New 30W stereo amplifier project – 2

Full circuit details

Here it is, our latest Playmaster amplifier. This compact unit is low in cost and very easy to build, yet provides all the essential features and excellent performance.

by ROB EVANS

In the June issue we discussed the design considerations for a new low cost, high performance stereo amplifier. This article considered the power, features and overall performance required for today's signal sources. We also looked at the requirements of the home constructor, in terms of ease of construction and reliability.

In fact, we set ourselves quite a challenge, since the actual design of such an amplifier has a few conflicting requirements. High performance for example, does not necessarily lend itself to low cost and reliability, while a construction technique with little interwiring means a more complicated printed circuit board (PCB) design.

However, since we at EA are not adverse to challenges, the time and effort was put in to overcome these hurdles. The end result is the Playmaster 30-30; an easy to build, moderately powered amplifier, with excellent noise and distortion specifications to satisfy the most fastidious listener.

It's neat as well. With the exception of the power transformer and output terminals, all components mount directly onto one square PCB – resulting in simple, trouble-free assembly. In fact, by connecting the power transformer to the assembled PCB, the amplifier may be tested as a free standing unit, without the cabinet. This is made possible by the use of a very careful PCB design, direct mounting potentiometers and input sockets, and small high efficiency heat sinks. As a bonus, all of this fits into a small, moderately priced box.

To simplify our design even further, we have elected to use integrated power amplifier chips for the main power amp stage. At moderate powers, this slightly unusual method has some distinct advantages over an equivalent discrete design.

Power from an IC

Integrated circuit power amplifiers have been viewed with some suspicion in the past, due to their reputation for questionable reliability, and poor noise and distortion performance. However, the newest generation of power ICs settles any doubts about their ability in these areas. Manufacturers have developed these devices to a performance level where they challenge the best discrete designs, while offering a host of self protection facilities and an attractive price.

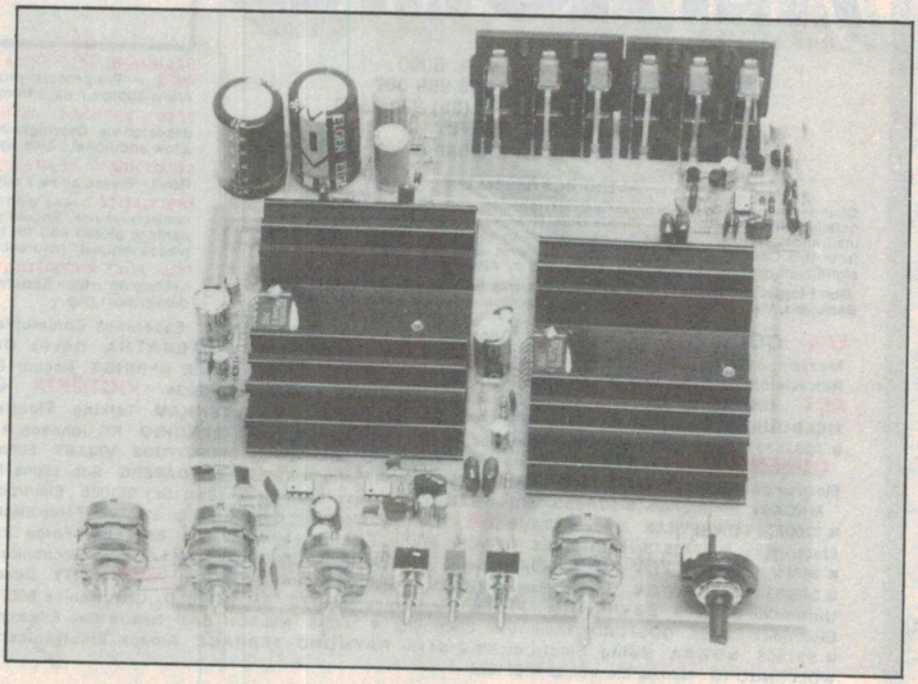
Just as we use the common op-amp instead of a handful of transistors, we may now also use these new power ICs as an effective replacement for discrete power designs. In the present case, the power IC is a neat physical and electronic solution to the conflicting requirements of our output stage. That is, it is small and self contained, yet offers high performance.

