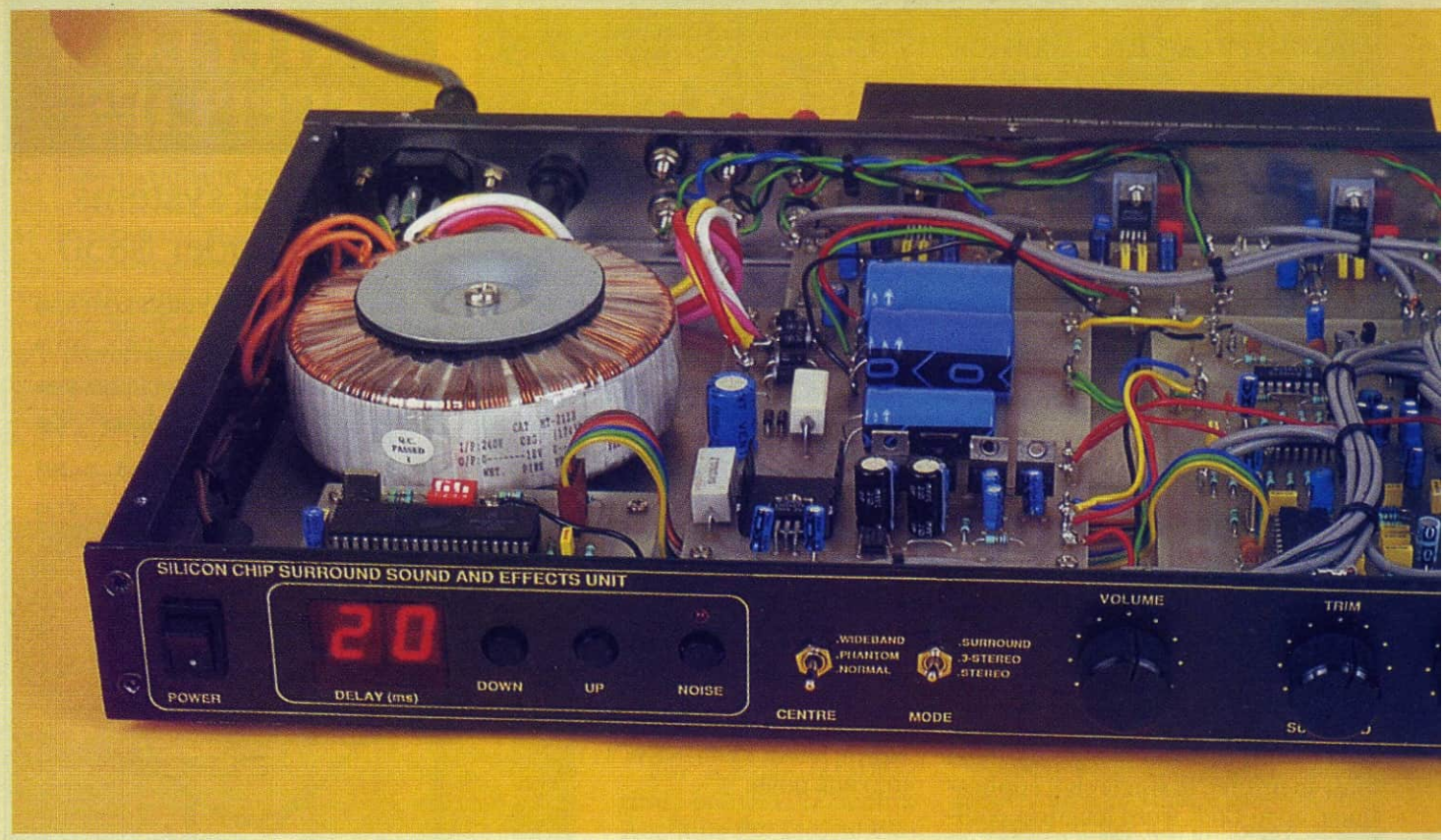
Build this Dolby Pro Logic Surround Sound Decoder

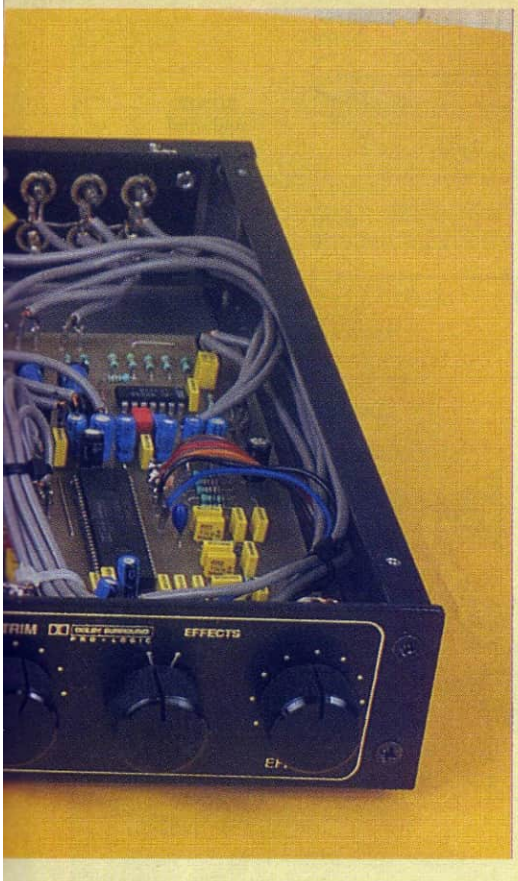
For big movie sound in your own home



Dolby Pro Logic Surround Sound Decoder, Mk.2

Set yourself up with movie sound in your living room, using this Dolby Pro Logic Surround Sound and Effects Unit. It includes a microprocessor for delay control plus power amplifiers. Fully approved and tested by Dolby Laboratories Licensing Corporation in the USA, it will provide you with a new standard of listening pleasure.*

By JOHN CLARKE



Main Features

- Genuine Dolby* Pro Logic active surround sound decoding
- Meets all Dolby specifications
- Stereo, 3-stereo, surround and effects modes
- Normal, wideband (full range) or phantom centre channel
- Noise sequencer to set up balance between channels
- Trim control for centre and surround channels
- Master volume control for all channels
- Subwoofer output
- Line outputs to left and right channels (to external stereo amplifier)
- 20W amplifiers for centre, surround left and surround right outputs
- Effects selection for simulated surround sound
- Adjustable delay from 15ms to 30ms
- Presettable power-up delay time

DOLBY PRO LOGIC Surround Sound provides an extra dimension to the sound of movies in your home and makes them so much more enjoyable. For big movie sound, you don't have to go to the cinema; you can now have it all at home.

