

The Yaesu FT-707 H.F. S.S.B. Transceiver

BY JOHN J. SCHULTZ*, W4FA

The Yaesu FT-707 is advertised as being "hardly larger than a book," and it comes pretty close to achieving that claim since it measures only 93 x 240 x 295 mm overall. Of course, the "book" meant was probably one like the *Home Medical Adviser* rather than a small pocketbook, but nonetheless, the "packaging" is remarkable for a full-featured h.f. s.s.b. transceiver.

Give or take a few ideas and features, the FT-707 is a compact version of the popular Yaesu FT-107 design concept.

Circuitry Details

Fig. 1 shows a block diagram of the FT-707. Like the FT-107, it turns out to be a sophisticated version of a 9 MHz i.f., single conversion h.f. transceiver, although some frequency mixing stages are included which might not allow one to clearly see this at first. Looking at the transmit side first, the s.s.b. transmit chain is conventional, with audio and carrier signals being fed into a balanced modulator stage, D3007-D3010 (upper left of fig. 1). The resultant 9 MHz (8.9875) d.s.b. signal is then buffered and reaches the 2.4 kHz s.s.b. filter XF2003 and a following buffer amplifier. The resultant s.s.b. signal proceeds to a double balanced mixer stage, Q1008 (which is also the first mixer stage used in the receive mode).

At this point, the s.s.b. signal is frequency translated to the final output frequency, and the following amplifier stages (Q1002, Q1003, and the PA unit) build up the signal to the 240 watt input level. The linear amplifier stages are all broadbanded so the PA stage is followed by a low-pass filter unit which switches in separate low-pass filters for different band combinations. These filters are all relay switched, the same as in the FT-107, which is quite a trick considering the size difference between the FT-107 and FT-707. The bandswitch in the FT-707 controls only d.c. voltages, by the way, and either relays or diode switches affect the actual r.f. signal paths.

A directional coupler samples the output signal before it reaches the antenna



The FT-707 is both handsomely and compactly packaged. It is shown with a scanning-type microphone, but the scanning feature requires the FT-707DM Digital VFO.

terminal and provides for both an ALC feedback voltage and s.w.r. sensing for protection of the PA unit (although the front panel "meter" indicator does not display s.w.r.). Thermal over-temperature protection is also provided for the PA unit, and if an excessive temperature is reached, an internal fan is turned on. Actually, all three protection systems for the PA unit (ALC or overdrive, excessive s.w.r., and excessive PA heatsink temperature) are interlocked so if any excessive condition occurs, drive to the PA unit will be reduced and/or the cooling fan will be activated.

Finally, in the transmit mode, one should mention the full VOX circuitry (gain and delay controls are on the front panel) and the semi-break-in feature on c.w. A built-in sidetone oscillator has part of its output on c.w. routed to the VOX circuitry to provide the c.w. semi-break-in feature. The microphone/carrier level controls can be adjusted to run any input level from QRP levels to full input on s.s.b. or c.w.

In the receive mode, the input signal is routed through a 1.7 MHz high-pass filter and then to a dual-gate MOSFET r.f. amplifier (Q1001). This stage has diode switched bandpass filters in its drain terminal for each band covered. The signal then goes to the same double balanced mixer stage as used on transmit which uses Schottky-type diodes. The combination of this type of mixer stage, the r.f. amplifier characteristics, and a

low-noise oscillator injection signal are the heart of the FT-707's "front-end" performance.

After being translated to the nominal 9 MHz i.f. frequency, the signal goes to a series of noise blanker stages. The principle is the same as in the FT-107: time constants in the noise blanker circuitry (Q2010, 2011, etc.) are chosen to distinguish between very short, high-amplitude pulses and slower, amplitude-varying signals so as to gate (squell) out the former. Unlike in the FT-107, the blanker threshold level is internally but not front-panel adjustable. The signal then goes through the 2.4 kHz s.s.b. filter (or optional 600 Hz c.w. filter) and on to the variable i.f. bandwidth circuitry. The principle of this type of circuitry has been described many times before, so no great detail will be given, although the basic FT-707 scheme is shown in fig. 2. By scanning/superimposing two s.s.b. filter characteristics on top of each other, an effective continuously variable bandwidth of 300 to 2400 Hz (at -6 dB) is achieved. So, there is absolutely no need for any additional i.f. filters, except if one desires extreme skirt selectivity on c.w. This latter point is not always clear, so it is further clarified in fig. 3.

