CQ REVIEWS:

Yaesu FT-77 Compact H.F. Transceiver

BY JOHN J. SCHULTZ*, W4FA

The front panel of the FT-77 is strictly functional and free of extraneous controls.

Is the Yaesu FT-77 just a cosmetic redo of the Yaesu FT-707 transceiver? There certainly are some very strong similarities. The FT-707 was basically an all-band s.s.b./c.w. transceiver having a single 9 MHz i.f. and measuring 93 × 240 × 295 mm overall. The FT-77 is an all-band s.s.b./c.w. transceiver (with an f.m. option) having a 9 MHz i.f. and measuring 95 × 240 × 300 mm overall. I would classify the FT-77 as a transceiver which has taken many basic circuitry ideas from the FT-707, improved on them, and repackaged them for more reliable and lower cost production.

The FT-77 is, in a sense, a simpler transceiver than the FT-707. The front-panel design is much cleaner and simpler than that found in the FT-707. For instance, the rather colorful but difficult to interpret LED bar graph meter found in the FT-707 has been replaced by a far more functional, conventional meter. The "knob count" has been reduced somewhat and better placed and sized, particularly for mobile operation. Overall, the FT-77 is a distinct improvement over the FT-707 and should appeal to those who want a solid, compact 100-watt-class h.f. transceiver without a lot of "bells and whistles" (although a few of the latter can be added via the optional FV-700 DM External Scanning VFO). Table I summarizes the overall specifications for the FT-77.

Circuitry Overview

Fig. 1 shows a block diagram of the FT-77. There seem to be a lot of blocks, but in reality all of the circuitry is contained on only nine basic PC boards.

Referring to fig. 1, an incoming r.f. signal is passed through the low-pass filter assembly, through a switchable 20 dB attenuator, through one of the eight diode-switched high-pass filters, and on to r.f. amplifier stages Q1002 and Q1003. The signal then is frequency translated in a passive double-balanced mixer stage, Q1005, to the 9 MHz i.f. frequency and goes through a broad 20 kHz i.f. filter.

*c/o CQ Magazine

GENERAL

Frequency coverage:
All amateur bands between 3.5 and 29.9 MHz, including the three WARC bands

Operating modes:
A3J (LSB/USB), A1 (CW)
F3 (FM) optional

Power requirements:
13.5V DC; 1A receive, 20A transmit

Size:
240(W) x 95(H) x 300(D) mm, including heat sink

Weight:
6 kg (13.2 lb)

TRANSMITTER

Power input:
240W DC for nominal 100W output (85W on 10 meter band)

Spurious radiation:
Less than –40 dB

Carrier suppression:
Better than 40 dB

Unwanted sideband suppression:
Better than 50 dB (W/1 kHz modulation)

Audio response:
350–2700 Hz (@ –6 dB)

Stability:
Less than 300 Hz drift during the first 30 minutes after a 10 minute warmup, less than 100 Hz every 30 minutes thereafter

Microphone input impedance:
500–600 ohms

RECEIVER

Circuit type:
Single conversion superheterodyne (double conversion for FM, when installed)

Intermediate frequency:
8987.5 kHz (plus 455 kHz for FM)

Sensitivity:
0.3μV for 10 dB S+N/N (SSB and CW-W)
0.15μV for 10 dB S+N/N (with CW-N option)
0.7μV for 12 dB SINAD (FM, with FM option)

Image rejection:
More than 70 dB

IF rejection:
More than 50 dB

Selectivity (@ –6/–60 dB):
2.4/5 kHz for SSB, CW-W
600/1300 Hz with CW-N option
12/24 kHz with FM Unit option

Audio output:
3W (4-ohm internal speaker, @10% THD)

External speaker impedance:
4–16 ohms

Table I– The straightforward specifications for the FT-77.

Fig. 1– Block diagram for the FT-77.

These stages are shown in some detail in fig. 2. Yaesu has made various changes, compared to the FT-707, in these stages, the most significant of which was to replace the old 3SK73GR dual-MOS FET r.f. amplifier stage with a combination 2SK125 junction FET and 2SC380TM bipolar transistor stage.

The 9 MHz i.f. signal is then further amplified, and a portion is fed to the noise-blanker circuitry starting with Q2016. The noise-blanker circuitry amplifies the noise signal, detects it, and controls the operation of noise-blanker gate stage D2002-4. The signal is passed through this gate whenever a noise pulse has not switched it off. Although this circuitry is in principle the same as in the FT-707, most transistor and diode types and various time constants have been changed. Also not noticeable in fig. 1 is the fact that the noise-blanker circuitry has been provided with two selectable time constants—a narrow position for impulse noise and a wide one for over-the-horizon radar-type signals. The 9 MHz signal then proceeds to the main i.f. selectivity, the standard 2.4 kHz s.s.b. filter, or an optional 600 Hz c.w. filter. There is no passband tuning or i.f. shift in the FT-77, just the straight-forward use of the standard s.s.b. filter or selection of the optional c.w. filter. After the selectivity stage, the received i.f. signal goes on through some more i.f. amplification, a product detector, and then audio amplifier stages which can provide 3 watts (at 10% THD) maximum to the built-in speaker or to an external speaker. Again, many of the transistors and other components used have been changed in comparison to the FT-707.