Not only will the SILICON CHIP Surround Sound Unit decode Pro Logic sound but it includes an effects facility which adds depth to unencoded sources. These include music from CDs, records and tapes. Once you have listened to music via the effects unit you may find it difficult to go back to standard stereo sound. The delay time between the front channels and rear surround loudspeaker outputs can be adjusted to suit your personal preference.

We first published a basic Pro Logic Surround Sound Decoder in the December 1994 and January 1995 issues of SILICON CHIP. Since then we have had many requests for a deluxe version with power amplifiers and adjustable delay. Here is the result.

Housed in a low profile case, it includes three power amplifiers, one for the centre channel and two for the rear surround speakers. Line outputs are provided to drive a standard stereo amplifier for the left and right front channels. And for those who like lots of bass, there is a subwoofer output which can be connected to a separate power amplifier and subwoofer loudspeaker.

On the front panel are the on/off switch, up and down delay and noise sequencer buttons, mode and centre channel selection switches, the centre and surround trim controls plus the main volume, Dolby/Effects switch and effects level controls. At the rear are six RCA sockets for stereo inputs and the left, right and subwoofer outputs. Six binding post terminals are provided for the left and right surround and centre loudspeaker outputs.

The 2-digit display on the front panel indicates the selected delay time for the surround channel. This can be varied from 15ms to 30ms in 1ms steps. An initial delay value is set whenever the unit is switched on. This can be preset to any value between 15ms and 30ms by DIP switches inside the unit.

Noise sequencer

The noise sequencer is used to set the balance between channels. When switched on, the sequencer LED lights and a noise signal is sent to each channel in turn for about two seconds. The LED display shows which channel has the noise signal by displaying L, C, R or S. Thus, the centre and surround channel outputs can be adjusted to match the sound levels from the front left and right channels.

The mode control selects stereo, 3-stereo or surround sound. Stereo selection simply passes the signal without any processing. "3-stereo" adds the centre channel, while "Surround" adds the surround output, as you would expect. Note that during noise sequencer operation only the channels selected will be fed with noise signal.

The centre switch controls the centre channel mode. In Normal position, frequencies below 100Hz are attenuated so that a wide range loudspeaker is not required. The signal below 100Hz is added to the left and right channels at a -3dB level to restore the bass balance. In Wideband mode, the centre channel receives the full frequency range and a wide range speaker will be required.

Finally, in Phantom mode, no centre channel speaker is required as the centre channel signal is fed equally to the left and right front speakers. Note that the subwoofer output is only available when Normal or Phantom modes are selected.

The Dolby/Effects switch selects between the Pro Logic decoding and the Effects operation. When in effects mode, the centre channel is simply the left plus right signal, while the

