

DAY-SEQUERRA FM REFERENCE TUNER

Larry Greenhill



Day-Sequerra FM Reference FM tuner

FM stereo analog tuner with digital frequency display and three selectable IF bandwidths: wide (280kHz), normal (180kHz), and narrow (130kHz). Tuning range, 88.0–108.0MHz; display tuning range, 87.70–108.30MHz. De-emphasis, 75 μ s (50 μ s, export). Usable sensitivity: less than 15dBf, mono or stereo. 50dB quieting sensitivity: 15dBf mono, 34dBf stereo. Capture ratio: 0.75dB. Selectivity: 100dB alternate channel, 40dB adjacent channel (narrow mode). S/N ratio at 65dBf: greater than 65 mono or stereo. THD at 1kHz: less than 0.15%, mono or stereo. Stereo separation at 1kHz: greater than 50dB. SCA rejection: 75dB. AM suppression: 80dB; 19 and 38kHz products suppression: 75dB. Balanced audio output level: 1.0 Vac RMS. Power consumption: 85W. Rack-mount front plate and panoramic display options available. Dimensions: 17 $\frac{1}{2}$ " (440mm) W by 14 $\frac{3}{4}$ " (375mm) D by 5 $\frac{1}{16}$ " (143mm) H. Shipping weight: 45 pounds. Approximate number of US dealers: 35. Price: \$4800. Day-Sequerra FM Reference Panalyzer: \$12,800. Used with the Day-Sequerra FM Urban Antenna, Price: \$285 without base. Serial number of review sample: 210179. Manufacturer: Davidson-Roth Corporation, 330 Turnpike Street, Canton, MA 02021. Tel: (617) 821-2313. Fax: (617) 821-2848.

Audiophiles are dreamers, and they dream of dream-machines. What is a dream machine? Its appearance must be "sexy" as all get out, its performance tops, and the price a bit too high to mention easily to your significant other. Everyone has their own list of "if I win the lottery" products, whether they be cigarette boats, 204mph Lamborghini Diablos, fully equipped Hasselblad cameras, Astromak 12" telescopes, Takahashi Epsilon 160 Astrographs, a Rod Johnstone J/37c cruising sloop, the new Apogee Grand loudspeakers, or the exotic Krell Audio Standard, dual-chassis mono amplifier.

The Day-Sequerra FM Reference fits right in with this fast crowd. Its styling and construction are like no other tuner's. Blazing-white function placards are set into its black-glass faceplate, framing the 4.5" central oscilloscope screen. Fully equipped, the FM Reference Panalyzer comes with a rack-mount faceplate and

a panoramic-display, spectrum-analyzer oscilloscope which can show, in real time, six FM stations signals spread over a 2MHz band. Internal features read like no other tuner's: an oversized power supply, built-in spectrum analyzer, star center ground configuration, low stray-field toroid power transformer, a set-on tuning accuracy of 100Hz, hand-picked IF filters, absence of AFC, balanced audio outputs, and an ability to log or detect signals as weak as 2dBf. In addition, it is one of the few component FM tuners built in the United States. The craftsmanship and ultra performance will set you back \$4800 for the basic configuration, \$12,800 for the unit with panoramic display.

The description alone suggests that the FM Reference may be very, very good. But could it be *too* good? Are the FM Reference's ultra-craftsmanship and red-hot performance wasted on FM, with its clutter of densely compressed

Salsa Music, Religious Messages Services, News Stations, Oldies But Goldies, and overmodulated Heavy Metal? At one time this may have been true. But recent changes in FM-station playback gear and the emergence of tuners like the FM Reference have greatly improved the FM listening experience.

FM is becoming a high-end source

JGH's original 1973 reservation about FM still bears repeating: Is an FM signal capable of matching other sources in one's audio system? The answer to this question is yes—things have greatly improved since 1973. Most important, most stations have increased the quality of their playback equipment, having replaced poor turntables, workhorse tonearms, and unmentionable cartridges with CD players. Nine of the 50 New York and New Jersey FM stations I can receive—three classical, two jazz, and one each playing reggae, pop/rock, light rock, and classic rock—now broadcast top-quality sound! Many FM stations now use high-end audio equipment, including Spectral CD players and amplifiers, Wadia DACs and transports, Day-Sequerra Broadcast Monitors and FM Reference Panalyzers for monitoring, and Cello Audio Palettes for equalization. Since reviewing the Broadcast Monitor in 1989 (Vol.12 No.6), I have welcomed five additional FM stations to the group of FM stations playing top-quality sound.

Second, there are more FM stations. The FCC has approved over 1000 new stations since the early 1980s in efforts to increase competition.² This should increase the number of fine music stations in most areas. Gilfer's *FM Atlas*³ shows that 58 of the 360 FM stations in the Northeastern Tri-State Area (New York, New Jersey, and

Connecticut) offer fine music (classical or jazz) programming. With my nine-element Channel Master FM antenna pointed South, I often pulled in 50 (some evenings, 63) stations with the FM Reference: middle-of-the-road rock (13 stations), easy listening (10), jazz (4), heavy-metal (4), classical (3), foreign language (3), pop (3), reggae (3), rap (2), oldies (2), religious (2), and country (1).

As a response to this increase in quantity and quality of FM stations, a number of FM tuners now available include decent audio output sections in addition to their exotic RF front ends.⁴ They avoid the typical "FM tuner sound," which is flat, compressed, whitish, hazy, and cold, in many ways the exact opposite of tube sound. All in all, the time for an FM tuner "dream machine" has now arrived.

Product background

In many ways an evolving product, the FM Reference has strong stylistic and performance ties to earlier Day-Sequerra tuners. To date, all three tuners follow the styling of the ca-1970 Sequerra Model 1. David Day, President and chief designer at Davidson-Roth, had admired the Sequerra Model 1 for many years. In 1984 Day bought all rights to, and many parts of, the Model 1 and other Sequerra products from the former owner's widow, and proceeded to re-engineer and re-manufacture the unit as the Day-Sequerra FM Broadcast Monitor for the 1986 marketplace. Now out of production, the Broadcast Monitor revived the Model 1's luxurious styling, terrific wideband RF performance, and panoramic display tuning features. The next unit, the much less expensive FM Studio Tuner, received a rave review in January 1990 (Vol.13 No.1) for its electronic design, build quality, glamorous styling, and precision analog-based oscilloscope tuning. Most of all, the FM Studio tuner delivered an unusually transparent, three-dimensional musical signal, possessing a greater dynamic range and inner

1 See Edmund L. Andrews's article, "All About/Commercial Radio," in the *New York Times*, June 30, 1991. Prices for radio properties have "plunged" from an average of \$6.2 million for a combination AM/FM station in 1987 to \$1.8 million in 1990. Even though this is a buyer's market, sales of stations fell from 1400 in 1987 to less than 1000 in 1990.