In the transmit mode a d.s.b. signal is produced at the 9 MHz i.f. frequency and fed through the 2.4 kHz s.s.b. filter. The signal is then translated to the output frequency in the same double-balanced mixer stage, Q1005, used in the receive mode. After further low-level amplification it is delivered to the 100 watt PA unit. This unit is the same as is used in the FT-707 as well as in other Yaesu designs. It seems to be a very proven design, and it's an integrated package with a heatsink and a cooling fan. The cooling fan is temperature controlled and comes on automatically.

After the PA stage the output is routed through one of five low-pass filters, a directional coupler, and the antenna transfer relay. An interesting feature about the low-pass filters is that they are switched directly by the bandswitch and not via relays. There is absolutely nothing wrong with such switching, but it does mean that an operator should take care not to switch bands for some reason when in the transmit mode, or else the bandswitch contacts will suffer. The low-pass filter assembly is shown in fig. 3. The figure also shows the directional coupler. The directional coupler performs several functions. It supplies relative forward and reflected power information to the metering circuitry for s.w.r. measurement. It also supplies a control voltage to the PA stage to reduce the input power if the s.w.r. should rise above a preset point (75% of full power output is still delivered into a load presenting a 1:3 s.w.r., but with increasing s.w.r. the output power falls off very rapidly). Finally, it supplies a control voltage to an a.l.c. amplifier stage. The FT-77 does not appear to have any speech processing incorporated as such, but the a.l.c. circuitry seems to be more elaborate than in the FT-707.

The frequency control and display circuitry is much more sophisticated in the FT-77 than in the FT-707, although here again one can be fooled by a too quick glance at the circuitry. Basic tuning is still done by an analog 5.0 to 5.5 MHz variable oscillator. This signal is mixed with various crystal-controlled frequencies to produce the proper local oscillator signal for a 9 MHz i.f. However, the FT-77 has a PLL loop for which one of eight v.c.o.'s and one of ten crystal reference oscillators are selected. The output of the applicable v.c.o. is applied to the i.f. mixer stage, not to that of the crystal oscillator directly. The PLL mixer receives a portion of the signal from the v.c.o. being used and from the crystal oscillator stage, while a phase detector stage receives an output from the PLL mixer and the internal v.f.o. (or from an external v.f.o. when used). The result of all this is that the v.c.o. signal is phase locked to the v.f.o. signal and drift in any direction by the v.f.o. is cancelled. The v.f.o. circuitry itself is beautifully simple as shown in fig. 4. Provisions are made for the installation of one crystal in the 5.0 to 5.5 MHz range for fixed-frequency operation. This one crystal will allow for an output on all of the bands, but the output frequency on bands other than that for which the crystal was specifically selected will not be obvious, as one might think. For instance, if a crystal were selected for 21.2500 MHz, the output frequencies on the various other bands would be:

3.7470 MHz (LSB)	24.750 MHz
7.2470 MHz (LSB)	28.250 MHz
10.2500 MHz	28.750 MHz
14.2500 MHz	29.250 MHz
18.250 MHz	29.750 MHz

One obviously can get a lot of mileage out of one crystal, but one does have to be careful not to get into a situation where out-of-band operation is possible. It's all explained in the FT-77 manual.

The frequency display unit is driven from the PLL circuitry, and its counter has preset offests for the different modes, so the correct carrier frequency is always displayed. The display unit has its own internal time base. The six-digit display is of the green fluorescent type and is very easy to read. Besides the frequency display, the display area also includes **VFO-A**, **VFO-B**, and **F** symbols to indicate whether the internal v.f.o., external v.f.o., or fixed crystal is being used. The display does not follow the **RIT** control setting in the receive mode.

Test Results

Most of the claimed specifications for the FT-77 are conservative. The power output averaged about 110 watts on all bands, falling to about 90 watts at the high end of 10 meters. IMD products were about −30 dB at full power input. Unwanted sideband suppression, spurious radiation, and carrier suppression figures were all around −45 to −50 dB. The harmonic attenuation on some of the lower frequency bands was better than 60 dB, and never less than about −45 dB. No sophisticated measurements were made of receiver performance, since most amateurs probably would not be buying an FT-77 based on such specifications. Sensitivity figures were better than those specified, ranging around 0.4 uv for 20 dB S + N/N ratio on s.s.b. The only specification that could not be verified was an image rejection of 70 dB. No more than 50 dB could be measured on 10 meters, and this is in line with that achievable by most single conversion designs with a 9 MHz i.f. In reality, 50 dB is

