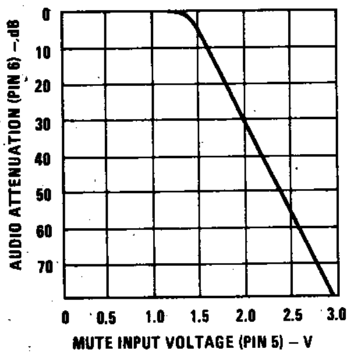

FIGURE 3.7.8 Typical Audio Attenuation (Pin 6) vs. Mute Input Voltage (Pin 5)

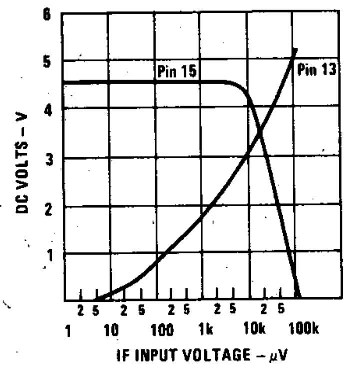

FIGURE 3.7.9 Typical AGC (Pin 15) and Meter Output (Pin 13) vs. IF Input Signal

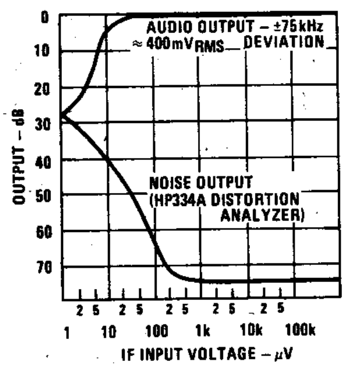

FIGURE 3.7.10 Typical (S + N)/N and IF Limiting Sensitivity vs. IF Input Signal

$$R_S = \frac{V_{MAX(13)}}{I_{FS}} = \frac{5V}{150\mu A} = 33k$$

The maximum current from pin 13 should be limited to approximately 2mA. Short circuit protection has been included on the chip.

The delayed AGC (pin 15) is also a voltage source (Figure 3.7.9). The maximum current should also be limited to approximately 2mA.

Figure 3.7.10 shows the typical limiting sensitivity (measured at pin 1) of the LM3089 when configured per Figure 3.7.3b and using PC layout of Figure 3.7.3a.

3.8 FM STEREO MULTIPLEX

3.8.1 Introduction

The LM1310/1800 is a phase locked loop FM stereo demodulator. In addition to separating left (L) and right (R) signal information from the detected IF output, this IC family features automatic stereo/monaural switching and a 100mA stereo indicator lamp driver. The LM1800 has the additional advantage of 45dB power supply rejection. Particularly attractive is the low external part count and total elimination of coils. A single inexpensive potentiometer performs all tuning. The resulting FM stereo system delivers high fidelity sound while still meeting the cost requirements of inexpensive stereo receivers.

Figures 3.8.1 and 3.8.2 outline the role played by the LM1310/1800 in the FM stereo receiver. The frequency domain plot shows that the composite input waveform contains L+R information in the audio band and L–R information suppressed carrier modulated on 38kHz. A 19kHz pilot tone, locked to the 38kHz subcarrier at the transmitter, is also included. SCA information occupies a higher band but is of no importance in the consumer FM receiver.

The block diagram (Figure 3.8.2) of the LM1800 shows the composite input signal applied to the audio frequency amplifier, which acts as a unity gain buffer to the decoder section. A second amplified signal is capacitively coupled to two phase detectors, one in the phase locked loop and the other in the stereo switching circuitry. In the phase locked loop, the output of the 76kHz voltage controlled oscillator (VCO) is frequency divided twice (to 38, then 19kHz), forming the other input to the loop phase detector. The output of the loop phase detector adjusts the VCO to precisely 76kHz. The 38kHz output of the first frequency divider becomes the regenerated subcarrier which demodulates L–R information in the decoder section. The amplified composite and an "in phase" 19kHz signal, generated in the phase locked loop, drive the "in phase" phase detector. When the loop is locked, the DC output voltage of this phase detector measures pilot amplitude. For pilot signals sufficiently strong to enable good stereo reception the trigger latches, applying regenerated subcarrier to the decoder and powering the stereo indicator lamp. Hysteresis, built into the trigger, protects against erratic stereo/monaural switching and the attendant lamp flicker.

