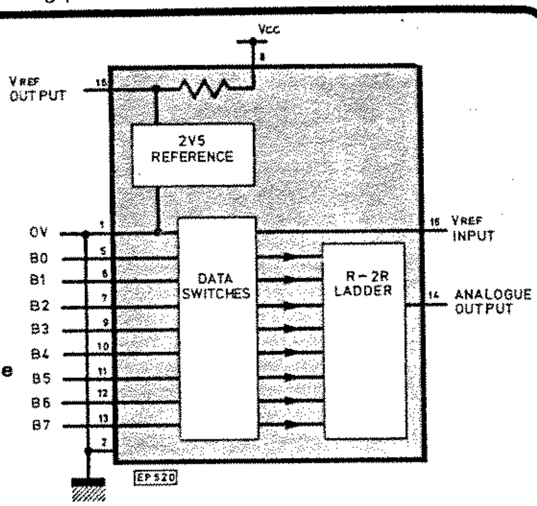
In the author's experience, far more satisfactory power control is achieved using thyristors rather than triacs. One advantage of the thyristor is the ease with which unijunction transistor delay circuits may be used with them; and secondly they cannot suffer from asynchronous firing in the two directions of current flow, as may occur with the triac, and which is indeed one of the factors causing flicker in the controller of Fig. 4.10.

Fig. 4.11 gives the circuit of a thyristor controller which may be used to vary the power to some 12 volt d.c. device for currents up to two or three amperes. Control using the 500k resistor is smooth and flicker-free. An l.d.r. driven by an l.e.d. from the D/A converter may be introduced in a number of ways into this circuit. About the simplest is to take the l.d.r. from point X to earth via a resistor in the range 20 to 100k. To obtain smooth control it will be necessary to adjust the 500k pot in conjunction with VR1 and VR2 on the Analogue Board. Again, however, it should be stressed that this is an experimental circuit, and some adjustment of values may be necessary to obtain the best performance.

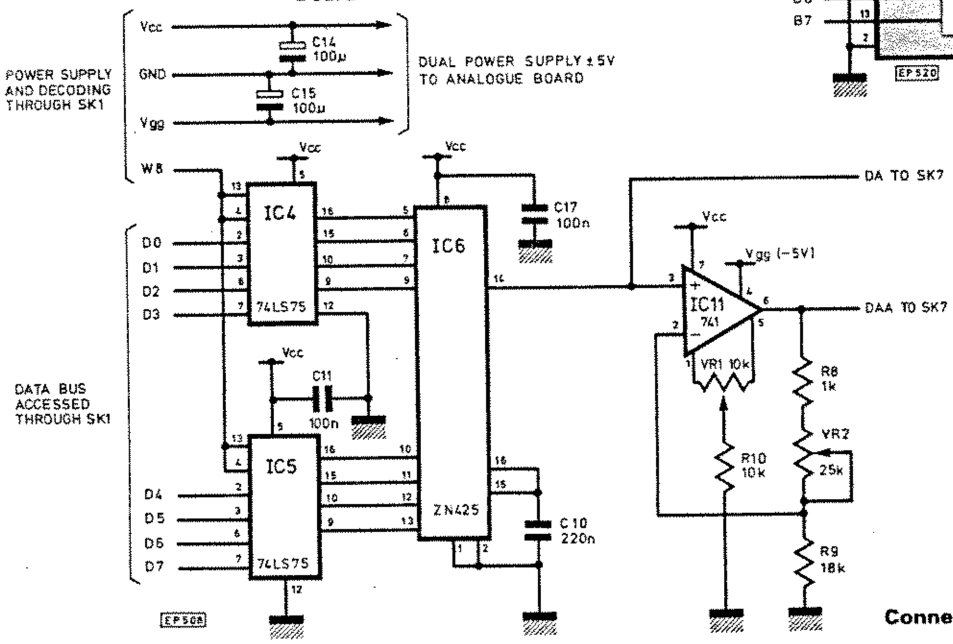
If it is desired to use this circuit for power control at a higher voltage, then it should be possible to increase the supply voltage; and adjust the Zener diode dropper resistor R1 accordingly. If a.c. control is required, then the load



