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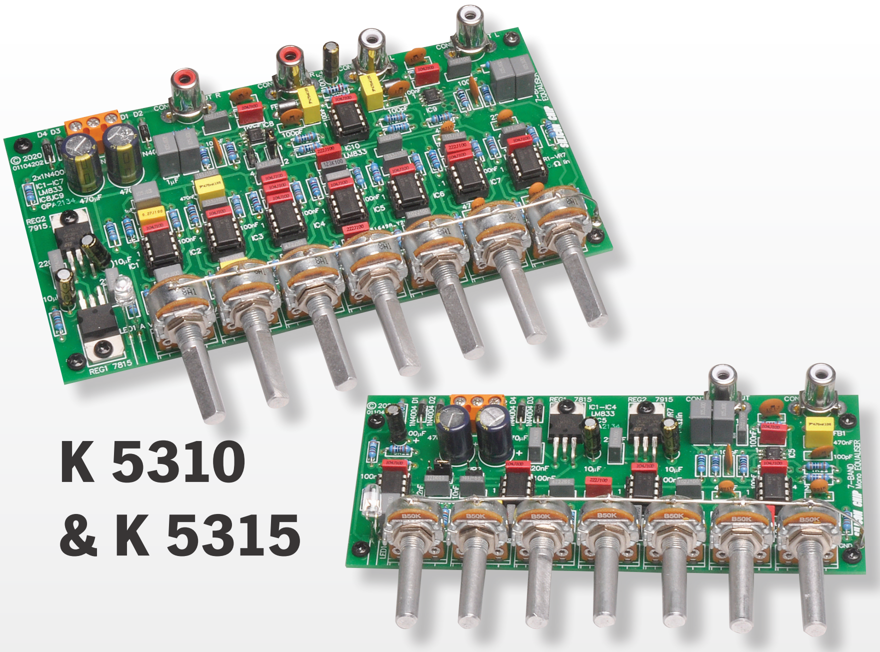
7 - Band Mono or Stereo Equaliser



K 5310 & K 5315

These stereo or mono 7-Band Equalisers let you tailor the sound of your listening experience to suit your preferences. They can also be used to correct for room acoustics and deviations in loudspeaker response. The stereo version suits hifi systems, while the mono version is best for musical instruments or PA systems. Both feature extremely low noise and distortion, so they won't degrade your signal.

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In December 1995 silicon chip published an article about a 5-Band Equaliser that was intended for musicians. The equaliser could be installed within an amplifier. That design was so popular that it is still sold as a kit by Altronics (K5305) to this day – a quarter of a century later!!

An excellent article about a 10-Band Stereo Graphic Equaliser was published more recently, in the June & July 2017 issues (siliconchip. com.au/Series/313), that design is considerably more complex and more expensive to build. And the slide pots do not lend themselves to being fitted into an existing amplifier. Besides, for musical instrument use, you generally don't need the stereo function.

Hence, we decided to come up with a new design, similar to the one from December 1995 but instead, modernised and upgraded. We've added two more bands, giving finer control over the sound, and while we were at it, we also designed a stereo version. We are still using similar rotary pots, making it easy to mount in an existing amplifier (provided there is space). As a bonus, they're cheaper than slide pots.

We've also made the power supply much more flexible, so it can run from 15-16V AC, 30V AC with a centre tap, 18-20V DC or a regulated source of ±15V DC. Plus we have considerably improved the performance, giving it extremely low noise and distortion figures.Having different versions of the PCB for mono and stereo makes it easier to construct the version you want, and keeps the mono version as small as possible, keeping in mind the limited space that may be available for it to fit into.

Perhaps surprisingly, the mono version of this 7-band equaliser, at 143 x 63.5mm, is smaller than the original 5-band version, which used a PCB that measured 167 x 65mm.

We're presenting both versions of the 7-band equaliser as bare PCBs. All the components mount onto these PCBs, including the input and output RCA sockets; you just need to organise a case and power supply.

Typical applications

The stereo version of our new Equaliser can be connected to an amplifier or receiver in several ways. First, it can be connected in the"Tape Monitor"loop that's still provided on many amplifiers and receivers. Alternatively, the equaliser may be connected between the preamplifier and power amplifier. Some home theatre stereo receivers include preamp output and power amp input connectors for this purpose. If you're using a separate preamp or input switcher, then the equaliser can be interposed between it and the power amplifier. Or, if you only have a single sound source that has a nominal line level output level (anywhere between 500mV and 2V RMS), the equaliser input can be connected to that source output and preamplifier/amplifier input.

Features

- Channels: one (mono) or two (stereo)
- Equaliser bands: seven (63Hz, 160Hz, 410Hz, 1kHz, 2.5kHz, 6.2kHz, 16kHz)
- Boost/cut: approximately ±12.5dB (bands overlap; see Fig.1) Signal-to-noise ratio: 108dB (2V RMS), 102dB (1V RMS)
- Total harmonic distortion: <0.0005%, 20Hz-20kHz, 20Hz-22kHz bandwidth (see Fig.2)
- Input impedance: 100kΩ || 100pF Output impedance: 470Ω
- Supply options: 15-16V AC, 15-0-15V AC, 12-24V DC, ±15V DC
- Channel separation (stereo version): >50dB, 20Hz-20kHz (>=80dB 20Hz-1kHz)
- Other features: compact design, uses rotary pots for easy panel mounting

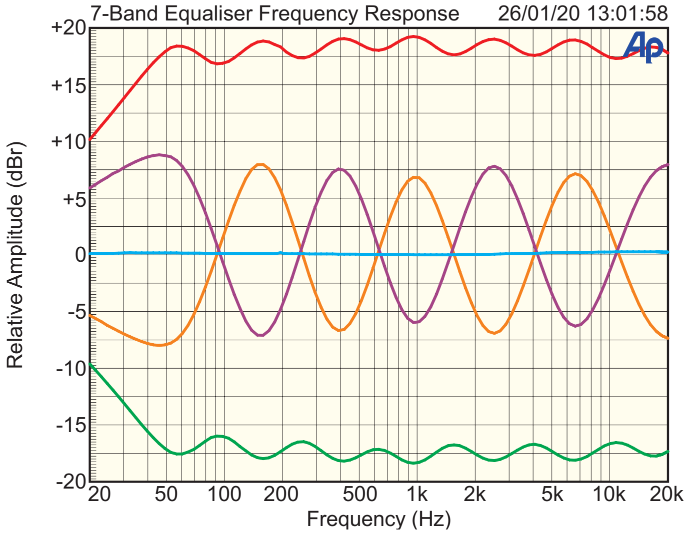


Fig.1: The blue curve shows the frequency response with all controls set to the centre position, with a flat response across the 20Hz to 20kHz band. The red and green curves show the response with all pots in the maximum boost setting (red) and with all pots in the maximum cut setting (green). Finally, the purple and orange curves show the response with alternate full cut and full boost between each band.

