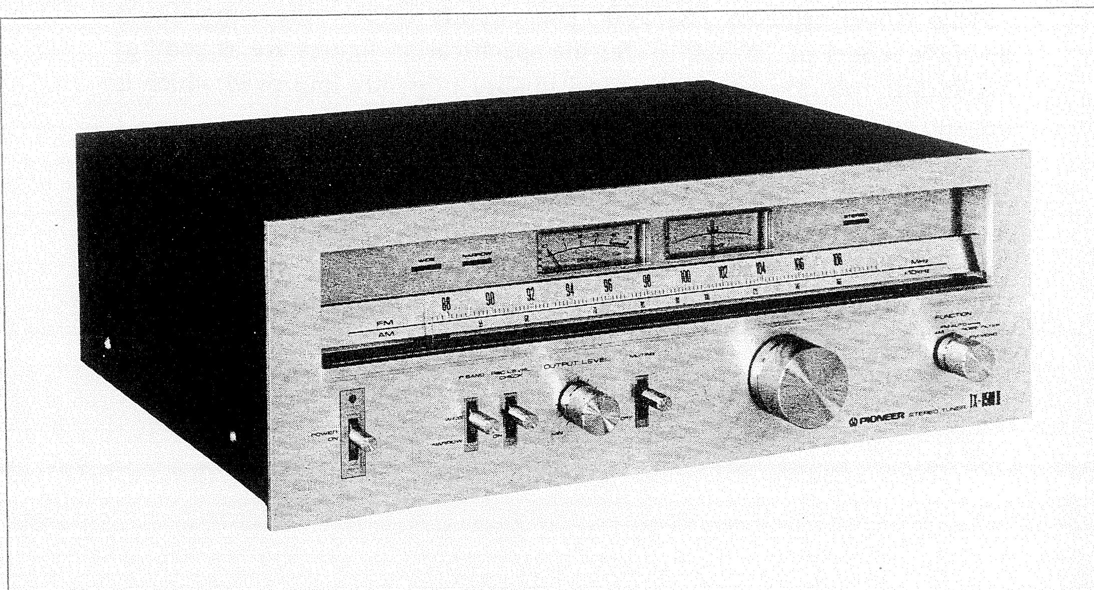
Technical Manual

Vol. 2

stereo tuner
TX-8500II



PIONEER®

PLANNING CONCEPT

Performance on a tuner system has been rapidly improved since IC engineering was introduced into the Hi-Fi field. The use of ICs saves us considerable cost at manufacturing level and it also provides stable performance and reliability for the users to enjoy Hi-Fi sound for a long time without any inconvenience.

This time, Pioneer developed four new ICs which are used for new tuner line-up. That means Pioneer developed many ICs in the past, but those ICs were used or copied by many other manufacturers, so naturally differences among manufacturers were getting smaller.

One of ICs is for FM-IF. It particularly improved the signal to noise ratio, for example, if this IC is used in a previous tuner of which the signal to noise ratio is 68dB to 70dB, it becomes 75dB. One more IC which we would like to introduce is a FM-MPX IC. The PLL circuits and 19kHz auto pilot signal canceller circuits are built in it. Conventional unit used to employ a low pass filter and it caused high frequency to decrease, however, the use of new IC improved performance a lot and the 15kHz decrease became only –0.5dB.

So far, only Pioneer is using the IC-equipped 19kHz pilot signal auto canceller circuit. Only few other manufacturers are using this circuit with many transistors currently on the market.

This model replaces TX-7500. The circuits employ the same ICs as up-grade model of TX-9500II. So the specification figures are as good as TX-9500II too. Moreover, the tonal quality is greatly improved which is not shown up in the specification list.

An easy way of selling tuners at retailers is to appeal specifications, especially FM sensitivity and FM selectivity. That is fine with this model, however, the retail sales will increase by "let them hear it."

TX-8500II has many features that are explained on the next page. Those features and performance will be strong enough to compete with the others.