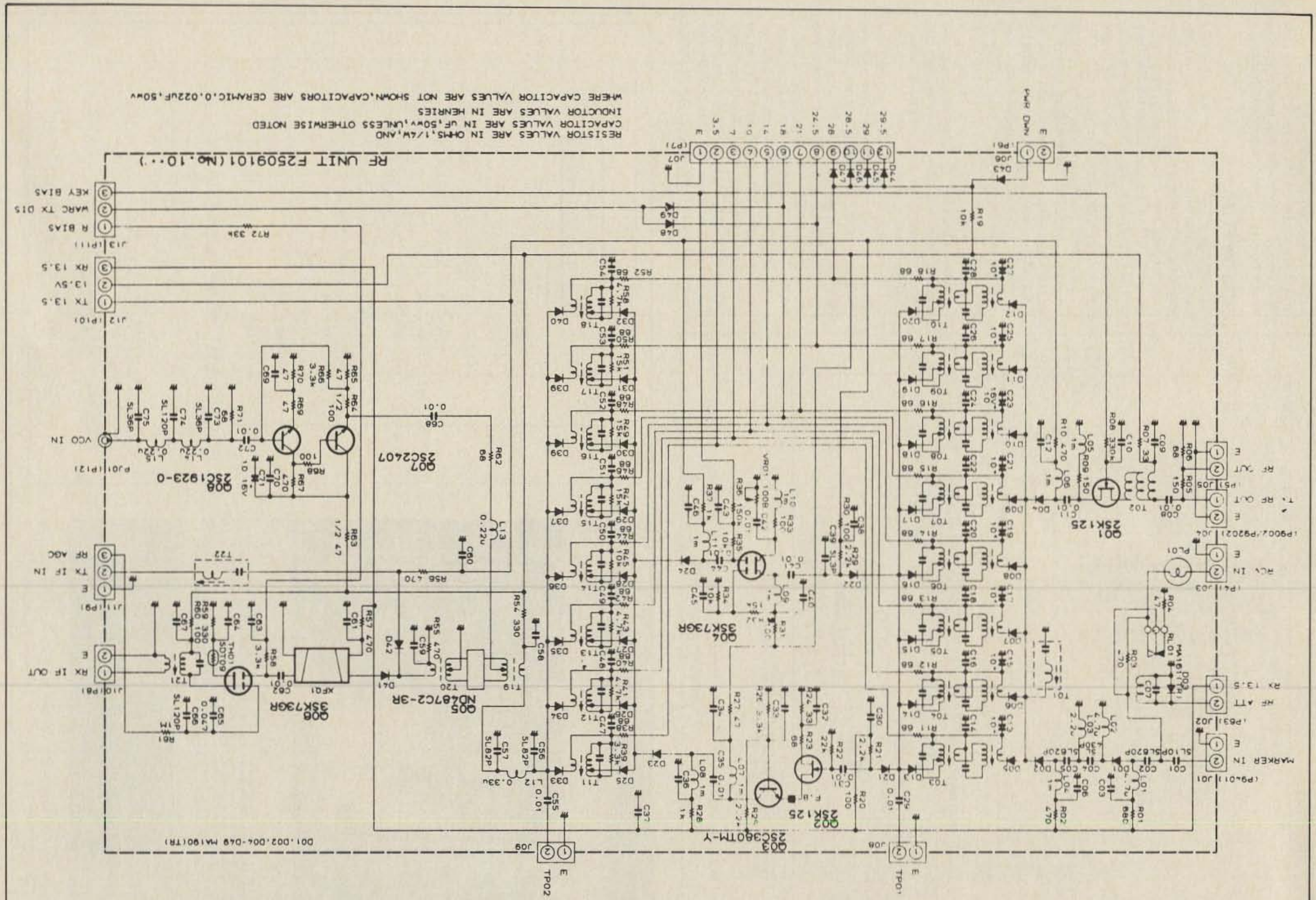


Fig. 2– The "front end" of the FT-77. The 3SK73GR stage is not the receive r.f. preamplifier as one might imagine. It is a buffer stage for the transmit signal chain.

