

Low Cost IC Stereo Receiver

National Semiconductor
Application Note 147
Jim Sherwin



INTRODUCTION

The recent availability of a broad line of truly high-performance consumer integrated circuits makes it possible to construct a high quality, low noise, low distortion and low cost AM/FM/Stereo receiver. Design emphasis is placed on a high level of performance, minimum factory adjustments and low parts count. As such, the receiver has immediate applications to table-top, high-fidelity, automotive and communications markets.

Provisions are included for the addition of a ceramic phono unit as well as a tapehead amplifier allowing inclusion of eight-track or cassette transport systems. Complete tone control circuitry is provided offering both boost and cut of Bass and Treble frequencies. Left and right channel Balance, and system Volume complete the manual front-panel controls.

Panel meters are employed in the FM system for both signal strength and center tuning, allowing for easy and accurate tuning. A directly driven LED offers immediate indication of FM stereo reception.

The complete design requires just five IC's, restricting the use of discrete active elements to the preassembled FM front-end and the single transistor tone control design.

FM AND FM STEREO

A preassembled front-end was selected as the cost-effective approach to minimum parts count and minimum factory adjustments. This model features an FET input stage providing excellent distortion performance. High selectivity is obtained through the use of two cascaded ceramic filters yielding an approximate 6-pole response with less than 12 dB insertion loss.

The LM3089 FM IF System does all the major functions necessary for FM processing, including a three stage amplifier/limiter and balanced product detector, as well as an audio preamplifier. A single quadrature coil was used for ease of alignment; yielding recovered audio with THD less than 0.5%, however a double coil may be used to diminish THD to 0.1% if required. Carrier level detectors provide delayed AGC, SIGNAL strength meter drive, and adjustable interstation mute control R_{11} . The internal AFC amplifier was used to drive the TUNING meter, giving a visual indication of center tuning.

FM stereo demodulation is accomplished by the use of the LM1800 phase locked loop, thereby eliminating the need for external coils. Only two adjustments are necessary: R_{14} , which sets the 19 kHz oscillator, and R_{17} , which corrects

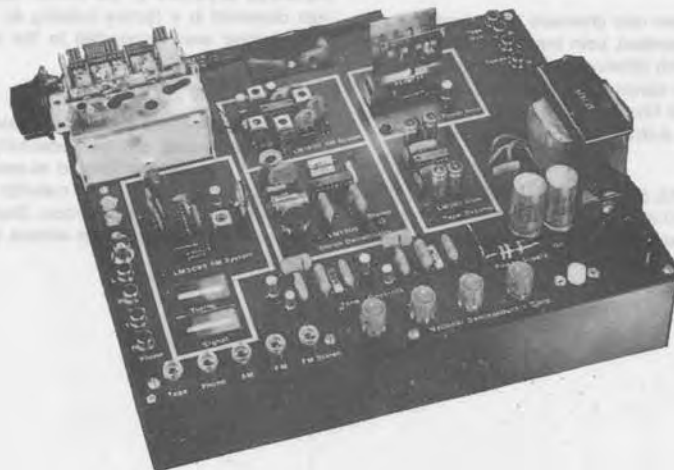


FIGURE 1. IC Receiver

TL/H/7250-1

which corrects for excess phase shift thru the IF stages, and yields maximum channel separation. Automatic stereo/monaural switching is built-in, and may be used in lieu of mechanical switching if desired. The open collector lamp driver is used to light a LED whenever a stereo station is encountered. (Further details available from application note AN-81.)

AM

The AM function of the receiver is done completely with the LM3820 AM radio system. While designed for 3 section tuned superheterodyne applications, the LM3820 may be used with the less expensive 2 section tuned designs by omitting the RF stage and redefining its function as 2ND IF stage (see linear brief LB-29). As shown, the LM3820 provides the necessary converter/oscillator, IF, and AGC detector functions, while the external diode D_1 does the audio demodulation. D_1 is slightly forward biased thru R_2 for improved distortion performance. In addition its resistance is used in conjunction with C_9 to form the first stage of the required low pass filter; the second stage consists of R_3 and C_{10} .