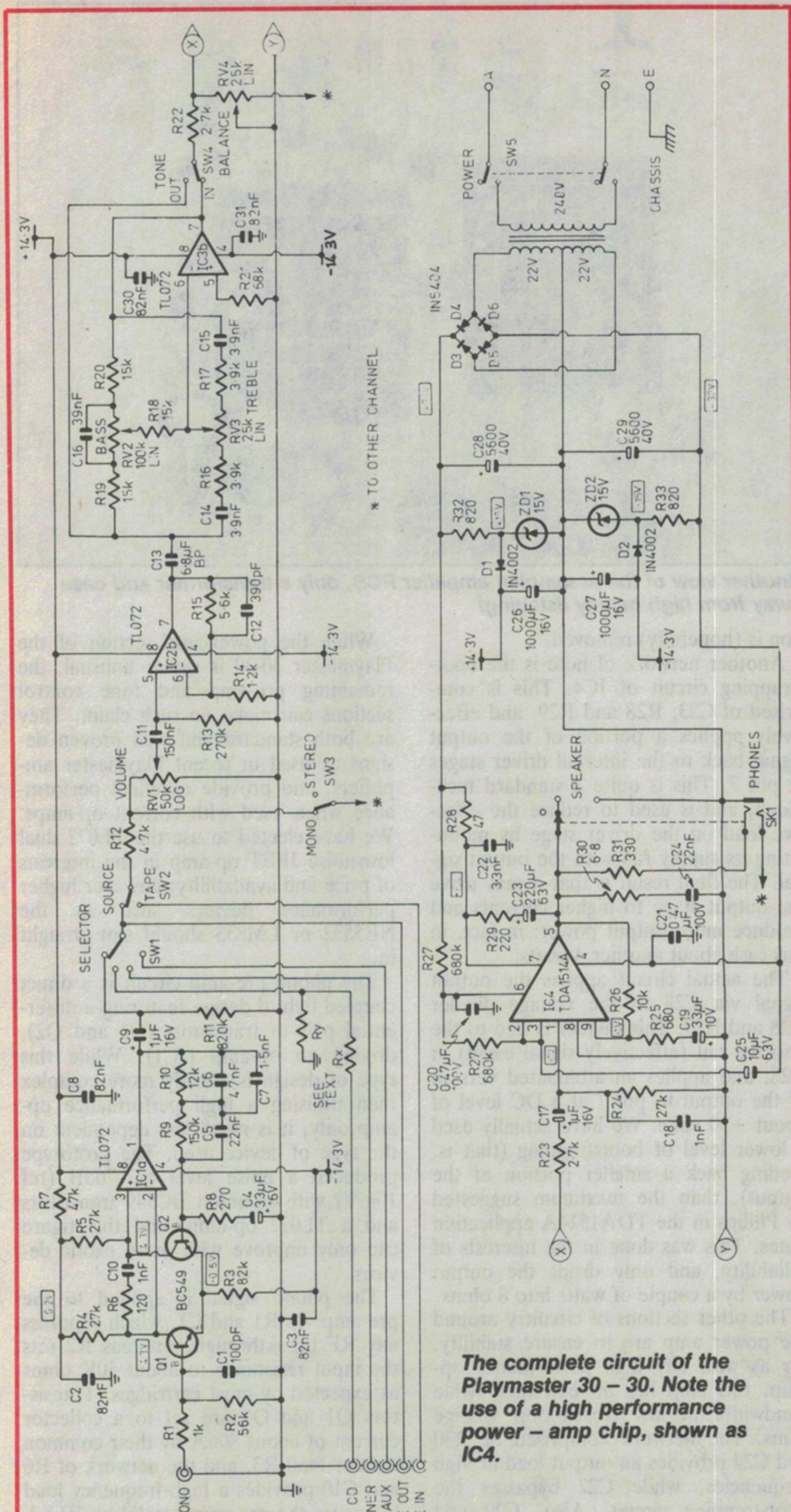
The reason for this high reliability and performance is the power IC's internal construction. In the same manner as an op-amp, the intimate thermal coupling and optimised component layout produces a highly stable device. As a further advantage, an IC is simple to implement thanks to the small physical size and minimal external components. This means a less complicated assembly procedure and lower risk of error.

So, with this high production technology and long periods of research and development, how can manufacturers charge so little for such a sophisticated device? The answer is simply large production runs and high volume sales, which is due to the wide range of applications and predictable results.

The Philips TDA1514A

An excellent example of these new high performance power chips is the





The complete circuit of the Playmaster 30 – 30. Note the use of a high performance power – amp chip, shown as IC4.