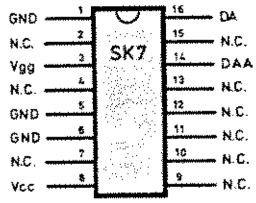
4.5. R/2R D/A converter



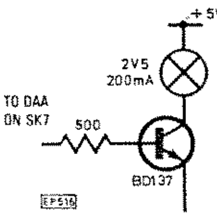
4.6. ZN425 block diagram



4.7. D/A Converter section of Analogue Board

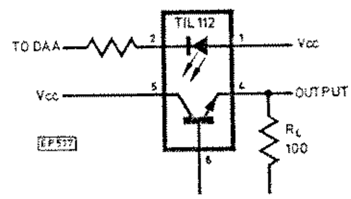


CONNECTIONS TO SK7



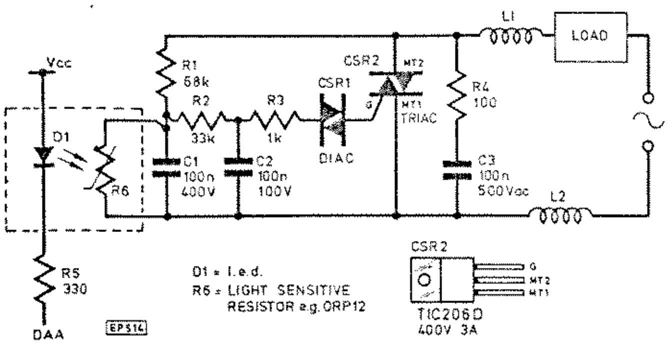
4.8. BD137 Current Amplifier

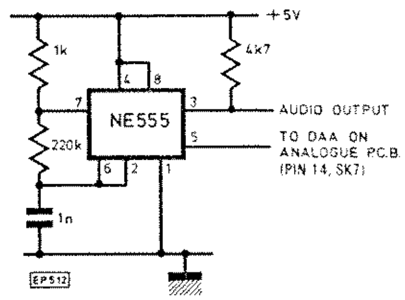
Connection of l.e.d. to D/A converter



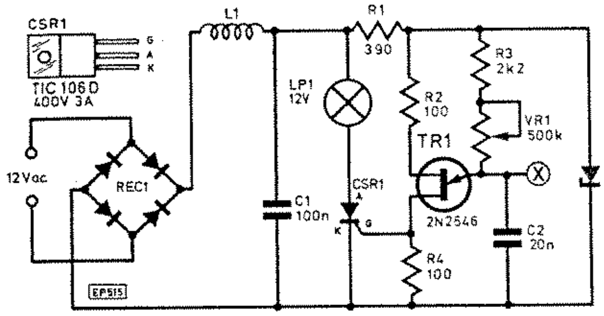
4.9. L.e.d. and Resistor (to opto-isolator)

4.10. Triac Power Controller. All resistors are 1 Watt

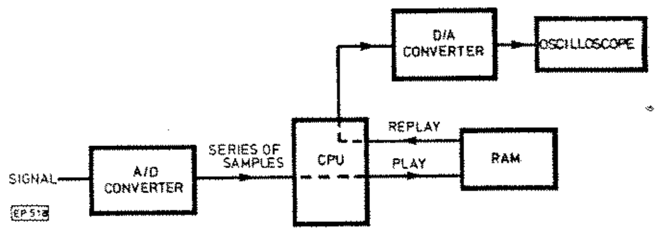




4.12. NE555 signal generator



4.11. Thyristor Power Controller



4.13. Block diagram of storage oscillocope

COMPONENTS . . .

Resistors

R1, R6, R8	1k (3 off)
R2	100k
R3	10
R4	390
R5	82k
R7	3k9
R9	18k
R10	10k

Potentiometers

VR1	10k preset
VR2	25k preset
VR3	100k log + switch

Capacitors

C1, C2, C6, C11, C12, C17	100n disc ceramic (6 off)
C3, C4, C13	10µ/10V (3 off)
C5	1n
C7, C14, C15	100µ/10V (3 off)
C8	200µ/10V
C9	47n mylar
C10	220n mylar
C16	50n mylar

Integrated Circuits

IC1	6522
IC2	AY-3-8910
IC3	LM386
IC4, IC5, IC7	74LS75 (3 off)
IC6	ZN425
IC8	4051
IC9	74LS90
IC10	ZN427
IC11	741

Miscellaneous

P.c.b.
SK1 2 × 25 0·1in. edge connector
SK2–SK7 16-pin d.i.l. sockets (6 off)
40-pin d.i.l. sockets (2 off)
16-pin d.i.l. sockets(5 off)
8-pin d.i.l. sockets (2 off)
14-pin d.i.l. sockets
14-pin d.i.l. sockets
length of 40 strand ribbon cable

Constructors' Note

A complete kit of parts, excluding loudspeaker, is obtainable from **Technomatic Ltd., 17 Burnley Road, London NW10** should be placed in series with the a.c. supply feeding the bridge rectifier. Additionally the reader is referred to the many power control circuits that have appeared in *P.E.* in the past, and to the useful book on the subject by *D. Marsden*, entitled *110 Thyristor Projects.* The use of one of these with a controlling l.d.r. or opto-isolator should meet most individual requirements; though it should be noted that the recently published circuit for the *Slave Light Dimmer (P.E. Feb. 1981)* is not suitable for this purpose.

