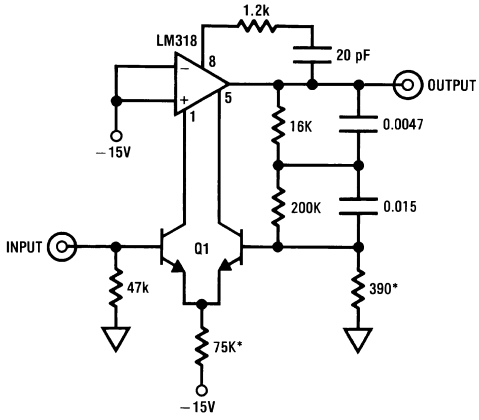

Q1 = LM394, SSM2210

Frequency	Total Harmonic Distortion				
20	<0.002	<0.002	<0.002	<0.002	<0.002
100	<0.002	<0.002	<0.002	<0.002	<0.002
1000	<0.002	<0.002	<0.002	<0.002	<0.002
10000	<0.002	<0.002	<0.002	<0.0025	<0.003
20000	<0.002	<0.002	<0.004	<0.004	<0.007
Output Amplitude (Vrms)	0.03	0.1	0.3	1.0	5.0

FIGURE 4.

ULTRA-LOW NOISE RIAA PREAMPLIFIER

In *Figure 4*, an LM394 is used to replace the input stage of an LM118 high speed operational amplifier to create an ultra-low distortion, low noise RIAA-equalized phono preamplifier. The internal input stage of the LM118 is shut off by tying the unused input to the negative supply. This allows the LM394 to be used in place of the internal input stage, avoiding the loop stability problems created when extra stages are added. The stability problem is especially critical in an RIAA circuit where 100% feedback is used at high frequencies. Performance of this circuit exceeds the ability of most test equipment to measure it. As shown in the accompanying chart, harmonic distortion is below the measurable 0.002% level over most of the operating frequency and amplitude range. Noise referred to a 10 mV input signal is −90 dB down, measuring 0.55 µVrms and 70 pArms in a 20 kHz bandwidth. More importantly, the noise figure is less than 2 dB when the amplifier is used with standard phono cartridges, which have an equivalent wideband (20 kHz) noise of 0.7 µV. Further improvements in amplifier noise characteristics would be of little use because of the noise generated by the cartridge itself. A special test was performed to check for transient intermodulation distortion. 10 kHz and 11 kHz were mixed 1:1 at the input to give an rms output voltage of 2V (input = 200 mV). The resulting 1 kHz intermodulation product measured at the output was 80 µV. This calculates to 0.0004% distortion, quite a low level, considering that the 1 kHz has 14 dB (5:1) gain with respect to the 10 kHz signal in an RIAA circuit. Of special interest also is the use of all DC coupling. This eliminates the overload recovery problems associated with coupling and bypass capacitors. Worst-case DC output offset voltage is about 1V with a cartridge having 1 kΩ DC resistance.

MICROPHONE PREAMPLIFIER

Figure 5 shows a microphone preamplifier which runs from a single 1.5V cell and can be located right at the microphone. Although the LM10 amplifier-reference combination has relatively slow frequency response, performance can be considerably improved by cascading the amplifier and reference amplifier together to form a single overall audio amplifier. The reference, with a 500 kHz unity-gain bandwidth, is used as a preamplifier with a gain of 100. Its output is fed through a gain control potentiometer to the op amp, which is connected for a gain of 10. The combination gives a 60 dB gain with a 10 kHz bandwidth, unloaded, and 5 kHz, loaded with 500Ω. Input impedance is 10 kΩ.