

Project update:

New MOSFETs for audio power amps

If you have been planning to build the Playmaster Pro Series One power amp, but were put off by reports that Hitachi has discontinued the MOSFET devices used in its output stage, we're pleased to report that a new range of *direct* replacements are now available. In this short article we'll report on how these devices perform in the circuit, and also suggest a couple of simple ways in which the amplifier can be improved.

by ROB EVANS

Since the Pro Series One amplifier was presented in the December 1989, plus January and February 1990 issues of *Electronics Australia*, it has proved to be very popular with constructors seeking a high performance power amp which can be built for a fraction of the cost of a comparative 'high end' commercial unit.

It was hardly surprising, then, that we received a stream of correspondence from readers lamenting the fact that Hitachi had ceased production of the 2SK134 and 2SJ49 power MOSFET devices, and that as a result they were unable to build the amp — in fact, one correspondent even accused us of being downright irresponsible for designing a desirable, but 'obsolescent' project...

In this respect, we'd have to point out that the design has now been around for nearly four years and the MOSFETs themselves have been available since the early 1980's, which is a pretty good run by all accounts. And as it turns out the

run is definitely *not* over, since Altronics has managed to find a secure supply of direct replacement MOSFETs for the amp. We should also mention that Jaycar Electronics has tracked down a sizable quantity of the *original* Hitachi devices.

While there has been a price increase in both of the above cases, chances are that this will end up being a one-off purchase for constructors. This is thanks to the very rugged nature of the power MOSFETs, which allow the amp's output stage to withstand an extraordinary degree of overload without damage. In short, it's unlikely that you will ever need to buy a replacement set of MOSFETs.

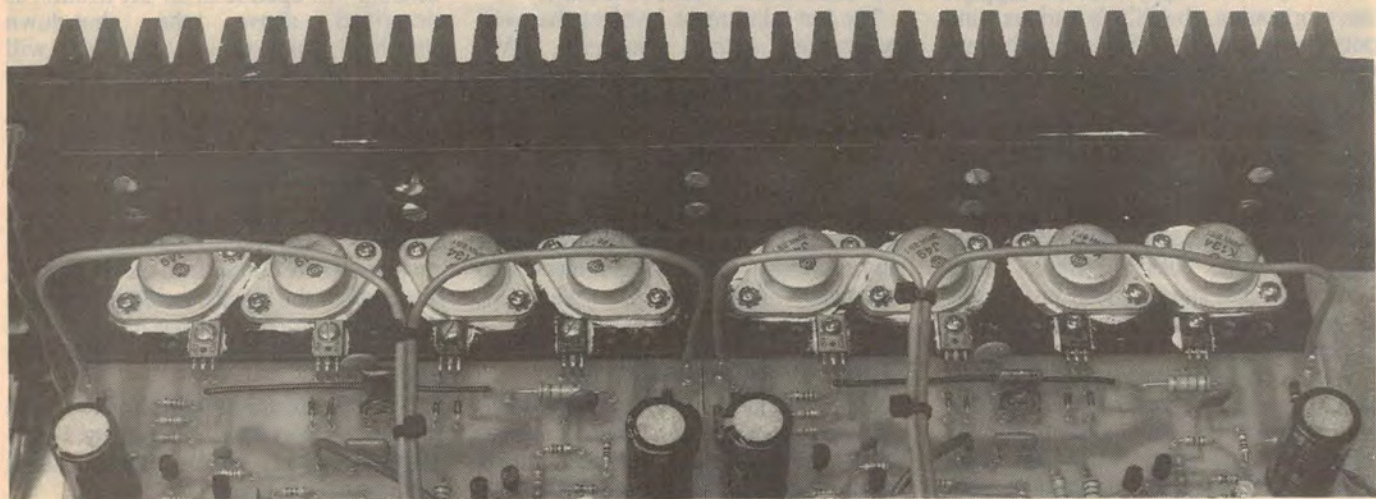
The new MOSFETs

The MOSFETs to suit the Pro Series One on offer from Altronics are designated ECF10N16 (N-channel) and ECF10PN16 (P-channel), and are intended as a direct substitute for the original Hitachi 2SK134 and 2SJ49

devices, respectively. As it happens however, the Altronics MOSFETs have a maximum Drain-to-Source (Vds) rating of 160V, a maximum Drain current rating (Id) of 8A, and a power dissipation (Pd) figure of 125W, which are all significantly better ratings than those for the 'equivalent' Hitachi devices — whose Vds/Id/Pd figures are listed as 140V/7A/100W.

In fact the ECF10N16 and ECF10PN16 MOSFETs are those with the *lowest* ratings in the new Altronics range, which offers three other sets of complementary pairs (matched N-channel and P-channel devices), all with higher ratings. These are the ECF10N20/ECF10P20 rated at 200V/8A/125W, the ECF20N16/ECF20P16 at 160V/16A/250W, and the ECF20N20/ECF20P20 rated at 200V/16A/250W.