AUDIO OUTPUT

For some purposes it may be found useful to run an audio generator from the Analogue Board D/A converter, or from a R-2R converter running from an unused port, and buffered with an operational amplifier similar to that used on the Analogue Board. In either case the DAA output (or similar) may be used directly with i.c.s such as the NE566 function generator or the NE555 timer. Fig 4.12 gives a circuit for audio production using the 555. The DAA line from pin 14 of SK7 is used to directly drive the control pin (pin 5) of the 555. With the components specified this will give outputs in the range 5 to 10kHz. VR1 should be set to null output for zero data, and VR2 to maximum gain. This will result in outputs of about 10kHz for 255, and about 5kHz for data of around 80. If zero is POKEd to the converter, the generator ceases to oscillate, so providing a convenient means of switching off audio output.

FURTHER APPLICATIONS

The D/A converter on the Analogue Board may also be used for directly handling audio and other waveforms. It can, for example, be used in the direct generation of virtually any conceivable waveform. The program below produces a staircase output at the DA and DAA pins of the converter:

```
100 A=61320
110 INPUT "SAMPLE RATE: TRY 5"; C
120 FOR B=1 TO 255 STEP C
130 POKE A, B
140 NEXT
150 GOTO 120
```

Using BASIC for this purpose limits the output frequency of any waveform generated to a few Hz or so. For higher frequency outputs, the program would have to be executed in 6502 code. It would be a relatively simple matter to write a short routine in 6502 code that successively output the contents of a block of memory to the D/A converter. The block could then be filled beforehand, using a POKE routine in BASIC, with any desired waveform, e.g. sin, square, triangular step, etc. The short 6502 code program could then be accessed via the USR(X) call to output the data at any given speed.

Using similar techniques in conjunction with an A/D converter it would be possible to write software for a storage facility for an oscilloscope. The A/D converter would sample a given waveform, and store the data in a given block of RAM. The D/A converter could then be used to output the sequence repeatedly, and at any frequency and repetition rate, so as to provide a permanent display, with the option of recall facilities, etc. See Fig. 4.13.

Next month we will look at the use of the PSG on the Analogue Board, and discuss applications such as a 14-note organ operated from the UK101 keyboard. Details will also be given on the use of the Programmable Sound Generator as a 3-channel D to A converter

Readout...

A selection from our Postbag

Readers requiring a reply to any letter must include a stamped addressed envelope.
Opinions expressed in Readout are not necessarily endorsed by the publishers of Practical Electronics.

Excellent Combination

Sir—I have recently constructed a *PE* Congress amplifier from a kit supplied by Wicca, as a re-introduction to electronics after a fifteen year break. Apart from bridging two tracks in the phono stage, the unit worked first time. I must congratulate the designer(s) on the performance of this design—it really is incredibly good to listen to, and is capable of 'demolishing' a number of commercial units with a higher 'paper' performance.

I have only two small points of criticism. Firstly, the effectiveness of the balance control can only be described as minimal. I can find no fault in the construction, so can you advise? The second problem (about which I intend to speak to Wicca) is transformer hum, which, in an amplifier that generates so little noise internally, is very noticeable. Perhaps a toroidal unit would have been worthwhile?

My second reason for writing is to give a pat on the back to a company which has given me superb service. Some six months ago, I purchased a pair of Videotone GB3 speakers through the *PE* Special Offer. These were used a few times on an old stereo record player which at best could be described as poor, but did play old records, so I took little notice of the poor sound. When I had completed the Congress, I connected the GB3 units, and with a decent input to them, it was immediately obvious that one tweeter was inoperative.

I telephoned Videotone and explained the problem, which they suggested may have been caused by clipping on the old amplifier (which I doubt as I treated the unit very carefully in deference to its meagre output), but they took my address and offered to supply a new tweeter under warranty. It duly arrived and was installed, and the speakers were connected. The performance of those tiny (and cheap) boxes is a revelation. There is ample bass during the day with a little boost, but the real beauty is at night. With the bass rolled off a little, the sound quality is retained without annoying the neighbours. Try doing that with the bus-sized speakers that so many people seem to think necessary. In any normal residence, the Congress and GB3 pairing will be found capable of generating excrutiating volume without distortion, even to those with 'disco-ears'.

To any reader who may have built a Congress, I would say without hesitation, "hang on a pair of GB3s, you will not believe your ears". I bought the GB3s on the strength of an earlier auditioning of the older 'Minimax', which was very good, but not, I believe, in the same class as the GB3. As for the service from Videotone, what can I say except "thank you".

S. G. West,
Northampton.

Noddy Radio

Sir—As a reader of your magazine I would be quite content if the sickeningly over-exposed letters "CB" appeared never again. I have no enthusiasm for citizens band radio, and I suspect that 99% of the population of this country is similarly disinterested.

What we have is a verbose minority creating a furore over what is, after all, Noddy radio. I am prepared to tolerate occasional breakthrough on my domestic equipment when it is the police going discreetly about their business—or even a local taxi firm.