TX-8500II MAJOR FEATURES

1. **Automatic Pilot Signal Cancelling Circuit in Newly Developed IC Results in Outstanding Frequency Characteristics**

   Previous multiplex circuit designs have usually depended on low pass filters to remove the 19kHz pilot signal and 23kHz to 53kHz subcarriers after demodulation. Such filters, however, also remove some of the wanted signals, resulting in loss of fidelity.
   The new IC (PA1001) developed by Pioneer features an automatic pilot signal cancelling circuit which removes the 19kHz carrier leak without any loss in frequency characteristics at all. Remaining subcarriers are removed by 5-element low pass filters.

Frequency Characteristics:	20Hz–10kHz (±0.2dB)
	20Hz–15kHz (+0.2dB, –0.5dB)
Carrier Leakage:	–72dB

2. **Use of 4 Advanced IC's Greatly Diminishes Distortion and Improves S-N Ratio**

   Adoption of 4 recently developed IC's has reduced distortion, and improved S-N ratio almost beyond the limits of measurable levels. Besides the improved S-N ratio in the IF stage (PA3001) and reduced residual ripple in the power supply (PA2002), all switching and interstation noises have been eliminated (PA1002).

S-N Ratio:	79dB (mono)
	75dB (stereo)

3. **IF Amplifier Featuring Wide and Narrow Switchable Bandwidths**

   The wide band employs a single dual-element ceramic filter in the IF amplifier stage for high-fidelity low-distortion reception of stronger signals, while the narrow band employs 4 such filters for greater selectivity and less interference in reception of weaker signals.

Wide:	Harmonic Distortion 0.1% (stereo), 0.08% (mono)
Narrow:	Alternate Channel Selectivity 60dB (300kHz), 80dB (400kHz)

4. **Built-in Recording Level Check Oscillator for Air-check**

   Good quality tape recordings of FM programs depends on proper setting of the recording level of the Tape-deck. With the TX-8500II, this can now be accomplished simply and accurately by oscillator signal which is equivalent to 37.5kHz deviation.

5. **Improved Quality in AM Reception**

   With the incorporation of another recently developed IC (HA1197), distortion in the low frequency region has been reduced to less than 1/3 previous levels.

COMPARISON CHART PIONEER VS OTHERS

Brand Name Model No.	PIONEER TX-8500II	KENWOOD KT-7300	MARANTZ 112	SANSUI TU-5900
FM TUNER SECTION				
IHF Usable Sensitivity	10.3dBf (1.8μV)	10.3dBf (1.8μV)	9.8dBf (1.7μV)	10.3dBf (1.8μV)
50dB Quieting Sensitivity				
Mono	16.1dBf (3.5μV)	16.8dBf (3.8μV)	—	16.0dBf (3.5μV)
Stereo	37.2dBf (40.0μV)	38.3dBf (45.0μV)	—	38.0dBf (45.0μV)
S/N, Mono/Stereo (65dBf)	79/75dB	73/68dB	70/60dB	70/60dB
T.H.D. Wide/Narrow (1kHz)				
Mono	0.08/0.15%	0.1%	0.15%	0.25%
Stereo	0.1/0.4%	0.2%	0.3%	0.35%
Capture Ratio Wide/Narrow	0.8/2.0dB	1.0dB	1.6dB	2.0dB
Alternate Ch. Selectivity Wide/Narrow	35/80dB	80dB	60dB	60dB
Stereo Separation (1kHz) Wide/Narrow	45/45dB	45dB	42dB	40dB
Frequency Response	20Hz–15kHz$^{+0.2}_{-0.5}$dB	20Hz–15kHz$^{+0.2}_{-1.5}$dB	50Hz–15kHz±1.0dB	30Hz–15kHz$^{+1.0}_{-2.0}$dB
FEATURES				
V.C. Composition FM/AM	4/2	4/2	—	3/2
Meters	2	2	1	2
Output Level Control	Yes	Yes	No	Yes
Rec. Level Check	440Hz Tone Burst	No	No	No
IF Band Switch	Yes	No	No	No
Multipath	Multipath Output	Multipath Output	No	No
Muting Switch	1 step	1 step	1 step	1 step
Pilot Cancel Circuit	Yes (Auto Cancel)	No	No	No
AM Tuner	Yes	Yes	Yes	Yes