The rest of the receive chain is fairly conventional with additional i.f. amplification, detection (a separate 1N60 diode being used for a.m.), and audio amplification. The latter includes a 2.7 kHz low-pass filter stage and a 3 watt output stage

*c/o CQ Magazine

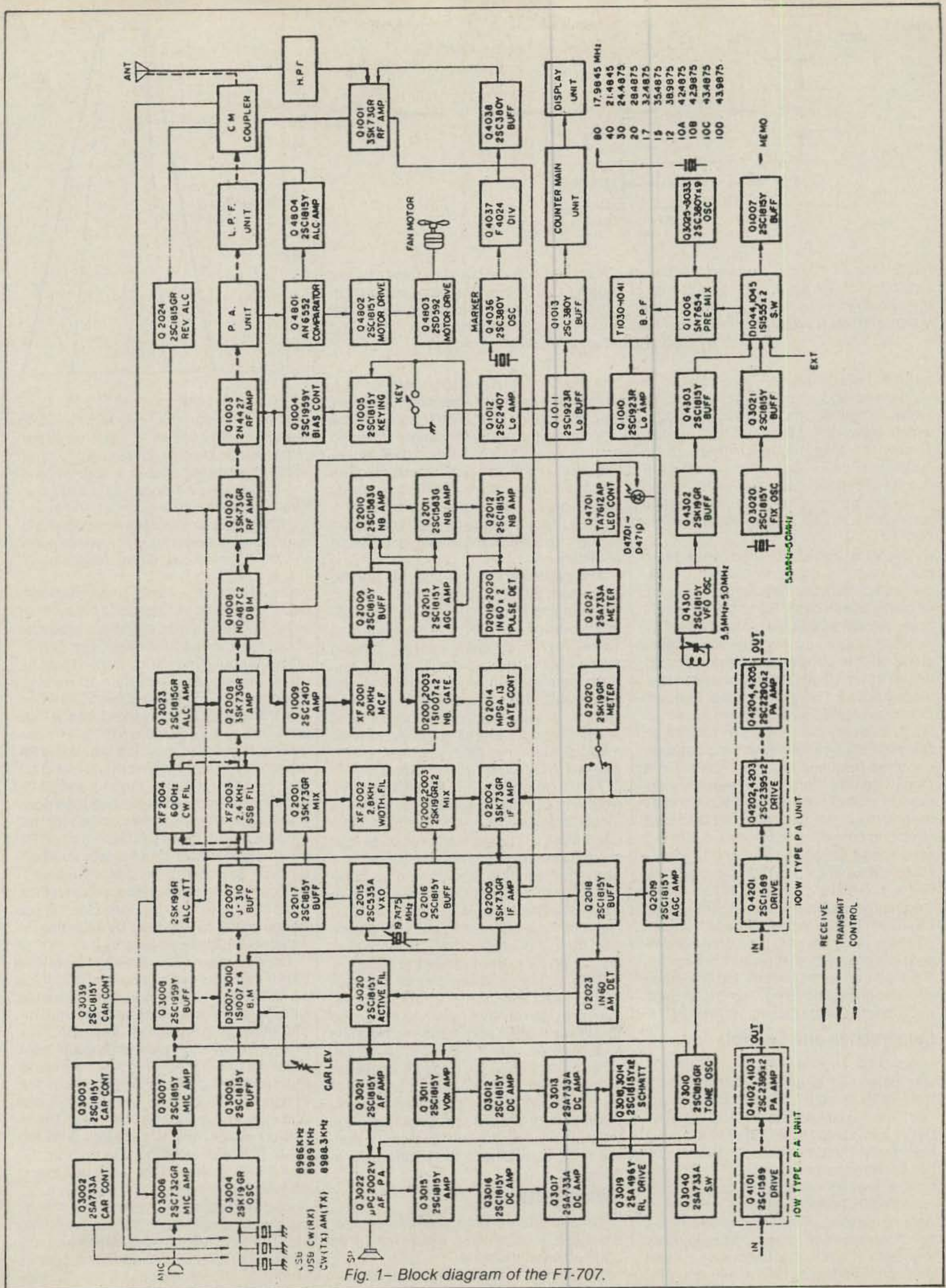


Fig. 1- Block diagram of the FT-707.