In the monaural mode (electronic switch open) the decoder outputs duplicate the composite input signal except that the de-emphasis capacitors (from pins 3 and 6 to ground) roll off with the load resistors at 2kHz. In the stereo mode (electronic switch closed), the decoder demodulates the L–R information, matrixes it with the L+R information, then delivers buffered separated L and R signals to output pins 4 and 5 respectively.

Figure 3.8.3 is an equivalent schematic of an LM1800. The LM1310 is identical except the output turnaround circuitry (Q_{35}-Q_{38}) is eliminated and the output pins are connected to the collectors of Q_{39}-Q_{42}. Thus the LM1310 is essentially a 14 pin version of the LM1800, with load resistors returned to the power supply instead of ground. The National LM1800 is a pin-for-pin replacement for the UA758, while the LM1310 is a direct replacement for the MC1310.

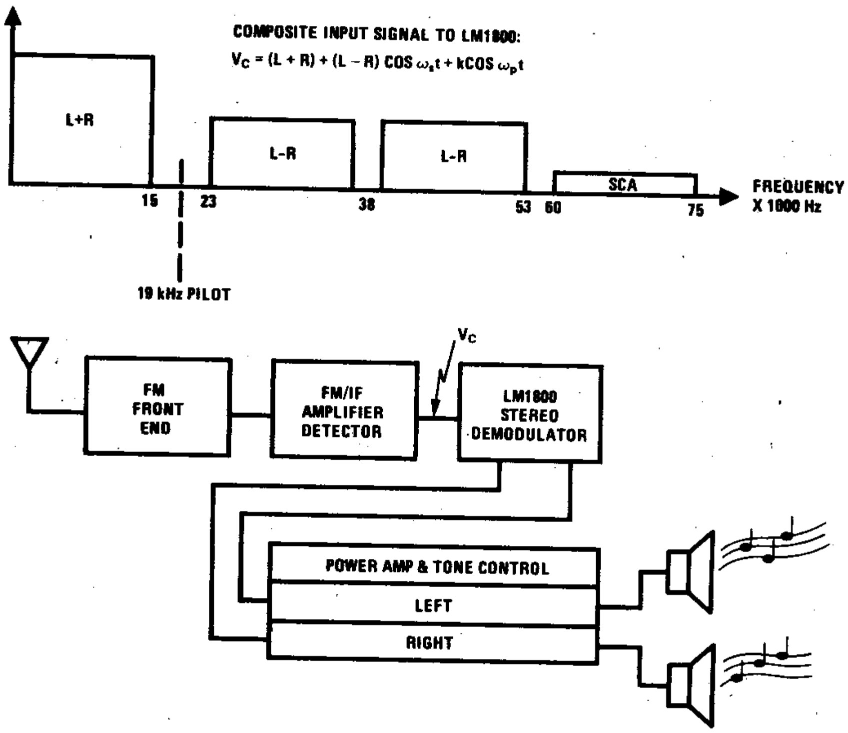

FIGURE 3.8.1 FM Receiver Block Diagram and Frequency Spectrum of LM1800 Input Signal