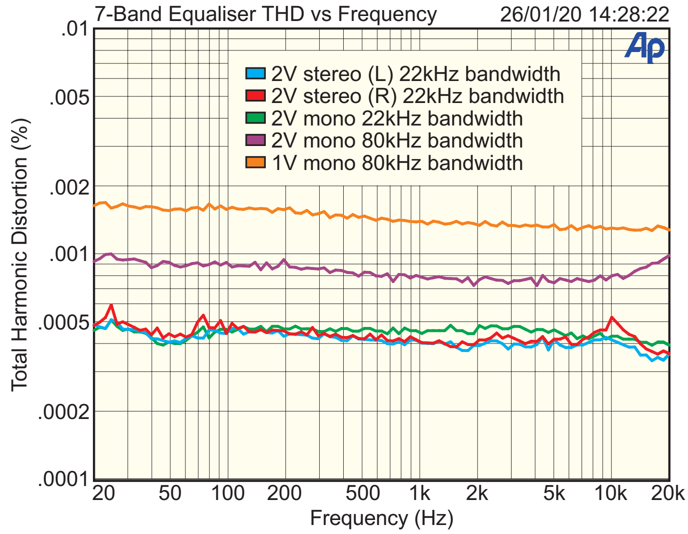


Fig.2: The harmonic distortion performance is excellent with less than 0.006% distortion at 2V from 20Hz to 20kHz measured with a 22kHz low pass filter. Even with an 80kHz filter distortion does not rise above 0.001% for a 2V signal. Noise was measured at 108dB down with 2V as a reference level. The 0.0005% distortion means that the noise and distorrtion measured is -106dB down in level from 2V.

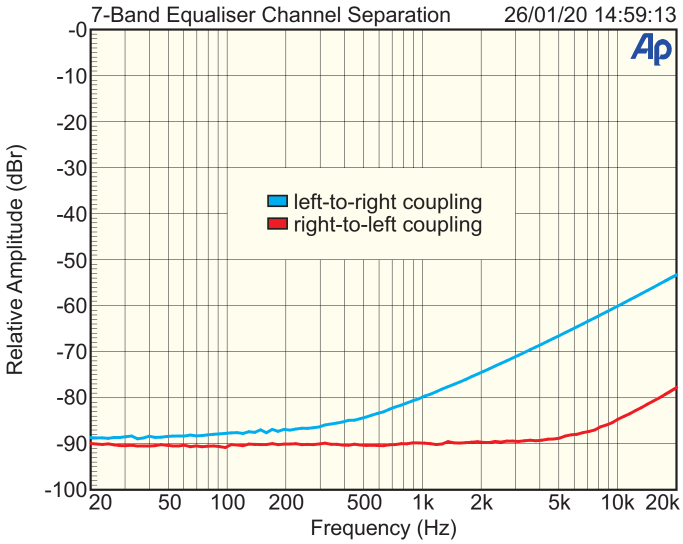


Fig.3: Channel separation response between left to right channel (blue) and right to left channels (red) show that separation is worse for the left to right coupling as frequency rises. These graphs are for the stereo version only. Separation figures do not apply with the mono version.

For sound reinforcement use, you can connect the equaliser between the sound mixer output and amplifier input. In that case, you may need to add balanced-to-unbalanced and/or unbalanced-to-balanced converters on each channel. We published suitable designs for this in the June 2008 issue;
see siliconchip.com.au/l/aacv

Performance

The overall performance is summarised in the Features & specifications panel and Figs.1-3. Its signal-to-noise ratio for a 2V RMS input is excellent at 108dB, and the distortion curves show that there is virtually no harmonic distortion present; the THD+N figures are consistent with pure noise. Fig.1 has several coloured response curves which show what you can do with the controls. The blue curve shows the frequency with all controls set to the centre position, giving a ruler flat re- sponse over the audio band of 20Hz to 20kHz (it's tough to get it precisely flat due to pot variances, hence the slight amount of ripple visible). The red and green curves show the response with all poten- tiometers in the maximum boost and cut settings, respectively. The mauve and orange curves show the response with the po- tentiometers alternately set for maximum boost and cut; these show the effective width of each band.

Note that you would never use an equaliser in these extreme settings as the result would sound very strange. Instead, you usually use comparatively small boost or cut settings.

For example, if your loudspeakers are a touch too bright in the 6kHz region, you might apply a couple of decibels of cut to the respective potentiometer. Or if you wanted to lift the bass response at around 60Hz, you could apply some amount of boost on the 63Hz band and get a much more subtle effect than would be possible with a conventional bass control.

The Equaliser's overall performance is far beyond CD-quality au- dio. Fig.2 demonstrates that the harmonic distortion performance is limited by the residual noise “floor” of the crucial gain stage in the circuit; that of IC9b and IC8a for the stereo version and

