NAB Reference Receiver

- Produced by DENON in 1992

  High Performance Stereo AM/FM Tuner

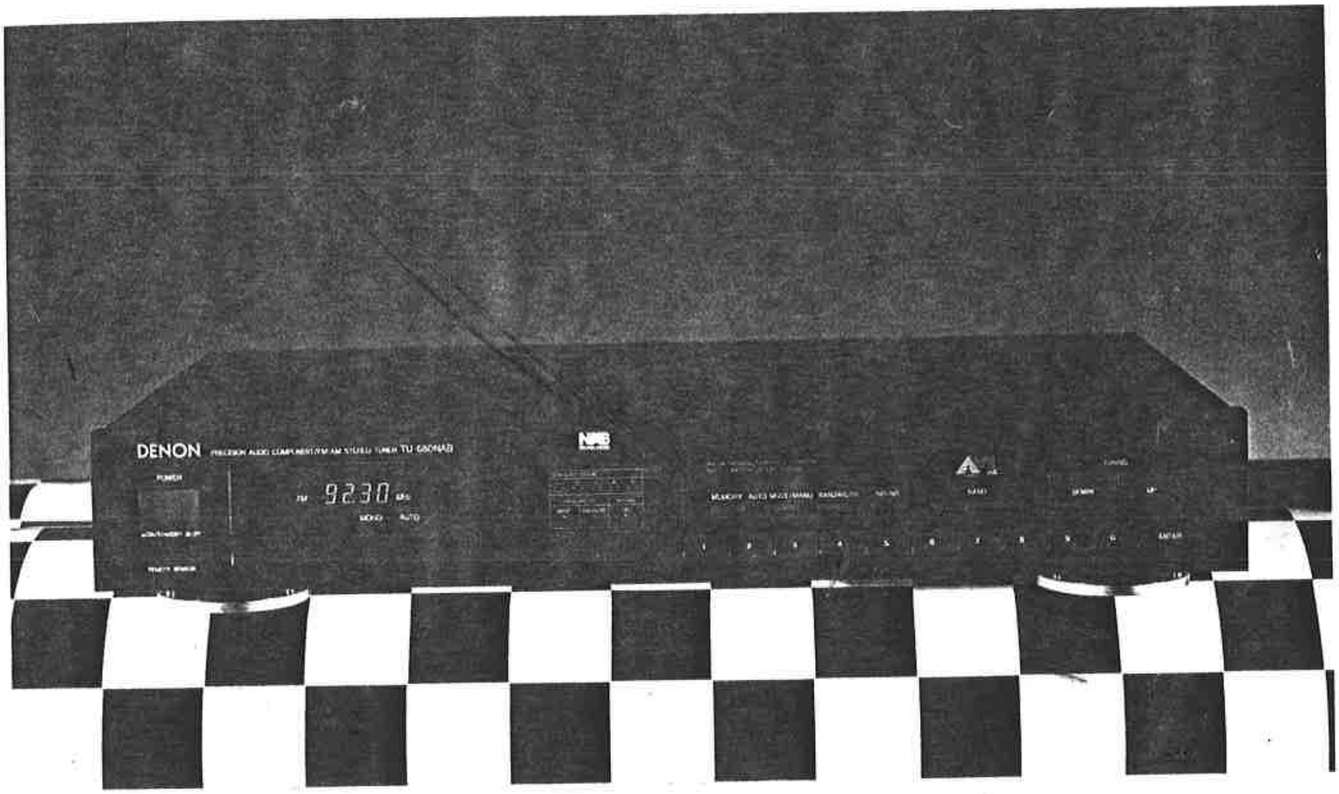
  "AMax Stereo" Certified

- Sold Through DENON Retailers and NAB Store

- Only About 3,000 Produced; Now Very Rare

EQUIPMENT PROFILE

DENON TU-680NAB "SUPERRADIO"



For some years now, I have bemoaned the fact that the AM circuitry in most "high-fidelity" tuners and receivers does not take advantage of the signal quality that AM stations are capable of transmitting. As readers of *Audio*'s tuner reports know, AM frequency response typically rolls off at around 2.5 kHz or, in exceptional cases, at 4 or 5 kHz. Yet AM broadcasters can transmit signals whose response extends far beyond this limit.

To show how good AM could be, the National Association of Broadcasters (NAB) commissioned a "SuperRadio" tuner from Denon, originally made for NAB members but now available to audio enthusiasts. The project resulted from the improved AM broadcasting and reception standards developed by the National Radio Standards Committee (a joint effort of the Electronic Industries Association and the NAB). The NAB has also set up a certification standard, called AMAX (AM at its maximum) for high-fidelity tuners. To get

THE DENON TU-680NAB IS BOTH A BYPRODUCT AND A JUSTIFICATION OF TODAY'S IMPROVED AM BROADCAST STANDARDS.

AMAX certification, a tuner must have frequency response from at least 50 Hz to 7.5 kHz, with correct NRSC de-emphasis; it must also have automatic noise blanking to reduce impulse noise, manually or automatically selectable audio bandwidth, connections for an external AM antenna, and the capacity to pick up all stations on the newly expanded AM band (now 540 to 1,700 kHz). If stereo is included, an AMAX tuner must be able to decode the Motorola-developed C-QUAM system. According to Denon, the TU-680NAB is the first tuner to incorporate all of the AMAX requirements, and the NAB is offering it directly to its member stations.

