STAGE YOUR OWN LIGHT SHOW

These days when you go to hear your favourite band or disco there is always a top light show. Now you can have many of these exciting light show effects — with the Discolight.

By JOHN CLARKE & LEO SIMPSON

The Discolight is a compact and affordable unit which drives four channels of coloured lights to produce an exciting and highly varied light show. It can be driven directly from your stereo system's loudspeakers or it can be triggered from live music picked up by an inbuilt microphone. It can also produce all sorts of light patterns on its own, with or without modulation by the music.

With the Discolight you don't need to go to the trouble and expense of hiring a disco system and disc jockey — you can put on your own light show and do it better. In fact, we reckon that as soon as disco operators find out about SILICON CHIP's Discolight, they'll all be building them.

The Discolight has a great many features which are summarised in an accompanying panel.

The Discolight turns sound into light. Feed music from your stereo, Walkman or whatever into its rear terminals and it then drives four sets of mains-powered coloured lamps. The brightness of the lamps is directly proportional to the loudness of the music signal.

In fact, the Discolight divides the audio signal from your stereo into four frequency bands and then uses each of those frequency bands to modulate the brightness of the lamps. Most people will have seen such set-ups on TV shows, in discos and in hotels. The lights may be coloured 100W floodlamps or banks of smaller coloured lights.

Typically, four differently coloured floodlamps or sets of lamps would be connected, one set to each channel. You might use red for the lowest frequency band, then yellow, green and blue for the highest band.

Not only does the Discolight turn music into fascinating light patterns but it also generates its own light patterns, for when the music stops. If you're operating a disco show and the band stops for a rest break or the music has to stop for some reason, the Discolight generates its own light patterns: chaser, strobe and alternate patterns (we'll describe these later).

Understanding how to use the Discolight may be best explained by briefly describing its various front panel controls and rear panel features.

On the rear panel are four 3-pin

mains sockets to which you connect your banks of coloured lights. There is also a set of four spring-loaded terminals so that you can connect the audio outputs from your stereo amplifier. These are connected in parallel with your speakers and cause negligible loading of your amplifier's outputs.

On the front panel are two knobs, a fuseholder, large power switch and five miniature toggle switches, three of which are 3-position types. There are also four LEDs (light emitting diodes), one for each of the light channel outputs. Let's look at the function of these miniature toggle switches first.

Right next to the SENSITIVITY knob is the SOURCE (microphone/speaker) switch. This selects the audio from your stereo system (via the 4-way terminals on the back panel) or the sounds picked up by the Discolight's inbuilt electret microphone. If you have a live band, you can simply place the Discolight nearby and switch to Microphone mode, thus eliminating the need for cable connections.

As you might expect, the adjacent SENSITIVITY knob adjusts the audio signal levels for the best light display.

In the centre of the five toggles is the DISPLAY switch. This 3-position switch is the key to the Discolight's functions. In its top position, "4-Band Modulated", you get the basic Discolight function whereby the audio signal is split into four separate frequency bands (low bass, upper bass, mid-treble and upper treble) and each of these bands control their respective lights.

The brightness of the lamps at any instant is directly proportional to the sound level in the respective audio frequency band.

In the Modulate (MOD) position of the DISPLAY switch, the audio signal both modulates the lights and triggers the various modes selected by the PATTERN switch. Finally, the Unmodulated setting of the DISPLAY switch allows the light display to be set by the pattern switch.

The PATTERN switch gives three light displays: 4-light chaser, strobe and alternate. The Chaser mode is self explanatory; the four lights chase each other in one direction or the other, as set by the DIRECTION switch. The speed at which the lights chase each other is set by the RATE control knob.

In the Strobe mode, all four sets of lights flash on simultaneously, as set by the RATE control. In the Alternate mode, two pair of channels flash on and off alternately, at a speed set by the RATE control.

The DIRECTION switch controls the Chaser mode. You can have the lamps chase in one direction or the other or change direction automatically, every minute or so.

Finally, the BEAT switch gives beat triggering from the music for the Chaser, Strobe and Alternate pattern modes. In the Oscillator setting of the BEAT switch, these functions are controlled by the RATE knob.

The four LEDs on the front panel mimic the behaviour of the four light channels, so that even if you can't see the lamps directly (say you are acting as disco operator), you can tell what they are doing by looking at the LEDs. The LEDs will also come in handy during any troubleshooting which may have to be done.