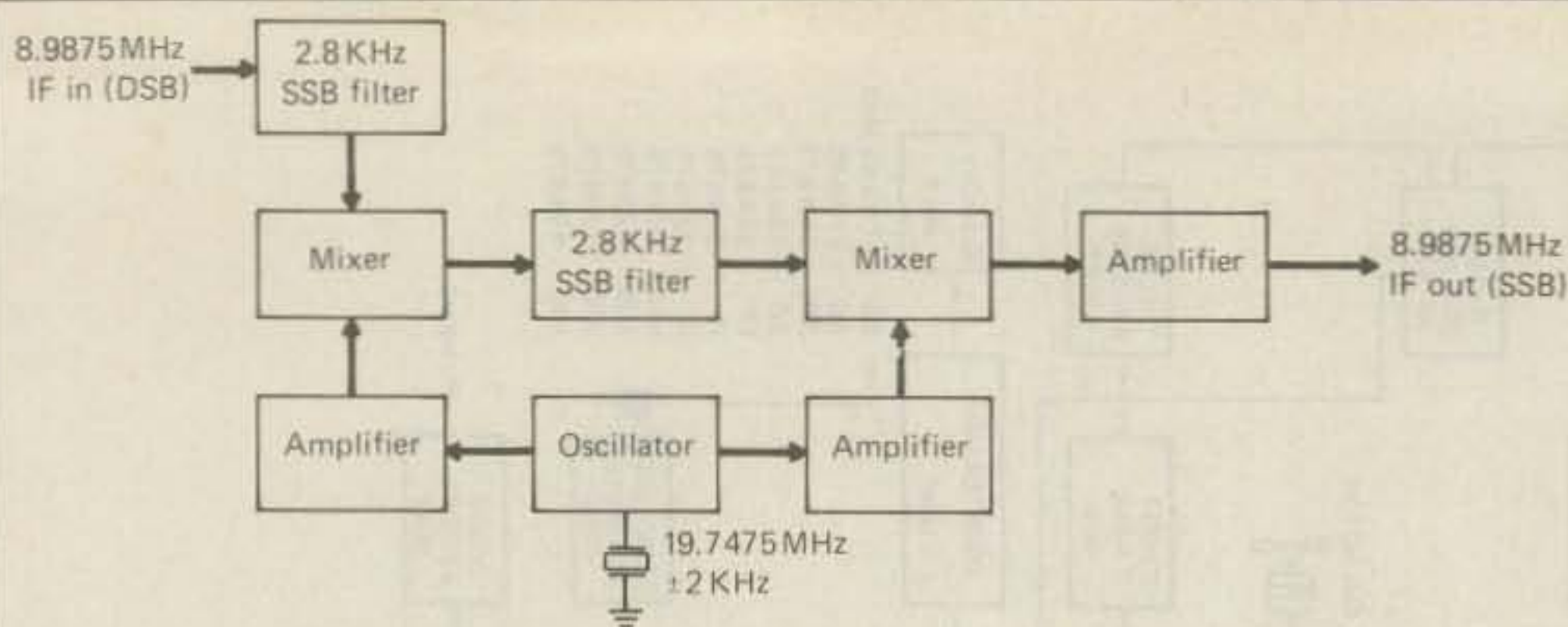


Fig. 2— The FT-707 has true variable bandwidth control in its i.f. chain by imposing the passband of one s.s.b. filter across that of another s.s.b. filter. The block diagram of the circuitry shows the idea involved. The s.s.b. filter in between the two mixer stages is centered on 10.76 MHz. The crystal frequency, in the actual circuitry, is varied ± 2 kHz by means of a tuning diode.

(at 10% THD distortion). Receive a.g.c. is i.f. derived and also includes additional meter amplifier stages (Q2020, 2021) which drive the LED-type "S" meter. Twenty-five kHz frequency markers on receive for calibration of the analog frequency readout (skirt of main tuning knob) are provided by a 3.2 MHz crystal oscillator (Q4036) with divide-down circuitry.

The v.f.o. and digital frequency readout circuitry is common to both the receive and transmit functions. The v.f.o. circuitry uses a basic 5.0 to 5.5 MHz variable oscillator (Q4301), the output of which is frequency translated in a mixer stage so it is correct for the double balanced mixer stage Q1008 which was previously noted. The exact crystal frequencies used for v.f.o. mixing are shown in fig. 1. In every case they are chosen so the main tuning knob always indicates increasing frequency as it is rotated in a clockwise direction. Fixed frequency operation is also possible on each band by means of crystal oscillator Q3020 which uses one optional crystal in the 5.0 to 5.5 MHz range for each band and is simply switched in, when desired, to replace the 5.0 to 5.5 MHz v.f.o. output. The digital frequency counter revolves around an LSI IC which reads the injection frequency to the mixer stage Q1008. Internal presets are provided so the counter displays the true carrier frequency for any mode of operation being used. The 6-digit readout provides resolution to 100 Hz.

