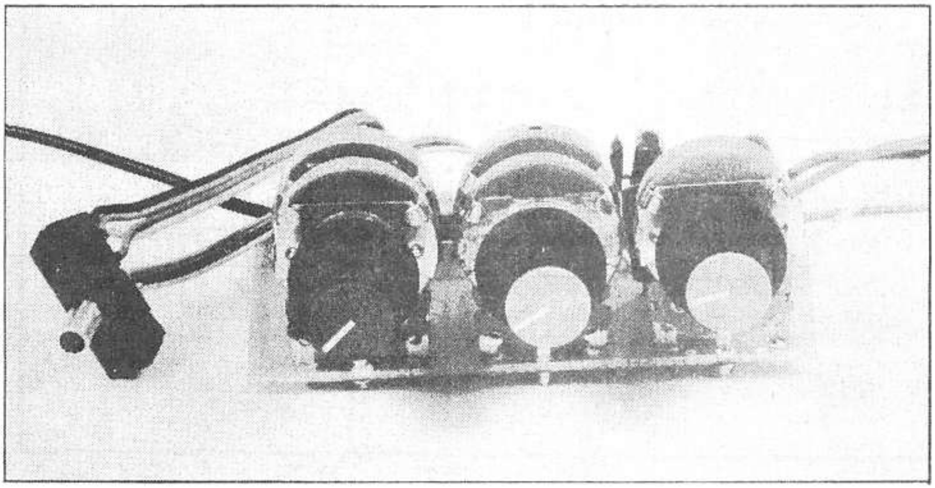
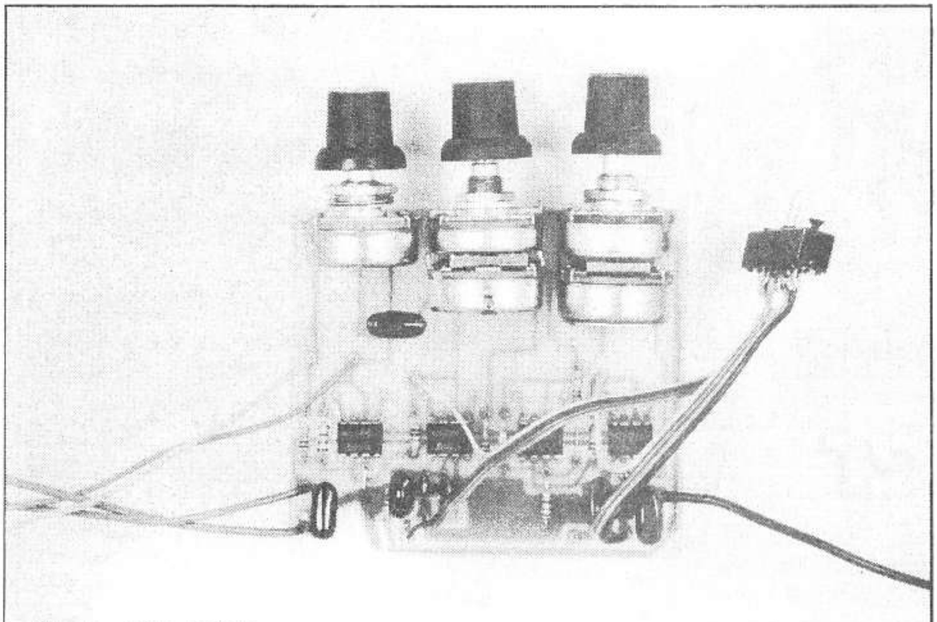
Project 1406

PARAMETRIC EQUALISER

Does your music system want a new frequency response? Does your guitar or keyboard need some equalisation to brighten the sound? Well, here is a module which can be used by itself on individual instruments or ganged to equalise your music system.

Neale Hancock





Top view of the module.