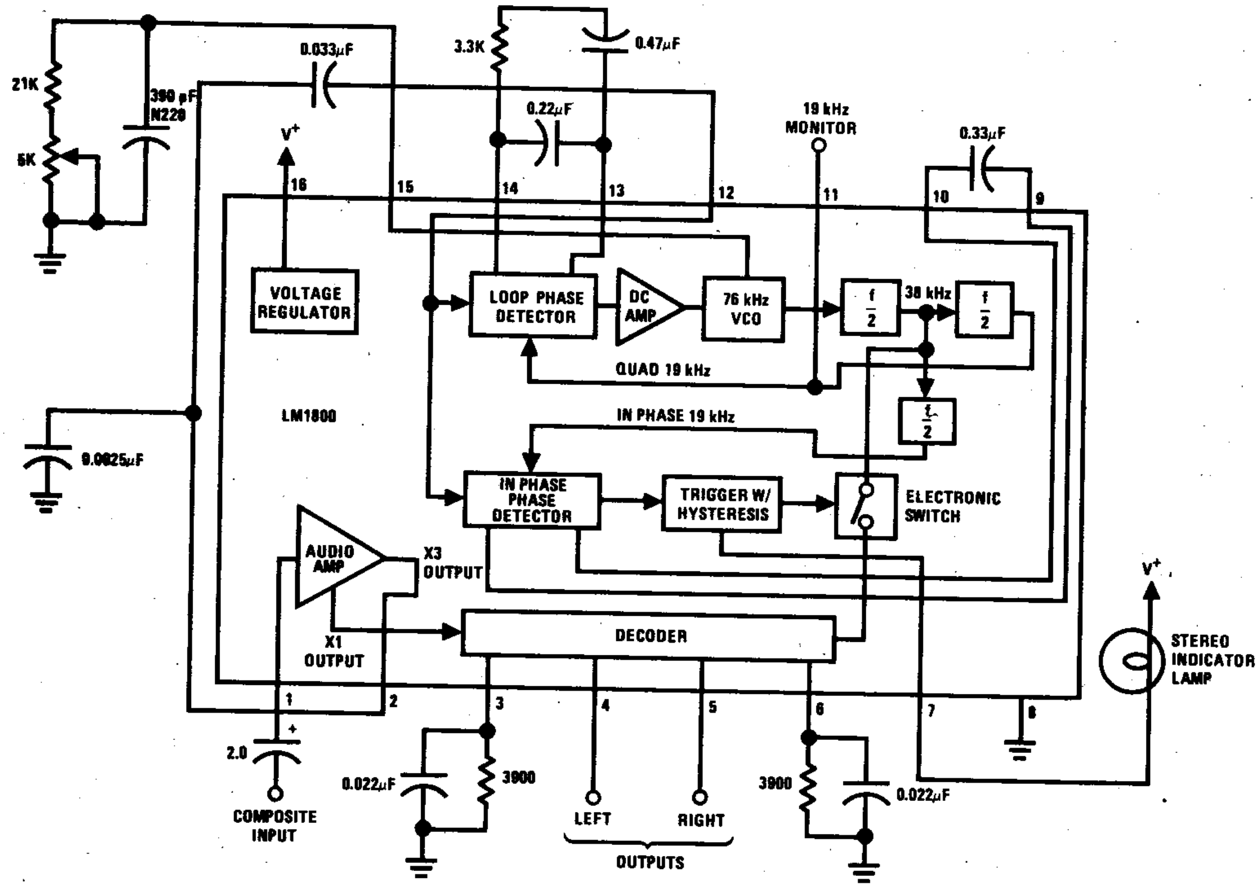

FIGURE 3.8.2 LM1800 Block Diagram

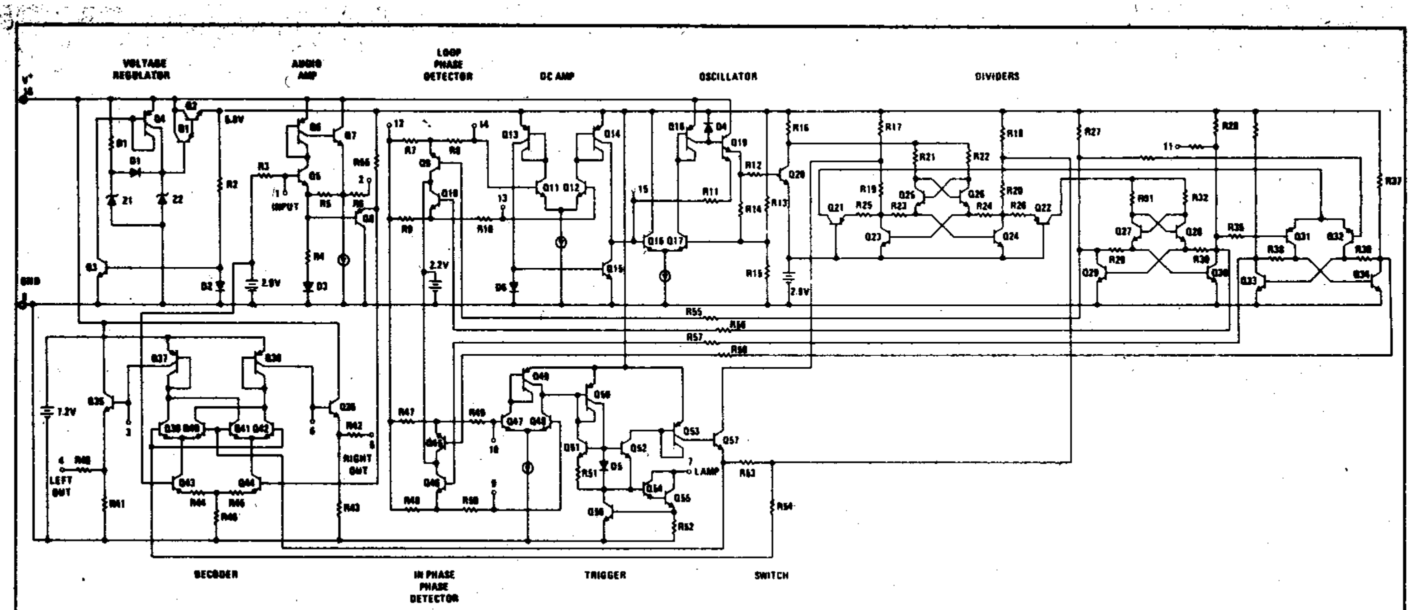

FIGURE 3.8.3 LM1800 Equivalent Schematic

3.8.2 LM1800 Typical Application

The circuit in Figure 3.8.4 illustrates the simplicity of designing an FM stereo demodulation system using the LM1800. R_3 and C_3 establish an adequate loop capture range and a low frequency well damped natural loop resonance. C_8 has the effect of shunting phase jitter, a dominant cause of high frequency channel separation problems. Recall that the 38 kHz subcarrier regenerates by phase locking the output of a 19 kHz divider to the pilot tone. Time delays through the divider result in the 38 kHz waveform leading the transmitted subcarrier. Addition of capacitor C_9 (0.0025μF) at pin 2 introduces a lag at the input to the phase lock loop, compensating for these frequency divider delays. The output resistance of the audio amplifier is designed at 500Ω to facilitate this connection.

The capture range of the LM1800 can be changed by altering the external RC product on the VCO pin. The loop gain can be shown to decrease for a decrease in VCO resistance (R_4 + R_5 in Figure 3.8.4). Maintaining a constant RC product, while increasing the capacity from 390 pF to 510 pF, narrows the capture range by about 25%. Although the resulting system has slightly improved channel separation, it is more sensitive to VCO tuning.

When the circuits so far described are connected in an actual FM receiver, channel separation often suffers due to imperfect frequency response of the IF stage. The input lead network of Figure 3.8.5 can be used to compensate for roll off in the IF and will restore high quality stereo sound. Should a receiver designer prefer a stereo/monaural switching point different from those programmed into the