2 See the 11th edition of Bruce Elving's handy *FM Atlas and Station Directory*, available for \$9.95 from Gilfer Associates. Tel: (800) GILFER-1.

3 I used a high-gain (12.5dB greater than a dipole), nine-element Yagi Channel Master Stereo Probe 9 Antenna with a rotor mounted to the chimney, about 25' above ground. For this review, the antenna was pointed south (toward New York City). Of the 50 stations received with my rooftop antenna, 9 had top-quality sound and musical material. The classical stations included WNCN (104.3MHz), WQXR (96.3), and WNYC (93.9). Two jazz stations had "superb" reception, including WBGO (88.5) and WQCD (101.9). The remaining "super sonic sources" played classic rock (WXXR, 92.3), standard rock (WNEW, 102.7), multi-ethnic/reggae (WNWK, 105.9), and easy-listening (WCTO, 94.3).

4 FM tuners represent a small market in audio, at least in terms of products available. The 1990 edition of the "Industry Bible," *Audio Magazine's* October Equipment Listings issue, devoted only two pages to FM tuners. If each page of this encyclopedic listing of audio gear holds 55 products, then 110 tuners were listed. I leave it to the reader to estimate the exact numbers of products if I state that amplifiers took up 12 pages, CD players 8 pages, and phono cartridges (we don't need *them* any more, right?) over 4 pages! The FM Reference is the only tuner with a spectrum analyzer 'scope option listed in the Equipment Directory. As Don Scott pointed out to me, the FM Reference is one of the few tuners actually built in the US; the Soundstream tuner (reviewed by DAS in Vol.14 No.11) is also built here.

detail than found in other FM tuners at the time.

Following on these two high-end, made-in-America analog FM designs, David Day introduced the FM Reference at the 1991 Summer Consumer Electronics Show. The FM Reference's two optional configurations, with and without the panoramic oscilloscope display, allow it to replace *both* the Broadcast Monitor and Studio Tuner in cost as well as in function.

Operation

The FM Reference's front panel has 12 pushbuttons and a tuning knob. Using the FM Reference is very straightforward, taking much longer to describe than to actually carry out. First, one activates the tuner with the power pushbutton, which is at the bottom of the right row. Pushing this in, the panel lights all come on, including the white function placards that sit adjacent to each pushbutton, the red numerals for the tuning frequency, the 'scope trace, and the thin red border framing the 'scope tube.

Second, the tuning knob is then rotated to adjust the front panel's red digital readout to a station's frequency. This brings us to the main tuning device, the tuner's large oscilloscope. The 'scope functions are selected using the top four pushbuttons on the left, which are interdependent: one of the four must always be depressed. The first of the four pushbuttons selects the "FM Tuning Display" which illuminates the tuning display graticule, an engraved piece of plexiglass placed over the 'scope face. This calibrated set of reference lines includes a center reference line and two parallel vertical lines on either side. Once a station's signal trace (which appears as a thin horizontal line) is centered, these white graticule sidelines show the limits for normal FM modulation, $\pm 75\text{kHz}$.

Besides center tuning, the FM Tuning Display mode shows signal strength and multipath. The vertical height of the trace on the center 'scope line shows its strength. The center line has been crosshatched with horizontal graduations (tic marks), which have been positioned to represent relative signal-strength levels used in specifying FM tuner performance. For example, the bottom point of the central vertical line represents 10dBf (usable sensitivity in mono), which is still above the weakest signal that can be detected by this tuner. Moving up the central vertical line, next comes the lowest tic mark, set at 20dBf (usable sensitivity in stereo). Next comes the center tic mark, at 35dBf (typical FM

signal level required for 50dB quieting in stereo). If the incoming FM station's signal sits over the tic mark just above center, it has a signal level of 65dBf (FM signal required to produce maximum quieting). Signal traces may appear at any height on this vertical line, the span representing an effective dynamic range of 100dB.

In addition to showing RF signal strength, the 'scope shows the quality of the signal received. A wide, blurry trace indicates multipath; this would instruct the owner to move the antenna until its shape is flatter and narrower. LED readouts or analog meters cannot begin to communicate the amount of information about multipath interference contained in the FM Reference's 'scope trace. The manual suggests how one can detect the presence of SCA subcarriers or the presence of adjacent-channel distortion. One could then eliminate adjacent-channel distortion by switching the tuner's IF bandwidth or even rotating the antenna to lower the signal strength of the unwanted signal. This latter step is helped considerably by the panoramic display option. After tuning the signal and optimizing its appearance by rotating a rooftop antenna, the tuner's selectivity can be adjusted to reduce inter-station noise for weak signals, or pick up signals where there is considerable adjacent-channel interference. This is done by picking the optimal IF bandwidth. Normally, the tuner would be left with the "Wide IF bandwidth" button depressed, giving an IF bandpass of 280kHz. Increasing selectivity and relative sensitivity are achieved by pressing "Normal IF Bandwidth" (180kHz) or "Narrow IF Bandwidth," although distortion rises slightly with narrower bandwidths. If an FM signal is very, very strong, then the owner may choose to leave all three pushbuttons out, producing a -20dB drop in signal intensity so the tuner's circuits are not overloaded.

Two other pushbuttons, Tuner Vector Display and Balanced Tuner Vector Display, give the relative gain, phase, and stereo separation characteristics of the audio modulation of the FM signal. A narrow vertical trace reveals a mono signal; a wide trace, a stereo signal with good separation. The External Vector Display takes in a line-level signal via four RCA connectors on the back panel, thus allowing visual 'scope analysis of another signal, in either unbalanced or balanced mode. If one upgrades the FM Reference to include the Panoramic Dis-

play option, the factory reassigns the "Tuner Vector Display" pushbutton for switching on the Panoramic Display option.

The remaining pushbuttons put the tuner into more specialized modes of operation. The Stereo Contour Override button defeats the FM Reference Tuner's equivalent of a high-blend circuit. The Audio Phase Inversion mode inverts the polarity of the left and right audio signal at both the balanced and unbalanced outputs. As previously discussed, the top three buttons on the right select the IF bandpass. Depressing the Muting Defeat pushbutton allows signals weaker than 20dBf to be heard. The Mono Forcing option inhibits the stereo decoder operation, so all signals are received in mono.

