Reviving the Quad FM1 valve tuner

Noel Keywood investigates the restoration of the Quad FM1 valve tuner.

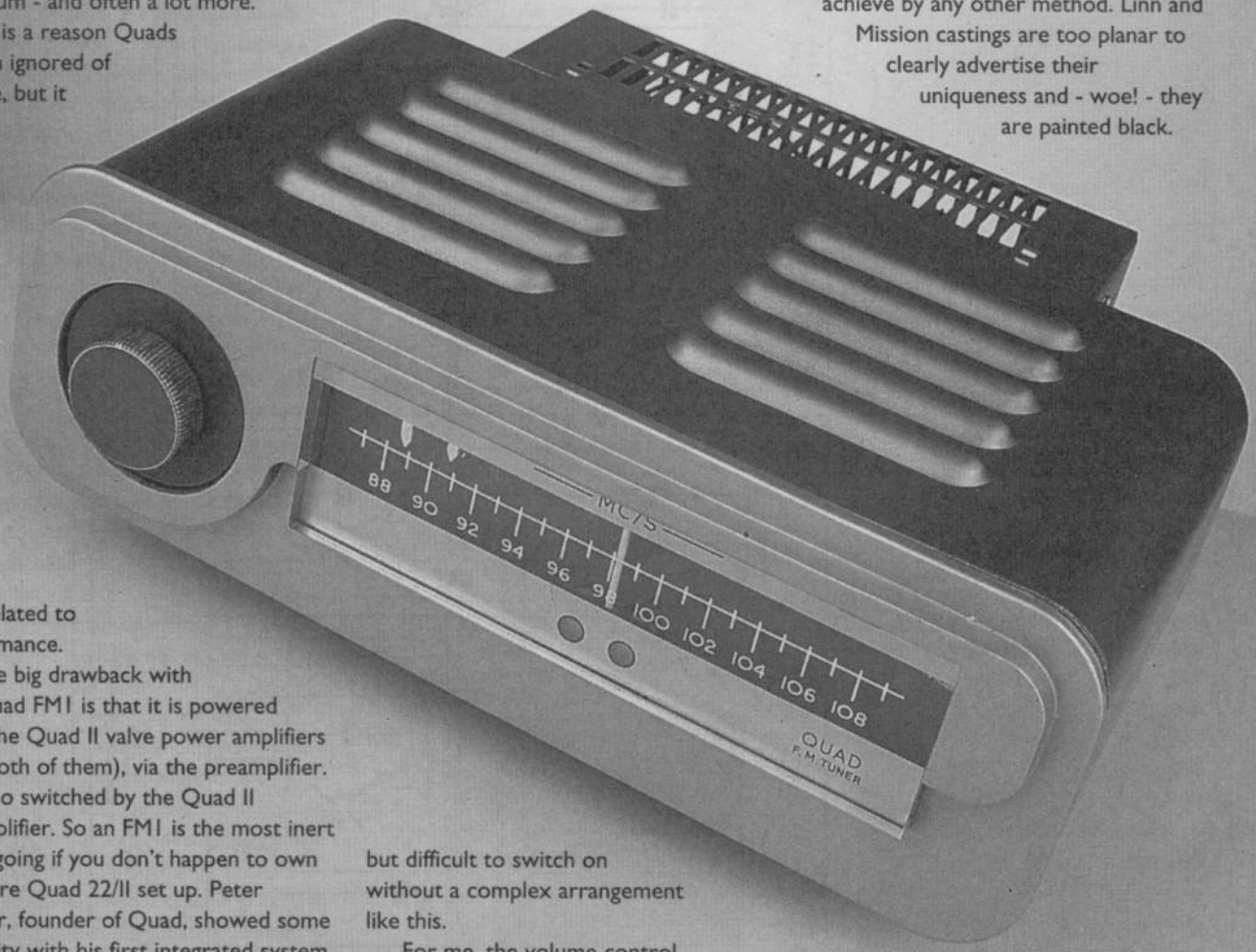
I've seen boxes of unloved Quad FM1s tuners sitting under trestle tables, to clear for around £10 apiece. Why does a lovely valve tuner like this so commonly inhabit the lowlier regions of a vintage swap-meet? A Leak Troughline these days goes for £50 minimum - and often a lot more. There is a reason Quads remain ignored of course, but it isn't related to performance.