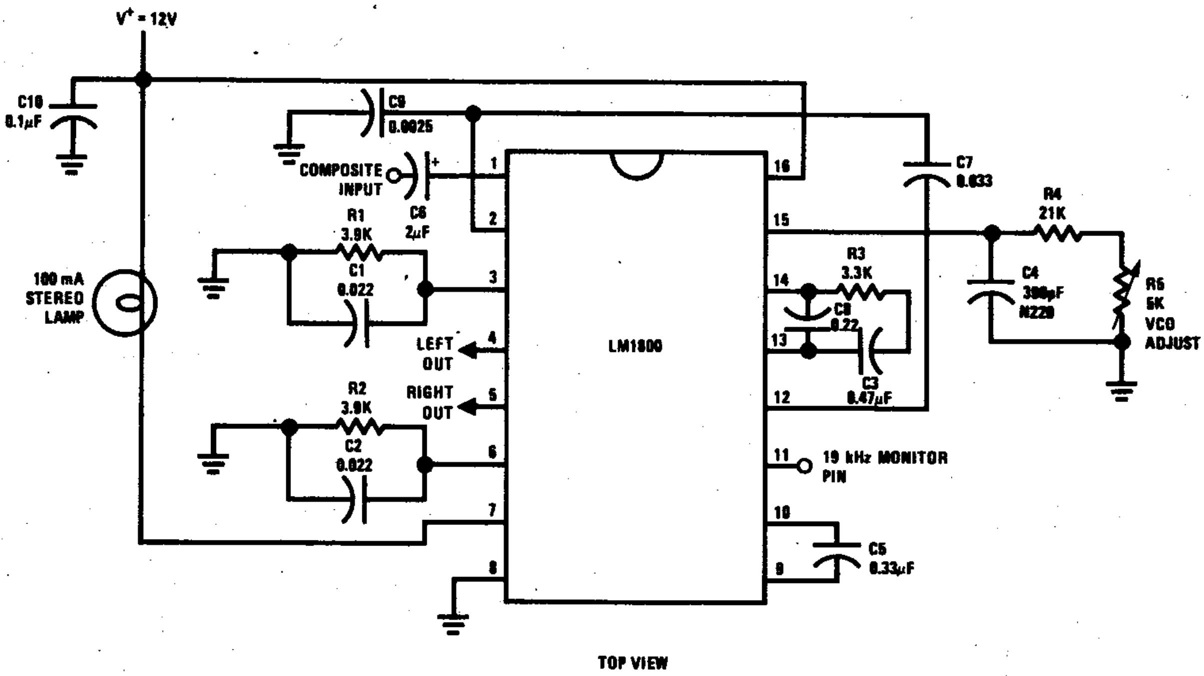

FIGURE 3.8.4 LM1800 Typical Application

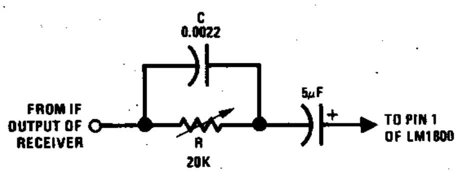

FIGURE 3.8.5 Compensation for Receiver IF Rolloff

LM1800 (pilot: 15mV$_{RMS}$ on, 6.0mV$_{RMS}$ off typical), the circuit of Figure 3.8.6 provides the desired flexibility.

The user who wants slightly increased voltage gain through the demodulator can increase the size of the load resistors (R_1 and R_2 of Figure 3.8.4), being sure to correspondingly change the de-emphasis capacitors (C_1 and C_2). Loads as high as 5600Ω may be used (gain of 1.4). Performance of the LM1800 is virtually independent of the supply voltage used (from 10 to 16V) due to the on-chip regulator.

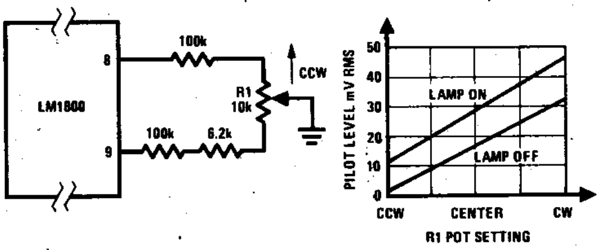

FIGURE 3.8.6 Stereo/Monaural Switch Point Adjustment

Although the circuit diagrams show a 100mA indicator lamp, the user may desire an LED. This presents no problem for the LM1800 so long as a resistor is connected in series to limit current to a safe value for the LED. The lamp or LED can be powered from any source (up to 18V), and need not necessarily be driven from the same supply as the LM1800.

3.8.3 LM1310 Typical Application

Figure 3.8.7 shows a typical stereo demodulator design using the LM1310. Capture range, lamp sensitivity adjustment and input lead compensation are all accomplished in the same manner as for the LM1800.

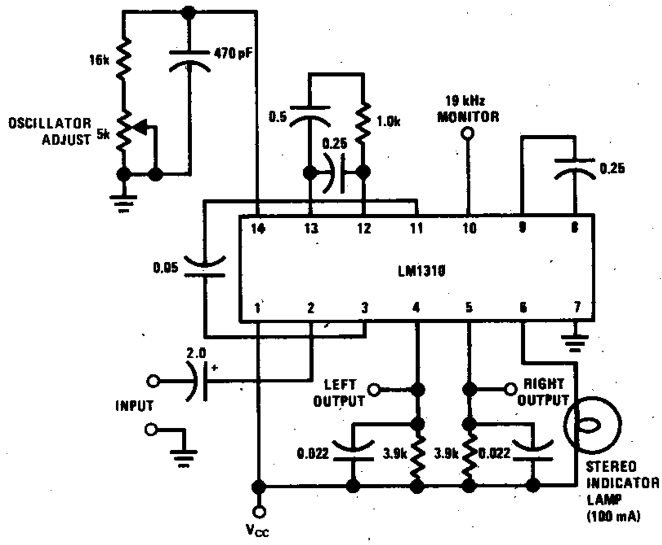

FIGURE 3.8.7 LM1310 Typical Application

3.8.4 Special Considerations of National's LM1310/1800

A growing number of FM stereo systems use the industry standard IF (LM3089) with an industry standard demodulator (LM1310/1800) as in Figure 3.8.8.

