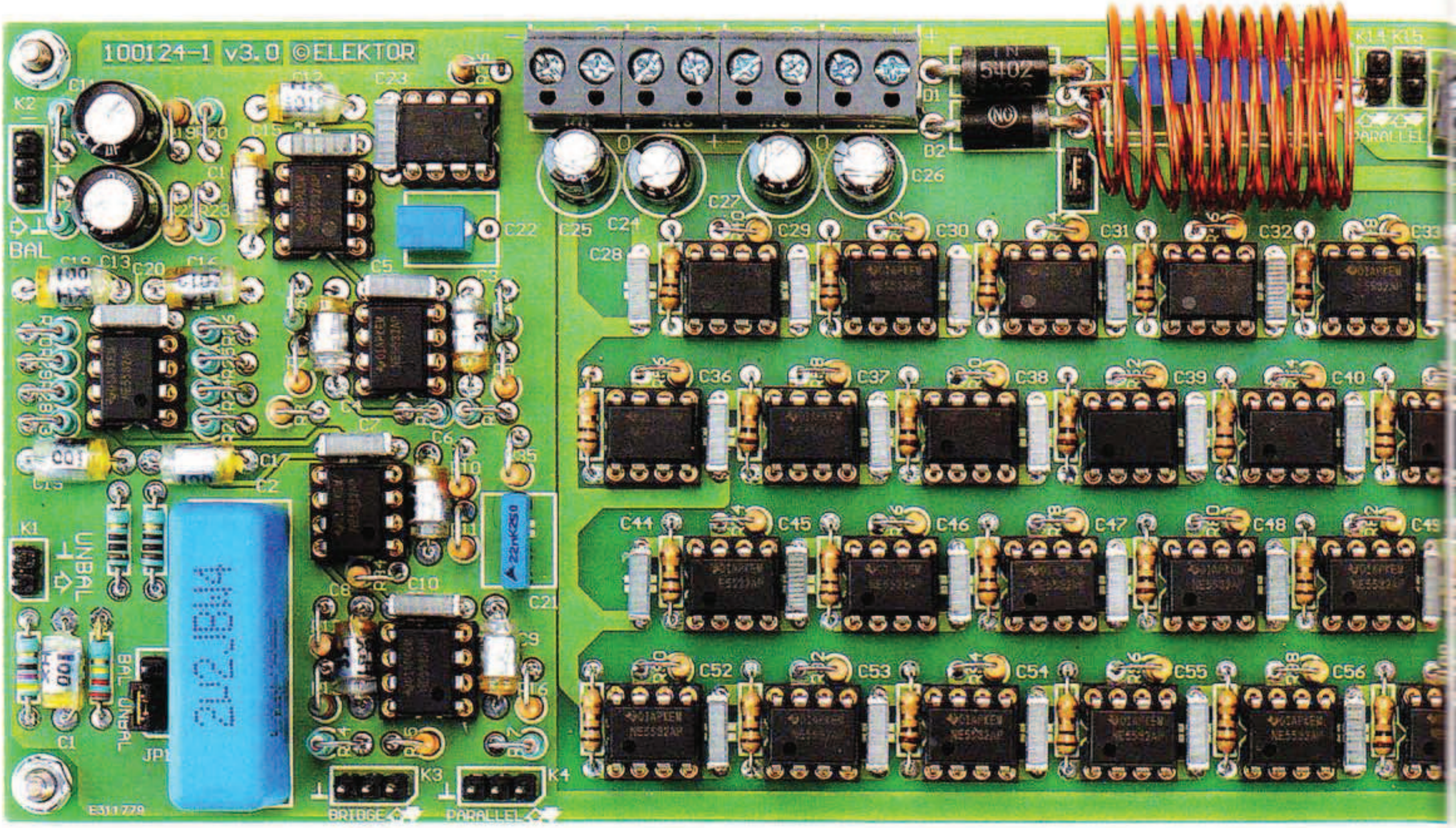
The 5532 OpAmplifier

Part 1: design philosophy and schematics



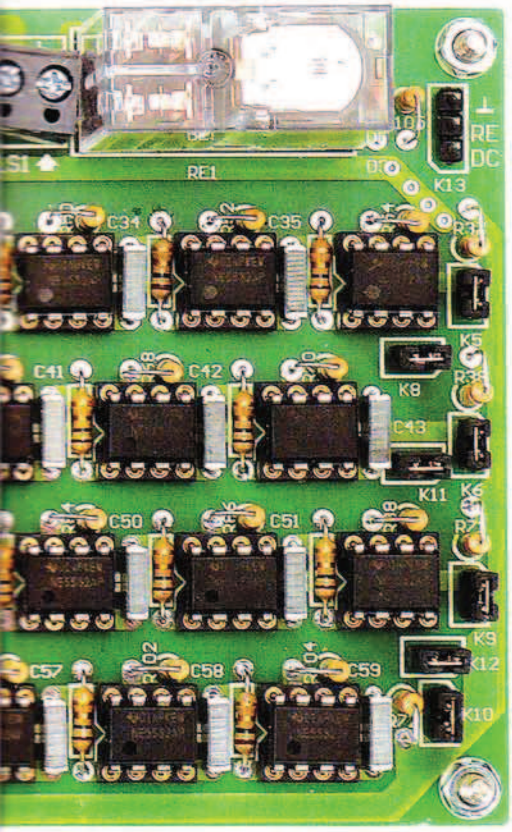
By Douglas Self (UK)

The most popular dual opamp in the world of audio is the (NE)5532. An interesting power amplifier can be made by connecting enough 5532s in parallel, how about 32 for a start? This may sound like a radical course of action, but it actually works very well, making it possible to build a very simple amplifier that retains not only the excellent linearity but also the power-supply rejection and the inbuilt overload protection of the 5532, which reduces the external circuitry required to a minimum.