As you can see, the latter two pairs in the range have pretty impressive specifications, and are the highest power MOSFETs of this type that



we've seen. So while the devices in this new range are mainly intended to replace the now defunct Hitachi TO-3 series, their capabilities are somewhat greater. For reference, the highest rated Hitachi MOSFET pair was the 2SK176 and 2SJ56 at 200V/8A/105W, which is equivalent to just the second level in the new series, the ECF10N20 and ECF10P20.

In the Pro Series One amp

According to both Altronics and the data sheets provided with our samples, the new MOSFETs offer very similar characteristics to the earlier Hitachi devices, and therefore should drop straight into existing designs. Since our main interest was with the Pro Series One amp at this stage, we duly removed the four Hitachi MOSFETs from one of its channels and fitted sets of the new ECF10N16/ECF10P16 devices in their place. With this arrangement, we then had the opportunity to directly compare the modified channel with that of the original (Hitachi) arrangement.

This was all somewhat of an anticlimax as it turned out, since from what we could tell from our lab instruments and listening tests, the modified channel performed just as it had with the Hitachi devices.

So happily, we can safely say that with the new MOSFETs the amp should still exhibit the same extremely low levels of total harmonic distortion (THD) and intermodulation distortion (IM) that are characteristic of the design. Both its continuous and IHF (pulse) power output capabilities are also retained, by the way.

Other changes

During the process of checking out how the new MOSFETs performed in the Pro Series One amp, we decided that this might be a convenient time to try out a couple of improvements that we've developed since the project was first presented. These are relatively minor changes, and existing owners of the amplifier may wish to make the modifications, as well as those about to build a new unit.

The first involves capacitors C9, C10 and C11, which are used to equalise the N-channel MOSFET's input capacitance to that of the P-channel devices, and to help stabilise the output stage. In practice the main benefit of these components is as an aid to stability, since while the MOSFETs have an input capacitance (Cgs) in the hundreds of picofarads, as source followers they only present a fraction of this to the

preceding driver stage. Therefore the practical difference between the input capacitance the N-channel and P-channel devices is negligible — just a few picofarads, in fact.

In the light of this, we have determined a much simpler scheme to stabilise the output stage, which makes no attempt to compensate for differences in input capacitance. This involves removing C9, C10 and C11, and adding a 47pF ceramic capacitor between the gate and drain connections of each of the N-channel MOSFETs (Q9 and Q10) —

STOP PRESS

New MOSFET amp on the way

Jaycar Electronics has sourced a supply of Hitachi's official replacement MOSFETs for their TO-3 style devices, which are now housed in a large plastic flatpack-type package designated TO-3P ('P' for plastic, presumably). These offer the same ratings as the original TO-3 devices, and will soon be available from Jaycar stores.

A new high-performance amplifier using these devices is under development in our lab, and at the time of writing is looking very impressive indeed. Without giving too much away, the new amp has been christened the 'Pro Series Three', and offers the same high performance as the Pro Series One but with a significant hike in power at very little (if any) increase in cost.

Stay tuned...

which turns out to be a very effective stabilising technique for this circuit.

Note that the capacitors should be fitted to the underside of the circuit board and soldered directly to each MOSFET's PCB pads. The MOSFET's drain pins are those connected to the positive supply rail, and you will need two 47pF capacitors in all. Also, take care not to overheat these relatively fragile parts as they are being soldered in place.

The other modification involves lowering the value of Q5's load resistor (R11) from 12k to 8.2k, so as to raise the voltage at its collector to greater than 0V. This was found to cure the tendency of some amplifiers to deliver a series of quiet 'pops' to the speaker, some time after the unit has been turned off.

While the reasoning behind this minor problem and its solution is somewhat convoluted, it's suffice to say that with Q5's collector at around -18V (or thereabouts), the Q5/Q6 differential pair may 'shut down' in an uneven manner as the supply rails fall.

After several seconds the collector

voltage at Q6 will eventually bias Q9 and Q10 on, which allows the positive supply to discharge through the speaker until the level at Q6's collector falls (in sympathy with the falling supply rail). This in turn shuts off Q9 and Q10, and so on. This continues through a number of cycles (a second or so apart) until the supply rails are fully discharged.

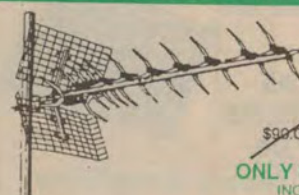
On the other hand, when R11 is lowered to around 8.2k the collector of Q5 will be at about +10V, and the differential pair will shut down in a more balanced manner — that is, the voltage at the collector of Q6 will remain close to 0V as the supply rails fall.

If you don't wish to actually remove R11 in an existing amp, by the way, you can simply install a 27k 0.25W resistor in parallel with the existing 12k resistor, producing a value of around 8.3k. Also note that changing the value of R11 to shift the voltage at the collector of Q5 will not affect the amp's sonic performance.

So that's about it. As you would expect, we're more than pleased that the Pro Series One power amp will be a viable construction project for some time to come, and we're sure that many readers will share our feelings about this popular project. ♦

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