The big drawback with the Quad FM1 is that it is powered from the Quad II valve power amplifiers (yes, both of them), via the preamplifier. It is also switched by the Quad II preamplifier. So an FM1 is the most inert tuner going if you don't happen to own an entire Quad 22/II set up. Peter Walker, founder of Quad, showed some ingenuity with his first integrated system arrangement (he did beat B&O), but he didn't do much for second hand prices.

Unbelievably, to split the load, the Quad 22 preamp and the FM1 draw L.T. for their heaters (6.3V) from one power amp, and H.T. (330V) from the other power amp. The mains connection to the preamplifier exists only so that the whole shooting match can be switched on by the volume control. In those days - the late 1950s - power amps were hidden away, leaving a set up as compact as any today, and certainly more elegant, but difficult to switch on without a complex arrangement like this.

For me, the volume control mounted power switch and illuminated Quad legend were distinguishing features of Quad pre/powers, not to mention the delightfully solid cast fascias. I was going to say they don't build 'em like it today, but they do.

Both Mission and Linn acknowledge the example of Quad in this respect, and both use complex castings that cost a fortune to tool up. Trouble is, neither really exploit the styling benefits casting provides, certainly not in the way Quad did with the FM1, sculpting wonderful curves, bevels and ledges, difficult to achieve by any other method. Linn and Mission castings are too planar to clearly advertise their uniqueness and - woe! - they are painted black.



So that's the glory of the FM1; it's beautiful to look at and to use, one of a kind, but a trifle difficult to get going. What do you expect for a tenner? There's definitely leeway here for many evenings entertainment, restoring an

FM1, so as usual let me first pour a little cold water on the idea.

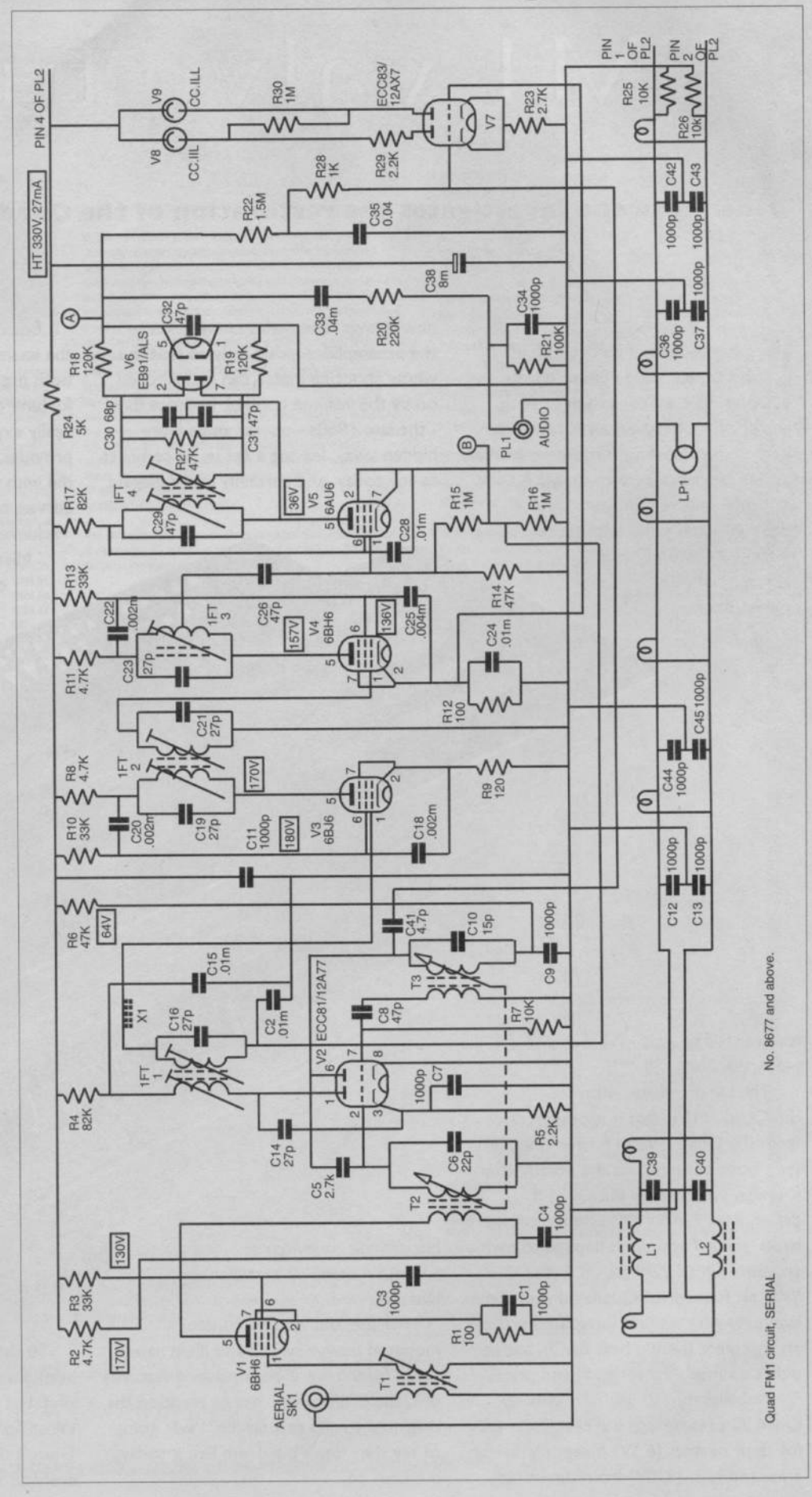
Building a power supply for the FM1 gets it up and running as an independent unit. This is a simple enough task for anyone conversant with electronics, but dangerous if you don't know how. The FM1 needs 330V H.T. (High Tension). The good news is that a complete supply will cost just £20 or so.

