Second article has full circuit details

Playmaster 60/60 stereo amplifier

Following last month's introductory article on our new Playmaster amplifier, we present the full circuit diagram and describe its features. The circuitry has been kept as simple as possible while still including all essential features and maintaining a very high performance standard.

by JOHN CLARKE & LEO SIMPSON

As outlined briefly last month, the circuitry of the new Playmaster Sixty-Sixty is based on that for the Playmaster Series 200 described during 1985. However, it has been greatly simplified by leaving out that amplifier's CMOS signal switching circuitry, the logic circuitry which provided memory of signal selections and the 20Hz rumble filter.

This also enabled the omission of quite a few buffer amplifier stages which were necessary to obtain low distortion figures from the CMOS switching circuitry.

Let's now have a look at the functions of the new amplifier which are illustrated in the block diagram, Fig.1. This has been reproduced from last month's article, for ease of reference.

Fig.1 shows one channel only, for simplicity's sake, so keep in mind that all circuit functions are repeated in the other (unseen) channel. The same goes for the main circuit diagram, by the way, otherwise we would have had to devote two whole pages to it.

Four signal sources are catered for, plus a tape deck. The input selector (S1 on the main circuit diagram) gives a choice of the output of the phono preamplifier or the three line level inputs, CD player, Tuner or Auxiliary. The wiper connection of S1 then feeds the selected signal to the Tape Out connection and to the Tape Monitor switch (S2 on the main circuit diagram).

S2 selects either the chosen input signal or the tape playback signal and then feeds the volume control via a 4.7kΩ resistor. The signal is also fed to the mono/stereo switch which effectively shorts the two channel signals together for the mono mode. Now simply shorting signals together is not good as far as distortion is concerned.

Consider the phono preamplifier, for example. If the two stereo signals from this preamplifier are simply connected together the difference signals (L-R) will tend to be distorted because the left channel output will be severely loaded by the very low impedance of the right channel output. And the same principle applies for the loading of the right channel.

So to avoid this distortion of the difference signals we include the 4.7kΩ resistor(s) just referred to. They cause a slight signal loss (about 10%) but eliminate the distortion.

The signal from the volume control, which can be regarded as a variable voltage divider, is fed to a buffer stage with a gain of about 5.7 times and then to the active tone controls which can be bypassed by the Tone Defeat switch S4.

Balance control

From S4 the signal is fed to the balance control which is a dual ganged potentiometer with an unusual characteristic which is alluded to by its symbolic representation on both the block diagram and circuit diagram. This shows a resistance symbol combined with a solid bar, with the wiper sitting at the junction of the two.

