SONICS ACTIVE DI BOX

This inexpensive, easy to build DI box was designed in conjunction with *Sonics* magazine and is fine for both live PA and home recording work. It takes an unbalanced input and produces an output suitable for driving a balanced audio line.

A VERY USEFUL bit of equipment to have lying around if you're doing a bit of home recording or setting up any sort of PA system is a so-called 'DI' box. DI stands for 'direct injection' or 'direct insertion' and involves taking a signal source from one piece of equipment and conditioning it such that it will be suitable for connection to another piece of equipment.

In audio applications, a DI box is used to take an unbalanced output from an instrument (and sometimes an amp) and convert it to a signal that looks like it has come from a balanced microphone output. This, then, allows it to be plugged directly into a balanced-input mixer. In live situations, particularly where long cable runs are encouraged, a DI box can be used as a balanced line driver for any unbalanced mics or other single-ended outputs which may need to be sent down the multicore and thus minimize any hum pickup down the line.

The usual method of obtaining a balanced signal from an unbalanced one is to use a 'balanced output' line transformer, but the disadvantage of this is that good audio-quality transformers of this type cost quite a bit. One of the original criteria for the design of this DI was that it should be cheap enough for even the most limited of home studio budgets to accommodate, so it was decided to go for an inexpensive 'electronically' balanced system that would be easy to build and useful for a variety of live and studio applications.

SPECIFICATIONS

Signal-to-noise ratio	> 100 dB rel to 0 dBm
Distortion	< 0.03% @ + 4 dBm
Input impedance	> 500 kohm nominal
Output impedance	600 ohm nominal

Robert Irwin

Design details

TL072 dual op-amp forms the heart of the circuit. These op-amps are very low noise, FET input devices and are ideally suited to this application, one being used as a unity-gain buffer and the other as a unity-gain inverter. This provides two anti-phase signals for the balanced output. To cater for large input voltages such as those from a keyboard or the output of a power amp, two pads (attenuators) are provided to give 20 dB or 40 dB of attenuation.

Power is provided by two 9 V batteries which are connected to give split ± 9 V rails. It was decided to use two batteries rather than one to give a bit of extra headroom, and they can also be run down further before the DI will begin to cut out. Some of the more expensive commercial units incorporate back-up battery systems and the like, but for the sake of keeping the cost down, we decided against such circuitry in this case. For anyone wishing to add some form of low battery indication, the ETI-280 (March 1985 ETI) could be built into the unit. (See Figure 3.)

All the switches are push-on/push-off types and mount directly on the pc board. They sit in a row down one side of the unit and should be out of the way. The prototype was housed in a small diecast aluminium box sturdy enough to be kicked about and trodden on. (I think they call it 'roadworthy'!)

The output socket is the standard male, 3-pin XLR socket which looks like the back of a standard microphone so a normal balanced mic lead can be used to connect the box into the system.

The input impedance is kept as high as is practical (around 500k or so), so that minimal loading will be put on the instrument connected to it, and there are two paralleled input sockets so that the instrument can be hooked up to an amplifier as well as going through the DI.

WHY A BALANCED LINE?

One question that may be asked is why go to all this trouble to generate a signal which is 180 degrees out of phase with the signal with which you started. A lot of professional audio gear (mainly mixers and amplifiers) is designed with differential input stages. Now, the main properties of a differential amplifier are that it has two inputs and that it will only amplify those signals which create a difference between the two inputs. In other words, if you apply the same signal to both inputs you will ideally get no output. If you apply differing signals to each input, the differential amp will amplify the difference between each input. This property is exploited in balanced audio systems to minimize hum due to induction in the leads connecting the system together.

To see how this is done examine the single ended system in Figure 1. We see that any induced hum in the cable will be amplified by the same amount as the incoming signal. If A_V is high then even a small amount of radiated hum from, say lighting circuits, could get into the system through the cable and create a problem.

If we now examine the balanced system in Figure 2 we see that any hum picked up in the cable will be the same in both in phase and out of phase. Because the differential input amp will only amplify difference signals, the hum is eliminated.

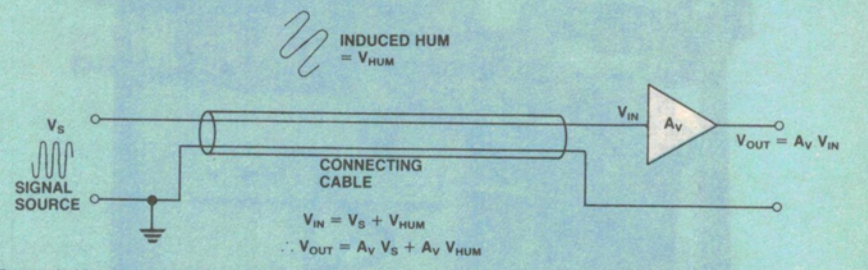


Figure 1. Unbalanced system. Hum can be picked up in the connecting cable.