Both the FM and AM sections of the TU-680NAB have selectable bandwidth but not in quite the same way. The FM section has selectable wide or narrow *i.f.* bandwidth, with the narrow setting used for increased selectivity in areas where stations are closely spaced on the dial. The AM section has selectable *audio* bandwidth; the "Wide" setting has a rated bandwidth of 7.5 kHz, while the "Narrow" setting varies automatically with signal strength, narrowing as far as 3 kHz when conditions call for it. The AM section also incorporates a noise-blanking circuit that significantly reduces interference from such sources as fluorescent lights and electric motors. According to Denon, this circuit detects and suppresses impulse spikes, filling in with a portion of the preceding signal. The button that actuates noise blanking in AM mode also switches in the multiplex filter for FM. Confusingly, Denon has labelled this button "NR/NB," implying that the multiplex filter is some sort of noise reducer; actually, the only connection to "NR" is that the filter enables a tape deck's Dolby noise-reduction circuits to work properly when taping a signal from this tuner.

Up to 30 channels of either AM or FM can be stored in memory for instant recall. A remote control, capable of handling virtually all the tuner's functions, is supplied. The remote control also has a "Preset Scan" button that is not found on the tuner's front panel. Supplied accessories include the usual stereo interconnect cable, FM ribbon antenna, and snap-on AM loop antenna. Separate connections are provided for an external AM antenna, so the loop need not be disconnected when an outdoor antenna is used. (According to Denon, disconnecting the loop antenna from this or most other AM tuners will change the resonance of some front-end circuits, preventing proper operation even when an external antenna is substituted for the loop.) The tuner's AM frequency band extends from 520 to 1,710 kHz, covering the expansion of the AM band recently authorized by the FCC.

A NOISE-BLANKING CIRCUIT SIGNIFICANTLY REDUCES AM ELECTRICAL INTERFERENCE.

Control Layout

The "Power" switch and remote-control sensor are at the far left of the panel. Just to their right is a display that shows the current tuning frequency, preset number, radio band, tuning mode ("Auto" or "Manual"), reception mode ("Mono" or "Stereo"), and which of the mixed AM/FM preset banks is in use. The display also shows the presence of a signal, even if it's too weak to be indicated by the signal-strength section of the small secondary display further to the right. This secondary display also indicates the current bandwidth and if the noise blanker and multiplex filter are on.

The right half of the panel is dedicated to pushbuttons, including "Memory" for storing station frequencies and others for auto/manual tuning, "Bandwidth," "NR/NB," AM/FM "Band" selection, and "Tuning (Down/Up)." Below this row are 10 numbered buttons and an "Enter" button, used in entering and recalling preset stations.

The rear panel of the TU-680NAB is equipped with a bracket for the AM loop antenna. Terminals are provided for this AM antenna and for an external or outdoor antenna, as is an F-connector for a 75-ohm coaxial FM antenna lead and the usual left and right phono jacks for audio output.

Although Denon and the NAB emphasize the AM performance of this component, I was equally interested in finding out just how good its FM circuitry is. After all, to be dubbed a "SuperRadio" implies that its performance is super in all respects. Accordingly, I tested FM performance before tackling the AM section.

FM Measurements

Figure 1 shows frequency response. Despite a rise of almost 2 dB at 10 kHz, overall

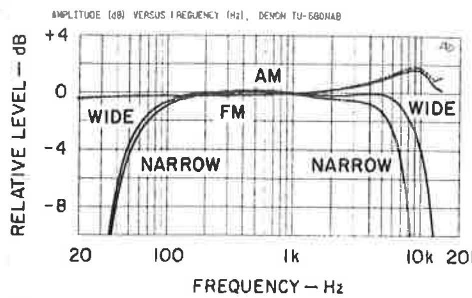


Fig. 1—Frequency response.

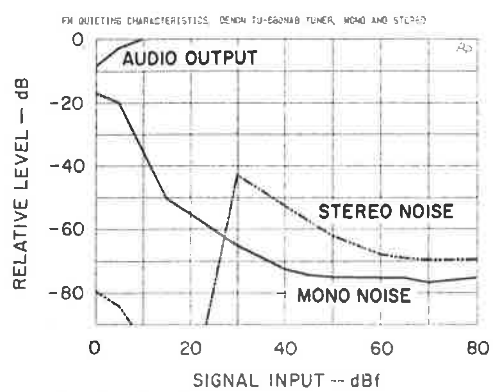


Fig. 2—FM quieting characteristics; see text.

SPECS

FM Section
Usable Sensitivity: 11.3 dBf.
50-dB Quieting Sensitivity: Mono, 15.3 dBf; stereo, 37.2 dBf.
Frequency Response: 20 Hz to 15 kHz, +0.5, –1 dB.
S/N: Mono, 88 dB; stereo, 82 dB.
THD at 1 kHz: Mono, 0.06%; stereo, 0.1%.
Capture Ratio: 1.3 dB.
Image Rejection: 80 dB.
I.f. Rejection: 100 dB.
Alternate-Channel Selectivity: Wide, 50 dB; narrow, 75 dB.
Separation: 50 dB at 1 kHz.
AM Suppression: 60 dB.