The other big problem with old tuners is alignment. This is quite likely to be awry and tuner realignment is not an easy task. If a simple RF generator is used it requires skill and experience. A poorly aligned tuner will distort, be insensitive and suffer interference. But I have more good news: Quad offer an alignment service that costs £40.

Ageing valve units like this - and the FM1 is now 40 years old - usually have a lot of resistors and capacitors that need replacing, since old components drift in value over the years and fail. The few decent condition FM1s I've encountered to date worked in a fashion, but not properly. However, armed with a circuit diagram and a good electronic multimeter it isn't difficult to repair a tuner like this, if you have a little electrical knowledge. Fail, and you have either lost £20 or so, or you can ask Quad to bail you out, since they still service and repair the FM1.

I need to point out that this article is a guide to getting the FM1 going, identifying the main problems. You must have some electronic knowledge to be able to tackle such a project. This is not a subject for beginners and this article is not meant for those with scant knowledge.

Circuit Diagram



CIRCUIT DESCRIPTION

Here is Quad's circuit description:
"A broad band fixed tuned transformer couples the low impedance aerial to a RF pentode (6BH6) the output of which is transformer coupled to a low noise triode (one half of 12AT7) mixer stage.

The local oscillator (other half of 12AT7) is fully temperature compensated and provides an output 10.7MHz above the signal frequency. It is capacitively coupled to the mixer grid.

Both the mixer grid and local oscillator circuits are ganged and permeability tuned by special low loss cores driven from the spindle via a precision worm drive mechanism.

The resultant 10.7MHz IF signal at the mixer anode is transformer coupled to the automatic gain controlled first IF stage (6BJ6). A combination of critical and over coupled circuits and a single tuned circuit in the second IF stage (6BH6) together with a close control of the Q of these circuits ensures a wide passband with a steep cut-off outside the band.

The second IF anode tuned circuit is coupled via a short time constant CR circuit to the limiter valve (6BH6), the anode of which contains a transformer with a capacitively centre tapped secondary winding feeding two diodes (6AL5) in a phase discriminator circuit. Again, the coupling and Q are chosen to give low distortion in the audio output.

The audio signal is fed via a two position switch either, in the unmarked mono position, to the appropriate de-emphasis network and DC blocking condenser, or in the red spot position, to the output cable when an uncorrected signal is needed for feeding into a stereo decoder.

The DC component at the discriminator output whose magnitude is proportional to the amount of mistune and of polarity dependent upon the direction of mistune, is fed to a cathode coupled phase invertor stage (12AX7) which contains a miniature neon in each anode. Slight mistuning extinguishes one neon, showing the direction of mistune, while even illumination of both indicates correct tuning. In addition, this stage provides Automatic Frequency Control, one section of the double triode acting as a reactance valve across the local oscillator tuning coil."

CHECKING WITH A MULTIMETER

Quad quote the H.T. as "between 250V and 350V". However, the nominal is 330V, the exact value being determined by mains supply volts and component tolerances, etc. The tuner consumes 27mA. The heaters consume 1.5A, and there's a 0.3A lamp, making for 1.8A total L.T. consumption, at 6.3V. These values must be checked with a multimeter.

