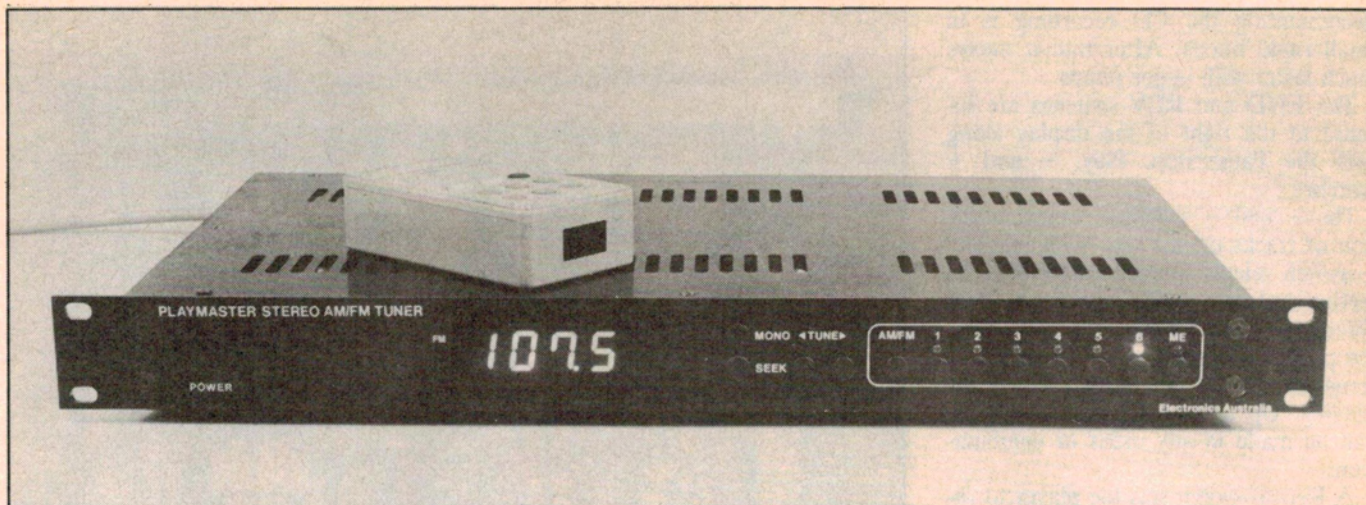




Second article has all the circuit diagrams

Playmaster

AM/FM

Pt. 2

stereo tuner

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

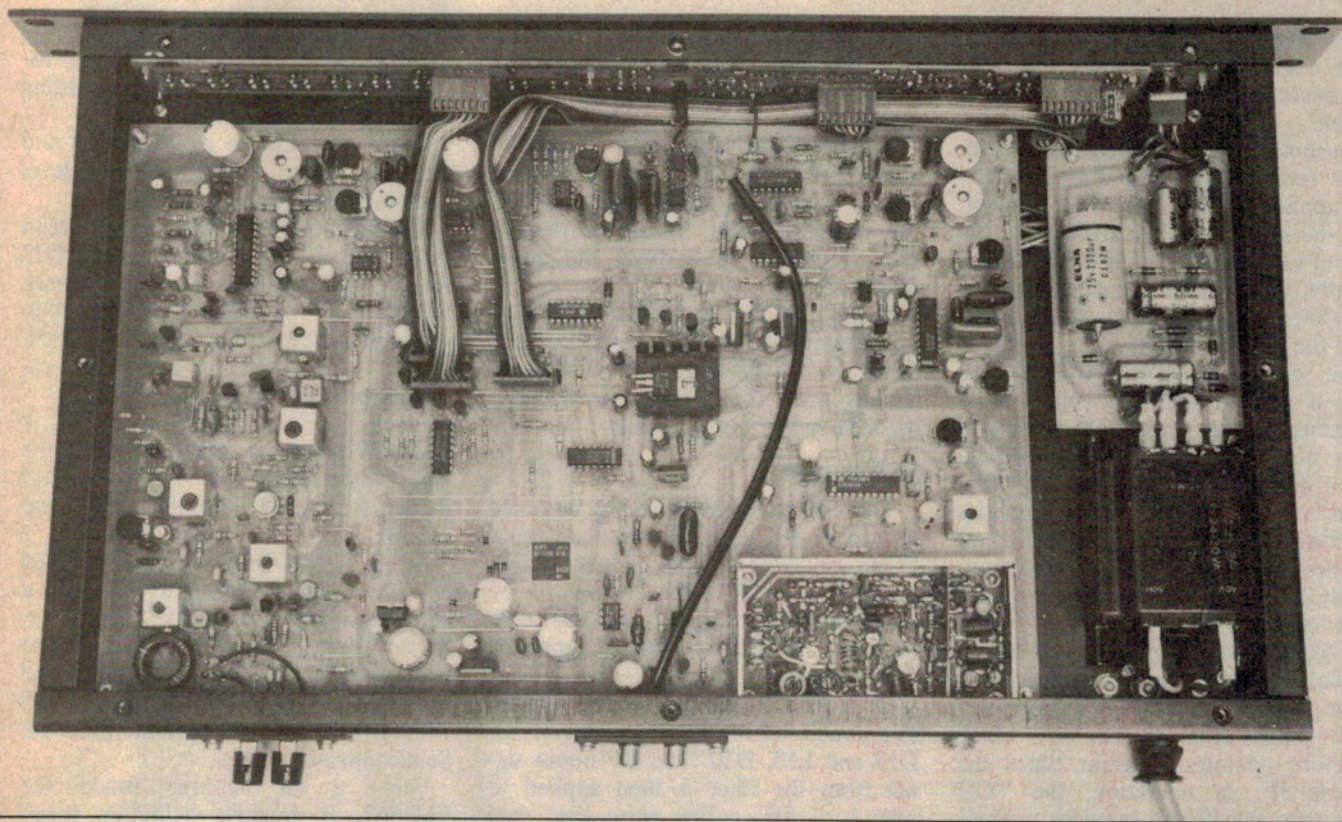
The AM tuner circuit is a high-performance superheterodyne design employing varicap tuning, a double-balanced mixer, ceramic filters and stereo

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 trimmer 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 1M Ω 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 220 Ω source resistor while the AGC (automatic gain control) voltage is applied to gate G2 via the 100k Ω and 47k Ω 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 560 Ω resistor and 0.1 μ F 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

± 12 kHz and is 60dB down at ± 40 kHz. However, it also has secondary peaks in its response so that the attenuation of the filter is only 15dB down at ± 150 kHz. 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

Playmaster AM/FM stereo tuner

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 2.2k Ω and 6.8k Ω 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 75 Ω unbalanced antenna. When used with a balanced 300 Ω dipole antenna, a 300 Ω to 75 Ω balun will be necessary. The standard adaptor type used for television antenna inputs is quite suitable.

L8 is the 75 Ω input and this couples to a double-tuned filter consisting of L9, D19 and L10, D20. The RF output 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 2.2k Ω resistor and 6.8 μ F 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,