The back of the FM Reference is identical to that of the Studio Tuner. XLR jacks, to allow for balanced operation, are centered below the high-quality, gold-plated RCA audio output jacks. Next to the XLR connectors sit four input RCA jacks for 'scope analysis of external line-level signals, from the preamplifier tape output for example. The AC line cord is detachable, a real blessing for installation. Antenna input requires a standard 75 ohm "F" connector and RG-59/U coaxial cable.

Circuit features

The FM Reference evolved from the lessons learned in the design, listening tests, and manufacture of the Studio Tuner, and shares a number of characteristics with its predecessor: three selectable IF bandwidths to enable the tuner to capture adjacent-channel stations with low distortion, a dual-mono audio section, and balanced outputs. Its chassis is made from aircraft-grade aluminum alloy with rounded corners and monocoque construction. It has the Studio Tuner's countersunk, Torx-screw chassis fasteners with machined-floating centers, MIL SPEC silicone boots to even lamp temperature, composite Viton bumpers to reduce microphonics, six independent power supplies, and an instrument-grade oscilloscope. As with the Studio Tuner, the FM Reference remains in low-voltage standby mode when turned off as long as it is plugged into the house AC lines, giving the power supply a "softer" turn-on and all the lamps a soft-start, and stabilizing the tuner's circuitry. This also prolongs the life of the oscilloscope CRT. Mechanical build quality is superb, considerably superior to any other FM tuner

I've encountered, and better than that of most high-end amplifiers or preamplifiers.

Most circuitry is set out on a heavy glass-epoxy motherboard with solder mask and component reference designator laid over bare, polished-copper traces. Discrete components are used whenever possible, and those integrated circuits that are used are socketed for quick replacement. As with the FM Studio Tuner, 0.1% Dale metal-film resistors, high-quality Roederstein (ERO) polypropylene, polystyrene, and Teflon capacitors populate the motherboard. Eight large computer-grade Sprague electrolytic capacitors, and five 2.5"-tall heat-sinks for the voltage regulators dominate the power-supply section. The RF front-end circuitry is encased in a nickel-plated Faraday shield that sits at the left rear of the chassis. The newly mu-metal-shielded oscilloscope is securely mounted to the motherboard. The quality of this sizeable motherboard matches the craftsmanship and CAD design of a Rowland Consonance, Spectral DMC-20, or Levinson No.26 preamplifier. The RF and IF sections of the FM Reference alone contain many more discrete parts, and are far larger than the one-sided pcb that constitutes the entire signal-carrying circuitry and power supply of Magnum Dynalab's Etude Tuner (reviewed in Vol.13 No.8).

The basic layout of the FM Reference's subsystems somewhat resembles that of the FM Studio tuner (see Vol.13 No.1). A number of new circuits have been added, these best understood by tracing the tuner's subsystems using an FM signal. Some of these subsystems handle the signal (RF front end, IF Amplifier/FM Detector, Stereo Multiplex Decoder, Dual Mono Audio amplifiers), while other subsystems provide power (high and low voltage supplies), or tuning/display functions (Display Matrix, oscilloscope driver 4.5" X-Y cathode ray tube, RF Frequency Counter).

The FM Reference's RF front end receives the signal from the coaxial F connector at the chassis rear. This stage uses three parallel tuned RF circuits which feed a double-stage MOSFET tetrode amplifier and a bipolar mixing device. New with this design is an "overtuned mixer" whose Q is very steep, giving a very tight skirt response and improving the signal/noise ratio of the tuner by 5dB. Three air-tuned, air-coupled transformer circuits are used to improve image rejection. A varactor diode tuning circuit allows the RF front end to be analog-tuned, with a set-

on accuracy of better than 100Hz, using the FM Tuning Display. No automatic frequency control (AFC) or other global feedback arrangement is used in the front end.

The signal is next sent to the intermediate frequency (IF) subsystem. This incorporates parallel IF processors and electronic RF switching circuits to allow the tuner to be switched to three different receiving bandwidths for optimal selectivity. Day claims that the tuner's use of parallel IF sections, each optimized for its own bandwidth, yields the optimum Q for lowest distortion for each selected bandwidth. The gain and phase responses of the filters are measured and hand-matched for each tuner, and each IF circuit has three compensation networks to produce the lowest group delay through that particular IF stage. New assembly and testing techniques involving two additional adjustments for each IF bandwidth position during final production allow the FM Reference to be trimmed to yield the lowest-band edge/phase distortion.

The tuner's stereo multiplex decoder system is a sophisticated, third-generation monolithic device. It demodulates the FM signal to produce stereo output. Day claims that this new circuit offsets the SCA subcarrier, which then prevents phase-angle distortion. Day believes that this circuit contributes to the tuner's sense of intertransient silence, because it prevents phase angle delay between the mono sum (L+R) and stereo difference (L-R) signals, and is very effective in eliminating interference from the SCA's modulated 57kHz subcarrier. This subsystem uses a second-generation quadrature detector, which has a much improved phase response. The circuit employs a phase-locked-loop oscillator operating at 228kHz that is locked to the 19kHz stereo pilot. The output of the stereo decoder is fed to a sophisticated seventh-order low-pass filter supplied by Toko of Japan.

The low-pass filter system then feeds the dual-mono audio amplifiers used in the output stage. These amplifiers use discrete devices in the form of an input-source-coupled J-FET pair and matched constant-current source, all fed by low-feedback complementary bipolar transistors operating in class-A. Each mono channel is shielded to prevent spurious RF products in the audio. This circuitry generates the necessary inverted and normal signals at the XLR output jacks to yield a balanced output sig-

nal. (Davidson-Roth continues to be the only manufacturer of FM tuners with balanced audio outputs.)

The FM Reference's power supply is a textbook "purist" design, consisting of six independent DC regulated supplies to totally isolate the tuner's IF, RF, and audio sections for optimum performance. A specially wound, low stray-field 250VA toroidal transformer, weighing more than most FM tuners, sits at the right rear of the chassis flanked by 30,000 μ F (film-capacitor bypassed) of capacitance. The use of center-tapped secondaries and a "star" grounding scheme establishes a solid ground reference and a shunt capacitance route to eliminate any RF noise in the AC line. The physical isolation of individual tuner subsystems permitted Day to significantly reduce the tuner's hash and noise.