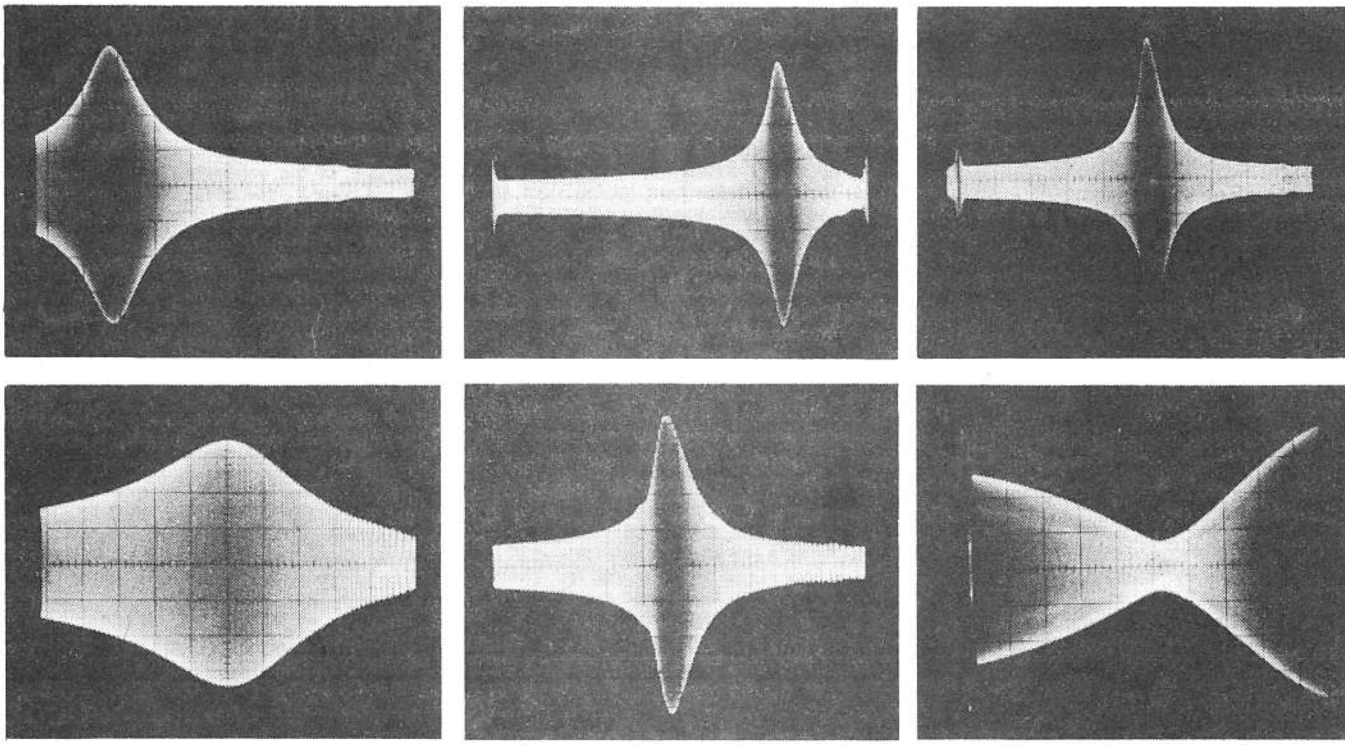
GRAPHIC EQUALISERS are widely used and accepted by audio enthusiasts as a means of correcting the acoustic deficiencies of a listening space. They are also used (probably by the majority of us) to make a stereo system sound better, by making the bass thump and adding more sparkle to the treble. The graphic equaliser is one way of optimising the frequency response of a music system to give our ears what they want.

Equalisation is not a process solely used in hi-fi applications. It's also used in public address systems as a way of eliminating feedback and in recording studios as a way to give an instrument a desired sound. In recording situations the parametric equaliser is a very versatile instrument, because it can be cascaded to give overall equalisation of a recording or used individually on separate instruments.

Both graphic and parametric equalisers use active bandpass filters to achieve equalisation. But whereas graphic equalisers use a number of preset bandpass filters called 'gyrators' (one for each slider on the front panel), parametric equalisers are tunable bandpass filters. This use of tunable bandpass filters in parametric equalisers allows each band to be more effective, thus reducing the number of bands required. And the increased efficiency allows a multiband parametric equaliser to be modular in design, with one bandpass filter in each module, making it more versatile than the graphic equaliser in the studio.

However, the ETI-1406 parametric equaliser module is designed to be used in any application where equalisation is required. These modules can be used independently or connected in series to form a multiband equaliser. The unit requires a signal of 100 mVrms line level or greater (up to 700 mV) to drive it, and runs from a ±15 volt supply. Casing details are left up to the user.

FREQUENCY RESPONSES (see text).