TX-8500II OTHER SPECIFICATIONS

FM SECTION

Image Response Ratio 85dB
IF Response Ratio 100dB
Sprious Response Ratio 90dB
AM Suppression Ratio 55dB
Subcarrier Product Ratio 72dB
SCA Rejection Ratio 62dB

AM SECTION

IHF Sensitivity Ferrite Antenna 300μV/m
External Antenna 15μV
S/N 50dB
Selectivity 30dB

OTHERS

Power Consumption 20W
Dimensions (Without Package) . . . . 420(W) x 150(H) x 395(D)mm
Weight (Without Package) 8.1kg

NEW TECHNOLOGY AND TECHNICAL TOPICS

IF BAND SELECTOR

1. The Need for an IF Band Selector

The 2 most important features of any tuner are the ability to accurately select the desired broadcasting station from among the numerous other radio signals, and to reproduce that signal with a high degree of fidelity. However, in order to reduce the amount of distortion in reproduced sound, it is necessary to widen the pass band in the IF stage. But this runs counter to the necessity to make the band narrower in order to eliminate unwanted interference signals. Hence, the IF band selector has been developed in order to satisfy both requirements. In areas with little interference, reception in the wide band will give sound of a very high quality. In areas with considerable interference, reception in the narrow band will ensure a high degree of selectivity and a clear, interference-free sound. Pioneer has adopted this system in both the TX-8500II and TX-9500II.

2. IF Band Selector in the TX-8500II

Fig. 1 is a block diagram of the FM IF amplifier in the TX-8500II. The band switching in this circuit is performed by switching diodes. When the IF BAND switch (S_1) is put in the WIDE position, the diodes D_3 and D_4 are biased in the forward direction, and consequently turn ON. The signal path goes via the ceramic filter (F_1) and the IF AMP (A_1), then through the 2 diodes (D_3 and D_4) and onto the IC (PA3001). When the switch (S_1) is in the NARROW position, however, the diodes D_1 and D_2 are biased in the forward direction, and thus turned ON. The signals consequently pass through 4 ceramic filters (F_1, F_2, F_3, and F_4) before reaching PA3001. The filters used in this system are 2-element ceramic filters which feature 35dB selectivity ratings, and long group delay times. As a result, total harmonic distortion in the WIDE position is 0.08% for mono, and 0.1% for stereo. In the NARROW position, using 4 of these ceramic filters, an alternate channel selectivity of about 80dB has been achieved, while distortion has been suppressed to 0.15% during mono, and 0.3% during stereo. The selectivity characteristics, and distortion level changes, for the WIDE and NARROW positions are shown in Figs. 2 & 3.