Construction and Controls

Although the circuitry of the FT-707 was patterned after that of the FT-107, the FT-707 is quite different in construction. The FT-107 consists of a large number of individually shielded plug-in circuit boards to a "mother board" plus a number of wired-in boards. The FT-707 has only a limited number of large, fixed-mounted PC boards with plug-in interconnecting cabling. The "soldier-like" lineup of transformer "cans," etc., is really impressive. A quick count showed about 55 such enclosures on the two main PC

boards. Certainly any alignment or servicing necessary would appear to be very much simplified by this arrangement. The v.f.o. is in its own completely shielded enclosure, as are the PA and PA driver circuitry. The outside of the unit consists of a heavy die-cast front panel and sturdy rolled steel top and bottom covers. Overall, the construction appears rugged enough for almost any mobile or portable application.

The placement of the controls can be seen from the photograph. Obviously, in repackaging the FT-107 into the small dimensions of FT-707, the engineers at Yaesu had to do quite a bit of thinking about control placement. Certainly one thing that was done very well was the placement of the large-size main tuning control. It has an extremely good "feel" in operation and is as large as anyone might desire, although one is dealing with a semi-miniaturized transceiver.

The frequently used **AF/RF Gain** controls and **Clarifier/Bandwidth** controls are nicely bracketed by the less frequently used **Mode** and **Band** switches. One can see the line-up of the various pushbuttons above the controls, and they serve to select VOX or PTT operation, AGC fast or slow, Calibrator on/off, Meter to ALC readout, Fixed Frequency or VFO operation, Noise Blanker on/off, and Clarifier on/off, in that order from left to right.

Two miniature knobs below the main tuning knob, which are a bit difficult to see, provide for VOX gain and delay setting. Four LED's above the main tuning knob indicate when the calibrator is on, when fixed frequency (crystal) operation is being used, and whether the internal or an external VFO controls the transceiver. Considering the space available, one would have to rate the number, placement, type, and size of the controls as excellent.

Bench Tests

On both the transmit and receive side, the FT-707 essentially meets all of its claimed specifications.

