A basic requirement for any measurements on FM tuners, either mono or stereo, is an FM signal generator. There are several well-established manufacturers manufacturing laboratory-grade FM signal generators, but until recently there has been no single instrument whose performance parameters matched or surpassed those of a modern FM tuner and whose operating functions met the needs of an equipment manufacturer or a hi-fi specialist's service department.

The traditional laboratory-grade FM signal generator is a general-purpose instrument. It covers a wide range of frequencies, with a calibrated tuning dial, and its metered and calibrated output level is adjustable down to a fraction of a microvolt, usually with an accuracy of ±10%, or ±1 dB. Often the generator is equipped for other modes of modulation such as AM or pulse. Its versatility is reflected in its price, typically from almost $1000 to over $6000, yet it still requires the use of an external multiplex generator ($500 to $1000 for an instrument of comparable quality) and a low-distortion audio generator in order to make measurements on a stereo-FM tuner.

Even with such an imposing and costly array of equipment, it is not possible to make meaningful distortion measurements on most FM tuners. The inherent distortion of the signal generator's own modulating circuits is about 0.5% at best (at 75 kHz deviation), and even this level cannot be guaranteed except over a limited frequency range. Most tuner and receiver manufacturers claim distortion levels under 0.2% for their products. Measurement or verification of these specifications heretofore has required a specially modified and calibrated signal generator.

A new company, Sound Technology of Cupertino, California, has recently introduced a unique instrument designed specifically for the hi-fi FM-receiver manufacturer or service organization. Its Model 1000A FM alignment generator represents a radical departure in features and performance from any previous commercial FM test equipment we have seen.

Features and Specifications

The Model 1000A is a multipurpose instrument. It is an FM signal generator, covering 88 to 108 MHz, with an output attenuator calibrated from 0.5 microvolt to 30 millivolts. The frequency dial is calibrated only at the ends and middle of the FM band (88, 98, and 108 MHz), but its smooth planetary drive permits a tuning resolution of 10 kHz. The output level, into 50 ohms, has a rated accuracy of ±2.5 dB and its shielding is adequate for making accurate measurements down to 0.5 microvolt.

A unique feature of the Model 1000A is its wide-band linear modulator. Deviations up to ±300 kHz are possible and, with 100% modulation (±75 kHz deviation) at 1 kHz, the generator harmonic distortion is less than 0.1%. There is a built-in 1-kHz low-distortion (less than 0.1%) source and an external modulating signal can be used for modulation over the full range of 50 Hz to 15 kHz (flat within ±0.5 dB). One-hundred-percent modulation requires a signal of 0.4 volt r.m.s. at the 10k-ohm input connector. With modulation removed (CW mode), the residual FM noise level is at least 70 dB below 100% modulation. Modulation level, either from internal or external sources, is adjustable and is read directly on a meter scale calibrated from 0 to 180°, with 100% corresponding to ±75-kHz deviation.

The instrument also contains a stereo multiplex generator capable of delivering a standard composite modulating signal from the 1-kHz internal oscillator, or from an external source. A selector switch connects the internal signal source to provide L, R, L+R (mono), or L-R modulation modes. Separate input connectors for external L and R signals can be switched into the circuit. The 19-kHz pilot carrier level is read on the meter by pushing a button, which expands the meter scale by a factor of ten. The pilot carrier may then be set accurately within the standard 5% to 10% modulation limits, since the meter reads 15% full scale. Three connectors on the front panel carry out the 19-kHz pilot signal, the internal 1-kHz modulating signal, and the composite stereo modulating signal, for scope synchronization or for checking a multiplex demodulator unit. All connectors are type BNC.

The function selector switch has positions for Stereo, Mono, CW, SCA, and Dual Sweep. In the SCA position, external modulation is removed and an internal 67-kHz signal is applied to the modulator, for checking or aligning SCA traps in stereo tuners and receivers.

The Dual-Sweep function is a unique feature of the generator. It provides a means for aligning an FM tuner rapidly, with a constant display of over-all distortion on an oscilloscope as the alignment is performed. The Dual-Sweep technique in effect plots the slope of the discriminator S-curve over a wide and adjustable deviation range. The generator frequency is swept by a 60-Hz signal, on which is superimposed a small deviation at a 10-kHz rate. The sweep width is adjustable from 0 to 600 kHz, and is indicated on the meter.

The audio output from the tuner is returned to the instrument where the 60-Hz component is filtered out and a clean 10-kHz signal is extracted. The amplitude of the 10-kHz component is proportional at all times to the slope of the tuner's discriminator characteristic. With a perfectly linear discriminator, it would have a constant level as the 60-Hz sweep moves the generator frequency across the tuner passband.

