AM stereo plus synthesised tuning

Playmaster AM/FM stereo tuner Pt.1

Our new Playmaster synthesised AM/FM stereo tuner will outperform anything presently available on the market, regardless of price. As well as including an FM tuner section which is every bit as good as any other synthesised design, it is the only unit featuring a genuine wideband, low distortion AM stereo tuner. Naturally, it has a digital readout, 12-station memory, automatic seek and an optional infrared remote control.

by JOHN CLARKE

There's just one way to sum up the performance of our new AM/FM stereo tuner. In a word, it's superlative.

We've been hard at work on this beauty for almost a year now and to say that we're proud of the result would be the understatement of the year. Our new design includes the latest technology and boasts such high falutin' features as stereo AM decoding, synthesised tuning and microprocessor control. But this is one synthesised tuner that doesn't sacrifice performanace at the expense of fancy features.

In designing the new tuner, we kept just one object in mind: we wanted the best possible performance, regardless of the cost. The result is this superb design which puts most commercial units in the shade.

As can be seen from the photograph, most of the circuitry is accommodated on one large printed circuit board (PCB). Three separate, smaller boards are used for power supply components, the front panel LED displays and control pushbuttons, and the FM front end. The main board and the display board are connected by means of several plug and cable assemblies while the FM front end plugs directly onto the main board.

No expensive test gear is needed to build the tuner. A digital multimeter and two plastic alignment tools will suffice.

Stereo AM

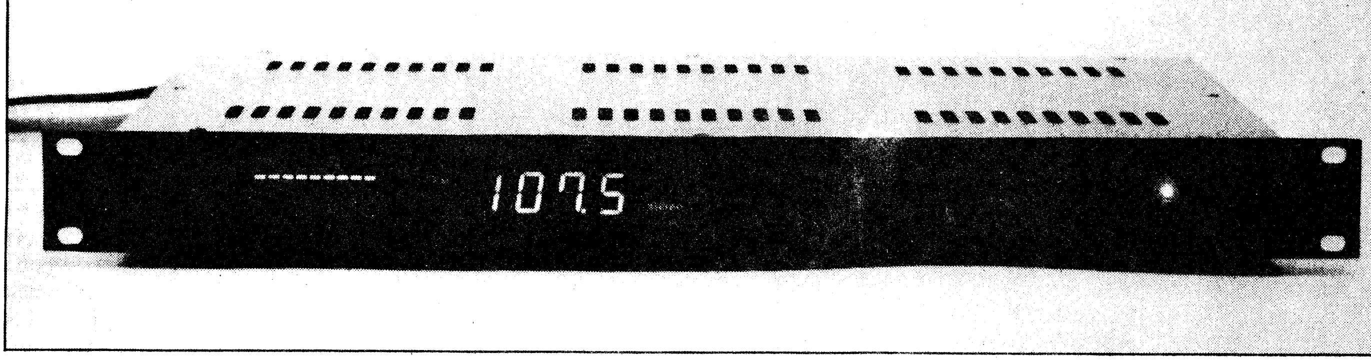
Despite the introduction of AM stereo on February 1st 1985, commercial AM/FM tuner manufacturers have done little to cater for the Australian AM stereo market. Only three brands are currently on the market and the performance of these generally leaves something to be desired, both in terms of audio bandwidth and distortion. We wanted to do much better.

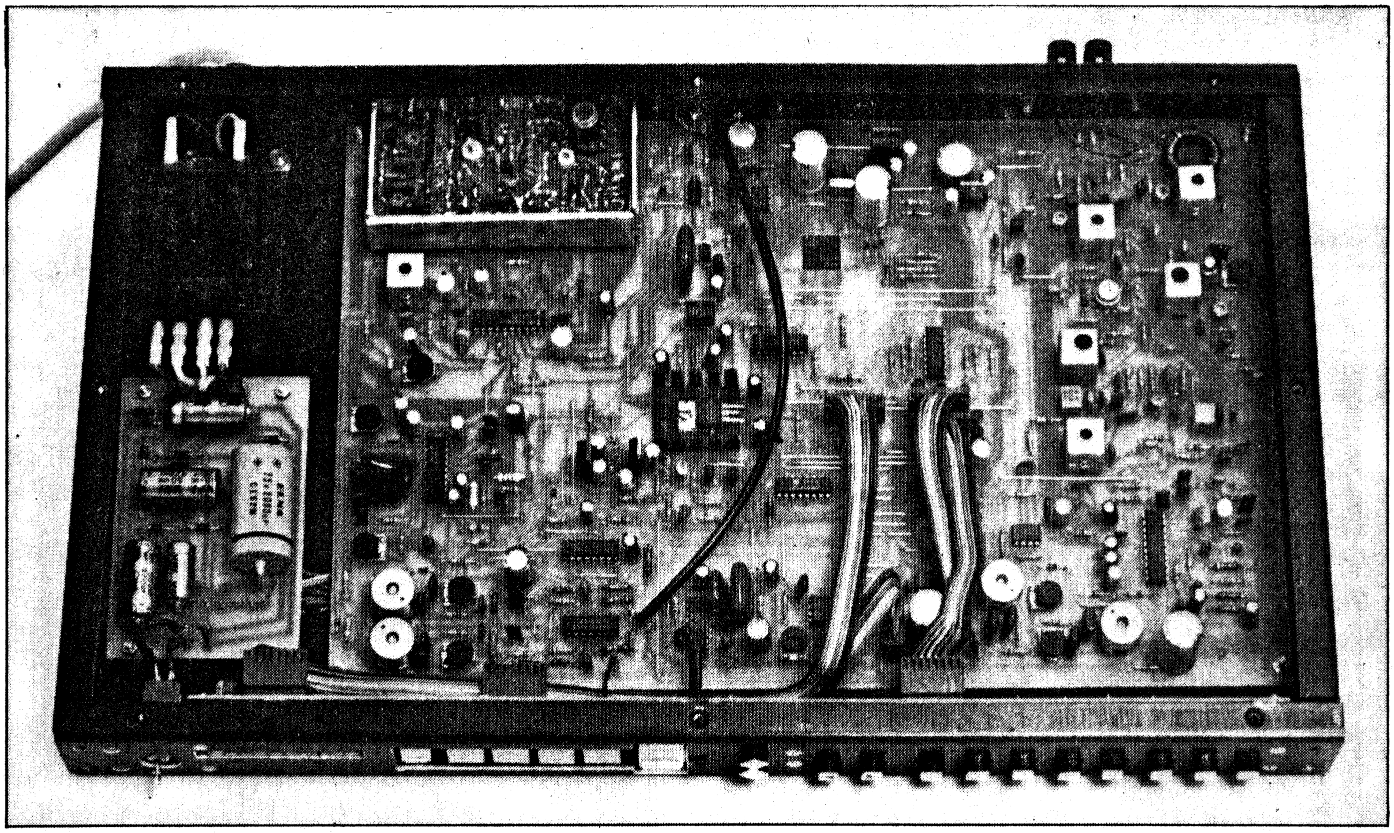
Our new Playmaster stereo tuner has not been compromised with regard to AM bandwidth, distortion or overall performance. It utilises the wide frequency bandwidth available from the AM transmitters to give the best sound possible in AM stereo. Until you've heard it, you won't believe that AM stereo could sound so good. Depending on the program material it can sound every bit as good as FM stereo!

But the new tuner not only produces exceptional sound; it is also a delight to operate. It is all pushbutton controlled and responds instantly to your commands. Press one of the six memory pushbuttons and the tuner locks quickly onto the pre-programmed station. A highly visible 15mm high green readout displays the received frequency.

The 10-level signal strength meter is without doubt the most useful available on any tuner we have seen for a long time. Combined with the quieting curves

The tuner is housed in a slimline rack-mounting case. This view shows the unit prior to silk-screening of the front panel.





View inside the prototype. The FM front end is in the screened metal enclosure at the top left of the main board.

(to be published next month), it gives you all the information you need to allow you to get the best signal quality.

Slimline styling gives the tuner a neat and up-to-the-minute appearance. The black anodised front panel is screen printed and is fitted with black pushbutton switches. The switches and memory indicating LEDs protrude through holes in the front panel while the green LED display is located behind a neutral perspex sheet inserted into the front panel.

This display includes the digital frequency readout, signal strength meter and AM/FM and stereo/mono indicators. The AM, FM, stereo and mono indicators each consist of a LED light bar module which emits a diffused green light. Covering these is a black film negative of the indicator lettering.

When the light bar module is lit, the light only shines through the clear lettering of the covering film. The indicator word is thus displayed with a very professional appearance.

Controls

The front panel controls are quite straightforward. At the extreme left is a pushbutton on/off power switch while immediately to the right of the display window are pushbuttons for forced mono and station seek.

The Seek control does just as its name suggests. When pressed, it sends the tuner scanning up the frequency band and automatically locks it onto the next available station.

Station selection is by means of the up/down Tune pushbuttons or any one of the pre-programmed memory pushbuttons. The two Tune pushbuttons provide manual station selection. Press the up button and the tuner increments in steps of 9kHz for AM or 100kHz for FM. Similarly, pressing the down button causes the tuner to decrement.

If either button is held down, the tuner will scan at a fast rate until the button is released.

To the right of the Tune buttons are the AM/FM switch, the six memory pushbuttons and the Memory Enable switch. Up to 12 stations can be pre-programmed into the memory switches, six for the AM band and six for FM.

It's quite easy to store a station in one of the memory locations. The tuner is simply tuned to the desired frequency, using the Seek or Up/Down buttons. Then the Memory Enable switch and appropriate station pushbutton is pushed to store the setting. If a station button is not pressed within the five seconds, the ME light will extinguish.

Tuner development

As previously stated, work first began on the tuner circuitry about 12 months ago. Many of the components required for the project were specialised and we were fortunate that manufacturers and parts suppliers were keen to assist in meeting our needs.

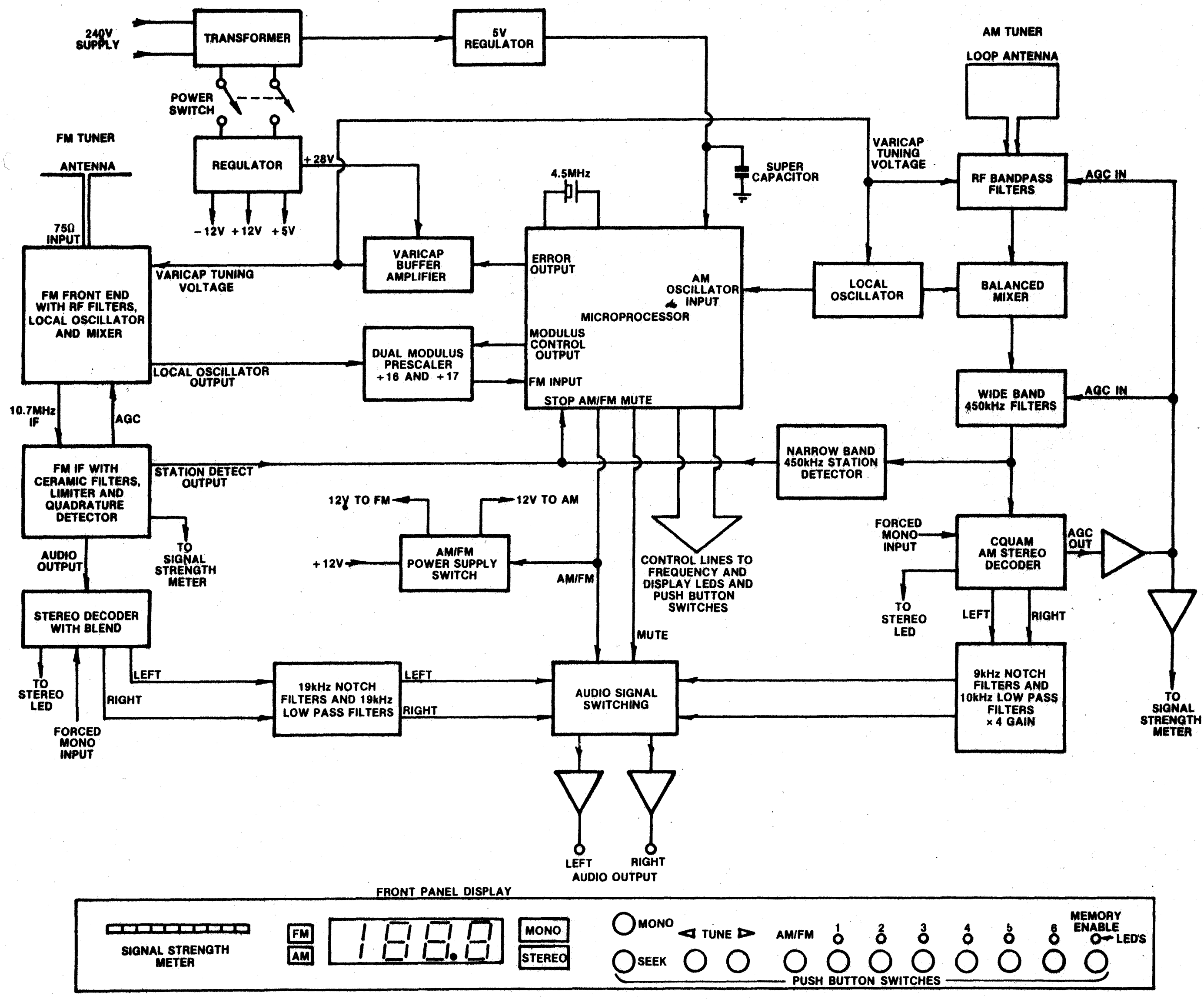
We needed ceramic filters for the AM intermediate frequency (IF) stages and for station detection, as well as for the FM IF stage. A ceramic resonator was also required for the AM stereo decoder. IRH Components were very helpful in this regard and supplied us with the necessary samples, some of which were specially imported for the project.

Similarly, we obtained various ICs and components from Geoff Wood Electronics, Motorola, National Semiconductor, Philips, Plessey, Neosid, Soanar and Watkin Wynne.

Our major problem, however, was to find a suitable microprocessor IC, vital for frequency synthesis and control. Eurovox Australia (Melbourne) was able to help out here. They use a custom NEC microprocessor in their car radios and car cassette players fitted as standard equipment in GMH, BMW, Porsche and Alfa Romeo vehicles. In particular, we acknowledge the help and enthusiasm of Klaus Schuhen at Eurovox who supplied us with sample microprocessors, companion prescaler ICs and crystals, a Eurovox car radio and service information.

Using this information, we have developed a completely original tuner design, based around the NEC custom microprocessor. To our knowledge, its overall performance exceeds that of any commercial AM/FM tuner, produced in Australia or anywhere else.

Playmaster AM/FM stereo tuner



An NEC microprocessor drives the front panel display and provides synthesised tuning of the AM and FM front ends.

Block diagram

The importance of the microprocessor in our new tuner is emphasised by the block diagram. In addition to driving the front panel display, it provides frequency synthesised tuning of the AM and FM tuner front ends and controls power supply and audio output signal switching.

Before discussing the microprocessor control further, let's first take a look at the AM and FM tuner stages.

Both the AM and FM tuners operate on the superheterodyne principle. In each case, a local oscillator tracks the RF filters and is mixed with the incoming RF signal. For AM, the oscillator frequency is always 450kHz above the frequency of the tuned station while for FM it is always 10.7MHz above the tuned frequency.

As a result of this mixing, we obtain a constant intermediate frequency (IF) of 450kHz for the AM tuner and 10.7MHz for the FM tuner, regardless of the tuned frequency. These intermediate frequencies are then filtered and detected.

AM tuner

The AM tuner utilises a large loop antenna which provides a virtually noise free signal to the tuner. Since the loop antenna is a balanced circuit, it acts to reduce common mode interference. In practice, there is almost a complete lack of background noise when tuned to a station.

Following the antenna are the RF bandpass filters. They provide gain at the tuned frequency, with sufficient bandwidth to ensure a wide audio frequency response.

An essential feature of the AM section is the fully balanced mixer. It enables the use of a wideband 450kHz ceramic filter in the IF stage, giving a response only 6dB down at ±12kHz, but sharply rolled off to 35dB down at ±20kHz and 60dB at ±40kHz.

Signal from the IF stage is directed to a narrow band station detector and to a C-QUAM AM stereo decoder stage.

The narrow band station detector block comprises a gain stage, a narrow band ceramic filter and a detector. The ceramic filter has a bandwidth of about 2.5kHz and is 24dB down at 9kHz which is the frequency separation of the AM stations. A station detect signal thus appears at the output only when the tuner is set to the correct station frequency.

At a setting 9kHz away from the station, the attenuation from the ceramic filter is sufficient to prevent a station detect signal.

The AM stereo decoder is a complete stereo decoding and pilot detection system based on the Motorola MC13020P C-QUAM chip. This provides a high quality detector plus stereo decoding.

Stereo reception is obtained when a 25Hz pilot tone is detected and there is sufficiently low signal noise. As soon as noise appears on the signal, the decoder automatically switches to mono. The decoder can also be manually switched to mono using the forced mono input.

In addition to the left and right audio outputs, the C-QUAM decoder also provides an automatic gain control (AGC) signal. This signal is inverted and controls the gain of the RF bandpass and 450kHz filter stages.

The AGC voltage is also used to drive the signal strength meter via another inverter stage.

The left and right audio outputs from the decoder are filtered using 9kHz notch and 10kHz low pass filter stages. The notch filter removes 9kHz whistles caused by adjacent stations beating with the received station while the low pass filter cum gain stage removes high frequency noise from the audio.

It also boosts the output level from the AM tuner so that it matches the audio output from the FM tuner.

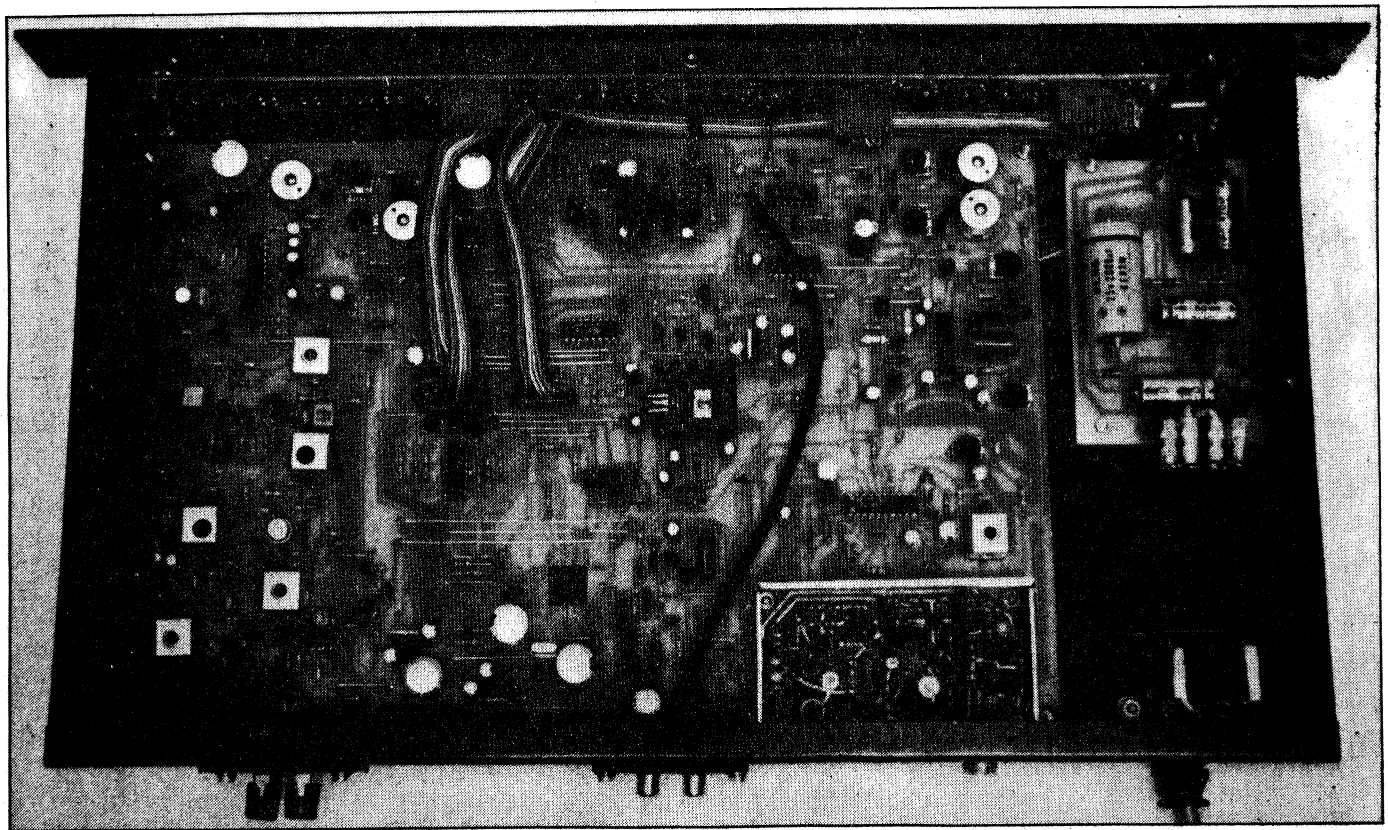
FM tuner

There's nothing radical about the design of the FM tuner. It's a perfectly conventional arrangement with both the IF and stereo decoder stages based on standard National Semiconductor ICs.

The front end includes the RF filters, a local oscillator and the mixer. Double tuning is used on the first stage before amplification using a dual gate MOSFET device. The unbalanced mixer is tuned to the 10.7MHz IF and its output passed to ceramic filters in the IF circuitry.

A National Semiconductor LM1865 advanced FM IF intergrated circuit is used for this section of the tuner. It includes gain, limiting and quadrature detection of the modulated FM signal. A feature of the IC is linearisation of the quadrature detection to considerably reduce distortion.

The IC also provides an AGC signal output which is applied to the front end and eliminates the need for local/distance switching. It also reduces third order intermodulation products due to strong out of band signals overloading the front end.



The microprocessor chip is at bottom centre of the main board, the AM tuner circuit at left, and the FM tuner at right.

Playmaster AM/FM stereo tuner

Also included with the IC is a station detect output and a signal strength output suitable for driving the signal strength meter.

Following the detector is a National Semiconductor LM1870 FM stereo decoder chip. This device incorporates a blend feature which reduces the stereo separation at low signal levels to improve the signal-to-noise ratio.

The left and right audio outputs are filtered with 19kHz notch filters and 38kHz low pass filters. The notch filters filter the 19kHz stereo pilot tone while the low pass filter reduces the 38kHz residual output produced by the stereo decoder.

Phase lock loop control

Varicap diodes are used to tune the local oscillator and RF sections of both tuners. These diodes change capacitance in response to a control voltage and are connected in parallel with inductors to form tuned circuits.

The varicap control voltage is derived from the error output of the microprocessor. This error output drives a varicap buffer amplifier which supplies a control voltage in the range from 0V to 28V DC.

In a superheterodyne tuner, the local oscillator frequency varies according to the tuned station and this frequency is read by the microprocessor controller. In the case of the AM tuner, the local oscillator signal is applied directly to the input of the microprocessor.

A somewhat different arrangement is employed for the FM local oscillator. In this case, the oscillator output is divided with a dual modulus prescaler chip before being applied to the microprocessor. The dual modulus prescaler divides by either 16 or 17, depending on the modulus control output from the microprocessor.

Inside the microprocessor is a phase lock loop (PLL) comprising three separate components: a reference frequency generator, a phase detector and a programmable divider.

The reference frequency generator produces a reference frequency by dividing down the external crystal reference of 4.5MHz. For AM, the reference frequency is 9kHz and for FM, 25kHz.

The programmable divider divides the incoming station frequency and compares it with the reference frequency in the phase detector. This produces the error voltage which is fed to the local oscillator varicaps to "lock" the tuner onto the station.

Since the local oscillator is a precise multiple of the internally generated reference frequency, this phase lock control loop is called a "frequency synthesiser".

Apart from synthesis control, the microprocessor performs several other functions.