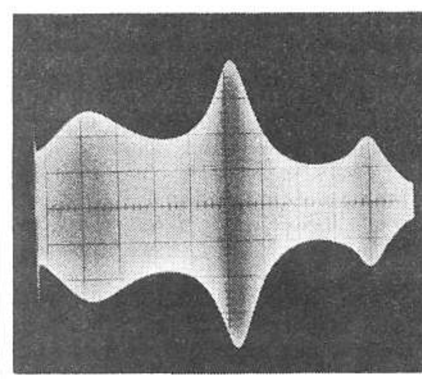


TABLE 1. PERFORMANCE OF ETI-1406

Range of centre frequencies	20 Hz to 19 kHz	Continuously adjustable
Range of Q	1 to 10	
Cut	−23 dB	
Boost	+18 dB	
Roll off	15 dB/octave	
Dynamic range	100 dB	measured at maximum * gain and maximum Q
S/N ratio	90 dB	measured at maximum * gain and maximum Q
Distortion	0.005%	measured at maximum * gain and maximum Q

Measured at 1 kHz and a signal level of 500 Vrms.

Circuit concepts

As I mentioned earlier, the parametric equaliser modules consist of tunable active bandpass filters. To make a bandpass filter tunable, parameters such as centre frequency, bandwidth and the amount of cut and boost are made adjustable. Graphic equalisers have the centre frequency and width of the band preset, with only the cut and boost variable.

The accompanying series of photographs shows the effect on the frequency response of changing the tunable parameters. All the photographs show the same range of frequencies being swept, with the lower frequency on the left (2.6 kHz) and the higher frequency on the right (7.5 kHz).

Figures 1 and 2 show the effect of shifting the centre frequency of the parametric equaliser. Figure 1 shows the parametric equaliser set on a high frequency which would result in a boost of the frequencies around the peak. Figure 2 shows it set to a lower frequency.

Figures 3 and 4 illustrate the effect of increasing or decreasing the width of the passband. This is also referred to as the Q. In Figure 3 the circuit has a high Q, thus a narrow range of frequencies around the peak is emphasised. Figure 4 has a low Q and shows a broad range of frequencies being emphasised.

Figures 5 and 6 show boost and cut of the range of frequencies. In Figure 6 the signal was amplified vertically so that the cut could be more closely observed.

The circuit for the parametric equaliser is based on a state variable filter circuit. This type of filter features low pass, high pass and bandpass outputs. They are also capable of providing a high Q and they can be readily tuned.

To convert a state variable filter into a parametric equaliser, the circuit has to be modified to so that its Q, centre frequency and gain are all variable. Q can be varied by replacing the pair of resistors used to set it with a dual-ganging potentiometer. The centre frequency can be tuned by using a switch to select the range and a dual-ganging potentiometer to tune the centre frequency of the filter within that range. The range is selected by switching in different capacitor values and the dual-ganging potentiometer replaces the resistor pair used to set the centre frequency.

To enable the filter to have variable gain or attenuation (boost or cut) at the centre frequency, a gain stage is added to the state variable filter circuit. This gain stage allows the filter to have bandpass or band reject characteristics.

The circuit has been designed using high performance op-amps, such as the NE-5534AN and the TL-071. Of these two op-amps the NE-5534AN gives the best results for noise and distortion, but at a higher component cost. The specifications for the ▶

circuit using NE-5534AN op-amps are listed in Table 1. The circuit can also use the good old 741 op-amp however higher levels of noise and distortion can be expected when using this device.

Construction

Commence construction by examining the pc board for broken tracks, and bridges between tracks. The first components to be mounted are the resistors, capacitors and the link. Next mount the ICs, but first check their orientation with the overlay. To supply the voltage rails of the modules, the +15 and −15 volt power supply is used. The ETI-581 dual power supply would be ideal in this case.

To keep the number of flying leads in the project to a minimum I have used pcb-mounting pots. The only hassle involved in using these pots is that you may need to drill 2 mm mounting holes in the pc board to accommodate their pins. After the mounting holes have been drilled the pots can be mounted on the board.

The triple-throw toggle switch can now be connected to the pc board. The best way of connecting the switch is to use ribbon cable as it makes the wiring neater and simpler. Try to obtain the thicker gauge cable as it is easier to work with in this case.

The wires connecting the input and output sockets and the power supply to the pc board can now be connected. It is best to leave these connections until you have decided what case to use.

The type of case used to house the parametric equaliser depends largely on how you want to use it. For instance, if you use a single module as an independent unit, it should be housed in a case by itself. However, if you are constructing a multiband parametric equaliser or integrating the modules into a music system, you will have to drill out your case to suit.