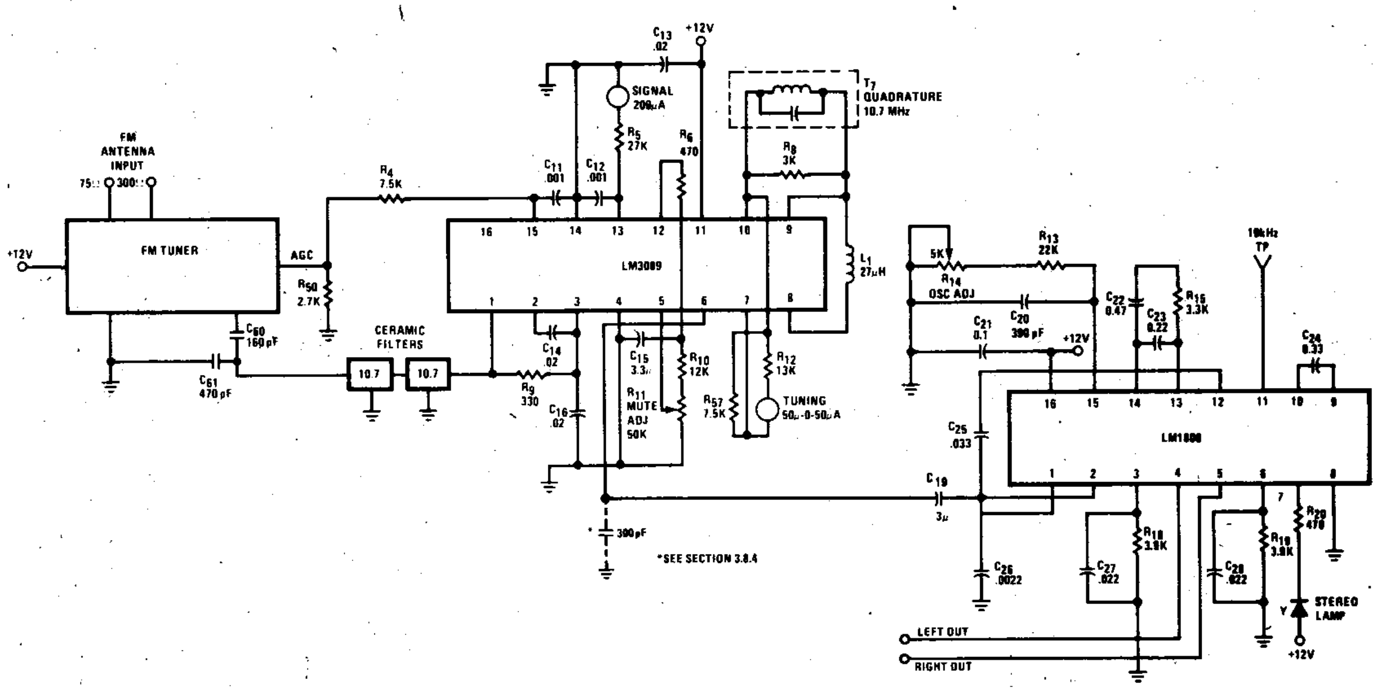

FIGURE 3.8.8 LM3089/LM1800 Application

The optional 300pF capacitor on pin 6 of the LM3089 is often used to limit the bandwidth presented to the demodulator's input terminals. As the IF input level decreases and the limiting stages begin to come out of limiting, the detector noise bandwidth increases. Most competitive versions of the LM1310 would inadvertently AM detect this noise in their input "audio amplifier," resulting in decreased system signal-to-noise. They therefore require the 300pF capacitor, which serves to eliminate this noise from the demodulator's input by decreasing bandwidth, and thus the system maintains adequate S/N.

The National LM1310 has been designed to eliminate the AM noise detection phenomenon, giving excellent S/N performance either with or without a bandlimited detected IF. Channel separation also is improved by elimination of the 300pF capacitor since it introduces undesirable phase shift. The National LM1800 has the same feature, as do competitive 16 pin versions.