This "overkill" power supply and grounding scheme also made it possible to design-in the "hooks," or loading resistors, for the add-in panoramic mode circuitry, so it could be installed at a later date without replacing the motherboard. The upgrade to include the Panalyzer subsystem is simple, if costly at \$8000. This is understandable, because RF spectrum analyzers aren't cheap. For example, Tektronix's "economy" spectrum analyzer, the Model 2710, with a 10kHz-1800MHz range, currently lists for \$8750 (Tektronix's 1991 catalogue, p.179); their "high-end" analyzer, the 2782, costs \$69,550. Addition of the Panalyzer subsystem chassis with its Faraday shield cover (containing circuit boards and subchassis) and stainless-steel audio shield, requires no additional trimming or adjustments. When a customer decides to add the panoramic feature to his FM Reference, the factory removes the jumpers and resistors "loading" the tuner from the motherboard, installs the new panoramic circuit board, changes the front panel placard, and ships the tuner back.

Other circuit innovations have been designed into the FM Reference. Day learned that the FM Studio Tuner's frequency counter (driving the front panel's numeric LED frequency readouts) created hash and noise. Turning off the counter made the audio signal much quieter. He redesigned the counter's circuits and decoupled the local oscillator and the counter from ground. Then the counter could be turned on, but the hash and noise did not reappear. As a result, the FM Reference is quieter than the FM Studio.

As before, the owner is protected by a five-

year warranty and supplied with a superbly written, 48-page typeset owner's manual. This jewel of a manual is complete with detailed 'scope pictures, extraordinarily lucid instructions on operation of the unit, and one of the best explanations of FM antenna selection and FM tuner design to be found anywhere. Should David Day tire of making tuners, he could always find work teaching Microsoft how to write software manuals.

Design evolution

The FM Reference's new design fixes minor field problems encountered in the Studio Tuner. The first Studio Tuners used a Lucite faceplate, which was vulnerable to minor scratches. The FM Reference replaces that with a 3/4" grey-tinted glass, laser-cut and polished. The FM Reference also employs a longer-lasting lamp. The Broadcast Monitor sported back-panel controls for brightness adjustments and 'scope alignment; these were not available on the less expensive FM Studio tuner. Owners were concerned that the small, bright trace on the Studio's 'scope might "burn" the phosphor and leave a permanent mark. Day switched to a new AEG/Telefunken oscilloscope tube for the FM Reference tuner that employs a brighter phosphor that is more resistant to burns. The FM Reference also comes with a 'scope tuning kit for brightness and alignment. The controls are internally placed on the motherboard, set under a plexiglass shield (to keep the owner's fingers away from high-voltage circuitry) with silk-screened trimming instructions so one doesn't need to hunt for the manual to align the 'scope.

Finally, owners had been concerned that the Studio's 'scope trace could be misaligned if the unit were placed too close to the steel chassis of another component. The new FM Reference is more resistant to such effects for three reasons: the new 'scope tube is better shielded internally; a mu-metal shield has been placed around the yoke of the 'scope; and a specially wound toroidal transformer with an unusually low stray field is now employed in the power supply.

RF Performance

Performance data were obtained from two sources. One was the unit's "Performance Data Record," or "Production Traveler," which tracks and records each tuner's progress as it is assembled and tested. The rest of the data

came from signal-level measurements made with the Sound Technology FM Alignment generator in the closed-circuit FM Broadcasting setup (see sidebar). The Production Traveler is stored at Davidson-Roth for later reference after the tuner is sold. The unit under test (serial no. 210179) completed its part QA tests on 2/25/91 and chassis assembly on 3/25/91, began burning-in on 4/9/91 and finished on 4/22/91. Thus, two months of assembly, testing, and burn-in were devoted to this tuner! In addition to actual measurements and signatures from the assembly and testing personnel, the Traveler includes a two-page drawing of the motherboard identifying each component; during assembly, the picture of each component is crossed out with a marker as it is inserted into the unit. As with the Broadcast Monitor reported on in Vol.12 No.6, all factory tests were conducted right on the factory bench, not in a screen room. Day's Sound Technology instruments are calibrated yearly.

Adjacent-channel performance has received high priority from other reviewers, particularly Don Scott. As the number of FM stations increases, the ability to select a low-powered fine music station spaced 400kHz from a high-powered heavy-metal station becomes increasingly important, as long as the tuner's distortion and noise do not climb. The FM Reference's three different IF bandwidths enable its owner to choose either high or low adjacent-channel selectivity, maximizing either low distortion or high selectivity. The narrow IF position, at 130kHz, allows the FM Reference to do as well or better than four other "hot" FM performers available to me during this review, the Onkyo TU-9090 Mk.II,⁵ Don Scott's own modified Magnum/Dynalab FT-11 (set up especially for selectivity and sensitivity),⁶ the Magnum/Dynalab Etude,⁷ the Revox B-260-S,⁸ and the Day-Sequerra Broadcast Monitor.⁹

The FM Reference, in narrow bandwidth mode, has an adjacent-channel selectivity (ACS) of 40dB and a 1kHz THD specification of 0.51%.

⁵ DAS reviewed the Onkyo TU-9090 Mk.II in Vol.11 No.5, pp.112-114. DAS noted that the TU-9090's 50dB quieting was mediocre, but the sonics were good.

⁶ DAS also reviewed the stock Magnum/Dynalab FT-11 in Vol.12 No.10, pp.172-173. DAS liked this single-bandwidth FM unit with its fixed, sliding high blend (full mono for any signals under 25dBf). At the levels used in the closed-circuit FM broadcast, tests of sensitivity and quieting for the DAS-modified FT-11 are therefore all in mono. To equally compare the DAS-modified FT-11 with other tuners in this test suite, the others must be set for mono operation.

This is less than the 1.0% THD measured under the same conditions by the all-time champion for this spec, the McIntosh MR-80, with its ACS of 60dB (DAS, Vol.9 No.3). When one examines the tradeoff between high adjacent-channel selectivity and low distortion, the FM Reference's test-bench performance is excellent, not sacrificing musicality for the last dB of selectivity.

FM tuner sensitivity is the other critical specification. This has been defined as the minimal signal required to produce a given level of

quieting (see JGH's and DAS's excellent glossary of FM tuner definitions in Vol.7 No.7, p.54). The lower the rated input voltage in dBf for the same amount of quieting, the more sensitive the tuner. Don Scott's modified Magnum/Dynalab FT-11 tuner required 11.5dBf for 30dB of quieting, the FM Reference about 7.5dBf.