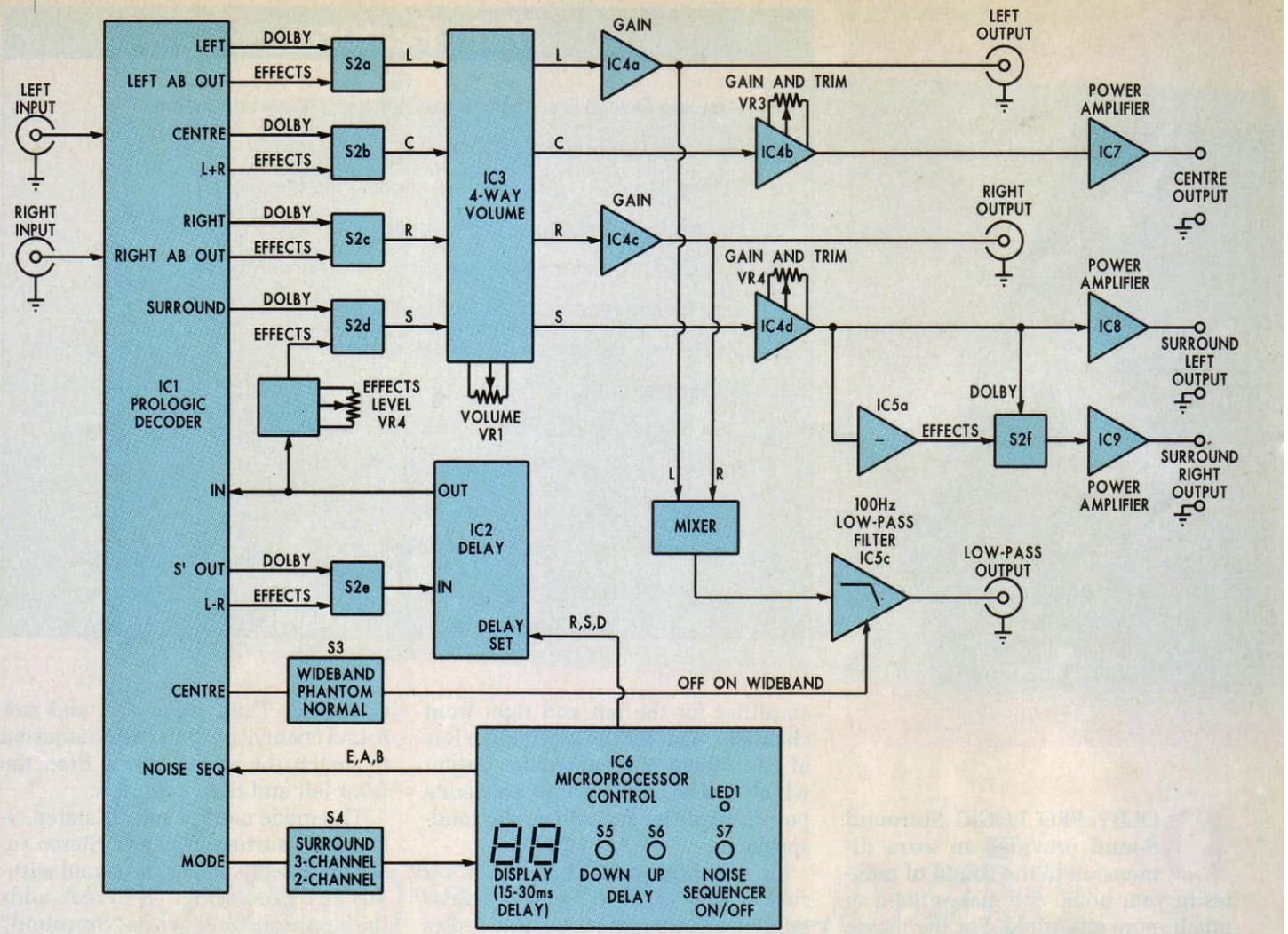


Fig.1: the block diagram for the Surround Sound Decoder. Most of the decoding work is done by IC1 and IC2, while IC6 controls the delay times and noise sequencer operation.

surround channel is the left minus right signal. The surround channel is also delayed by the value set on the display and the surround volume is set by the effects level control.

Block diagram

Fig.1 shows the block diagram for the SILICON CHIP Surround Sound Decoder. Most of the decoding work is done by IC1 and IC2, while IC6 controls the delay times and noise sequencer operation.

The left and right channel encoded signals (Lt and Rt) are initially processed by an automatic balance control within IC1. This detects any difference between the left and right channels and adjusts the gain in each channel until the difference is nulled out. Precise balance between the left and right channels is important for obtaining the best separation between each of the four channels.

At this point, either the balanced left and right outputs or noise sequencer signals are passed through to the following stages. This is selected by the Noise Sequencer input signals (E, A and B) under control from IC6. When the noise sequencer is selected, a noise signal is passed in turn to the Left, Centre, Right and Surround outputs. The channel mode switch (S4) sends a signal to IC6 so that it is aware of the switch position. In the stereo mode, noise is sent to only the left and right channels, while in 3-stereo, the centre channel also receives a noise signal.

When the noise sequencer is off, an L-R and L+R signal is produced from the left and right balanced outputs. In its most simple form the L+R signal becomes the centre channel and the L-R signal becomes the Surround channel. These outputs are used for the effects selection while the Pro Logic outputs include further processing to improve channel separation, channel dominance and directional accuracy in each channel. Effects or Pro Logic decoding is selected by switch S2a-S2f.

The surround output (designated S') or the L-R signal is sent to an anti-alias filter within IC2 prior to delay processing. This filter removes frequencies above 7kHz. Without this anti-alias filter, extraneous signals can occur at the output of the delay unit and these would cause distortion plus a variety of spurious beat effects. The delay time is adjusted by IC6 (the microprocessor).

A 7kHz low pass filter also follows the delay to limit the signal to the same bandwidth as the originally recorded surround signal. This reduces noise and improves the surround sound reproduction.

A modified Dolby B-type noise reduction within IC1 restores the signal to its original flat response.

The L, C, R & S signals from S2a-

PARTS LIST

1 folded metal case, 436 x 50 x 260mm, with screened front panel
1 input/output socket label, 65 x 40mm
1 loudspeaker terminal label, 75 x 40mm
1 Dolby licence label, 145 x 7mm
1 heatsink, 180 x 42 x 26mm
1 2 x 18V 160VA toroidal transformer (T1)
1 IEC mains male socket
1 3-core mains lead with moulded 3-pin plug & IEC female plug
1 M205 panel mount fuseholder (F1) plus 3A fuse
1 6-way RCA panel sockets
6 banana sockets – 3 red, 3 black
1 SPST miniature rocker switch (Altronics Cat S 3210) (S1)
1 6-pole 2-position break before make rotary switch (S2)
2 DPDT centre off switches (S3,S4)
1 5kΩ linear pot (VR1)
2 50kΩ log pots (VR2,VR3)
1 10kΩ log pot (VR4)
1 6m length of shielded audio cable
1 500mm length of 7.5A brown mains rated wire
1 100mm length of 7.5A blue mains rated wire
4 500mm lengths of hookup wire – red, green, yellow & black
1 800mm length of 3-way rainbow cable
1 300mm length of 0.8mm tinned copper wire
1 2-way mains terminal block
5 22mm black anodised knobs
1 solder lug
4 12mm tapped spacers plus 8 screws
8 9mm tapped spacers plus 16 screws
7 6mm standoffs plus 7 screws & nuts
20 100mm long cable ties
100 PC stakes
1 0.47µF MKT polyester capacitor
1 0.1µF 3kV ceramic capacitor
1 S14K 275V metal oxide varistor

Decoder PC Board

1 PC board, code 01409951, 160 x 165mm
1 2MHz crystal (X1)
4 5V reed relays, Jaycar Cat. SY-4036 (RLY1-RLY4)

Semiconductors

1 M69032P Mitsubishi Dolby Pro Logic Surround Decoder (IC1)
1 M65830P Mitsubishi Digital Delay (IC2)
1 TDA1074A quad VCA (IC3)
2 LF347 quad op amp (IC4,IC5)
1 BC338 NPN transistor (Q1)
1 1N4004 1A 400V diode (D11)