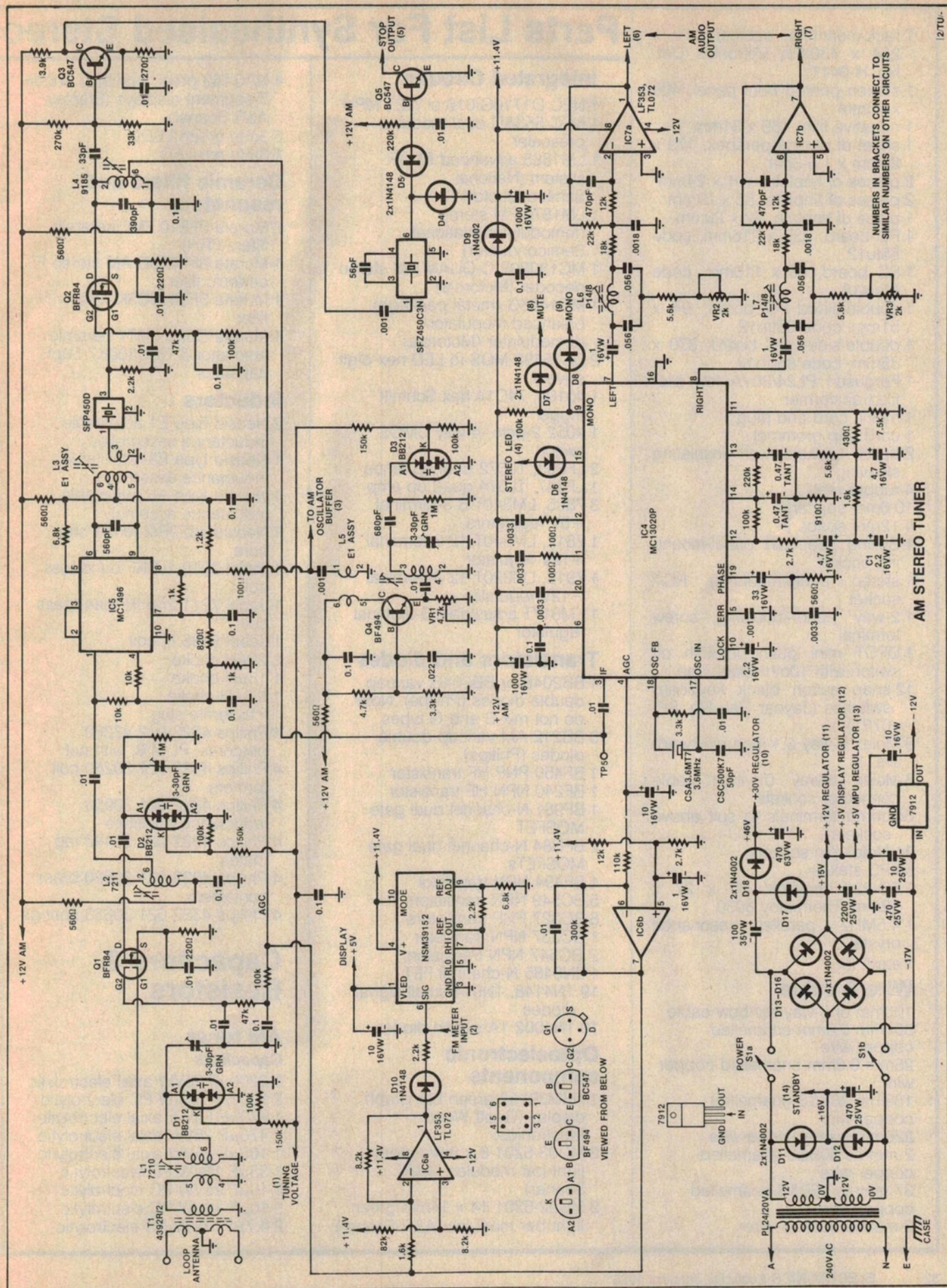
Specifications

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 4.7k Ω 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	350 μ V 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 4.7k Ω 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



NUMBERS IN BRACKETS CONNECT TO SIMILAR NUMBERS ON OTHER CIRCUITS

AM STEREO TUNER

12TU-

- 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, Thermalloy 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

Parts List For Synthesised Stereo

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 & CSC500K7 50pF capacitor

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 22260 potcores, PL14/8, with nut
- 4 Philips 4322 021 30250 coil formers
- 4 Philips 4322 021 30950 inductance adjusters
- 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 2.2 μ F 16VW PC electrolytic
 3 1 μ F 16VW PC electrolytic
 2 0.47 μ F 16VW tantalum
 11 0.1 μ F ceramic
 4 .056 μ F metallised polyester
 1 .022 μ F metallised polyester
 10 .01 μ F ceramic
 2 .01 μ F (10nF) ceramic plate,
 Philips 222 629 09103
 4 .0033 μ F metallised polyester
 2 .0018 μ F metallised polyester
 1 .001 μ F metallised polyester
 1 .001 μ F ceramic
 1 .001 μ F (1nF) miniature ceramic
 plate, Philips 222 630 09102
 1 680pF miniature ceramic plate,
 Philips 222 630 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 1M Ω , 1 x 300k Ω 2%, 1 x
 270k Ω , 2 x 220k Ω , 3 x 150k Ω , 1
 x 110k Ω 2%, 7 x 100k Ω , 1 x
 82k Ω , 2 x 47k Ω , 1 x 33k Ω , 2 x
 22k Ω 2%, 2 x 18k Ω 2%, 3 x 12k Ω
 2%, 2 x 10k Ω , 2 x 8.2k Ω 2%, 1 x
 7.5k Ω 2%, 2 x 6.8k Ω , 3 x 5.6 k Ω ,
 1 x 4.7k Ω , 1 x 3.9k Ω , 2 x 3.3k Ω ,
 2 x 2.7k Ω 2%, 3 x 2.2k Ω , 2 x
 1.6k Ω 2%, 1 x 1.2k Ω , 2 x 1k Ω , 1
 x 910 Ω 2%, 1 x 820 Ω , 5 x 560 Ω ,
 1 x 430 Ω 2%, 1 x 270 Ω , 2 x
 220 Ω , 3 x 100 Ω , 1 x 4.7k Ω
 miniature horizontal trimpot, 2 x
 2k Ω miniature horizontal trimpots