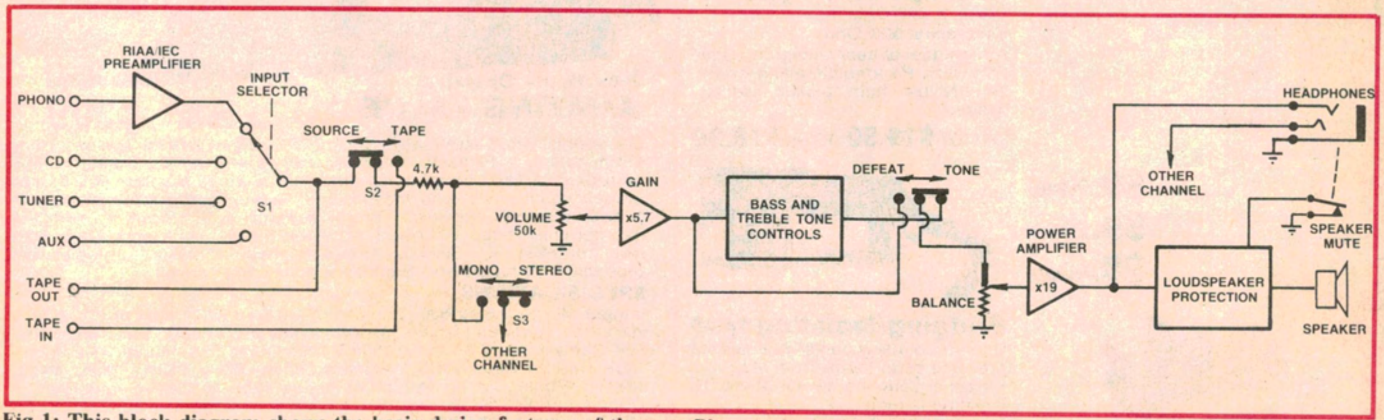
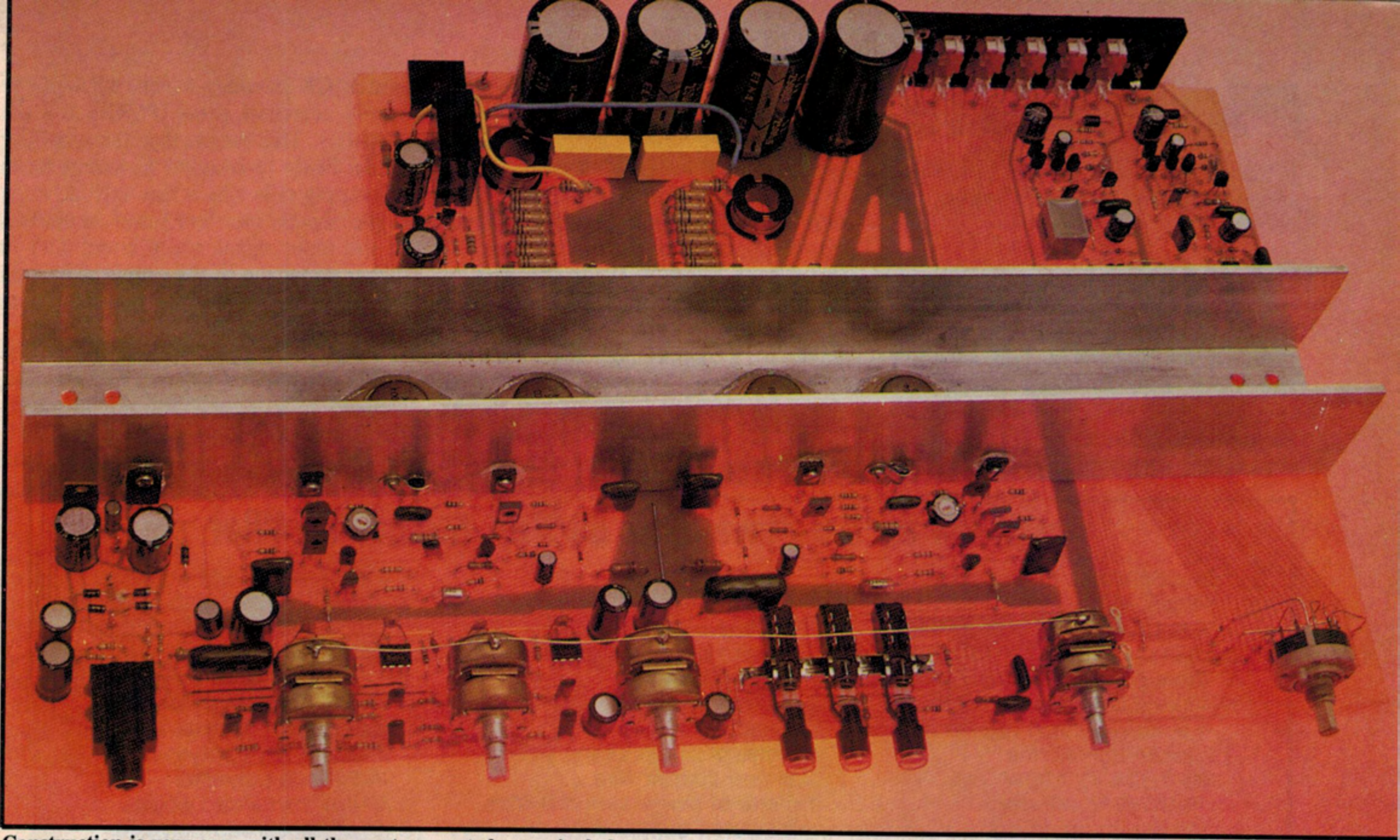


Fig.1: This block diagram shows the basic design features of the new Playmaster Sixty-Sixty stereo amplifier.



Construction is very easy with all the parts mounted on a single large printed circuit board.