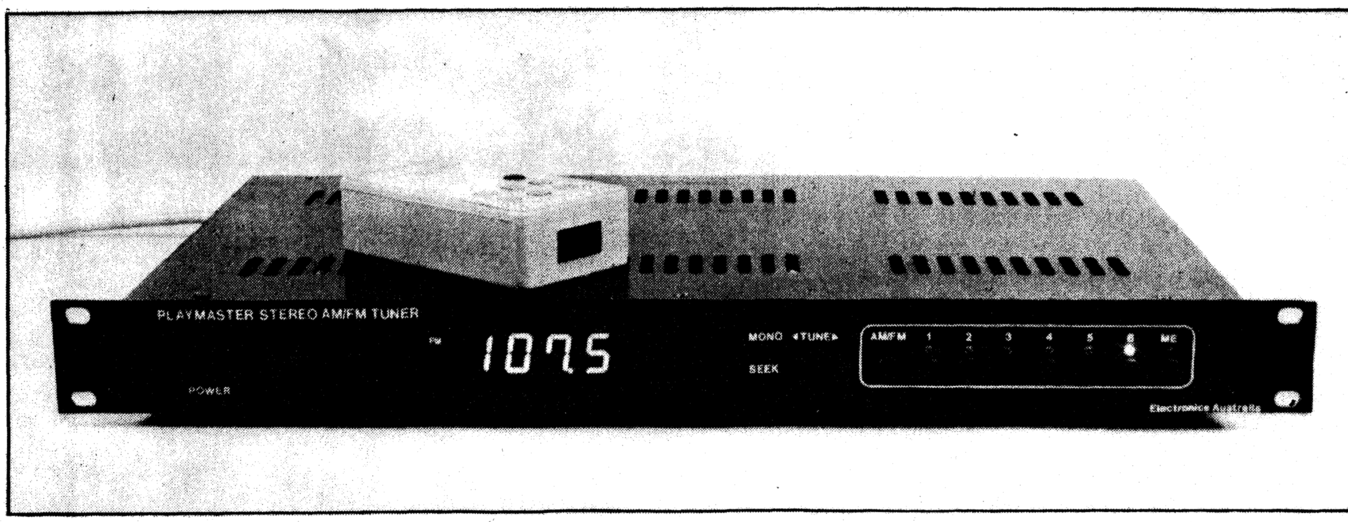
To begin with, it has several control lines which drive the frequency display, the mono and AM/FM status indicators, and the memory selection LEDs. With the exception of the mono indicator these are all multiplex driven.

The microprocessor also scans the pushbutton control switches. When one is pressed, the microprocessor responds to the switch function and this response is seen as a change in the display.

Power supply and audio signal switching is controlled by the AM/FM output. The mute output mutes the audio signal whenever the microprocessor is changing stations. The stop input is used during the seek mode, when the tuner is used to automatically scan to the next station. When a station is located, the station detect output from the powered tuner goes high and the microprocessor locks onto that station.

Finally, the microprocessor is permanently powered up via a 5V regulator. However, if the tuner is disconnected from the mains supply, either intentionally or because of a blackout, a super capacitor (47,000μF) maintains power to the memories so that the tuner does not have to be re-programmed.

So much for the block diagram. In Pt. 2 next month, we'll publish the full circuit details.



Second article has all the circuit diagrams

Playmaster AM/FM stereo tuner Pt. 2

Last month, we introduced our new synthesised AM/FM stereo tuner and described the block diagram. In part 2 this month, we give the full circuit details and list the specifications.

by JOHN CLARKE

The circuit for our new Playmaster Stereo AM/FM Tuner is quite large and, as a consequence, covers several pages. This is something of a blessing, however, since it breaks the circuit into three manageable sections: AM tuner, FM tuner and microprocessor control. We will describe the operation of each circuit section separately.

As discussed last month, microprocessor IC1 performs a major roll in driving the display, tuning the AM and FM front ends, and switching power to either tuner as appropriate. Before we discuss this further, let's first take a look at the AM and FM tuner circuits.

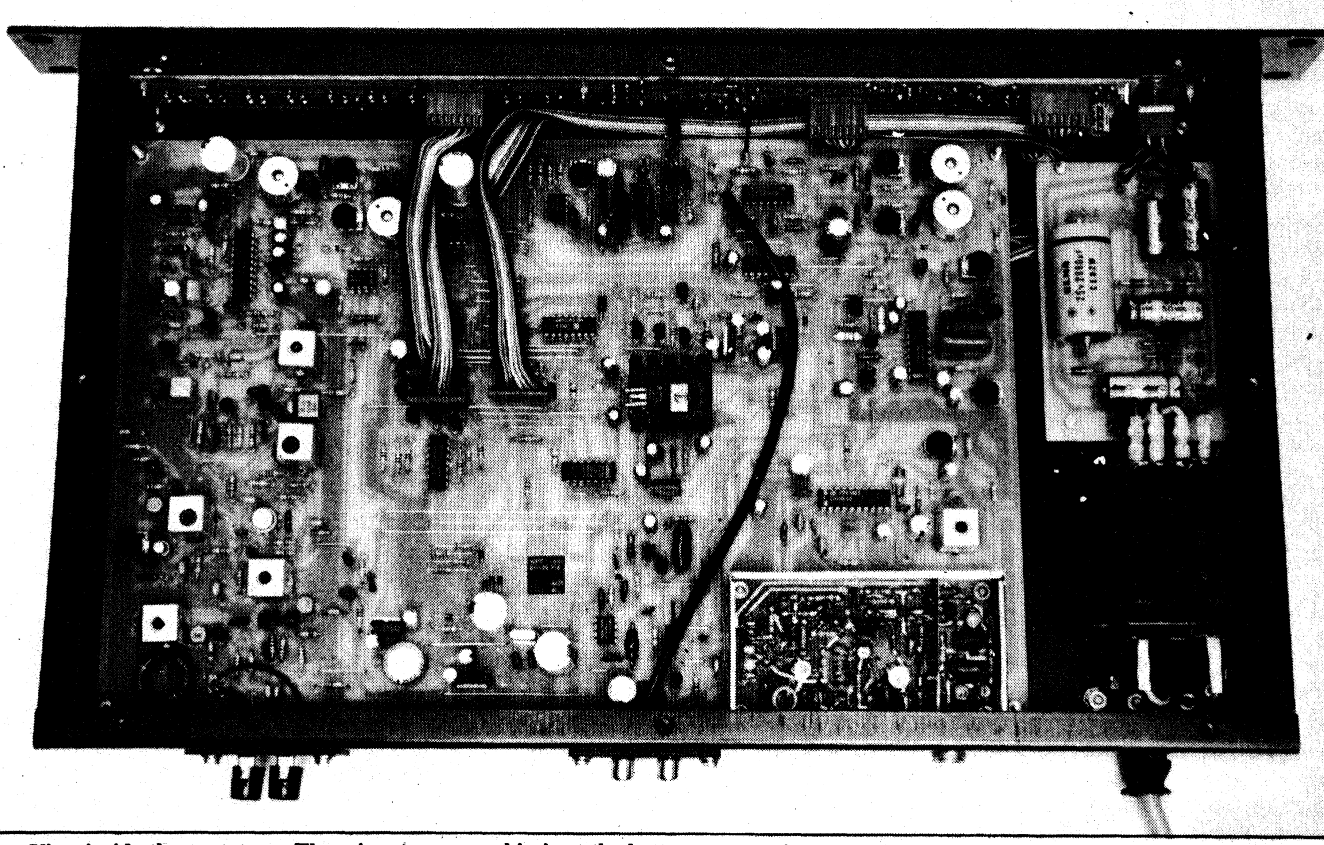
AM tuner

The AM tuner circuit is a high-performance superheterodyne design employing varicap tuning, a double-balanced mixer, ceramic filters and stereo decoding. It is a brand new design, developed completely from scratch.

Input signals from the loop antenna are fed to a balanced circuit consisting of toroidal transformer T1. As stated last month, this acts to reduce common-mode interference so that the tuner is provided with a noise-free signal. The unbalanced secondary of T1 is direct-coupled to terminal 5 of antenna coil L1.

The winding across terminals 4 and 5 is a special modification to the standard 7210 coil assembly and comprises a few hand-wound turns on the L1 coil former. These provide very light coupling to the tuned winding across terminals 1 and 2.

RF tuning of the antenna circuit is provided by varicap diode D1 in conjunction with the 3-30pF timmer connected across the 7210 winding. A tap-



View inside the prototype. The microprocessor chip is at the bottom centre of the photograph.

ping of the winding at terminal 6 directly couples to gate 1 of dual gate MOSFET Q1.

Q1 is used as a self-biased common source amplifier with the L2 winding (7211) forming the drain load. Varicap diode D2 and its associated 3-30pF trimmer are capacitively coupled to L2 to form the second RF tuned circuit. The 1MΩ resistor across D2 discharges the varicap when the control voltage at its cathode is altered.

Note that self-bias for Q1 is provided by the 220Ω source resistor while the AGC (automatic gain control) voltage is applied to gate G2 via the 100kΩ and 47kΩ resistors.

The output from the second RF stage appears at terminal 6 of L2 and is coupled to the differential input of double-balanced mixer stage IC5 (MC1496) at pins 1 and 4. The open collector outputs at pins 6 and 9 are loaded with the balanced primary windings of L3 and its parallel 560pF capacitor which form a tuned circuit at 450kHz.

Supply decoupling is via a 560Ω resistor and 0.1μF capacitor.

Q4, L5, D3 and the associated 3-30pF trimmer form the local oscillator. A feedback tapping between Q4's emitter and terminal 4 of L5 ensures continued oscillation, while VR1 sets the level of oscillation. Note that D3 is isolated from the L5 winding via a 680pF capacitor. This reduces the maximum tuned circuit capacitance.

To explain further, the RF stages must be tuned from 522 to 1611kHz which represents a capacitance ratio of 9.5:1 (which is the square of the 1611/522 ratio). The local oscillator, on the other hand, must be tuned from (522 + 450) kHz to (1611 + 450)kHz which represents a 4.5:1 capacitance ratio.

A separate winding on L5 couples the oscillator output to the second differential input stage of the mixer (IC5) at pins 7 and 8.

Because the mixer is a balanced type, only the sum and difference frequencies appear at the output. This fact is very useful since it allows the use of a wide band ceramic filter (SFP450D) in the IF stage.

As stated last month, the filter sharply rolls off the response beyond ±12kHz and is 60dB down at ±40kHz. However, it also has secondary peaks in its response so that the attenuation of the filter is only 15dB down at ±150kHz. Normally, this would render the filter useless, since signals around 600kHz would pass through the IF filter virtually unattenuated.

The balanced mixer neatly solves this problem, however. It rejects both the incoming RF and local oscillator signals, and allows only the mixed signal through to the IF stage. Consequently, the rising response outside the passband of the ceramic filter is unimportant.

The output from the ceramic filter is coupled to gate 1 of Q2, another BFR84 dual-gate MOSFET transistor. L4 and the 390pF capacitor form a tuned drain load for Q2 which provides some gain for the IF stage.

At this point, the IF output is split into two paths. One path is derived from the drain of Q2, amplified by common emitter stage Q3, and applied to a narrow band ceramic filter (SFZ450C3N). This filters a very narrow band centred on 450kHz which means that it passes signal only when the IF stage is centred on 450kHz. In other words, an output from the filter only occurs when the tuner is exactly on station.

The output from the narrow-band filter is rectified by D4 and D5, filtered and applied to the base of Q5. Whenever the signal is sufficiently strong, the base of Q5 is pulled below 0.6V. Consequently, Q5 turns off and supplies a station detect or stop output signal to pin 13 of the microprocessor.

The second signal path from the IF stage is derived from a tapping on L4 (terminal 6) and coupled to the pin 3 input of IC4, an MC13020P Motorola stereo decoder. This versatile chip performs a range of functions. It provides low-distortion synchronous detection of the incoming IF signal, stereo decoding, an AGC output and automatic stereo-mono switching.

A forced mono input (pin 9) allows manual switching to mono operation.

The 3.6MHz ceramic resonator sets the frequency of an internal VCO which therefore operates at eight times the 450kHz IF. In operation, the VCO locks onto the IF and provides a phase reference for stereo decoding. The decoded left and right audio outputs appear on pins 7 and 8 respectively and are fed to the notch and low-pass filter circuits.

The AGC output from IC4 appears at pin 4 and is applied to inverting amplifier IC6b. The resulting AGC output signal appears on pin 7 and is used to control the gain of MOSFET transistors Q1 and Q2 as discussed previously. In this way, a constant signal level is provided at the input to IC4 over a wide range of signal conditions.

Further, IC6a inverts and level shifts the AGC signal to drive an NSM39152 LED-bargraph signal strength meter. This features 10 LEDS and has a logarithmic response. It accepts a DC signal and displays the relative level compared to RLO (ground) and RHI, the high reference set by the 2.2kΩ and 6.8kΩ resistors.

Diode D10 isolates the output of IC6a from the FM signal meter drive circuitry.

The left and right audio outputs from IC4 are fed to 9kHz notch filters based on L6 and L7. These remove any 9kHz whistles caused by adjacent stations. VR2 and VR3 are used to adjust the depth and sharpness of the notch (in each channel), while tuning is provided by adjusting the slugs in the L6 and L7 inductors.

Following the 9kHz notch filters are active filter stages IC7a and IC7b, each with a gain of 1.2. These filters roll off the response above 10kHz to remove high frequency noise from the audio output signals.

Finally, the left and right audio outputs are applied to IC12, a 4052 CMOS analog switch (shown on the FM tuner circuit) page 37) which selects either the AM or FM tuner outputs.

FM tuner

The FM tuner front end is designed to accept a 75Ω unbalanced antenna. When used with a balanced 300Ω dipole antenna, a 300Ω to 75Ω balun will be necessary. The standard adaptor type used for television antenna inputs is quite suitable.

L8 is the 75Ω input and this couples to a double-tuned filter consisting of L9, D19 and L10, D20. The RF ouput signal from the filter is then applied to gate 1 of Q6, a low noise dual gate MOSFET with L11 as its drain load. The amplified output appears at the drain of Q6 and is fed via a 1.5pF capacitor to another tuned stage consisting of L12 and varicap diode D21.

AGC is applied to gate 2 of Q6 and operates during very high signal level conditions to prevent overload.

The local oscillator has a tuned circuit comprising L13 and varicap diode D22 for the collector load of Q8. Feedback via the 3.3pF capacitor from emitter to collector ensures that the circuit oscillates. A 2.2kΩ resistor and 6.8μF capacitor provide supply decoupling.

Local oscillator injection to mixer stage Q7 is via a 4.7pF capacitor to the base, while the output signal from L12 is also fed to the base via a 6.8pF capacitor.

Mixer stage Q7 has a 10.7MHz tuned collector load consisting of L15 and a 47pF capacitor. The output signal is extracted from pin 3 of L15 and applied to ceramic filter CF1 and to the wide band AGC input (pin 20) of IC2, an LM1865 FM IF/detector chip from National Semiconductor.

Quite a lot happens inside the LM1865. It contains a buffer stage, limiter amplifier, quadrature detector,

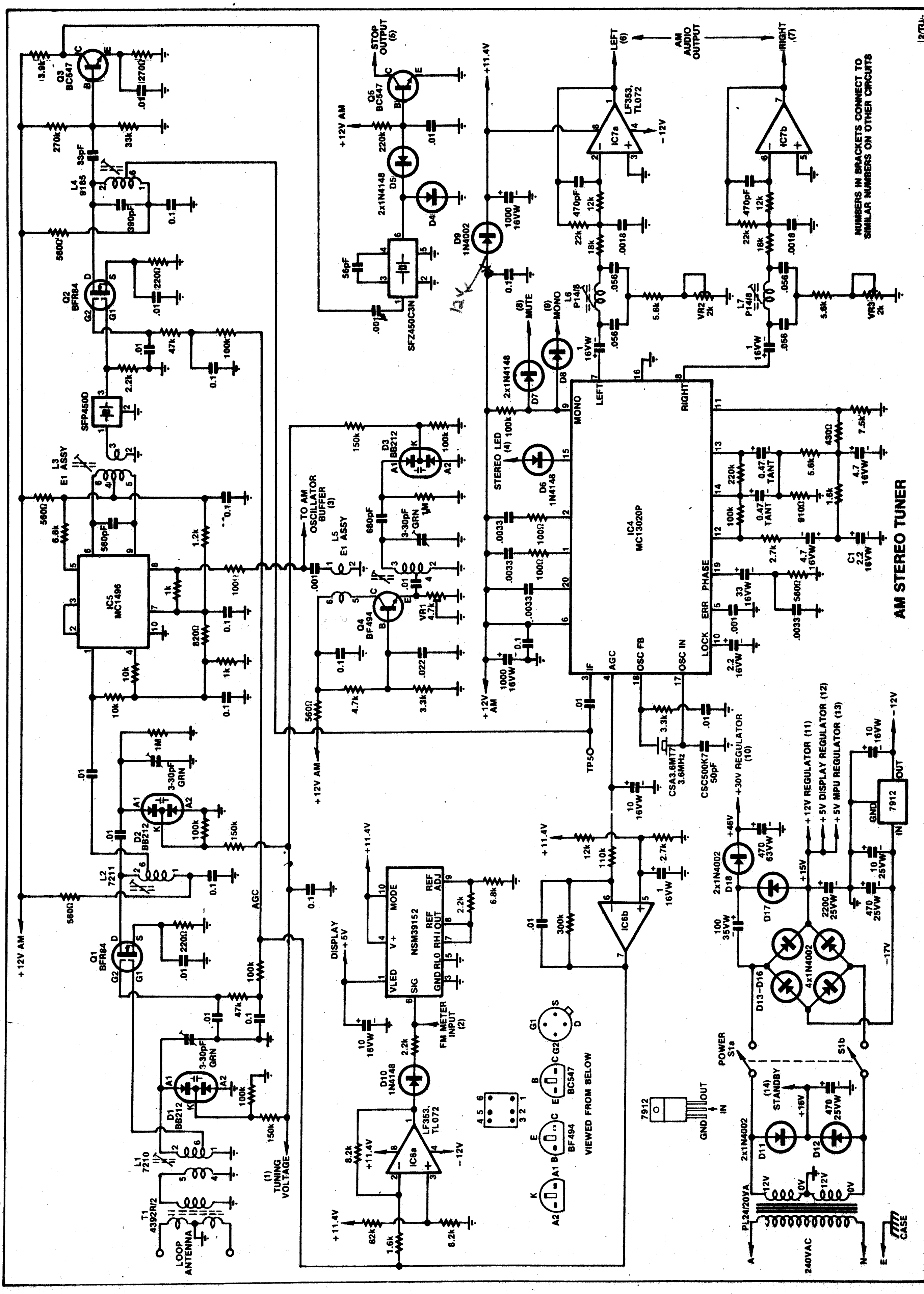
Specifications

AM Tuner

Tuning Range	522 to 1611kHz
Frequency Response	−3dB at 5.5kHz (see graph)
Harmonic Distortion	mono: 0.4% at 30% modulation stereo: <1% at 30% modulation
Audio Output	450mV RMS into 4.7kΩ load at 100% modulation
Stereo Separation	typically 30dB
AGC Range	40dB for a 6dB change in audio output
Signal-to-Noise Ratio	70dB with respect to full output for signal levels of 9 and 10 on bar graph display; better than 60dB with respect to full output for signal levels greater than 6
Usable Sensitivity	350μV at −6dB audio level

FM Tuner

Tuning Range	87.9 to 107.9MHz
Frequency Response	−1dB at 20Hz, −0.5dB at 15kHz
Harmonic Distortion	mono: 0.15% (100Hz); 0.15% (1kHz); 0.2% (6kHz) stereo: 0.4% (100Hz); 0.4% (1kHz); 0.4% (6kHz)
Audio Output	450mV RMS into 4.7kΩ load at 100% modulation
Stereo Separation	34dB (50Hz); 34dB (1kHz); 36dB (10kHz)
Subcarrier Product Rejection	48dB
19kHz Rejection	62dB
Signal-to-Noise Ratio	see graph


AM STEREO TUNER
NUMBERS IN BRACKETS CONNECT TO SIMILAR NUMBERS ON OTHER CIRCUITS
IC4 MC13020P
IC5 MC1496
NSM39152
LF353, TL072
SFP450D
SF2450C3N
CSA3.6MT7 3.6MHz
CSC500K7 50pF
LOOP ANTENNA
(1) TUNING VOLTAGE
TO AM OSCILLATOR BUFFER (3)
FM METER INPUT (2)
STOP OUTPUT (5)
LEFT (6)
AM AUDIO OUTPUT
RIGHT (7)
STEREO LED (4)
(8) MUTE
(9) MONO
+12V REGULATOR (11)
+5V DISPLAY REGULATOR (12)
+5V MPU REGULATOR (13)
+30V REGULATOR (10)
(14) STANDBY
POWER S1a
S1b
PL24/20VA
240VAC
VIEWED FROM BELOW
BF494
BC547
7912

Parts List For Synthesised Stereo

1 rack-mounting cabinet, 44 x 254 x 430mm (Altronics Cat. No. H-0411)
1 screen printed front panel, 486 x 46mm
1 negative film, 185 x 31mm
1 sheet of neutral perspex, 179 x 24mm x 1.5-3mm
2 pieces of tinplate, 101 x 24mm
2 pieces of tinplate, 52 x 24mm
1 piece of tinplate, 52 x 20mm
1 PC board, 330 x 216mm, code 85tu12
1 PC board, 66 x 110mm, code 85ps12
1 double-sided PC board, 94 x 51mm, code 85fm12
1 double-sided PC board, 370 x 35mm, code 85db12
1 Ferguson PL24/20VA low profile transformer
1 mains cord and plug
1 cord grip grommet
2 bullet sockets with insulating sleeving
4 rubber feet
10 6mm spacers
4 12mm spacers
1 Belling Lee 75Ω panel-mounting socket
1 stereo panel-mounting RCA socket
1 2-way panel-mounting screw terminal
1 DPDT mini push on/push off switch with 10mm black cap
12 snap action black keyboard switches (Jaycar Cat. No. SP-0721)
9 Molex 8-way 0.1-inch pin headers
8 Molex 8-way 0.1-inch cable connector sockets
64 crimp terminals to suit above sockets
94 Molex pin sockets
50 PC stakes
1 TO-220 heatsink, 30 x 27 x 12mm, Thermaloy 8030
1 4.5MHz parallel resonance crystal
1 earth lug

Wire & cable

100mm of 8-way rainbow cable
300mm 0.8mm enamelled copper wire
25mm 0.6mm enamelled copper wire
130mm 26B&S enamelled copper wire
220mm twin shielded wire
2 metres 30B&S enamelled copper wire
37 metres 36B&S enamelled copper wire
3 metres hookup wire

Integrated Circuits

1 NEC D1710G/016 or /227 MPU
1 NEC 553AC dual modulus prescaler
1 LM1865 advanced FM IF system (National Semiconductor)
1 LM1870 FM stereo demodulator (National Semiconductor)
1 MC13020P C-QUAM AM stereo decoder (Motorola)
1 MC1496G (metal package) balanced modulator/demodulator (Motorola)
2 DS75492 MOS to LED hex digit drivers
1 40106, 74C14 hex Schmitt trigger
1 4052 2-pole, 4-way CMOS switch
2 LF353, TL072 dual op amps
1 LF347, TL074 quad op amp
3 7805, LM340T-5 3-terminal +5V regulators
1 7812, LM340T-12 3-terminal +12V regulator
1 7912, LM320T-12 3-terminal −12V regulator
1 LM317T adjustable 3-terminal regulator

Transistors and diodes

4 BB204B or BB204G varicap double diodes (Philips). Note: do not mix B and G types.
3 BB212 AM varicap double diodes (Philips)
1 BF450 PNP HF transistor
1 BF240 NPN HF transistor
1 BF981 N-channel dual gate MOSFET
2 BFR84 N-channel dual gate MOSFETs
1 BF494 NPN transistor
5 BC549 NPN transistors
8 BC327 PNP transistors
1 BC337 NPN transistor
2 BC547 NPN transistors
1 2N5485 N-channel FET
19 1N4148, 1N914 small signal diodes
10 1N4002 1A silicon diodes