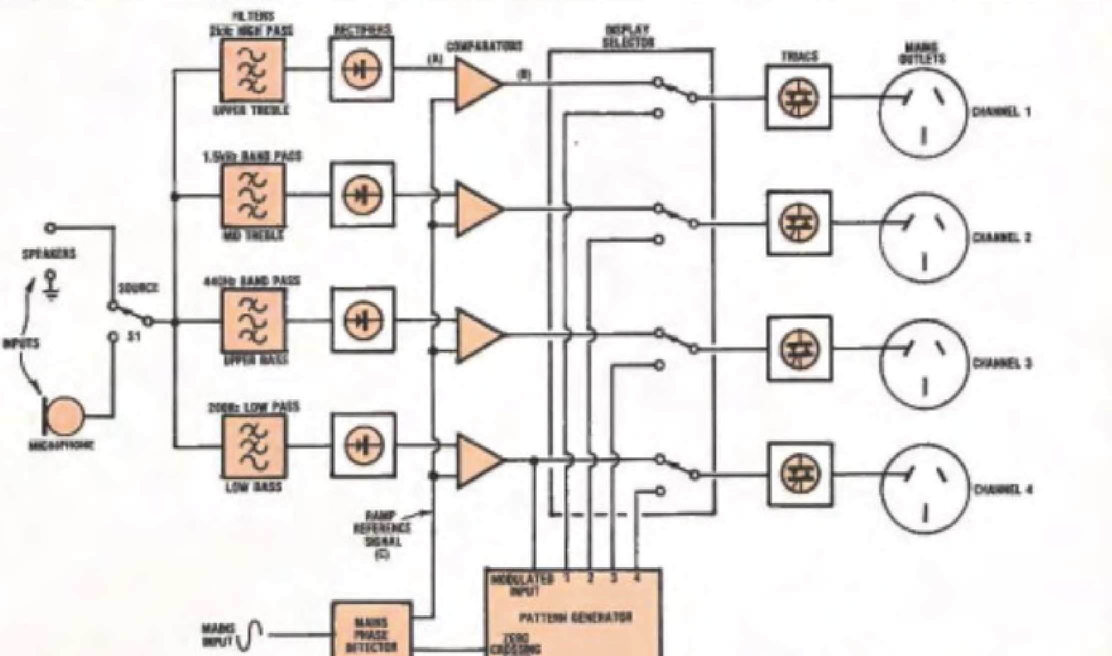


Fig.1: the audio signal is split into four frequency bands, rectified and compared with a 100Hz ramp reference signal. The Triacs are then triggered either by the comparator outputs or by signals from the inbuilt pattern generator.

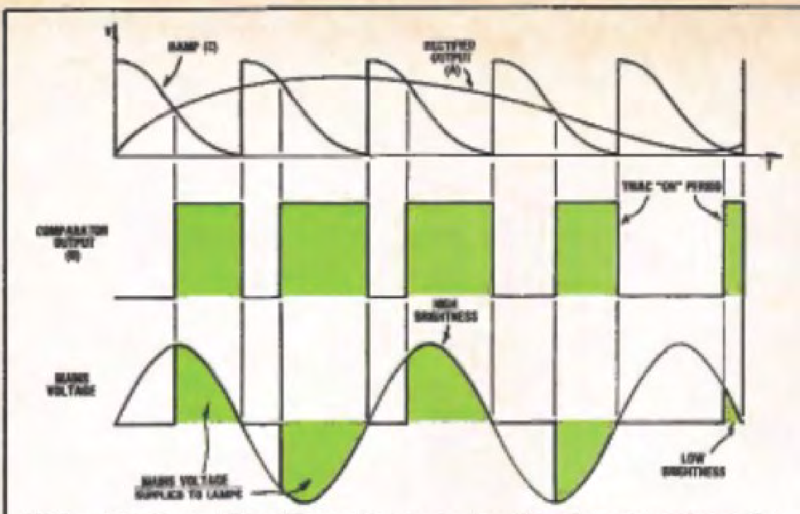


Fig.2: when the rectified filter output is greater than the ramp voltage, the comparator output is high and the associated Triac turns on. If the Triac turns on early in the mains half cycle, the lamp will be bright; if it turns on late in the half-cycle, the lamp will be dim.

How it works

The circuitry for the Discolight consists of four quad op amp ICs, five CMOS ICs, four opto-isolated Triac triggers, four isolated tab Triacs, four LEDs, two 3-terminal regulators and 21 diodes. And that's just the semis. Add in the resistors, capacitors, inductors, switches, pots and all the other hardware bits and it comes to a stack of components. Our total component count comes to over 230, so depending on how you look at it, it is the most complicated circuit we have presented in SILICON CHIP to date.

Fig.1 shows the block diagram of the circuit. Switch S1 selects the audio signal, either from the internal microphone or from the loudspeaker terminals (which connect to your stereo). The audio signal is then fed to four filters which split it into four distinct frequency bands: Low Bass, Upper Bass, Mid Treble and Upper Treble.

The Low Bass frequency band is provided by a 200Hz low pass filter — this means that only signal frequencies below 200Hz are allowed to pass. Then there is the Upper Bass band which passes signals between about 200Hz and 700Hz. This is actually a bandpass filter centred on 440Hz.