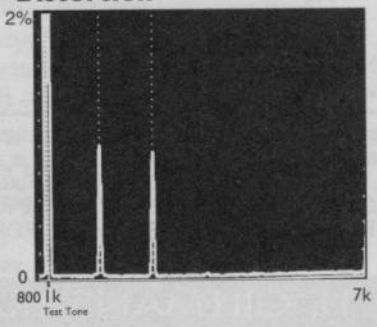
The valves V1 (6BH6), V3 (6BJ6) have around 170V on the anodes, and V4 (6BH6) has 157V. Around 0.75V-1V should exist on the cathodes. The mixer/oscillator, V2 runs at lower voltages and the limiter, V5, works in saturation mode. It has no grid bias, so the cathode is connected to ground, and it has just 35V on the anode. All the main voltages are marked on our circuit.

Ken Bunting, who has been with Quad servicing their products since 1970, told me that all the resistors in the high voltage lines tend to go high; one of ours had drifted from 82kΩ up to 103kΩ over the years, for example. They inspect and replace these first. The old capacitors, he told me, might look a little rough by modern standards, but they were more likely to be acceptable. In 'our' FM1, a tidy unit supplied by Graham Tricker I should point out, all the capacitors had been replaced, but not the resistors. In spite of the resistors being generally high, and the voltages a little low, it worked well. However, it was obvious to me from distortion figures, frequency response and the way it tuned into and out of stations that alignment of our FM1 was out, and the de-emphasis needed tweaking. So, be aware that just checking all DC voltages with a meter is not enough.

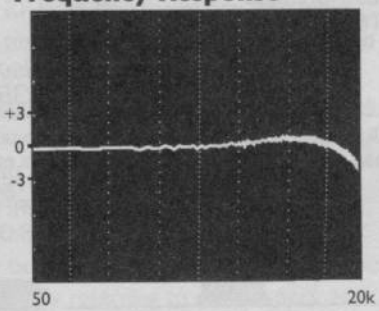
Ken Bunting, who has been with Quad servicing their products since 1970, checked and re-aligned our FM1 for optimum performance.

QUAD FM1 TEST RESULTS

Distortion



Frequency Response



Frequency response	14Hz-16kHz	Signal for minimum hiss	2mV
Stereo separation	mono	Selectivity (at 0.4MHz)	54dB
Distortion (50% mod.)	1.3%	Sensitivity	
Hiss (CCIR)	-81dB	mono	4µV

DE-EMPHASIS & DECODING

Demodulation from a 10.7MHz IF (Intermediate Frequency) signal to audio takes place in V6, which is a shunt-loaded Foster Seeley discriminator. So the audio signal (mono) passes through few components on its way to the output socket, ignoring for a moment the need for a stereo decoder.

Our circuit shows an early mono FM1 with an internal de-emphasis network. Later stereo compatible units have a two-position switch that, moved to the Red position, switches out de-emphasis to give a raw feed for a stereo decoder. This must be used to feed either Quad's own original decoder or the modern design such as the 1310 based design Graham Tricker can supply. De-emphasis is then applied later, within the decoder. Quad told me that C32 between the discriminator cathodes should be reduced to 15pF or so (from 47pF) when feeding a decoder direct, in order to strengthen the 19kHz pilot tone.

I should explain here that in order to lessen the audibility of hiss an FM signal is pre-emphasised above 2kHz (i.e. has treble lift) by the broadcaster to increase treble energy. The signal is then de-emphasised (i.e. has reciprocal treble fall) after demodulation in the receiver to give a net flat response. This technique is used in mono and stereo FM transmissions alike.

The Zenith GE stereo system, introduced in the late 1950s and used today, possesses a 19kHz pilot tone and a 38kHz suppressed sub-carrier, modulated with the stereo information. De-emphasis would ruin this composite signal, so it is applied after stereo decoding. So a stereo decoder always takes a raw audio feed, lacking de-emphasis.

For mono listening the stereo decoder can be ignored, but then the capacitors C33 (DC blocking) and C34, and resistors R20 and R21 must all be correct value. De-emphasis is carried out by R20,21 and, believe it or not, the output load (100k) all in parallel, in conjunction with C34, to give nominally 48µS de-emphasis time constant (the UK uses 50µS). Incorrect values here upset audio frequency response, as will any stereo pre-amp input impedance other than 100kΩ! So you must pay special attention to these component values and to the item an FM1 feeds if it is to sound right when delivering mono audio direct out.