TAPE

The LM382 dual preamplifier was selected for its minimum parts count and low noise capability. With a guaranteed maximum equivalent input noise voltage of $1.2 \mu\text{Vrms}$ (10 kHz BW), it easily amplifies the low level tape signals while retaining excellent S/N ratio (~ 64 dB below 2 mV input level). An ion-implanted resistor matrix is supplied on the chip for self-biasing the output to half-supply, and provides the resistors necessary to create the NAB equalization curve; requiring only four external capacitors per channel to complete the amplifier. For production models this preamplifier would normally be mounted directly on the tape player to minimize hum and noise pick-up.

TONE CONTROLS

A single transistor tone control circuit was designed as the optimum cost/performance trade-off. The transistor is configured in a shunt-shunt feedback design, allowing gain variations between input functions. This is necessary to prevent sudden changes in output level when different inputs are selected. With a shunt feedback design the gain is easily controlled by choice of source impedance per Figure 5.

Approximately 20 dB of boost or cut of Bass and/or Treble frequencies is possible with the network shown. The turn-over frequencies are approximately 500 Hz and 1600 Hz for bass and treble, respectively. The insertion loss of approximately 27 dB is made up by the gain of the transistor tone

control amplifier. Balance and Volume controls are included as shown. Loudness control may be included by using a tapped Volume pot and the associated bass boost RC network if desired. More elaborate tone controls such as Baxandall feedback are possible, but at a premium in cost.

POWER AMPLIFIER

The stereo power section, consisting of the LM378 dual audio amplifier, delivers 3W/channel with total harmonic distortion (THD) less than 1% and 4W/channel with THD less than 10%, operating from split supply voltages of $\pm 11\text{V}$. Split supplies were chosen to facilitate a minimum parts count design. This approach allows direct coupling of the amplifier to the speakers since the output DC level is zero volts (offset voltage will be less than 25 mV), thereby eliminating the need of large coupling capacitors and their associated degradation of power, distortion and cost. Since the input bias voltages are zero volts, the need for bias resistors and the bias-pin supply bypassing capacitor are also eliminated. Input capacitors are omitted and bias current for the positive input is obtained directly thru the Volume pots since the tone control circuitry has been designed such that there is no DC potential applied.

It is important to apply proper supply voltages and adequate heatsinking in using the LM2878. Note that while the standby and low output power operating points of the power supply are $\pm 15\text{V}$, the maximum power out point causes the supply to sag to $\pm 11\text{V}$ therefore reducing package dissipation to acceptable levels.

POWER SUPPLY

The worst case ripple rejection of 45 dB for the IC's used allows for a simple unregulated power supply, however the discrete front-end and tone control amplifiers require some regulation to preserve the IC performance. A single zener diode Z_1 was selected to create a +12V supply for this function. The split supplies required for the power amplifier are derived from a conventional full-wave bridge rectifier operating off of the center-tapped secondary of the line transformer.

REFERENCES

1. Isbell, T.D. and Mishler, D.S., "LM1800 Phase Locked Loop FM Stereo Demodulator". National Semiconductor Application Note AN-81, June 1973.
2. Papanicolaou, E.S. and Mortensen, H.H., "Low-Cost AM-Radio System Using LM1820 And LM386". National Semiconductor Linear Brief LB-29, May 1975.