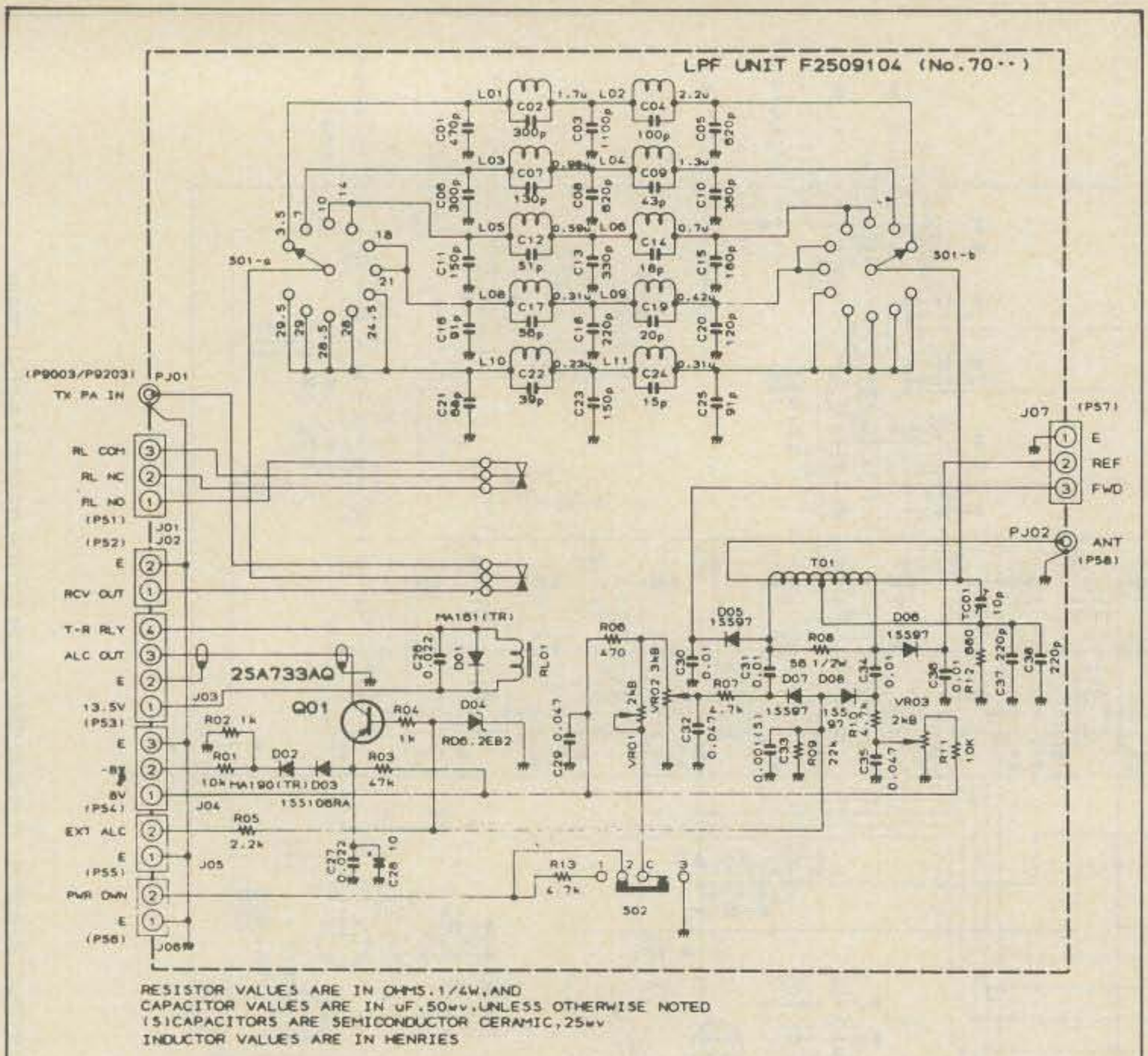


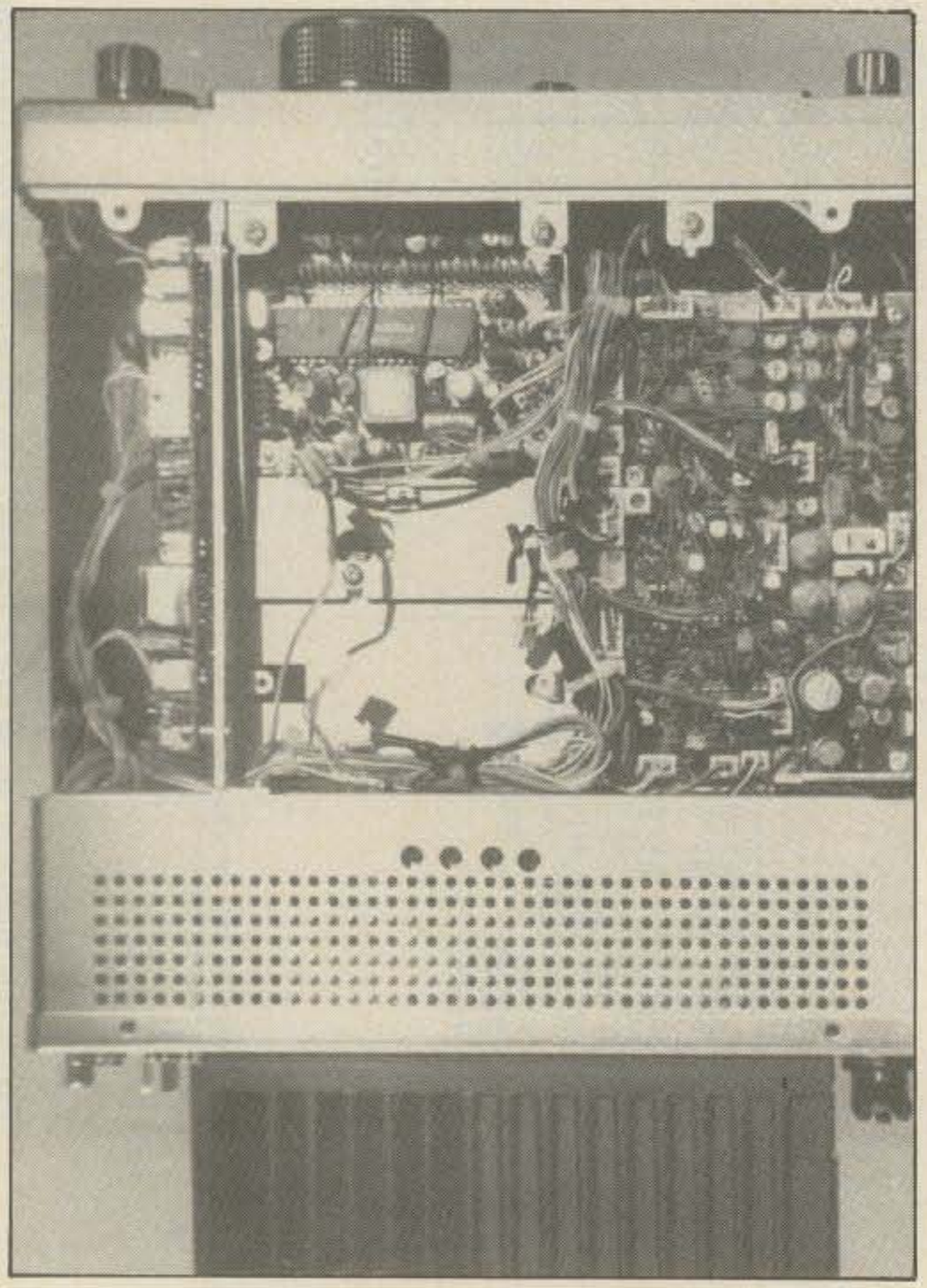
Fig. 3– The bandswitch in the FT-77 switches the PA output lowpass filters directly instead of having relays do the job.