What this represents is a resistance element in both sections of the ganged potentiometer which is essentially a short circuit from the centre of the element to one side (and vice versa for the other channel). When the balance control is wound away from the centre setting to favour one channel the other channel's signal is then smoothly reduced towards zero (at the end of travel) while the favoured channel does not increase in level.

This is a subtle refinement on balance controls in earlier stereo amplifiers whereby the favoured channel would increase in gain as the balance control was wound away from the centre setting. You might think this is a small point but when you set the balance control you don't want to make the program sound louder. This is ensured by the specified balance control. It also has a detent position in the centre, for ease of use.

After the balance control, the signal is fed to the power amplifier and then via the protection relay to the loudspeaker. This also incorporates speaker muting when the headphones are plugged in, which obviates the need for a separate loudspeaker switch.

Circuit description

Let us now examine the circuit of the new amplifier in detail, starting with the phono preamplifier. This comprises a low noise operational amplifier, IC1, which is driven by ultra-low-noise transistors connected in a differential pair. To keep noise from this stage to an absolute minimum, we have used paralleled transistors, Q1 and Q3 and Q2 and Q4.

A FET current source in the differential amplifier tail, Q5, sets the collector currents to slightly less than 1mA for each pair. This ensures excellent common mode and supply rejection as well as selecting the operating current for minimum noise.

IC1 has the ability to drive a 600Ω load and this enables the use of a relatively low impedance feedback network to again minimise the noise generated by these components. The feedback components set the RIAA response curve and close tolerance capacitors and resistors (2% and 1% respectively) have been used here for accuracy.

The 39Ω resistor in series with the .018μF capacitor in the feedback is used to limit the amount of negative feedback at very high frequencies and thereby improve the slew rate response.

Note that the 0.22μF capacitor at the output of IC1 provides a degree of rumble filtering (below 20Hz). This curtails the response to the very low frequencies generated by the phono cartridge when playing warped records.

Output from the volume control is capacitively coupled to the input of op amp IC2. This is a low-noise bipolar op amp, type NE5534AN which is largely responsible for the very good noise performance of the amplifier when fed with signals from CD players and other line level sources. The feedback around IC2 is set by the 4.7kΩ and 1kΩ resistors to give a gain of 5.7.

To prevent RF pickup at this point in the circuit, a 1kΩ stopper resistor at the input (pin 3, IC2) has been included. The 18pF compensation capacitor and 470pF capacitor across the 4.7kΩ resistor provide high frequency roll off and ensure stability of this amplifier stage.

IC3 forms the tone control stage which operates by providing variable frequency-dependent negative feedback. When the bass and treble controls are centred, the gain is flat over the audible frequency range.

Winding the bass or treble controls towards the input side of IC3 causes the gain to increase for frequencies above 2kHz and below 300Hz for the treble and bass controls respectively. Similarly, if the controls are wound in the opposite direction, the bass and treble response is reduced.

As noted above, the tone defeat switch, S4, bypasses the tone controls to negate the effect of the tone control settings. The output from the switch is AC-coupled to the Balance potentiometer. This is necessary to prevent any DC offset from IC3 causing DC current to pass through the balance pot which would otherwise become noisy to operate.

Power amplifier

Following the balance control is the power amplifier. The input to the amplifier is coupled via a 1μF capacitor and 2.2kΩ resistor. These in conjunction with the 330pF shunt capacitor act as a low-pass filter, to reduce the response to supersonic and radio frequency signals.

Q6 and Q7 form a differential pair with Q8 acting as a constant current tail. It operates as follows: Diodes D1 and D2 set about 1.3V at the base of Q8. Due to the nominal 0.7V across the base-emitter junction of Q8, there is about 0.7V across the 680Ω emitter resistor. The collector current is thus about 1mA which is shared equally by Q6 and Q7.

The inclusion of the constant current source Q8 provides a very high power supply rejection ratio (PSRR) for the amplifier. This means that the amplifier is less likely to respond to variations in the supply rails which may include large ripple signals (ie, hum) and harmonics of the input signal which could lead to higher distortion in the output. Thus Q3 helps improve the distortion and hum performance figures.