Capacitors

5 100µF 16VW PC electrolytic
1 47µF 16VW PC electrolytic
1 22µF 16VW PC electrolytic
5 10µF 16VW PC electrolytic
1 10µF 25VW PC electrolytic
1 10µF 16VW RBLL electrolytic
2 4.7µF 16VW PC electrolytic
11 1µF 16VW PC electrolytic
1 0.68µF MKT polyester
1 0.33µF MKT polyester
5 0.22µF MKT polyester
1 0.18µF MKT polyester
15 0.1µF MKT polyester
2 .068µF MKT polyester
1 .056µF MKT polyester
3 .047µF MKT polyester
2 .022µF MKT polyester
3 .0056µF MKT polyester
1 .0047µF MKT polyester
1 .0033µF MKT polyester
1 .0022µF MKT polyester
2 680pF ceramic
3 470pF ceramic
4 180pF ceramic
2 100pF ceramic

Resistors (0.25W 1%)

3 10MΩ	1 8.2kΩ
1 1MΩ	6 7.5kΩ
1 330kΩ	1 5.6kΩ
1 150kΩ	3 4.7kΩ
6 100kΩ	1 2.7kΩ
4 68kΩ	1 1kΩ
7 47kΩ	1 470Ω
1 33kΩ	7 100Ω
7 22kΩ	1 30Ω
2 18kΩ	2 10Ω
14 15kΩ	

Power Supply PC Board

1 PC board, code 01409952, 105 x 140mm
1 TO-220 heatsink, 30 x 25 x 13mm

Semiconductors

1 7815 15V 3-terminal regulator (REG1)
1 7915 15V 3-terminal regulator (REG2)
1 7812 12V regulator (REG3)
1 317T adjustable regulator (REG4)
1 7805 5V regulator (REG5)
4 1N5404 3A diodes (D1-D4)
6 1N4004 1A diodes (D5-D10)
1 PO4 1A bridge (BR1)

Capacitors

2 10,000µF 25VW PC electrolytic
1 4700µF 25VW PC electrolytic
1 1000µF 25VW PC electrolytic
2 470µF 25VW PC electrolytic
1 47µF 25VW PC electrolytic
7 10µF 25VW PC electrolytic

Resistors (0.25W 1%)

1 10kΩ	1 120Ω
1 1.8kΩ	1 100Ω 5W
1 680Ω 5W	

Amplifier PC Board

1 PC board, code 01409953, 200 x 50mm
12 M205 PC mounting fuse clips
6 3A M205 fuses
3 TO220 insulating bushes & washers
3 LM1875 20W amplifiers (IC7-IC9)

Capacitors

6 100µF 25VW PC electrolytic
3 22µF 25VW PC electrolytic
3 2.2µF bipolar electrolytic
3 0.22µF 63V MKT polyester
6 0.1µF MKT

Resistors (0.25W 1%)

3 22kΩ	3 1kΩ
3 18kΩ	3 1Ω

Microcontroller & Display PC boards

1 PC board, code 01409954, 76 x 90mm
1 PC board, code 01409955, 26 x 115mm
1 4MHz crystal (X2)
1 4-way DIP switch
3 momentary PC switches (S5-S7)
1 6-way PC board header plug
1 6-way PC board header plug

Semiconductors

1 MC68HC705C8P programmed microprocessor (IC6)
2 HDSP5301 common anode 7-segment displays (DISP1, DISP2)
3 1N914 diodes (D12-D14)
1 3mm red LED (LED1)

Capacitors

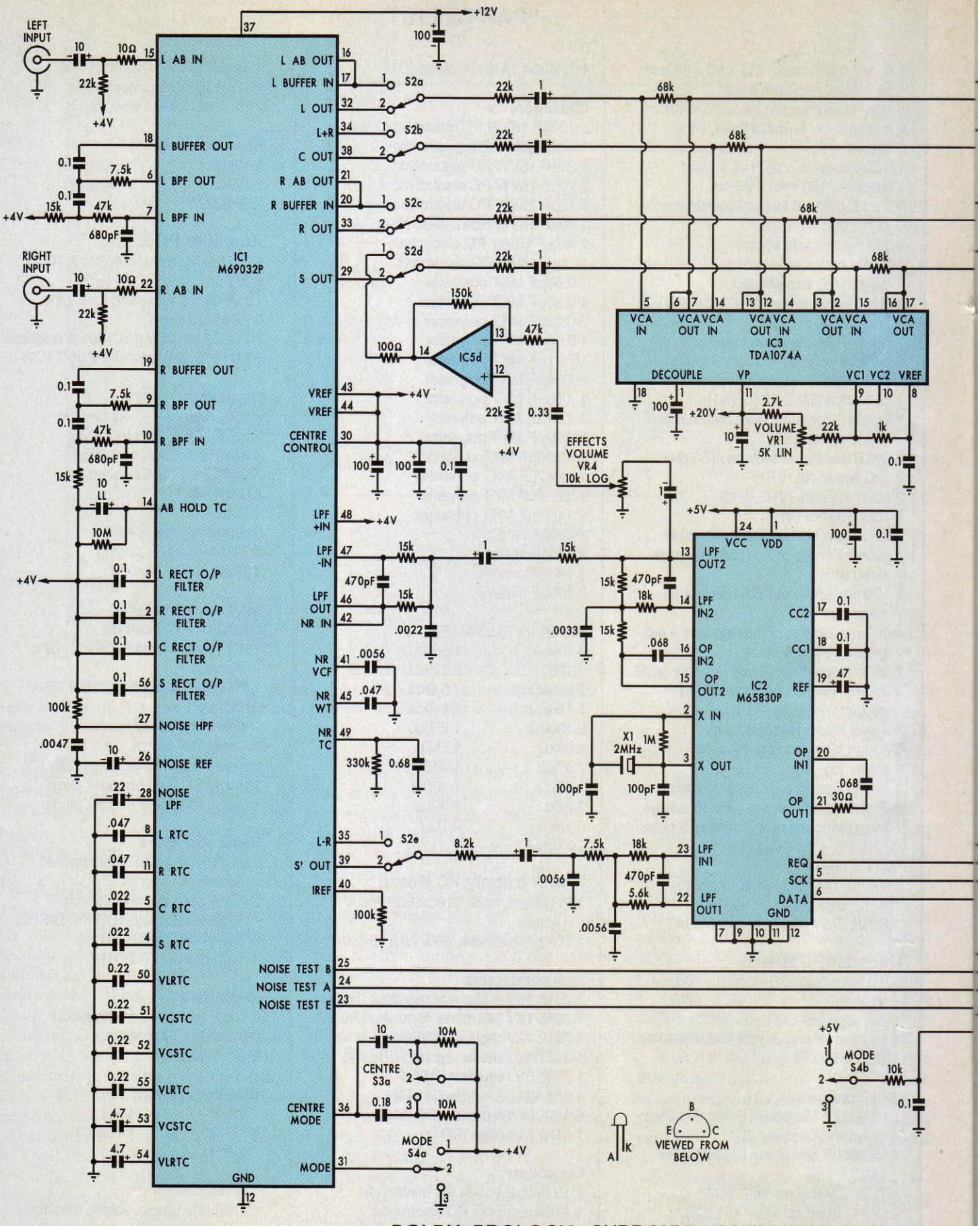
1 10µF 16VW PC electrolytic
2 0.1µF MKT polyester
2 39pF ceramic