AM Section
Frequency Response: 50 Hz to 7.5 kHz, +1.5, –3 dB.
Channel Separation: 32 dB at 1 kHz, 50% modulation.
THD for 50% Modulation at 1 kHz: Mono, 0.3%; stereo 0.5%.
S/N: Mono, 53 dB.

General Specifications
Power Requirements: 120 V, 60 Hz a.c., 12 watts.
Dimensions: 17 1/16 in. W × 2 15/16 in. H × 11 5/16 in. D (43.4 cm × 7.4 cm × 28.7 cm).
Weight: 6.8 lbs. (3.1 kg).
Price: $650.
Company Address: 222 New Rd., Parsippany, N.J. 07054.
For literature, circle No. 92

FM response extends out to 15 kHz. We'll get to AM performance later, but note how well the AM section's frequency response, superimposed for comparison, stands up to that of the FM section.

Figure 2 shows FM quieting characteristics for both mono and stereo, as a function of incoming signal strength. In mono, 50-dB quieting is achieved with input signals of only 15.3 dBf, exactly as claimed by Denon. To measure this, I had to press the "Auto Mute/Manu" button, which controls muting, automatic or manual tuning, and mono switching. Stereo reception is only possible when this button is set to "Auto Mute." Stereo muting occurs somewhere below 30 dBf, by which time S/N is already well above 40 dB. This is typical of sets that combine the muting and mono/stereo switching functions in a single control; such sets can only receive stereo signals whose signal strength exceeds the muting threshold. In the TU-680NAB, this threshold has been set at just about the right level.

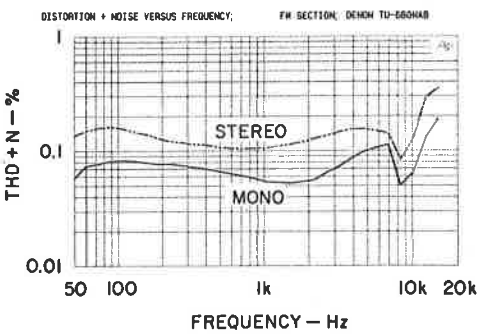


Fig. 3—THD + N vs. FM modulating frequency.

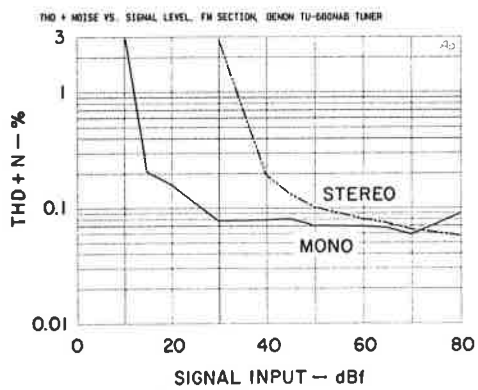


Fig. 4—THD + N vs. FM signal strength.

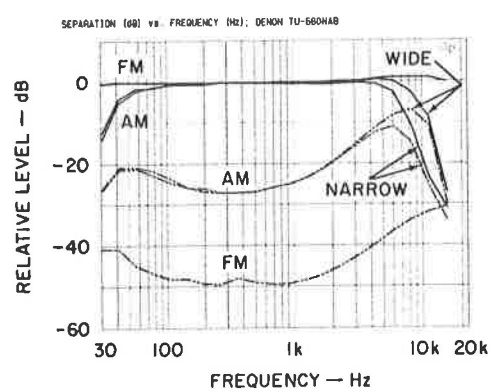


Fig. 5—Frequency response and channel separation.

Figure 3 is a plot of THD + N versus modulating frequency. In mono, THD + N at 1 kHz is a very low 0.057%, increasing to 0.085% at 100 Hz and a bit over 0.1% at 6 kHz. For stereo reception, THD + N measures just over 0.1% at mid-frequencies, increasing to 0.17% at 100 Hz and to 0.16% at 6 kHz. Figure 4 shows how distortion of a 1-kHz modulating signal varies with signal strength. For a 65-dBf signal, THD + N is 0.07% in mono and 0.08% in stereo.

Figure 5 shows frequency response and channel separation for FM, with the AM section's response and separation overlaid for comparison. In the FM mode, separation is excellent, reaching nearly 50 dB at 1 kHz and maintaining that level at 100 Hz. At 10 kHz, the separation remains greater than 30 dB.

A further test of stereo FM performance involved a spectrum analysis of the modulated (left-channel) and unmodulated (right-channel) outputs of the tuner for a 5 kHz left-only signal modulating my FM signal generator (Fig. 6). The top curve shows the reference output level of the 5-kHz signal (peaking at 0 dB) as well as harmonic components at 10 and 15 kHz and at 5-kHz intervals out to the end of the sweep. Even the greatest of these harmonic components (that at 10 kHz) is down about 70 dB below reference level, equivalent to a second-harmonic distortion level of only 0.03%. Note, too, that the 19-kHz pilot carrier has been suppressed by 80 dB, while the sidebands of the suppressed 38-kHz subcarrier, at 33 and 43 kHz, are attenuated by almost 60 and 65 dB, respectively. As for the output of the unmodulated channel, 5-kHz crosstalk is down some 40 dB relative to the reference level. Other harmonic components and subcarrier components are also adequately attenuated.

EVEN IN NARROW-BAND MODE, THE AM SECTION'S FIDELITY WAS BETTER THAN I'VE HEARD FROM AM IN MANY YEARS.