Balanced output signals from the 4.7kΩ resistors of Q6 and Q7 are then coupled to a second differential amplifier stage consisting of Q10 and Q11. These have a dynamic collector load

Parts list for the Playmaster 60/60W Stereo Amplifier

1 printed circuit board, code 86sa5, 420 x 249mm with 111 x 111mm corner cutout
1 chassis, 430 x 82 x 254mm (front panel 88 x 482mm)
1 420mm length of 50 x 50mm x 3.5mm U-section aluminium
1 toroidal transformer, 35-0-35VAC, 160VA plus 15-0-15VAC windings (Altronics Cat. M3071)
2 red, 2 black 4mm binding posts
1 6-way PCB mounting stereo RCA socket panel
1 12V DPDT relay, 5A contacts
4 rubber feet
1 6.5mm PCB-mounting insulated headphone socket with changeover contacts
2 plastic coil formers, 20mm OD x 12mm ID x 10mm
2 FX1115 ferrite beads
1 3-pole 4-position rotary switch
1 DPDT pushbutton mains switch
3 PCB mounting push-on/push-off switches (DPDT with 10mm dia pushbuttons, non-interlocked bank with 17.5mm pitch between switches)
4 black knobs, 22mm dia
1 black knob, 40mm dia
8 3AG fuse clips
4 5A 3AG fuses
1 cord clamp mains grommet
1 mains cord and plug
4 earth lugs
26 PC stakes
4 TO-3 mica washers
4 TO-126 mica washers
1 TO-220 mica washer
9 insulated mounting bushes (or 1 bush and 8 insulating sleeves)
2 25mm tapped standoffs
1 500mm length of 6.3mm ID insulating sleeving
1 metre 24/.20 green hookup wire
1 300mm length 24/.20 brown hookup wire
1 200mm length 24/.20 blue hookup wire
2 250mm lengths of 13/. 12 hookup wire
1 metre of single strand 0.8mm tinned copper wire
1 metre of single strand 0.8mm insulated copper wire

Semiconductors

6 NE5534AN op amps
2 MJ15003 NPN transistors
2 MJ15004 PNP transistors
2 MJE340 NPN transistors
2 MJE350 PNP transistors
4 BF469 NPN transistors
2 BF470 PNP transistors
6 BC556 PNP transistors
5 BC547 NPN transistors
1 BC557 PNP transistor
1 BC327 PNP transistor
8 2SC2545 NPN transistors
2 2N5485 N-channel FETs
6 1N914, 1N4148 diodes
6 1N4002 diodes
1 P0-4 6A 400PIV diode bridge
1 7815 three terminal regulator
1 7915 three terminal regulator
2 5.6V 400mW zener diodes
1 3mm green LED

Capacitors

4 2500μF 63VW PC electrolytic
2 1000μF 25VW PC electrolytic
1 1000μF 16VW PC electrolytic
2 220μF 16VW PC electrolytic
5 100μF 16VW PC electrolytic
4 47μF 16VW PC electrolytic
4 47μF 50VW bipolar PC electrolytic
4 22μF 50VW bipolar PC electrolytic
2 10μF 16VW PC electrolytic
2 6.8μF bipolar PC electrolytic
2 1μF metallised polyester (greencap)
8 0.22μF metallised polyester
2 0.15μF 250VAC dual dielectric (Philips MKT-P 2222 330 40154)
7 0.1μF metallised polyester
2 .068μF 2% polystyrene or metallised polyester
2 .018μF 2% polystyrene or metallised polyester
2 .012μF metallised polyester
2 .01μF metallised polyester
4 .0047μF metallised polyester
2 .0033μF metallised polyester
2 470pF ceramic
2 330pF polystyrene
2 100pF polystyrene
2 68pF ceramic
4 18pF ceramic
2 10pF ceramic