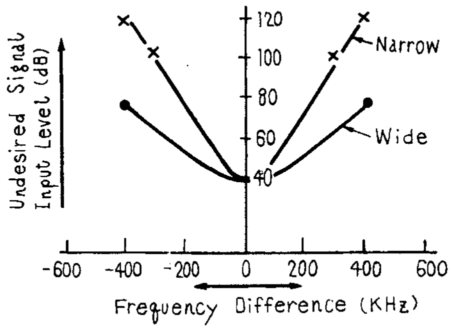


Fig. 2

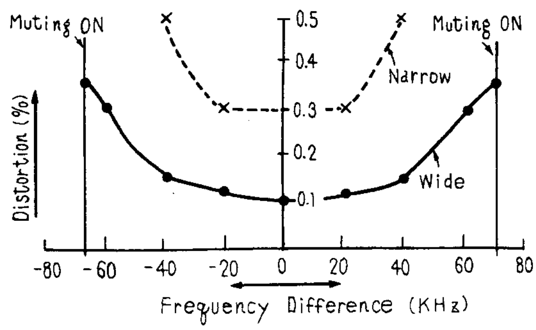


Fig. 3

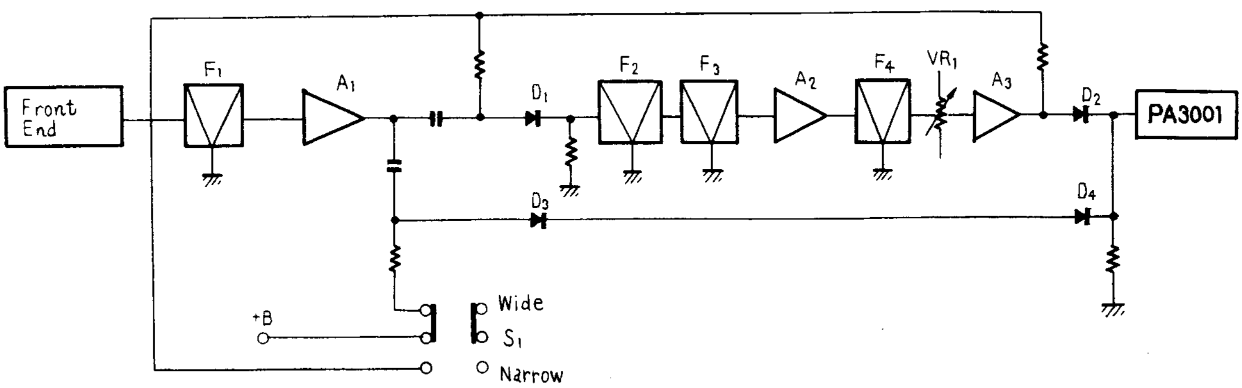


Fig. 1

RECENTLY DEVELOPED IC's

The 4 IC's employed in the TX-8500II and TX-9500II are all completely new IC's developed independently by Pioneer. Their high performance, diversified functions, and high reliability help satisfy the high demands made of top quality hi-fi tuners.

1. Use of the New IC's

PA3001 .... IF amplifier, detector, tuning meter, signal meter, and muting level control.

PA1001 .... NFB type PLL stereo demodulation, automatic pilot canceller circuit.

PA1002 .... low noise NFB operational amplifier, muting.

PA2002 .... constant voltage power supply, protector circuits.

2. Features of the PA3001

The PA3001 features less noise (than the previous HA1137), a new detector circuit (quadrature detector), and better S-N ratio.

The IF amplifier (see block diagram in Fig. 4) consists of the high-gain 3-stage differential IF amplifier plus diode limiter and quadrature limiter, in total 5-stage limiter, and serves to amplify the audio output following quadrature detection. Besides featuring better detector stage NF and detector efficiency than the previous HA1137, it also has a considerably reduced distortion (absolute value) and a better S-N ratio, due to greater flatness in its delay characteristics.

As a result, the TX-8500II features a distortion of 0.1% and an S-N ratio of 80dB during stereo. And in the control system, it is also now possible to adjust the muting level in accordance to the signal level.

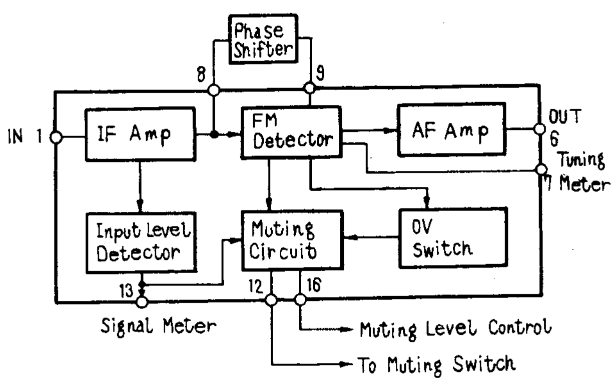


Fig. 4

3. Features of the PA1001

The circuit composition of the PA1001, whose block diagram is shown in Fig. 5, is that of an NFB type PLL multiplex IC featuring an automatic pilot signal canceller. Although this feature has been described in further detail in the Technical manual for the TX-9500II, it is briefly, a circuit designed to cancel the 19kHz pilot signal automatically without any loss in the frequency characteristics of the demodulated signal. Previously, the pilot signal has been removed by the use of low pass filters with a dip point at 19kHz, but at the expense of some of the high end frequencies. The frequency characteristics, especially in the high frequency region, have consequently been greatly improved by this circuit. In the TX-8500II, this rating is +0.2dB, −0.5dB at 15kHz. In addition, because of the adoption of the NFB type operational amplifier as the demodulated signal amplifier in this IC, further improvements have also been achieved in S-N ratio.