Alternate-channel selectivity measured 60 dB in the wideband mode, increasing to 77 dB when the narrow mode was selected. Image rejection exceeded the published spec; it was 85 dB, as against 80 dB claimed. AM suppression was exactly 60 dB, as claimed, while capture ratio measured 1.2 dB. I.f. rejection was in excess of the 100 dB claimed.

AM Measurements

What a pleasure it was to finally come across a tuner whose frequency response in AM extends well beyond 5 kHz. In fact, as was shown in Fig. 1, response in the wideband AM mode extends way out to 9.2 kHz before the attenuation reaches 3 dB! (In other tuner reports, I usually use a more permissive 6-dB criterion for AM frequency response.) Even when I used the narrow mode, frequency response of this remarkable AM section extended beyond 6 kHz for a 10-mV signal. At the bass end of the spectrum, the –3 dB point was reached at approximately 50 Hz.

Figure 7 shows how THD + N varies with frequency for the AM section, with modulation levels of 90%. At 1 kHz, the THD + N measures 1.2% in the wide mode and increases slightly, to 1.4%, in the narrow mode. Note that the published specs for AM distortion were given for 50% modulation. At that modulation level, the claimed THD figures of 0.3% in mono and 0.5% in stereo were met or surpassed.

Harmonic distortion itself, without the noise component, was just under 1%, as measured by spectum analysis of a 1-kHz signal at 90% modulation. Ultimate S/N, with strong signals applied, was 55 dB for monaural operations, as against 53 dB claimed.

TO MY EARS AND OTHERS', THE AM ACTUALLY SOUNDED BETTER THAN AN FM SIMULCAST!

As shown in Fig. 5, channel separation in AM is just over 24 dB at 1 kHz, regardless of the audio bandwidth setting, and it is more than adequate. At 100 Hz, separation is approximately 23 dB for either bandwidth setting. At 6 kHz, it decreases to just over 8 dB for either mode at the 10-mV r.f. signal level I use.

Use and Listening Tests

I hooked up an ordinary indoor dipole antenna to the FM antenna terminal and oriented the dipole towards the west, in the direction of most of the transmitter antennas in my metropolitan area. Under these conditions, I was able to receive no fewer than 53 acceptable signals in mono, nearly a half dozen more than I've usually gotten with typical "hi-fi" tuners and receivers I have tested in the last several years. Switching to the automatic tuning mode (thereby activating stereo circuitry), I logged some 43 acceptably noise-free stereo signals on the FM band.

Orienting the supplied AM loopstick for best reception, I then switched to the AM band and logged 26 acceptable signals. There was little difference in the signal count when I switched from automatic to manual tuning mode. A few of the stations exhibited less interference when I switched to the narrow-band mode, but even then, audio fidelity was better than I have heard from an AM tuner in many years. (Back in the 1940s and 1950s, AM receivers—then in the majority—sounded a lot better than most AM tuner sections do today. The Denon TU-680NAB is a happy exception to this unhappy trend.) Perhaps the most startling revelation occurred when I tuned to a classical music station on the FM band that also simulcasts on AM. This enabled me to switch back and forth between them while listening to the same program. I know you may find this hard to believe, but to my ears (and to those of several visitors in my lab when these tests were going on), the audio quality of the AM transmission actually seemed better than that of the FM band!

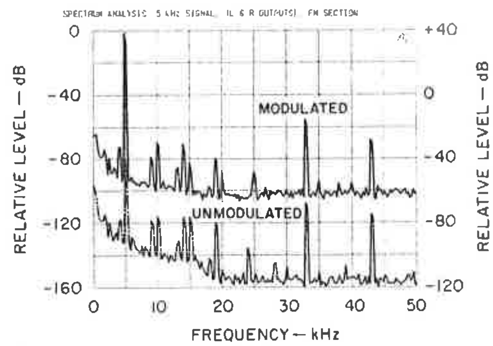


Fig. 6—Spectrum analysis, showing FM stereo crosstalk and distortion products. Use right-hand scale for bottom curve.