a quite respectable figure for 10 meters, and the difference between 50 and 70 dB will not mean much under most practical operating situations on 10 meters, especially mobile.

Using the FT-77

Using the FT-77 is just about simplicity itself. If the antenna load is known and reasonably matched, there is nothing more to do on s.s.b. except set the operating frequency, close the PTT circuit, and adjust the **Mic/Drive** control so the meter indicates within the a.l.c. range as one modulates the transceiver. There is no VOX circuitry; operation is strictly PTT. On c.w. operation is equally as simple. Under key-down conditions the **Mic/Drive** control is set such that the a.l.c. indication on the meter is just at the upper edge of the a.l.c. zone indicator (for full power output), and the transceiver is ready for operation. Sidetone as well as a delay feature for semi-break-in are built-in. Two controls in a recessed panel on top of the transceiver are available to adjust the *sidetone level* and *delay time* after the last keyed character before the transceiver switches to the receive mode.

If an antenna tuner has to be adjusted for minimum s.w.r., one simply has to reduce the **Mic/Drive** control to minimum, set the operating mode to **CW,** and close the PTT line or key-down the transceiver (the PTT line and key line are the same circuit), and then slowly increase the **Mic/Drive** level as the antenna tuner is adjusted. The s.w.r. meter in an antenna tuner or the s.w.r. reading circuitry in the FT-77 can be used to make the adjustment. The only slightly awkward thing about using the s.w.r. feature in the FT-77 is that the switch that changes the meter indication from a.l.c. to s.w.r. during



A look inside the FT-77 reveals a "busy" but not over-crowded layout. The v.f.o. unit and PA unit are shielded separately.