The component overlay shows the purpose of each pot, and what frequency range is selected by each position on the triple-throw switch. The overlay also shows how to connect the modules in series, using switched 3.5 mm or 6.5 mm phono jacks, to create a flexible multiband parametric equaliser. The use of switched jacks between each module allows them to be used independently

Using it

When using individual parametric equaliser modules to modify the sound of a musical instrument, first set the Q control to the centre position the frequency range selection switch to its centre position and the cut/boost control either fully clockwise or fully anticlockwise

Play a sustained note (preferably middle C) and turn the centre frequency control until you hear the sound of the note change. If the cut/boost control is turned fully anti-

HOW IT WORKS — ETI-1406

As mentioned in the text, the circuit is based around an active state variable filter. The op-amps in this filter are ICs 1, 2 and 3. The output from IC1 is high pass, the output from IC3 is low pass and the output from IC2 is bandpass. The output from IC2' goes into the gain stage, which consists of IC4, R6, R9 and RV3.

The centre frequency of the parametric equaliser is determined by resistors RV2, R5 and R10 and capacitors C2 and C7. The frequency range is selected by switching in a pair of capacitors using a dual-pole triple-throw switch, SW1. The frequencies within the range are determined by the resistor pair R5 and R10 with the dual-ganging potentiometer RV2. The equation which sets the centre frequency, fc, is:

$$fc = 1/2\,(RV2 + R5)Cx$$

where Cx can be C2, C3 or C4.

This equation could also be written using R10, C5, C6 and C7 since all these components are the matching pairs of those in the equation.

C2 and C5 select the frequency range of 2 kHz to 20 kHz, C3 and C6 select the range 200 Hz to 2 kHz and the pair C4 and C7 selects the range 20 Hz to 200 Hz. The frequencies within the ranges are obtained by using a dual-ganging potentiometer RV2.

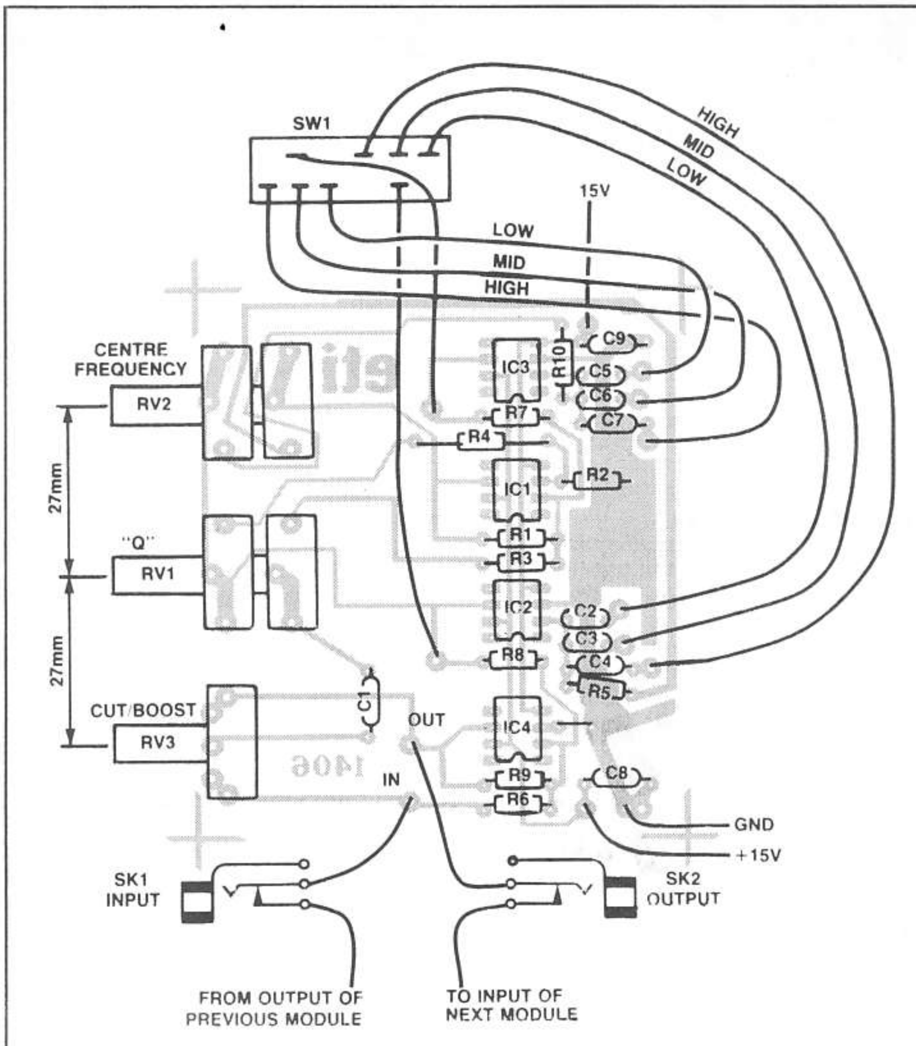
The highest frequency in the range is obtained when RV2 is turned fully clockwise making RV2 equal to zero in the equation above Therefore, R5 and R10 set the high end of the frequency range. When RV2 is turned fully anti-clockwise its value is equal to 100k in the equation above, thus setting the low end of the frequency range.