Resistors (0.25W, 1%)

1 1MΩ	1 1kΩ
4 47kΩ	14 330Ω
6 10kΩ	

Miscellaneous

Heatshrink tubing, solder, machine screws & nuts.



DOLBY PROLOGIC SURROUND SOUND DECODER

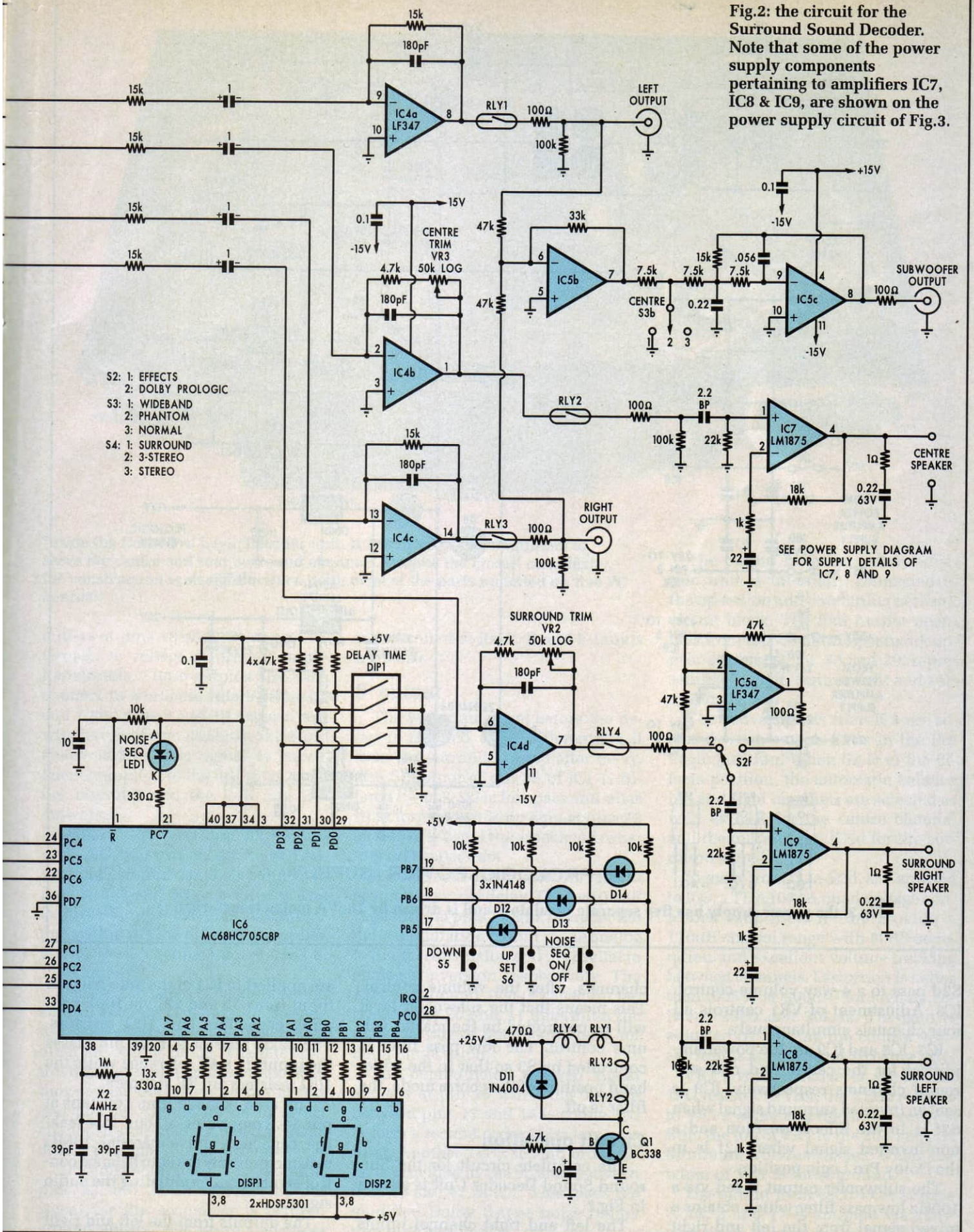


Fig.2: the circuit for the Surround Sound Decoder. Note that some of the power supply components pertaining to amplifiers IC7, IC8 & IC9, are shown on the power supply circuit of Fig.3.