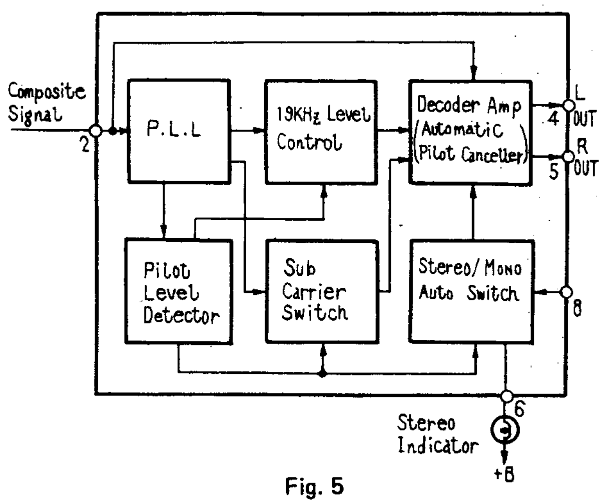


Fig. 5

4. Features of the PA1002

See Fig. 6 for the block diagram of this IC. Its circuit features a differential direct-coupled NFB type operational amplifier with extremely low distortion, and a dynamic range above 150kHz modulation. And processed for ultra low noise, this IC alone boasts an S-N ratio in excess of 90dB. The de-emphasis characteristics also make use of the NFB loop in the AF amplifier. Special attention has also been given to the selection of circuit elements which have influence on the frequency characteristics. Variation among such elements has been greatly reduced by the use of metal film resistors (1% tolerance) and carefully selected styrol capacitors. Furthermore, non-distorting electronic switches have also been used in muting circuits. These switches are activated immediately a trigger voltage appears at pin No. 8, or when a DC voltage is applied from the power supply ON/OFF muting circuit, thus short circuiting signal circuits electronically to ground with much less noise than in reed relays.

5. Features of the PA2002

See Fig. 7 for the block diagram of the PA2002. This IC, incorporating constant voltage circuits with protective circuits, features a ripple suppression factor of 80dB. The protection circuits include control circuits, some of which are activated by over-voltages, and others by over-currents. For example, extra large currents appearing at the output circuit of the IC due to overloads caused by short circuiting of the load, or when a voltage in excess of 27V appears at the input of the IC (pin No. 1).

As a result of the adoption of these outstanding IC's, all of which employ very recent technological advances, the distortion, S-N ratio, and frequency characteristics etc. in the TX-8500II certainly stand head and shoulders above those of other similar units.

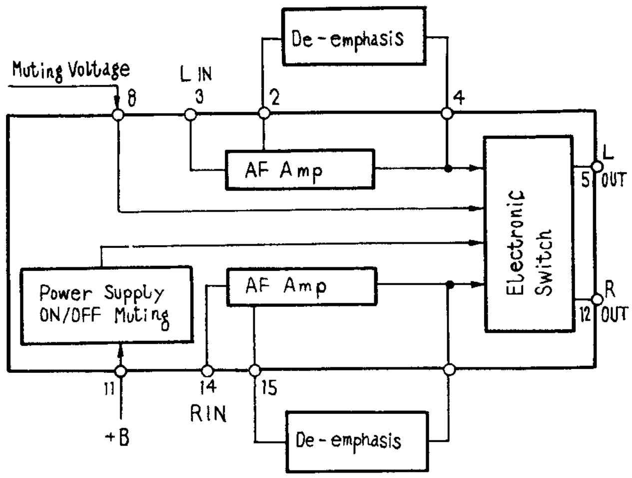


Fig. 6

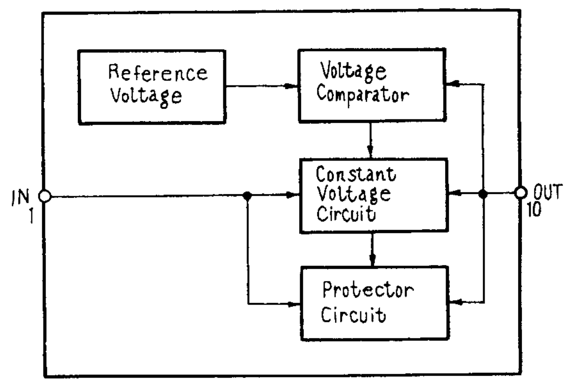


Fig. 7

BASIC TECHNOLOGY

THE FM FRONT-END

1. Role of the FM Front-End

The front-end consists of the 4 following sections (see Fig. 1):
(a) antenna input circuit, (b) radio frequency amplifier, (c) mixer circuit, and (d) local oscillator.