The Q of the parametric equaliser is set by the combination of R2, R4 and RV1. The equation used to determine the Q of a state variable filter is as follows:

$$(R4 + RV1)/R2 = 3Q-1$$
$$1 + (R4 + RV1)/R2 = 3Q$$
$$(1 + (R4 + RV1)/R2)/3 = Q$$

By substituting in the values of R2 and R4 as well as the maximum and minimum values for RV1, a maximum value for Q is 10 and a minimum value for Q is 1.

The gain stage gives the parametric equaliser circuit the ability to cut or boost the frequencies to which the filter is tuned. RV3 gives control over the amount of cut or boost while R6 and R9 set the overall gain of this stage. The capacitors C8 and C9 are there to remove high frequency noise from the supply rails.



PARTS LIST — ETI-1406

Resistors .... all ¼W, 5%
R1, 7 .... 100k
R2 .... 3k9
R3-6, 8, 10 .... 10k
R9 .... 22k
RV1, 2 .... 100k dual-ganging linear with pc mounting pins
RV3 .... 10k linear with pcb mounting pins

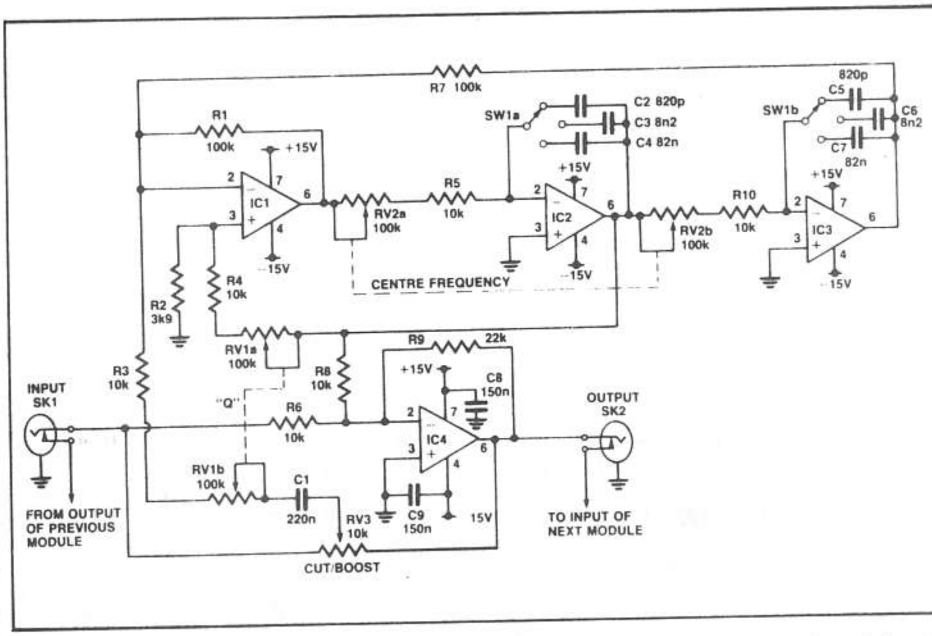
Capacitors
C1 .... 220n greencap
C2, 5 .... 820p ceramic
C3, 6 .... 8n2 greencap
C4, 7 .... 82n greencap

Semiconductors
IC1-4 .... NE-5534AN or TL-071 (see text)

Miscellaneous
ETI-1406 pc board; 3 x potentiometer knobs; 2 x switched phono sockets; dual-pole triple-throw switch; hookup wire; case to suit.

Price estimate: $22-$33*

*The lower figure corresponds to the circuit using TL-071s



clockwise, the effect will be a dulling of the note, alternatively the sound will be brighter if the cut/boost control is turned fully clockwise By turning the Q control clockwise the range of notes dulled or brightened will be reduced. When it is turned anticlockwise the range of notes will be increased.

A good multiband parametric equaliser can be created by using three or four modules in series. Using such a multiband equaliser on orchestrated music would require a similar procedure to that outlined above. The only differences are that the input into the equaliser is different and that there are more bands to tune.

When using a number of modules in series each one increases the gain and the Q of the system. Make sure that the first module in the system does not have a high gain or Q; this applies to a lesser extent to each successive module. If the gain or the Q of the system is too large the result will be excessive distortion of the musical signal. ●