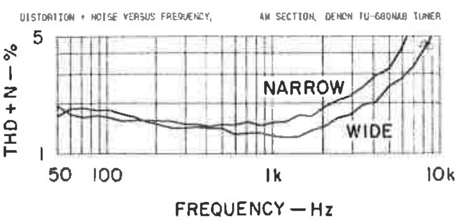
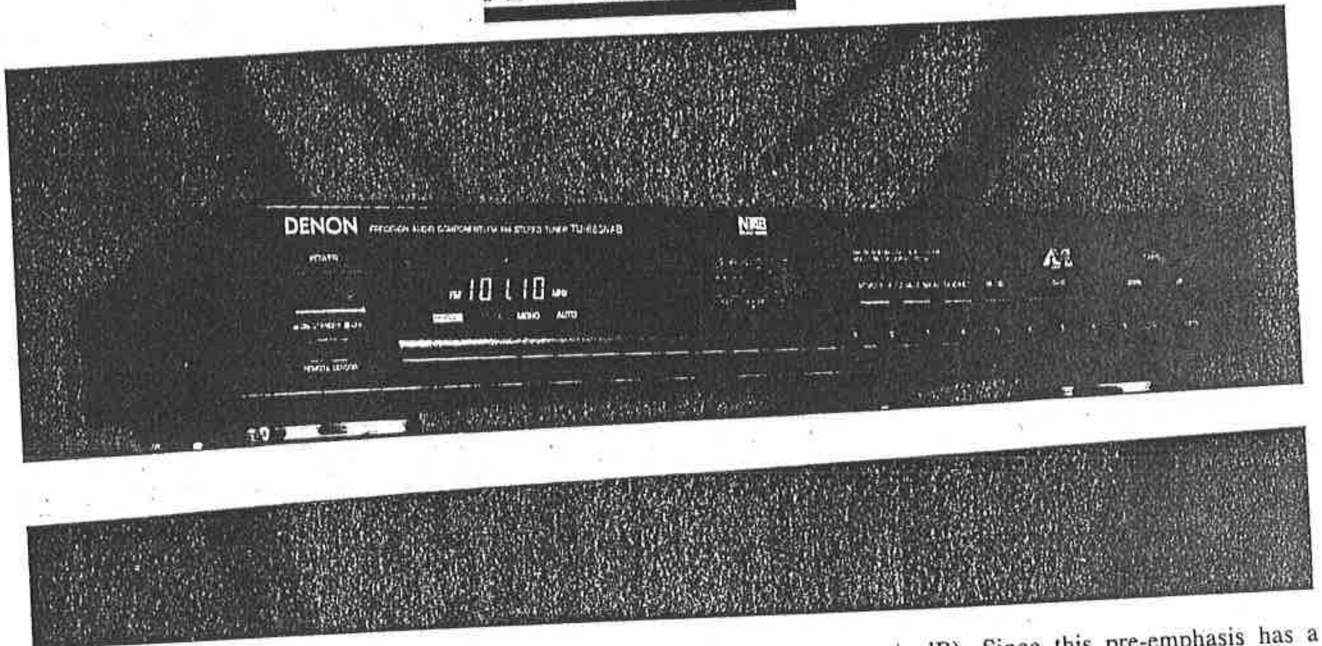


Fig. 7—THD + N vs. AM modulating frequency, with monophonic input signals.

Denon deserves to be congratulated for its effort. The TU-680NAB "SuperRadio" may very well inspire other equipment manufacturers to follow a similar course in designing tuners and receivers.

Leonard Feldman



Denon TU-680NAB AM/FM Tuner

JULIAN HIRSCH
HIRSCH-HOUCK LABORATORIES

As our regular readers probably know, AM performance is perhaps the least of the concerns of most tuner designers. Of the hundreds of tuners and receivers I have tested and used over the past thirty-five or more years, those with AM quality adequate for anything more than speech reproduction could easily be counted on the fingers of one hand. The frequency range of their audio output rarely extends as high as 3,000 Hz, and a more usual upper limit is in the range of 2,000 to 2,500 Hz.

In an effort to expand the audience for AM radio, the Electronic Industries Association (EIA) and National Association of Broadcasters (NAB) several years ago jointly established a committee (the NRSC) to develop standards for improved AM broadcast quality. To enable broadcasters to evaluate the success of the proposed AM broadcast standard, Denon designed and manufactured a limited number of tuners incorporating the committee's recommendations.

The Denon TU-680NAB is essentially that tuner, now available to the general public. Its stereo AM tuner section, using the widely accepted C-Quam system, meets the new AM broadcast standards (AMAX), and its FM tuner section is of comparable quality. A major goal of the AMAX standard was to increase the audio bandwidth of AM programs, as received by the listener, to a range of 50 to 7,500 Hz. To that end, it calls for a 75-microsecond pre-emphasis (the same characteristic used in FM transmission) to boost the level of the high frequencies in the audio program. A fully compatible receiver will have a complementary de-emphasis in its audio section, resulting in an overall response essentially flat over a range of 50 to 7,500 Hz or more (the specifications of the NRSC call for an AM response of 50 to 7,500 Hz +1.5, −3 dB). Since this pre-emphasis has a negligible effect below 2,000 or 3,000 Hz, it will not impair the quality of reception through existing receivers or tuners that do not pass the higher frequencies. If anything, it should slightly improve their sound.

Dimensions
17⅛ inches wide, 2⅞ inches high, and 11¼ inches deep

Price
$600

Manufacturer
Denon America, Dept. SR, 222 New Rd., Parsippany, NJ 07054

The Denon TU-680NAB is a very conventional-looking component, with none of the "glamorizing" design or styling features often found on state-of-the-art products. It is small and light (less than 7 pounds), with a simple black panel and a conventional grouping of control buttons. A row of ten numbered buttons and an Enter button enable up to thirty preset AM or FM station frequencies to be memorized and recalled. A parallel row of buttons above them controls the tuning mode (auto-mute or manual), intermediate-frequency (IF) bandwidth (wide or narrow on both AM and FM bands), and FM and AM noise reduction (NR/NB). Two large tuning buttons scan up or down in frequency, one channel at a time or continuously until a signal is acquired, depending on the setting of the auto mute/manual switch. A large power button is located at the left end of the panel.

The display window shows the tuned frequency, band, and preset channel number (if applicable), plus legends identifying the operating mode (stereo, mono, auto, manual). A multisegment signal-strength indicator and identifying lights for the bandwidth and noise-reduction functions complete the display.

PHOTO JEFFREY KREIN

On the rear apron are the output phono jacks for left and right channels and three sets of antenna terminals. These include inputs for the furnished detachable and pivoting AM loop antenna, a separate powered AM antenna or long wire, and a coaxial 75-ohm FM antenna.