The popular notion of sensitivity, however, goes beyond the strictly defined IEEE definition, and includes a tuner's ability to log or detect distant stations regardless of noise. By pressing pushbuttons labeled "Muting Defeat" and "Stereo Contour Override," the FM Reference tuner's owner could pull in very faint signals. Ham radio operators¹⁰ call such radio work "DX." The traveler shows, for example, that the FM Reference reviewed here could easily detect 2dBf signals. The FM Reference actually betters its predecessor, the Day-Sequerra FM Studio, in logging faint signals. If one drops the input signal to below 1dBf, the signal/noise ratio (S/N) of the FM Studio runs around 12.5dB; the FM Reference has a significantly higher S/N of 21.5dB. This means that the FM Reference has a far greater ability to pull in weak signals than the earlier FM Studio Tuner, at a level well below its quieting threshold.

On a particularly good day, the FM Reference pulled in 63 stations, while the DAS-modified FT-11 picked up only 58. The FM Reference even picked up WQHQ in Ocean Park, MD, some 250 miles away! On another evening, the FM Reference was paired with an Etude; both tuners pulled in 56 stations. The FM Reference was adept at pulling in adjacent-channel stations whose signals were in the 10-15dBf range, producing a quieter signal with less hash in the background.

I carried out further RF-performance evaluations between the FM Reference, a DAS-modified Magnum/Dynalab FT-11, the Magnum/Dynalab Etude, the Onkyo TU-9090 Mk.II, and the Revox B-260-S, using the closed-circuit FM Broadcasting system (see sidebar). This permitted an evaluation of the musical quality of a tuner's audio and a subjective estimate of a

7 DAS reviewed the basic circuitry of the Magnum/Dynalab FT-101A in Vol.8 No.4, Vol.10 No.5, and Vol.13 No.10. DAS liked this unit for its strong RF performance, particularly in quieting and sensitivity. These qualities were evident in later reviews of the company's Etude. DAS found that the FT-101A's selectivity was not as strong as the Onkyo's, although this Magnum/Dynalab's selectivity did not equal those of the Onkyo TU-9090 Mk.II, the Citation 23, and the Denon TU-800. The FT-101A sounded superior to those other units on most stations.

I reviewed the Magnum/Dynalab Etude in Vol.13 No.8, praising its good RF performance and very listenable sonics. Technically, the \$1295 Etude is an upgrade of the \$805 FT-101A, the \$490 difference in cost buying you a machined faceplate, gold-plated RCA audio output plugs, audiophile-quality output capacitors, four 3" silver or Kimber Kable leads between the audio output devices and RCA jacks, and two additional hours of hand-alignment. For an additional \$1200 the factory will supply the Etude with a gold-plated faceplate. The Etude's innards are much more utilitarian than those of the Day-Sequerra and Revox units, featuring a large number of standard carbon resistors, a generous amount of point-to-point wiring, and single-sided pcbs. The sonics feature strong dynamic contrasts, a distortion-free midrange, and freedom from hash, grit, and glaze. Its RF performance is very good, with sensitivity and quieting rivaling those of the Revox. But the Etude is somewhat noisier than the Revox and FM Reference, and its sonics do not possess the level of transparency or transient response found in the FM Reference.

8 I reviewed the \$2500 Revox B-260-S in Vol.12 No.7, pp.120-123, lauding its beautiful exterior, high sensitivity and selectivity, and excellent RF performance. I also noted these qualities in the current test. The Revox approaches the Day-Sequerra units in glamor and appearance. The RF front end is very good, at times coming close to the FM Reference in its ability to log weak stations from the noise floor. The audio quality did not subjectively change when the tuner was switched into its narrow IF bandwidth setting of 130kHz. Still, the sonics were not quite in a league with the FM Reference Tuner, as noted in this review. The Revox's 60 presets are tedious to program, and its operation is not always understandable. For example, a station can be tuned up by scanning the dial; closing the accessory door will sometimes set the tuner on a different station.

9 Day did an admirable job remanufacturing the ca-1970 Sequerra Model 1 audio classic as his ca-1986 Day-Sequerra Broadcast Monitor. The modern-day version had greatly enhanced reliability. Its sonics were quite good (considering it used LM301A op-amps as audio output devices!), with very low noise, well-defined imaging, and natural timbres. The single, wide IF bandwidth of 280kHz facilitated good sonics, but could also prove a problem with closely spaced FM stations. Cosmetics on the Broadcast Monitor are among the best I've ever seen on an audio component. I particularly liked the use of color indicators in the faceplate display, with red arrows indicating which pushbuttons had been depressed. The Broadcast Monitor's panoramic display also included a separate tuning graticule in addition to that used for the FM Tuning Display mode. While the Broadcast Monitor's high-resolution FM Tuning Display mode is as accurate as the FM Reference's, the owner might be tempted to use the Panoramic Mode to center-tune a station. In some ways, this can be a misuse of the Panoramic mode, for its 2MHz bandwidth display means lower resolution and tuning accuracy.

10 I have been a General Class Ham Radio Operator for the past 35 years (my call letters are K2HKU). "DX" is a typical ham abbreviation, a shorthand that can easily be transmitted via morse code or CW. Signal excellence is important to ham radio operators, but distance, or "DX," is the most important. "Working" a distant station at low power (like making voice contact with another ham radio operator in New Zealand at midnight from a 10W mobile transmitter sitting on Miami Beach—when 10 meters was great, back in 1957) gives the same thrill as those rare days when your system sounds good and the VTA is finally correct.

tuner's performance by listening to the effect of its quieting response on the musical quality of its audio. The subjectivity of this test involves the audible assessment of the point where a station begins to be received clearly enough that speech, then music, can be deciphered.

In addition, very minor factors, such as the type of connector used in the FM tuner, could affect the signal strength received by a particular tuner. Different connector types are used, for example, for the Revox B-260-S (European E), the Onkyo TU-9090 Mk.II (J Connector), the Naim Tuner (British E Connector), and the FM Reference (EIA Standard F Connector). These measurements were based both on the RF output dial on the Sound Technology M-1000A, and on the signal-strength meters in each tuner. Even though the two different coaxial feeds always delivered the identical signal at the FM Reference, sticking on an adapter and hooking up the second tuner didn't guarantee identical signal readings; this made rigorous number-gathering less meaningful. Accurate and repeatable sensitivity measurements require a good screen room and the absence of large electrical devices (transformers, copying machines) in the area. Therefore, the goal of the closed-circuit FM Broadcasting setup was not to bench-test the tuners, but to learn more about their musicality and quieting characteristics.