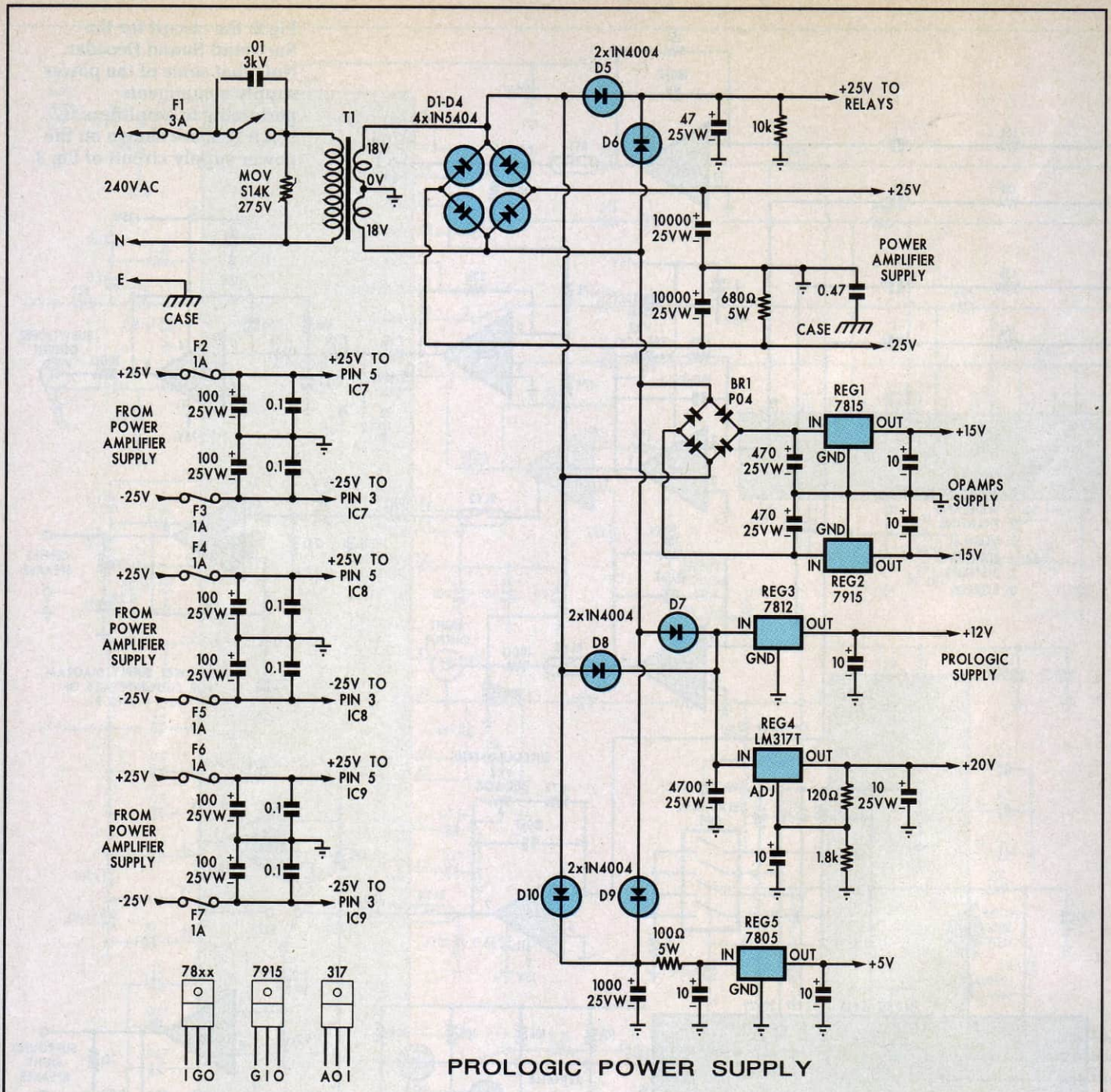


Fig.3: the power supply has five separate regulators and is driven by 160VA mains transformer.

S2d pass to a 4-way volume control, IC3. Adjustment of VR1 controls all four channels simultaneously.

IC7, IC8 and IC9 are the power amplifiers for the centre and rear surround channels respectively. IC9 is sent an inverted surround signal when S2f is in the Effects position and a non-inverted signal when S2f is in the Dolby Pro Logic position.

The subwoofer output is fed via a 100Hz low pass filter which obtains a mixed signal from the left and right channels, after the volume control. This means that the subwoofer level will be controlled by the master volume control. The low pass filter is controlled by S3 so that in the wideband position of the centre mode, the filter is off.