On transmit, the carrier suppression

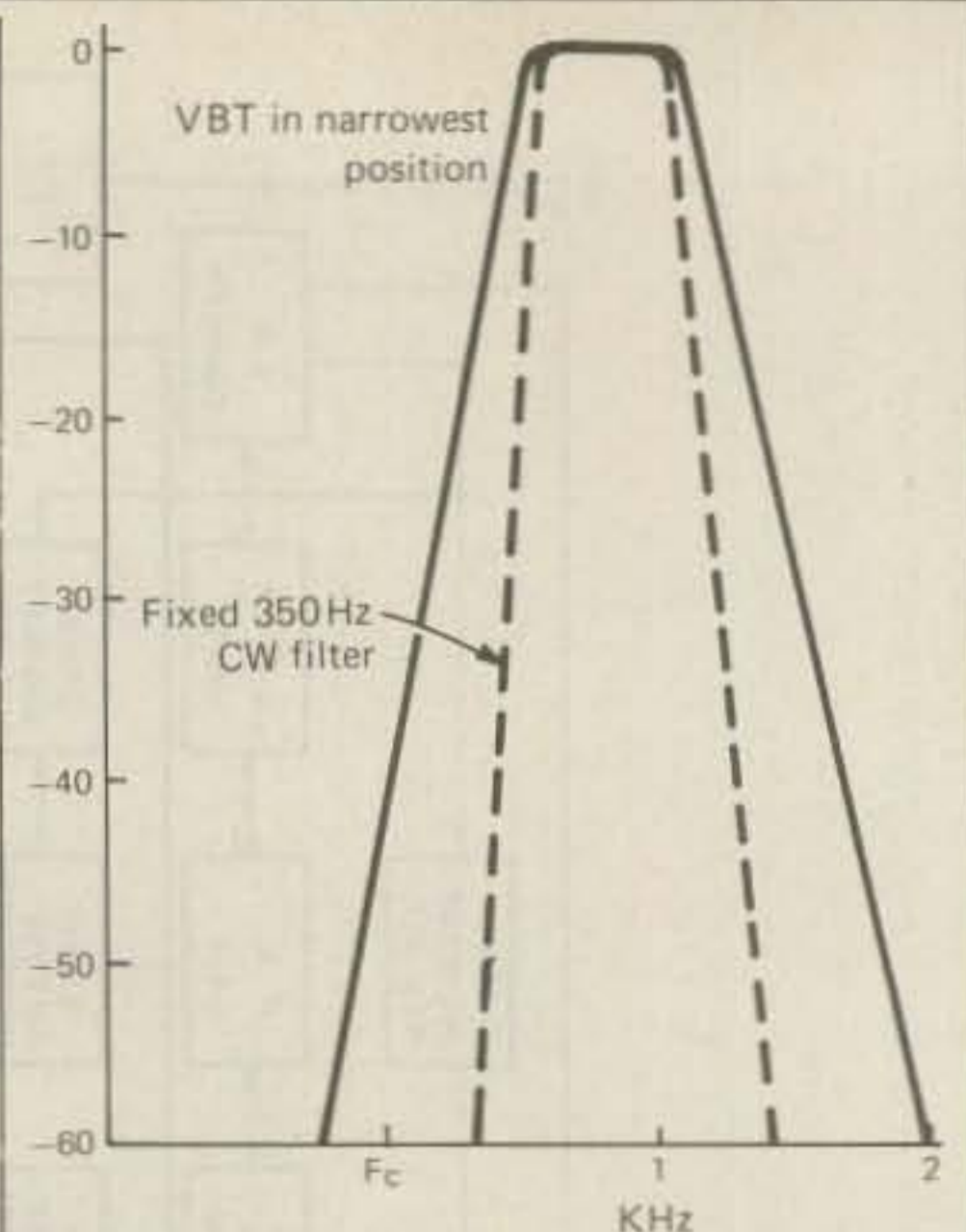


Fig. 3— The variable bandwidth tuning feature in the receive i.f. does an excellent job, but even in its narrowest bandwidth position, as shown, it will not have the same skirt sharpness as a fixed c.w. filter. Most amateurs will not need an extra filter even for c.w., but dedicated c.w. users should consider the advantages of the optional c.w. filters available.

was better than -40 dB, unwanted sideband and spurious radiations better than -50 dB, and third-order IMD products about -32 dB at full power. The carrier power output itself varied from 115 watts on 80 meters to 95 watts on 10 meters. The power output fell to about 50% when the transceiver was worked into a 150 ohm load to approximate a 3:1 s.w.r. The built-in, thermally activated fan for the PA never came on during normal testing on c.w. or s.s.b. The a.m. mode was not intensively tested, but at the reduced power input of 80 watts d.c. specified for this mode, all indications would be that no PA overheating would occur under even extended "key-down" periods. "Tune-up," of course, is really non-existent since there are no tuning controls. One simply brings up the carrier level by adjusting an antenna tuner, if necessary.

On the receive side, the sensitivity was better than claimed at less than $0.2 \mu\text{V}$ for 10 dB S/N on all bands. The dynamic range was a good 85 dB, and the third order intercept point about $+10$ dBm. The image frequency rejection varied from -65 dB on 80 meters to -45 dB on 10 meters (the latter being more than the claimed -50 dB but hardly significant and still very good for a "no-tune" transceiver). Selectivity is excellent with the s.s.b. filter varying in bandwidth from 2.4 to 4.0 kHz at the -6 to -60 dB points. The variable bandwidth feature functioned very smoothly, varying the -6 dB bandwidth from under 300 to over 2400 Hz. The LED level meter, which actually consists of nine LED elements, functions smoothly enough, but has a tremendous

jump (relative to input signal level) of the LED's which bracket the S9 readout. The one immediately below S9 comes on with about $8 \mu\text{V}$ input signal and the one above with $40 \mu\text{V}$ input level. One will probably tend to give rather "generous" "S" reports to stations below the S9 level if one goes by the LED indications.

The frequency stability leaves nothing to be desired in any of the operating modes. Drift was less than 100 Hz even far before the 30 minute warmup period specified to achieve that value.

Operational Results

If one accepts the FT-707 as a benchmark attempt to achieve full-performance, 100 watt output level transceiver performance in a semi-miniature package, it must get high marks. It covers the full range from 80-10 meters (including the WARC bands), tuning is very smooth, frequency stability and readout are excellent, selectivity is excellent, c.w. and s.s.b. characteristics are very good, etc. On-the-air reports were consistently good both as to s.s.b. voice characteristics and c.w. keying. Standing it next to some transceivers costing two to three times more left nothing to be desired in the receive mode except for the lack of an r.f. attenuator in those rare cases in which extreme signal input levels are encountered.