The Mid Treble band, from about 700Hz to 2kHz, is another bandpass filter, centred on 1.5kHz. Finally, the Upper Treble band is from 2kHz to 20kHz and is provided by a 2kHz high pass filter (ie, everything above 2kHz passes).

The audio signal from each of the four filters is rectified and smoothed to provide a varying DC level, which is then fed to one of four comparators. The comparators compare the varying DC signal to a 100Hz ramp reference signal which is derived from the 240VAC mains supply (via the power transformer).

Phase control

The next part is messy. We vary the brightness of the lamps, in response to the loudness of the audio signal, by using "phase control". This is a method whereby a Triac (a semiconductor switch) is turned on earlier or later in each mains half-cycle. If the Triac turns on early in each half-cycle, the power delivered to the lamp is high; if the Triac turns on later, the power delivered to the lamp is low.

The four comparators shown in Fig.1 each determine whether their associated Triac turns on early or late in each mains half-cycle. They therefore determine the brightness of the lamps at any instant, depending on the loudness of the audio signal, as represented by the varying DC levels referred to earlier.

Fig.2 shows how each comparator controls its associated Triac. It looks as "clear as mud" but be patient and all will be revealed. First, look at Fig.2c. This shows the 50Hz mains supply waveform and also the time at which the Triac switches on in each each mains half-cycle.

As before, when the Triac turns on early in the half-cycle, the lamp will be bright; when the Triac turns on late in each half-cycle, the lamp will be dim.

Fig.2b shows the DC output from the comparator, corresponding to the Triac "on" times. The DC output from the comparator actually turns the Triac on (although not directly, as we shall see later).

Fig.2a shows the interaction of the varying DC, from one of the audio filters, with the 100Hz reference signal (note how this signal is synchronised to the mains waveform in Fig.2c). Whenever the slowly varying DC signal is above the 100Hz reference signal, the output of the comparator goes high and triggers the Triac. So that's the basic process of how the audio signal is rectified and then controls the Triac to vary the respective lamp's brightness.

But, as you might have guessed, there's a lot more to it than that, otherwise the overall circuit of the Discolight (which you've probably looked at and shuddered) would be a lot simpler.

Now refer back to Fig.1. Instead of the four comparator outputs going directly to trigger the Triacs

> **Warning!**
>
> The Discolight is not a project for beginners. Unless you have already successfully built a number of mains-powered projects we advise you to leave this one strictly alone. Part of the circuitry is powered directly from the 240VAC mains supply and therefore must be regarded as potentially dangerous. We have designed it to comply with SAA regulations but if it is not wired correctly and tested out properly it could be lethal.

Main Features

Operating features

★ Four light channels controlled by four separate audio channels.
★ Forward, reverse and auto-reversing chaser patterns.
★ Simultaneous strobe on all four channels.
★ Alternate light mode.
★ Music modulation available on chaser, strobe and alternate modes.
★ Adjustable rate for chaser, strobe and alternate modes.
★ Inbuilt microphone for beat triggering or audio modulation of lights.
★ Direct inputs for beat triggering or audio modulation of lights.
★ Sensitivity control.
★ Internal presettable sensitivity levels for each channel.
★ Front panel LEDs mimic light display.

Electrical features

★ 2400W maximum lamp load.
★ 600W maximum lamp load in each channel.
★ Fused mains supply to lamps.
★ Isolated tab Triacs for extra safety.
★ Opto-coupled Triac triggering for complete isolation of control circuitry from 240VAC mains supply.
★ RF interference suppression components on each light channel.
★ Zero voltage switching of Triacs used for unmodulated chaser, strobe and alternate modes — for minimum radio interference.

they go via a block labelled as the Display Selector. This can be regarded as a four pole switch which selects either the signals from the comparators or a pattern generator. Signals from the pattern generator drive Triacs and hence the lamps in the chaser, strobe or alternate modes.

Well, that's probably as far as we can go with block diagrams in describing the basic operation of the Discolight. Now, we have to stop dithering about and get into the circuit description proper.

Circuit description

Let's start at the extreme top lefthand corner of circuit. This shows an input attenuator consisting of two 10kΩ resistors, one for each speaker lead from your stereo amplifier. The 10kΩ resistors connect via a common 1.8kΩ resistor to ground. This network mixes the two stereo channels together as well as attenuating them. From there, the signal goes to the SOURCE switch S1.

Op amp IC1b provides gain for the signal from the electret microphone. The electret is powered via a network consisting of a 1kΩ resistor and 100μF capacitor which provide decoupling from the main +12V supply while bias current is fed via the 4.7kΩ resistor. The electret's signal is coupled by a .047μF capacitor to the non-inverting input of IC1b which boosts the signal by about 31 times.

After SOURCE switch S1, the signal is fed to the SENSITIVITY control (VR5) and then to op amp IC1a (a stage identical to IC1b) which again provides a gain of 31 times. IC1a's output is then fed to the four filter stages to provide the four frequency bands mentioned previously when we described Fig.1.