FM front end

Capacitors

1 6.8 μ F tantalum
 7 .01 μ F (10nF) miniature ceramic

plate, Philips 222 629 09103
 3 .001 μ F (1nF) miniature ceramic
 plate, Philips 222 629 09102
 1 47pF miniature ceramic plate,
 Philips 222 652 10479
 1 27pF miniature ceramic plate,
 Philips 222 652 10279
 1 6.8pF miniature ceramic plate,
 Philips 222 652 09688
 1 4.7pF miniature ceramic plate,
 Philips 222 652 09478
 1 3.3pF miniature ceramic plate,
 Philips 222 652 09338
 1 1.5pF miniature ceramic plate,
 Philips 222 652 09158
 3 4.2-20pF Murata D series
 trimmers
 1 3-11pF Murata D series
 trimmer

Resistors (0.25W, 5%)

1 x 1M Ω , 4 x 56k Ω , 1 x 33k Ω , 1
 x 18k Ω , 2 x 10k Ω , 1 x 3.3k Ω , 1 x
 2.2k Ω , 1 x 1.5k Ω , 1 x 1k Ω , 1 x
 220 Ω , 2 x 22 Ω

FM IF and stereo decoder

Capacitors

1 220 μ F 16VW PC electrolytic
 2 47 μ F 16VW PC electrolytic
 1 22 μ F 16VW PC electrolytic
 2 10 μ F 16VW PC electrolytic
 2 4.7 μ F 16VW PC electrolytic
 3 2.2 μ F 16VW PC electrolytic
 3 1 μ F 16VW PC electrolytic
 1 0.33 μ F metallised polyester
 1 0.22 μ F metallised polyester
 3 0.1 μ F ceramic
 1 .047 μ F metallised polyester
 4 .012 μ F metallised polyester
 5 .01 μ F (10nF) miniature ceramic
 plate, Philips 222 629 09103
 2 .0056 μ F metallised polyester
 3 .0047 μ F metallised polyester
 2 .0018 μ F metallised polyester
 2 .0015 μ F metallised polyester
 1 .001 μ F metallised polyester
 2 150pF ceramic

1 82pF miniature ceramic plate,
 Philips 222 652 58829

Resistors (0.25W, 5% unless
 stated)

2 x 390k Ω , 2 x 270k Ω , 3 x
 100k Ω , 1 x 47k Ω , 1 x 33k Ω , 2 x
 22k Ω , 2 x 20k Ω 2%, 4 x 15k Ω ,
 1 x 12k Ω , 3 x 10k Ω , 6 x 10k Ω 2%,
 1 x 8.2k Ω , 1 x 7.5k Ω 2%, 2 x
 4.7k Ω , 1 x 4.3k Ω 2%, 2 x 3k Ω 2%,
 1 x 2.2k Ω , 1 x 330 Ω , 1 x 22k Ω
 horizontal cement trimpot, 3 x
 10k Ω horizontal cermet trimpot, 1
 x 5k Ω horizontal cermet trimpot