Optoelectronic components

1 NSM39152 green bar graph display (Geoff Wood Electronics)
2 MU03-5201 6 x 9mm green light bar modules (A&R Soanar)
2 MU02-5201 14 x 14mm green light bar modules (A&R Soanar)
4 NAG163 green common anode 7-segment displays (Stanley, A&R Soanar)
6 3mm green LEDs
1 3mm red LED

Ceramic filters and resonators

2 Murata SFE10.7ML ceramic filters (IRH)
1 Murata SFP450D AM stereo IF ceramic filter
1 Murata SFZ450C3N ceramic filter
1 Murata CSA3.6MT7 ceramic resonator & CSC~~500K7 50pF~~ capacitor or 300K 30PF

Inductors

2 Neosid type E1 adjustable inductance assemblies
1 Neosid type E3 adjustable inductance assembly
1 Neosid type A5 adjustable inductance assembly
1 Neosid 4329R/2 ferrite ring core
1 Jabel 7210 1st RF bandpass coil
1 Jabel 7211 2nd RF bandpass coil
1 Jabel 9185 IF coil
1 22μH choke
1 18μH choke
1 6.8μH choke
1 F16 ferrite slug
4 Philips 4322 022 22265 potcores, PL14/8, with nut
4 Philips 4322 021 30250 coil formers
4 Philips 4322 021 30950 inductance adjustors
4 Philips 4322 021 30440 tag plates
4 Philips 4322 021 30520 brass containers
4 Philips 4322 021 30630 springs

Capacitors & Resistors

AM tuner

Capacitors

1 2200μF 25VW axial electrolytic
2 1000μF 16VW PC electrolytic
1 470μF 63VW axial electrolytic
2 470μF 25VW axial electrolytic
1 100μF 25VW axial electrolytic
1 33μF 16VW PC electrolytic
1 10μF 25VW PC electrolytic
3 10μF 16VW PC electrolytic
2 4.7μF 16VW PC electrolytic

AM/FM Tuner

2 2.2μF 16VW PC electrolytic
3 1μF 16VW PC electrolytic
2 0.47μF 16VW tantalum
11 0.1μF ceramic
4 .056μF metallised polyester
1 .022μF metallised polyester
10 .01μF ceramic
2 .01μF (10nF) ceramic plate, Philips 222 629 09103
4 .0033μF metallised polyester
2 .0018μF metallised polyester
1 .001μF metallised polyester
1 .001μF ceramic
1 .001μF (1nF) miniature ceramic plate, Philips 222 630 09102
1 680pF miniature ceramic plate, Philips 2222 630 09681
1 560pF ceramic
2 470pF ceramic
1 390pF ceramic
1 56pF ceramic
1 33pF ceramic
3 5.2-30pF Murata D series trimmers

Resistors 0.25W, 5% unless stated)
2 x 1MΩ, 1 x 300kΩ 2%, 1 x 270kΩ, 2 x 220kΩ, 3 x 150kΩ, 1 x 110kΩ 2%, 7 x 100kΩ, 1 x 82kΩ, 2 x 47kΩ, 1 x 33kΩ, 2 x 22kΩ 2%, 2 x 18kΩ 2%, 3 x 12kΩ 2%, 2 x 10kΩ, 2 x 8.2kΩ 2%, 1 x 7.5kΩ 2%, 2 x 6.8kΩ, 3 x 5.6 kΩ, 1 x 4.7kΩ, 1 x 3.9kΩ, 2 x 3.3kΩ, 2 x 2.7kΩ 2%, 3 x 2.2kΩ, 2 x 1.6kΩ 2%, 1 x 1.2kΩ, 2 x 1kΩ, 1 x 910Ω 2%, 1 x 820Ω, 5 x 560Ω, 1 x 430Ω 2%, 1 x 270Ω, 2 x 220Ω, 3 x 100Ω, 1 x 4.7kΩ miniature horizontal trimpot, 2 x 2kΩ miniature horizontal trimpots

FM front end

Capacitors
1 6.8μF tantalum
7 .01μF (10nF) miniature ceramic plate, Philips 2222 629 09103
3 .001μF (1nF) miniature ceramic plate, Philips 2222 629 09102
1 47pF miniature ceramic plate, Philips 2222 652 10479
1 27pF miniature ceramic plate, Philips 2222 652 10279
1 6.8pF miniature ceramic plate, Philips 2222 652 09688
1 4.7pF miniature ceramic plate, Philips 2222 652 09478
1 3.3pF miniature ceramic plate, Philips 2222 652 09338
1 1.5pF miniature ceramic plate, Philips 2222 652 09158
3 4.2-20pF Murata D series trimmers
1 3-11pF Murata D series trimmer

Resistors (0.25W, 5%)
1 x 1MΩ, 4 x 56kΩ, 1 x 33kΩ, 1 x 18kΩ, 2 x 10kΩ, 1 x 3.3kΩ, 1 x 2.2kΩ, 1 x 1.5kΩ, 1 x 1kΩ, 1 x 220Ω, 2 x 22Ω

FM IF and stereo decoder

Capacitors
1 220μF 16VW PC electrolytic
2 47μF 16VW PC electrolytic
1 22μF 16VW PC electrolytic
2 10μF 16VW PC electrolytic
2 4.7μF 16VW PC electrolytic
3 2.2μF 16VW PCelectrolytic
3 1μF 16VW PC electrolytic
1 0.33μF metallised polyester
1 0.22μF metallised polyester
3 0.1μF ceramic
1 .047μF metallised polyester
4 .012μF metallised polyester
5 .01μF (10nF) miniature ceramic plate, Philips 2222 629 09103
2 .0056μF metallised polyester
3 .0047μF metallised polyester
2 .0018μF metallised polyester
2 .0015μF metallised polyester
1 .001μF metallised polyester
2 150pF ceramic
1 82pF miniature ceramic plate, Philips 2222 652 58829

Resistors (0.25W, 5% unless stated)
2 x 390kΩ, 2 x 270kΩ, 3 x 100kΩ, 1 x 47kΩ, 1 x 33kΩ, 2 x 22kΩ, 2 x 20kΩ 2%, 4 x 15kΩ, 1 x 12kΩ, 3 x 10kΩ, 6 x 10kΩ 2%, 1 x 8.2kΩ, 1 x 7.5kΩ 2%, 2 x 4.7kΩ, 1 x 4.3kΩ 2%, 2 x 3kΩ 2%, 1 x 2.2kΩ, 1 x 330Ω, 1 x 22kΩ horizontal cement trimpot, 3 x 10kΩ horizontal cermet trimpot, 1 x 5kΩ horizontal cermet trimpot

Tuner control circuit

Capacitors
1 47,000μF (.047F) 5VW super capacitor
2 1000μF 16VW PC electrolytic
4 47μF 16VW PC electrolytic
4 10μF 25VW PC electrolytic
4 10μF 16VW PC electrolytic
2 1μF 63VW PC electrolytic
1 1μF 35VW PC electrolytic
1 1μF 25VW PC electrolytic
1 0.33μF metallised polyester
1 0.1μF ceramic
2 .01μF ceramic
2 .01μF (10nF) miniature ceramic plate, Philips 2222 629 09103
1 .01μF metallised polyester
1 680pF miniature ceramic plate, Philips 2222 630 09681
1 100pF miniature ceramic plate, Philips 2222 652 58101
2 22pF ceramic
2 4.7pF ceramic

Resistors (0.25W, 5%)
1 x 1MΩ, 1 x 220kΩ, 1 x 150kΩ, 1 x 33kΩ, 9 x 10kΩ, 4 x 5.6kΩ, 2 x 4.7kΩ, 1 x 2.7kΩ, 1 x 2.2kΩ, 1 x 1.8kΩ, 7 x 1kΩ, 6 x 820Ω, 1 x 680Ω, 1 x 470Ω, 1 x 330Ω, 1 x 220Ω, 2 x 120Ω, 2 x 82Ω, 2 x 56Ω, 4 x 47Ω, 7 x 22Ω

signal strength meter drive circuit and an AGC output. In addition, it provides a stop output which is connected directly to the stop input (pin 13) of the microprocessor.

The output from the input buffer stage of IC2 appears at pin 3 and is fed to a second 10.7MHz ceramic filter (CF2). It then passes to the limiter amplifier which ensures that the input signal is driven well into clipping. The limiter, in turn, drives the quadrature FM detector associated with the tuned circuits on pins 10 and 11.

The circuit effectively performs quadrature detection by measuring the voltage across L16 and the parallel 82pF capacitor. L17 limits the voltage swing across the quadrature coil while the 4.3kΩ resistor reduces the Q of the tuned circuit to provide more linear detection.

The AGC output is extracted from pin 18 and applied to gate 2 of Q6 in the front end via a 1kΩ/33kΩ voltage divider. It operates when a strong signal is present or when a strong out-of-band signal is detected at the wideband AGC input (pin 20). In the latter case, the AGC acts to reduce intermodulation distortion.

Pin 8 of IC2 provides the meter output signal which is split into three separate paths. First, it drives the signal strength meter via D23. Second, it drives the stop threshold (pin 13) via a voltage divider consisting of a 4.7kΩ resistor and trimpot VR4. And third, it drives the blend input of IC3, the LM1870 phase locked loop FM stereo demodulator.

VR4 sets the stop input threshold while VR5 sets the blend threshold (ie, the signal level below which blending from stereo to mono begins). The idea behind blending is to improve the signal-to-noise ratio at very low signal levels. It does this at the expense of stereo separation of the upper treble frequencies.

In addition to the blend signal, IC3

Playmaster AM/FM stereo tuner

also accepts the detected audio signal from pin 15 of IC2. This signal is fed via two 2.2μF capacitors to pins 2 and 19.

VR6 sets the frequency of the VCO which forms part of the phase locked loop. The PLL locks onto the transmitted 19kHz stereo pilot tone and drives an electronic switch at a 38kHz rate to decode the stereo information.

Q9 connects to the forced mono input (pin 4). When Q9 is on, the input is pulled low and the VCO is stopped, thus forcing mono reception.

The 50μs de-emphasis components are at pins 14 and 15. The parallel 15kΩ and 22kΩ resistors set the output level.

The left and right channel audio outputs appear at pins 13 and 12 and are AC-coupled to 19kHz notch filters based on L18, VR7 and L19, VR8. Adjustment of the notch filter frequency in each channel is by means of a tuning slug in the relevant inductor, while the associated trimpot adjusts the sharpness and depth of the null.

Following the notch filters are two simple third order low pass filters based on IC8b and IC8c. These roll off the response above 19kHz to remove the residual 38kHz switching components.

The resulting left and right channel audio outputs appear at pins 7 and 8 and are fed to pins 11 and 4 of IC13.

Audio switching

IC13 is a 4052 analog multiplexer/demultiplexer used here as a 2-pole 3-position switch.

The A and B inputs control the switch input selection. Input A selects either the AM or FM audio inputs. When A is high, the FM audio at inputs 3X and 3Y are fed through to the outputs at X and Y. When A is low, the AM inputs at 2X and 2Y are fed to X and Y.

Input B is the mute input and selects either the 0X, 1X or 0Y, 1Y inputs which are all connected to ground. Thus, when B is low (ie, during tuning), the audio inputs are tied to ground and the outputs at X and Y are muted.

Inverting op amps IC8a and IC8d buffer the X and Y outputs of IC13. These each have a gain of 1.44 and provide a nominal 450mV RMS audio output signal.

Microprocessor control

The A and B control signals for IC13 are derived from IC1 which is the NEC microprocessor. In the case of the A input, the control signal is applied from pin 29 via inverters IC9d and IC9e. The B input is direct driven by pin 2.

IC9e also drives Q10, Q11, Q12 and Q13 to switch the power supply rails to the AM and FM tuners. When pin 13 of IC9e is high, Q12 and Q11 are turned on and power is supplied from the +12V regulator to the FM tuner.

When pin 13 of IC9e is low, Q12 and Q11 are off and Q13 is on. This switches on Q10 so that power is now applied to the AM tuner.

Pin 30 of IC1 (ST) controls mono/stereo switching of the AM and FM tuners. When the tuner is switched to mono, pin 30 goes high and the output of IC9b goes low to switch on the mono LED indicator.

Assuming that FM is selected, Q9 also switches on and pulls pin 4 of the FM stereo demodulator (IC3) low. If AM is selected, pin 7 of IC9b goes low and pulls pin 9 of the AM stereo demodulator (IC4) low via D8.

Pin 9 of IC4 is also connected via D7 to the mute output of IC1. This forces pin 9 low during muting, and enables stereo reception almost immediately a station is received. Without this feature, the decoder would detect noise during tuning and go into a long count mode before switching to stereo.

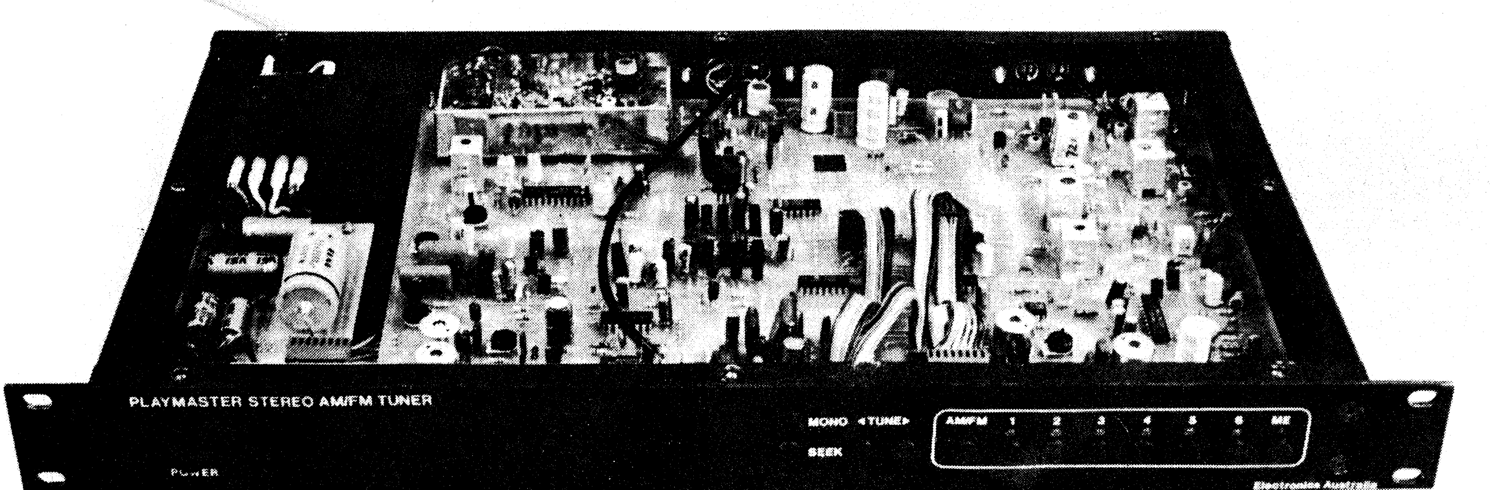
Control loop

The synthesised control loop for the AM and FM tuners involves local oscillator buffer stages Q16 and Q17, dual modulus prescaler IC11, and error output buffer stage Q15 and Q14.

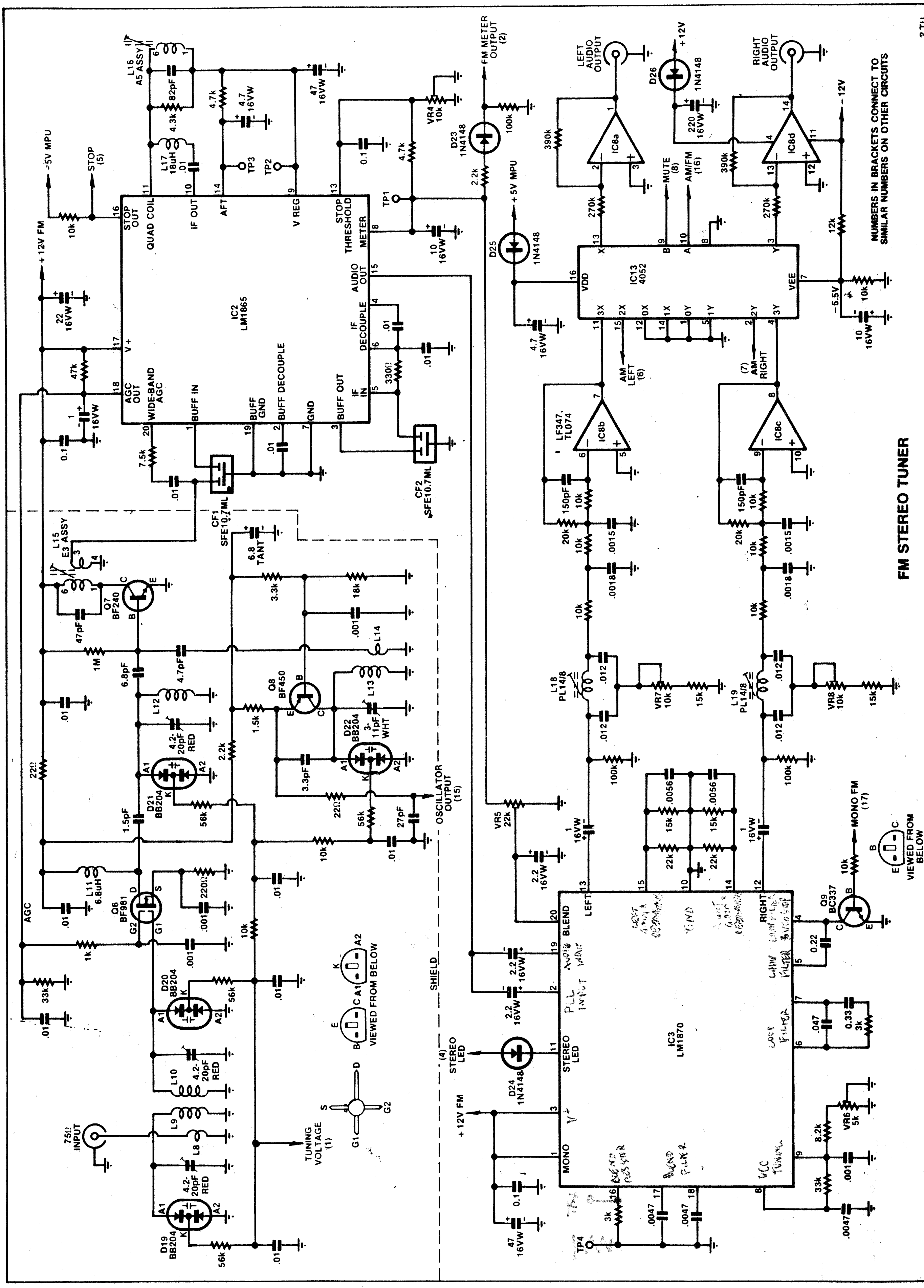
Pin 11 of IC1 drives the error output buffer. It controls the buffer such that, if the local oscillator frequency is lower than the internal reference frequency, the error voltage is low and Q15 and Q14 turn off.

Conversely, if the local oscillator frequency is greater than the internal reference, the error voltage goes high and Q15 and Q14 turn on. When both frequencies are equal, the error output floats (ie, goes open circuit).

A high voltage supply for the error output buffer is derived from an LM317T 3-terminal adjustable regulator. The 2.7kΩ resistor connected between the adjust terminal and ground sets the output of the LM317 to +30V. Q15 and Q14 then set the tuning volt-



The new Playmaster tuner is built into a slimline rack-mounting case fitted with a screened front panel.


FM STEREO TUNER
NUMBERS IN BRACKETS CONNECT TO SIMILAR NUMBERS ON OTHER CIRCUITS
2 TU
IC2 LM1865
IC3 LM1870
IC13 4052
LF347, TL074
75Ω INPUT
TUNING VOLTAGE (1)
OSCILLATOR OUTPUT (15)
FM METER OUTPUT (2)
LEFT AUDIO OUTPUT
RIGHT AUDIO OUTPUT
STEREO LED (4)
MONO FM (17)
MUTE (8)
AM/FM (16)
AM LEFT (6)
AM RIGHT (7)
STOP (5)
+5V MPU
+12V FM
SHIELD
VIEWED FROM BELOW

age applied to the varicap diodes in the tuner front ends.

Q16 and Q17 buffer the FM and AM local oscillator outputs. For FM, buffering is achieved using FET Q16 which has L20 as its drain load. This stage drives IC11 which divides by either 16 or 17, depending on the modulus control output from IC1 (pin 16).

The output of IC11 is fed to the FM oscillator input of IC1, divided by an internal programmable divider, and compared with the reference frequency, as discussed last month.

Multiplexing

Apart from synthesis control, IC1 also drives the multiplexed display. D1-D6 are the digit driver outputs while the segment driver outputs are from Sa and Sg.

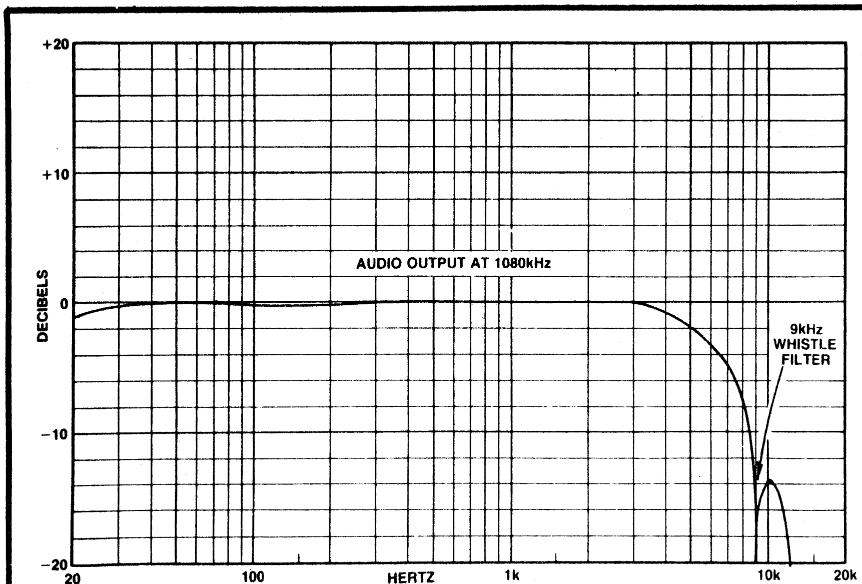
The D1-D6 outputs are fed to Schmitt trigger inverters IC12a to IC12f and these drive transistors Q18-Q23. Q19-Q22 switch the display digits while Q23 switches the memory indicator LEDs. Q18 switches the FM and AM LED indicators.

The Sa to Sg segment outputs drive the display via 75492 display drivers. Note that 10kΩ resistors are connected in series with the inputs to these drivers. These reduce the current drawn from the segment outputs of IC1 and thus help reduce the multiplex noise induced into the tuner circuitry.

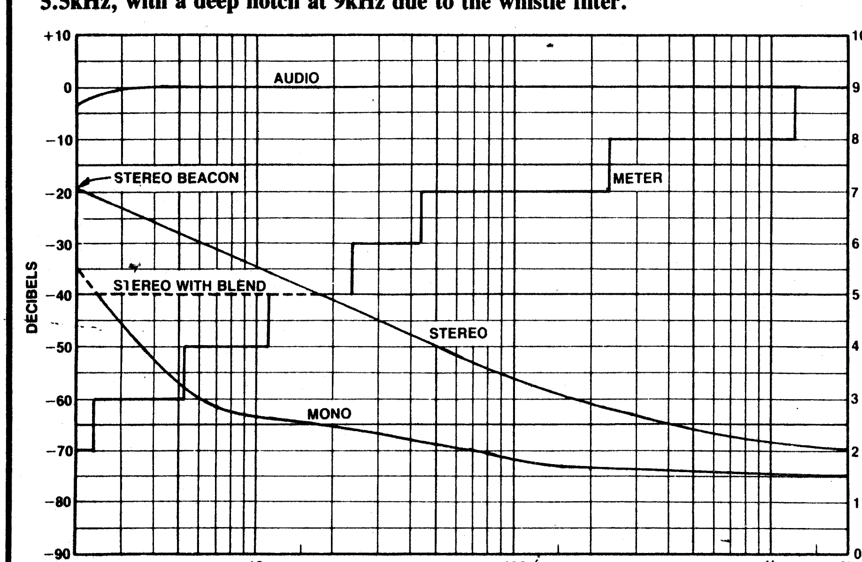
In addition to driving the display drivers, the Sa, Sb, Sc, Se and Sf segment outputs are also connected via diodes D28-D32 to the switch matrix. The other side of the switch matrix is connected to the K0 to K3 inputs of IC1. These inputs are normally held low with the 5.6kΩ resistors.