Operating the tuner is as simple as can be. Stereo/mono switching is automatic for both AM and FM (with a clear indication of stereo reception in the display window). The bandwidth selector offers narrow-band reception for best interference rejection or wide-band reception for highest sound quality with clean signals. The noise-reduction system has distinctly different functions for the two bands. In stereo FM reception, it progressively blends the two channels at high frequencies as the signal weakens, reducing noise while maintaining useful stereo separation at middle frequencies. In stereo AM, it switches in a noise-blanking circuit designed to reduce impulse noise rather than the hiss that can disturb weak FM signal reception.

The tuner comes with a wireless remote control that duplicates the front-panel band-selector, tuning-mode, and band-scanning functions as well as providing buttons that automatically scan the preset channels or an entire band.

The instruction "manual" is a single sheet, folded in quarters, explaining the tuner's operating controls and rear-apron terminals and their functions. Although it also includes the usual performance specifications, there is no information on the tuner's special features.

Our laboratory tests confirmed the TU-680NAB's outstanding performance on both the AM and FM bands. Lacking stereo test facilities for AM, we had to judge that aspect of the tuner's performance by listening to stereo AM broadcasts. The stereo indication in the display window lit on six AM channels, although the program material rarely gave any audible clues that it was broadcast in stereo.

The basic quality of its AM reception, however, in respect to both frequency response and noise, was clearly superior to what we are accustomed to hearing on that band. Subjectively, it came remarkably close to FM quality. Unfortunately, the only good music station in the New York area to have simultaneous outlets on the AM and FM bands recently changed the format of its AM facility, so we were unable to make a true A/B comparison between the two modes.

The measured AM tuner frequency response was flat within ±1 dB from 100 to 8,800 Hz and down 3 dB at 57 and 10,000 Hz in the wide-bandwidth mode. In its narrow-band mode, the response was identical to the wide-band measurements up to 3,000 Hz, down 1 dB at 6,500 Hz, and down 3 dB at 7,300 Hz. In either mode, the TU-680NAB was vastly superior to any other AM tuner we have seen in years.

A notice accompanying the tuner advised that its AM noise blanker is effective on impulse noise like that created by some automobile ignition systems but may have no effect on constant noise. We discovered this for ourselves: The noise blanker had no effect that we could discern (our major sources of AM noise are the fluorescent lamps in the lab, and only critical positioning of the AM loop antenna has any effect on that). But I must say that this was the quietest AM tuner we have used in many a year, in addition to its other admirable qualities.

The FM section was equally noteworthy. As with most good tuners, its frequency response was flat within better than ±0.5 dB from 20 to 12,000 Hz, though it fell off sharply to −1.3 dB at 15,000 Hz (not an audibly significant loss). The stereo channel separation, as often happens, was slightly different from left to right than from right to left. The "poorer" of the two displayed 50 dB of separation (outstanding) from 300 to 3,000 Hz and was still a very good 43 dB at 12,000 Hz, above which the separation fell sharply. In the "better" direction, the separation was greater than 60 dB from 350 to 1,200 Hz, falling to about 50 dB between 3,000 and 12,000 Hz. In both cases, the separation fell at low frequencies, where it is subjectively less important, to about 33 dB at 20 Hz. The narrow-IF-bandwidth FM mode considerably reduced channel separation, although it always remained greater than required for subjectively complete stereo separation—about 35 dB across most of the audio range, falling to 25 dB at 14,000 Hz.

The FM 50-dB quieting sensitivity was good in mono and superb in stereo. The "usable sensitivity," which actually has little practical significance, matched the published specification. The other tuner specifications were also verified, and in some cases surpassed, in our tests, within the normal range of measurement error. Especially noteworthy were the 1.1-dB capture ratio, 80-dB AM rejection, and 80-dB image rejection. We verified the rated 75-dB alternate-channel selectivity with the narrow IF bandwidth, and in its wide mode our reading came very close to its 50-dB rating.

Good as these measurements are, the proof of the tuner's quality lies in the listening. Without checking back through years of test files, I cannot say with certainty whether this is the "best" tuner we have ever tested, but my strong impression is that it *is*. Totally lacking in glamour, it brings AM into almost the same league as FM insofar as audible qualities are concerned. I have no doubt that if AM and FM stations were transmitting the same program, it would be difficult to distinguish between them with much material. The Denon TU-680NAB is a winner if I ever saw and heard one, and a good value at its price. □

MEASUREMENTS

All figures are for FM only except frequency response.