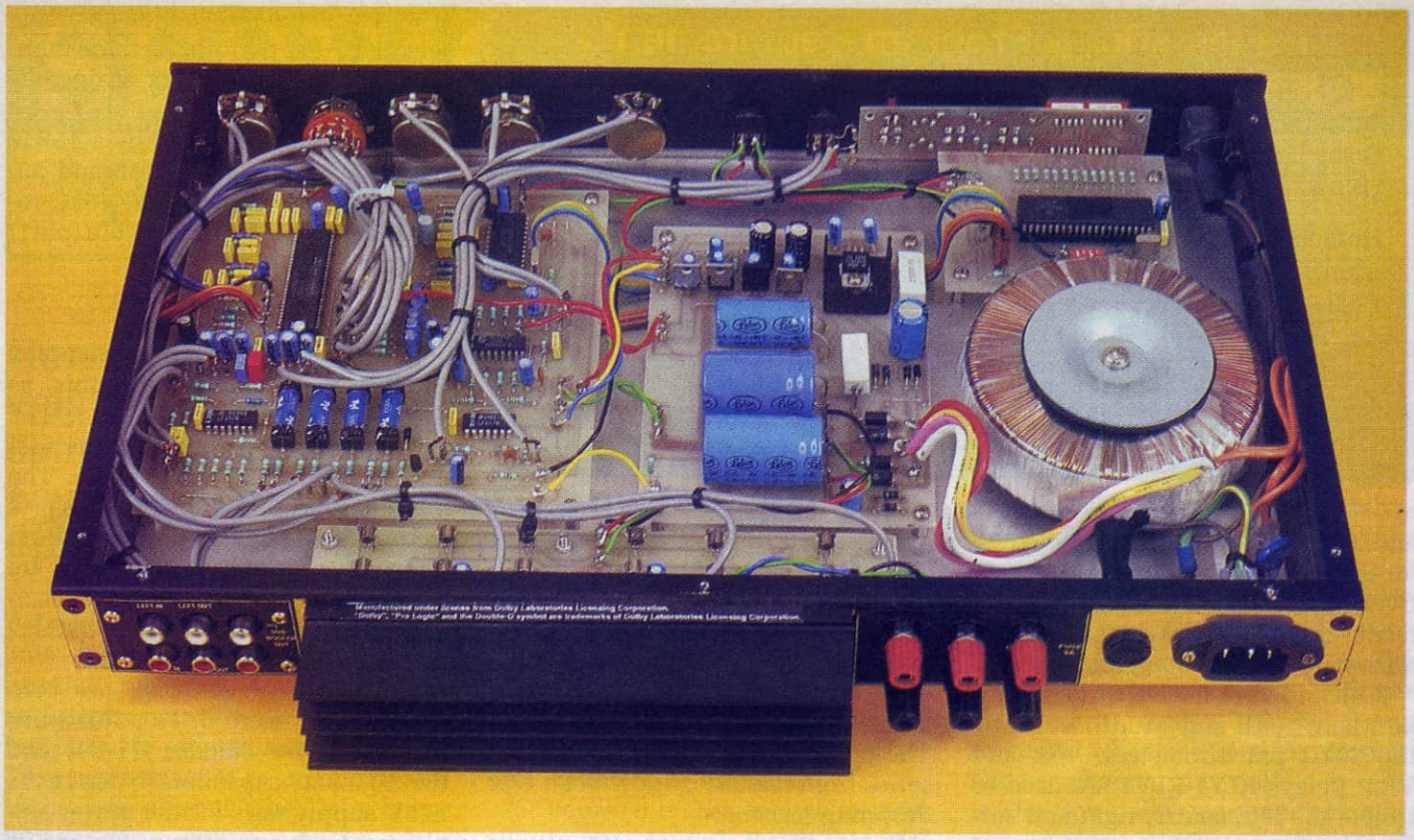
Circuit operation

The complete circuit for the Surround Sound Decoder Unit is shown in Fig.2.

The left and right channel inputs are applied to IC1 at the auto balance input (pins 15 and 22) via 10µF coupling capacitors and 10Ω resistors. The 22kΩ resistor at each pin biases the inputs to a 4V reference while the 10Ω resistors are RF stoppers.

The auto balance time constant at pin 14, comprising a 10µF low leakage capacitor and a parallel 10MΩ resistor, prevents the auto balance control signal from modulating the audio signal.

The outputs from the left and right



Inside the Dolby Pro Logic Decoder unit. It has three power amplifiers to serve the centre and rear surround channels. Despite the circuit complexity, the construction is straightforward, with most of the parts mounted on five PC boards.

buffers at pins 18 and 19 connect internally to voltage controlled amplifier circuits. These outputs also each connect to bandpass filters at pins 6 and 7 and pins 9 and 10 respectively which roll off signals above 5kHz and below 200Hz. The signal is subsequently applied to the full wave rectifier circuitry and the L+R and L-R networks.

Output filter capacitors for the full wave rectifiers on the Left, Right, Centre and Surround channels connect to pins 3, 2, 1 and 56 respectively. The Rectifier Time Constant (RTC) capacitors within the log difference amplifiers for these channels are at pins 8, 11, 5 and 4.

The time constant capacitors which control the rate at which the sounds can move from one channel to another are at pins 50-55. The rate control time constants are important since they prevent the system becoming lost and placing sounds in the incorrect channel if subject to sudden transients or loss of signal due to dropouts.

The noise source in IC1 is filtered at pins 27 and 28 so that the output signal for the sequencer is centred around 500Hz. The noise sequencer is controlled at its A, B and E inputs from IC6.

S' output

The surround signal before the delay is labelled S' to differentiate it from the surround signal after delay. The S' output at pin 39 of IC1 is filtered by an 8.5kHz low pass anti-alias filter formed by the op amp at pins 22 and 23 of IC2 and the associated resistors and capacitors.

IC2 is clocked by a 2MHz crystal to accurately set the delay. The two 0.1µF capacitors at pins 17 and 18 are for the delta modulation circuit in the analog to digital conversion and the digital to analog conversion respectively. The 30Ω resistor and .068µF capacitor between pins 20 and 21 determine the response rate of the op amp used for delta modulation.

The demodulated delayed signal appears at pin 15 while the op amp between pins 13 and 14 is connected to form a second order 7kHz low pass filter. Another 7kHz second order filter is provided by the op amp between pins 46 and 47 in IC1. This feeds the modified Dolby B-type noise reduction unit within IC1.

The output from the noise reduction unit is internally connected to the operation and combining network circuit block. The four output channels from this combining network appear at pins 32, 38, 33 and 29, representing the left, centre, right and surround signals.

The above signals from IC1 are selected when switch S2 is in the Pro Logic position. When S2 is in the Effects position, the automatic balance left and right channels are selected as well as L+R for the centre channel and the output from IC5d for the surround signal.

Signals from S2a-S2d are applied to IC3, a TDA1074A quad voltage controlled amplifier. It can provide a 110dB control range with 80dB separation and excellent volume tracking between channels. Distortion is better than .005% at 300mV for signals between 20Hz and 20kHz. The gain is adjusted by varying the control voltage inputs at pins 9 and 10 using VR1.