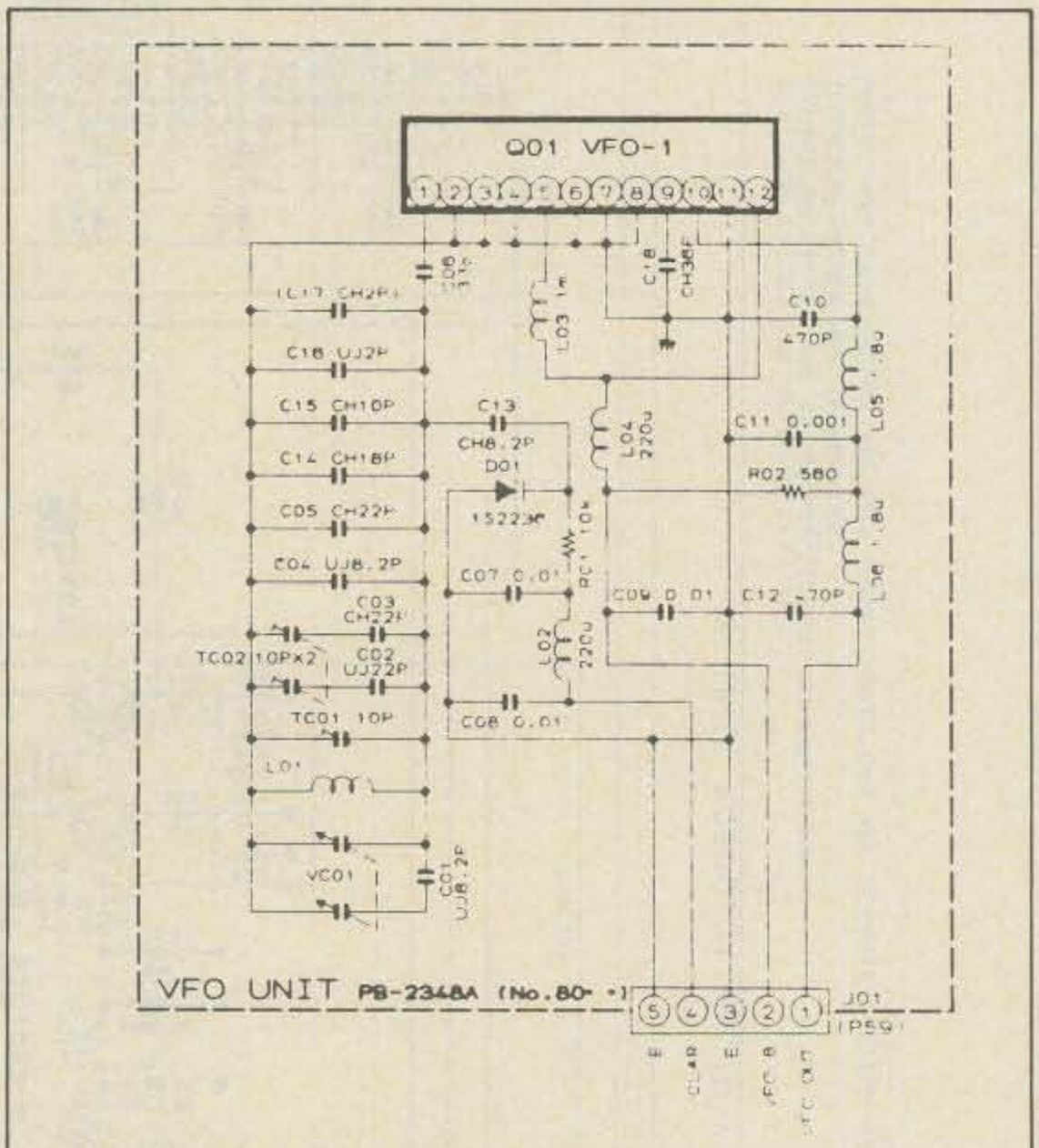
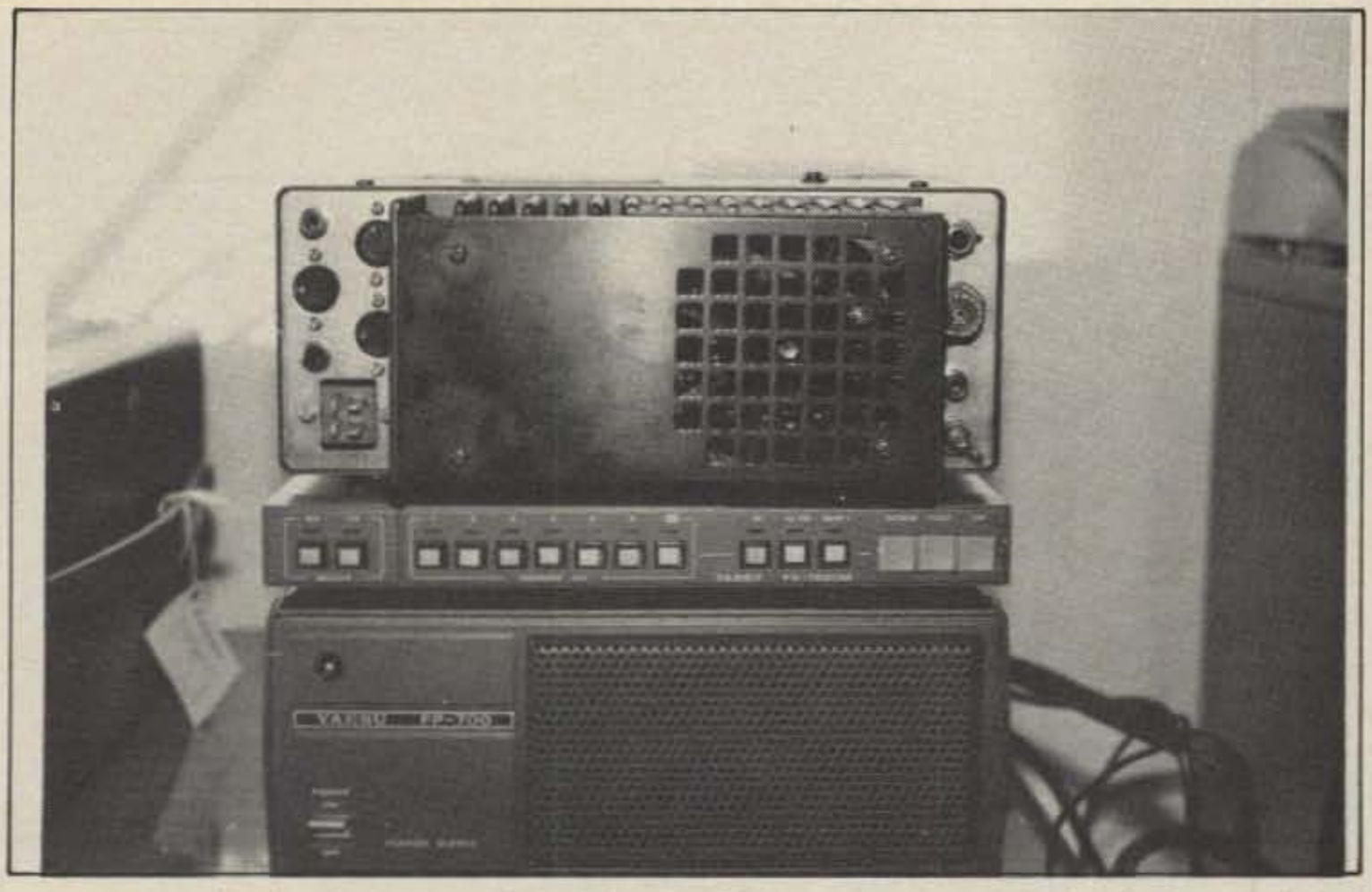


Fig. 4– The elegantly simple analog 5 MHz v.f.o. in the FT-77.



