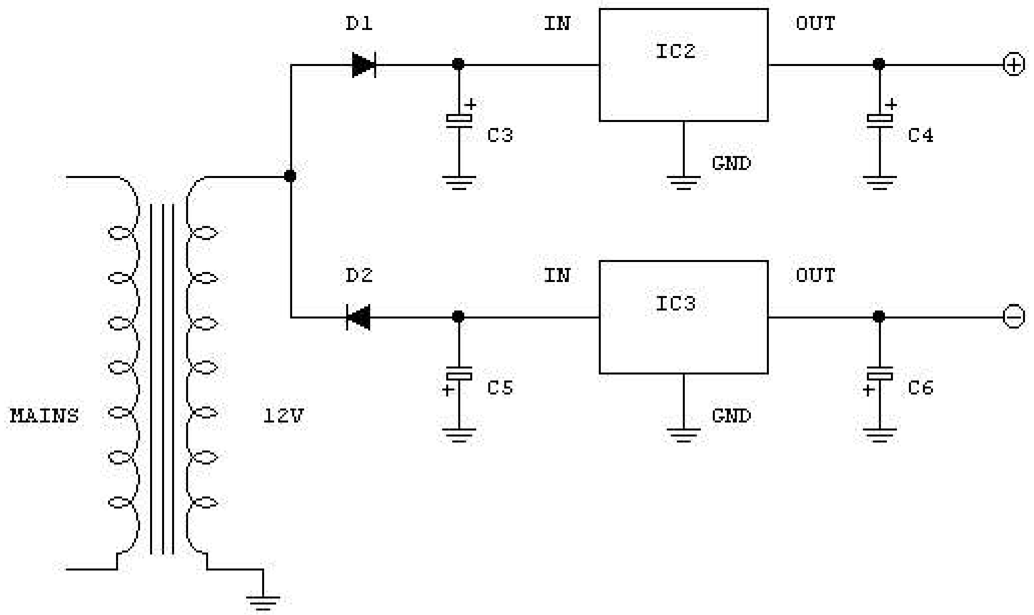
R2 and C2 set the HF corner of the amplifier; I use 100 kohm and 500pF for a 3 kHz cut. If you need 30kHz band use 33kohm and 150pF.
Q1 and Q2 work as low-leakage clipping diodes. Usual diodes in glass envelope, like the common 1N4148, may have quite high leakage currents; the B-C junction of a signal transistor is superior in this aspect. In case the input voltage increases over +/- 15V the diodes conduct, avoiding destruction of the op-amp.
The operational amplifier is an OP07, manufactured by Analog Devices, Burr Brown, and probably others. It has very good noise and dynamic characteristics, and a very low leakage current. It costs about $3 in small quantities. Mount it on a socket ... and buy more than one, it may decide to break down in extreme conditions (thunderstorms).
The voltage gain of the op-amp is set by R3 and R4. In my case it is 100 (100ohm and 10kohm). You may wish to replace R3 with a 10kohm potentiometer with a 10ohm resistor in series, and have a variable gain to adapt to the input sensitivity of the following circuits (SoundBlaster, DAT, etc.).



The power supply is very simple. I use mains power, but for portable/remote operations some batteries in series are OK – the OP07 only drains a few mA. In this case omit the regulators; C4 and C6 should be at least 100 µF, and mounted close to the op-amp.

COMPONENT LIST - VALUES ARE INDICATIVE (SEE TEXT)

R1:	10 Mohm	**L1:**	10 µH moulded inductor
R2:	100 kohm	**NE1:**	Neon bulb, without series resistor
R3:	100 ohm	**D1-D2:**	1N4002 or similar
R4:	10 kohm	**Q1-Q2:**	BC237B, BC108B, BC107, 2N3904 (NPN)
C1:	see text (cable capacitance)	**IC1:**	OP07
C2:	470 pF	**IC2:**	78L15
C3:	100 µF 25V electrolytic	**IC3:**	79L15
C4:	10 µF 25V electrolytic	**Transf. Primary:**	mains voltage (230V or 115V, dep. on your country)

C5:	**100 µF 25V electrolytic**	**Transf. Secundary:**	**12V, 100 mA min.**
C6:	**10 µF 25V electrolytic**		

TESTING, USING, TUNING, MODIFYING.

By first, you need an antenna. Try to keep the wire vertical and away from obstacles, trees, buildings. Bring the signal to your station by a coaxial cable. Connect the braid of the cable to a good earth (water pipe, ground stack), possibly separated from your mains earth. The system is VERY small respect to the wavelengths in use (100 km at 3 kHz, 30000 km at 10 Hz!), so it is not important what side of the braid is actually connected to the earth.
Leave the antenna disconnected, connect an oscilloscope or at least a voltmeter to the op-amp output and monitor the voltage. It should be 0V +/- 500mV. Now connect the antenna – the voltage should start to fluctuate, and probably a 50Hz (well, 60Hz outside Europe) component will show up. It should be three volt peak-to-peak maximum (1Veff if you use the volmeter). If the 50 Hz component exceedes this value you will need to decrease the gain (increase R3).
If the AC component is low but the DC drives the op-amp in saturation you may lower R1, down to 1Mohm or so. If the DC component is still a problem you have to add a capacitor in series with R2 (10nF or so) and a resistor in parallel to C2 (1Mohm); in this case also the lower part of the spectrum will be very attenuated. You may also consider using a smaller antenna.
The mains signal and relative harmonics are usually the limiting factor for ELF weak signal listening. There are two ways to suppress it: notch filters and low pass filters. A notch is a filter that suppresses a single frequency. It has to be tuned to the mains frequency. Many designs are available; I will publish some experiments with notch filters later. Currently I use a professional variable filter (KEMO VBF/8 at 48 dB/octave), cutting from 45Hz up. This setup is excellent to monitor Schumann resonances. Renato IK1QFK instead added a capacitor in parallel with R4, building an integrator. He has a roll-off starting at 10 Hz, and the 50 Hz is suppressed by about 15 dB. You must experiment with Spectrogram and look for the best S/N ratio of the Schumann resonances; or leave the civilization and listen at some km from the mains grid.

CONCLUSIONS

A preamplifier has been descripted for ELF/ULF monitoring. The preamplifier has protection for atmospheric discharges, and low noise properties. It may be used as-is or adapted to different listening situations.

Marco Bruno – IK1ODO – Dec., 1999

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