IC2a and associated components form the 2kHz high pass filter. This is a third order (three RC time-constants) filter which means that signals below 2kHz are rolled off at 18dB/octave.

IC2d and associated components form the 200Hz third order low pass filter for the Low Bass channel.

IC2b and IC2c and their associated components form twin-T filters. These are the 440Hz and 1.5kHz bandpass filters for the Upper Bass and Mid Treble frequency bands (as shown on Fig.1). Each of these four filter stages has a gain of about unity.

The output of each filter is rectified using diodes D1, D2, D3 and D4 and smoothed with 1μF capacitors except for the 200Hz low pass rectified output which uses a 2.2μF capacitor. The larger capacitor provides a somewhat slower response time for the low frequency band.

The varying DC output from each filter stage is fed to a 50kΩ preset potentiometer (VR1-VR4). Thus the sensitivity of each channel can be set to provide equal brightness of lamps for typical music signals. Following the presets, the DC signals are fed to comparators IC3a, IC3b, IC3c and IC3d. These compare the varying DC for each frequency with the ramp reference signal from IC4d.

By the way, IC1, IC2, IC3 and IC4 are all standardised as LM324 quad operational amplifiers. These are cheap and readily available.

Ramp reference

As mentioned above, each of the four comparators in IC3 use a common ramp reference voltage derived from the 240VAC mains. A 50Hz signal is picked up from the secondary of the 2851 mains transformer via a 100kΩ resistor, clamped to ±0.6V by diodes D14 and D15 and fed to IC4b which functions as a Schmitt trigger to "square up" the waveform. IC4b's 50Hz square wave output is then fed to Schmitt triggers IC9a and IC9b to obtain complementary signals. These signals are then fed to two differentiating networks, each consisting of a .022μF capacitor and 470kΩ resistor.

The spiky outputs of these two networks are fed via diodes D16 and D17 to the inverting input of IC4c. IC4c thereby delivers a 100Hz pulse train, with each pulse synchronised to the zero voltage points of the 50Hz AC mains waveform.

The pulse output from IC4c then feeds a 0.15μF capacitor via D18 with the discharge path being via two 22kΩ resistors in series and a 5.6V zener diode (D19). The result is the ramp curve depicted in Fig.2a, delivered from the ouput of IC4d, to the inverting inputs of quad op amp IC3.

The outputs of the four comparators connect to IC8 which is the Display Selector depicted in Fig.1. IC8 is a 4019 quad AND/OR gate which can be regarded as a