Tuner control circuit

Capacitors

1 47,000 μ F (.047F) 5VW super
 capacitor
 2 1000 μ F 16VW PC electrolytic
 4 47 μ F 16VW PC electrolytic
 4 10 μ F 25VW PC electrolytic
 4 10 μ F 16VW PC electrolytic
 2 1 μ F 63VW PC electrolytic
 1 1 μ F 35VW PC electrolytic
 1 1 μ F 25VW PC electrolytic
 1 0.33 μ F metallised polyester
 1 0.1 μ F ceramic
 2 .01 μ F ceramic
 2 .01 μ F (10nF) miniature ceramic
 plate, Philips 222 629 09103
 1 .01 μ F metallised polyester
 1 680pF miniature ceramic plate,
 Philips 222 630 09681
 1 100pF miniature ceramic plate,
 Philips 222 652 58101
 2 22pF ceramic
 2 4.7pF ceramic

Resistors (0.25W, 5%)

1 x 1M Ω , 1 x 220k Ω , 1 x 150k Ω ,
 1 x 33k Ω , 9 x 10k Ω , 4 x 5.6k Ω , 2
 x 4.7k Ω , 1 x 2.7k Ω , 1 x 2.2k Ω , 1
 x 1.8k Ω , 7 x 1k Ω , 6 x 820 Ω , 1 x
 680 Ω , 1 x 470 Ω , 1 x 330 Ω , 1 x
 220 Ω , 2 x 120 Ω , 2 x 82 Ω , 2 x
 56 Ω , 4 x 47 Ω , 7 x 22 Ω

signal strength meter drive circuit and
 an AGC output. In addition, it provides
 a stop output which is connected di-
 rectly 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 am-
 plifier which ensures that the input sig-
 nal 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 quad-
 rature detection by measuring the volt-
 age across L16 and the parallel 82pF ca-

pacitor. L17 limits the voltage swing
 across the quadrature coil while the
 4.3k Ω resistor reduces the Q of the
 tuned circuit to provide more linear de-
 tection.

The AGC output is extracted from
 pin 18 and applied to gate 2 of Q6 in
 the front end via a 1k Ω /33k Ω 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 out-
 put signal which is split into three sepa-
 rate 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 4.7k Ω
 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 sig-
 nal-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 $2.2\mu\text{F}$ 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 $50\mu\text{s}$ de-emphasis components are at pins 14 and 15. The parallel $15\text{k}\Omega$ and $22\text{k}\Omega$ 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.

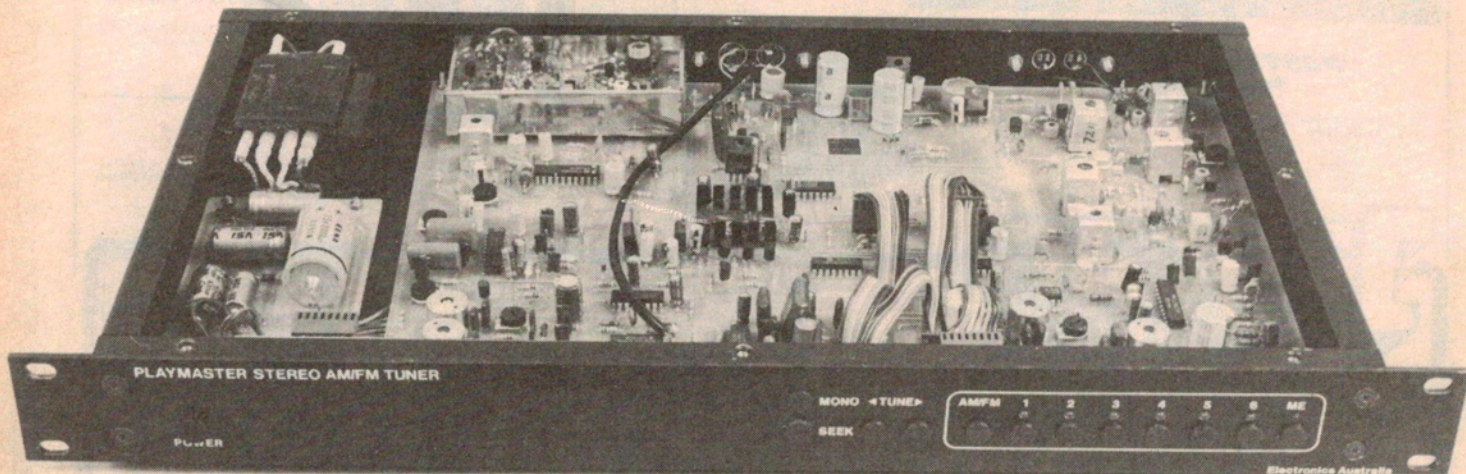
Control loop

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.