Philips TDA1514A integrated power amp. This remarkable little beastie has a nominal output power of 40 watts, a 10V/us slew rate, very low noise and distortion levels, and is contained in a 9-lead package (type SOT-131A) measuring only 24 x 12 x 4mm. It also has a number of very useful protection features that are ideal for our application.

The first of these features is an internal muting circuit, which may be activated by applying a low voltage level to its control pin. This condition may be induced by internal chip conditions, or an externally applied level. As the name implies, the muting circuit simply mutes the audio signal path to the IC's output stage.

The muting circuit's control pin may be wired to an RC network so that muting is activated for a pre-set time, during power-up conditions. This is effectively a "de-thump" circuit, for it blocks the DC offsets produced by charging capacitors in the earlier amplifier stages, until they have settled.

The second feature is primarily designed to protect the output transistors and is called SOAR protection. SOAR is an acronym for "safe operating area", and refers to the range of voltage and current combinations the output devices may safely handle. Since dissipated power is the product of the applied current and voltage (P=IV), a given device will pass a much higher current at a low terminal voltage and a low current at the maximum applied voltage. In practice, these two conditions are at the opposite ends of a SOAR curve.

The clever thing about the TDA1514A chip is that when the SOAR limit is exceeded, the internal muting circuit is activated automatically – which in turn shuts down the signal, thereby removing the overload. Clearly, a direct short circuit across the output will rapidly exceed the SOAR limit, so we may consider this chip as protected against short circuits.

A thermal overload is treated in a similarly clever manner, with the muting circuit activated when the chip temperature exceeds a predetermined level. This third feature is very handy in a stereo amplifier, which has to cope with a wide range of ambient temperatures and load conditions.

As previously mentioned, a current generation power amplifier chip is not unlike a high powered op-amp, and shares its versatility. This is typified in the TDA1514A, which has inverting and non-inverting inputs, an input impedance of 1M ohm, an open-loop voltage gain of 85dB, a supply ripple rejection of 72dB, and an input bias current of 1uA. In short, it is an extremely practical IC which easily slots in almost any high quality power-amp application.

Performance plus

So it's a great chip, but how does the final amplifier perform? In a word: great. As the accompanying table shows, the specifications for the Playmaster 30-30 exceed those of a commercial unit costing many times the price. It delivers a continuous 28 watts into 8 ohms (both channels driven), and up to 60 watts under the IHF tone burst technique. So in the practical sense, this little amplifier is capable of cleanly driving loudspeakers to *loud* levels.

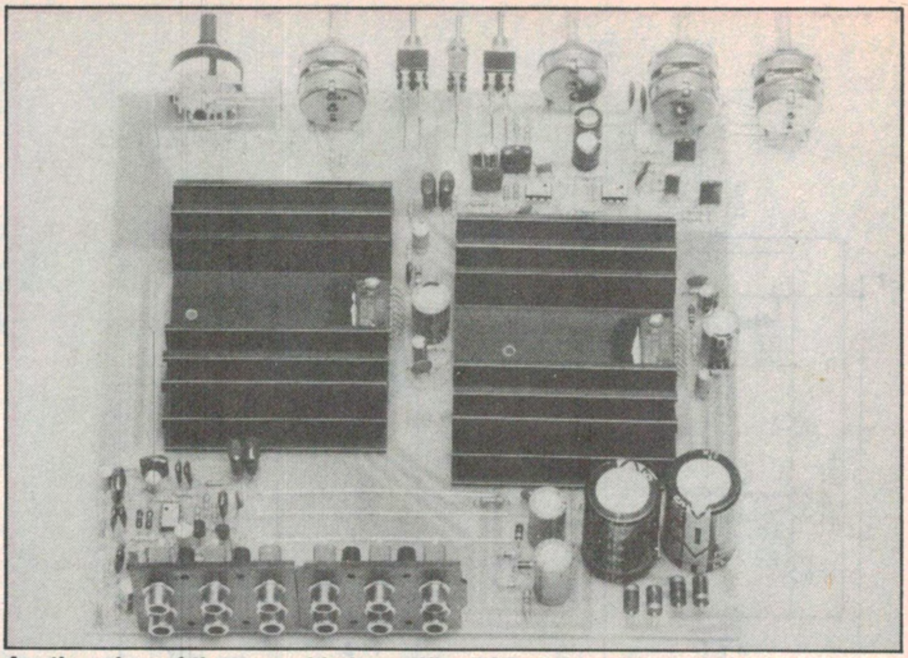
Naturally, the performance can be a little more civilized than attempts at speaker destruction. Using the Compact Disc input and the tone controls bypassed for example, the noise and distortion levels virtually drop to that of the CD player itself. In this "straight through" mode the performance of the amplifier is almost set entirely by the TDA1514A power amp chip; happily its conduct is first class.