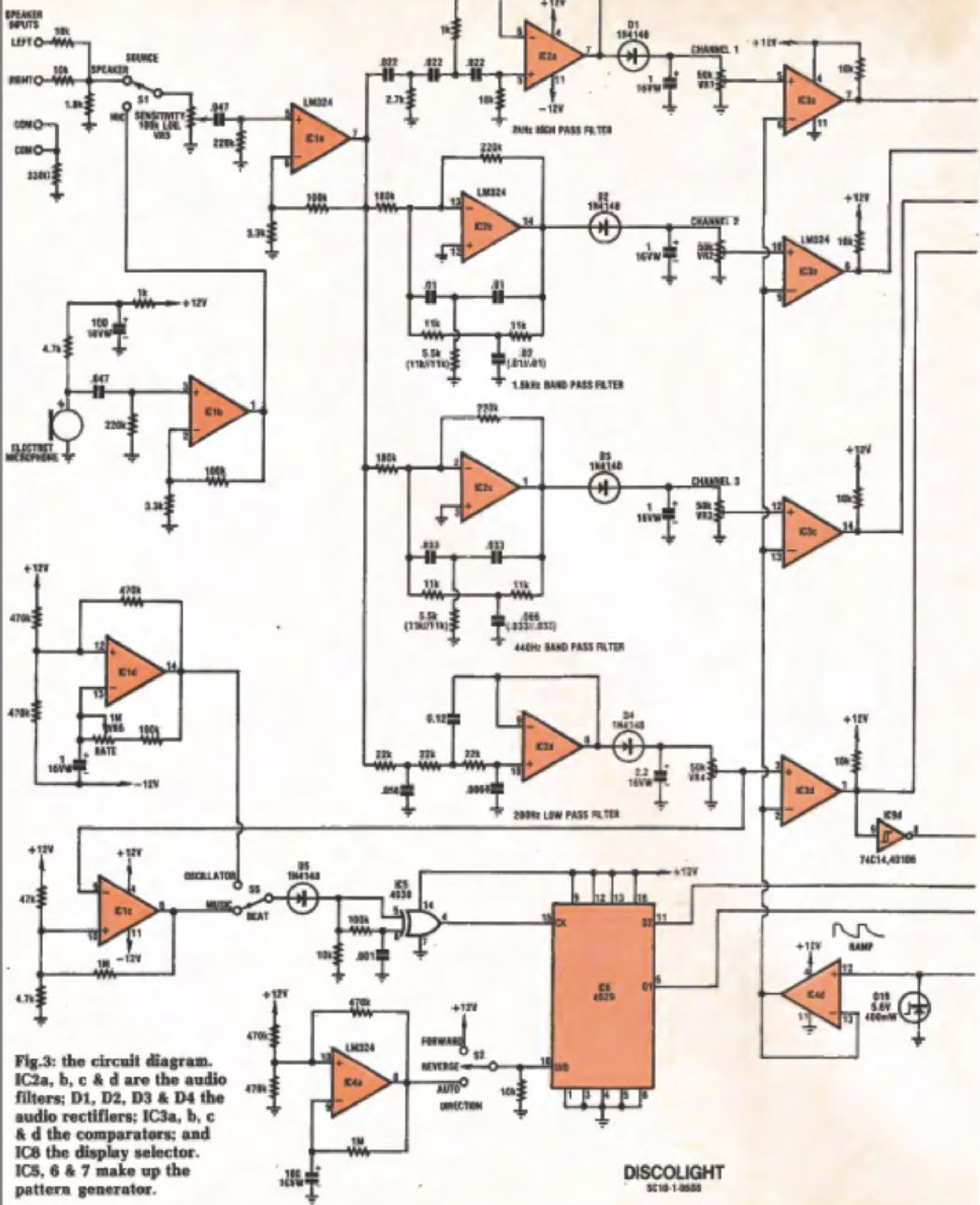
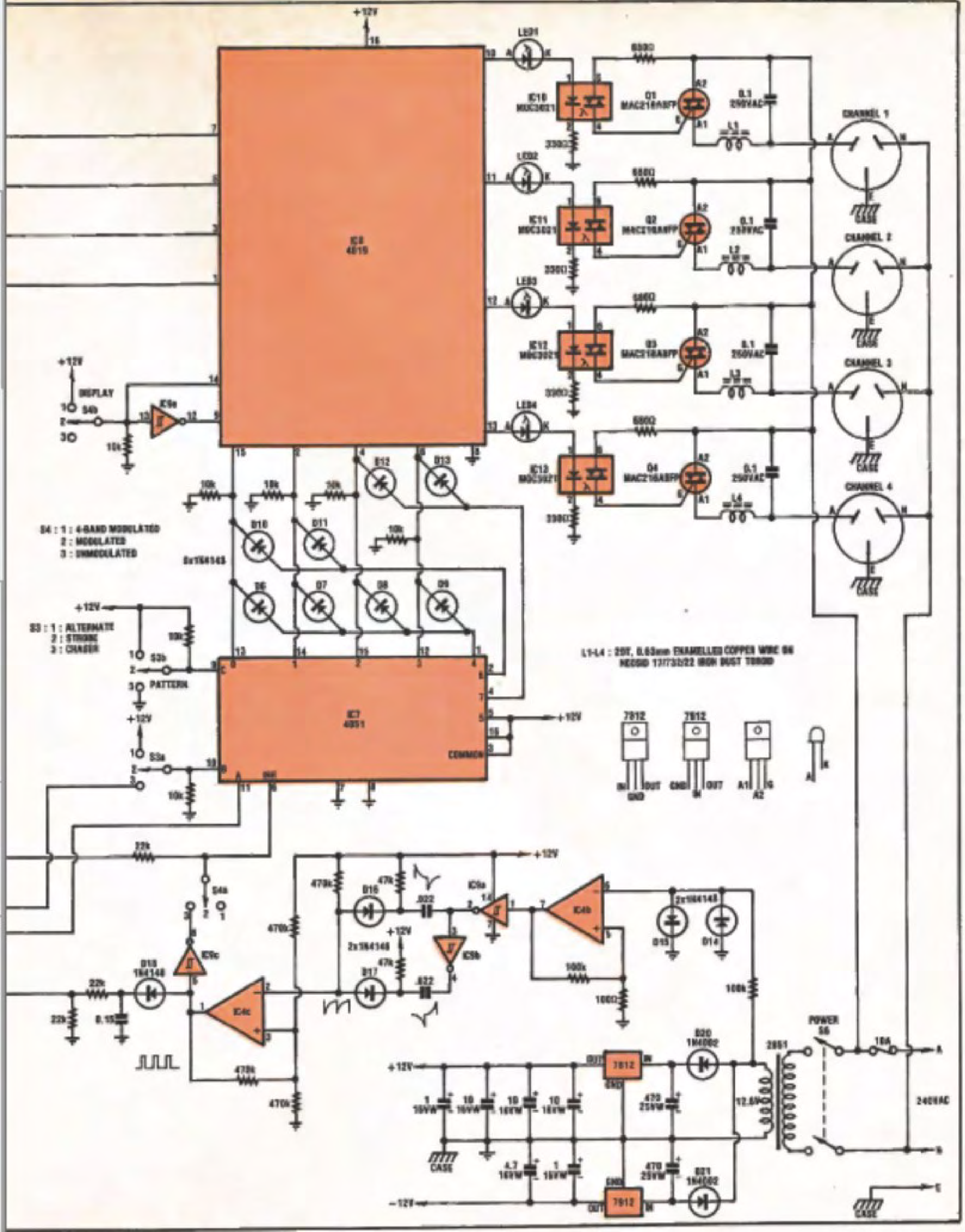