When a switch is closed, a high output from one of the segment outputs will pull K3, K2, K1 or K0 high, depending on the particular switch pressed.

Diodes D33-D36 select the various programmed options in IC1. For example, D36 ensures that memory indication is by way of separate LEDs. Without this diode, the memory display output would be in 7-segment format.



This graph plots the bandwidth of the AM tuner. The response is 3dB down at 5.5kHz, with a deep notch at 9kHz due to the whistle filter.



This graph plots the performance of the FM tuner. Ultimate signal-to-noise ratio is 75dB in mono and 70dB in stereo.

Power supply

The tuner circuitry requires several rail voltages and these are derived from a PL24/20VA transformer (shown on the AM tuner circuit).

First, an unswitched positive supply rail is provided by a full wave rectifier circuit consiting of D11, D12 and a 470μF filter capacitor. This provides the standby power for the 5V regulator connected to the VDD and INT-bar pins of IC1.

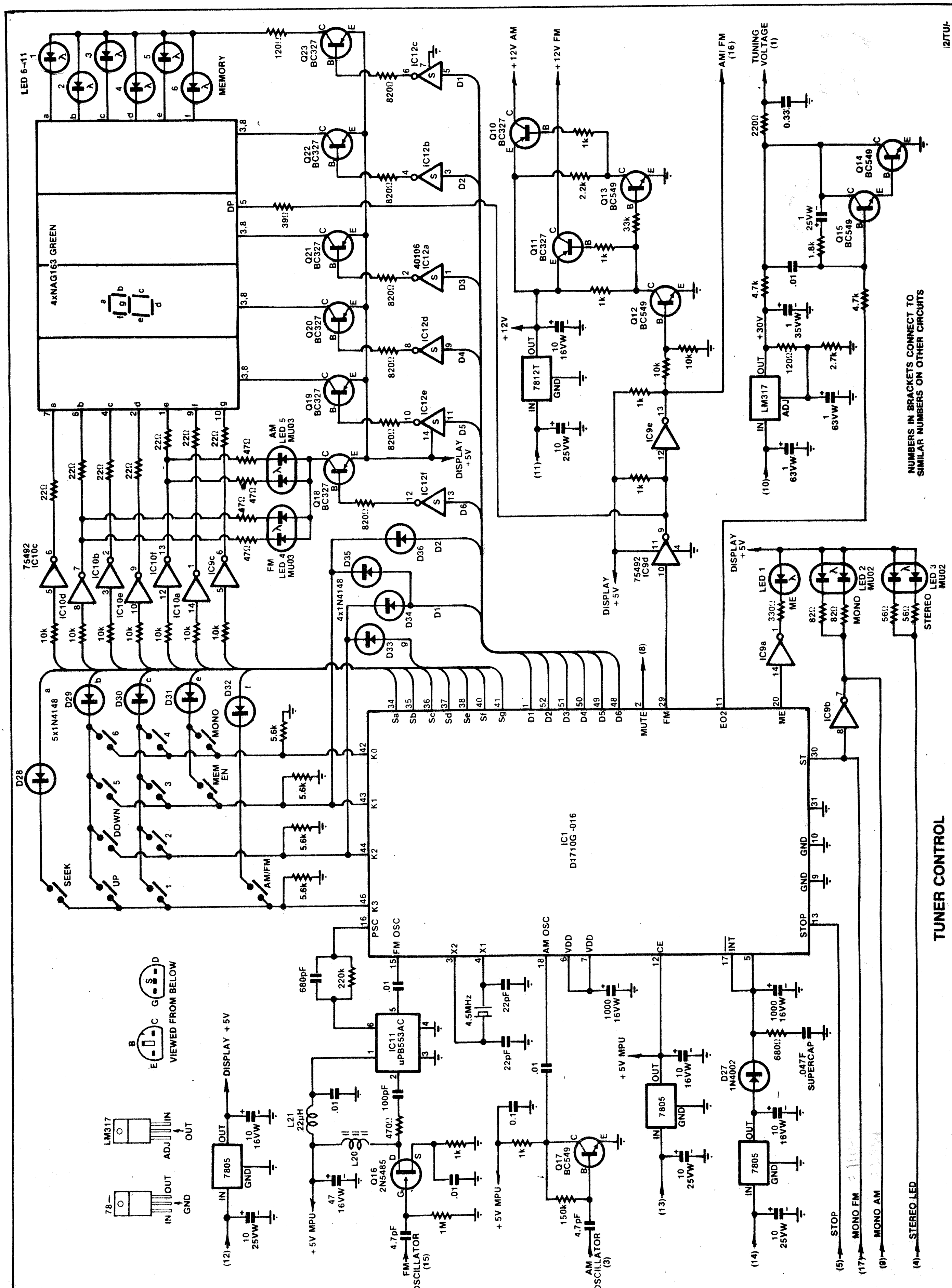
A 47,000μF (.047F) super capacitor is also connected to these pins via a 680Ω resistor. Diode D27 isolates the super capacitor from the regulator output. The supercap retains the station settings in memory when power is removed from the circuit.

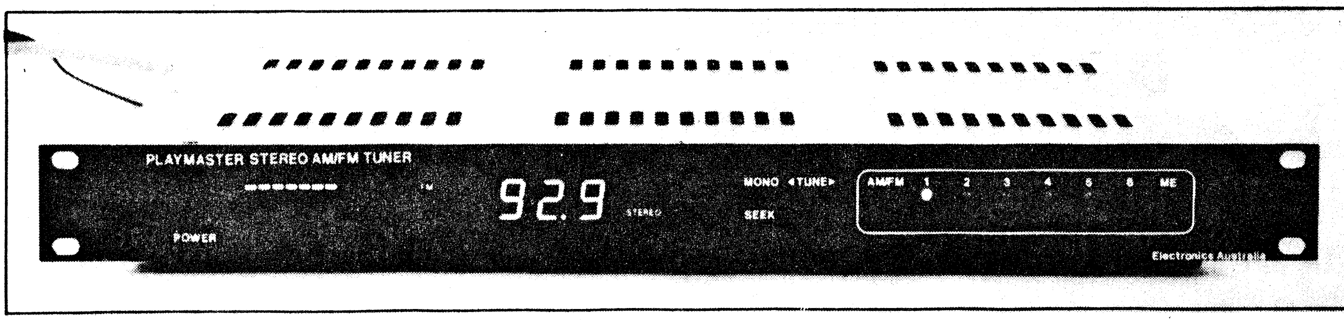
Following the power switch is a bridge rectifier (D13-D16) which supplies +15V and −17V rails. These unregulated DC rails drive several 3-terminal regulators to give regulated ±12V rails and two +5V rails.

Note that ICs 6,7,8, & 13 are supplied with power via isolating diodes. This has been done to provide a slow turn-off, thus preventing thumps in the audio output when the tuner is switched off.

Diodes D17, D18 and their associated capacitors function as a voltage doubler. The output of the doubler appears at the cathode of D18 and supplies a nominal +51V rail to the LM317 30V regulator.

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


TUNER CONTROL
NUMBERS IN BRACKETS CONNECT TO SIMILAR NUMBERS ON OTHER CIRCUITS
IC1
D1710G-016
4xNAG163 GREEN
LED 6–11
MEMORY
IC11
uPB553AC
Q16
2N5485
Q17
BC549
LM317
7812T
7805
VIEWED FROM BELOW
DISPLAY +5V
+5V MPU
+12V AM
+12V FM
AM/FM
(16)
TUNING VOLTAGE
(1)
FM OSCILLATOR
(15)
AM OSCILLATOR
(3)
STOP
MONO FM
MONO AM
STEREO LED
SEEK
UP
DOWN
MEM EN
MONO
AM/FM
5x1N4148
4x1N4148
.047F SUPERCAP
4.5MHz
12/TU-



Third article has the construction details

Playmaster AM/FM stereo tuner Pt. 3

Although the circuit of our new Playmaster AM/FM Stereo Tuner is fairly complex, construction is quite straightforward. This month, we detail the PCB assemblies, give the coil winding details, and present a complete wiring diagram.

by JOHN CLARKE

Because the tuner circuit includes a number of specialised components, we recommend that it be built from a complete kit. This constructional article will assume that pre-punched metalwork has been supplied, along with a screen-printed front panel and all other necessary parts.

A main single-sided printed circuit board (PCB) coded 85tu12 and measuring 330 x 220mm accommodates most of the tuner circuitry. This includes the AM tuner, FM IF strip, filters, and microprocessor control components.

A smaller double-sided PCB coded 85fm12 and measuring 94 x 49mm is used for the FM front end. This board is shielded with a tinplate box and secured to the main PCB with screws and nuts. Electrical connections between the two boards are via an 8-way pin header.

A second double-sided PCB accommodates the display and switch components. Coded 85db12 and measuring 370 x 35mm, it is secured to the front panel of the tuner case. Rainbow cables connect between this PCB and the main PCB via 8-way pin headers and matching cable connector sockets.

Finally, a single-sided PCB coded 85ps12 and measuring 65 x 100mm is used for the power supply circuitry.

The complete tuner circuit is housed in a slim-line rack mounting cabinet measuring 430 x 254 x 44mm.

Commence construction by inspecting the PCBs for shorts between tracks or breaks in the copper pattern. Check also that all the holes have been drilled and that a square cutout has been made in the main board for IC1.

If the square cutout has not been made, proceed as follows: Position IC1 on the underside of the PCB and line up the IC pins with the copper tracks. Now mark the outline of the IC body at each corner with a pencil and drill a large hole in the centre of the marked area.

The cutout can then be carefully filed to the correct size. Once completed, the IC should sit neatly in the hole with all pins lined up with the copper tracks.

Do not solder IC1 in position at this stage.

Begin assembly of the PCBs by installing PC stakes at all external wiring points. These points are clearly indicated on the wiring diagrams. PC stakes are also used on the main board to terminate the connections from the loop antenna sockets and to terminate the leads to T1.

Note that PC stakes 1 to 8 on both the main and power supply PCBs are inserted upside down (ie, with the shorter section on the component side). This is to allow the power supply wiring to be run to the underside of each PCB.

The PC stake on the display PCB (at point 11) is also inserted this way. All other stakes are inserted conventionally, with the longer section on the component side of the board.

Main PCB

Continue assembly on the main PCB by installing all the low profile components. These include the wire links, resistors, diodes, ICs and transistors. Note that some of the resistors are 2% tolerance types. These are marked with a star on the parts layout diagram.

Check the orientation of the diodes, transistors and ICs when they are being installed. Be sure to use the correct semiconductor type at each location.

A special technique is used for soldering IC1 into position. This is a surface-mounting component containing 52 closely-spaced leads. As a result, normal soldering methods will cause solder bridges between the tracks.

First, use your soldering iron to tin each of the copper track lands where the pins of the IC will make contact. Use a soldering iron temperature that is just sufficient to melt the solder and quickly tin the copper with a thin layer of solder.
along each of the pre-tinned leads of IC1 to clean them. The IC can then be installed from the copper side of the board with the pin 1 indication (a dot in one corner) positioned as shown in the parts layout diagram.

To solder the IC, first clean the tip of your soldering iron with a damp sponge to remove any excess solder. Now heat each corner pin of the IC along its whole length so that it melts the solder on the copper track below. At the same time, use a small screwdriver to hold the heated pin hard against the PCB until the solder cools.

The remaining leads of IC1 are then soldered in similar fashion.

The main PCB assembly can now be completed according to the wiring diagram. This involves installing the capacitors, ceramic filters, trimpots, 8-way pin headers, regulator ICs and the crystal.

Note that the display +5V regulator lies flat against the PCB and is fitted with a small U-shaped heatsink. Apply a smear of heatsink compound to the back of the regulator tab before bolting it down.

Six different capacitor types are used on the main PCB: electrolytic, tantalum, supercap, metallised polyester and two types of ceramic. The electrolytics and tantalums are the only polarised types. The supercap is non-polarised and can be inserted either way round.

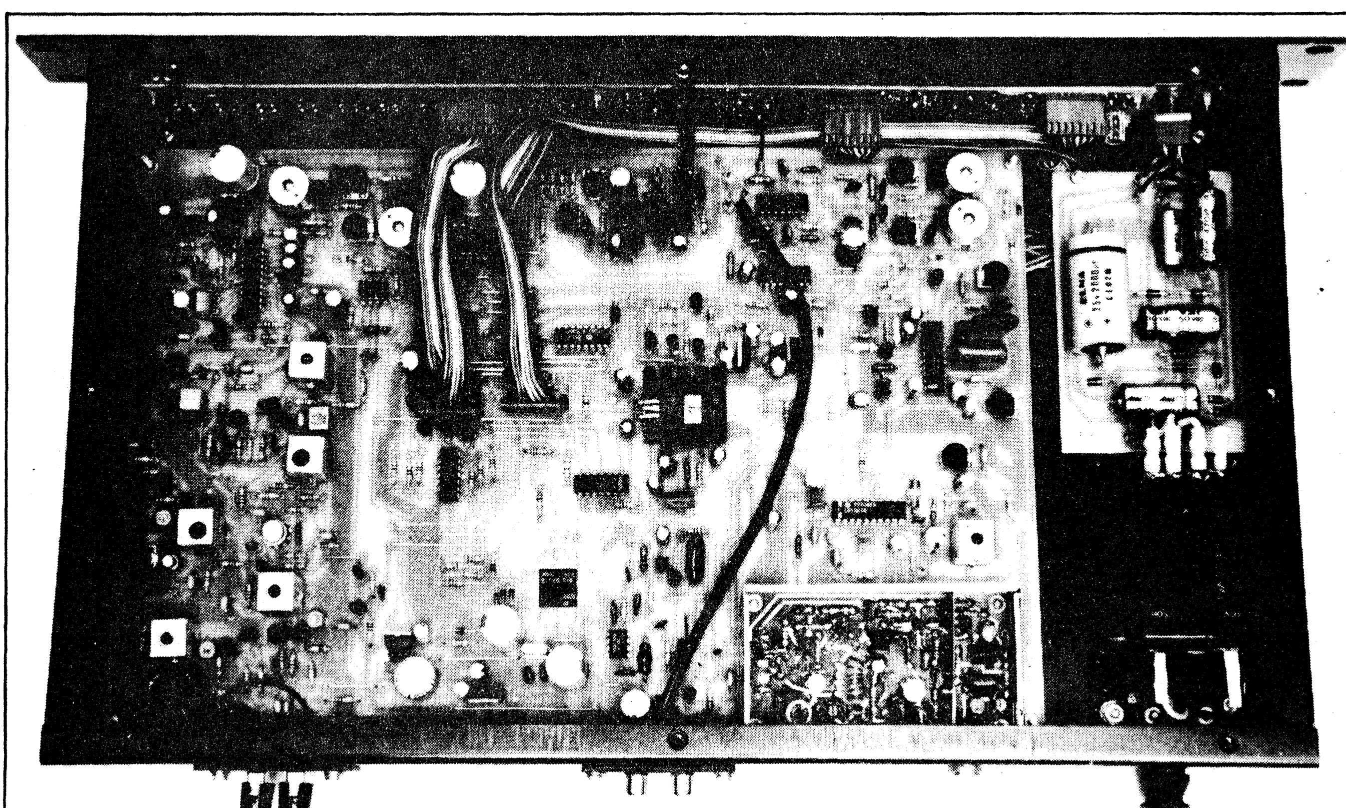
The Philips miniature ceramic plate capacitors are flat-bodied types with yellow bodies and coloured tops. Do not substitute for these capacitors otherwise the tuner will be microphonic. They are marked on the parts layout diagram with a small cross.

The three trimmer capacitors in the AM tuner section should all be oriented so that the flat side of the trimmer body is inserted into the ground track.

Ceramic filters

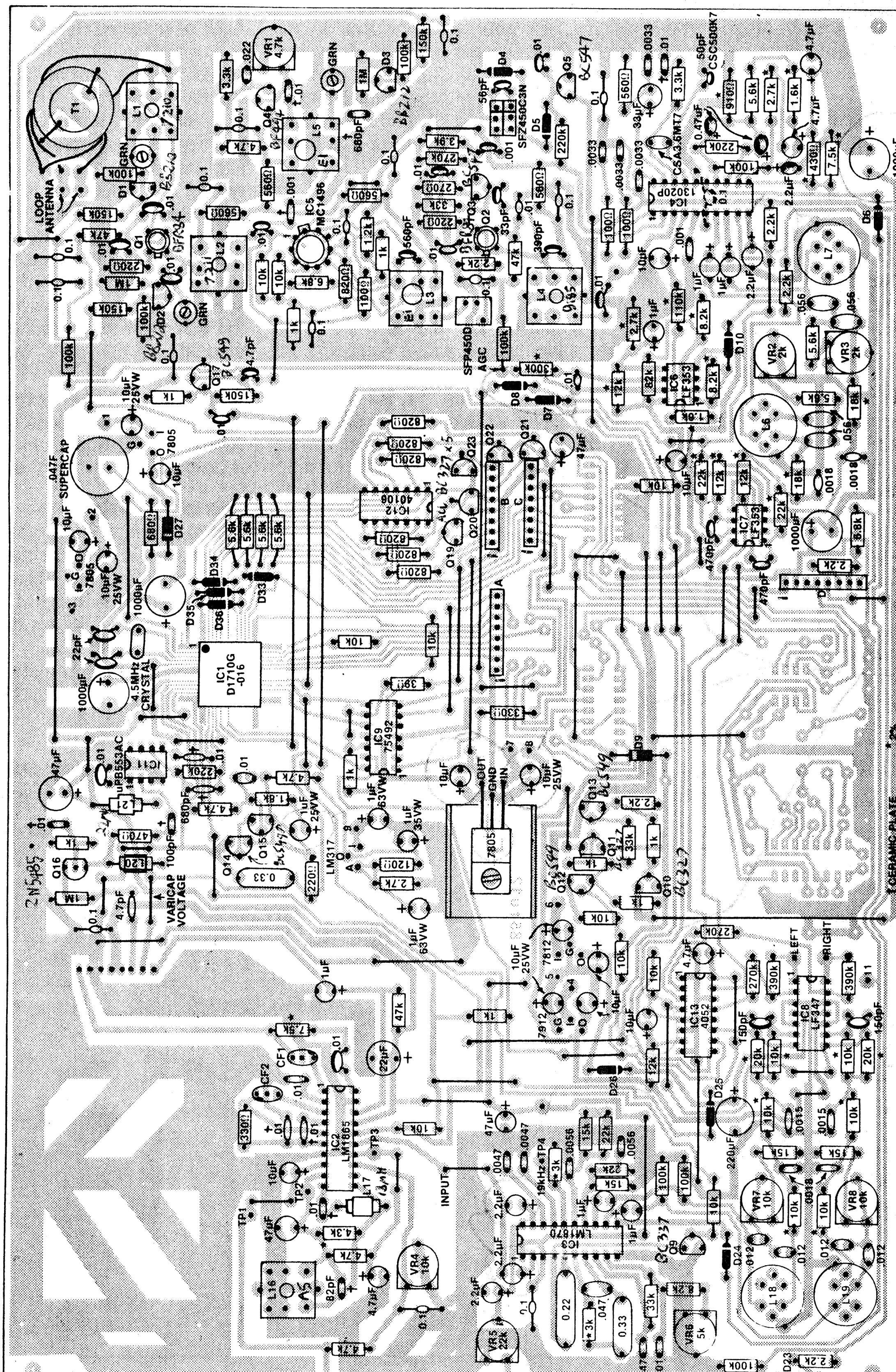
Five ceramic filters are used in the circuit, two in the FM tuner and three in the AM tuner. The SFE10.7ML ceramic filters in the FM section (CF1 and CF2) have a dot on the body to indicate the output pin.

The SFP450D can only be installed one way, while the SFZ450C3N narrow



Repeated from last month's issue, this view shows the layout inside the chassis. The FM front end is at bottom right.

Playmaster stereo tuner



IC7 TL072

IC8 TL074

Here is the parts layout for the main PC board.

band ceramic filter should be installed so that the arm of the cross embossed on top of the filter body is adjacent to the right hand side of PCB. The CSA3.6MT7 resonator can be installed either way round.

Coil winding

Fig.1, Fig.2 and Table 1 show the coil winding details. To avoid confusion, we recommend that each coil be soldered into circuit as it is completed.

The 16-turn centre-tapped primary of T1 is bifilar wound (see Fig.2). To do this, cut two 550mm lengths of 30B&S enamelled copper wire (ECW) and twist the two wires together using a hand drill until there is about one twist every 3mm.

Wind 16 turns on the toroid and determine the ends of each winding using a multimeter. The 50-turn secondary can now be wound on the opposite side of the toroid using 36B&S ECW.

Fig.2 shows how the primary and secondary windings are connected to the PC stakes on the main PCB. The toroid is secured to the PCB using two wire straps as shown in the layout diagram.

L1 is a standard 7210 coil which requires an extra winding between pins 4 and 5. To do this, first remove the metal cover from the coil baseplate. This done, jumble wind 50 turns of 36B&S ECW on the stem above the ferrite shield for the main coil. A few drops of molten candle wax over the coil will hold the windings in place.

Table 1

Coil	Type	Wire	Turns	Start	Finish
L1	7210	36B&S	50	pin 4	pin 5
		jumble wound			
L3	E1	36B&S	60	pin 5	pin 4
		36B&S	60	pin 4	pin 6
		bifilar wound			
		36B&S	46	pin 2	pin 3
		jumble wound			
L5	E1	36B&S	6	pin 2	pin 4
		36B&S	70	pin 4	pin 3
		36B&S	7	pin 2	pin 1
		36B&S	9	pin 6	pin 5
		jumble wound			
L6,L7	PL14/8	36B&S	~~250~~ 303	pin 3	pin 5
		jumble wound			
L15	E3	30B&S	16	pin 1	pin 6
		30B&S	7	pin 4	pin 3
		jumble wound			
L16	A5	30B&S	16	pin 1	pin 6
		single layer wound			
L18,19	PL14/8	36B&S	~~250~~ 303	pin 3	pin 5
		jumble wound			
~~L21~~ L20		26B&S	13 turns on F16 slug		
		single layer wound			

Clean the ends of the wire with a sharp knife or fine glass paper and solder them to terminals 4 and 5. Finally, replace the metal ~~shield.~~ 1 metre

L3 is wound ~~on~~ an E1 coil assembly. Cut two ~~755mm~~ lengths of 36B&S ECW and twist them together using a hand drill so that there is about one turn every 3mm. Wind on 60 turns and separate each winding by testing for continuity with a multimeter.

It is important that the start of one winding be connected to pin 5 and the start of the other to pin 4. The finish ends of the windings go to pins 4 and 6 respectively.

The 46 turns of 36B&S wire can now be wound on top of the bifilar winding. This done, slip the ferrite cylinder over the winding, install the plastic cover and screw in the ferrite slug. Finally, replace the metal shield.

L5 is also wound on an E1 coil assembly and is critical for correct oscillator operation. Table 1 has the winding details. Be sure to wind all coils in the same direction and seal the windings with wax after they have all been completed.