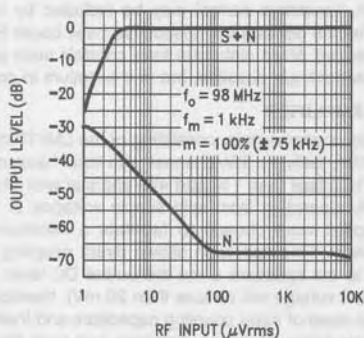


FIGURE 2. FM Sensitivity

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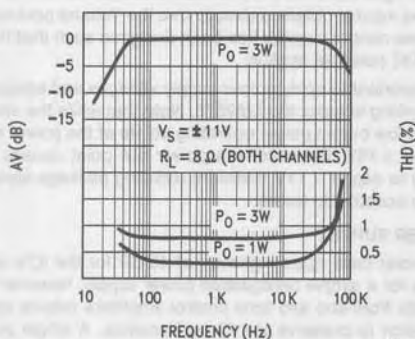


FIGURE 4. Power Amplifier Frequency Response and Total Harmonic Distortion

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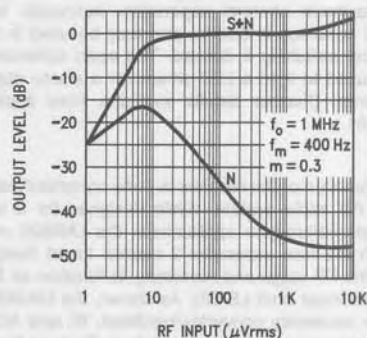
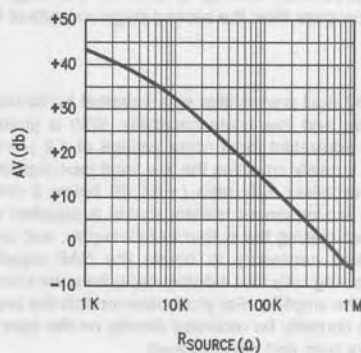


FIGURE 3. AM Sensitivity

TL/H/7250-3

FIGURE 5. A_v vs. R_{SOURCE} for Tone Control Preamp State

TL/H/7250-5

SPECIFICATIONS

FM-MONO

- Sensitivity: $2.5 \mu\text{V}$ for 30 dB quieting
- Harmonic Distortion: 0.3%
- Hum * Noise: -65 dB
- Frequency Response: 50-15 kHz ± 3 dB

FM-STEREO

- Channel Separation: 45 dB
- Harmonic Distortion: 0.4%

AM

- Sensitivity: $20 \mu\text{V}$ for 20 dB S+N/N
- Harmonic Distortion: 2%
- Hum & Noise: -45 dB

TAPE

- Frequency Response: NAB equalized ± 2 dB
- Harmonic Distortion: 0.3%
- Hum & Noise: -64 dB below 2 mV input level