If one has to "search" for constructive criticisms about the FT-707, I would present the following points:

1. The LED level meter is colorful, but not as exact as an analog meter and consumes too much current. If an analog meter were used and a disable provided for the LED frequency readout, the receive mode current drain could probably be reduced to 0.5 amp, and the transceiver would become a truly battery-operable portable unit.

2. S.w.r. information is available from the directional coupler circuitry in the transceiver but not presented on the front

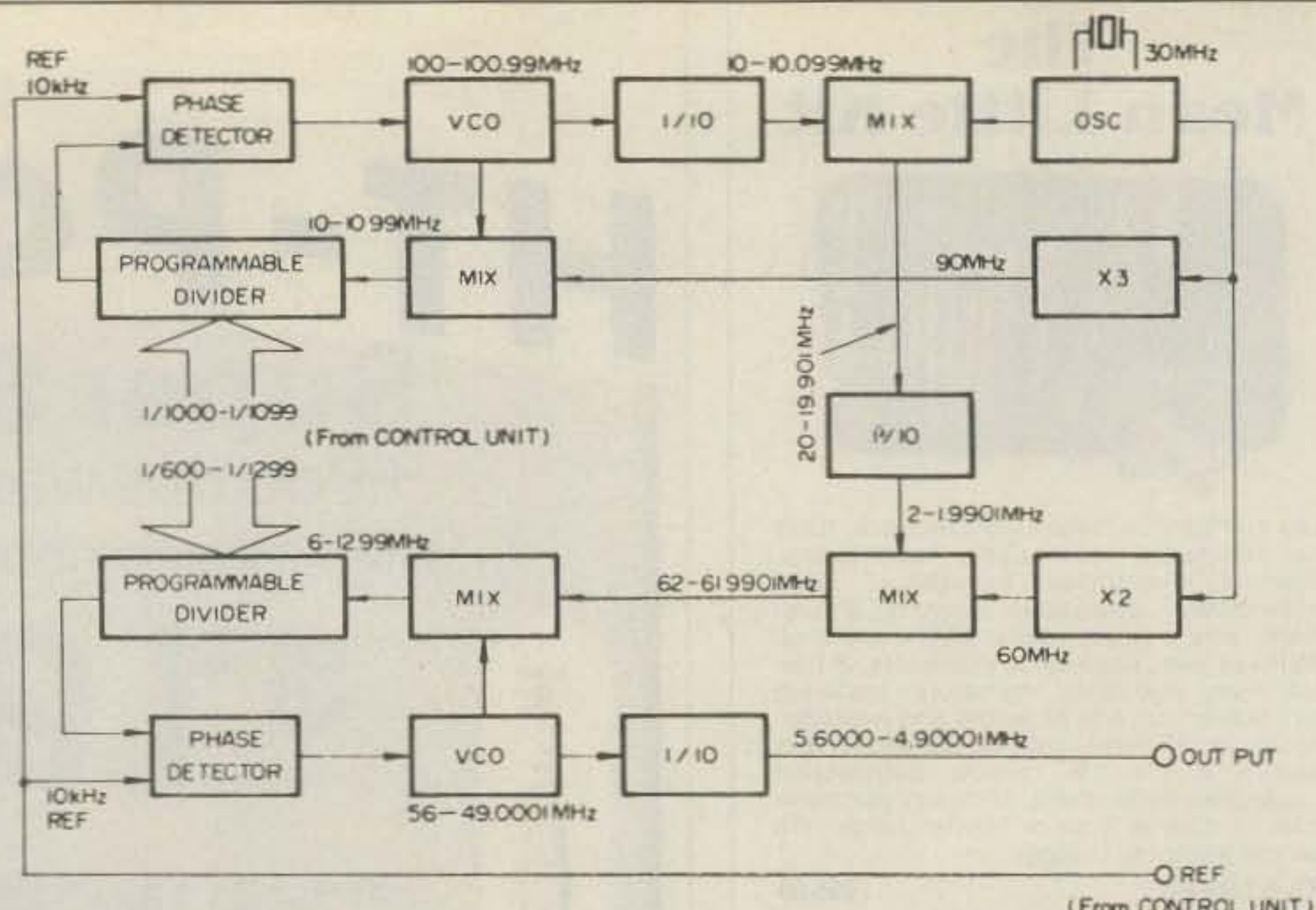


Fig. 4—The heart of the FV-707DM Digital VFO accessory is the PLL section shown in block diagram form. It delivers a synthesized signal in 10 Hz steps from 5.6 to 4.9 MHz to replace the analog 5.5 to 5.0 MHz v.f.o. signal in the FT-707. The other major section of the FT-707DM is a control one based on a microcomputer.

panel meter. Such a presentation would simplify the use of an accessory antenna tuner.