The circuit

Turning our attention to the actual circuit diagram, we can see the TDA1514A as IC4. It is arranged with an input impedance of 27K as set by R24, and a gain of about 15 as set by R25 and R26. The signal is coupled to the "non-inverting" input via R23 and C17, with R23 and C18 acting as a low-pass filter to remove any frequencies above the audio bandwidth.

Both the inverting and non-inverting inputs (pins 9 and 1) are AC-coupled by C19 and C17 respectively, since these inputs are at a slight negative bias voltage. Also, to prevent unwanted subsonic frequencies reaching the output, these capacitors form high-pass filters with R25 and R24 respectively.

The muting control network (R27 and C25) is connected at pin 3 of IC4, which is linked to pin 2, the control output from internal protection circuitry. Initially, when power is first applied the discharged state of C25 will hold pin 3 low, forcing IC4 into its muted state. The muting is maintained as C25 charges towards the positive supply rail via R27. When pin 3 rises to about +6 volts, the muting function is released allowing audio signals to pass. In a similar fashion, an internal overload condition of the TDA1514A will drive pin 2 and consequently pin 3 low, until the condition is (hopefully) removed.



Another view of the assembled amplifier PCB, only a transformer and case away from high quality listening!

Another network of note is the bootstrapping circuit of IC4. This is comprised of C23, R28 and R29, and effectively applies a portion of the output signal back to the internal driver stages at pin 7. This is quite a standard technique, and is used to reduce the effective load on the driver stage by modulating its supply rail with the output signal. The final result is that it may drive the output stage to higher currents and produce more output power: in fact, in this case about another 4 watts.

The actual circuit applies the output signal via C23 to the voltage divider R28 and R29. This divider is tied to the positive rail (effectively signal earth) at R28, and applies an attenuated version of the output to pin 7 at a DC level of about +30 volts. We have actually used a lower level of bootstrapping (that is, feeding back a smaller portion of the output), than the maximum suggested by Philips in the TDA1514A application notes. This was done in the interests of reliability, and only drops the output power by a couple of watts into 8 ohms.

The other sections of circuitry around the power amp are to ensure stability, for as with any high performance op-amp, this chip has an extremely wide bandwidth at low closed-loop voltage gains. The network comprised of R30 and C24 provides an output load at high frequencies, while C22 bypasses the bootstrapping circuit. Also, C20 and C21 bypass the two supply rails and *must* be mounted as close to the IC pins as possible.

While the power-amp section of the Playmaster 30-30 is rather unusual, the remaining pre-amp and tone control sections can make no such claim. They are both standard and well proven designs as used in recent Playmaster amplifiers, and provide excellent performance when used with current op-amps. We have elected to use the TL072 dual low-noise JFET op-amp in the interests of price and availability; however higher performance devices such as the NE5532 or LM833 should slot straight in.

The phono pre-amp circuit is a direct coupled hybrid design featuring a differential pair of transistors (Q1 and Q2), driving an op-amp (IC1). While this type of design is slightly more complex than utilising a high performance op-amp only, it is much less dependent on the type of device used. The prototype produced a noise level of -76dB (ref 10mV) with common BC549 transistors and a TL072 op-amp, and this figure can only improve with more exotic devices.

The phono signal is applied to the pre-amp via R1 and C1, which suppress any RF breakthrough, whereas R2 sets the input resistance to about 50K ohms as expected by most cartridges. Transistors Q1 and Q2 are set to a collector current of about 80uA by their common emitter load R3, and the network of R6 and C10 provides a high frequency load to ensure the pre-amp's stability. RIAA phono equalisation is provided by the network comprising of R8, R9, R10, C5, C6, and C7. Bass rolloff below