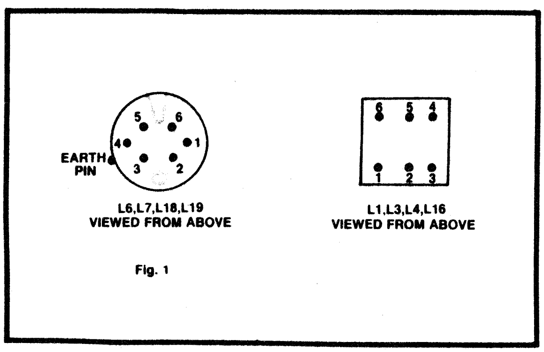


Fig. 1

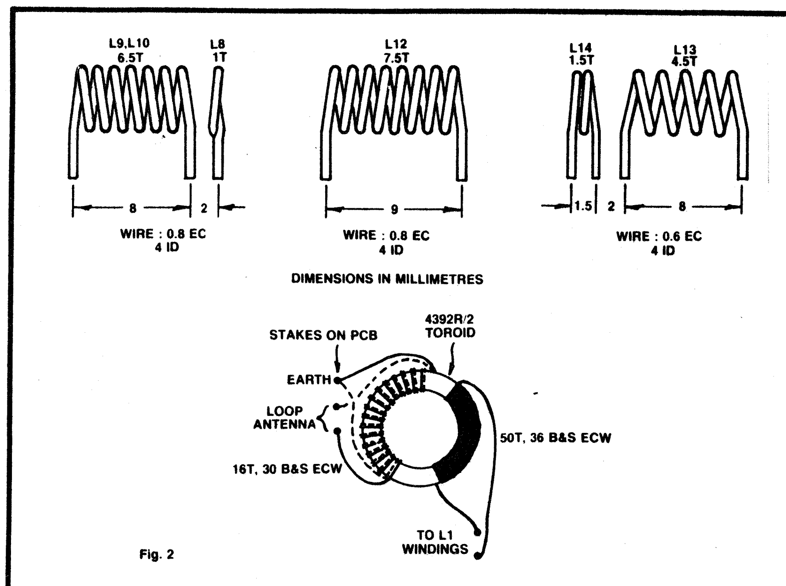


Fig. 2

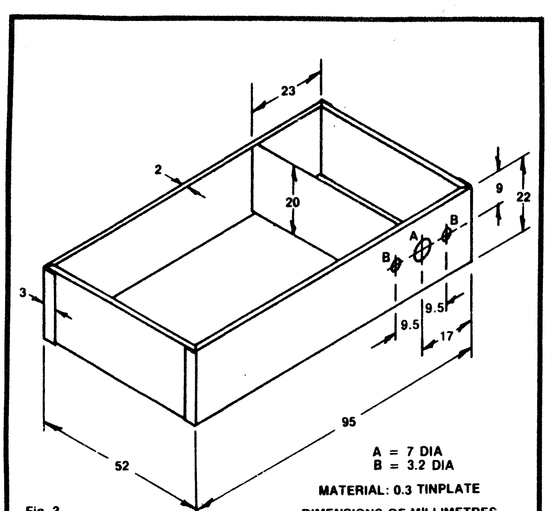
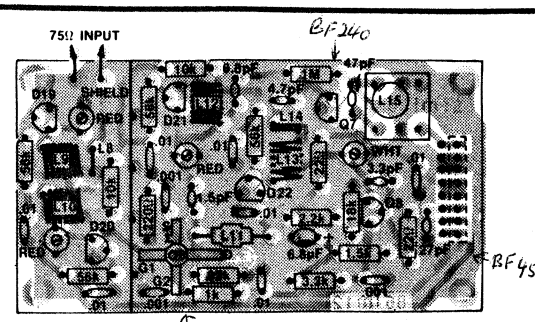


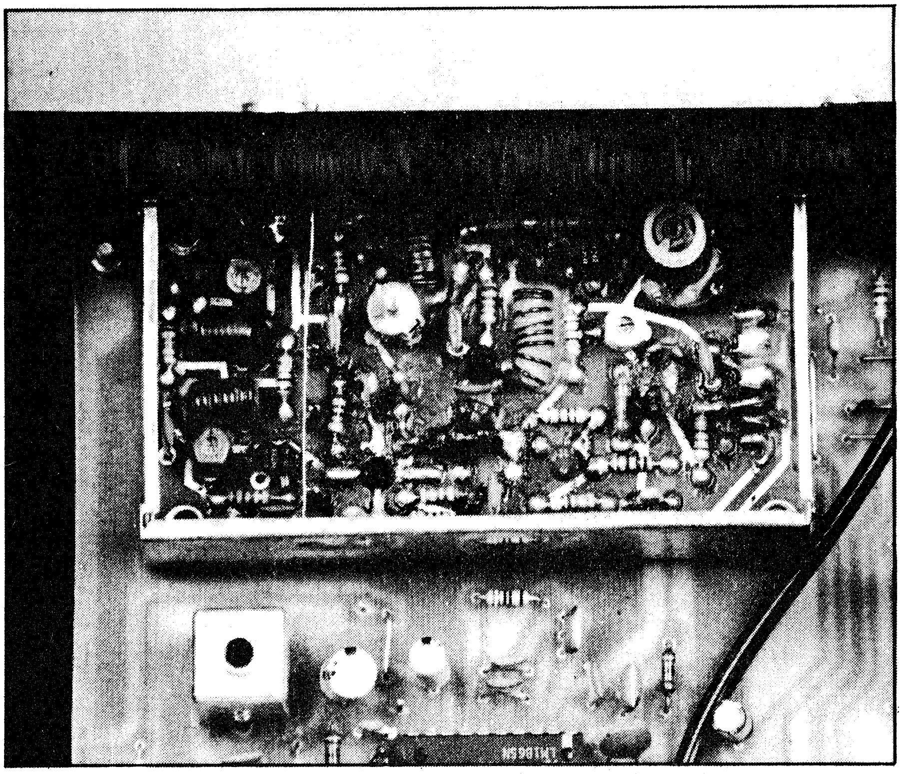
Fig. 3

This diagram shows the dimensions of the metal shield for the FM front end.



Parts layout for the FM front end. The parts are mounted on the track (blue) side of the PCB.

Playmaster stereo tuner



Above: view of the FM front end. The coils are waxed after alignment to prevent microphonics. At right are the parts layout diagrams for the display PCB.

L6, L7, L18 and L19 each require ~~250~~ 303 turns of 36B&S ECW wound on PL14/8 formers. These coils are best wound using a hand drill. The coil former can be held between two washers with a bolt and nut to secure the assembly. The bolt is then held in the drill chuck.

A small amount of molten wax can be used to keep the winding in position. Alternatively, insulation tape can be used.

Note that there are two halves to the PL14/8 potcores: the basecore which includes an integral nut, and the top half from which the inductance adjustor enters to screw into the nut. The two halves go together and enclose the coil former.

This assembly is housed within the brass container with the spring located between the top of the container and the top half potcore.

Be sure to solder the leads of the windings to pins 3 and 5 as shown on the baseplate diagram. The baseplate then inserts into the brass container and is aligned so that the rectangular cutout in the side of the container coincides with the slot on the baseplate. Tabs on the container bend over to hold the completed coil assembly together.

L16 and ~~L21~~ L20 are relatively straightforward and consist of single layer windings on their respective formers (see Table 1). Seal the L16 winding with wax after it has been completed.

FM front end

The first thing to note here is that the parts are installed on the track side of the 85fm12 double-sided PCB. This means that the component leads must be soldered on the component side of the PCB and, in some cases, on the groundplane side as well.

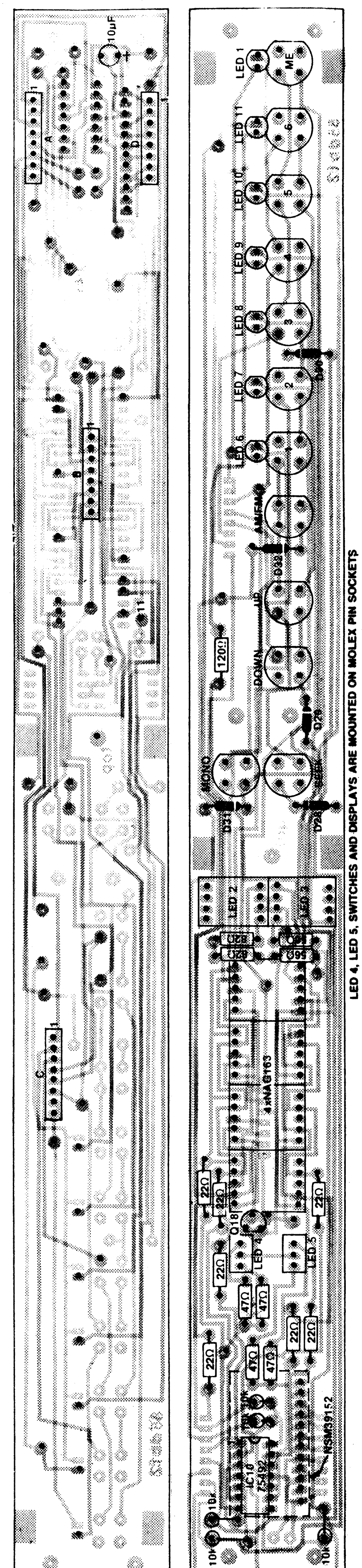
The procedure is quite simple: just remember to solder each component lead wherever it passes through a copper pad.

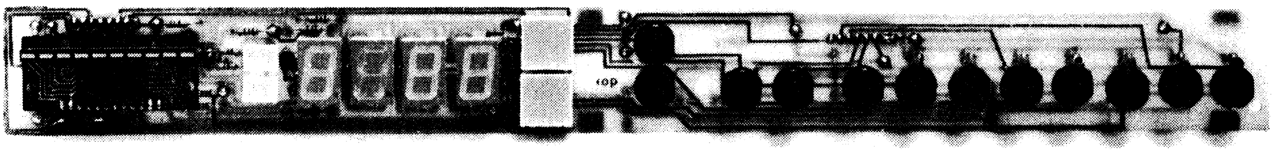
Begin by installing the six PC stakes (two for the antenna input and four to support part of the metal shield). The resistors, capacitors, transistors and varicap diodes can then be installed, together with inductor L11.

Keep all component leads as short as possible. That is mandatory if it is to perform well.

The 8-way pin header is shown dotted on the parts layout diagram. It is mounted on the underside of the board. Note that several through-board links must be installed adjacent to the pin header.

The trimmer capacitors should be ori-





The assembled display PCB. Note that many of the parts are mounted using Molex pins (see text).

ented so that the pin on the flat side of the trimmer moulding connects to ground.

Coils

Diagrams for the air wound coils are shown in Fig.2. These should all be tightly wound on a 4mm mandrel (eg, a 5/32-inch drill bit) to agree with the dimensions shown on the diagram.

Be sure to wind each coil in the direction indicated in Fig.2 so that it will correctly fit the PCB. Remove the enamel from the ends of the windings before soldering.

L15 is wound according to the data in Table 1 but note that the metal cover is not used with this coil. Note also that the coil must be waxed to prevent microphonic effects. The pins of L15 are soldered to the underside of the PCB only.

Metal shield

A tinplate metal shield surrounds the FM front end and the diagram for this is shown in Fig. 3.

Cut the tinplate to size with tinsnips and bend up the pieces with flat nose pliers. This done, drill holes for the 75-ohm panel socket and attach it to the panel using machine screws and nuts. The side pieces can then be soldered to the ground plane of the PCB and the corners soldered together.

The inner shield piece is soldered at either end to the side pieces and also to the four PC stakes located in-line across the PCB.

Connections between the 75-ohm socket and the PCB are made using short lengths of tinned copper wire.

The FM front end module is secured to the main board using screws and nuts. First, insert the screws from the top of the FM front end PCB and screw on the nuts. The nuts are then soldered to the PCB groundplane and the screws removed.

Finally, mount the module in position, secure it by inserting the four screws from beneath the main PCB, and solder the 8-way pin header.

That completes the FM front end.

Display PCB

The display PCB (85db12) involves several unusual construction methods, so it would be wise to read the following procedure carefully.

There are two overlay diagrams, one showing the components on the top of the PCB and the other showing the components mounted on the underside.

Begin assembly by installing the resistors, diodes, transistor and IC10 on the top of the board. Note that some of the resistors are mounted end-on. As before, component leads must be soldered to both sides of the PCB.

Those pads that do not hold component leads are used for through-board links. There are nine of these through-board links in all.

LED 4, LED 5, the pushbutton switches and the 7-segment displays are all mounted using Molex pins. Take care not to get solder inside the pins when soldering them to the top of the board. You can avoid this by soldering on the flat side of the pin only.

Once the Molex pins have been mounted, the displays and switches can be installed. Orient the switches so that the flat of each switch body faces the right hand side of the PCB.

The 7-segment displays and switches are pushed all the way into the Molex pins, while the LED 4 and LED 5 bar modules are only partially inserted. Line them up with the tops of the 7-segment displays, then solder the bar modules to the Molex pins to secure them.

LEDs 2 and 3 are installed by standing them off the PCB as far as possible.

The NSM39152 bar display module is mounted proud of the PCB using 0.7mm tinned copper wire. You will need 12, 15mm lengths. Solder these into the edge connector bus, then mount the module on the PCB so that it lines up with the 7-segment displays.

The rear side of the display board carries the 8-way pin headers and a 10μF electrolytic capacitor. Solder these in position, then return to the top of the board and install LED 1 and LEDs 6-11 in position (but don't solder them yet).

Next, mount the display PCB on the sub-front panel using 12mm standoffs and countersunk screws and nuts. The front panel can then be bolted to the case using the Allen screws supplied, and the LEDs pushed into the front panel holes. Check that the LEDs are all correctly aligned before soldering their leads.

At this stage, you should check that all switches operate without sticking before removing the display board from the front panel assembly. Any switches that catch in the front panel holes can be adjusted by carefully bending the supporting Molex pins.

Construction of the display PCB can now be completed by soldering the LEDs to the pads on the top side of the board.

Power supply PCB

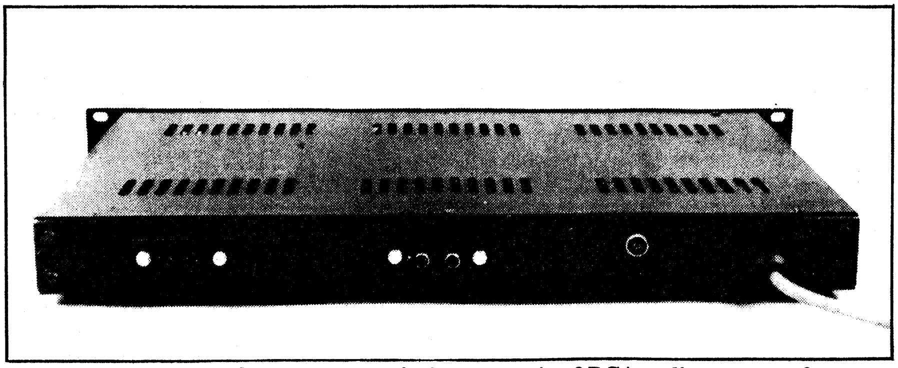
Assembly of the power supply PCB (85ps12) is straightforward. The main point to watch here is that one of the 470μF capacitors must be rated at 63VW (to allow for variations in mains voltage). The other two 470μF capacitors are rated at 25VW.

Check the orientation of each component before soldering. The diodes are all 1N4002 types.

Chassis assembly

Now that all the PCBs have been completed, wiring can proceed between the power supply PCB and the main PCB. This wiring is run beneath the two PCBs and must be installed before the boards are mounted in the case.

Playmaster stereo tuner



The rear panel carries the antenna terminals and a pair of RCA audio output sockets.

With this job completed, the various items of hardware can be mounted. Begin by fitting the four rubber feet to the corners of the baseplate, then mount the antenna terminals, RCA sockets and power transformer. The wiring diagram shows the general layout inside the chassis.

The main PCB is mounted on 6mm spacers and should be located so that the 75-ohm antenna socket passes through a matching hole in the rear panel. We secured each of the untapped spacers with a nut before installing the PCB. A second set of nuts is then used to secure the board to the stand-offs.

The power supply PCB is mounted on 12mm spacers directly in front of the transformer.

The method of securing the power on/off switch will differ according to the brand of switch. It must be mounted so that the pushbutton knob protrudes the correct disance through the front panel.

In some cases, the switch can be mounted directly on the sub-front panel. In other cases, a mounting bracket may be required to move the switch away from the front sub-panel.

We used a mounting bracket made from fibreglass board material. This was stood-off the sub-front panel using 6mm spacers.

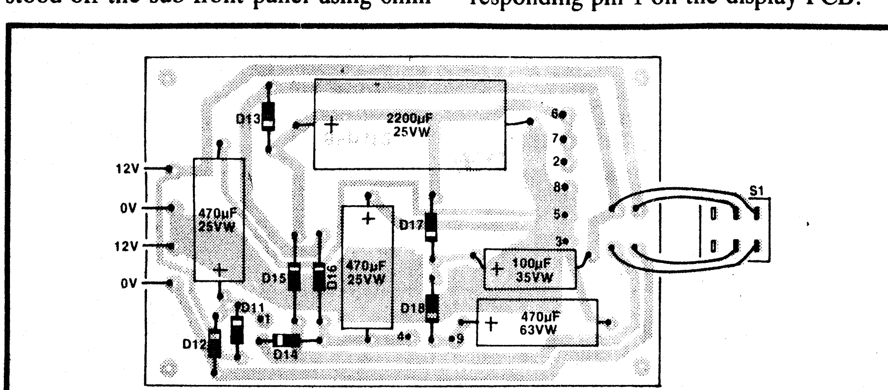
The next step is to mount the display PCB on the sub-front panel using the 12mm standoffs. Note that it may be necessary to use insulating washers between the PCB and standoffs to avoid shorting out the PC tracks. Check this point carefully or you'll strike trouble later on.

The wiring between the display and main PCBs is run using four 8-way cable assemblies. Cut four lengths of 8-way cable — two at 260mm, one at 330mm, and one at 100mm. Separate the ends for 25mm and strip 2mm of insulation from each wire.

The cables can now be connected to the sockets. Insert the cable through the connector socket shell and crimp and solder each wire to the crimp terminals. This done, pull the terminals back into the connector socket.

When the cable assemblies are completed, they can be plugged into the PCB headers. Connect the long cable between the A headers, the two medium length cables between the B and D headers, and the short cable between the C headers.

Check that pin 1 of each header on the main PCB matches up with its corresponding pin 1 on the display PCB.



Parts layout for the power supply PCB. Note the 470µF 63VW electrolytic capacitor.

The display board wiring can now be completed by running a short length of hookup wire from point 11 back to the corresponding point on the main board.

Rear panel wiring

A dual screened cable connects the left and right audio outputs on the main PCB to the output RCA terminals. Note that the cable screen is soldered directly to a PCB stake on the PCB adjacent to the output sockets. From there, a short length of hookup wire also runs to the outer contacts on the RCA sockets (see wiring diagram).

The AM antenna terminals are connected to the main board using short lengths of hookup wire.

Mains wiring

The mains cord passes through the rear panel and is clamped with an inline cord clamp grommet. The earth wire (green/yellow) is terminated to an earth lug while the active (brown) and neutral (blue) leads are terminated on the transformer pins using bullet connectors. These connectors should be insulated using plastic sleeving.

Scrape away the anodising from around the mounting hole before bolting the earth lug to chassis. This is essential to ensure a good earth contact. Make the earth lead slightly longer than the active and neutral leads so that it will be the last to break if strain is placed on the cord.

The transformer secondary is connected to the power supply PCB using the four leads supplied. Connections to the on/off switch should be run using mains-rated hook-up wire.

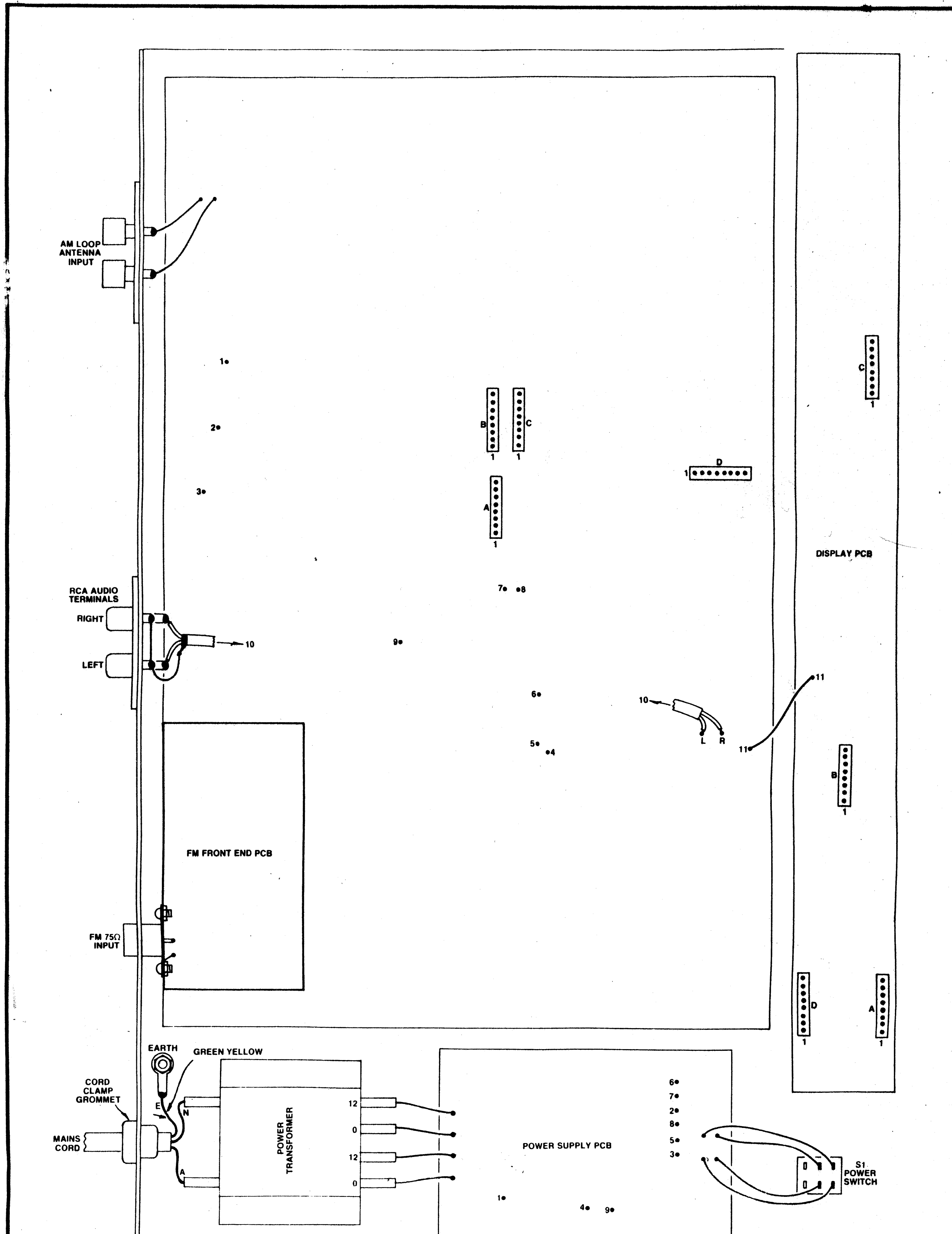
Final assembly

A negative film artwork will be supplied with each kit and this should be affixed to the sub-front panel using double-sided adhesive tape. Position the artwork so that the 7-segment displays and the signal strength meter are all visible.

Finally, the plastic sheet can be fitted to the front panel cutout and the panel bolted to the case. In the prototype, the plastic sheet was held in position by virtue of being a force fit into the panel cutout.

Alternatively, the plastic can be secured by applying a thin film of adhesive to several points along the edges.

That's all we have space for this month. Next month, we will continue with the alignment details. In the meantime, do not be tempted to switch the unit on as there are a few important points to follow.


AM LOOP ANTENNA INPUT
RCA AUDIO TERMINALS
RIGHT
LEFT
FM FRONT END PCB
FM 75Ω INPUT
DISPLAY PCB
EARTH
GREEN YELLOW
CORD CLAMP GROMMET
MAINS CORD
POWER TRANSFORMER
POWER SUPPLY PCB
S1 POWER SWITCH

Step-by-step alignment details

Playmaster AM/FM stereo tuner Pt.4

Alignment of the Playmaster AM/FM Stereo Tuner is quite straightforward and requires only a few simple tools. The procedure mainly involves adjusting the various tuned circuits in the RF, IF and local oscillator stages on a step-by-step basis.

by JOHN CLARKE

While most readers will be unfamiliar with the alignment of superheterodyne tuner circuits, the procedure is really very simple. You don't need a lot of fancy tools and instruments either. The only tools required are a small screwdriver, a plastic alignment tool, a tuning wand and a multimeter.