For systems demanding superior THD performance, the LM1800A is offered with a guaranteed maximum of 0.3%. Representing the industry's lowest THD value available in stereo demodulators, the LM1800A meets the tough requirements of the top-of-the-line stereo receiver market.

Utilization of the phase locked loop principle enables the LM1310/1800 to demodulate FM stereo signals without the use of troublesome and expensive coils. The numerous features available on the demodulator make it extremely attractive in a variety of home and automotive receivers. Indeed the LM1310/1800 represents today's standard in integrated stereo FM demodulators.

3.9 DEFINITION OF TERMS

AGC DC Output Shift: The shift of the quiescent IC output voltage of the AGC section for a given change in AGC central voltage.

AGC Figure of Merit (AGC Range): The widest possible range of input signal level required to make the output drop by a specified amount from the specified maximum output level.

AGC Input Current: The current required to bias the central voltage input of the AGC section.

AM Rejection Ratio: The ratio of the recovered audio output produced by a desired FM signal of specified level and duration to the recovered audio output produced by an unwanted AM signal of specified amplitude and modulating index.

AM Suppression: See AM Rejection Ratio.

Capture Ratio: A measure of an FM tuner's ability to reject an interfering signal of the same frequency as the desired signal (i.e., operating on the same carrier frequency); it is the ratio of desired to undesired signal required for 30dB suppression of the undesired signal (IHF Std.).

Channel Separation: The level of output signal of an undriven amplifier with respect to the output level of an adjacent driven amplifier.

Harmonic Distortion: That percentage of harmonic distortion being defined as one hundred times the ratio of the root-mean-square (RMS) sum of the harmonics to the fundamental. Percent harmonic distortion equals:

$$\frac{(V_2^2 + V_3^2 + V_4^2 + \ldots)^{1/2}\ (100\%)}{V_1}$$

where V_1 is the RMS amplitude of the fundamental and V_2, V_3, V_4, ... are the RMS amplitudes of the individual harmonics.

IF Bandwidth: The range of frequencies centered about the IF frequency limited by the −3dB amplitude points.

IF Selectivity: The ability of the IF stages to accept the signal from one station while rejecting the signal of the adjacent stations; it is the ratio of desired to undesired signal required for 30dB suppression of the undesired signal (IHF Std.).

Input Bias Current: The average of the two input currents.

Input Resistance: The ratio of the change in input voltage to the change in input current on either input with the other grounded.

Input Sensitivity: The minimum level of input signal at a specified frequency required to produce a specified signal-to-noise ratio at the recovered audio output.

Input Voltage Range: The range of voltages on the input terminals for which the amplifier operates within specifications.

Large-Signal Voltage Gain: The ratio of the output voltage swing to the change in input voltage required to drive the output from zero to this voltage.

Limiting Sensitivity: In FM the input signal level which causes the recovered audio output level to drop 3dB from the output level with a specified large signal input.

Limiting Threshold: See Limiting Sensitivity.

Monaural Channel Unbalance: The ratio of the outputs from the right and left channels with a monaural signal applied to the input.

Noise Figure: The common logarithm of the ratio of the input signal-to-noise ratio to the output signal-to-noise ratio.

Output Resistance: The ratio of the change in output voltage to the change in output current with the output around zero.

Output Voltage Swing: The peak output voltage swing, referred to zero, that can be obtained without clipping.

Power Bandwidth: That frequency at which the voltage gain reduces to $1/\sqrt{2}$ with respect to the flat band voltage gain specified for a given load and output power.

Power Supply Rejection: The ratio of the change in input offset voltage to the change in power supply voltages producing it.

Recovered Audio: The value of the audio voltage measured at the output under the specified circuit conditions.

RF Noise Voltage: The equivalent input noise voltage of the RF stage.

RF Transconductance: The ratio of the RF output current to the RF input voltage.

SCA Rejection: The ratio of the 67kHz SCA signal at the output to the desired output with the standard FCC signal input.

Sensitivity: See Limiting Sensitivity.

Slew Rate: The internally limited rate of change in output voltage with a large amplitude step function applied to the input.

Supply Current: The current required from the power supply to operate the amplifier with no load and the output at zero.