SPECIFICATIONS

Performance of prototype

Power output	One channel	Both channels
4 ohms	44W	32W
8 ohms	33W	28W
Dynamic power (IHF-A-202)		
4 ohms	60W	50W
8 ohms	40W	40W
Harmonic distortion		
8 ohms	0.025% at 30W	
4 ohms	0.065% at 30W	
Typically less than 0.015% at normal listening levels		
Frequency response		
Phono input	RIAA/IEC equalisation within ±0.5dB (30Hz to 20kHz)	
Line inputs	+0/−1dB from 20Hz to 20kHz	
Hum and noise		
Phono input	−76dB unweighted	
(ref: 10mV/1kHz, terminated in typical MM cartridge)		
Line inputs	−91dB unweighted	
(ref: 250mV/1kHz)		
Damping factor		
Approximately 80 (8 ohm load)		
Channel separation		
100Hz	−83dB	
1kHz	−72dB	
10kHz	−54dB	
(ref: 30W output)		
Input sensitivity		
Phono input	4mV (overload at 1kHz: 150mV)	
Line inputs	250mV	
CD input	2V (as set by optional pad resistors)	
(ref: 30W output)		
Tone controls		
Bass	±12dB at 60Hz	
Treble	±12dB at 16kHz	

about 20Hz is provided by C4 to prevent sub-sonic signals from warped records and other turntable anomalies. This is in line with the latest IEC recommendations.

The output from the phono pre-amp is coupled to the input selector switch via C9, and R11 holds the output at 0 volts to prevent any switching transients. A reasonably high value has been chosen for C9; this prevents an excessive bass rolloff from the phono stage when a load is connected to the "tape out" connections.

Two optional resistors, Rx and Ry are shown in the path between the CD input socket and the selector switch SW1. When included, these resistors attenuate the high output of a CD player to match the amplifier's nominal input sensitivity of 250mV. For example, if we choose 47K ohms and 6.8K ohms for Rx and Ry respectively, a CD player with an output of 2 volts will deliver our nominal input level at the selector switch.

The signal is then applied to the volume control via the input switching networks, and the isolating resistor R12. This resistor prevents loading between the channels of the signal source when "mono" mode is selected.

From this point, the signal is applied to a buffer amplifier stage (IC2) by another high pass filter, comprised of R13 and C11. Incidentally, the various high pass filters throughout the Playmaster 30-30 are generally set to about 6 or 7Hz. This has the total effect of a sharp rolloff filter below about 10Hz, which is a very efficient sub-sonic filter for the whole system.

The buffer amplifier stage (IC2) is set to a gain of about 6 by R14 and R15, and high frequency bypassed by C12. This in turn drives the following stages via C13. The load may be the tone control stage, or both the tone and balance control sections, depending upon the position of the tone defeat switch SW4. Since the load presented by these sections may vary greatly, for example the balance control at one extreme, C13 is chosen as a high value to prevent significant bass rolloff.

A standard "Baxandall" style feedback network is arranged around op-amp IC3 to produce the tone control stage, which has a maximum boost and cut of about +/-12dB. The network is comprised of R16 to R20, C14 to C16, with RV2 and RV3 controlling the bass and treble frequencies respectively. This stage (or the previous amplifier stage) then drives the power-amp via the balance control, which is arranged as a simple variable voltage divider.

That's about it for the signal path. The remaining circuitry generates the unregulated supply voltages for the power-amp, and the low voltage, regulated power supply rails for the earlier stages.

The power supply is quite a standard circuit with the transformer's centre-tapped secondary feeding a pair of full wave rectifiers (D3 to D6). The rectifiers' positive and negative outputs are filtered by C28 and C29 respectively, and applied directly to the power amplifier chip IC4 (and the equivalent chip for the other channel).

The supply is reduced for the rest of the circuitry by simple zener diode shunt regulators, comprised of R32, R33, ZD1 and ZD2. These regulators produce about +/-15 volts, which is applied to the filtering capacitors C26 and C27 via diodes D1 and D2, producing a final supply of about +/-14 volts. The diodes will prevent the low voltage supply at C26 and C27 from being discharged by the falling main supply (via R32 and R33), when the amplifier is turned off. This keeps the pre-amp and tone control circuitry "alive" until the power-amp has completely shut down, thus preventing any spurious signals which would be generated if all stages "died" at the same time.

That about wraps it up for the circuit description. As you can see from the pictures, it all mounts neatly on a single PCB. The TDA1514A power chips attach directly to the heatsinks which lie in the centre of the board, while the remaining circuitry is arranged around the edges of the PCB.

The metal backing plate of the TDA1514A chip is internally cconnected to the negative supply rail, but may be bolted directly to the heatsinks without the need for insulating washers. This is possible since the heatsinks are not attached to the case (or earth) and are effectively "floating".

The pots and switches are also mounted in a simple manner; either directly to the board or on short wire stalks, allowing the unit to be assembled and fully tested out of its case.

Next month we will show the amplifier in its final form and provide full construction details. EA