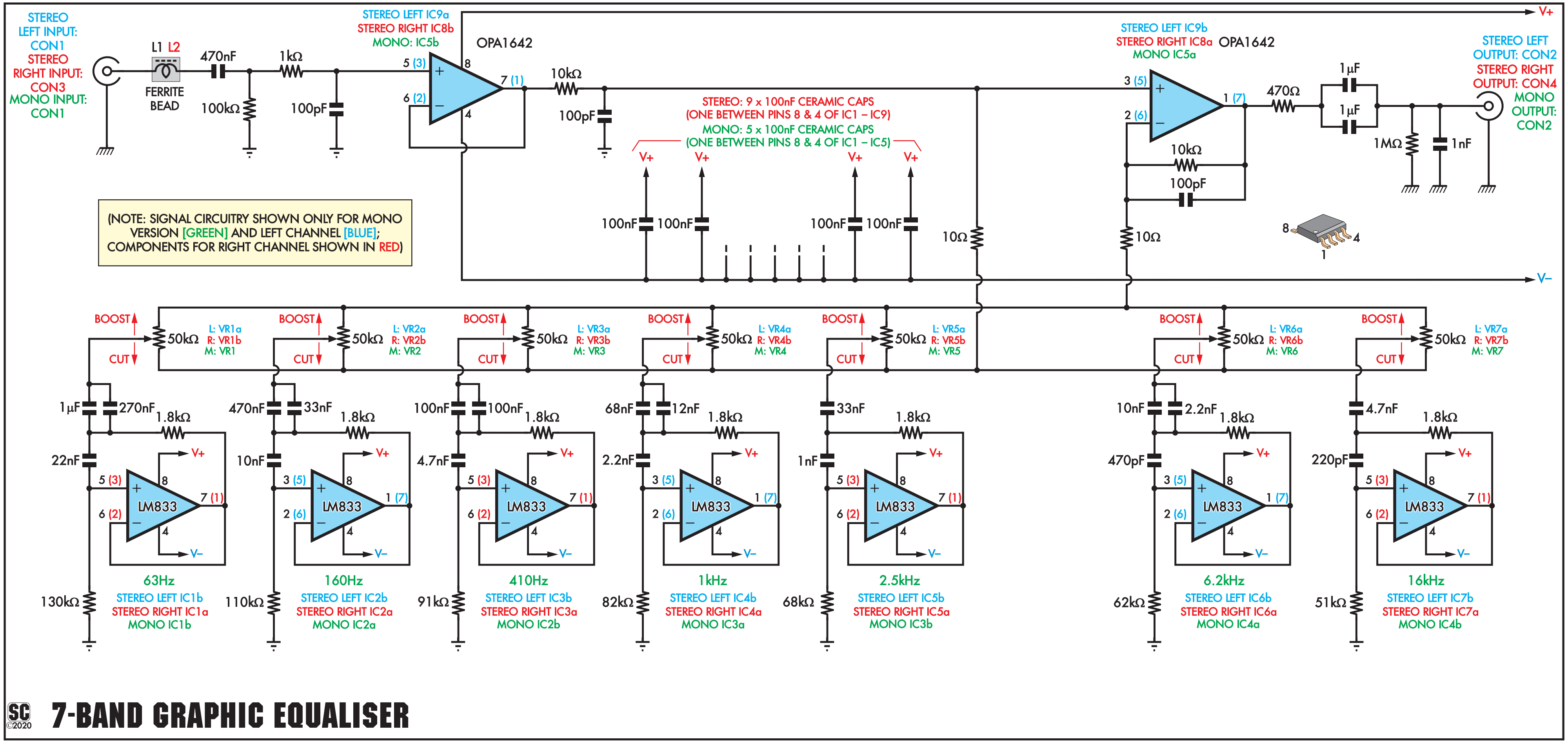


Fig.4: This is the complete circuit for the mono version, minus the power supply. The stereo version essentially duplicates all the parts for the second channel, except for the shared power supply and the use of dual-gang potentiometers in place of single-gang. Labels in green apply to the mono version, in blue to the left channel portion of the stereo version and in red, to the right channel portion of the stereo version. When pin numbers are in red brackets, that is for the right channel and the black pin number applies to the left channel and the mono version. Numbers in blue brackets are for the left channel, with the number for the mono version and right channel of the stereo version in black.

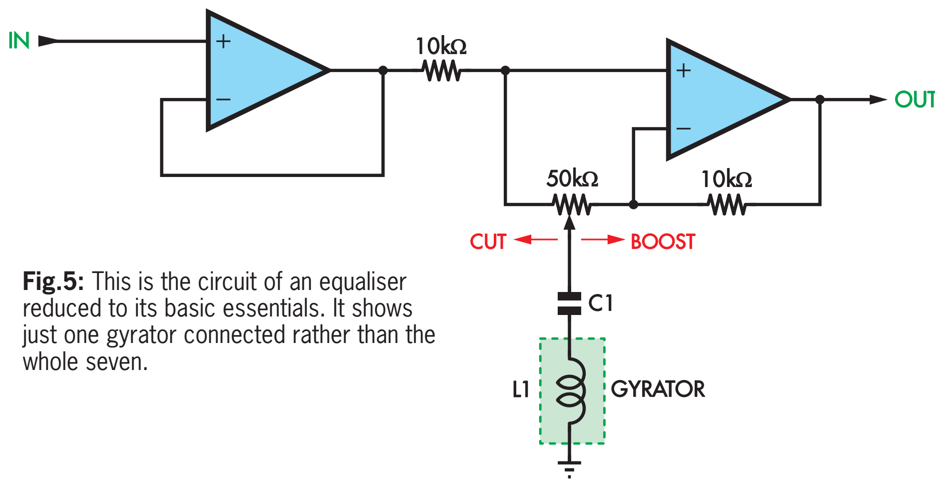
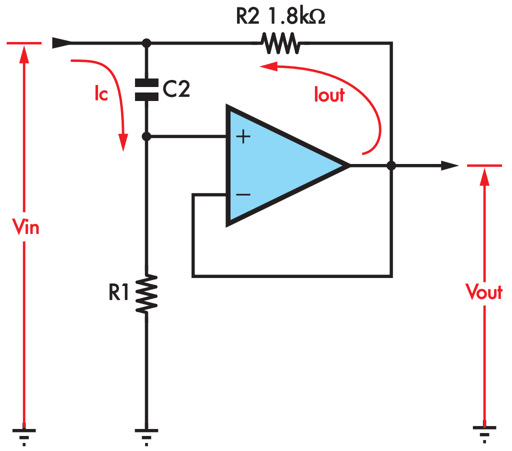


Fig.5: This is the circuit of an equaliser reduced to its basic essentials. It shows just one gyrator connected rather than the whole seven.



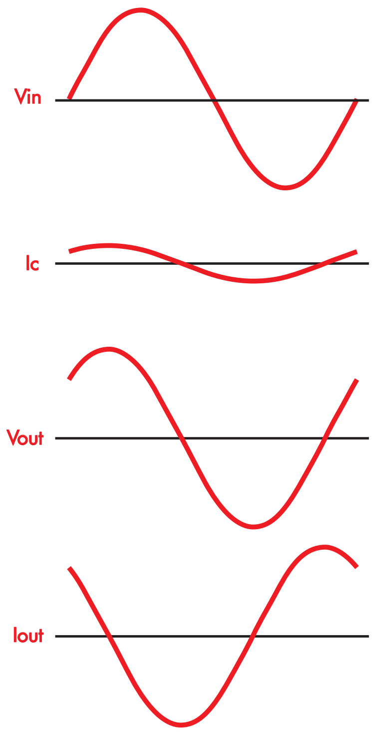


Fig.6: Each gyrator in the circuit is essentially a capacitor C2 and op amp and the two work together as though they ar an inductor. The accompanying waveforms show how the current at Vout lags Vin in the same way as an inductor.

IC5a in the mono version. With a realistic bandwidth of 20Hz-22kHz, the THD+N level is below 0.0006% for all audible frequencies. Even with 80kHz measurement bandwidth, there is virtually no rise in distortion at higher frequencies. While the plot does seem to have a small rise up to 0.001% at 20kHz, other measurements we've taken under similar circumstances did not have such a rise, so we think it is probably a measurement artefact.

Suffice to say that the harmonic distortion introduced by this circuit is so far below that from a typical CD, DVD, Blu-ray or com- puter source that it will not adversely affect the sound quality of signals from such sources. Finally, Fig.3 shows the channel separation for the stereo version of the equaliser. It exceeds 50dB at all frequencies and for both channels, and is at least 80dB for signals up to 1kHz.

Circuit details

Fig.4 shows the circuit of our 7-Band Equaliser. This is the complete circuit for the mono version, minus the power supply. The stereo version essentially duplicates all the parts for the second channel, except for the shared power supply and the use of dual-gang potentiometers in place of single-gang. Labels in green apply to the mono version, in blue to the left channel portion of the stereo version and in red, to the right channel portion of the stereo version.

When pin numbers are in red brackets, that is for the right chan- nel and the black pin number applies to the left channel and the mono version. Numbers in blue brackets are for the left channel, with the number for the mono version and right channel of the stereo version in black.

We have used dual low-noise/low distortion LM833 op amps for the gyrators (described below). These have a noise level of 4.5nV÷√Hz and very low distortion. These op amps use bipolar input transistors, with a typical input bias current of 500nA (1μA maximum). While this is not a problem for the gyrator circuits, as they are AC-coupled to the rest of the circuit, it is too high for the main signal path.

That's because, if such a current were to flow through the adjust- ment potentiometers, they could produce a noticeable scratching noise when rotated. So for the main signal path op amps (IC5 for the mono version and IC8/IC9 for the stereo version), we are using OPA1642 op amps which have JFET input transistors.

These have an ultra-low-distortion specification of 0.00005%, low noise at 5.1nV÷√Hz and a 2pA typical (20pA maximum) input bias current. So their input bias current is typically 250,000 times less than the LM833s.