I came to realize that making RF measurements involved working with very weak signals. The "just detectable" stations coming in at 5dBf involved RF signals of approximately 1 μ V. An Ortofon moving-coil cartridge, considered "low-output" (*ie*, requiring a very-low-noise head amp), puts out a 150 μ V signal, over 150 times stronger!

This emphasizes the great importance of making certain that connectors and coaxial cables in any home tuner installation are in superb shape. Poor antenna feeds can completely defeat a powerful rooftop antenna and a top FM tuner with a supersensitive RF section.

By reading the settings on the M-1000a's level control (and subtracting 8dB to compensate for insertion loss in the test setup—see sidebar), it was possible to make a subjective impression of the relative sensitivity of the tuners. The FM Reference was the most sensitive, just detecting signals at 5dBf, with the stereo light coming on at 10dBf. The Revox B-260-S did almost as well, picking up an 8dBf signal. Don Scott's modi-

fied FT-11 detected signals at 8.25dBf. The Onkyo TU-9090 Mk.II detected signals at 17dBf. Quieting first became apparent at 18dBf for the FM Reference, and at 38dBf on DAS's modified FT-11. The M-1000A's RF output was then slowly increased while I listened for the lowest signal-input level which produced each tuner's best quieting. Best quieting was first heard at 32dBf on the FM Reference, 33dBf for the Revox B-260-S, 35dBf on the Magnum/Dynalab Etude, 49dBf on DAS's modified FT-11, and 62dBf on the Onkyo TU-9090 Mk.II. All the tuners had silent audio outputs at 65dBf input.

The most meaningful aspect of this low-level signal performance was not reflected in numbers, however. The closed-circuit test allowed a subjective estimate of the quieting curve's slope. As the signal level dropped, static and noise invaded the signal, either gradually and gracefully, or with a sudden eruption of hash and static. For example, the Revox B-260-S had a very steep curve with a sudden spray of static as it lost its quieting, whereas the FM Reference gradually became noisier over a wider range of signal strengths. It was less spitty or hashy as the input signal was reduced. Most tuners quieted between 32dBf (FM Reference) and 35dBf (Magnum/Dynalab Etude), although it was possible to hear some tuners continue to become quieter as the input signal was increased to a much higher level (the Onkyo TU-9090 Mk.II).

As always in life, imperfections remind us that we are not dreaming. Very faint signals could not be center-tuned on the FM Reference, appearing as hazy, elongated clouds at the bottom left of the screen; in truth, the Onkyo TU-9090 Mk.II and the Magnum/Dynalab Etude could not center-tune these signals either; I had to center-tune these stations by ear. Also, strong signals received on the FM Reference in FM Tuning Display 'scope mode showed a top strength of 70dBf, even though the center graticule line supposedly extends to 100dBf using the FM. Signals set to be greater than 100dBf (even with the signal splitters) on the M-1000A reached only an indication of 70dBf.

Actual use & listening tests

Pulling in Radio Moscow should not be the primary reason to buy a high-end FM tuner. The FM Reference should be musical as well as being a DX hound. Evaluating its sonics required prolonged listening with the closed-circuit FM

Broadcasting test.

The FM Reference was the first tuner that I have evaluated with a closed-circuit FM broadcasting setup. As pointed out in the sidebar, this allowed me to compare the audio signal output of a Krell MD-1 CD turntable/Krell SBP-32X digital audio converter played through the

tuner under test, or straight through a Krell KBL preamplifier. This created an optimal auditioning atmosphere for reviewing a given tuner's audio capability using CDs as source material, rather than having to depend both upon the scheduling of each station's musical programming and on the unknown quality of the trans-

Closed-Circuit FM Listening Test

The closed-circuit FM broadcast allows for careful selection and repeated playing of musical selections, the heart and soul of detailed subjective audio reviewing. The listener need not depend upon the musical selections offered by the FM broadcast stations. Instead of an antenna, the musical signal originates from the audio outputs of a suitable reference source, such as the Krell MD-1 CD Turntable feeding a Krell SBP-32X Digital Audio Converter (DAC) via balanced interconnects. This DAC has two line-level analog outputs. I connected one of the outputs directly to the Krell KBL preamplifier (selector position B1) via balanced interconnects; the second output was connected, single-ended fashion, to a Dan D'Agostino-designed, broadcast-quality pre-emphasis network which applies the appropriate 75 μ s pre-emphasis to the audio signal (in the case of the US). The output of this pre-emphasis network was then connected to a Sound Technology Model 1000A FM Multiplex Generator to simulate an FM broadcast.

The M-1000A's frequency was set to 88.0MHz, because of the absence of strong FM stations in my area at or near that frequency. The modulated RF from the M-1000A is fed into RG-59 coaxial transmission line terminated at the other end with a Sound Technologies Model 105 Matching Transformer (to match the 50 ohm output impedance of the M-1000 to the 75 ohm load of standard RG-59 cable), which is then connected to one arm of a signal splitter. Two Mini-Circuits precision signal splitters (model ZFSC-2-1) are yoked together (using a female-to-female BNC adapter) to mix two input sources (from the rooftop antenna and from the M-1000A FM stereo signal generator) and deliver the resulting signal to two output coaxial cables (two 8' lengths of RG-59U coaxial cable attached

to the antenna inputs of two FM tuners under test). Two preamplifiers (a Krell KBL and a Mark Levinson No.26) and precision potentiometers are used to match the signal levels between the FM tuner's audio outputs and the direct feed from the Krell SBP-32X digital audio converter, all coming back to the Krell KBL.

The signal splitters have an insertion loss of 3dB each, and the cable connectors reduce the level by an additional 2dB, for a total loss of 8dB. This results in fewer stations being received, so the actual number of stations received by any one tuner cited here is a very conservative underestimate. However, each tuner receives the same attenuated signal; therefore, comparisons using the outside antenna are meaningful. When used to simulate an FM broadcast, the M-1000A's precision power output dial must be adjusted 8dB higher to compensate for the 8dB insertion loss. The maximum quieting for most tuners was heard at about 73dBf on the M-1000A's RF output dial, which equates to 65dBf at the tuner's RF inputs.

Before the test started, I checked to make sure that both cables delivered the same-strength RF signal. This was determined by reading the signal strength from each cable, using the Y-axis scale on a Day-Sequerra Broadcast Monitor set to FM Tuning Display.