Resistors

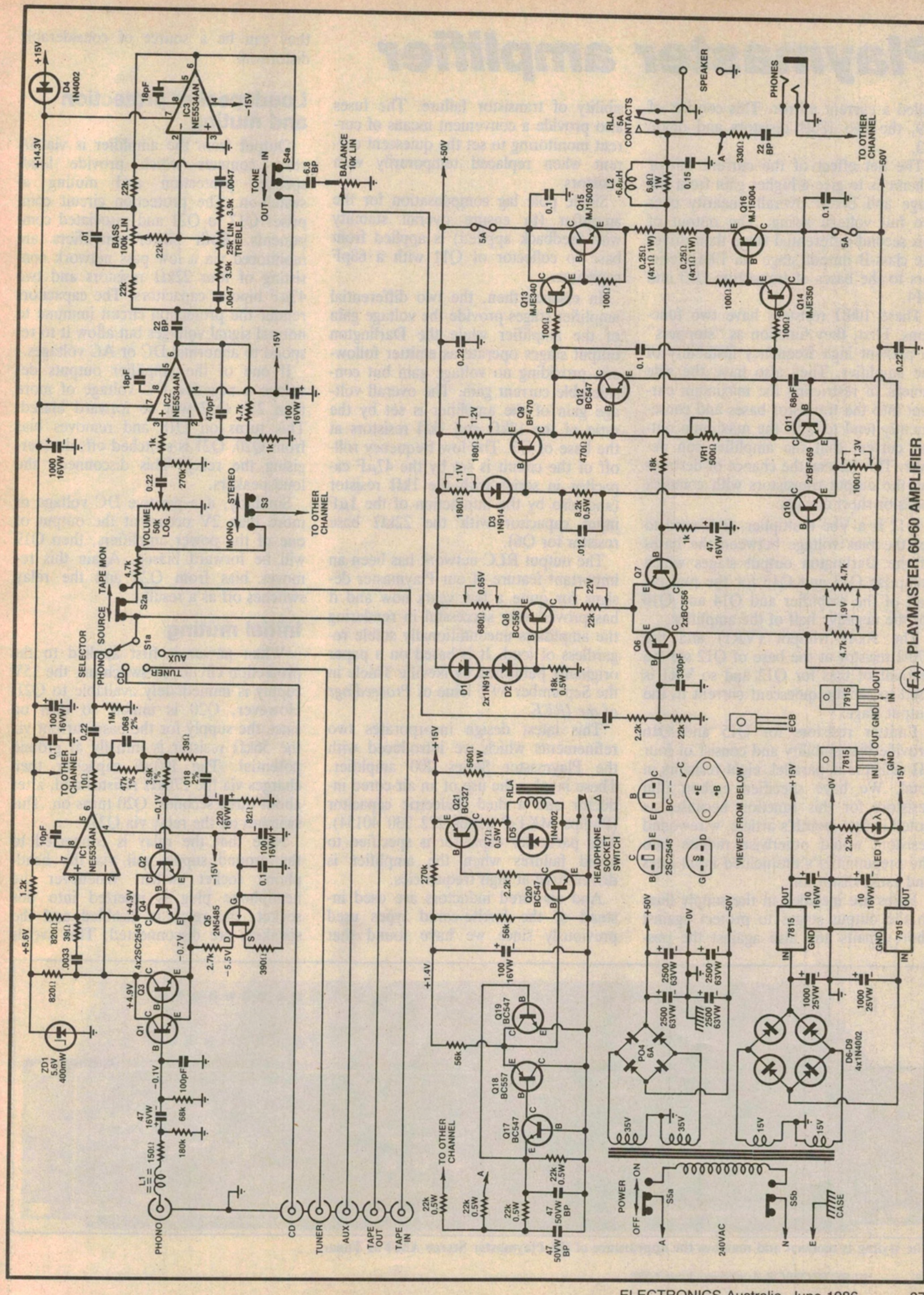
(0.25W, 5% unless stated)
2 x 1MΩ, 3 x 270kΩ, 2 x 180kΩ, 2 x 68kΩ, 2 x 56kΩ, 2 x 47kΩ 1%, 10 x 22kΩ, 4 x 22kΩ/0.5W, 2 x 18kΩ, 2 x 18kΩ/0.5W, 2 x 8.2kΩ/0.5W, 8 x 4.7kΩ, 4 x 3.9kΩ, 2 x 3.9kΩ 1%, 2 x 2.7kΩ, 4 x 2.2kΩ, 2 x 1.2kΩ, 6 x 1kΩ, 4 x 820Ω, 2 x 680Ω, 2 x 560Ω 5W (for setting quiescent current), 1 x 560Ω/1W, 2 x 470Ω, 2 x 390Ω, 2 x 330Ω, 4 x 180Ω, 2 x 150Ω, 10 x 100Ω, 2 x 82Ω, 1 x 47Ω/0.5W, 4 x 39Ω, 2 x 10Ω, 2 x 6.8Ω 1W, 16 x 1Ω/1W.