VR1's voltage range is set by the 1kΩ resistor to Vref, the 22kΩ resistor to VR1's wiper and the 2.7kΩ resistor from the top of VR1 to the 20V supply. Minimum volume occurs when the wiper of VR1 is set at ground.

The output from each VCA at pins 7, 12, 2 and 17 is coupled via 10µF capacitors to quad op amp IC4. IC4a

*Trademarks & Program Requirements

Note 1: "Dolby", "Pro Logic" and the Double-D symbols are trademarks of Dolby Laboratories Licensing Corporation, San Francisco CA94103-4813 USA.)

Note 2: this Dolby Pro Logic surround sound decoder requires a program source such as a stereo TV set or hifi stereo VCR. The program must be Dolby Surround encoded as depicted in the movie credits by the Dolby double-D surround symbol. For unencoded stereo signals, the Dolby 3-stereo selection will provide the centre front channel. Effects selection will provide surround sound from any stereo signal source. The decoder will not operate from a mono signal.

and IC4c provide a nominal gain of -1 for the left and right channels respectively. The 180pF capacitor across the feedback resistors provides a high frequency roll-off at about 40kHz.

IC4b and IC4d have a variable gain between -10dB and +10dB, as set by the 50kΩ potentiometers, VR2 and VR3. Relays RLY1-RLY4 are used to isolate the left, centre, right and surround outputs at power up to prevent audible thumps in the loudspeakers.

The subwoofer signal is derived by mixing the left and right channel signals in op amp IC5b which feeds the second order Butterworth low pass filter based on IC5c. Note that switch S3b grounds the signal applied to the filter when it is set in the wideband centre mode position.

IC5a is a unity gain inverter for the right channel surround amplifier which is used when switch S2f is in the effects position.

The three power amplifiers (IC7-IC9) for the centre and rear surround channels are National Semiconductor LM1875 20W devices. They come in a 5-pin TO-220 package. Their gain is set by the 18kΩ feedback resistor between pins 2 & 4 and a 1kΩ resistor to ground via a 22µF capacitor.

A 2.2µF bipolar capacitor couples signal into the non-inverting input at pin 1. The output at pin 4 is connected to a Zobel network comprising a 1Ω resistor and 0.22µF capacitor. This prevents high frequency instability when driving inductive loads such as loudspeakers.

Microprocessor control

IC6 is a 68HC705C8P microprocessor. It sets the delay value in IC2, controls the noise sequencer operation, drives the 2-digit display and operates relays RLY1-RLY4 via transistor Q1.

Initially, when power is first applied, the relays are off since the PC0 output of IC6, pin 28, is low. After a delay of about five seconds, PC0 goes high which turns on transistor Q1. The relay coils are then powered in series from the 25V supply via a 47Ω dropping resistor.

Before PC0 goes high, IC6 checks the switch positions of DIP1 and sets the IC2 delay with this value. The 2-digit display is driven accordingly. Once PC0 goes high, the microprocessor goes into stop mode where it draws low power and produces minimum noise. This is desirable, to keep noise out of the audio circuitry.

If a switch is pressed, the interrupt input at pin 2 goes low via one of the diodes D12-D14. The microprocessor wakes up and responds accordingly. If the up switch is pressed, then the delay value will increment on the display and will also be updated in IC2. Similarly, if the down switch is pressed, the delay value will decrease.

If the noise sequencer switch is pressed, it will set IC1 to produce noise in each channel and drive LED1. The PD4 input at pin 33 monitors the mode switch so that the noise sequencer will function only on the channels selected. After performing these functions, the microprocessor again goes into sleep mode.

Finally, IC6 is clocked by a 4MHz crystal oscillator at pins 38 and 39. The 10µF capacitor and the 10kΩ resistor connected to the reset pin (pin1) provide a power-on reset.

Power supply

The power supply is quite complex and has five separate regulators, as shown in the circuit of Fig.3. The mains transformer is a 160VA toroidal unit with two 18V secondaries. The primary side of the transformer is protected with a 3A fuse while switch-off transients caused by switching S1 are suppressed with a .01µF/3kV capacitor and a metal oxide varistor (MOV) across the transformer primary.

The two 18V windings are connected in series to drive a full wave bridge rectifier (diodes D1-D4) and two 10,000µF capacitors to derive the ±25V supply rails for the power amplifiers. Each power amplifier has its supply rail decoupled with 100µF and 0.1µF capacitors.

The 18V windings also drive three pairs of diodes to derive other supply rails. First, D5 and D6 and a 47µF capacitor provide the +25V rail for the relays. Using such a small reservoir capacitor ensures that the voltage will fall quickly once power is removed. The relays must switch off quickly to decouple the outputs of IC4 and thus prevent switch off thumps.

A separate bridge rectifier (BR1) and two 470µF capacitors feeding 3-terminal regulators REG1 and REG2 are used for the ±15V rails for the op amps.

Diodes D7 and D8 and a 4700µF capacitor drive two 3-terminal regulators, REG3 and REG4, to produce a +12V rail for IC1 (the Pro Logic decoder) and a +20V rail for IC3 (the quad VCA chip). Finally, diodes D9 and D10 feed a 1000µF capacitor. Again, this produces raw DC of about +25V and this is fed via a 100Ω 5W resistor to 3-terminal regulator REG5, to produce a +5V rail for IC3 and IC6.

That's all we have space for this month. Next month, we will complete the description of the Dolby Pro Logic Decoder by giving the full construction details and the performance specifications. SC

Kit Availability

Kits will be available from all Jaycar Electronics stores. Our thanks to Jaycar Electronics for their assistance in the development of this project and for their liaison with Dolby Laboratories who have approved the design. Jaycar Electronics is the licensee for the design which was developed in our laboratory.