The function of the front-end is to select the desired radio signal, reject all other unwanted signals (including radio signals from adjacent stations), amplify the very weak radio signals, and convert them into intermediate frequencies by means of the local oscillator and mixer.

2. Antenna Input Circuit

The antenna input circuit is the tuner's "front door" where the impedance of the antenna is matched with the input circuit impedance, adjacent station interference is suppressed, and signals from the desired station only are received. This antenna input circuit is one of the more vital stages as far as designing is concerned because of the need for strong suppression of intermodulation and spurious interference, and the consequent effects on sensitivity and noise figure. Noise figure is determined by the amount of insertion loss of the antenna input circuit, and the quality of the amplification elements.

The insertion loss of the antenna input circuit is employed so as to cause deterioration in the noise figure. Insertion loss may be calculated by the following formula:

$$\rho_{\ell} = \left(1 - \frac{Q_L}{Q_o}\right)^2$$

where Q_o is unloaded Q
and Q_L is loaded Q

Since Q_o is determined by the coil and printed circuit board materials, insertion loss reductions have to be accomplished by reducing Q_L.

But any reduction in Q_L will lead to deterioration of the selectivity in the antenna input circuit, resulting in deterioration of image rejection intermodulation interference and spurious interference. In tuner designing, the problem is whether to give priority to improving interference suppression, or