3. The excellent noise blanker should somehow have an accessible threshold control—either front or back panel. The circuitry used is excellent, but it responds far better to QRM such as the "woodpecker" if the threshold is adjustable.

4. R.f. speech processing, if used with care, can enhance the signal punch of almost any s.s.b. transceiver. The major, expensive components involved in realizing such a processor are already there in the FT-707 (the 2.4 and 2.8 kHz filters), but switching between the receive/transmit chain is necessary, so one gets double-duty use out of these filters for both variable bandwidth tuning on receive and r.f. speech processing on transmit as per the ICOM 720A design.

Again, one must mention that the above comments are not critical of the FT-707. Some of the features mentioned can easily be achieved by outboard accessories or even internally in the FT-707 by those who are handy at circuit work.

Accessories

The basic accessory one might want to consider for use with the FT-707 is the FP-707 power supply. It's about as compact as the FT-707 itself, which is significant for a full 13.5 volt/20 ampere output supply, and includes an accessory speaker. The a.c. input is adjustable from 100 to 234 volts in various steps. The regulation is 5%, no load to full load, and considering its weight at 7.4 kg (about one kg more than the FT-707 itself), it's quite a good unit.



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The major accessory available for the FT-707, however, is the FV-707DM Digital v.f.o. This accessory directly interconnects with the FT-707 and is extremely compact at 27 x 238 x 235 mm. It provides for 12 frequency memories, up/down frequency scanning in slow or fast modes, and split frequency operation using a combination of the FV-707 VFO setting and/or the FT-707 VFO setting. In essence, the FV-707DM is a more advanced version of the DMS unit incorporated in the FT-107M transceiver. Any frequency displayed on the FT-707 readout can be stored in memory in the FV-707DM by depressing the memory channel pushbutton on the FV-707DM. It can be recalled in the same manner, after the FT-707 main v.f.o. is moved to a new frequency, by again depressing the memory channel pushbutton. The 12 available memories can be split up or combined in any manner desired among the various bands.

If one calls up a memory frequency, it can also be used as an up/down scanning reference frequency. Scanning up/down can be initiated by pushbuttons on an optimal scanning microphone. If the Down or Up pushbuttons are depressed momentarily, the frequency changes in 10 Hz steps. If the buttons are held down continuously for 1 to 2 seconds, scanning steps in 20 Hz increments. If in addition to the Down/Up button, a Fast button is depressed, the scanning speed is increased by a factor of 10. One has to manually stop the scanning action of the FV-707DM, but between the combination of memory channels available and scanning speeds, one can cover about any possible DX search or net call-in/frequency shift operation desirable. For those interested in the more technical details, fig. 4 presents a block diagram of the FV-707DM functions.

An optimal accessory for the FT-707 is the FC-707 Antenna Coupler. It sort of recognizes the fact that if you don't have to tune the FT-707, you may have to tune an antenna coupler to achieve maximum power transfer between the FT-707 and a specific antenna. The FC-707 covers, of course, all the same bands as the FT-707 and has calibrated power scales for 15 or 150 watts plus an s.w.r. scale. It will match a resistive load impedance (unbalanced) of 10 to 250 ohms, which is more than enough to handle all the band-edge to band-edge variations found using the usual multiband trap dipole or beam. Insertion loss is less than 0.5 dB.

If one really wishes to tie all parts of the FT-707 and its accessories together, there is the MR-7 Rack Assembly. It's not exactly an interior decorator's style delight, but for an approximate 350 mm height it allows a very functional, practical combination of the FT-707 Transceiver, FP-707 Power Supply, FV-707DM Digital VFO, and FC-707 Antenna Coupler.