Potentiometers

2 500Ω miniature vertical trimpots
1 dual gang 100kΩ linear PC-mount pot
1 dual gang 50kΩ log PC-mount pot
1 dual gang 25kΩ linear PC-mount pot
1 dual gang 10kΩ linear PC-mount balance pot

Miscellaneous

Screws, nuts, solder, etc.


PLAYMASTER 60-60 AMPLIFIER

Playmaster amplifier

called a current mirror. This consists of Q9, the two 180Ω resistors and diode D3.

The net effect of the current mirror scheme is to give a higher gain from the stage and better overall linearity over the full voltage swing. The output of this second differential stage then drives the class-B output stage via 100Ω resistors to the bases of transistors Q13 and Q14.

These 100Ω resistors have two functions. First, they function as "stoppers" to prevent high frequency instability of the amplifier. They also have the side benefit of restricting the maximum current into the transistor bases and consequently tend to limit the maximum output current that the amplifier can deliver. This lessens the chance of destroying the output transistors with complex loads or short circuits.

Q12 is a Vbe multiplier. It is used to set the bias voltage between the bases of the Darlington output stages which comprise Q13 and Q15 for the positive half of the amplifier and Q14 and Q16 for the negative half of the amplifier.

The 500Ω trimpot (VR1) and the 470Ω resistor at the base of Q12 set the amount of bias for Q12 and so VR1 is used to set the quiescent current in the output stage.

Emitter resistors for Q15 and Q16 provide bias stability and consist of four 1Ω resistors in parallel, eight resistors in total. We have specified carbon film resistors for this function because, as noted in last month's article, wirewound resistors would otherwise radiate into the preamplifier's unshielded input lines and cause distortion.

Fuses are included in the supply lines to the output stages to protect against short-circuits and also against the possibility of transistor failure. The fuses also provide a convenient means of current monitoring to set the quiescent current when replaced temporarily with resistors.

Single pole lag compensation for the amplifier (to ensure overall stability with feedback applied) is applied from base to collector of Q11 with a 68pF capacitor.

In essence then, the two differential amplifier stages provide the voltage gain of the amplifier while the Darlington output stages operate as emitter followers, providing no voltage gain but considerable current gain. The overall voltage gain of the amplifier is set by the ratio of the 18kΩ and 1kΩ resistors at the base of Q7. The low frequency rolloff of the circuit is set by the 47μF capacitor in series with the 1kΩ resistor (and also by the interaction of the 1μF input capacitor with the 22kΩ base resistor for Q6).

The output RLC network has been an important feature of our Playmaster designs for quite a few years now and it has proved very successful in rendering the amplifiers unconditionally stable regardless of load. It is based on a paper originally published by Neville Thiele in the September 1975 issue of *Proceedings of the IREE.*

This latest design incorporates two refinements which we introduced with the Playmaster Series 200 amplifier. These involve the use of an air-cored inductor and a dual dielectric capacitor (Philips MKT-P series 222 330 40154). This particular capacitor is specified to avoid failures when the amplifier is driven hard at high frequencies.

And air-cored inductors are used instead of the ferrite-cored types used previously since we have found that they can be a source of considerable distortion.

Loudspeaker protection and muting

Output from the amplifier is via 5A relay contacts which provide loudspeaker protection and muting at switch-on. The protection circuit comprises Q17 to Q21 and associated components. Both power amplifiers are monitored via a low pass network consisting of four 22kΩ resistors and two 47μF bipolar capacitors. The capacitors render the protection circuit immune to normal signal voltages but allow it to respond to abnormal DC or AC voltages.