While not exactly a brand-new design, the type (NE)5532 dual operational amplifier (opamp) is a very capable device giving low distortion with good load-driving capabilities, and a remarkably good noise performance. It is only quite recently that better opamps for audio work have become available. While these can give truly outstanding results, the cheapest of them costs ten times more than the 5532, which is available at a remarkably low price — in fact it is one of the cheapest opamps, because it is so widely used in audio applications.

It should be mentioned at once that the obvious limitation with using opamps to drive loudspeakers is that the output voltage swing is limited compared with a conventional power amplifier, and using a single-ended array of 5532s will give about 15 W_{rms} into 8 Ω. This output can be greatly extended by using two such amplifiers in bridge mode; one amplifier is driven with an inverted input signal so the voltage difference between the two amplifier outputs will be doubled, and the power output is quadrupled to about 60 W_{rms} into 8 Ω. This should be enough for most domestic hifi situations.

The other unalterable limit set by the opamps is the maximum output current, set by the internal overload protection. A single 5532 section (one half of the dual package)



Specification — per channel, 8 ohm load

Supply voltage	±18.3 V	
Input sensitivity	- unbalanced	840 mV (16 W, 1 % THD)
	- balanced	833 mV (16 W, 1 % THD)
Input impedance	- unbalanced	38.8 kΩ
	- balanced	93.6 kΩ
Output power, sinewave	- 0.1 % THD	16 W
	- 1 % THD	16.8 W
Output power bandwidth		1.5 Hz – 275 kHz
Slew rate		5 V/µs
Rise time		4 µs
Signal/noise ratio	(1 W ref.)	110 dBA
	- 108 dB (B = 22 Hz – 22 kHz linear/unweighted)	
Harmonic distortion + noise	- 0.0005% (B = 22 kHz, 1 kHz, 1 W)	
	- 0.0009% (B = 80 kHz, 1 kHz, 1 W)	
	- 0.0004% (B = 22 kHz, 1 kHz, 8 W)	
	- 0.0005% (B = 80 kHz, 1 kHz, 8 W)	
	- 0.003 % (B = 80 kHz, 20 kHz, 8 W)	
Intermodulation distortion	- 0.0012% (1 W)	
	- (50 Hz : 7 kHz = 4 : 1) 0.0015% (8 W)	
Dynamic IM distortion	- 0.0011% (1 W)	
	- (3.15 kHz square wave + 15 kHz sine wave)	0.0035% (8 W)
Damping factor	- 194 (1 kHz)	
	- 111 (20 kHz)	
DC-protection	±1.5 V	
Quiescent current	300 mA	

will drive 500 Ω to the full voltage output, though it is advisable to keep the loading lighter than this to maintain low distortion at high levels. If 4 Ω operation is required, twice as many opamps must be used to supply the doubled current demand. This also applies to bridged operation into 8 Ω. The system is designed so that either single-ended or bridged operation can be used; the basic design described here gives a working stereo amplifier with just three PCBs. The amplifier cards can be paralleled without problems, and facilities are provided to connect more PCBs in parallel for driving low-impedance speakers.

Overload protection is inherent in the opamps, but output relays are used for on/off muting and to protect loudspeakers against a DC fault.

A tour of the design

The schematic in **Figure 1** shows one channel of the complete amplifier, which consists of unbalanced and balanced line inputs, and the power amplifier itself, which is divided into a +22.7 dB gain stage and an array of paralleled output opamps configured as voltage-followers, giving the maximum amount of negative feedback around them to minimise distortion. Let's have a look at the various sections of the circuit.

The unbalanced input

This consists simply of RF filter R1, C1 and DC-drain R2, which are directly connected to the gain stage when JP1 is in the 'unbalanced' position.

The balanced input

This amplifier is an innovative design that gives very low noise. The conventional balanced input stage built with four 10 kΩ resistors and a 5532 opamp has a far worse noise performance than a simple unbalanced input, and is also much noisier than most power amplifiers; output noise is approximately –104 dBu. This balanced amplifier here solves this problem partly by the use of a dual balanced stage (IC5A, IC5B) amplifier that partially cancels the uncorrelated noise from each amplifier, giving a 3 dB noise reduction, and in a similar way improves the CMRR; it also uses much lower resistor values than usual (820 Ω instead of 10 kΩ) which produces less Johnson noise in the first place. This is only possible because it is driven by unity-gain buffers IC4A, IC4B, which also allow the input impedances to be much higher than usual, preventing loading of external equipment and further improving the CMRR. The noise output is less than –112 dBu, an 8 dB improvement over conventional technology.

The gain stage

The main input amplifier is another innovative design that achieves very low distortion by spreading the gain required over three stages. +22.7 dB could easily be obtained with one opamp but 5532s are not