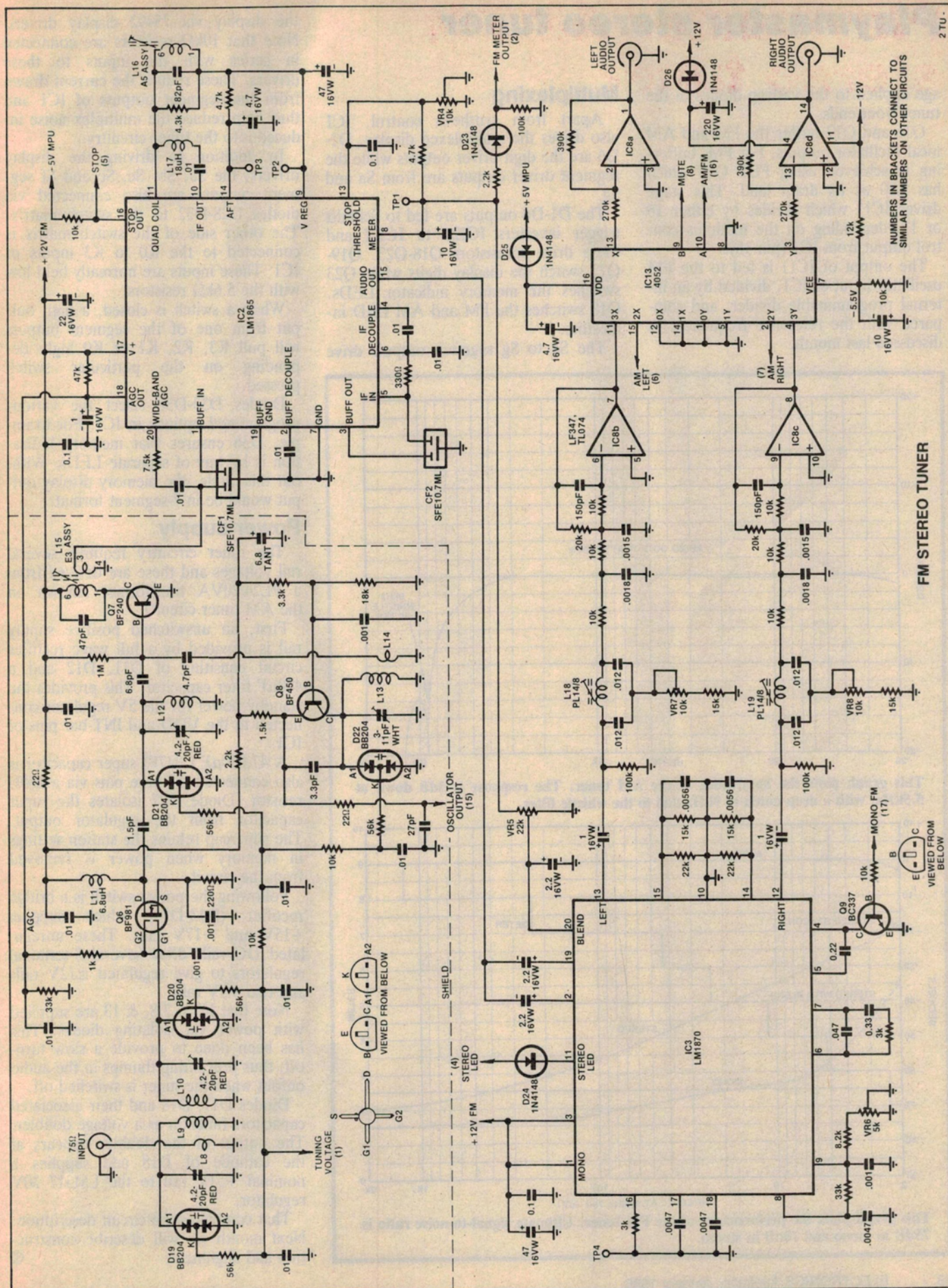
Pin 11 of IC1 drives the error output buffer. It controls the buffer such that, if the local oscillator frequency is lower than the internal reference frequency, the error voltage is low and Q15 and Q14 turn off.