Fig.3: the circuit diagram. IC2a, b, c & d are the audio filters; D1, D2, D3 & D4 the audio rectifiers; IC3a, b, c & d the comparators; and IC8 the display selector. IC5, 6 & 7 make up the pattern generator.



+12V
IC8
4015
IC7
4051
COMMON
PATTERN
DISPLAY
S4 : 1 : 4-BAND MODULATED
2 : MODULATED
3 : UNMODULATED
S3 : 1 : ALTERNATE
2 : STROBE
3 : CHASER
CHANNEL 1
CHANNEL 2
CHANNEL 3
CHANNEL 4
CASE
POWER
S6
240VAC
12.6V
7812
7912

PARTS LIST

1 plastic instrument case, 262 x 190 x 83mm (Altronics Cat. No. H-0482)
1 aluminium rear panel, 251 x 76mm (Altronics Cat. No. H-0488)
1 Scotchcal front panel label, 251 x 76mm
1 PCB, code 10106881, 218 x 172mm
4 10A panel-mount mains sockets
1 4-way spring-loaded speaker terminal panel
1 2851 12.6V mains transformer
1 panel mount 3AG fuse holder
1 10A 3AG fuse
1 electret microphone insert
4 Neosid 17/732/22 toroids
1 DPDT 240VAC toggle switch
2 DPDT centre-off toggle switches
2 SPDT toggle switches
1 SPDT centre-off toggle switch
2 knobs
1 cord grip grommet
1 mains cord and moulded 3-pin plug assembly
3 solder lugs
34 PC stakes

Semiconductors
4 LM324 quad op amps
1 4051 1-to-8 analog multiplexer/demultiplexer
1 4030 quad XOR gate
1 4029 4-bit up/down counter
1 4019 quad 2-input AND/OR selector
1 74C14, 40106 hex Schmitt trigger
4 MAC218A8FP or SC142-M or BT137F-600 isolated tab Triacs
4 MOC3021 optically isolated Triac drivers
1 7812 3-terminal +12V regulator
1 7912 3-terminal −12V regulator
2 1N4002 1A diodes
18 1N4148, 1N914 signal diodes
1 5.6V 400mW zener diode
4 5mm red LEDs
4 LED bezels

Capacitors
2 470μF 25VW PC electrolytic
2 100μF 16VW PC electrolytic
3 10μF 16VW PC electrolytic
1 4.7μF 16VW PC electrolytic
1 2.2μF 16VW PC electrolytic
6 1μF 16VW PC electrolytic
1 0.15μF metallised polyester
1 0.12μF metallised polyester
4 0.1μF 250VAC capacitors (Wima MP3 or Philips MKT-P 2222 330 40104)
1 .056μF metallised polyester
2 .047μF metallised polyester
4 .033μF metallised polyester
5 .022μF metallised polyester
4 .01μF metallised polyester
1 .0068μF metallised polyester
1 .001μF metallised polyester

Resistors (0.25W, 5%)
2 x 1MΩ, 10 x 470kΩ, 4 x 220kΩ, 2 x 180kΩ, 6 x 100kΩ, 3 x 47kΩ, 6 x 22kΩ, 1 x 18kΩ, 8 x 11kΩ, 15 x 10kΩ, 2 x 4.7kΩ, 2 x 3.3kΩ, 1 x 2.7kΩ, 1 x 1.8kΩ, 2 x 1kΩ, 4 x 680Ω, 4 x 330Ω, 1 x 100Ω, 4 x 50kΩ miniature vertical trimpots, 1 x 1MΩ linear pot, 1 x 100kΩ log pot

Miscellaneous
Screws, nuts, self-tapping screws, rainbow cable, 0.63mm enamelled copper wire (ECW), tinned copper wire, mains rated cable, insulating sleeving, solder etc.

4-pole 2-position switch. This is controlled by S4b, which is one half of the Display Selector switch.

When pin 14 is high and pin 9 is low, the comparator outputs are switched through (when switch S4 is in the 4-band modulated position) and thereby control the Triacs. On the other hand, when pin 14 is low and pin 9 is high, the signals from the pattern generator circuitry are switched through (position 2 of switch S4) to control the Triacs in Chaser, Strobe and Alternate modes.