Because I wanted to assess the basic tuner and not get too involved in the stereo decoder at this time - a whole subject in itself - I chose to set up, use and measure the FM1 in mono (dual-channel). Feeding an Audiolab 8000S preamplifier I found putting 47kΩ in series with the output and increasing C34 to 1250pF gave a flat response to 16kHz (there's no mpx filter to limit treble extension), shown in our spectrum analysis.

A Leak Troughline suffers none of this interfacing trouble, having a buffered output. And it is self powered of course, so now you know why the FM1 comes cheap nowadays. Audio output from our FM1, without decoder, measured 600mV at 100% modulation (i.e. full output).

Most FM1s are fitted with a piggy-back Quad stereo decoder, which is solid-state, using old germanium type transistors like OC44s (which some people insist sound better than modern silicons). By and large, early decoders give somewhat mediocre results, and Quad's has a complex power supply arrangement, which is why I've not concentrated on it here. My apologies if this is a slur on Quad's first decoder. I suggest the use of a modern stand-alone decoder such as Graham Tricker's.

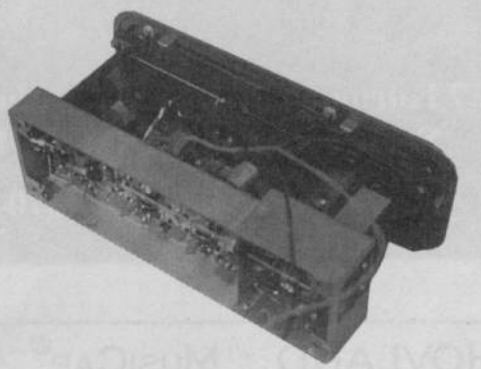
I visited Quad to get our FM1 aligned. Ken Bunting confirmed that it was in fair working order, but it could be improved by resistor replacement. He had some other interesting observations to make.

The neon tune indicators have 'popeye' lenses on them and, also, they produce RF interference that causes spurious whistling when tuning into and out of stations. Since the original popeye types are not now available Quad choose to fit a small circuit board carrying LEDs that do the same job, but better.

Many chip-based stereo decoders have been brewed up over the years for the FM1. National Semiconductor publish a circuit in their Audio Handbook that uses a LM1800 chip.

Quad have most parts for the FM1, but not the front panel. The gold bands normally corrode, making the FM1 look tatty after a time. Graham told us that "ours" (his in fact!) was the best sample he'd ever seen, and Quad agreed. Re-alignment showed that the IFs were too peaked. Ken flattened the passband and ensured the demodulator was fine.

This work optimises selectivity, minimises distortion and, very importantly, gives and optimum tune point. Where the tune indicators had appeared not to work properly, after alignment they did. Having built quite a few valve receivers myself in the past I knew not to bother assessing the FM1 until it had been aligned properly.



The Quad FM1 is simple enough inside to make servicing and renovation fairly straight forward. Quad themselves and specialists like GT Audio can help here if you're unsure what to do.

Tracking across Band II (88-108MHz) cannot be made perfect. Quad ensure the tuner is station accurate at the bottom end of the band (Radio 2/3/4) but admit it may be up to 1MHz out at the top end, around Radio 1, for example. Also, component position in the RF head (the metal box into which the tuning shaft goes) affects tracking so if any component is disturbed or replaced here - and it is likely that some resistors will need to be - then tracking needs to be reset.

You might have gathered there's a bit too all this. Sadly, there seem to be few books available now on this subject, especially referring to valve tuners. Just bear in mind, if you are looking for a book on the subject, that a tuner like the FM1 is configured much like any superheterodyne receiver, AM or FM, right up to its demodulator.

THE POWER SUPPLY

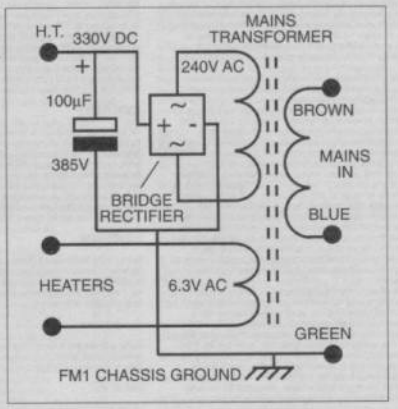
Very conveniently, 330V happens to be the peak value of 240V rms. This means that a mains 1:1 transformer can be used, since with a bridge rectifier, electrolytic smoothing capacitor and low current drain of 27mA we can expect 330V to be achieved almost exactly - and it was. Even more conveniently Maplin have just the right transformer. It delivers 240V AC at 100mA, plus 6.3V at 1.5A.