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 $2.7\text{k}\Omega$ 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.



NUMBERS IN BRACKETS CONNECT TO
SIMILAR NUMBERS ON OTHER CIRCUITS

VIEWED FROM
BELOW

Playmaster stereo tuner

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 10k Ω 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 5.6k Ω 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.

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 consisting of D11, D12 and a 470 μ F filter capacitor. This provides the standby power for the 5V regulator connected to the VDD and INT-bar pins of IC1.

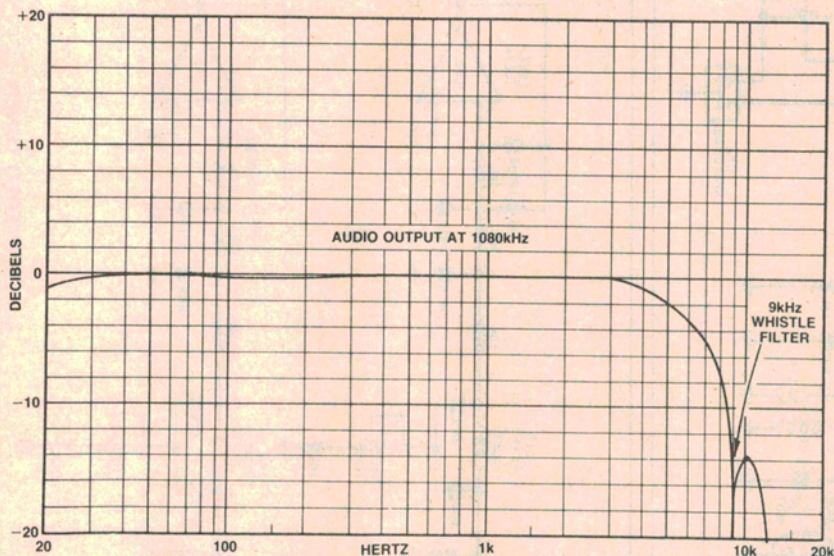
A 47,000 μ F (.047F) super capacitor is also connected to these pins via a 680 Ω resistor. Diode D27 isolates the super capacitor from the regulator output. The supercap retains the station settings in memory when power is removed from the circuit.

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 $\pm$ 12V rails and two +5V rails.

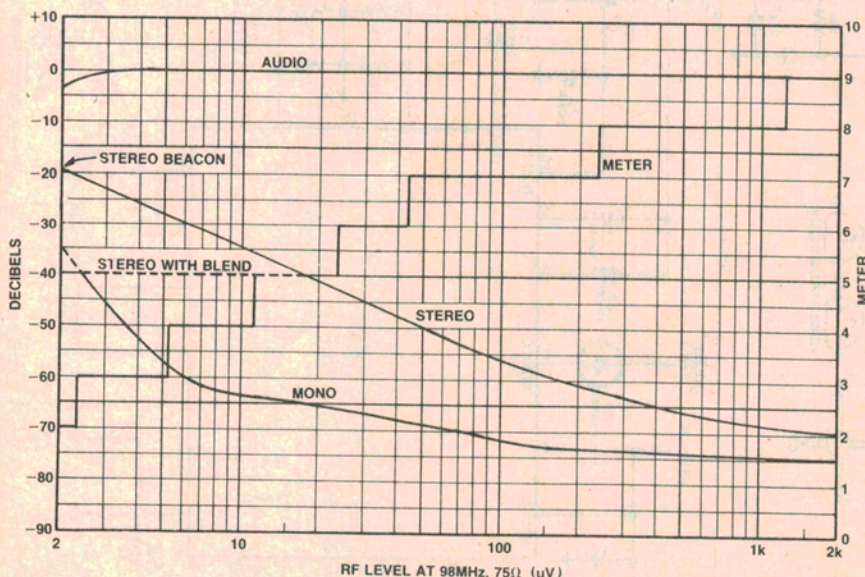
Note that ICs 6,7,8, & 13 are supplied with power via isolating diodes. This has been done to provide a slow turn-off, thus preventing thumps in the audio output when the tuner is switched off.

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.



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.