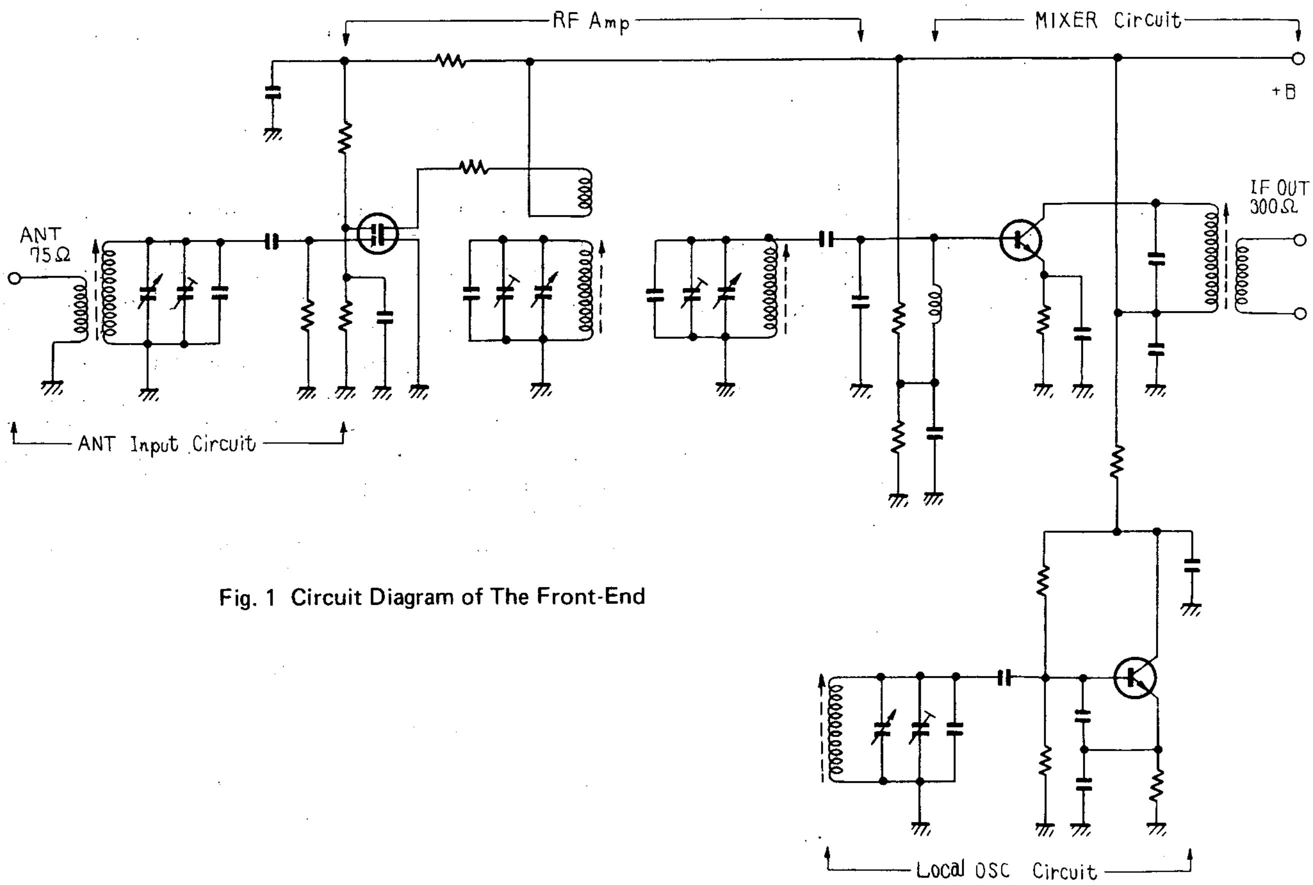


Fig. 1 Circuit Diagram of The Front-End

improvement of sensitivity (which will deteriorate if the noise figure deteriorates). And since tuners are hi-fi equipment, priority is given to suppression of interference.

3. Radio Frequency Amplifier Circuit

3.1 The role of the RF amplifier circuit is amplify the weak radio signals, suppress the noise generated within the front-end, and reject adjacent station interference. It then sends signals onto the mixer.

The amplifier elements in between the antenna input circuit and RF amplifier circuit also have to operate as perfect buffers. If a J-FET is used for this purpose, it is usually set to neutralization point, since the capacitance between drain and gate, that is, feedback capacitance, generates irregularities in oscillation etc.

Most ordinary tuners these days employ MOS-FET's. Because of the special features of the MOS-FET, described below, they are used in great numbers in the radio frequency circuits in TV sets as well.

(a) Since feedback capacitance is less than 1/10th of that in the J-FET, there is no need for neutralization.
(b) Small noise figure.
(c) Since mutual conductance is large, sufficient gain can be obtained.
(d) Also has much better squaring characteristics than the J-FET and other transistors, thus improving cross modulation and intermodulation characteristics.

Since the Q_L of the antenna input tuning circuit is usually set at a low value (because of the previously mentioned reasons), selectivity for rejection of adjacent channel interference is mainly determined by the selectivity of the tuning circuit in the RF amplifier.

3.2 The selectivity of the RF amplifier circuit may be by a number of different ways. Since double tuning circuits have better characteristics, and higher selectivity, than single tuning circuits, double tuning circuits are either combined with other double tuning circuits, or with single tuning circuits. The systems adopted by Pioneer are:

(a) Single tuning + single tuning (3-ganged VC)
(b) Single tuning + double tuning (4-ganged VC)
(c) Single tuning + double tuning + single tuning (5-ganged VC)
(d) Single tuning + double tuning + triple tuning (7-ganged VC)

The Front-end shown in Fig. 1 employs the 4-ganged VC circuit (b). The 5-ganged VC circuit (c) has been employed in the TX-9500II and SX-1250. With an image rejection ratio and spurious response of over 110dB, the use of multi-ganged variable capacitors with more than 5-gangs is not really necessary.

4. Mixer Circuit

The purpose of the mixer is to mix the signals received by the antenna and amplified by the RF amplifier, with frequencies generated by the local oscillator, and then select out only the intermediate frequency (10.7MHz). Where the frequencies of the antenna input signals are 87.4 to 109MHz, the local oscillator generates frequencies from 98.1 to 119.7MHz, so the difference between the received frequencies and the local oscillator frequencies will always be 10.7MHz.