I further checked by comparing the signal strength measured by level meters on both tuners; this was possible for those tuners with a dB readout scale, whether numerical (Onkyo TU-9090), LED (Revox B-260-S and Onkyo), or 'scope (FM Reference, Broadcast Monitor). In some instances, any numerical data is corrected by adjusting for signal-strength readings (a risky procedure for interpretation, but necessary in the case of the Revox B-260-S, whose Type E connector seemed to yield higher signal levels

mission chain. This means that reviewing tuners can more closely approximate *Stereophile's* methods of evaluating other audio components. The other tuners included in the FM Closed Circuit Evaluation were: the FM Reference, the Broadcast Monitor, a Magnum/Dynalab Etude, DAS's modified FT-11, the Revox B-

260-S, and an Onkyo TU-9090 Mk.II.

Yellow Cogelco balanced interconnects were used for all line-level signals except when the speakers were bi-amplified, at which time Audio-Quest LiveWire Topaz interconnects were used. Speakers included Quad US Monitor electrostatics with Gradient and Velodyne ULD sub-

on its signal-strength meter than noted with any tuner hooked to the other coaxial feed cable).

Two tuners were tested together, each attached to one of the two RG-59U coaxial cables coming from the "output" signal splitter. Care was taken to tune both tuners to the same frequency; if one tuner was left tuned to one frequency, it was very easy to "pick up" that tuner's oscillator when the two units were exactly 10.7MHz apart. The audio outputs of the two tuners were matched by attaching a precision stereo potentiometer between one tuner's stereo outputs and the line-level input of the Mark Levinson No.26 preamp. The potentiometer was changed until the gain of the two tuners was identical (I also could have used a preamp with individually adjusted inputs, as are found on the Spectral or Rowland preamps). Then it was possible to switch between the two tuners with no gain change. The gain control on the No.26 preamp was used to match its output (one of the two tuners) to the output level of the DAC (Krell SBP-32X), both feeding the Krell KBL. The end result: It was possible to move the main selection knob on the KBL from B1 to B2 (from direct-CD source to tuner output), with no change in gain level!

Then the M-1000A's modulation level was adjusted for an average modulation level of 25%; peaks were set to exceed 100% modulation less than 10% of the time. The stereo pilot was then set to 9%.

The M-1000A FM Alignment generator can simulate FM tuner mistuning, low signal strength, stereo pilot over/under-modulation, and SCA over-modulation. For purposes of this review, the closed-circuit FM test suite included subjective audio listening, signal-strength estimates, and subjective estimates of tuner quiescent noise.

The first test procedure involved determining the weakest musical signal that can

be detected by the tuner under test. The quality of such a signal is highly compromised, but does give an indication of the tuner's ability to log distant stations. This is done in conjunction with the "Quieting Curve Test." The M-1000A's RF signal output is gradually decreased from 70dBf. The tuner's response is noted (smooth, spitty, hashy) as its quieting disappears. The subjective impression of the slope of the quieting curve (sudden burst of noise vs gradual and smooth increase in noise) is also observed.

The closed-circuit FM Broadcasting test was mainly used for critical music listening, exactly as any audio component might be auditioned. The repeatable source material made sonic evaluations of these FM tuners much easier. I raised the M-1000A's gain until all the tuners quieted completely; usually this level was 65dBf, accounting for insertion loss. Five CD selections were chosen as the music for critical listening. These are listed in the "Use and listening tests" section. Each selection was evaluated, frequently switching between the "direct" (CD player/DAC to preamp) and "FM" modes (CD Player/DAC to M-1000A/FM tuner). It was also possible to switch between two tuners while a selection was being played. Instantaneous comparisons could be made between the direct CD signal and a given tuner, as well as a three-way comparison between two gain-matched tuners and the gain-matched source. This setup was not used for double-blind test conditions, but did permit quicker comparisons between direct signal and the tuner's output.

Thanks must be given for the helpful advice, technical support, and equipment loans from Krell Industries, Krell Digital, Magnum/Dynalab, Revox, Onkyo, and the Davidson-Roth Corporation. Watch for future reviews of FM tuners from Quad, Naim, and Meridian using this closed-circuit FM broadcasting test.

—JG

woofers. The US Monitors were driven by a Mark Levinson No.27 stereo amplifier, the Gradients by a Krell KSA-250. Later, Snell Type E/III's were used, driven by a single Krell KSA-250.

My first meeting with the Day Sequerra FM Reference occurred early, before the closed-circuit system had been debugged. It was not one of my best days. I had invited Don Scott and David Day for dinner, to comment on and advise me about the closed-circuit FM setup. David brought along the FM Reference. My wife Susan cooked a superb dinner and David and Don were perfect guests. Unfortunately, my RF cabling and outboard electronic crossover were acting up, like children when the boss comes to dinner. Troubles—did I have troubles! The Broadcast Monitor showed that FM signal levels were varying at a rapid rate, indicating that the coaxial cable connectors had become loose, requiring better crimping. My electronic crossover developed some kind of intermittent fault, heard neither before nor after that day. These glitches became painfully evident when Don brought out his modified Magnum/Dynalab FT-11, equipped with his hand-selected IF filters. This little unit started logging-in very faint FM stations, seemingly better than David Day's early-production FM Reference.

Then came the *coup de grâce*. In our hurry to compare Don's and David's tuners, I let an out-of-production Kenwood tuner slip from a shelf above. The three of us watched in horror and disbelief as the tank-like Kenwood smashed the formica shelf, careened off the top of the FM Reference's front panel, and left its initials in my newly "bleached" living-room floor. David fired off a comment about "unconventional review methods." David and Don stood silent for a second, then began muttering to themselves and each other; I chose not to listen. But the FM Reference and other tuners survived. My furniture and floor were another story, and Susan, who had gone all out for my friends, did not look happy. On my insistence, the FM Reference was to go back to the factory for realignment. I slept fitfully that night; the next day, I had mental flashbacks of the descending Kenwood.

After the fall

The FM Reference was shipped back a month later, after Day had thoroughly investigated and improved the tuner's ability to log stations

below the traditional quieting level associated with standard sensitivity measurements. Cabling problems in the closed-circuit FM broadcasting set had been cleared up by the time the FM Reference returned.

First, I simply installed the tuner and listened. Unlike the Studio Tuner, I did not have to float the AC ground with a cheater. The FM Reference is quiet—dead quiet—completely free of hash, spuriae, birdies, and whistles. There was nothing but silence—dead silence—between selections on any of my nine favorite local FM stations. This alone begins to make this tuner's audio signal musical and involving, quite a departure from the usual abysmal tuner sonics.