An audio signal generator and a digital frequency meter would also be handy for adjusting the 9kHz and 19kHz notch filter circuits, but are by no means essential.

An unusual but necessary tool is the coil tuning wand, which you will have to make yourself. It consists simply of a short length of plastic tubing with a piece of brass (a brass nut or screw) in one end and a piece of ferrite (coil slug) in the other. You can use the F16 slug from coil L16 to make a temporary wand.

The tuning wand is used when making adjustments to the FM front end.

The plastic alignment tool is used for adjusting the coil cores and trimmer capacitors and can be purchased from your kit supplier. Do not use a screwdriver or other metallic object, as these will affect the circuit operation and give incorrect results.

Switch on

Initially, the tuner power switch must be switched on before mains power is applied. This is to ensure correct resetting of IC1. After that, the tuner may be switched on and off using the power switch in the conventional manner.

Note: this switch-on procedure should also be adopted if the tuner is disconnected from the mains for more than a few days.

Check that the power switch is on (confirm this with your multimeter), then plug in the power cord and switch on the mains. Now check the supply voltages: there should be +5V at the output of each of the three 5V regulators, +12V and −12V on the 7812 and 7912 regulators respectively, and about +30V on the output of the LM317.

If any of these voltages is incorrect, check the input voltage to the regulator.

If all is correct so far, check the operation of the front panel switches and the display. There should be a frequency reading on the display and either the AM or FM indicator should be lit. Pressing the AM/FM switch should change both the indicator and the frequency reading.

Next, check that the +12V rail is switched to the AM circuit when AM is selected, and to the FM circuit when FM is selected. For AM, check for +12V on pin 6 of IC4; for FM, check for +12V at pin 17 of IC2.

Assuming all is well, operate the TUNE buttons and check that the AM display ranges from 522 to 1611kHz in 9kHz steps. Similarly, check that the FM display ranges from 87.9 to 107.9 MHz in 100kHz (0.1MHz) steps.

Each memory LED should light when its respective switch is pressed. Initially, all the memories will probably be set to the same frequency. To program each memory, select the required frequency using the TUNE buttons, then press the ME switch and the required memory switch.

The ME LED should extinguish as soon as a memory switch is pressed, or if the ME switch is re-pressed. If no switch is pressed it should automatically extinguish after five seconds.

Next, check that the SEEK control sends the tuner scanning up the frequency band. Don't expect it to lock onto a station at this stage though. That won't happen until after alignment.

The tuner should stop seeking as soon as another button (other than MONO) is pressed.

Finally, check that the programmed memories remain intact when the tuner is switched off and on at both the power switch and mains.

FM alignment

To align the FM front end you will need the tuning wand, alignment tool and multimeter.

The first step is to set the local oscillator range which must be from (87.9 + 10.7)MHz to (107.9 + 10.7)MHz. This is easily achieved by measuring the varicap voltage. The procedure is as follows:

(1) Select FM by pressing the AM/FM switch, then adjust the white 3-11pF trimmer capacitor associated with L13 to about half-setting. Note that the trimmer is at minimum capacitance when the pointer faces the flat side of the trimmer, and at maximum setting when it faces away from the flat side.

(2) Measure the output voltage from the LM317 regulator (between ground and the metal tab of the regulator) and write it down.

(3) Connect your multimeter between the link marked "varicap voltage" and ground (use the tinplate shield for ground), and set the display on FM to read 87.9MHz. Adjust the spacing between the L13 coil windings for a reading of about 3V.

Note that opening the coil decreases both the inductance and varicap voltage. Conversely, closing the coil increases the inductance and the varicap voltage.

Note also that the above conditions are only valid when the local oscillator is locked at the frequency indicated by the display plus the 107.9MHz offset. If the oscillator is not locked, the varicap voltage normally stays at around 28V.

(4) Once the varicap voltage at 87.9MHz has been set, set the display to 107.9MHz by pressing the TUNE down button. This done, adjust the 3-11pF trimmer capacitor (white) for a reading that is 2.5V less than the LM317 output voltage. Normally, this will be about 27V.

Note that the alignment tool may affect the FM local oscillator, so always read the voltage with the alignment tool out of the trimmer.

(5) Check that the varicap voltage at 107.8MHz is lower than at 107.9MHz. If not, readjust the trimmer for a slightly lower varicap voltage reading at 107.9MHz and check again.

(6) The new trimmer capacitor setting will have altered the voltage at 87.9MHz. This means that L13 will require further adjustment. Set the display to read 87.9MHz and readjust L13 for a reading of about 3V.

(7) Return to 107.9MHz and readjust the trimmer as in steps 4 and 5. Repeat the above process until both voltages are correct.

RF filters

The next step is to align the RF filters so that they track with the local oscillator. This requires two good off-air signals, one near 90MHz and the other around 106MHz. (A complete list of station frequencies appears elsewhere in this issue.)

Note that if there are no local stations near these frequencies or if there is only one FM station, then alignment accuracy will suffer. Where there is more than one station, choose two that are widely separated.

If only one station is available, alignment can only be achieved for that station. When another station begins transmission, the RF stage will require further adjustment.

Alignment of the RF filters requires use of the tuning wand. Here's how it works:

When the ferrite end of the wand is inserted into the coil, it increases the inductance. If the signal level increases, the coil needs to be made more inductive and this is achieved by compressing the coil.

Similarly, when the brass end is inserted into the coil, the inductance is decreased. If the signal level increases, the coil should be made less inductive by opening up the coil windings.

When the coil is adjusted so that the signal level goes down or does not change when the ferrite and brass ends are independently inserted, the coil is correctly tuned. Here's what to do:

(1) Connect an FM antenna to the 75-ohm input. This can be a dipole, an FM Yagi or log periodic (wide band) TV antenna. If the antenna is for a 300Ω termination, a 300-75Ω balun transformer will be required.

(2) Adjust each of the 4.2-20pF trimmers (red) associated with L9, L10 and L12 to about half setting.

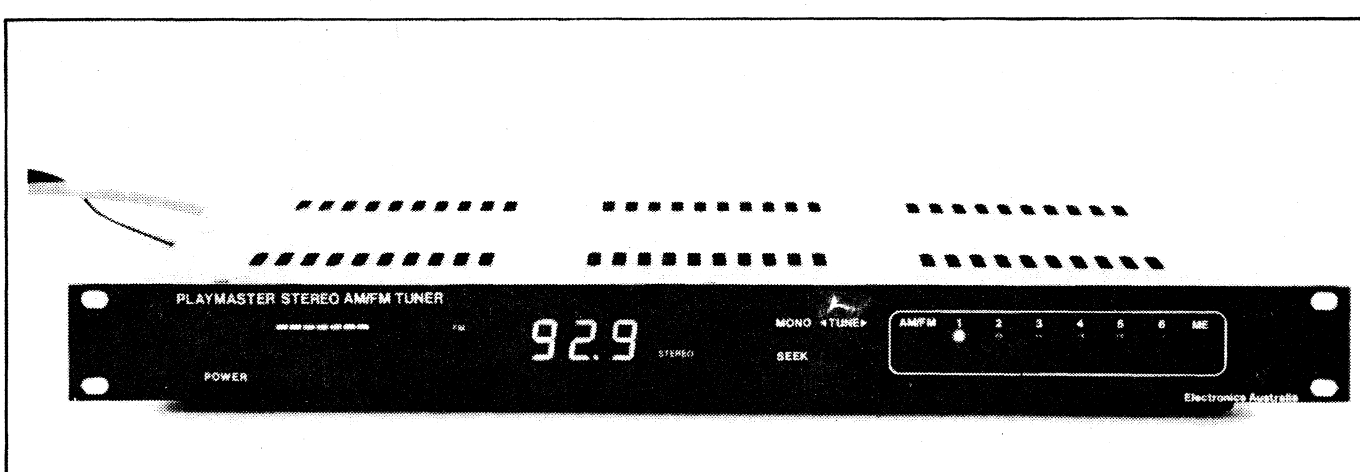
(3) Connect a multimeter between ground and test point TP1, and select the station near 90MHz. Program this station into memory 1 (press ME and memory 1).

(4) Using the tuning wand (see above), adjust L9 and L10 for maximum signal reading on the multimeter. Note that the signal from L9 couples inductively to L10. Do not attempt to alter the 4mm edge to edge spacing between them as set by the PCB hole positions.

During this entire procedure, make frequent checks of the AGC voltage at pin 18 of IC2. If it drops below +5V, temporarily short the AGC line to ground until the adjustment is complete.

(5) Tune L12 for maximum reading with the multimeter connected to TP1. Don't forget to check the AGC. (Note: it would be nice to have two multimeters, one to monitor TP1 and the other to monitor the AGC).

(6) Select the station near 106MHz and program this into memory 2. Ad-



Our new Playmaster tuner offers stereo AM performance matching that of professional studio monitors.

just the 4.2-20pF trimmer capacitors (red) with the alignment tool for a maximum reading (meter on TP1). Note: always check the reading after the tool has been removed from the trimmer.

(7) Return to the memory 1 frequency and re-align the coils again using the tuning wand. Re-adjust the trimmers at the memory 2 frequency. Repeat this procedure until the coils and trimmers both peak without further adjustment.

(8) Adjust L15 for a maximum signal when receiving either the memory 1 or memory 2 frequency.

(9) Impregnate the coils in the FM front end with wax. This is to prevent the coils from vibrating and producing microphonics in the resulting audio.

Quadrature coil

(1) Remove the F16 slug from the tuning wand and screw it into the L16 IF coil.

(2) Tune to a station that gives at least a level six reading on the signal level meter. Connect the multimeter across TP2 and TP3 and adjust L16 for 0V.

Seek adjustment

By now the FM tuner should operate on Seek. The level of signal at which the tuner stops is set by trimpot VR4. Rotate the trimpot until the tuner only stops at stations that give more than level 5 on the signal level display.

This setting stops the tuner at stations that will produce a noise free signal in stereo. You can of course set this control so that the tuner stops at any level of signal desired.

Blend adjustment

The blend adjustment at VR5 sets the signal level below which blending occurs. We opted to keep the stereo signal-to-noise ratio above 40dB. This is shown in the quieting curves published in January 1986.

(1) Connect your multimeter between the wiper of VR5 and ground. Tune to a station that gives level 5 on the signal strength meter.

(2) Adjust VR5 for a reading of 0.8V.

If you cannot find a station that provides a level 5 signal, try adjusting the antenna until the correct signal level is indicated (eg, try using a short length of wire).

Stereo decoder

VR6 must be adjusted so that stereo decoder IC3 can lock onto the 19kHz stereo pilot tone. This can be achieved in one of two ways:

(1) Set the mono/stereo switch to stereo mode.

(2) If a frequency meter is available, temporarily connect a 15kΩ resistor between the 19kHz output at TP4 and the positive supply. Note that there are two PC stakes provided for this. Connect the meter to TP4.

(3) Disconnect the antenna, tune to a vacant spot on the band and adjust VR6 for a reading of 19kHz on the frequency meter. Remove the 15kΩ resistor.

Note that the circuit diagram shows TP4 at ground potential. This is an error — TP4 should go direct to pin 16 of IC3.

(4) If no frequency meter is available, tune to a station and adjust VR6 for stereo indication on the front panel. Rotate the trimpot clockwise and find the position where the stereo switches off. Now rotate the trimpot anti-clockwise and find the position where stereo ceases.

The correct position for VR6 is midway between these two locations.

19kHz filters

The 19kHz notch filters are tuned by adjusting coils L18 and L19 and trimpots VR7 and VR8. This requires an audio signal generator. If no audio signal generator is available, ignore this step.

(1) If a frequency meter is available, set the output frequency of the audio generator to exactly 19kHz.

(2) If no frequency meter is available, the following method will allow the audio generator to be set to give a highly accurate 19kHz signal. It requires an audio amplifier and a loudspeaker.

Switch off the tuner and solder a 15kΩ resistor between TP4 and the adjacent PC stake for the positive supply of the FM tuner. This done, connect a 22kΩ resistor between TP4 and the input to the amplifier. Set tuner to MONO.

Finally, connect a 100kΩ resistor between the audio generator output and the same input of the amplifier.

Switch on the tuner and tune into a station broadcasting in stereo. The 19kHz output from TP4 will now beat with the audio oscillator output and this can be heard via the loudspeaker. Adjust the frequency of the audio generator until no beat note is heard.

The audio generator frequency will now be within about 20Hz of 19kHz.

(3) Alternatively, if a dual trace oscilloscope is available, compare the 19kHz output at TP4 with the audio generator frequency. Use the XY position on the timebase control to display a Lissajous figure. Both frequencies are the same when the trace does not rotate.

(4) Now cut the input link to IC3 (as marked on the overlay diagram) and apply the 19kHz signal from the audio generator to the IC3 side of the link.

The Balanced Loop Antenna

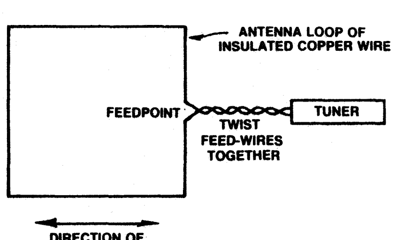


Fig. 1

In order to obtain a noise-free signal, the AM tuner circuit is designed for use with a balanced loop antenna. Because the loop antenna is a balanced circuit, it acts to reduce common mode interference.

The loop antenna should be made from a suitable length of insulated copper wire arranged as an upright rectangular loop. Ideally, it should be oriented so that the plane of the loop points towards the transmitting antenna. It should also be located as close to the tuner as possible to avoid long feedwires.

The pickoff point should be half way up one vertical side of the loop, preferably the side furthest away from the transmitter. The two feedwires should be twisted together and run to the antenna inputs of the tuner as shown in Fig.1.

In strong signal areas, a small loop which surrounds a window may be satisfactory. In most cases though, a much larger loop or a multiple loop antenna will be necessary to give adequate signal strength.

Playmaster stereo tuner

Note that the signal level from the generator should not exceed 3V RMS. If the generator cannot supply this amount of signal, set the level to maximum.

Use your multimeter to monitor the resulting 19kHz left and right audio outputs. This should be set to AC millivolts. Note that most digital multimeters will not measure at 19kHz, so it will be necessary to resort to a standard moving coil meter. Alternatively, use an oscilloscope.

(5) Adjust the tuning slug L18 for a null in the left channel. This done, adjust VR7 for best null. Similarly, adjust L19 and VR8 for the right channel.

(6) Switch off, remove the 15kΩ and 22kΩ resistors, and remake the link to IC3.

AM tuner local oscillator

As with the FM tuner, alignment of the AM tuner begins with adjustments to the local oscillator.

(1) Select AM by pressing the AM/FM switch.

(2) Connect a multimeter between ground and the emitter of Q4 and adjust trimpot VR1 for a reading of 1.6V. This sets the output level of the local oscillator.

(3) The next step is to set the local oscillator range which must be from (522 + 450kHz) to (1611 + 450kHz). As for the FM tuner, this is achieved by measuring the varicap voltage.

Rotate the green 3-30pF trimmer capacitor associated with L5 to about half-setting.

(4) Connect a multimeter between ground and the link marked "varicap voltage". Set the AM display to read 522kHz and adjust the slug in L5 for a voltage reading of 1.2V.

(5) Press the TUNE down switch to select 1611kHz on the display. Adjust the trimmer capacitor for a reading of about 27V.

Note that the alignment tool may affect the oscillator, so always check the voltage after the alignment tool has been removed.

(6) Tune to 1602kHz and check that the varicap voltage is lower than at 1611kHz. If not, readjust the trimmer for a slightly lower varicap voltage at 1611kHz and check again.

(7) Repeat steps 4 and 5 and continue until the voltages at each frequency are correct.

Note that if you cannot arrive at the correct voltages, the oscillator level should be slightly re-adjusted and the procedure repeated.

RF filters & IF stage

The RF filters must now be aligned so that they track with the local oscillator. Two strong off-air signals will be required, one near 603kHz and the other near 1395kHz.

If local stations are not near these frequencies, choose the two that are furthest apart. The low frequency station can be as low as 531kHz, while the high frequency station can be anywhere above 1206kHz.

To receive these, you will need to construct a balanced loop antenna. This should be connected as shown in Fig.1.

(1) Adjust the two trimmers associated with L1 and L2 to about half setting. Also, adjust the slugs in L1 and L2 so that they protrude slightly from the metal can. This will very roughly align the front end.

(2) Connect the multimeter between ground and the AGC point at the 100kΩ resistor (near D8) as indicated on the overlay diagram.

(3) Select the station near 603kHz and program this into memory 1. Adjust the slugs in L1 and L2 for a minimum reading on the meter.

(4) Tune the station near 1395kHz and program this in memory 2. Adjust the trimmers associated with L1 and L2 for a minimum reading on the meter.

(5) Repeat steps 3 and 4 and continue until the coils and trimmers require no further adjustment.

(6) Tune in any station that provides good signal strength. Adjust the slugs in L3 and L4 for a minimum reading on the meter.

Checking tracking performance

The AM section is now aligned at two frequencies; ie, those programmed into memories 1 and 2. At other frequencies, however, the alignment may not be satisfactory. This can be checked by selecting six stations which are spread evenly from the low frequency end of the band to the high frequency end.

(1) Program the six selected stations into memory.

(2) Select each station in turn and rotate VR1 slightly in either direction from its set position. Check that the AGC level is close to a minimum for each station — ie, within about 0.25V. Return VR1 to its original setting after each station has been checked.

If tracking is good across the band, you can skip the next section and proceed straight to the stereo decoder. On the other hand, if the alignment is out for some stations, the oscillator and RF stages will require further adjustment.

This will involve adjusting the varicap voltage range for the local oscillator and retuning the RF stages.

The main tracking problem is likely to be at the low frequency end of the AM band. To cure this, the maximum capacitance of the varicaps should be reduced by increasing the varicap voltage at the low frequency end of the band.

(3) Disconnect the multimeter from the AGC and reconnect it between ground and the link marked "varicap voltage". Now select 522kHz and increase the voltage from 1.2V to 1.7V by adjusting the slug in L5.

(4) Repeat steps 5, 6 and 7 in the section "AM tuner local oscillator". Note that VR1 may require further adjustment to accommodate the new range of varicap voltage.

(5) Retune the RF coils as described above under the heading "RF filters and IF stage". Check again for correct tracking and repeat this process until tracking performance is satisfactory. Note, however, that it is impossible to obtain perfect tracking right across the band.

Seek control

(1) Press the SEEK control and check that the tuner stops on the next local station higher up the frequency band.

(2) In most cases, the sensitivity of the SEEK control will be satisfactory for local stations. To increase the sensitivity, increase the 33pF capacitor at the base of Q3 and vice versa.

An alternative here is to replace the 33pF capacitor with a yellow 6.8-48pF Murata trimmer capactor. The trimmer can then be adjusted to provide optimum sensitivity for the SEEK control.

Stereo decoder

(1) Tune in a station (either stereo or mono) and measure the voltages at pins 10 and 19 of IC4 (MC13020P). These should both be about 4V with respect to ground.

9kHz notch filters

The left and right channel notch filters comprise L6 and VR2 for the left channel and L7 and VR3 for the right channel. These require adjustment to null out the 9kHz tone generated by adjacent stations.

(1) If a frequency meter is available, set the output frequency of the signal generator to 9kHz.

(2) De-solder the positive ends of the 1μF capacitors at pins 7 and 8 of IC4. Connect the signal generator output to each filter input in turn and monitor the corresponding audio output with a moving coil multimeter set to AC volts.

Note that up to 3V RMS can be supplied to the filter inputs. If the generator cannot supply this level, then set it for maximum output.

(3) Adjust L6 for a null in the left channel, then adjust VR2 for maximum null. Repeat these adjustments, then adjust L7 and VR3 for the right channel.

(4) If no frequency meter is available, the filters will have to be adjusted by ear. This should be attempted at night when distant stations 9kHz away from the local stations will cause loud 9kHz whistles.

Connect the left output of the tuner to your stereo amplifier, tune to a station with a loud 9kHz whistle and adjust the slug in L6 for minimum whistle. This done, adjust VR2 to eliminate the whistle completely.

(5) Connect the right output of the tuner to the amplifier, disconnect the left, and adjust L7 and VR3 to null out the whistle.

That completes the alignment of the Playmaster Stereo AM/FM Tuner.

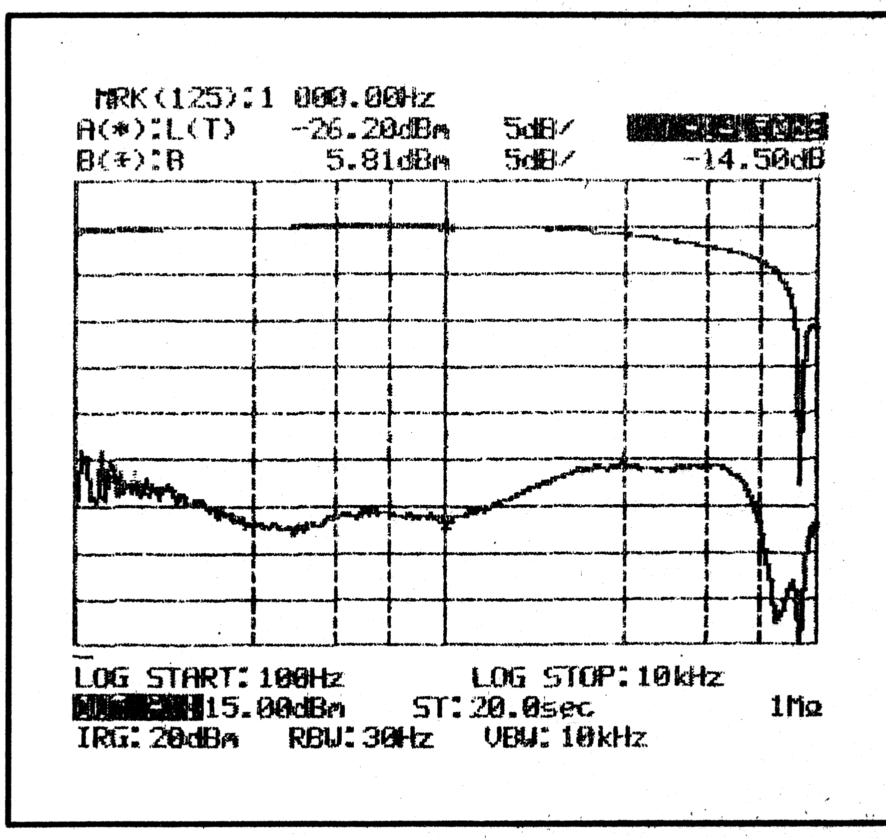
AM bandwidth

Some readers may be keen to experiment with a wider AM tuner bandwidth. This can be obtained by altering the response of the audio output filters, IC7a and IC7b.