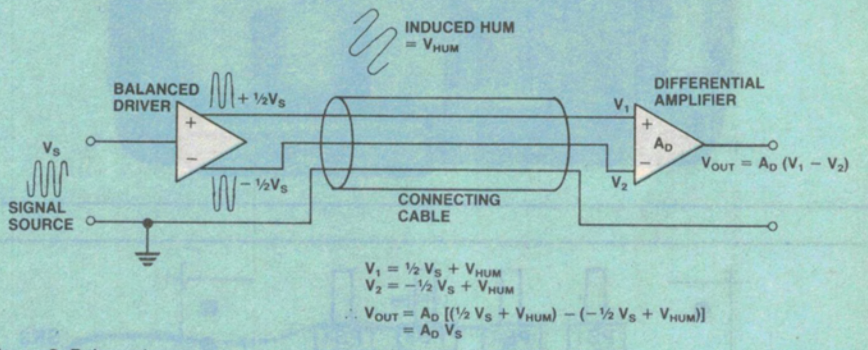


Figure 2. Balanced system rejects hum pickup in the connecting cable.

Such a set-up, however, means that there's a chance of creating an earth loop between the mixer (or whatever is attached to the output of the DI) and the amplifier, since the earths of both will be connected through the DI as well as through the mains. To save you the trouble (and potential danger) of ripping the earth pin out of one of the pieces of equipment, we included an 'earth lift' switch which disconnects the signal earth from pin 1 of the output socket.

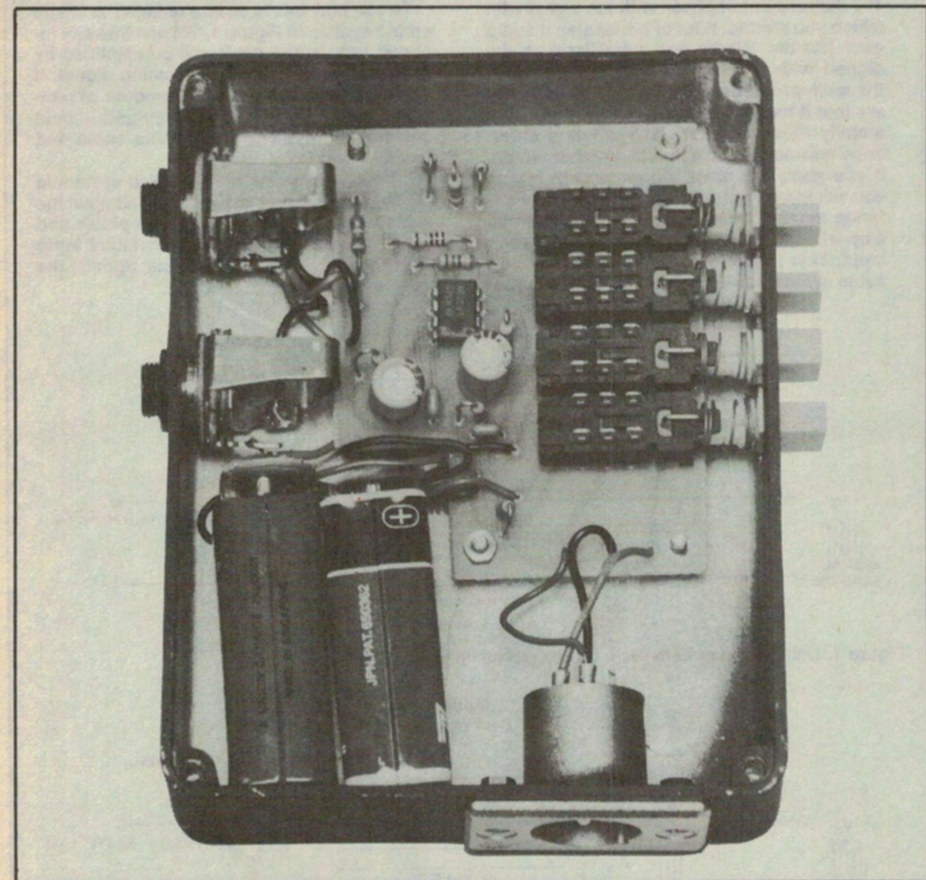
Because of the limited supply voltage, it is sometimes necessary to attenuate the input to avoid clipping the signal, so there is a resistive attenuator network ('pad') which enables the input voltage to be cut by a factor of 10 or 100.