Pattern generation

The patterns are generated by IC5, IC6, IC7, three op amps and a bunch of diodes, D6 to D13. IC6 is a 4029 up/down counter which drives the one-of-eight decoder IC7. To make the Chaser run in the forward direction, IC6 is made to count up; to run in the Reverse direction, IC6 is made to count down, as set by DIRECTION switch S2 (via pin 10).

The clock signal for IC6 is fed via IC5 from one of two sources, selected by the BEAT switch S5. With S5 in the Music setting, the clock signal is derived from the Low Bass filter via comparator IC1c, which converts the bass signal into a squared up waveform.

With S5 in the Oscillator setting, the clock signal comes from IC1d which is wired as a Schmitt trigger oscillator. The oscillator speed is set by the RATE control, VR6.

The clock signal selected by S5 is fed to diode D5 and then to exclusive-OR gate IC5. This is connected to give a short positive pulse output whenever the clock signal from S5 makes a positive transition. IC5 thus ensures that the pattern generator circuitry is clocked by every bass beat in the music signal.

Back to the one-of-eight

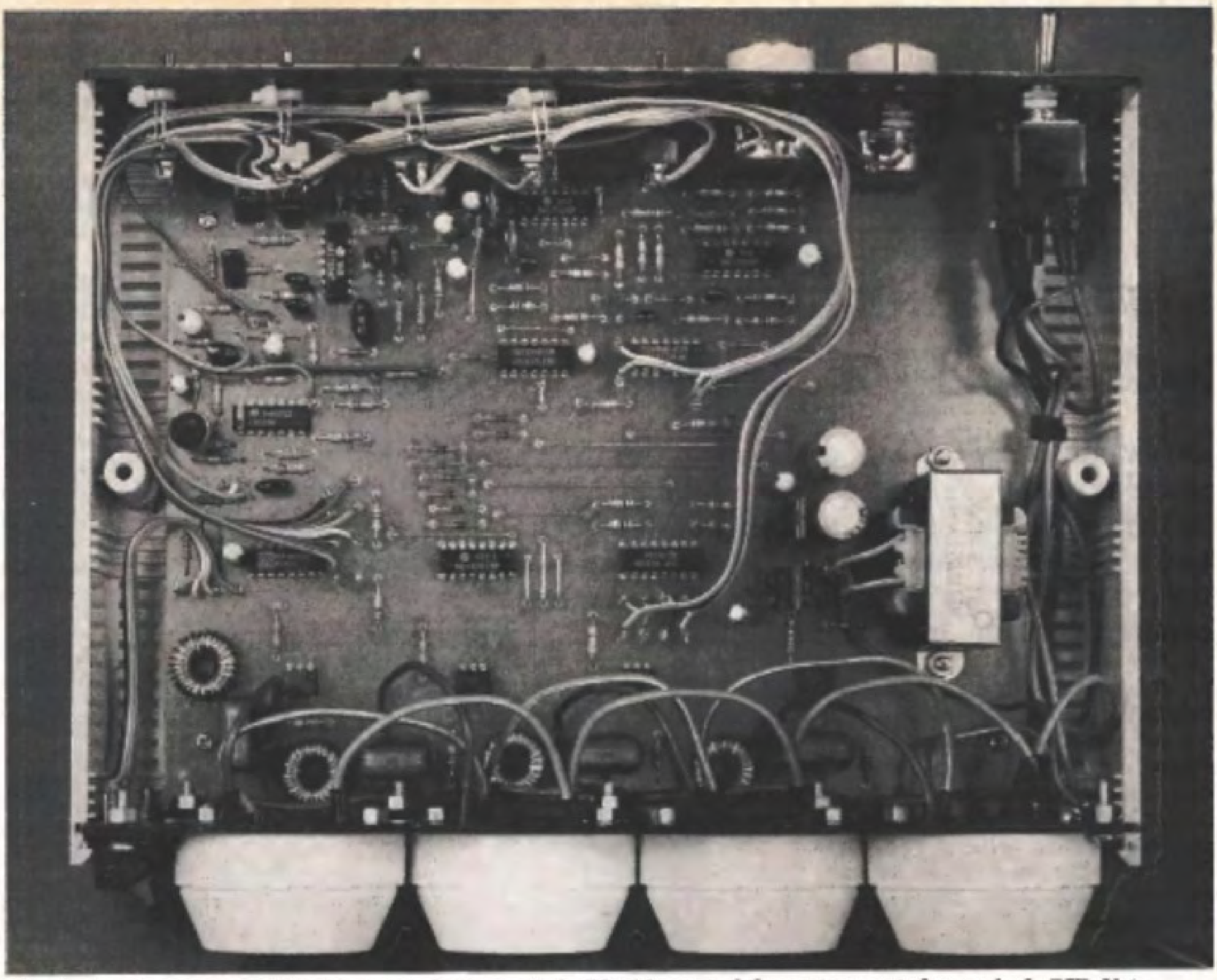
The Q1 and Q2 outputs from IC6 are connected to IC7; Q1 directly to the A input while Q2 goes via PATTERN switch S3a to the B input. The C input of IC7 is connected via the wiper of S3b.