Whilst we need a little more than the rated LT current, it's an extra 2VA from a 34VA transformer, and since we are 8VA short from full drain on the HT I'd not expect core heating. In practice this was the case; the transformer ran cool and the LT didn't droop, giving 6.3V at 1.8A, with 240V AC in. Maplin identify this part as Valve Transformer XP27E, priced at £12.99, on p991 of their Sept-Aug 96 catalogue. I bought one from Maplin's Hammersmith branch in West London one Saturday morning.

You need a bridge rectifier of 1A-1.5A capacity rated at a minimum of 260 forward volts, and 400 Peak Inverse Volts (PIV) minimum. The electrolytic needs to be around 100µF, rated at 385V or more. You'll have difficulty detecting hum (a buzz in fact) with this. However, to get rid of it completely a 1kΩ/1W resistor should be used with up to 100µF either side, in π filter arrangement. Better still the resistor should be replaced by a choke.

These parts must be mounted in an earthed metal box, or a plastic box, for safety. It should be fitted with a mains switch.

Connecting up the power supply to the FM1 is easy enough. I'd suggest the existing power leads and, especially, the horrid 4-pin plug, now unavailable, are cut off and replaced by modern cable. Trace the power lead back into the tuner and you will find it terminates at three feed-through insulators. A new cable can be soldered in here. Note that the heater feeds are not grounded, but the HT is, so there are two heater lines and one (red) HT line. HT negative runs via the chassis and there is a suitable solder tag close to the feed-throughs.



Building a separate power supply can be easily done with standard components from Maplin Electronics

PERFORMANCE

Under measurement, frequency response was flat, our de-emphasis values giving a little +0.5dB lift at 8kHz. Mono noise figures are always much better than stereo, but the FM1 was still very good, giving -81dB hiss no less - better than most solid-state tuners. Mono -50dB sensitivity was a healthy 4µV and quieting so good that the FM1 will, in mono, should work well even with a poor aerial. Selectivity was a bit lop sided on ours, giving a mediocre 48dB rejection to stations +0.4MHz away, but a healthy 60dB to stations -0.4MHz away.

In listening tests I was not surprised to find the FM1 lacked the hardness of tone, flatness of imaging and treble glare that can afflict solid-state designs. It wasn't as sweet and deeply atmospheric as our Troughline, that's for sure, and I have to say that I did have to wrestle it into action with a lot fiddling to ensure the de-emphasis components matched the preamplifier load. Since this was done with the aid of a stereo generator and spectrum analyser, to ensure a flat frequency response, the investment here was not inconsiderable. There's a good case for letting Quad's excellent service department sort out this sort of thing. You will have to pay of course, but their charges are reasonable.

Both Classic FM and Radio 3 transmissions lacked hiss, hardly surprising considering the unit's fabulous -81dB noise figure. To eliminate hum completely power supply smoothing must be very good. The FM1 also has its own internal smoothing capacitor, C38, which needs to be checked.

Lacking inter-station muting, and working from a large outdoor aerial, the FM1 picked up many "ghost" stations. These were distant transmitters in fact, solid-state tuners experiencing the same effect with muting out (mono mode). The difficulty here was tuning into the proper station in the absence of a signal strength meter. I listened for hiss and crackles; local transmissions are always quieter (stronger signal). The FM1 also produces images above and below a wanted signal, something modern tuners avoid, but the tune indicator indicates an off-tune condition to them.

With good solid bass and clean, well differentiated treble free from solid-state grain and rasp (excellent tuners like NAD's 412 excepted) I felt the Quad FM1 more than justified its £30 or so basic outlay. It pulled in myriads of stations, proving very sensitive, and it separated most satisfactorily. However, to be realistic, getting it running properly wasn't without its problems, making this a project for engineers with a bit of time on their hands. The FM1 is an elegant looking tuner though, and it's lovely to use as well. I hope to be able to tackle the stereo decoder problem in future.

Our thanks to:

GT Audio, tel: 01895 833099

Quad, Tel: 01480 52561

Classique Sounds, Tel: 0116 283 5821