The following description is for the mono version, but the operation of the two channels in the stereo version is identical. The incoming signal is applied to RCA socket CON1. It passes through an RF-suppressing ferrite bead (L1) and is then AC-coupled to non-inverting input pin 5 of buffer op amp IC5b. The 1kΩ/100pF RC low-pass filter feeding that pin is to filter out RF signals that pass through FB1. This signal is then fed, via another RF-suppression filter, to non-inverting input pin 3 of op amp IC5a. At first glance, this also appears to be operating as a buffer, albeit with a 10kΩ

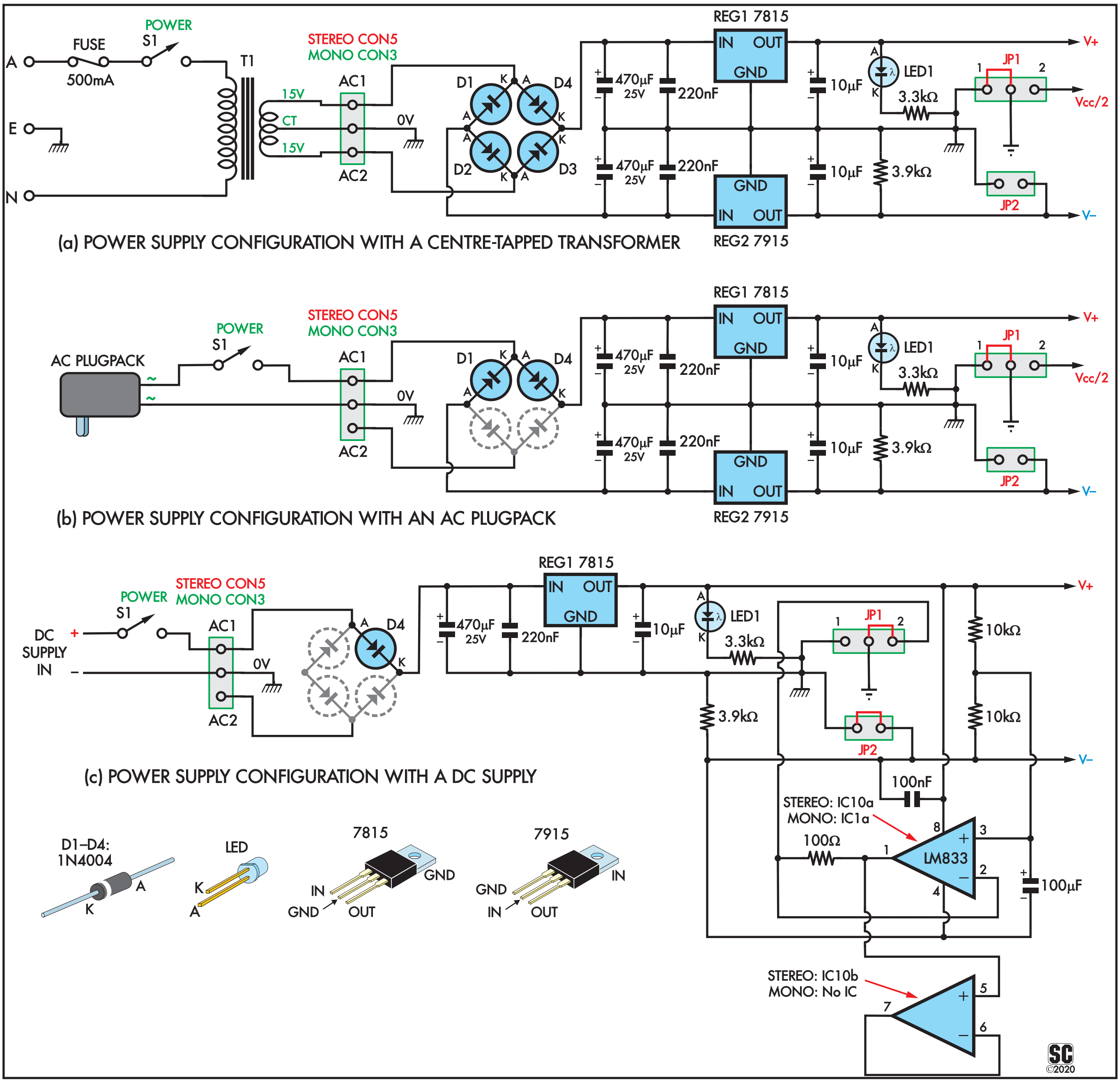


Fig.7: The three power supply variations: One for operation from a centre tapped mains transformer shown at top, the second for operation from an AC plugpack or non-centre tapped transformer and finally as shwn in the lower drawing, operation via a DC supply. The greyed out rectifier diodes show that these diodes aren't used and could be left off the PCB during construction.

feedback resistor between its output pin 1 and inverting input (pin 2) rather than a direct connection. However, there are also seven 50kΩ linear potentiometers (VR1-VR7) connected across the two inputs of IC5a, and these change its operation.The wipers of these pots are connected to seven op amp stages arranged along the bottom of the circuit diagram. These are all very similar, and are series resonant LC circuits built around the gyrators mentioned. There is one for each of the equaliser bands. An important aid in understanding how this circuit works is to consider what happens when the pot wipers are centred. Whatever the impedance seen by the wiper in this case, the effect is divided equally between the two 25kΩ half-tracks of the pots, and so equally affects the non-inverting and inverting inputs (pins 3 and 2) of IC5a. Therefore, in this case, that particular stage does not affect the circuit's behaviour.

It is only when the pot wipers are moved away from the centre positions that they start having any effect on the signal. While we said earlier that these seven circuits are tuned LC resonant networks, you will note that there are no inductors present. That's because the close tolerance, low-distortion inductors that would be required for good performance are very expensive and bulky, as well as being prone to hum pickup.

Therefore, as with virtually all equalisers designed over the last 50 years or so, we use gyrators instead. The gyrator is an op amp based circuit that simulates an inductor and can be connected in series with a capacitor to provide a resonant circuit.

Parts list - Graphic Equaliser

(Parts common to both versions)
7 knobs to suit pots (16mm maximum diameter) – see text
1 3-way PCB mount screw terminal, 5.08mm pin spacing (CON3 [mono]/CON5 [stereo])
1 3-way header, 2.54mm spacing (JP1)
1 2-way header, 2.54mm spacing (JP2)
2 jumper shunts/shorting blocks (JP1,JP2)
2 M3 x 6mm panhead machine screws and nuts
1 PC stake
1 150mm length of tinned copper wire
1 power supply (see text)

Semiconductors
8 LM833P dual low-noise op amps, DIP-8 (IC1-IC7,IC10)
2 OPA1642AID JFET-input op amps, SOIC-8 (IC8,IC9)*
[Digi-Key, Mouser, RS Components]
1 7815 +15V 1A linear regulator (REG1)
1 7915 -15V 1A linear regulator (REG2)
4 1N4004 400V 1A diodes (D1-D4)
1 5mm or 3mm LED (LED1)

Capacitors
2 470µF 25V PC electrolytic
1 100µF 16V PC electrolytic
2 10µF 16V PC electrolytic
3 1µF MKT polyester*
2 470nF MKT polyester*
1 270nF MKT polyester*
2 220nF MKT polyester
7 100nF MKT polyester*
1 68nF MKT polyester*
2 33nF MKT polyester*
1 22nF MKT polyester*
1 12nF MKT polyester*
2 10nF MKT polyester*
2 4.7nF MKT polyester*
2 2.2nF MKT polyester*
2 1nF MKT polyester*
1 470pF ceramic*
1 220pF ceramic*
3 100pF ceramic*

*** double the quantity for the stereo version**

Resistors (all 1/4W, 1% metal film)