The back panel looks simple enough, but the use of DIN connectors allows for the connection of many accessories.

transmit is located under the recessed panel on top of the transceiver. Therefore, one has to access the switch twice during the tune-up/operation sequence, a chore which might be a bit awkward in a mobile or portable installation. The situation can easily be corrected by those who are a bit handy with circuitry wiring. One of the front-panel switches for an unused accessory item (e.g., the marker option) could be used to switch the meter between its a.l.c. and s.w.r. reflected power functions.

The "feel" of the main tuning knob is excellent. The knob itself is about 1 inch deep and has a rubberized finish for a very comfortable yet firm feel. It covers about 18 kHz/revolution, which is a good compromise for s.s.b. tuning and even c.w. tuning using the optional 600 Hz c.w. filter. The frequency display is very comfortable to view either under bright or dim ambient light conditions. It does not have the "glare" that sometimes is associated with LED readouts. The frequency display is very stable except when the 100 Hz digit is just set on the fringe between 100 Hz digits. At some times a bit of flickering back and forth was observed when, for instance, the display couldn't decide whether to display 28.547.5 or 28.547.6 MHz.

All of the rest of the front-panel controls respond very smoothly. The **Clarifier** (RIT) control covers about ±2.5 kHz, and a red LED indicator signals that it is in use. Another red LED indicator signals when the 20 dB attenuator has been switched in the receive antenna line. The noise blanker on/off switch is on the front panel, while the selector switch for wide/narrow operation is under the recessed top cover. The separation of these two switches did not pose any inconvenience. The noise blanker always provided positive action against impulse noise in its narrow position and variable results against over-the-horizon radar signals in its wide position. Sometimes it was extremely effective against the radar signals (reducing an S9 signal to S1), and at other times it didn't seem to react to such signals at all.

The **CW-W** position on the mode switch means nothing more than the standard s.s.b. filter. The **CW-N** position selects the optional 600 Hz c.w. filter. This filter is nicely shaped with a 600/1300 Hz bandwidth at −6/−60 dB and fits very well with the fixed main tuning rate. Although there is no r.f. gain on the FT-77, c.w. operation using the 600 Hz filter proved to be very pleasant using the selectable fast a.g.c. action. By proper setting of the c.w. delay control, almost any c.w. operator, except those who demand high-speed full QSK, should be satisfied with the break-in action. The keying waveform rise/fall times were not measured, but monitoring of the keying indicated it was very clean with being just the slightest bit on the "soft" side.

Received s.s.b. audio was very clear using either the built-in speaker or the speaker in the FP-700 a.c. power supply. Reports on the transmitted audio using the MH-1 microphone supplied with the FT-77 were always favorable. Some stations, in fact, inquired as to whether any particular form of speech processing was being used because of the clear, "punchy" audio.

Accessory Provisions/Options

Although the back panel of the FT-77 is covered 80% by the PA heatsink, Yaesu did fit in very nicely a variety of connectors for various external accessories and options. There is a six-pin DIN connector dedicated to the switching and a.l.c. connections needed when using a phone patch or linear amplifier. An eight-pin DIN jack accepts the output of and provides regulated power for an external v.f.o. Still another seven-pin DIN jack is meant for interconnection with the optional FV-700 DM or FV-707 DM v.f.o.'s if one desires the frequency scanning/memory features provided by those units. Those connections are in addition to the usual ones for r.f. output, external speaker, d.c. input, ground, key, and low-power output (approximately 1 milliwatt) for a transverter.

The internal options for the FT-77 are the narrow c.w. filter, an f.m. unit, and a Marker unit. The narrow c.w. filter was mentioned before and is a highly effective unit. The f.m. unit installs directly in the FT-77 using the cable assemblies supplied with it. When it is installed and the mode switch on the FT-77 set