Usable sensitivity (mono)	11 dBf
50-dB quieting sensitivity	
mono	17 dBf
stereo (wide/narrow)	33/35 dBf
Signal-to-noise ratio (at 65 dBf)	
mono (wide/narrow)	82.5/82.2 dB
stereo (wide/narrow)	77/75 dB
Distortion (THD + N at 65 dBf)	
mono (wide/narrow)	0.10/0.24%
stereo (wide/narrow)	0.10/0.25%
Capture ratio (at 65 dBf)	
wide/narrow	1.1/3.2 dB
AM rejection (wide/narrow)	80/85 dB
Selectivity	
alternate-channel (wide/narrow)	48/75 dB
adjacent-channel (wide/narrow)	5/20 dB
Pilot-carrier leakage	−83 dB
Hum	−76 dB
Channel separation	
100 Hz	37 dB
1,000 Hz (wide/narrow)	62/40 dB
10,000 Hz (wide/narrow)	51/24 dB
Frequency response	
FM	30 to 15,000 Hz +0.3, −1.3 dB
AM (wide)	57 to 11,000 Hz +1, −3 dB
AM (narrow)	60 to 7,300 Hz +0.3, −3 dB

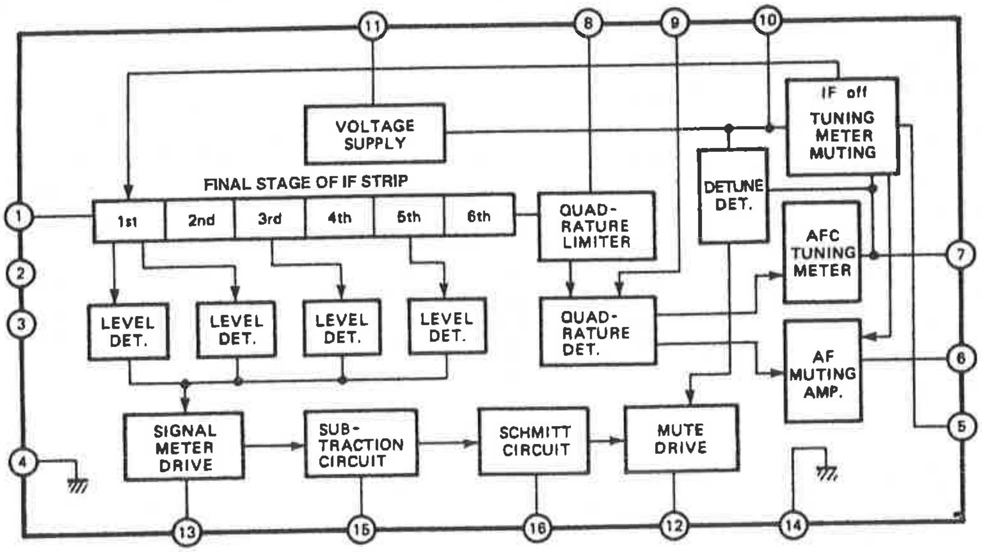


Figure 7: Block diagram of the ubiquitous Sanyo LA1235 chip (with the iniquitous quadrature detector).

Winston, 1974.

Panter, P. F. *Modulation, Noise, and Spectral Analysis.* McGraw-Hill, 1965.

Rich, D. "Cochannel FM Interference Cancellation Using Adaptive Notch Filters." Polytechnic University, Ph.D. Dissertation, January 1991. UMI Order Number 9117490.

Takahashi, S. and H. Numata. "Applications of Walsh Functions to a FM Stereo Demodulator." *Journal of the Audio Engineering Society* 33.9 (September 1985).

Taub, H. and D. Schilling. *Principles of Communication Systems.* McGraw-Hill, 1971.

Viterbi, A. J. *Principles of Coherent Communications.* McGraw-Hill, 1966.

Denon TU-680NAB

Denon Electronics, a division of Denon Corporation (USA), 222 New Road, Parsippany, NJ 07054. Voice: (201) 575-7810. Fax: (201) 575-2532. TU-680NAB AM/FM stereo tuner with remote control, $600.00. Tested sample on loan from manufacturer.

The RF section of this tuner is reasonably well-done with the equivalent of five gangs, one at the RF input and two at the mixer section. The mixer is fully balanced—but to no avail, as we shall see below. Another pair of tuned stages is in the local oscillator. One is used to set the local oscillator's frequency; the other filters the signal from the local oscillator as part of a buffer stage.

The IF strip starts with a single discrete stage and uses two integrated amplifiers between the ceramic filters. Two filters are used in the wide mode. Four filters are used in the narrow mode, with an additional integrated IF amplifier also switched in when narrow mode is engaged.

The final stage of the IF strip and the FM demodulator are in the ubiquitous Sanyo LA1235. This chip is the most popular (it's real cheap!) IF detector. It uses a quadrature detector design, as shown in Figure 7. Now, Denon knows that a quadrature detector just won't cut it in a high-end tuner. They used an advanced PLL detector in the last generation of products that did not cost more. Two tank circuits in the quadrature detector must be adjusted for the tuning to be on channel center and for minimum distortion (try to get that one done by your local TV repairman), and the unit came to us incorrectly adjusted. Another adjustment involving a distortion measurement must be performed on the tank circuit connected between the mixer and the IF stage. The remaining adjustments should be within the scope of a competent repair person.

The multiplex decoder is another IC, the Allegro ULN3827. Allegro is a U.S. company that designed this chip primarily for car audio, and most of its specifications are not state-of-the-art for monolithic multiplexer chips. It uses a 608 kHz mechanical resonator in the VCO and has a 19 kHz pilot canceler that requires no adjustments. Walsh functions are used to improve rejection of spurious signals like the SCA carrier. Surprisingly, Denon still chooses to use an antibirdie filter. A dynamic blend circuit is included, which activates when the noise ratio becomes high. Most autoblend circuits (clearly a function you need more in a car than at home, where you can flick the blend switch) activate the blend on signal level, not noise level, and can blend a weak but clean signal accidentally. The PLL loop bandwidth in this chip is made wide for fast acquisition when no stereo signal is present and then is made narrow to increase noise immunity when the stereo signal is captured.