2 10Ω*	1 100Ω	1 470Ω*	1 1kΩ*	7 1.8kΩ*	1 3.3kΩ
1 3.9kΩ	4 10kΩ	1 51kΩ*	1 62kΩ*	1 68kΩ*	1 82kΩ*
1 91kΩ*	1 100kΩ*	1 110kΩ*	1 130kΩ*	1 1MΩ*	

Extra parts for the stereo version
1 double-sided PCB coded 01104202, 157 x 86mm
7 50kΩ dual-gang linear 16mm potentiometers (VR1-VR7)
2 vertical PCB-mount white RCA sockets [Altronics P0131] (CON1,CON2)
2 vertical PCB-mount red RCA sockets [Altronics P0132] (CON3,CON4)
2 5mm-long ferrite beads (FB1,FB2)
2 10kΩ 1/4W 1% metal film resistors

Extra parts for the mono version
1 double-sided PCB coded 01104201, 143 x 63.5mm
7 50k single-gang linear 16mm potentiometers (VR1-VR7)
1 vertical PCB-mount white RCA socket [Altronics P0131] (CON1)
1 vertical PCB-mount red RCA socket [Altronics P0132] (CON2)
1 5mm-long ferrite bead (FB1)

Series-resonant circuit

To understand how these circuits work, let's consider a simplified version of the circuit with just one resonant circuit, as shown in Fig.5. As mentioned earlier, with the pot in its centre position, the impedance of the series network (C1+L1) affects both inputs of the right-hand op amp identically and so the frequency response is flat.

When the pot wiper moves to the boost end, more of the feedback from the output pin to the inverting input is shunted to ground by the series tuned circuit at frequencies around its resonance. Since its impedance is high at all other frequencies, this means that the feedback is only reduced over the narrow band centred around the resonance of the series tuned network.

As the feedback at these frequencies is reduced, the right-hand op amp will have to compensate by increasing its output signal swing at those frequencies, to return the feedback voltage to the same level as usual. So frequencies in that band will be boosted while others will be unaffected.

When the potentiometer is rotated towards the cut end, the tuned circuit instead shunts more of the input signals in its resonant band to ground. This results in a reduction of gain for the frequencies at or near the resonance of the series tuned network. As you would expect, the amount of boost or cut is proportional to the poten- tiometer settings, so intermediate settings give an intermediate level of signal boost or cut.

Gyrators

Fig.6 shows the circuit of a gyrator made with an op amp. It effectively transforms a capacitor into an inductor. In an inductor, the current lags the voltage by 90° while in a capacitor, the voltage lags the current by 90°.

Another way to explain this is that if you apply a large voltage step across a capacitor, a very high current flows initially, tapering off as the capacitor charges up. By comparison, if you apply

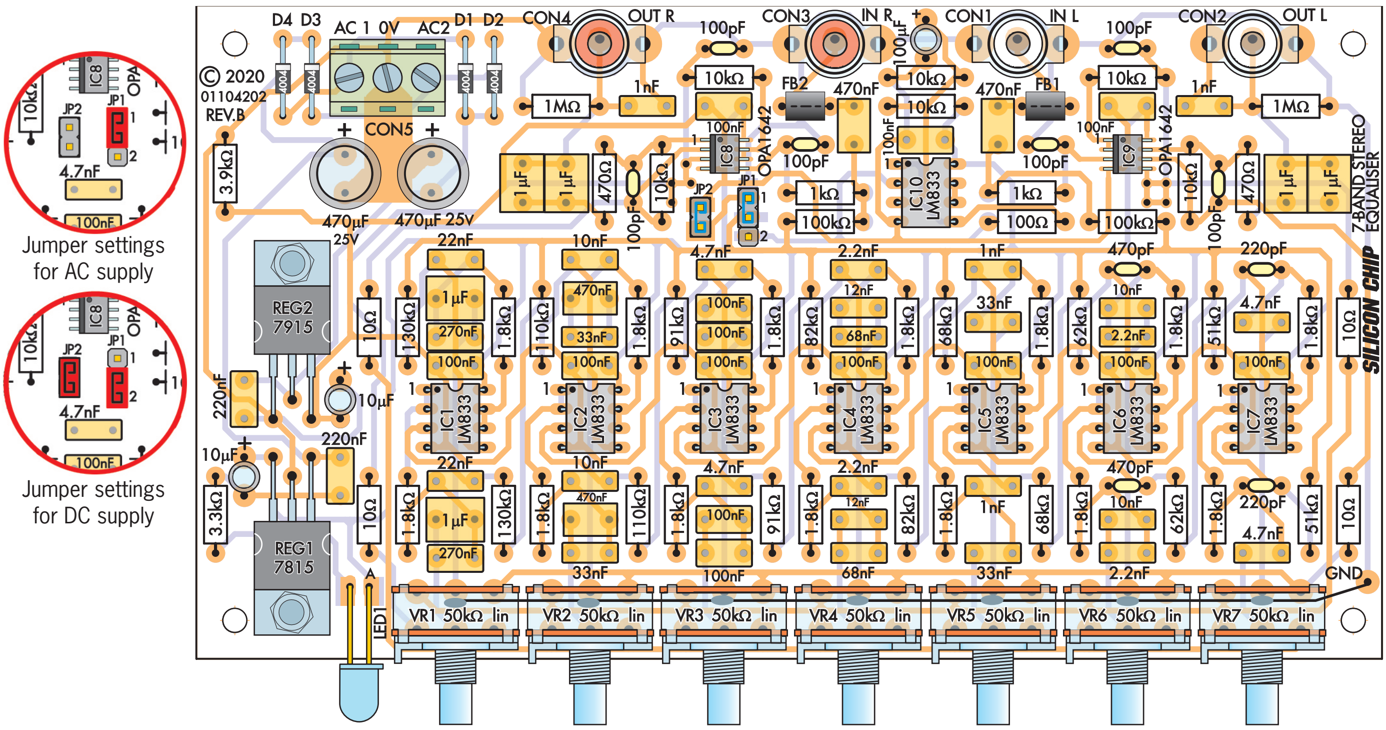


Fig.8: This is the overlay diagram for the stereo version of the equaliser. Take care to orient components correctly if they need to be. This includes the ICs, diodes, electrolytic capacitors and the regulators that must be in their correct position. No shown is the earthing wire soldered between the pots and to the earth terminal on the PCB. See the photo on the next page.

a large volt- age step to an inductor, at first the current flow remains the same as it was before, but eventually the current flow increases as the magnetic field density increases.
To understand how the gyrator behaves like an inductor, consider an AC signal source, VIN, connected to the input of Fig.6. This causes a current to flow through the capacitor and resistor R1. The voltage across R1 is thus proportional to the ca- pacitor current. This voltage is fed to the op amp, which is connected as a voltage follower (or buffer).

The voltage at the output of the op amp thus tracks the voltage across R1. This then causes a current to flow through resistor R2. This current, IOUT, adds to the input current Ic, the sum of which is the current that from the source and this lags the input voltage.

So as far as the signal source is concerned, the gyrator appears like an inductor. The formula to calculate the equivalent inductance is L=R1xR2xC2withLinHenries, R1 and R2 in ohms and C2 in Farads.

Consider the effect of a large voltage step at the input; for example, say the input rises suddenly by 1V. This is initially coupled through C2 directly to the op amp, and so its output also rises by 1V, keeping the voltage across R2 the same. Thus, the current flow from the input changes very little initially.