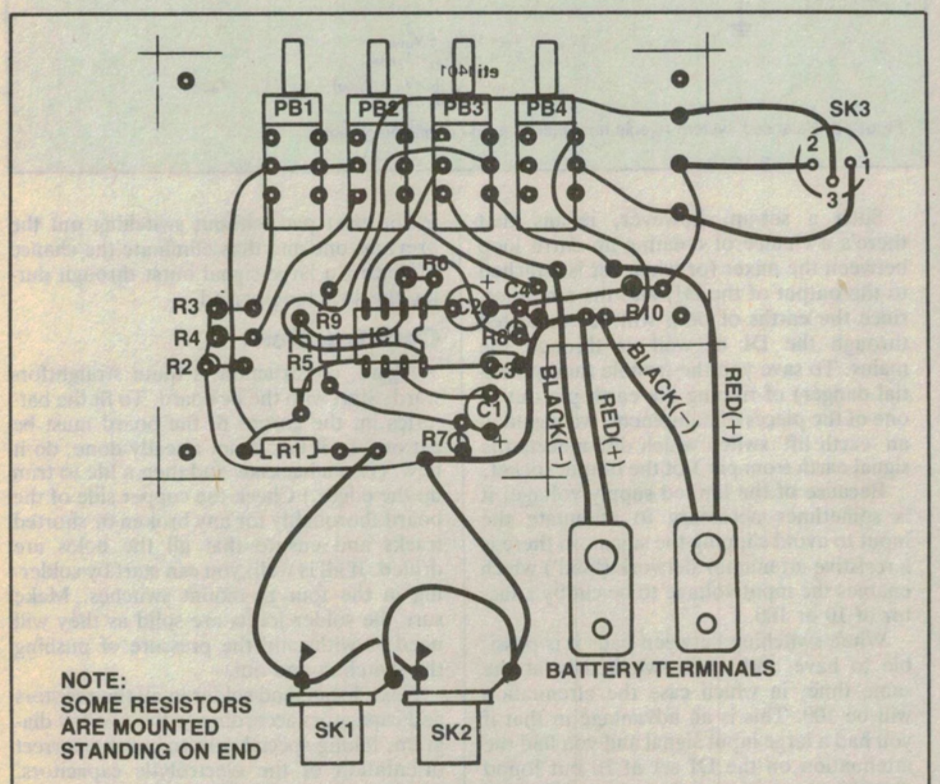
When switching between pads it is possible to have both pads switched in at the same time, in which case the attenuation will be 100. This is an advantage in that if you had a large input signal and you had the attenuation on the DI set at 10 but found that this was not enough, you could switch in the next pad without switching out the previous one and thus eliminate the chance of getting a large signal burst through during the switching period.

Construction

Again, construction is quite straightforward. Start with the pc board. To fit the batteries in, the corner of the board must be cut out, so if this is not already done, do it now. (Use a hacksaw and then a file to trim up the edges.) Check the copper side of the board thoroughly for any broken or shorted tracks and ensure that all the holes are drilled. If all is well, you can start by soldering in the four pc-mount switches. Make sure the solder joints are solid as they will need to withstand the pressure of pushing the switch in and out.

Next, locate and solder in all the resistors and capacitors according to the overlay diagram, taking special care to get the correct orientation of the electrolytic capacitors. You can then solder in the IC. Once again ▶





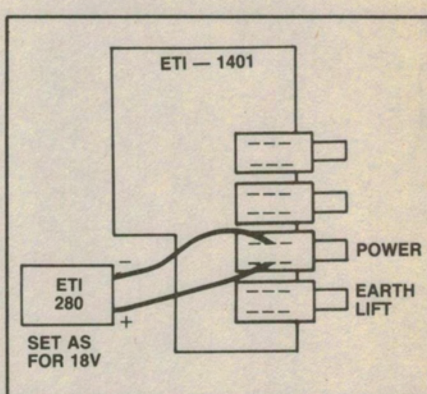


Figure 3. The ETI-280 Low Battery Indicator can be hooked into the circuit by soldering its inputs to the power supply switching as shown. The ETI-280 should be set for an 18 V supply as detailed in the relevant article. Mounting the board is up to you but the lid of the box might be easiest.

PARTS LIST — ETI 1401

Resistors	all ¼ watt, 5% unless noted
R1	470k
R2	1M
R3	47k
R4	4k7
5, 6	1M 1%
R7, 8	100k
R9, 10	680R
Capacitors	
C1, 2	47µ 35 V electro
C3, 4	100n ceramic bypass
Semiconductors	
IC1	TL072
Miscellaneous	
PB1, 2, 3, 4	DPDT pc mount pushbutton (Isostat range or similar)
SK1, 2	6.5 mm insulated mono jack
SK3	male 3-pin XLR panel mount socket

ETI-1401 pc board; 30 x 94 x 120 diecast aluminium box; 2 x 9 V battery terminals; 4 x 6 mm standoff spacers; 4 x 6BA nuts and bolts; 4 small rubber feet; hookup wire.

Price estimate: $30

take care to get it the right way round.

You should now solder short lengths of hookup wire to all the input and output points on the pc board, which will later be wired up to the sockets. Also, solder the 9 V battery terminals to the board making sure you get the polarities correct. Finally, check the underside of the board and ascertain you have created no solder bridges between tracks.

The next thing to do is to prepare the case. Remove the lid and don't lose the screws! By examining the pictures you should be able to get a rough idea of the lay-