Depending on the code fed to the A, B and C inputs, the common input of IC7, pin 3, is connected through to one of the eight outputs, 0 to 7.

One of the 0, 1, 2 and 3 outputs can be selected when the C input is low, and one of the 4, 5, 6 and 7 outputs selected when the C input is high. The B input when low can select the 0, 1, 4 or 5 outputs. When high the 2, 3, 6 and 7 outputs can be selected. The A input selects either the 0, 2, 4 or 6 output when low and the 1, 3, 5 or 7 outputs when high.

When switch S3 is set for Chaser mode, IC6 counts (up or down) and connects IC7 outputs 0, 1, 2 and 3 to the common input (pin 3; +12V) in sequence. These outputs connect to the four inputs of IC8 (the Display Selector, described above and shown in Fig.1) to drive the Triacs.

When S3 is set for Strobe mode,



Despite the circuit complexity, the Discolight is easy to build with most of the parts mounted on a single PCB. Note that part of the circuitry is powered directly from the 240VAC supply, so take care when working on the board.

the B input of IC7 connects to 0V (via S3a) while the C input is connected to +12V via a 10kΩ resistor. Thus outputs 4 and 5 of IC7 are selected in sequence. When output 4 is high, it is bridged to outputs 0, 1, 2 and 3 via diodes D6 to D9 so all four Triacs are driven. (Output 5 is connected to +12V and plays no active part). So all four channels flash on and off in unison.

Finally, when S3 is set to Alternate mode, both B and C inputs of IC7 are connected to +12V. Thus, as IC6 counts, outputs 6 and 7 of IC7 go high alternately. Then, as output 6 goes high, diodes D10 and D11 pull outputs 0 and 1 of IC7 high also. Similarly, as output 7 goes high, diodes D12 and D13 pull outputs 2 and 3 of IC7 high also. So two channels flash on alternately.

To modulate or not to modulate

Now for the messiest part; how to obtain the modulated Chaser, Strobe and Alternate modes.

Normally, when DISPLAY switch S4 is set to the unmodulated mode, the input to inverter IC9e is pulled low via a 10kΩ resistor. This feeds signal from the pattern generator circuitry through to the Triacs. Similarly, when S4 is set the Modulated mode, IC9e's input is still pulled low and the pattern generator signals are fed through to the Triacs but — and here is the tricky bit — have a look at S4a in position 2.

Signal from the Low Bass audio comparator feeds via inverter IC9d and a 22kΩ resistor, to the INHibit input of IC7. This allows the Low Bass channel to modulate the lamp brightness even though the normal mode would be for zero voltage switching of the Triacs and thus full brightness of the lamps. That is really tricky.

Isolation

IC8, the Display Selector (depicted on Fig.1), does not drive the four Triacs directly. It does so via four MOC3021 optically coupled Triac drivers. Between pins 1 and 2 of each MOC3021 is an internal LED and when this is driven, the emitted light turns on an optically triggered Triac. This, in turn, feeds the gate of the relevant power Triac and turns it on.

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So the MOC3021s provide very high voltage isolation between all the low voltage control circuitry and the 240VAC circuitry to the Triacs.

In series with each IC8 output to the MOC3021s is a LED and these are mounted on the front panel so that they give an indication of the behaviour of the Triac driven lamps.

Associated with each Triac is an inductor (L1 to L4) and a 0.1μF 250VAC capacitor. These two components form an RF suppression network for each Triac so that radio interference is reduced when the Triacs are in the phase control mode (for the 4-Band Modulated and Modulated settings of S4).

Note that we have specified Triacs with an isolated tab so that they can be mounted directly onto the rear panel without any need for mica washers, insulating bushes and so on. The types specified are Motorola MAC218A8FP, Motorola T-2500MFP, Philips BT137F-600 or General Electric SC142M.

Power supply

Power for the low voltage circuitry is provided by a 12.6V transformer feeding two half-wave rectifiers, D20 and D21, and two 470μF capacitors. The resulting unregulated positive and negative rails are fed to 3-terminal regulators to give ±12V DC supply rails.

The additional 10μF and 1μF capacitors connected at the output of the regulators provide decoupling and bypassing of high frequency "hash".

Note that the power switch (S6) connects mains power to the transformer only and not to the Triac output circuitry. The Active AC supply lead to the Triacs is fed directly to their anodes via the 10A front panel fuse.

That completes the circuit description of the Discolight. Next month we'll present the constructional information, set-up routine and troubleshooting procedure.