AMPLIFIER

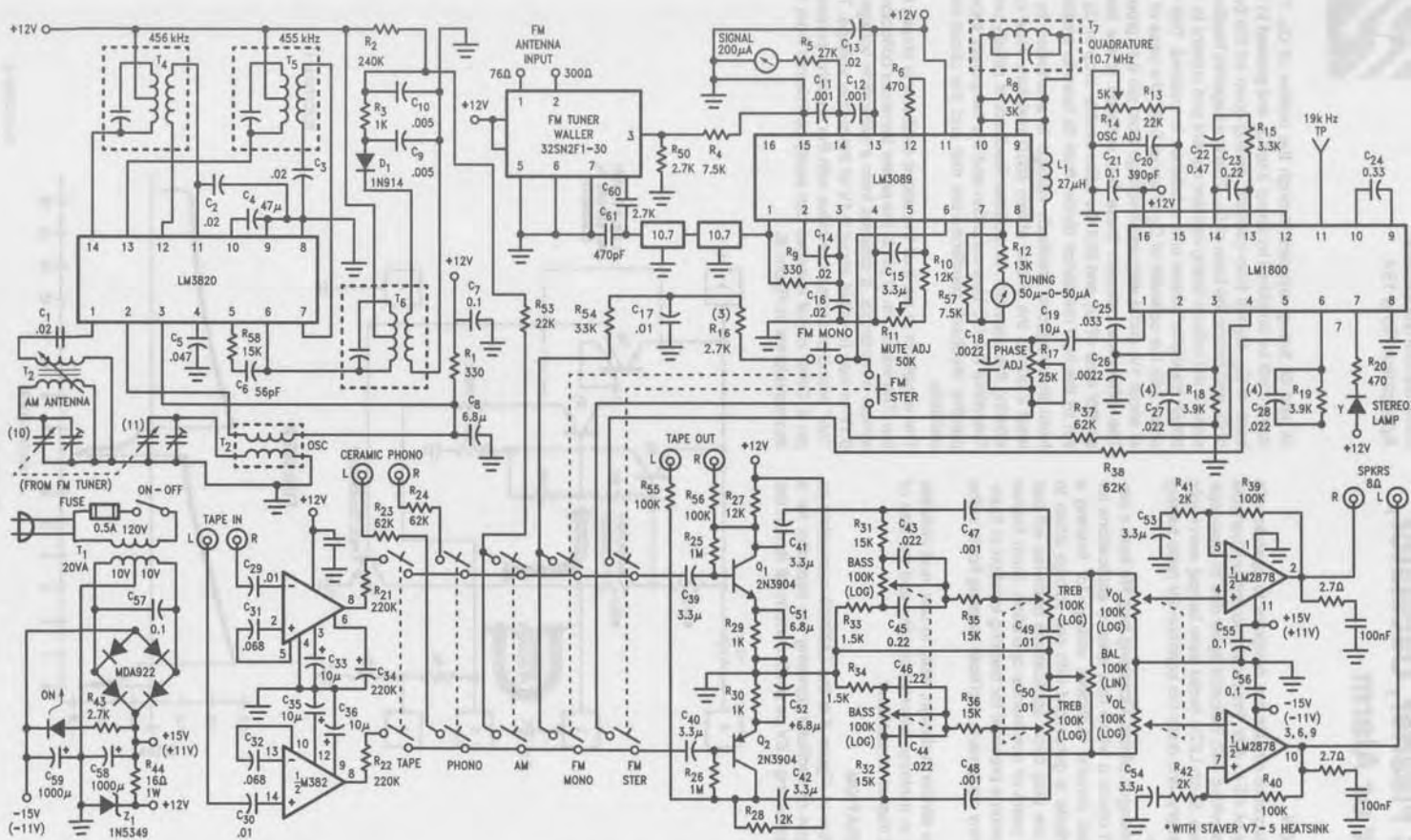
- Power Output: 3W RMS, per channel into 8Ω s at less than 1% THD from 40-30 kHz
- Frequency Response: 35-55 kHz ± 3 dbn

VENDOR DEVICES

- FM Tuner: Waller 32SN2F1-30
- Coils: T3: AM Osc. Toko RWO-6A6255
- T4: IF, 455 kHz Toko RRC-3A6426N
- T5: IF, 455 kHz Toko RRC-3A6427A
- T6: IF, 455 kHz Toko RZC-1A6425A
- T7: Quadrature, 10.7 MHz-Toko TKXC-33733BS
- Ceramic Filters: 10.7 MHz Toko CFS-30AE-10
- Selector Switch: IEE/Schadow Type F-4U with FA201 Mech. Reflecting Indicators
- Meters: TUNING: #11226, SIGNAL: #11222 Mercer Electronics

VENDOR LOCATIONS

- Waller Corp., Crystal Lake, ILL. (815) 459-6510
- Toko (America), Inc. Toko America, Inc. 1250 Feehanville Drive Mount Prospect, IL 60056 Tel: (312) 297-0070
- IEE/Schadow Corp., Eden Prairie Minn. (612) 944-1820
- Mercer Electronics (Simpson Electric Co.), Elgin, ILL. (312) 379-1130



Note 1: All unmarked resistors in Ω s, 1/4W.

Note 2: All unmarked capacitors in microfarads.

Note 3: Omit for 50 μ s de-emphasis.

Note 4: Change to 0.015 μ F for 50 μ s de-emphasis.

FIGURE 6. Complete Schematic

TL/H/7250-6