reasonably efficient speaker will produce a loud sound, a *continuous* five watts is becoming deafening, and ten will rattle windows. This assumes single channel, or mono, reproduction in a normal living room. The impact is, of course, greater with a stereo system.

This is at odds with the high power ratings of many of the quality amplifiers currently advertised. The desire for a big reserve of power, the low efficiency of some modern speakers, and different ways of measuring output, may account for the difference.

Output is variously rated as music power, sustained music, speech and music, and sinewave power. To add to the confusion, the figures are quoted at different distortion levels. The standard most often used when valves were commonplace, and the one adopted in this article, is the r.m.s. (root mean square) value of a continuous sinewave. This gives the lowest rating and is the most realistic expression of the amplifier's ability to deliver power into a load (speaker).

An increase in output power is reflected as much, if not more, in the cost of the power supply as it is in the actual amplifier. Because the theme of this article is good performance at modest cost, the most powerful amplifier described is rated at 12·5W r.m.s.

DISTORTION

Manufacturers of power-amplifier integrated circuits and modestly priced hi-fi systems (which invariably incorporate devices of this kind) usually rate the maximum power output at 10 per cent distortion. At this level there is a very noticeable roughness to the sound and clipping of the waveform on loud passages.

The power output levels quoted here have been measured just before the onset of clipping or any noticeable distortion of the output waveform. They are somewhat lower than the figures quoted by the i.c. manufacturers, but they do represent the highest output, free from audible distortion, that the device can deliver for a particular supply voltage and load.

NOISE

Modern power amplifier i.c.s have a very low noise level. Manufacturers usually define this internally generated electrical noise as an equivalent signal voltage at the input, but this doesn't give the average experimenter an immediate impression of its audible effect.

Accordingly, the devices described here were tested by disconnecting the signal source, turning the input or volume control to maximum, and then listening to the output on a pair of sensitive, Walkman type earphones.

In all cases the noise was no more than barely audible. The two devices which can be configured for high gain (LM386N and TBA820M) did produce a faint, but audible, hiss when the gain was set at maximum. The hiss was also noticeable with a loudspeaker connected.

However, when the gain preset was turned back a little, these i.c.s became as silent as the rest. Some constructors may need the highest possible gain, and details will be given later of measures which can be taken to eliminate the noise.

STABILITY

Provided a few basic precautions are observed, the amplifiers are all unconditionally stable. Most i.c.s of this kind have a ground connection for the input circuitry and a *separate* ground pin for the output stage.

The printed circuit board (p.c.b.) layouts have been designed to maintain this isolation, and care should be taken to ground the signal inputs and connect the negative power supply lead to the designated points on the board. Failure to do this could result in "motor boating" (low frequency instability).

Input leads should be *screened* to avoid mains hum and radio frequency (r.f.) signal pick up. Speaker leads should be twisted together to minimise external fields. Input and output leads should be spaced as far apart as possible: this is particularly important when the LM386N and TBA820M are set for high gain.

All of the circuits include high and low frequency bypass capacitors across the supply rails. The former minimise the possibility of r.f. oscillation: the latter avoid low frequency instability when long power supply leads are used, or when batteries are ageing.

HIGH FREQUENCY RESPONSE

The bandwidth of the amplifiers extends into the r.f. spectrum, and this makes the devices vulnerable to r.f. interference. Some of the i.c.s provide for the connection of an external capacitor in a negative feedback loop to "roll-off" the high frequency response. Selecting an appropriate value for this component will help to make the device immune.

The problem of r.f. pick up invariably manifests itself when a high value (more than 10 kilohms) input potentiometer (VR1) is used to match the amplifier to the impedance of a signal source. If the potentiometer or volume control must have a high resistance, connecting a 1nF or, at most, 10nF capacitor across its track will shunt unwanted r.f. to ground.