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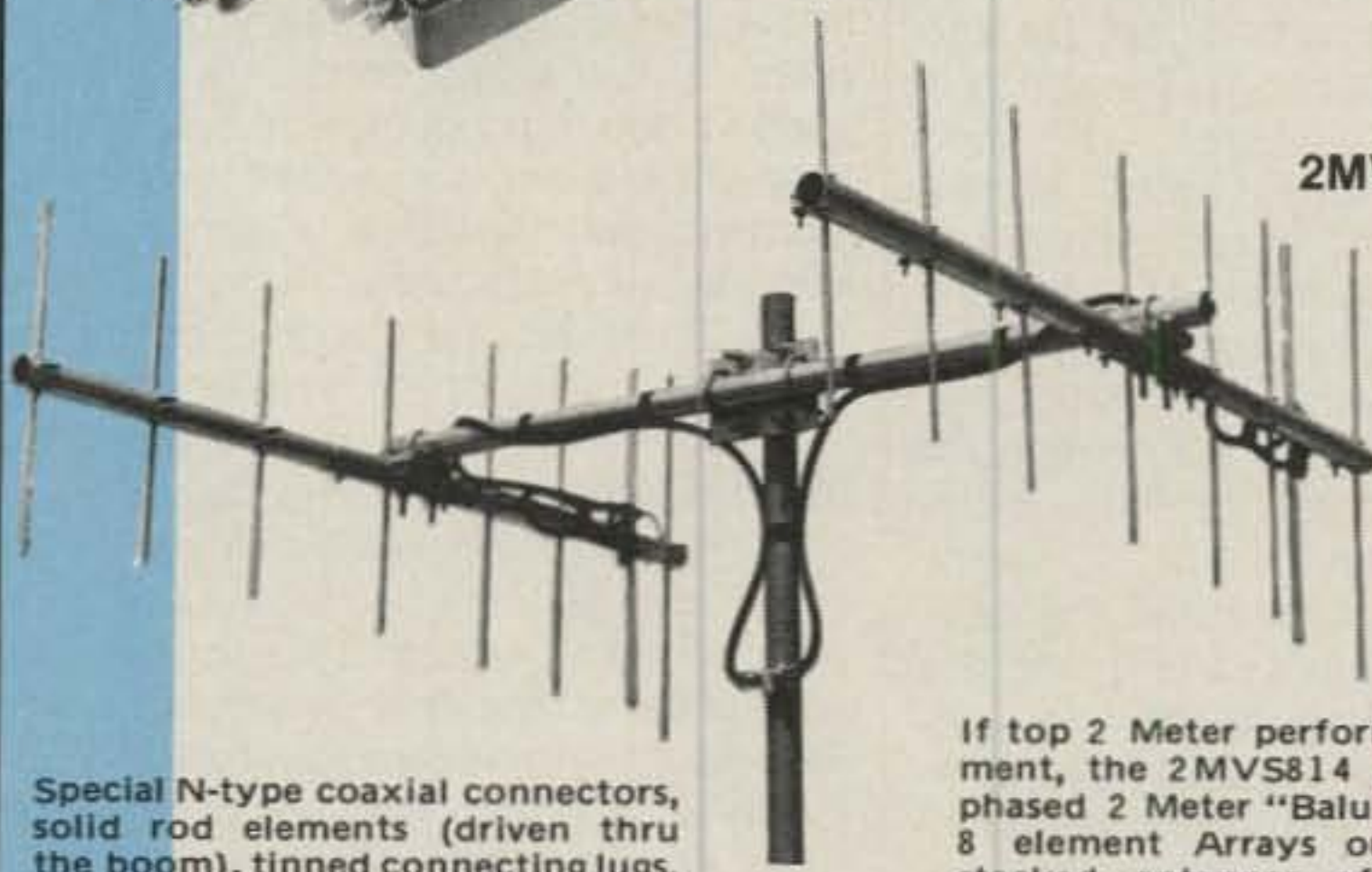
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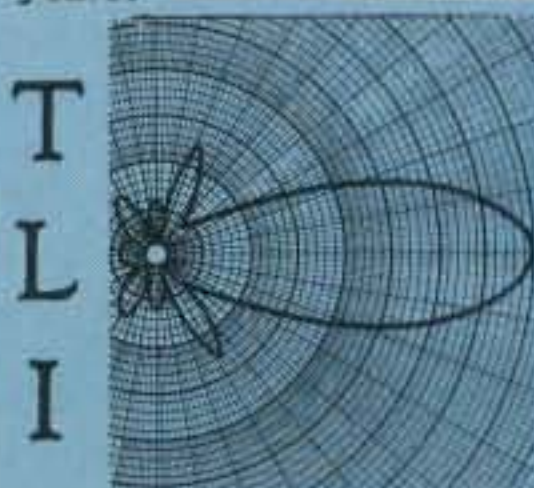
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