The current flowing is just the current required to charge C2, and the value of C2 is typically chosen to minimise this. As C2 charges, the voltage across R1 drops and so does the op amp output voltage, causing the current flowing from the input, through R2, to increase. As described above, this behaviour is much the same as if an inductor were connected instead of the gyrator.

To make the tuned LC circuit shown in Fig.5, all we need do is to connect a capacitor (C1) in series with the input to Fig.6. The result is a circuit with a dip in its impedance around a specific frequency. The values in our circuit set the bandwidth of each circuit to approximately 2.5 octaves.

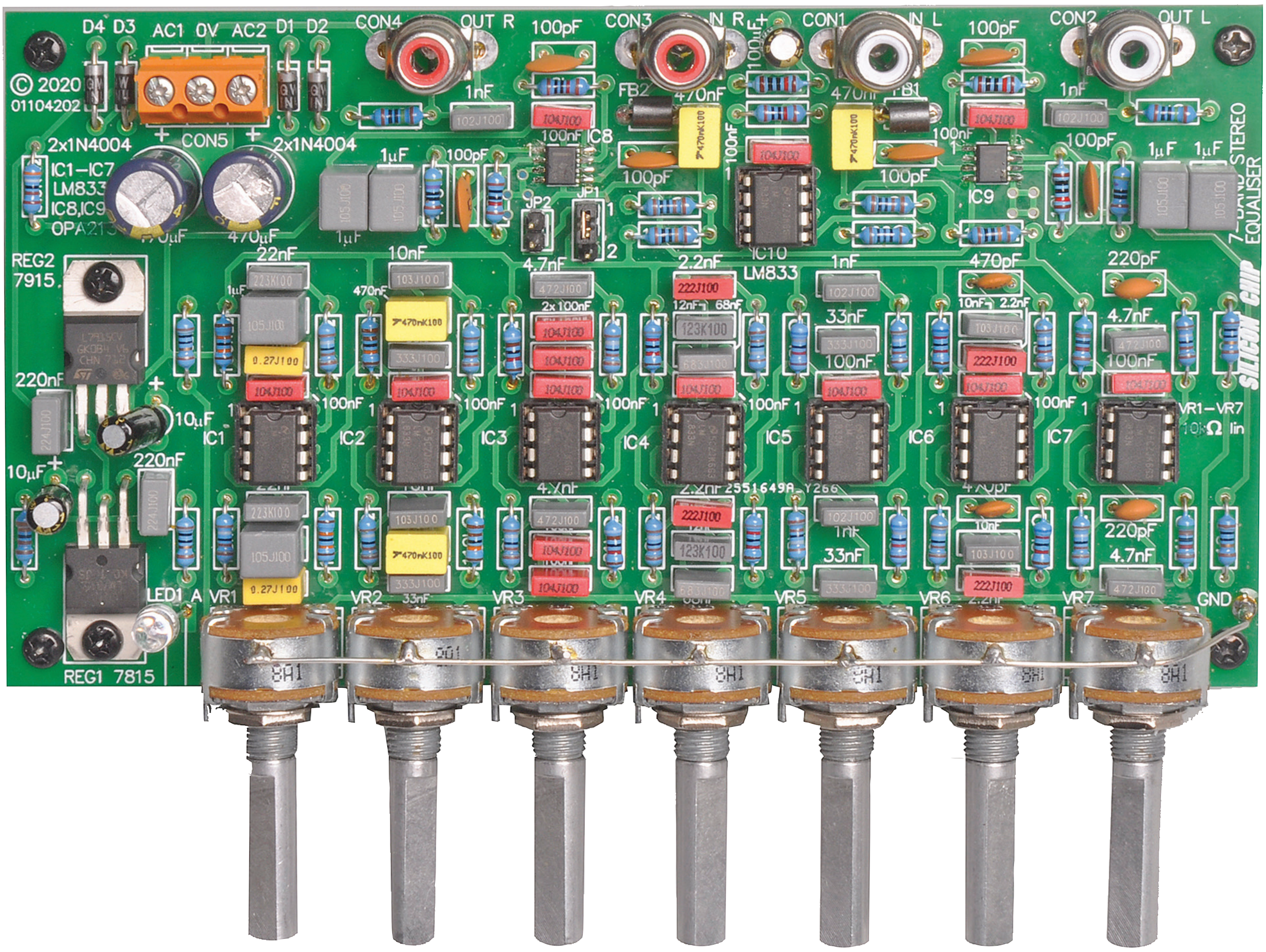
Back to the Equaliser

So remember that we have one op amp buffer stage with seven pots connected inside its feedback loop. The wiper of each potentiometer is connected to one of a series-tuned circuit described above. Each is tuned to a frequency that is two and a half times that of the last (ie, about 1 1/3 octaves higher), to provide seven adjust- able frequency bands.

The output signal of the Equaliser appears at output pin 1 of op amp IC5a, and this is fed via a 470Ω resistor and a 2µF DC blocking capacitor (using two parallel 1µF capacitors) to the output at CON2.

The 1MΩ resistor to ground sets the DC level for the output signal while the 1nF capacitor shunts any out-of-band high frequency noise to ground.

The 470Ω resistor determines the output impedance of the equaliser, while the 2µF output capacitor and 470nF input capacitor set the low frequency -3dB point of the entire circuit to about 4Hz.



Power supply

As already noted, there are three power supply options and these are depicted in Figs.7(a)-(c). You can use a centre-tapped 30V transformer, a 15-16VAC plugpack or a DC supply of up to 20V. There are two ground/earth connec- tions shown on the circuit with different symbols for each. One is the ground for the power supply, signal inputs and signal outputs, shown with an Earth symbol (although it's only actually connected to Earth if a mains transformer is used).

The second is the ground reference signal for the op amp circuitry, and this ground symbol is identical to the one used in Fig.4; indeed, all the points shown con- nected to ground in Fig.4 connect to the ground in Figs.7(a)-(c). The two grounds are connected directly together when using an AC supply, via JP1. In this case, the power supply ground is con nected to the centre tap of the transformer and the ground pins of REG1 and REG2. The AC from the transformer is converted to pulsating DC by the bridge rectifier formed by D1-D4 and filtered by two 470µF 25V capacitors, one for the positive supply and one for the negative.

The DC across these capacitors (with significant ripple) is then fed to regulators REG1 and REG2 which provide the +15V and -15V regulated supply rails to run the op amps.
The power LED, LED1, is powered from the +15V rail and its current is set to around 4mA by a 3.3kΩ resistor.
A 3.9kΩ resistor between 0V and the -15V supply rail provides a similar current flow in the negative supply rail, so that the supply rails collapse at the same rate when power is switched off. This prevents the op amps from oscillating as the supply capacitors discharge, and also prevents the output voltage from shifting markedly from 0V during power down. You can use a 15-16VAC plugpack, as shown in Fig.7(b), instead of the centre- tapped transformer in Fig.7(a). This con- nects between 0V and AC1 at CON5, and diodes D1 and D4 form two halfwave rectifiers to derive the positive and negative rails. Diodes D2 and D3 are thus unused, and may be omitted. The rest of the circuit works identically to the case in Fig.7(a); the only difference is that there will be twice as much ripple on the filtered but unregulated DC rails that form the inputs to REG1 & REG2.