Another nice feature of the Denon is that the channel-separation adjustments are made individually for the narrow and wide modes to insure the best possible performance in the narrow mode. A pair of passive filters follows the multiplex decoder to remove the pilot tone and other higher-frequency products. The outputs are buffered with JRC NJM4558 devices.

The AM section is quite complex and performs much better than most AM tuners. It has a wider audio bandwidth and lower distortion than traditional AM tuners, as well as sophisticated noise-reduction circuits. It also has excellent sensitivity. (We can confirm that Rush Limbaugh sounded better on the Denon, but we performed no controlled listening tests.) If you have an AM station in your area that broadcasts something of interest, this may be the tuner for you.

A single 12 V supply powers the analog stages. Two 10kΩ resistors tied to the 12 V supply and a 100 μF filter capacitor form the analog ground path. You cannot get any cheaper than this. General construction quality is that of a mass-market product.

The FM RF front end has a very low noise figure. The 50 dB RF quieting occurred at 10.5 dBf. Most tuners are 20 dB noisier at this signal level. RF intermodulation performance was not so good, however. Strong stations prevented reception of nearby weaker stations that could be received by other tuners in this survey. This indicates that the RF stage (and/or mixer stage—remember that mixer stages are very hard to design) does not have adequate dynamic range, although the cause could not be identified by me from the schematic. Poor dynamic range can cause intermodulation of signals at the RF stage's input, since the stage becomes nonlinear.

Measured 1 kHz THD out of the box was –57dB for a 30,000 μV signal at 91.1 MHz. This fell short of the specified –60 dB. In addition, minimum distortion was not achieved when the unit was tuned dead on. The Modafferi 10 kHz stereo IM test gave a result of –56 dB on our test sample; on another sample tested by Modafferi the result was –69 dB. Clearly our sample was misaligned as delivered, and that includes the quadrature detector. Channel separation from 50 Hz to 15 kHz was ≥39 dB in wide mode and ≥33 dB in narrow mode. It never met the specified 50 dB at 1 kHz, measuring 47 dB in wide mode, but the full-band results are very good. Frequency response in stereo just made the +0.5 dB, –1.0 dB strip given in the manufacturer's specification sheet. That *could* be audible and should be tighter in a $600 tuner.

The Denon proved to be an average performer when presented with good signals and did poorly under difficult signal conditions. The AM performance is truly exemplary, and the circuitry to achieve this must have added to the cost of the unit. If AM performance is important to you, consider this unit. Others should pass it by, as I believe the less expensive Harman Kardon TU9600, JVC FX-1100BK, Sony ST-S550ES, and Yamaha TX-950 should at least match its FM performance at much less cost. The slightly more expensive the Rotel RT-990BX and Onkyo T-9090MKII will blow it away on FM. (They have no AM, so again if that is important, look into the Denon.)

Harman Kardon TU9600

Harman Kardon Incorporated, a Harman International Company, 80 Crossways Park West, Woodbury, NY 11797. Voice: (516) 496-3400. Fax: (516) 496-4868. TU-9600 "active tracking" AM/FM stereo tuner with remote control, $449.00. Tested sample on loan from manufacturer.

We have had this not very new but still current model in-house for some time, but for some mysterious "organizational" reason it never got to be measured by Rich Modafferi. *[Mea culpa.—Ed.]* I don't want to wait, however, to tell you what you can get for $449.

The front end and IF sections are pretty typical of units in this price range, but the FM demodulator and stereo decoder are anything but. The tuner has a state-of-the-art PLL FM demodulator, but to make it work at this price they could not design a high-linearity VCO. So they got real smart (yes, it is patented) and realized that the output of the VCO in a PLL must always track the incoming signal accurately, even if the transfer function from voltage to frequency of the VCO is not very linear. This is because of the phase detector used in the PLL.

What Harman Kardon does is to take the output of the VCO and send it through a Sanyo LA1235 with its quadrature detector. No amplitude-modulation problem occurs in the quadrature detector because the VCO output is a constant and it's big. This combination does not allow the low-distortion properties of the PLL FM detector to be exploited but it does allow its excellent performance under poor signal conditions (including large amounts of AM) to be taken advantage of.

The loop bandwidth of the PLL is made narrow to exploit the circuit's special signal-demodulation properties under poor signal conditions; as stated in the main article, this may cause some distortion. The VCO output is thus an FM-modulated version of the desired signal cleaned up by the PLL. The quadrature detector then demodulates the cleaned-up signal.

OK, what more could you want for $449? Well, how about the top-of-the-line Sanyo multiplex decoder called the LA3450? It looks like a second source for the Sony CXA1064S chip used in the top-of-the-line Sony tuners. No other multiplex decoder has better specs than the Sanyo LA3450; it some cases it is significantly better. Yes, it has a pilot-tone canceler. Yes, the VCO runs at 456 kHz and requires no adjustment because it uses a mechanical resonator. Yes, it has no antibirdie filter because of a birdie noise-reduction system that appears to be similar to the Sansui approach. The decoded signal then goes, not to some cheap op-amp, but to a discrete amplifier designed in the Krell style. Other high-end touches can be found, although there are big limits at this price.

Measurements of the TU9600, plus more design details, will be published in the next issue.