Second, I used the 'scope to determine signal quality. Set in the FM Tuning Display mode, I was able to understand why a few stations of good signal strength were received with less than ideal sound quality. WPLJ (95.5MHz), which plays pop and rock music and delivers a signal of 40dBf, routinely over-modulates during transmission. This is shown by the signal trace's excursions far beyond the two vertical lines on the graticule which show ± 75 kHz limits. Other stations, such as WJRZ (100.10MHz), with a signal strength of 20dBf, showed severe multipath interference, their signal traces smeared into blurry blobs resembling out-of-focus snowballs. None of the other tuners under test (except the Broadcast Monitor) indicated this multipath on every station afflicted; the Etude's analog meters confirmed the multipath on some, but not all, of those identified by the 'scope tuners. Standard procedure would be to rotate the outdoor antenna until the signal trace changes from a "cloud" to a thin line on the 'scope. It's important to know that multipath is the culprit when a signal is received with poor fidelity, so one can reorient the antenna to obtain the best signal quality. Finally, one station at 100.3MHz overmodulated its SCA subcarrier, which could be identified as a small "x" at each end of the signal trace. This is the visible sign of intermodulation distortion between the SCA and the audio.

Third, I was delighted to hear the characteristic transparency, dynamics, and grainless sound I associate with Day's earlier design, the FM Studio tuner, but with a new quality I'd never before heard in an FM tuner. The bass response was tight, defined, and much more prominent than with any other tuner. Even when the signal was noisy (at an RF signal strength of just

8dBf!), the bass was punchy, fast, defined, and solid. At higher signal levels (20dBf and above), the tuner created a wide soundstage, complete with depth and instrument placement, making the FM Reference a full-fledged source for superb music. Across the spectrum, the FM Reference was the equal of anything the Krell MD-1/SBP-32X could deliver. The bass was extended, full, solid, dimensional, and detailed. The midrange was sweet, with striking lucidity and transparency. This transparency had an unusual quality, heard best over the Quad US Monitor. There was a freshness, immediacy, vitality, snap, and liveliness about the midrange that made the other tuners mentioned above sound opaque and distant. The highs were as extended as any other source at my disposal.

The best was yet to come. The closed-circuit listening test revealed just how quiet the FM Reference was, and how good its audio section is. The test allowed me to compare the CD source material directly to the simulated FM broadcast under controlled conditions. The M-1000's RF output was adjusted to deliver 65dBf (accounting for insertion loss) to produce maximal quieting in all the tuners; this was confirmed by listening and checking before any comparisons.

The FM Reference was able to correctly convey the depth and width of the soundstage. This was heard clearly during the "Chaconne" from Holst's Suite #1 in E-flat, played by the Dallas Wind Symphony under the direction of Howard Dunn (Reference Recordings RR-39CD). Switching to the Onkyo TU-9090 Mk.II caused an immediate shrinking of the perceived space occupied by the Dallas Winds. This CD's impressive dynamic range was conveyed by the FM Reference; the Onkyo, in comparison, was compressed, flat, and shrill. The Revox B-260-S's rendering of orchestral dynamics seemed quite good at first, but sustained listening revealed that orchestral peaks could overload and compress the sound, with occasional shrillness. (The particular B-260-S under test had more gain in its left channel, indicating possible problems in its audio output section.)

The test also exposed differences among the tuners in midrange fidelity. Harry Connick, Jr.'s voice took on a nasal, honky quality when played through the Onkyo ("I Don't Get Around Much Anymore," from *When Harry Met Sally*. . . , Columbia CK 45319). The Magnum/Dynalab Etude tended to thin out Con-

nick's voice, particularly in comparison to the FM Reference. The direct path (CD/DAC to pre-amp) was closest to the sound of the FM Reference. Connick's voice was close-miked; as a result it was slightly over-resonant, with no nasal emphasis, and greatly improved detail.

These vocal and spatial effects gave the FM Reference a real advantage in large-scale choral works. José Carreras's voice was warm, close-miked, and natural in timbre when heard over the FM Reference (*Misa Criolla*, Philips 420 955-2, DDD). The Day-Sequerra positioned the singer well in front of the chorus, which filled my listening room wall to wall. Switching to the Onkyo collapsed the image of the chorus, shrinking it to the area between the two speakers and moving it back to the rear wall. Again, Carreras's voice changed so much that he seemed to be a different person from the one heard over the FM Reference. Both the Etude and Revox maintained the wall-to-wall imaging, but without the vitality, warmth, and depth heard with the FM Reference.

The upper midrange and treble were also best represented by the FM Reference, as shown by Wynton Marsalis's *Standard Time Volume 3: The Resolution of Romance* (CD, Columbia CK 46143). Over the FM Reference, the bass drum was punchy, the cymbals had definite sheen, the snares under the drumhead were clearly audible, and Marsalis's trumpet was brash, gutsy, and powerful, without becoming shrill or tearing your ears off. Switching to the Onkyo, the drumheads became muffled, the cymbals dull, the trumpet harsh and constricted. The Etude's tonal balance was more similar to the source than is the Onkyo's, but seemed more distant, less dynamic, and flatter than the FM Reference's.

What about dynamic range? I'm sure you can guess. The FM Reference had already distinguished itself in terms of its transparency, bass power, midrange clarity, tonal balance, and high-end extension. Putting on Owen Reed's *La Fiesta Mexicana (Fiesta)*, Reference Recordings RR-38CD) answered the question. The Snell E/III, KSA-250, and FM Reference became a synergistic unit, reproducing the bass drum with tremendous weight, authority, and wad-cutter dynamics. Notes just exploded out of dead silence.

Conclusions

The Day-Sequerra FM Reference is truly a

"dream machine" with a sound new to the FM medium. Its CD-like silence and extremely fast, highly defined bass response have no peer among FM tuners I've auditioned, and the stunningly realistic portrayal of the human voice must be heard to be appreciated. There is a warmth and fullness to the sound; the total absence of white FM haze gives it a distinct advantage, as far as I'm concerned, when compared to other very-high-quality FM tuners. In many ways, it is the realization of a dream: the

combination, in one FM tuner, of a powerful RF front end with a very musical audio output.

The FM Reference redefines the state of the art in FM tuners. I won't be surprised if it becomes the "FM Reference" for musicality against which all new high-quality FM tuners will be measured; it should take top honors in our own "Recommended Components." For those who want the ultimate performance in an FM tuner, this is the one to buy. **S**