LOW FREQUENCY RESPONSE

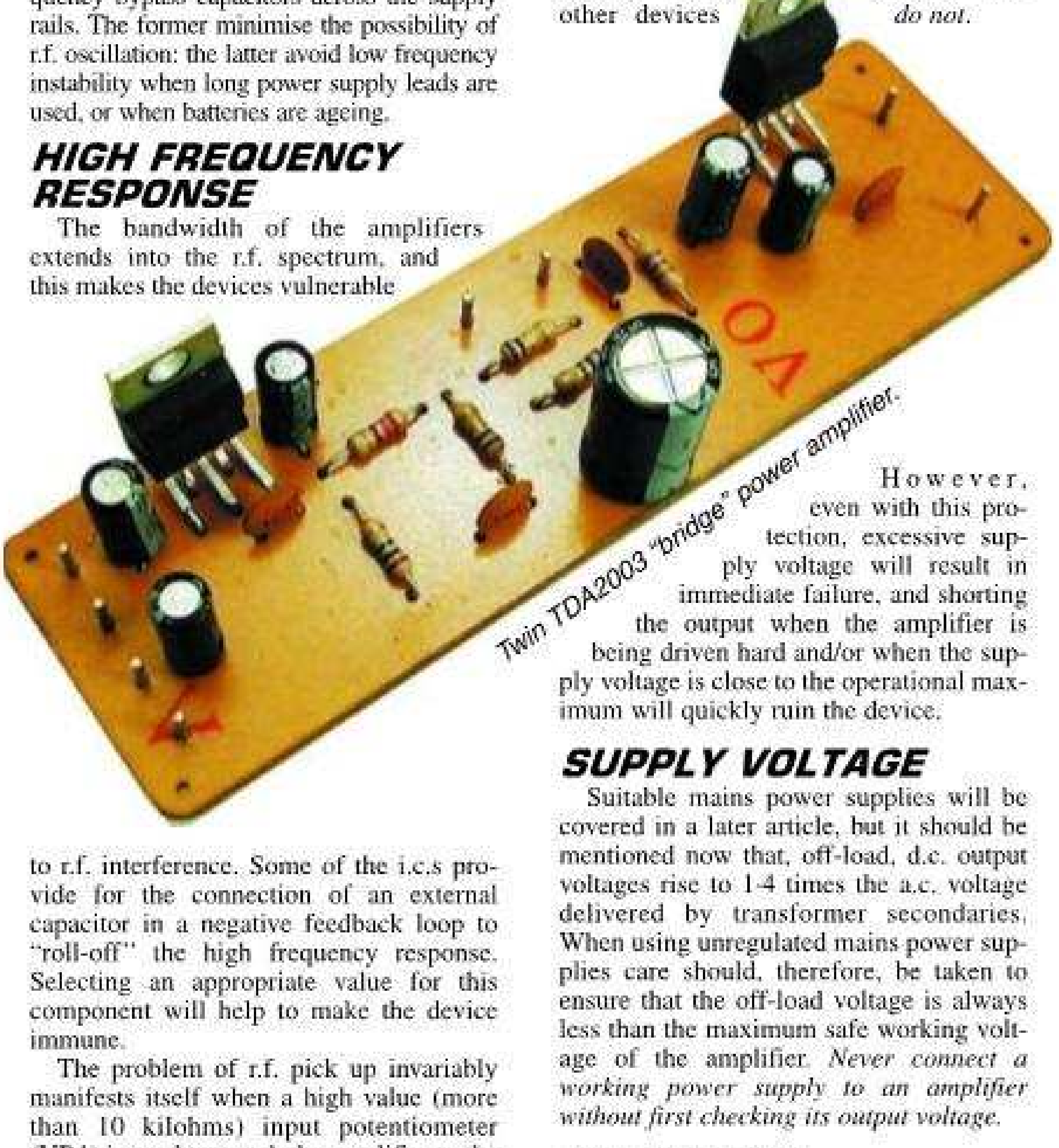
The low frequency response of three of the lower powered amplifiers has been curtailed a little by fitting a 220µF speaker coupling capacitor. Amplifiers of this kind are invariably used with small, inexpensive speakers which are incapable of producing an audible output at frequencies below 150Hz or so. Feeding low frequencies to speakers of this kind only overloads them, causing distortion and loss of clarity.

Indeed, if the amplifier is being used primarily for speech, clarity can be much improved by rolling-off the frequency response below 300Hz, and an even lower value of coupling capacitor, say 100µF or even 47µF, would be of benefit. Readers seeking quality music reproduction at low power, via a speaker of reasonable size, should increase the coupling capacitor to say 1000µF.

This relationship between coupling capacitors and frequency response will be considered more fully in the next article.

DEVICE PROTECTION

The integrated circuits covered here are electrically robust but they are by no means indestructible. The TDA7052, LM380, and the TDA2003 incorporate protection against overload and output short ciruits: the other devices *do not*.



Twin TDA2003 "bridge" power amplifier.

However, even with this protection, excessive supply voltage will result in immediate failure, and shorting the output when the amplifier is being driven hard and/or when the supply voltage is close to the operational maximum will quickly ruin the device.

SUPPLY VOLTAGE

Suitable mains power supplies will be covered in a later article, but it should be mentioned now that, off-load, d.c. output voltages rise to 1·4 times the a.c. voltage delivered by transformer secondaries. When using unregulated mains power supplies care should, therefore, be taken to ensure that the off-load voltage is always less than the maximum safe working voltage of the amplifier. *Never connect a working power supply to an amplifier without first checking its output voltage.*

ELECTRICAL CHARACTERISTICS

The electrical characteristics of the various devices are tabulated alongside the circuit diagrams (except one) for easy reference. Power output figures are based on measurements taken on a single, randomly purchased sample. For reasons already given, they are somewhat lower than the figures quoted by the manufacturers.

Recommendations are made regarding the speaker impedances to use with various supply voltages in order to keep the dissipation of the devices within reasonable limits.

The input resistance, maximum voltage ratings, and frequency response details are those supplied by the manufacturers.