For a DC supply, as shown in Fig.7(b), the positive voltage is applied to the AC1 terminal of CON5 and the negative voltage to the 0V terminal. Diode D4 provides reverse polarity protection; diodes D1-D3 may be omitted. For input voltages below 18V, REG1 should be omitted and its input and output terminals shorted, so that the external supply runs the circuit directly via D4. When using a DC supply, no negative rail is available so REG2 can be left off.

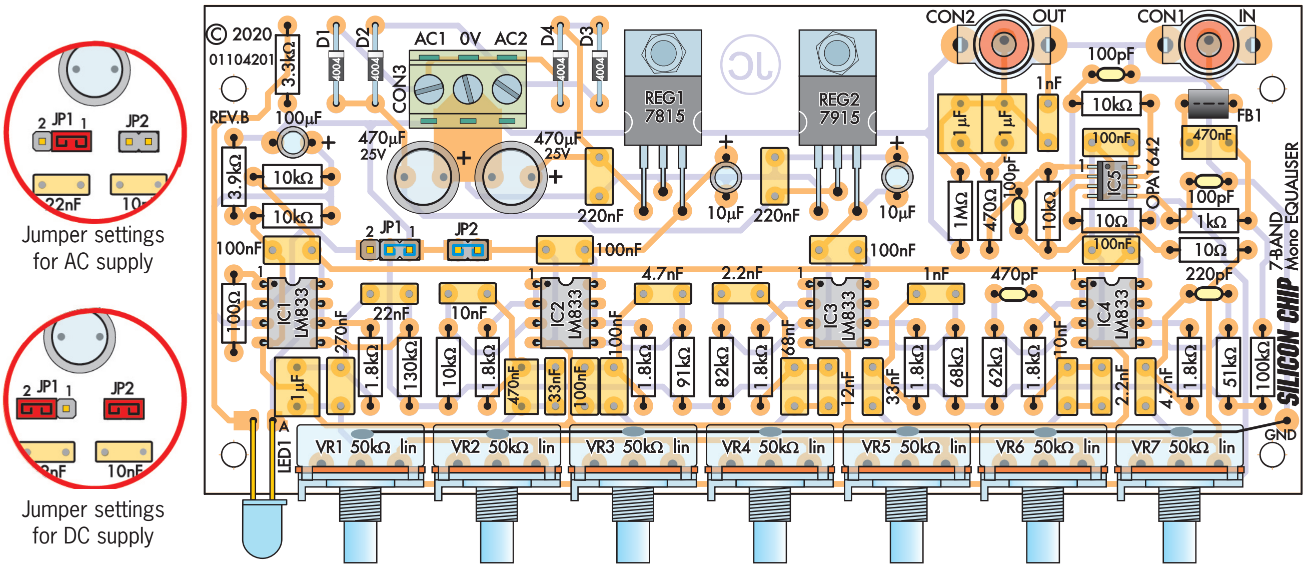


Fig.9: The overlay diagram for the mono version of the equaliser. Take care to orient components correctly if they need to be. This in- cludes the ICs, diodes, electrolytic capacitors and the regulators that must be in their correct position. No shown is the earthing wire soldered between the pots and to the earth terminal on the PCB. See the photo on the previous page.

A shunt is placed on header JP2 to connect the V- supply rail to the negative side of the external DC supply. JP1 is then positioned to connect the op amp grounds to a Vcc/2 half supply rail. This half supply rail is required as all signals to the op amps now must be biased at half supply so that there will be a symmetrical signal swing between the positive DC supply and 0V.

This rail is derived using two series 10kΩ resistors across V+ and V-, with the centre connection bypassed to V- with a 100µF capacitor, to reject supply ripple. Op amps IC10a (stereo version) and IC1a (mono version) buffer this half supply rail.

The spare op amp (IC10b) is not used in the stereo version, but is connected as a buffer from IC10a's output. This is to prevent the op amp inputs floating and causing oscillation. The mono version uses an existing spare op amp (IC1a) for the Vcc/2 buffer, so there is no unused op amp half.

Construction

The stereo version of the equaliser is built using a double-sided PCB coded 01104202, measuring 157 x 86mm. Its component overlay diagram is shown in Fig.8. The mono version is built on a different double-sided PCB coded 01104201, measuring 143 x 63.5mm. If building this version, refer to the mono overlay diagram, Fig.9.

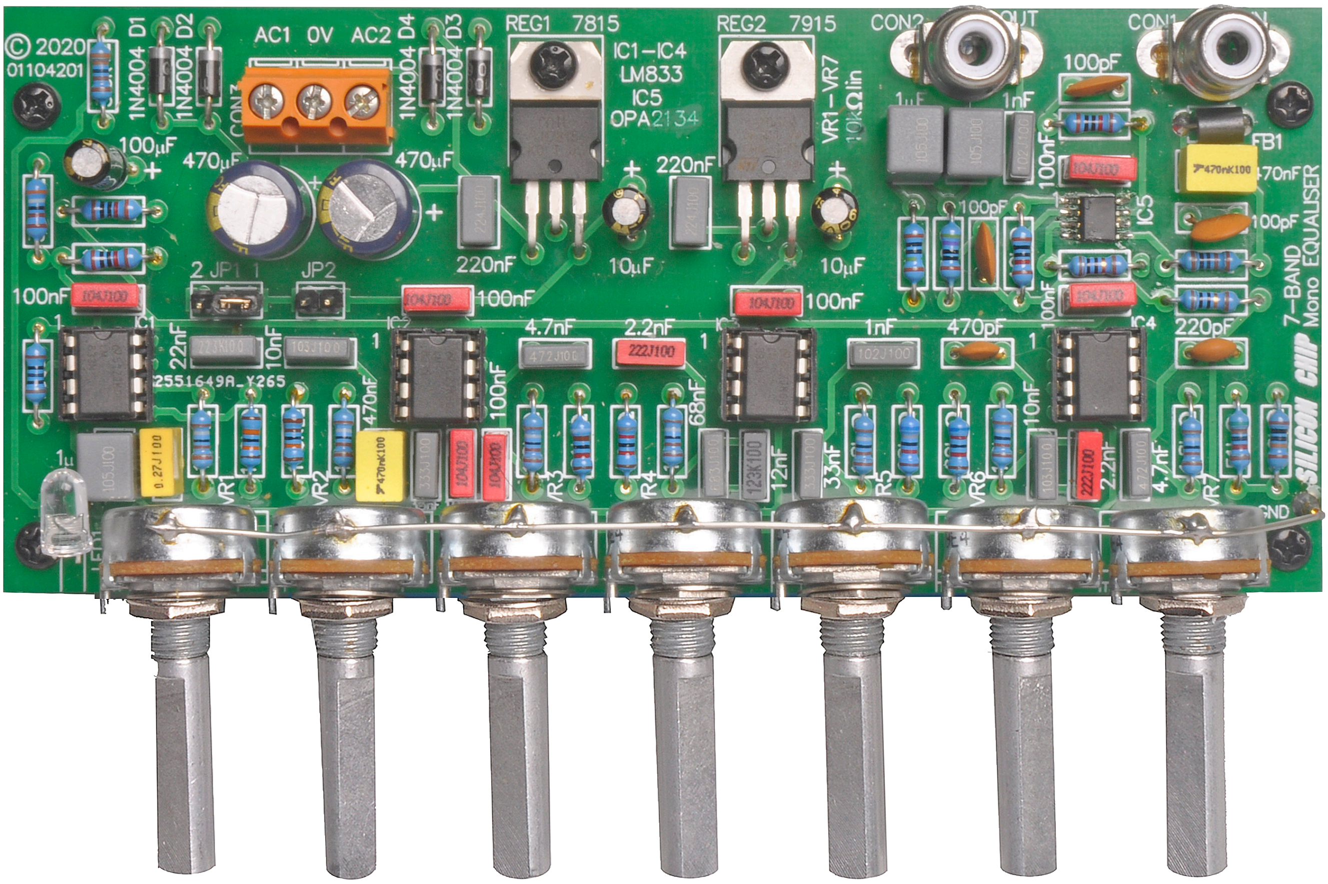
Note that if you are building the stereo version and you are not using a DC s upply, op amp IC10 does not need to be installed. That's because it's only used to buffer the Vcc/2 supply rail required for the DC power configuration. Begin construction by fitting the surface mount ICs. These are IC8 and IC9 for the stereo version and IC5 for the mono version. (This type of op amp is not available in a through-hole package).