If the received frequency is f_R, the local oscillator frequency f_o, and the intermediate frequency f_i, the task of the mixer, then, is to maintain the relation $f_o - f_R = f_i$. Or again, if the received frequency is represented by $\cos \omega_R t$, the local oscillator frequency by $\sin \omega_o t$, and the intermediate frequency by $\sin(\omega_o - \omega_R)t = \sin \omega_i t$, and the received frequency is multiplied by the local oscillation frequency thus:

$$\sin \omega t \times \cos \omega_R t$$
$$= \frac{1}{2}\sin(\omega_o + \omega_R)t - \frac{1}{2}\sin(\omega_o - \omega_R)t$$
$$= \frac{1}{2}\sin(\omega_o + \omega_R)t - \frac{1}{2}\sin \omega_i t$$

Component sums and differences of 2 signals are generated, the difference being used as the intermediate frequency. Since this is the simple multiplication of 2 frequencies, the mixer can be thought of as a multiplier used to produce the intermediate frequency. Where a dual gate MOS-FET has been used, the radio frequency signal is usually applied to gate 1, and the local oscillator frequency to gate 2. Mainly MOS-FET can be considered as a multiplier type of mixer.

Another method employs the non-linearity of the elements. Non-linearity can be considered according to the following formula:

$$i = A_o + A_1 e + A_2 e^2 + A_3 e^3 + \ldots\ldots$$

If the sum of the 2 previously described signals (where $e = \cos \omega_R t + \sin \omega_o t$), is applied to such non-linear elements,

$$i = A_o + A_1(\cos \omega_R t + \sin \omega_o t)$$
$$+ A_2(\cos \omega_R t + \sin \omega_o t)^2$$
$$+ A_3(\cos \omega_R t + \sin \omega_o t)^3 + \ldots\ldots$$

For brevity, only the (cos $\omega_R t$ + sin $\omega_o t)^2$ term will be considered, and this is expanded to

$$\cos^2 \omega_R t + 2(\cos\omega_R t \times \sin\omega_o t) + \sin^2 \omega_o t$$

Again, there is multiplied component of two signals, component sums and differences of 2 different frequencies are obtained, the difference component representing the intermediate frequency.

The mixer circuit shown in Fig. 1 includes a transistor to whose base both the radio frequency and local oscillator frequency have been applied. So it is apparent that the non-linearity characteristic of the transistor has been employed.

Fig. 2 shows an example of how the mixer circuit operates. If the frequency of the incoming signal is 98MHz, the frequency of the local oscillator will be 108.7MHz. The sum and difference components consequently generated are 206.7 and 10.7MHz. Only the 10.7MHz frequency is passed through the filter in this case.

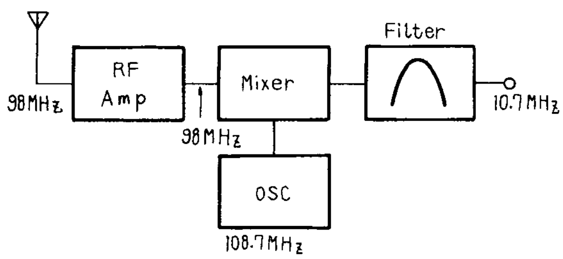


Fig. 2 Mixer Operation

5. Local Oscillator Circuit

Since the conversion of the radio frequencies into the intermediate frequency is impossible without the local oscillator, and because any drift caused by changes in temperature or humidity will have direct effect on the tuning scale position and other tuner features, this circuit is also known as the "heart" of the front-end.

6. Performance Ratings Determined by Quality of Front-End

The characteristics determined by the quality of the front-end are listed below:

(1) Spurious response (½ IF rejection ratio, 2nd oscillator ± IF rejection ratio)
(2) Image rejection ratio
(3) IF rejection ratio
(4) Sensitivity (IHF sensitivity)
(5) 50dB quieting sensitivity
(6) AM suppression ratio

Other characteristics required in the designing of the front-end include:

(7) Image rejection intermodulation interference
(8) Cross modulation interference
(9) Noise figure
(10) Power gain
(11) Blocking
(12) Frequency drift due to changes in temperature and humidity.