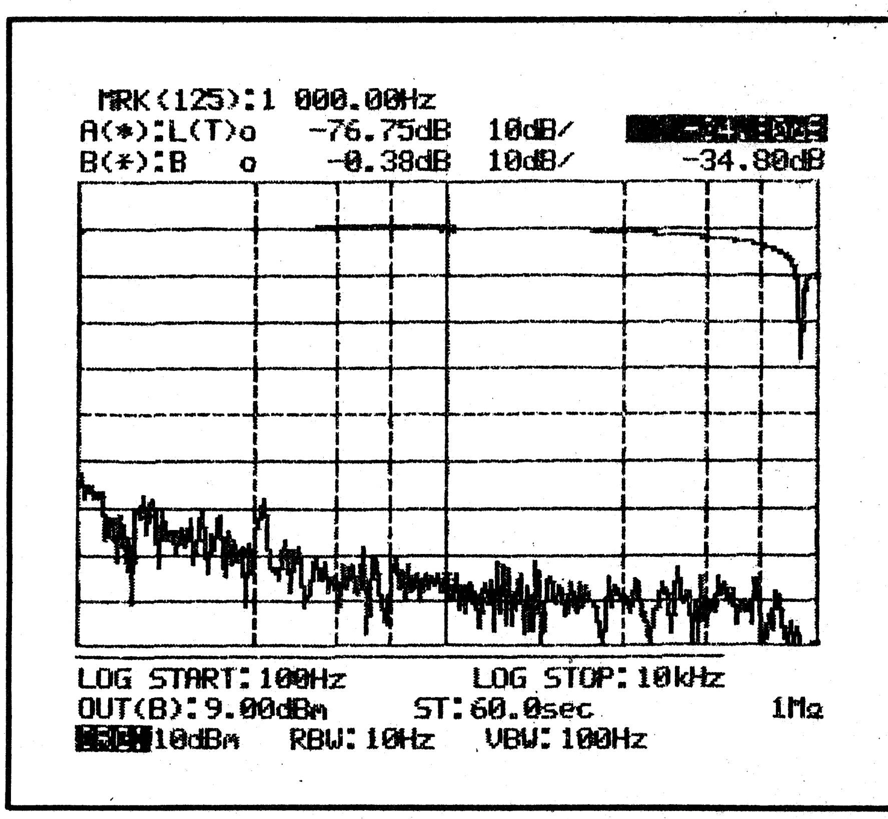
For example, if the .0018μF capacitors are changed to .0082μF, the 18kΩ resistors to 5.8kΩ, the 22kΩ resistors to 8.2kΩ and the 12kΩ resistors to 3.3kΩ, an overall response that is only 2dB down at 8kHz and 6dB down at 10kHz can be obtained.

Be warned, however, that the wider frequency response will result in high frequency monkey chatter becoming quite noticeable at night, particularly in poor signal areas. In most cases, the original values will provide the best overall compromise.

That's all on the new Playmaster tuner for now. We'll take a break for a few months before describing the infrared remote control. In the meantime, settle back and enjoy the results of your efforts thus far.



This graph depicts frequency response on the top trace (including the notch at 9kHz) and stereo separation for the left channel on the lower trace. Separation is better than 30dB at 1kHz. This performance is very closely matched in the right channel.



This graph shows the frequency response (upper trace) and residual noise (lower trace) with respect to 60% modulation. As shown, the signal-to-noise ratio is better than 70dB. These graphs by courtesy of Radio Manufacturing Engineers Pty Ltd.

PLAYMASTER STEREO AM/FM TUNER (December 1985, 2/TU/55): The four Philips PL14/8 potcores used for the 9kHz notch filters (L6 and L7) and 19kHz notch filters (L18 and L19) will be supplied with a different ferrite material from the original part specified. The new type number is 4322 022 22265. Coil winding details for these four coils are now 303 turns each using 36B&S enamelled copper wire. Please alter these details in Table 1 of the February 1986 issue.

In the alignment article of March 1986 the adjustment of the 19kHz notch filters in step 4, page 80, should be made with the FM tuner set in Mono.

The CSC500K7 50pF capacitor used with IC4, the MC13020P AM stereo decoder, will be replaced with a 30pF type in subsequent kits.

Some of the Philips miniature ceramic plate capacitor type numbers have been changed due to supply availability. The capacitance values, however, remain the same.

Notes and Errata

PLAYMASTER STEREO AM/FM TUNER (December 1985-February 1986, File 2/TU/55-57): the following points should be noted in addition to notes and errata previously published:

(1) Diodes D7 and D8 are shown incorrectly oriented on the parts layout diagram. The circuit diagram is correct.

(2) The 1μF capacitor on the collectors of Q14 and Q15 is shown with incorrect polarity on both the circuit and layout diagrams.

(3) The 2.2kΩ resistor shown connected to pin 9 of IC4 on the parts layout diagram is incorrect. The correct value is 100kΩ as shown on the circuit diagram.

(4) The anode of D9 should connect to the output of the +12V regulator, not to the AM +12V as shown on the circuit diagram for the AM Stereo Tuner. The parts layout diagram is correct.

In addition to the above, we recently had an opportunity to inspect a tuner which had been assembled from a Jaycar kit. Here's what we found:

(5) The four 5.6kΩ resistors connected from K0, K1, K2 and K3 of IC1 to ground may need to be increased to 15kΩ to increase the contact bounce time for the switches. Note that this modification is only necessary if the memory LEDs do not light or only light momentarily.

The resistors may need to be reduced again to prevent false triggering (station jumping) if the infrared remote control circuit is subsequently installed.

(6) The 560pF capacitor across L3 at pins 6 and 9 of IC5 may have to be reduced to 470pF to enable tuning of the coil.

(7) The 5.6kΩ resistors in series with VR2 and VR3 in the 9kHz notch filters may need to be reduced in order to obtain maximum null.

(8) For correct operation of the Seek control with FM, pin 12 of IC2 should be connected to ground (pin 7) via a 22kΩ resistor (any value between 10kΩ and 100kΩ will do). This resistor can be installed on the copper side of the PCB.

(9) The 220kΩ resistor at the base of Q5 may have to be reduced to as far as 47kΩ to provide correct sensitivity of the AM Seek control.

(10) Some readers may encounter problems with the AM local oscillator at the low frequency end of the band. This is due to excessive output from the oscillator forward biasing the varicap diode. The problem can be cured by reducing the nine turns of the feedback winding at terminals 5 and 6 of L5. Remove only a portion of a turn at a time and allow the pin 5 lead to exit from beneath the cylindrical ferrite ring covering the coil.

The best procedure is to determine how much of the winding needs to be removed to stop the oscillator altogether (ie, when the varicap voltage suddenly jumps to maximum) and then to wind about 0.2 of a turn extra on the coil. This done, check that the oscillator operates reliably over the entire frequency range and when the power is switched off and on again. If not, increase the winding on the feedback coil.

Notes & Errata

PLAYMASTER STEREO AM/FM TUNER (February 1986, File 2/TU/57): several electrolytic capacitors are shown with reversed polarity on the parts layout diagram on page 60. These are the 1000μF capacitor located at the bottom right hand corner of the PCB and the two 10μF electrolytics immediately to the right of the 7805 regulator (the one with the heatsink) near the centre of the board.

Notes & Errata

PLAYMASTER STEREO AM/FM TUNER (December 1985, File 2/TU/55-57): the 30pF compensation capacitor which replaces the CSC500K7 50pF capacitor in the AM stereo decoder section has three terminal pins instead of two. It should be installed with the centre pin connected to ground and the outer pins both connected to pin 17 of IC4.

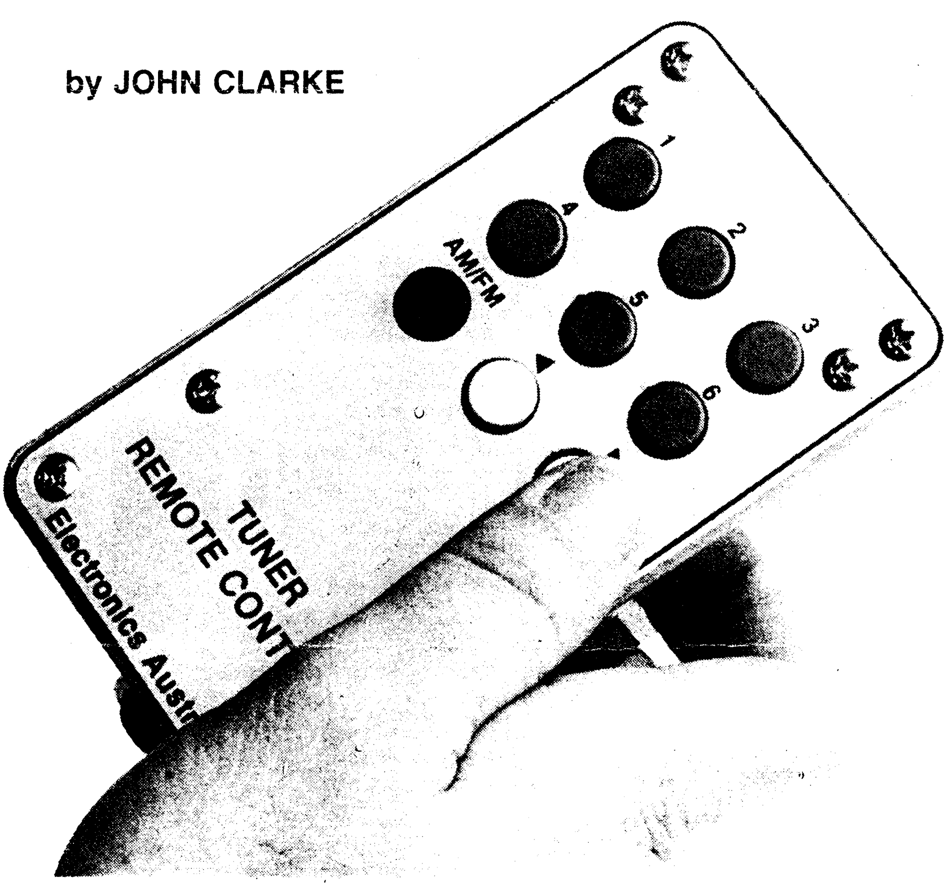
Readers should also note that a 1-metre length of wire is required to wind the 60 turns on coil L3, rather than the 755mm length specified in the article (page 61, Feb. 1986).

Finally, readers should note that L21 in the coil winding table (page 61, Feb.) should have been listed as L20. L21 is a standard off-the-shelf 22μH choke.

Remote control for the Playmaster tuner

For the final touch of luxury on your Playmaster Stereo AM/FM Tuner you need the Infrared Remote Control. With this you can sit back and select any of the 12 programmed stations at will or tune to any FM or AM station with the up and down tuning buttons.

by JOHN CLARKE



Are you an impatient radio listener, dodging from one station to another trying to find the music to suit your mood? Are you a lazy listener, not wanting to shift from your chair when the station you have selected started putting out the wrong notes? If so, you need this remote control accessory if you are to obtain full enjoyment from the Playmaster stereo AM/FM tuner.

You can be far more selective with the remote control. If a particular piece of music or advertisement is not to your liking, then you can zap onto another station with a flick of your button-pushing digit. S'wonderful, S'marvellous!

Although the remote control does not mimic all the control functions available on the tuner, it does allow remote tuning to any station. There are two ways to do this.

Firstly, each of the six AM and six FM stations in memory can be selected. This is done using the six memory switches in conjunction with the AM/FM switch on the remote control. Secondly, to access unprogrammed AM or FM stations, use the Tune up or Tune down switches.

The functions not available on the remote control are Seek, Mono, ME (memory enable) and Power on/off.

The remote control transmitter unit consists of a small plastic case incorporating nine pushbutton switches. Two infrared (IR) transmitting diodes located behind a small red window at the front of the case emit coded infrared light. Power for the unit is supplied from a small nine volt battery.

The remote control receiver circuitry is part of the main printed circuit board for the tuner. For receiving the IR transmission an IR detector diode is located directly behind the neutral density plastic screen used for the tuner display.

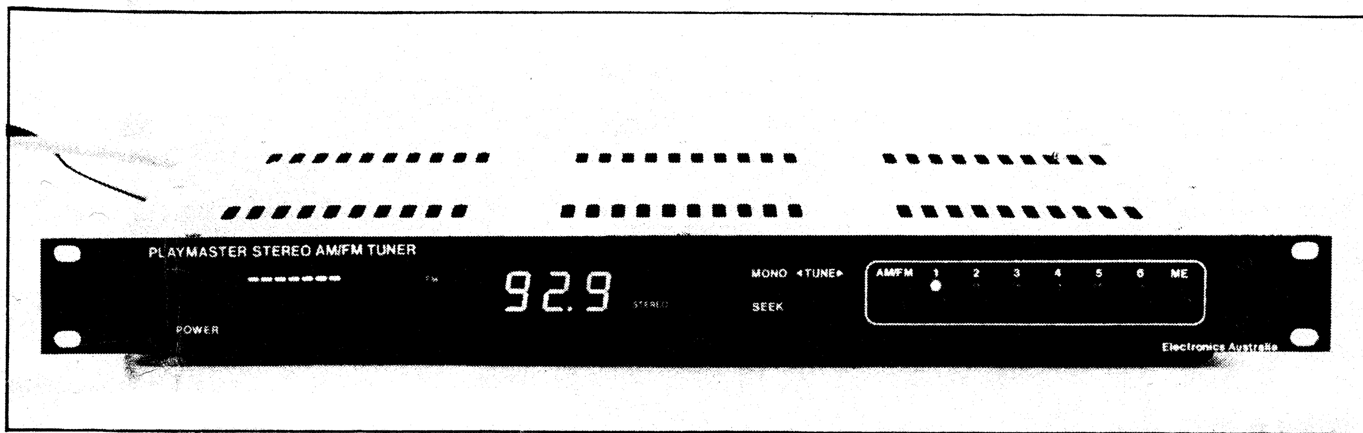
The transmit and receive circuitry is based on the Plessey range of remote control ICs. There is one transmitter and one preamplifier IC in this range, and ten different receiver ICs. These are suitable for TV remote control, models, computers and other general applications.

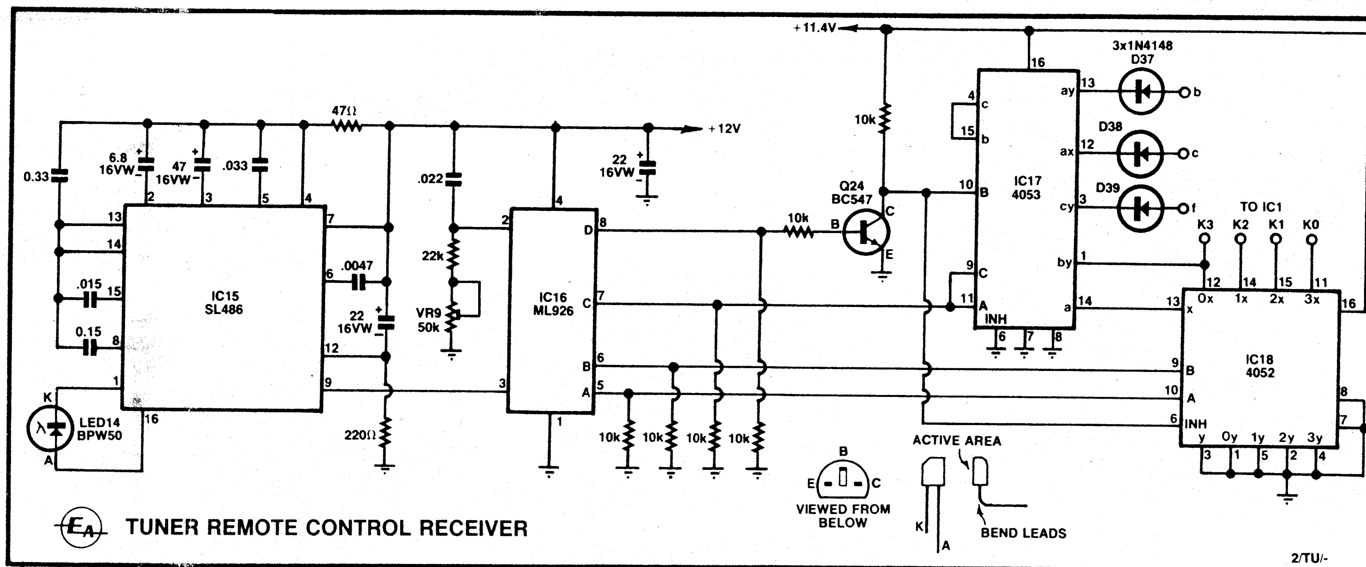
We used the SL490B transmitter, SL486 preamplifier and the ML926 receiver.

Transmitter circuitry

The transmitter circuit comprises the SL490B, IC14, two transistors and two IR LEDs plus a few capacitors and resistors. The IR LEDs transmit a pulse position modulation (PPM) 5-bit code whenever one of the switches is pressed.

1





The remote control receiver circuit is based on the Plessey SL486 and ML926 preamplifier and decoder ICs.

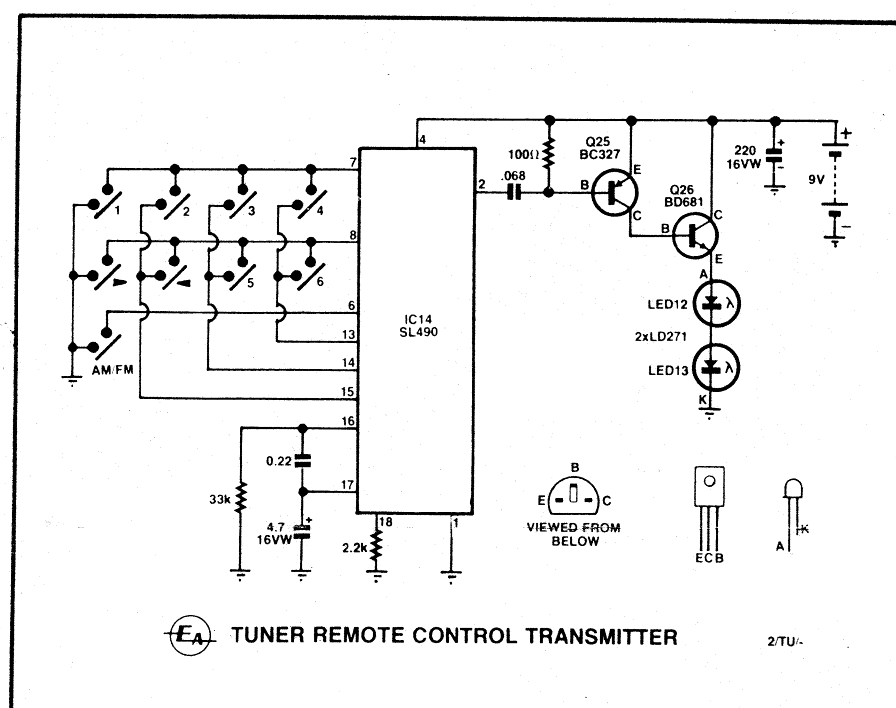
Up to 32 separate code commands are available with the SL490B. This is possible with 32 switches in an 8-row by 4-column switch matrix. Our remote control needs less than this and uses nine switches in a 4-column by 3-row matrix.

Switches for memories 1,2,3 and 4 have transmit codes from 01000 to 01011. The tune down, tune up and memories 5 and 6 have transmit codes from 01100 to 01111 and finally, the AM/FM switch sets transmission of 00100.

Transmit code output is at pin 2 of IC14. It is AC-coupled via the .068μF capacitor to the base of transistor Q25 which produces a 15μs current pulse, each time pin 2 goes low. Thus Q26, which is driven by Q25, directly drives two IR LEDs with these very short current pulses.

The pulse position modulation frequency of transmission is set by the 33kΩ resistor and 0.22μF capacitor.

Filtering for the internal 4.5V regulator of the SL490B is provided by the



The transmitter uses a Plessey SL490 IC to pulse code modulate two infrared LEDs.

Remote control

4.7μF capacitor connected between pin 17 and the 0V line.

The 9V battery powers the transmitter while a 220μF capacitor across the supply provides the high current surges required when the IR LEDs are pulsed on. Standby current of the circuit is less than 10μA.

Receiver circuitry

The remote control receiver comprises four ICs. Two of these are the above-mentioned SL486 preamplifier and the ML926 decoder. The remaining ICs are the 4052 and 4053 CMOS analog switches.

An IR photodiode, the BPW50, is the detector for the transmitted IR signal. It is connected across the differential inputs to the preamplifier, IC15, at pins 1 and 16. The differential input stage provides rejection of common mode noise from the diode and connecting leads.

Following this is a gyrator and four gain stages. Each of these has a low frequency roll-off below 2kHz, effectively rejecting any 100Hz signals (radiated by mains powered lights) picked up by the receiver diode. To provide these roll-offs, the 6.8μF, 47μF, .015μF, .033μF and finally the .0047μF capacitors (pins 2,3,15,5 and 6) respectively are used for decoupling.

An automatic gain decoupling 0.15μF capacitor at pin 8 filters the output from an internal peak detector which measures the final output at pin 9. The resulting signal controls the gain of the first three amplifier stages.

An internal regulator stabilises supply to the amplifiers and the input to this is at pin 12. Filtering for the supply input is with a 22μF capacitor while the 220Ω resistor reduces the overall supply voltage to the regulator. Supply decoupling between the sensitive input circuitry and the output circuit is via the 47Ω resistor and 0.33μF capacitor.

After amplification in IC15, the received signal is sent to decoder IC16. This demodulates the transmitted pulse position modulation code and waits for two consecutive and identical codes before providing a 4-bit binary output.