In each case, make sure you have orientated the IC correctly; a white line is printed on the top of the package between pins 1 and 8. Position the IC over the PCB pads and solder one corner pin. Check its alignment and re-melt the solder if you need to adjust its position. When the IC is aligned correctly, solder the remaining seven pins. Make sure that there no solder dags bridging any of the adjacent pins.

However, keep in mind that the following pins are joined on the PCB, so bridges between them do not matter: (stereo version) pins 1 & 2 of IC9 and pins 6 & 7 of IC8; (mono version) pins 6 & 7 of IC5.

Continue by installing the resistors using the colour code table as a guide to the value, although you should check using a multimeter set to read ohms to be safe. Then fit the two ferrite beads by feeding a resistor lead offcut through each bead before soldering them in place. Diodes D1-D4 can be mounted now; make sure they are orientated correctly. As shown in Figs.7(b) & (c), if you are powering the unit from a plugpack or DC supply, you may omit some of these diodes, although it doesn't hurt to fit them all. Continue by installing the remaining ICs. These are in DIP packages, so you can use IC sockets if you prefer. This makes it easier to swap them later, or replace a failed op amp; however, the sockets themselves can be the source of problems due to corrosion in the metal which contacts the IC pins.

Regardless of whether you are soldering sockets or ICs to the board, make sure they are all orientated correctly. Now fit the ceramic and MKT polyester capacitors, which are not polarised, followed by the electrolytic capacitors, which are. Their longer leads must go into the holes marked with the "+" symbols on the PCB; the striped side of each can indicates the negative lead. LED1 also needs to be mounted with the correct orientation. Its longer lead



is the anode, and this goes to the pad marked “A” on the PCB. Fit it with the top of the lens 12mm above the PCB. The leads can be bent over so the LED is horizontal later, when installing the Equaliser into its case. When mounting the RCA sockets, the white ones are for the left channel and the red ones are for the right channel. The 3-way screw terminal (CON5 for the stereo version or CON3 for the mono version) can then be installed with its wire entry holes towards the edge of the PCB.

Fit regulators REG1 and REG2 next. These are mounted horizontally, with the tabs secured using screws and nuts. If you are using a DC supply for the equaliser, then REG2 and associated components do not need to be installed (this includes the 470µF and 220nF capacitors at REG2’s input and the 10µF capacitor at the output). If you are unsure of which component to leave off, fit them all.

This means the board will work if you decide to use an AC power source later. For the DC supply version, use a 7815 for REG1 if the supply is between 18V and 24V (25V absolute maxi mum). If the supply is 15-18V, use a 7812 regulator. For 12-15V, dispense with REG1 and instead fit a wire link between the IN and OUT terminals (the two outer pads). In this case, the incoming DC supply will need to be reasonably free of noise and ripple for good performance.

We don’t recommend using a supply lower than 12V for the op amps as the signal swing becomes limited. Once you’ve figured out which regula- tors to install, start by bending their leads to fit into the holes in the PCB, with the tab holes lined up with the PCB mounting holes. Attach the regulator bodies with screws and do them up tight before soldering and trimming the leads.

Mount jumper header JP1 & JP2 next. For an AC supply, insert the jumper link on JP1 in position 1 and leave JP2 open. For a DC supply, insert the jumper link on JP1 in position 2 and also fit a jumper link on JP2. All that’s left now are the potentiome- ters. The pot bodies should be grounded using tinned copper wire that is soldered to each pot body and then to the GND terminal point (see photos). To do this, you will need to scrape off some of the passivation coating on the top of each pot body before soldering them to the board.

Selecting the knobs

You must use knobs 16mm in diameter or less, and this includes any flange/ skirt at the base (ie, measure the maximum diameter). Note that some potentiometers have a D-shaped shaft while others are fluted, so you will need to make sure that you purchase knobs which match your shafts. Also, keep in mind that knobs for 6mm (metric) shafts will not fit pots with 1/4” (6.35mm) shafts.

Whether you use a knob with a skirt depends on how you will be mounting the potentiometers. Knobs with skirts are designed to cover the potentiometer nut, if this is exposed on the mounting panel. If the pot is mounted on a recessed panel, it is not necessary to use knobs with skirts. Suitable knobs for the 1/4” D-shaft potentiometers from Altronics (Cat H6040). Both have skirts. Aluminium knobs without a skirt are also available: Altronics Cat H6331 (silver) and H6211 (black). Altronics also has the black Cat H6106 and coloured cap series, Cat H6001-H6007. All of the above are grub screw types. These allow the knob to be secured with the pointer opposite the flat portion of the D-shaped shaft. Knobs with an internal D-shaped hole should not be used unless the pointer can be reorientated.

Fixed pointer knobs generally point in the direction of the flat portion of the D-shaped shaft, which is the opposite of what we require.

Initial testing
You can now power up the Equaliser board to test for voltage at the op amps. Refer to Figs.7(a)-(c) for how to wire up the power supply. If using a mains transformer, make sure everything is fitted in a properly Earthed metal box with tidy and suitably insulated mains wiring. Do not attempt this if you don't have experience building mains-based projects.

If fitting the Equaliser into an existing chassis and using the pre-installed trans- former, that transformer must be capable of supplying the extra current drawn by the equaliser circuit. This is 70mA maximum for the stereo version and 45mA for the mono version. That's low enough that it's unlikely it will cause any problems.

Power up the circuit and check that LED1 lights, then measure the DC voltage between pins 4 and 8 of the op amps. This should be close to 30V (29.5V-30.5V) if you are using the AC supply. For the DC supply version, check that this voltage is close to 15V (14.75-15.25V) if you've fitted a 7815 or 12V (11.75-12.25V) if you've fitted a 7812. If REG1 is linked out, you can expect about 0.7V less than the incoming supply voltage.

The voltage between pin pairs 4 & 1 and 4 & 7 of each op amp should show half the supply voltage. In other words, this volt- age should be 7.5V or thereabouts if you measured 15V between pins 4 & 8. All that's left then is to centre the pots, connect a signal source to the input and an amplifier to the output and check that the sound from the amplifier is clean and undistorted. Experiment by rotating the various knobs and check that you can vary the frequency response as expected.

Important Note:
Please note that we can offer a warranty only on the components supplied with this kit. Because we are unable to guarantee your labour, there is no warranty on either par- tially or fully built kits. We are able to offer a repair service, but once construction has commenced, this service is chargeable.

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