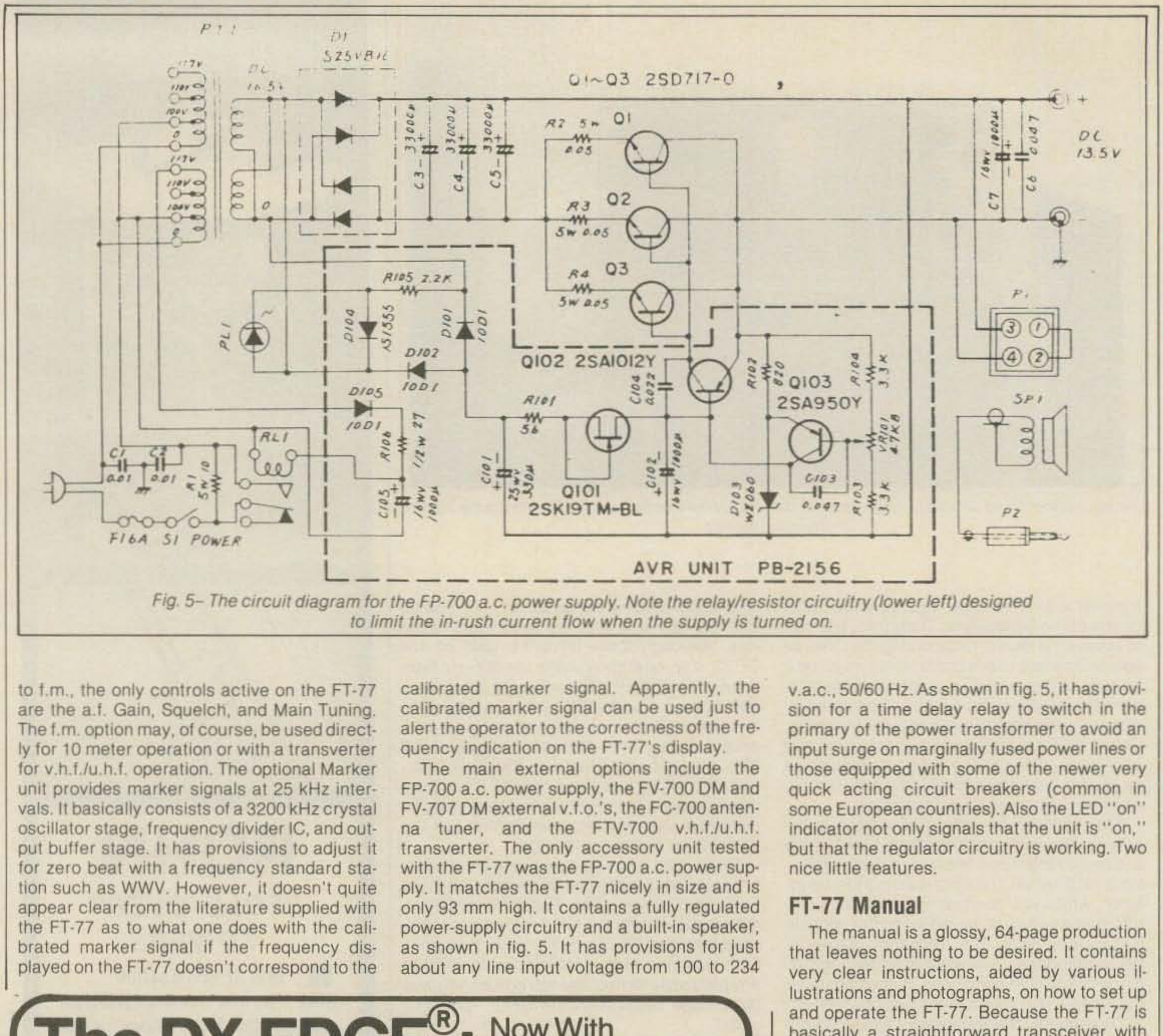


Fig. 5– The circuit diagram for the FP-700 a.c. power supply. Note the relay/resistor circuitry (lower left) designed to limit the in-rush current flow when the supply is turned on.

to f.m., the only controls active on the FT-77 are the a.f. Gain, Squelch, and Main Tuning. The f.m. option may, of course, be used directly for 10 meter operation or with a transverter for v.h.f./u.h.f. operation. The optional Marker unit provides marker signals at 25 kHz intervals. It basically consists of a 3200 kHz crystal oscillator stage, frequency divider IC, and output buffer stage. It has provisions to adjust it for zero beat with a frequency standard station such as WWV. However, it doesn't quite appear clear from the literature supplied with the FT-77 as to what one does with the calibrated marker signal if the frequency displayed on the FT-77 doesn't correspond to the calibrated marker signal. Apparently, the calibrated marker signal can be used just to alert the operator to the correctness of the frequency indication on the FT-77's display.

The main external options include the FP-700 a.c. power supply, the FV-700 DM and FV-707 DM external v.f.o.'s, the FC-700 antenna tuner, and the FTV-700 v.h.f./u.h.f. transverter. The only accessory unit tested with the FT-77 was the FP-700 a.c. power supply. It matches the FT-77 nicely in size and is only 93 mm high. It contains a fully regulated power-supply circuitry and a built-in speaker, as shown in fig. 5. It has provisions for just about any line input voltage from 100 to 234 v.a.c., 50/60 Hz. As shown in fig. 5, it has provision for a time delay relay to switch in the primary of the power transformer to avoid an input surge on marginally fused power lines or those equipped with some of the newer very quick acting circuit breakers (common in some European countries). Also the LED "on" indicator not only signals that the unit is "on," but that the regulator circuitry is working. Two nice little features.

FT-77 Manual

The manual is a glossy, 64-page production that leaves nothing to be desired. It contains very clear instructions, aided by various illustrations and photographs, on how to set up and operate the FT-77. Because the FT-77 is basically a straightforward transceiver with regard to its circuitry, the manual also provides complete service and alignment information. There are detailed diagrams and photographs (for parts layout) of every PC board. There is also a complete parts list giving the Yaesu part number and commercial equivalent, except in the case of a few custom IC's.

Summary

The FT-77 is a dandy little transceiver and a delight to use. It has one or two minor convenience faults, in my strictly personal opinion, but none of them detract from the operating quality of the unit. It is very ruggedly constructed, and one would have to rate it as a prime choice for someone who wants a top-performing mobile or portable unit or a starter-type home station unit, without a lot of "bells and whistles," at a modest price.

Numerous accessory items (FC-700 antenna tuner, MD-1 microphone, FV-700DM digital v.f.o., and the FTV-707 2 meter transverter) were only made available after this article was finished. They will be covered in a follow-up article which should be of general interest, since only the FV-700DM is a dedicated accessory for the FT-77.) CQ