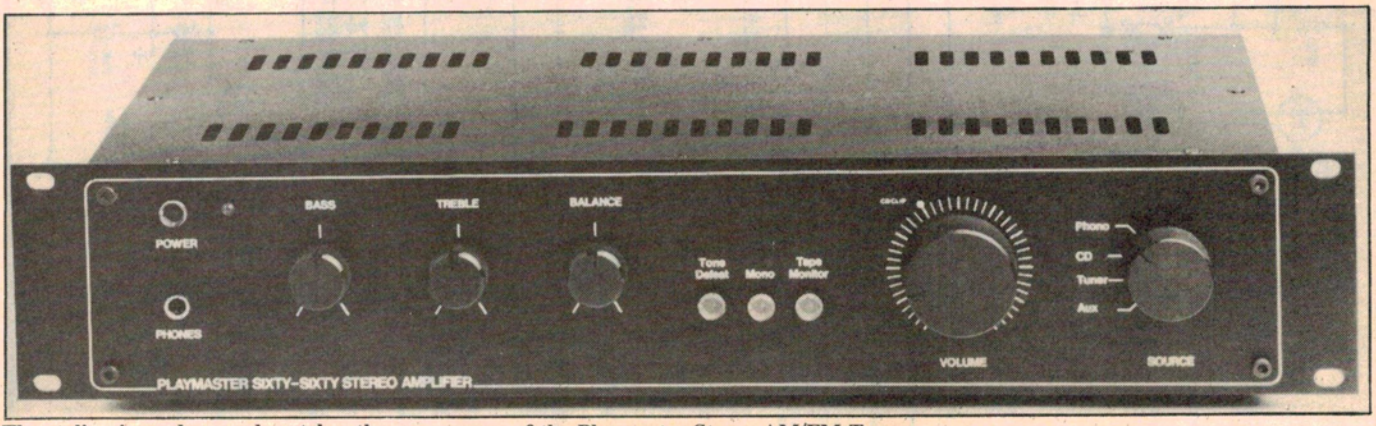
If one of the amplifier outputs develops a negative DC voltage of more than 2V, Q17 will be forward biased. This turns on Q18 and removes bias from Q20. Q21 is switched off, de-energising the relay. This disconnects the loudspeakers.

Similarly, if a positive DC voltage of more than 2V occurs at the output of one of the power amplifiers, then Q19 will be forward biased. Again this removes bias from Q20 and the relay switches off as a result.

Initial muting

When power is first applied to the protection circuit, at switch-on, the 15V supply is immediately available to Q21. However, Q20 is unable to turn on since the supply for the base current via the 56kΩ resistor is initially at ground potential. The 100μF capacitor then charges via the 270kΩ resistor and, after about three seconds, Q20 turns on. This switches on the relay via Q21.

Note that the relay is connected to the ground supply rail via the headphone socket switch. Whenever the headphone plug is inserted into this socket, the relay is disabled and the speakers are disconnected. This avoids



The styling is modern and matches the appearance of the Playmaster Stereo AM/FM Tuner.

the need for a separate switch to disconnect the speakers.

The second contact of the changeover switch then connects a 560Ω 1W resistor across the +15V supply. This resistor is used to load the +15V supply rail when the relay is not connected and thus gives the same rate of discharge of the supply rail after switch-off. This is important to avoid switch-off thumps.

Headphone protection

The headphone circuit itself is permanently connected to the amplifier outputs and so the headphones are ostensibly not protected from large DC faults. However, they are effectively protected from overdrive or DC faults by virtue of the series 330Ω resistor and 22μF bipolar capacitor.

The positive supply to the op amps is isolated from the +15V rail using diode D4 and a 1000μF capacitor. This capacitor maintains the positive op amp supply voltage after the power is switched off so that the positive and negative rails to the op amps fall at the same rate.

This is done so that the op amps maintain control of their outputs until the balanced supply rails fall almost to zero. If one of the supply rails falls much faster than the other, the op amps effectively stop working early and "latch up", delivering a large DC pulse to the following stages. The result of this is an audible thump as the amplifier is turned off.

Power supply

As noted last month, the key to the power supply is the 160VA toroidal power transformer which has very low hum radiation. The transformer feeds a centre tapped 70VAC to a bridge rectifier and two 5000μF (2 x 2500μF) filter capacitors. This gives unregulated supplies of ±50V which feed the power amplifiers.

Separate 15VAC windings on the transformer are full wave rectified with bridge-connected 1N4002 diodes and filtered with two 1000μF capacitors to give unregulated supplies of about ±21V. Separate positive and negative three terminal regulators produce the necessary ±15V DC supplies. The 10μF capacitors at the output of the regulators ensure stability and provide improved ripple rejection.

A 2.2kΩ resistor in series with the power on LED connects across the negative 15V supply.

That completes the circuit description. Next month we will describe construction.