A reference oscillator input at pin 2 of IC16 sets the operating frequency with an RC network. In our case a .022μF capacitor and a 22kΩ resistor in series with a 50kΩ trimpot are used. Only when the transmission rate is cor-

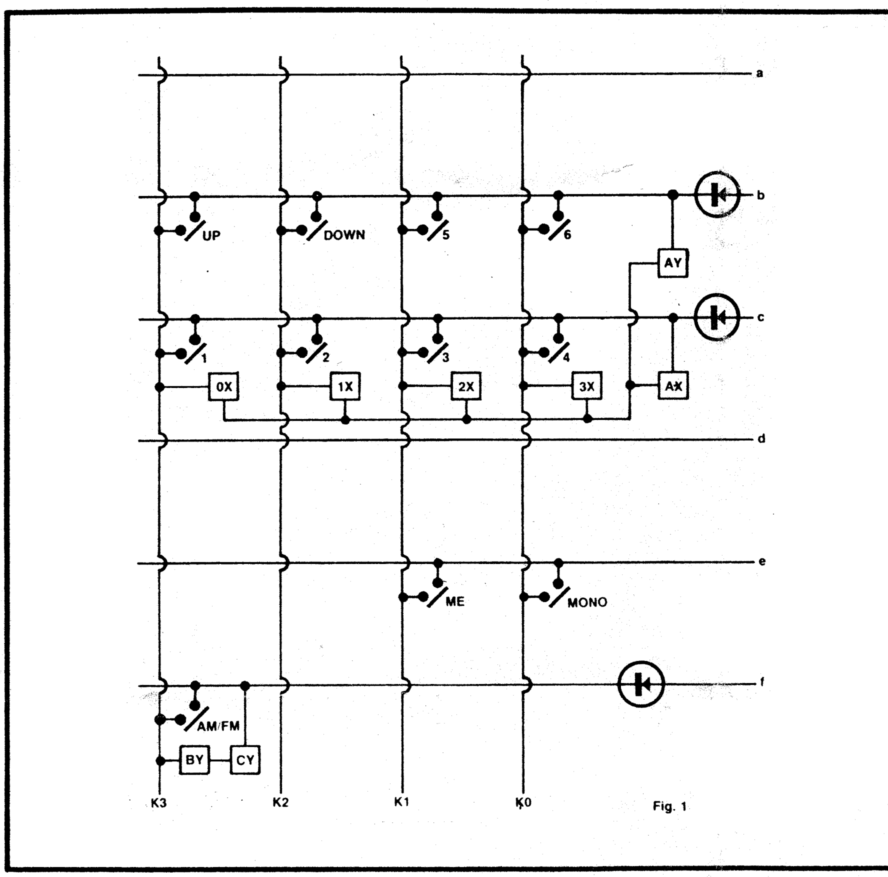
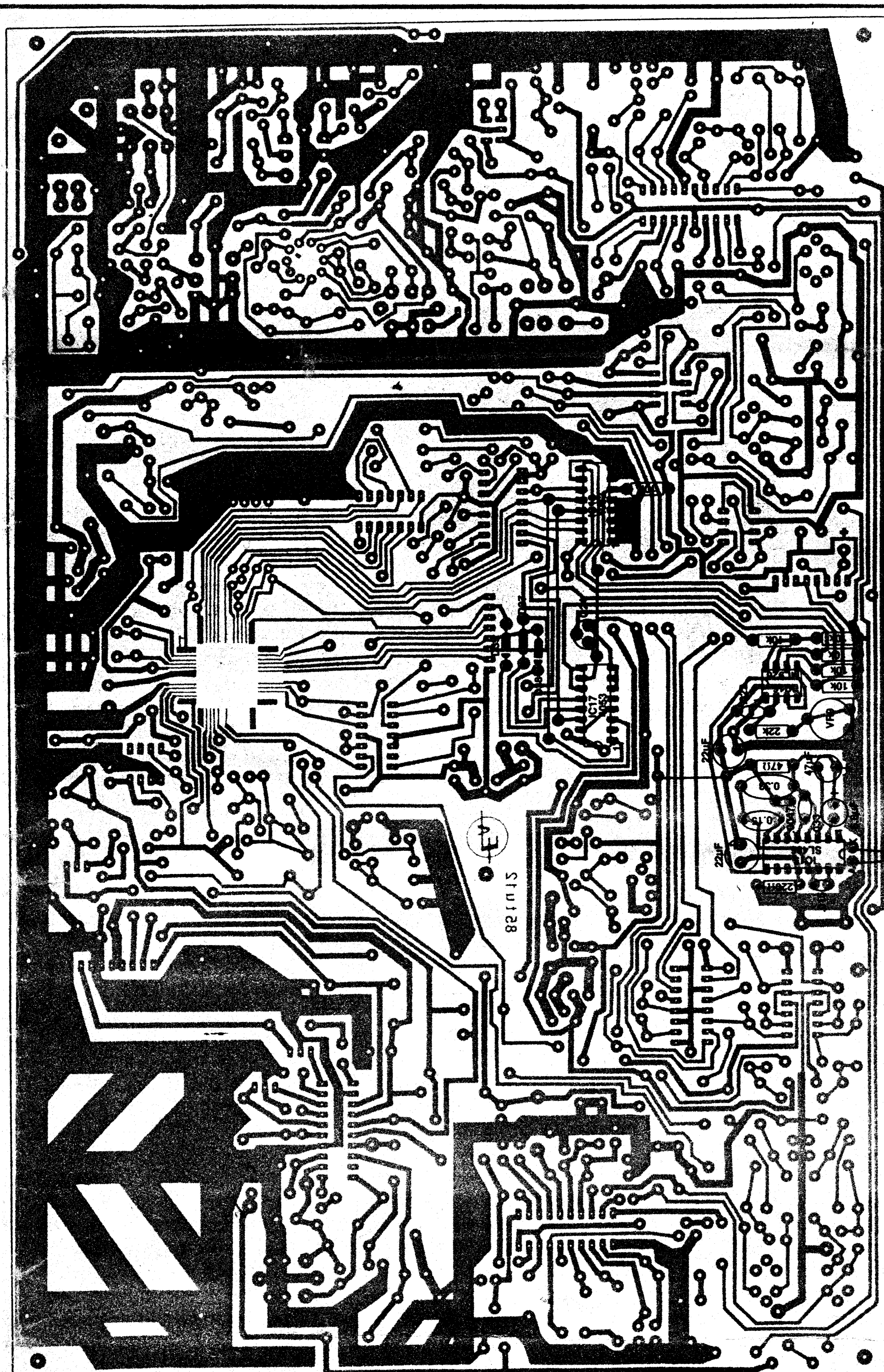


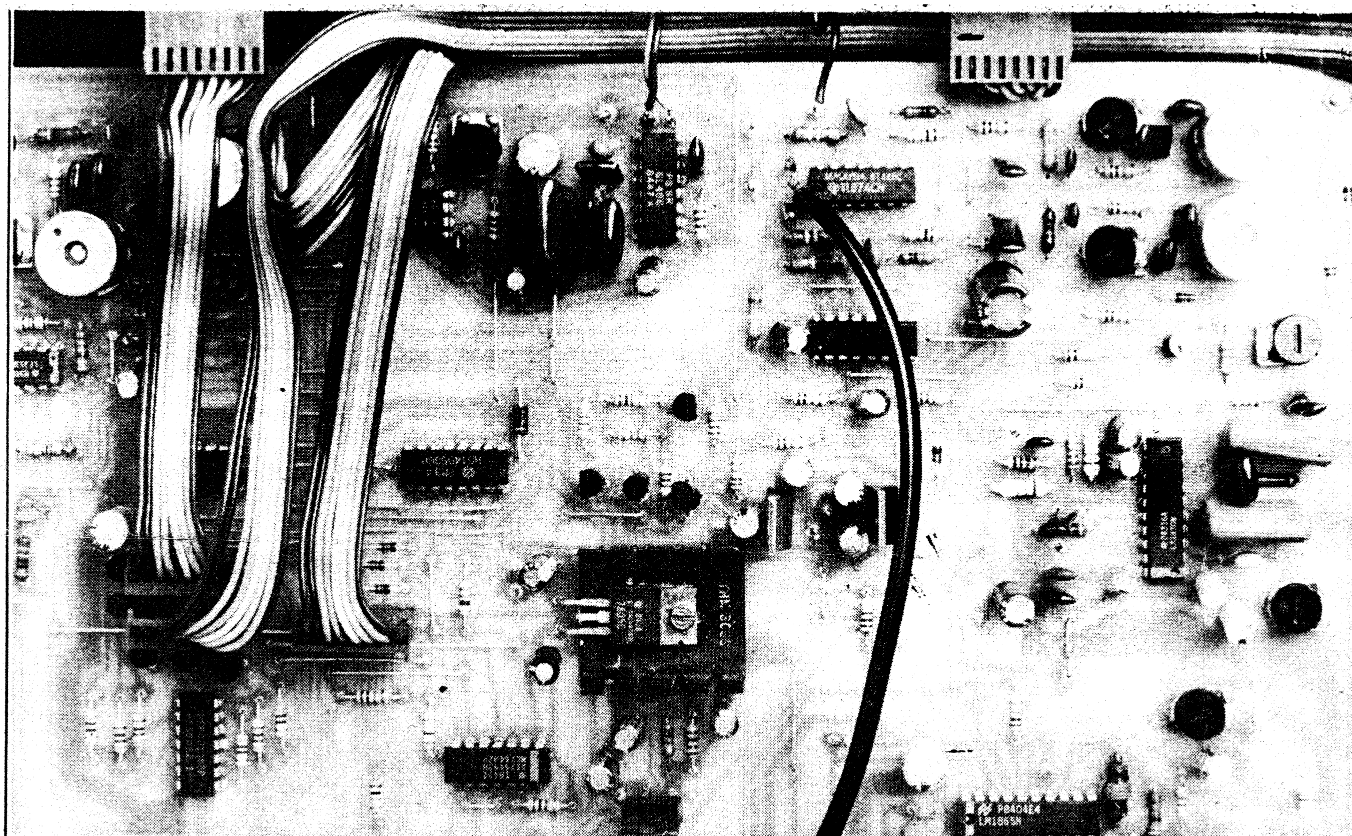
Fig.1: how the IC17 and IC18 CMOS switches are arranged on the IC1 switch matrix.



The receiver circuitry is accommodated on the main tuner PCB.

rect will IC16 provide a decoded output from the received signal.

Outputs at A,B,C and D are normally pulled low with 10kΩ resistors. When a correct code is received, outputs will go high. Note that the ML926 is designed only to receive 5-bit transmitter codes that have the most significant bit low, ie. it really only decodes 4-bit signals. (Another version of this IC is the Plessey ML927. This type responds to codes with the most significant bit high.)



Close-up view of the receiver circuitry on the main tuner PCB. The BPW50 photodiode is mounted behind the perspex front panel.

Remote control

The most significant (D) output from IC16 is inverted by transistor Q24. This D-complement plus the A, B and C signals are applied to IC17 and IC18.

These two ICs are CMOS binary decoders with analog switches. IC17 can be considered as a three-pole two-way switch responding to binary input codes fed to pins 9, 10 and 11. The binary inputs are the A, B and C pins (9, 10 and 11) which have independent control over their respective "a", "b" and "c" switch poles. For example, when A is high, the Y position of the "a" switch pole is selected (AY). When A is low, the X position is selected (AX).

The AX, AY and CY switch output (pins 12, 13 and 3) positions connect via diodes D37, D38 and D39 to the b, c and f segment outputs of IC1 in the Playmaster stereo AM/FM tuner. The BY pole connects to the K3 switch matrix input of IC1.

For its part, IC18 can be considered as a two-pole four-way switch also responding to binary control codes except that we are using it only as a single-pole four-position switch, with the common (wiper) being pin 13.

Note that the INHibit input at pin 6 is normally held high by virtue of the inversion of the D output from IC16. When pin 6 is low, IC18 is selected. This means that when no signal codes are being transmitted, IC17 and IC18 are effectively disabled and do not affect the tuner functions.

The "0X" switch is selected when A and B are both low. When A is high and B low, the "1X" switch is selected. To select the "2X" switch, A is low and B high and finally the "3X" switch is selected with a high on both the A and B inputs.

The 0X, 1X, 2X and 3X switches connect to the K3, K2, K1 and K0 lines respectively. These are the switch matrix columns of IC1.

Fig.1 shows how the IC17 and IC18 switches are arranged on the IC1 switch matrix on the main tuner board. To select memory 1, we close both the 0X and AX switches simultaneously. For the UP selection we need 0X closed but AY is closed instead of AX. Similarly, for the 2, 3 and 4 memory selections, we need AX closed and 1X, 2X and 3X closed respectively. For the DOWN and the 5 and 6 memory, the AY switch is closed along with the respective 1X, 2X and 3X switches.

AM/FM switching occurs when both the BY and CY switches are closed.

Construction

The Tuner Remote Control transmitter is housed in a small platic case measuring 112 x 62 x 31mm. All components are mounted on a PCB coded 85rc12 and measuring 56 x 74mm. A front panel label measuring 114 x 64mm indicates the switch functions as well as providing the finishing touch.

The Tuner Remote Control receiver circuitry is mounted on the main 85tu12 PCB used in the Playmaster stereo AM/FM tuner. Receiver diode BPW50 is secured to the sub-front panel of the tuner behind the neutral density filter screen on the front panel.

Construction of the remote receiver is straightforward. Firstly, the main tuner PCB (85tu12) will need to be removed from the tuner case. Disconnect the audio and AM antenna leads and remove the rear panel. Unclip the 8-way leads between the main PCB and display PCB as well as the short stereo lead. Now undo the screws securing the main PCB. It should be possible to have the PCB sitting up on edge to give sufficient room for inserting the remote control components without removing the power supply wires.

The front panel and display PCB will also require removal to fit the IR diode. Drill a 4mm hole through the display PCB directly opposite IC15 on the main PCB. This position is clearly marked with a copper pad just next to the "t" in the word "top" on the display side of the PCB.

Directly in front of this hole on the sub-front panel, drill another hole to expose the IR detector diode. The leads are bent back on the IR diode as shown on the circuit diagram. Note that the infrared active area is the flat face side of the diode.

Use epoxy resin to secure the IR diode to the sub-front panel. Note that it is important not to allow the leads to make contact with the metal panel and avoid placing glue on the active area of the diode.

Solder short leads to the diode and feed them through the hole in the display PCB. The front panel, sub-front panel and display PCB can now be reassembled.

When assembling components onto the main tuner PCB, follow the overlay diagram and do not forget the links. Note that the ICs, electrolytic capacitors and diodes must be oriented as shown.

After this PCB is completely assembled, it can be bolted back into the case. Replace the rear panel and resolder the audio plus AM antenna wiring. Reconnect the 8-way cables.

With the receiver complete, work can begin on the transmitter.

Insert the resistors, BC327 (Q25), and IC14 in position first. The capacitors and the BD681 (Q26) unconventionally lie sideways on the PCB. This is to leave sufficient room for the switches to protrude through the front panel.

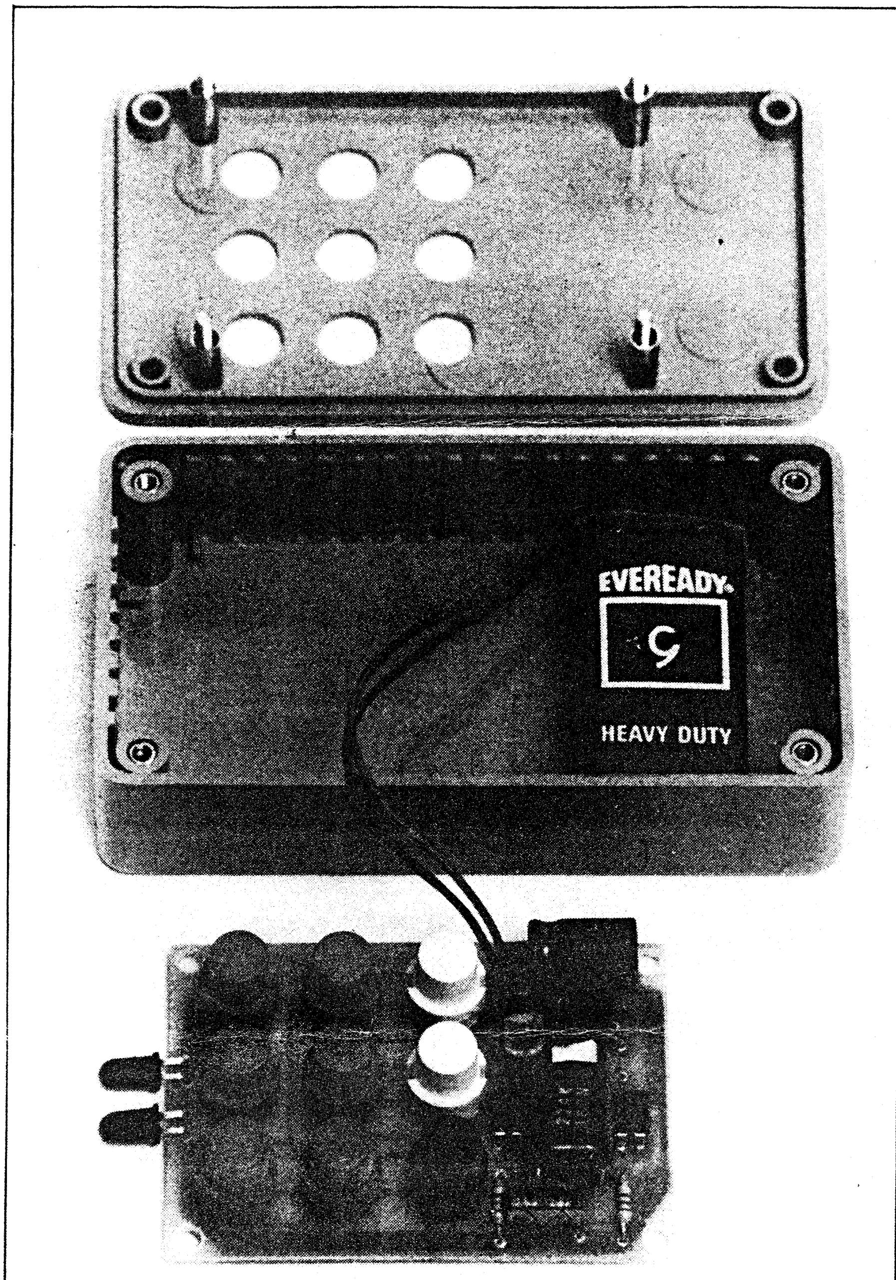
Lying flat on the PCB are the 4.7μF and 220μF capacitors. The 0.22μF capacitor lies across the IC, while the .068μF sits on top of the 100Ω resistor. Transistor Q26 straddles the .068μF capacitor.

All switches are mounted with the same orientation, ie, with the flat side to the right side of the PCB. Both IR LEDs are mounted close to the edge of the PCB and are bent over so that they point along the plane of the PCB. Wires for the 9V battery clip can also be soldered in place.

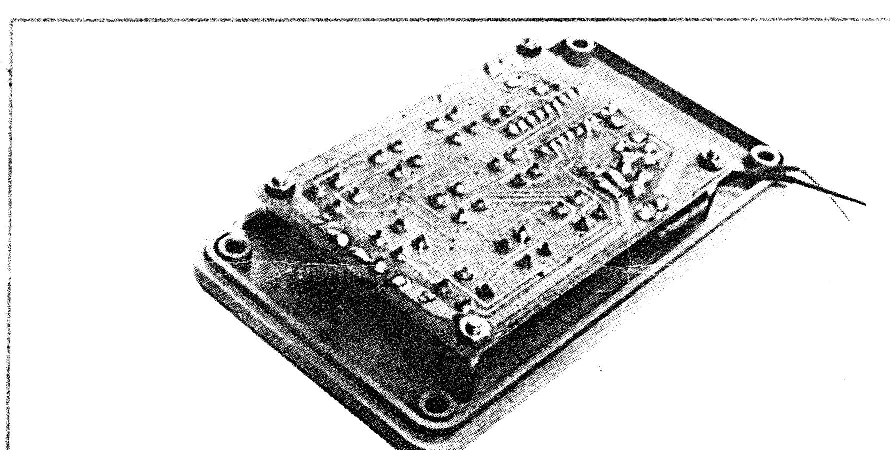
The PCB can be held within the box using one of two methods. We used screws, 12mm spacers and nuts to support the PCB at the four corners from the front panel. If you prefer not to see securing screws on the front panel, then the plastic clips that are supplied with the box can be used. These are designed to clip into the corrugations in the side of the box and hold the PCB at the correct height. Cut the clips to length so that the switch tops will just protude through the front panel.

Place the Scotchcal label on the lid of the box making sure it is lined up correctly before sticking it down. Drill holes for each switch and the PCB corner mountings if used.

Make a rectangular cut-out at the

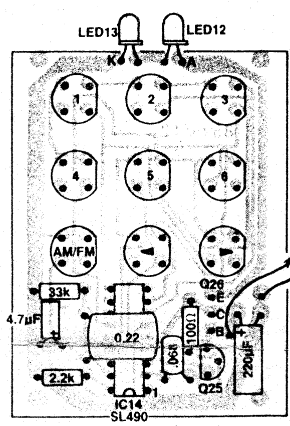


View showing the completed transmitter PCB, ready for assembly into the case.

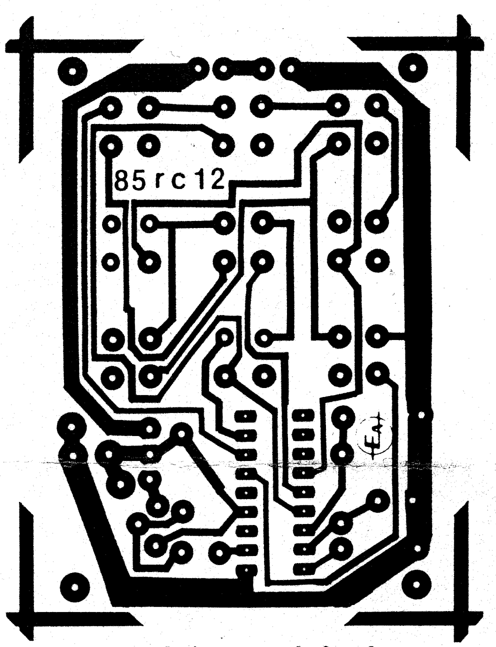


The transmitter PCB is mounted on the lid of the case using four 6mm standoffs.

Remote control



Above: parts layout for the transmitter PCB.



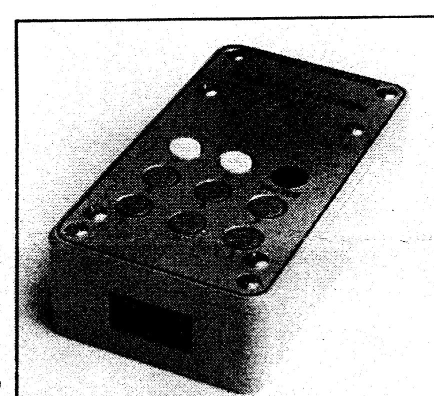
Above: actual size artwork for the transmitter PCB.

front end of the box in a position so that the two IR LEDs will be central to the hole. We made our hole 24mm x 12.5mm and fitted a circularly polarised red filter into this.

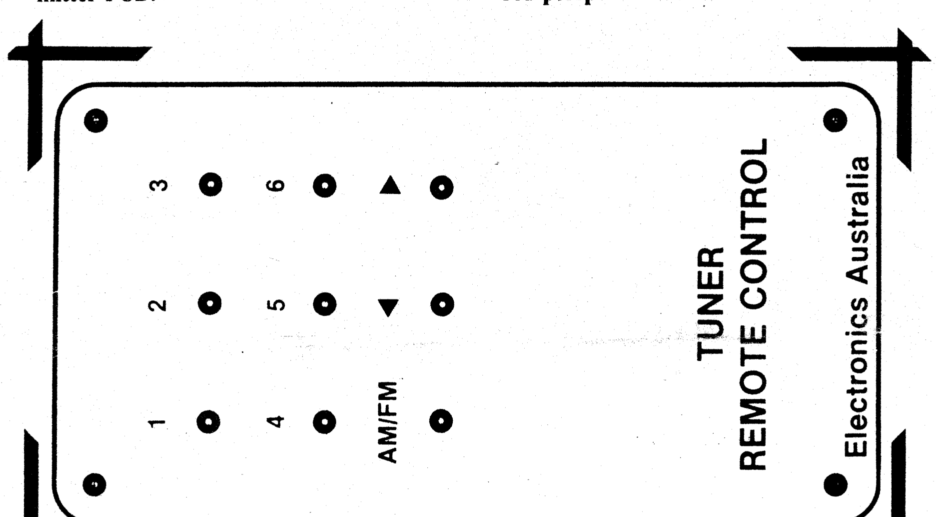
Now the transmitter construction is complete apart from assembly. The 9V battery squeezes between the bottom end of the case and the edge of the PCB. In some cases, the lower corner pillars within the case may need shaving with a knife so that the battery will fit correctly.

If screws are used to secure the PCB to the front panel, place a plastic washer under the nut at the top right mounting hole. This will insulate the PCB track from the electrically connected screws on the aluminium Scotchcal front panel. The remaining three corner mounting holes have adjacent PC tracks that are of the same ground potential and do not require insulating.

Assemble the transmitter into the box and it is ready for testing.



The two infrared diodes "look" through a red perspex window.



Actual-size front panel artwork for the transmitter.

Testing

Switch on the Playmaster stereo AM/FM tuner and aim the transmitter at the tuner. Push either the tune down or tune up remote control switches and adjust the VR9 trimpot in the receiver until the tuner responds correctly to the transmitter commands. Now check the remaining remote control functions and you are finally in business.

PARTS LIST

1 PC board, 56 x 74mm, code 85rc12
1 Scotchcal front panel, 114 x 64mm
1 plastic case, 112 x 62 x 31mm
1 red perspex sheet approx 24 x 12.5mm x 1-2mm
9 snap action keyboard switches, 6 green, 2 white, 1 black
1 216 9V battery
1 9V battery clip
4 6mm standoffs and screws and nuts

Semiconductors

1 SL490 remote control transmitter (Plessey)
1 SL486 IR remote control preamplifier (Plessey)
1 ML926 remote control receiver (Plessey)
1 4052 CMOS switch
1 4053 CMOS switch
1 BD681 NPN Darlington transistor
1 BC327 PNP transistor
1 BC547 NPN transistor
2 LD271 IR LEDs
1 BPW50 IR detector diode
3 1N4148, 1N914 small signal diodes

Capacitors

1 220µF 16VW PC electrolytic
1 47µF 16VW PC electrolytic
2 22µF 16VW PC electrolytics
1 6.8µF 16VW PC electrolytic
1 4.7µF 16VW PC electrolytic
1 0.33µF metallised polyester
1 0.22µF metallised polyester
1 .068µF metallised polyester
1 .033µF metallised polyester
1 .022µF metallised polyester
1 .015µF metallised polyester
1 .0047µF metallised polyester
1 .15 uF metallised polyester

Resistors

(0.25W, 5% unless stated)
1 x 33kΩ, 1 x 22kΩ, 6 x 10kΩ, 1 x 2.2kΩ, 1 x 220Ω 1/2W, 1 x 100Ω, 1 x 47Ω, 1 x 50kΩ horizontal cermet trimpot.