Two output connectors on the generator supply vertical (10 kHz) and horizontal (60 Hz) deflection signals to an external oscilloscope. Any variation in the vertical dimension
of the sweep display indicates a nonlinearity in the tuner. The i.f. and
discriminator circuits are aligned to pro-
duce the smoothest, widest, and most
uniform display possible. As a final
check, the sweep width can be re-
tduced to 150 kHz, corresponding to
100% modulation, and the vertical scale of the oscilloscope expanded to
reveal the smallest departure from flat-
ness. The amplitude of any irregulari-
ty, expressed as a percentage of the to-
tal vertical amplitude, is a direct mea-
sure of IM distortion. The rated peak
nonlinearity of the generator in the
Dual-Sweep mode is less than ±0.3% over a 150-kHz bandwidth.

Clearly, the Model 1000A is an un-
commonly versatile instrument. It was
designed for a manufacturer's final-test
or quality-assurance departments, or
for the service specialist dealing in the
highest caliber of home receiving
equipment. This unit makes more use
of up-to-date components and tech-
niques than any comparable laboratory
instrument we have seen. For exam-
ple, its design employs 8 linear IC op-
erational amplifiers, an IC power-sup-
ply voltage regulator, and two digital
IC's serving flip-flop and gating func-
tions. In addition, there are 22 transis-
tors (5 of them FET's) and 13 diodes.

The end result is a compact instru-
ment, 8 3/4" high by 11 3/4" wide by
11 3/4" deep and weighing only 12
pounds. It is very nearly a single unit
FM/stereo-FM test laboratory, whose
functions could only be partially duplic-
cated by a clumsy and expensive array of
separate instruments.

Tests and Evaluation
Our tests of an instrument such as
this had to be done indirectly, by com-
parison with other instruments whose
performance was in some respects in-
ferior to the unit we were "testing."

Nevertheless, we were able to satisfy
ourselves that this instrument does
what is claimed for it, and then some.

Our own FM signal generator, a
Boonton Model 202B, has a residual
distortion of about 0.5% at 75-kHz de-
viation. We used it to measure the IHF
usable sensitivity, distortion, signal-to-
noise ratio, and stereo crosstalk of a
new FM receiver, and similar measure-
ments (except for crosstalk) on an older
mono-FM tuner of high quality. A Scott
Model 830 multiplex generator was
used to develop the composite modulat-
ing signal for the stereo measure-
ments. The same measurements were
then repeated using only the Sound
Technology Model 1000A.

With our own equipment, the IHF
sensitivity of the receiver measured 3.0
microvolts; with the Model 1000A it
was 2.9 microvolts—remarkably close
in view of its relatively loose output-
level specifications. The distortion
measured 0.54% with our equipment,
and a remarkable 0.07% with the Model
1000A. The two sets of stereo-crosstalk
measurements agreed within 3 dB at
distortion. The signal-to-noise
ratio was 72 dB with our equipment;
73 dB with the Model 1000A.

With the monaural equipment, our equi-
ipment showed an IHF sensitivity of 2.1
microvolts, while the Model 1000A
gave a reading of 2.6 microvolts—still
within specification limits. Distortion
with our generator was 0.53%; with
the Model 1000A it was 0.19%. The
signal-to-noise ratios were, respective-
ly, 70 dB and 73 dB.

We then used the Dual-Sweep mode
to align the monaural receiver. It was in-
teresting to note how easily rather
large irregularities from 100 kHz to
300 kHz away from the center fre-
quency could be produced by conven-
tional alignment methods. With a little
practice, the Dual-Sweep technique al-
lowed a modest reduction in distortion,
but with an improved symmetry over a
wide bandwidth which makes the re-
ceiver easier to tune for low distortion.

In effect, Dual Sweep replaces the
rapid, but purely qualitative sweep
alignment of a discriminator by visual
display of its S-curve with an equally
fast, but precise and quantitative indi-
cation of the tuner's IM distortion.

Our only criticism of the generator is
the choice of 1 kHz as its internal modu-
Iating frequency. The IHF standard
on FM tuner measurements specifies a
400-Hz modulating frequency and this
frequency has long been a part of other
standard measurement practices for
home FM receivers. The principal rea-
son for this, we believe, is that harmoni-
ies of 400 Hz appear in the correct am-
plitude relationship to the fundamental,
even the third harmonic is reduced by
only about 1 dB by the tuner's de-
phasis circuits. On the other hand,
the second harmonic of a 1-kHz modu-
lating signal is reduced by 1.9 dB, and
the third harmonic is down 3.8 dB, rela-
tive to the 1000-Hz level, since de-
phasis begins just below 1000 Hz.
This can give misleadingly optimistic
readings of tuner distortion. Of course,
400 Hz can be used with the Model
1000A, from an external source (which
we did), but it should be internally
available, either instead of or in addi-
tion to the 1-kHz signal.

(Editor's Note: The manufacturer
will supply the instrument with a 400-
Hz modulating frequency if desired at
no extra cost. However, this means that
separation will have to be measured at
400 Hz rather than 1 kHz. Both fre-
quencies are available at the flick of a
switch as an extra-charge option.)

All in all, the Sound Technology
Model 1000A is a fine instrument,
which we wouldn't mind having in our
own laboratory. Its price is $1250. ▲