PROJECT

Active TRANSFORMER DI BOX

Design by Alan Williamson
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A DI (Direct Injection) Box is a unit used to match the impedances of two items of electronic audio/music equipment, being particularly useful for matching unbalanced line level signals into low (microphone) level balanced inputs on mixing desks or amplifiers. The DI Box can also be used to eradicate annoying earth loop hum from appearing within an audio system.

PROJECT RATING 1

Kit Available
Order as 95139
Price £32.99

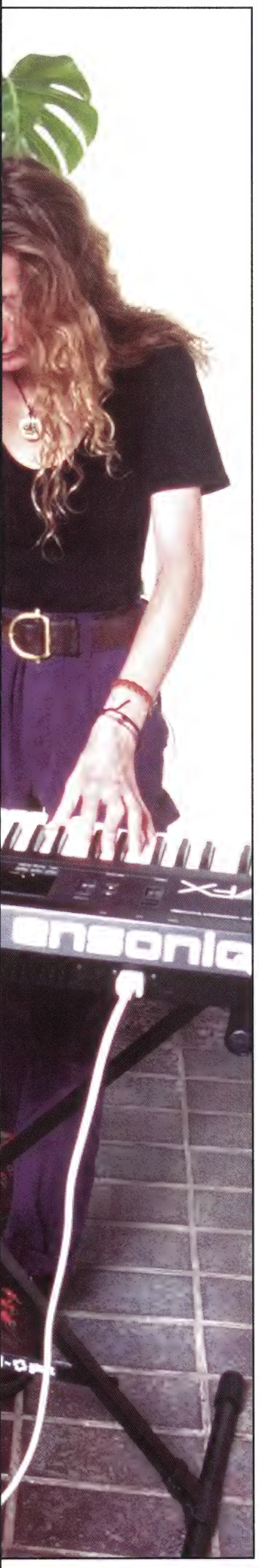
FEATURES

- Battery or PSU operation
- Low power consumption
- Low battery and power on indicators
- ¼in. jack input and XLR output
- Pre-punched, silk-screen printed panels
- Compact and rugged

APPLICATIONS

- Stage PA and recording
- Gigging bands
- Eliminating earth loop hum

The completed prototype unit.



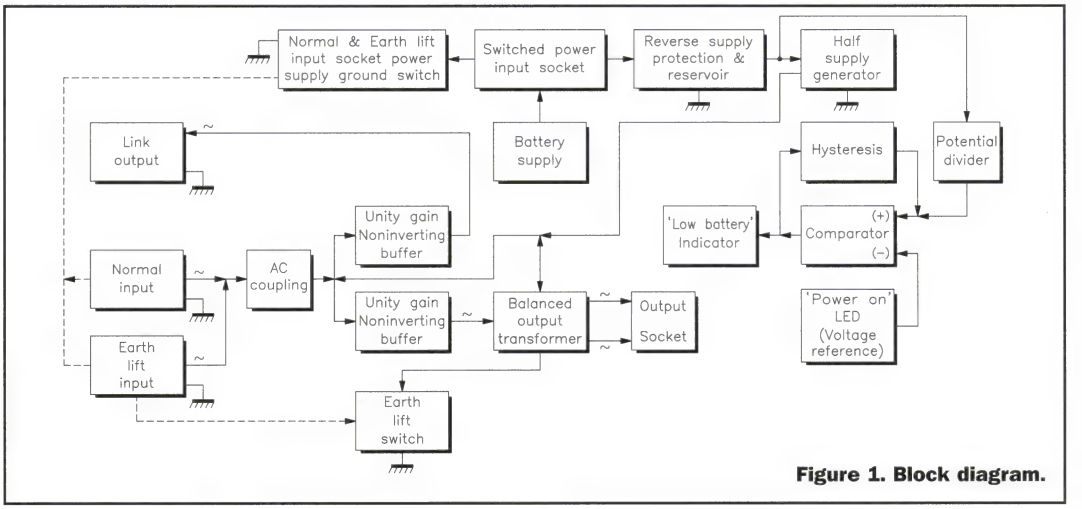


Figure 1. Block diagram.

In most cases, a Passive DI Box (such as the unit featured in Issue 102 of *Electronics*, Order Code 95099/LU23A) can be used effectively, but some items of equipment, for example, Rhodes electric pianos, require an Active version, such as the unit described in this article.

The Active Transformer DI Box is used with items of electronic musical equipment that, due to their high output impedance, are incapable of driving a transformer directly, as would be required when using a Passive DI Box. The circuit design ensures that the transformer is driven properly, while retaining unity overall gain (i.e. no amplification).

Circuit Description

Refer to the block and circuit diagrams, shown in Figures 1 & 2, respectively.

SK1 is the 'Normal' input; SK2 is the 'Earth Lift' input, which is wired in parallel with SK1. Inserting a jack plug into the 'Earth Lift' input socket will break the connection between the transformer secondary centre tap and the circuit ground.

Capacitor C1 AC-couples the signal to the inputs of the non-inverting amplifiers IC1a&b; IC1a is used to drive the transformer and IC1b is used as a 'loop through' buffer, preventing loading of the input signal. The 1MΩ input impedance of the amplifiers is set by R1.

Power for the circuit can be derived from either an external DC supply via SK4 (preferably regulated) or an internal PP3 battery. Inserting a ¼" jack plug into either the 'Normal' or 'Earth Lift' sockets SK1 & SK2 will close the switch contacts (SK1b & SK2b), completing the ground circuit.

Diode D1 is normally reverse-biased across the supply rails, which prevents accidental reverse polarity connections from the external PSU or battery, by clamping the reverse potential to –1V. This is preferable to a series connected diode, where battery voltage is at a premium; maximum use of the battery must be made because they are not cheap, and the circuit cannot afford the 1V loss (with the battery potential of +7V) and maintain maximum input signal headroom at 4V Pk-to-Pk.

Capacitor C4 provides the main supply decoupling and C5 the high-frequency decoupling.

The potential divider resistors R3 & R4 form a half supply reference, symmetrically decoupled by the capacitors C6 & C7. The noise-free reference is then buffered by IC2b, used to generate the low impedance half supply reference, VREF; the output of the op-amp is also symmetrically decoupled by C8 & C9 to improve (current) transient behaviour.

The second half of IC2 (IC2a) is a comparator, used as a low supply voltage detector; the Green LED, LD1, not only serves as a power ON indicator, but also as a voltage reference for the (–) inverting input of the comparator. The (+) non-inverting input of the comparator is connected to the potential divider, formed by R5 & R6; when the supply voltage drops to approximately +7V, the (+) non-inverting input potential will be below the potential at the (–) inverting input. This will switch ON the comparator output, illuminating the Red LED, LD2; this is where R8 & D2 come in to play, which are now effectively in parallel with R6, reducing the potential even further at the (+) non-inverting input of the comparator. The Red LED, LD1, will only extinguish when the supply voltage is raised above (approximately) +7·5V.

PCB Construction

Refer to the PCB legend and track drawing, shown in Figure 3. Construction is fairly straightforward; fit all components to the PCB except the XLR plug, which MUST be fitted to the front panel before being fitting to the PCB.

Begin with the smallest components first, working up in size to the largest; be careful to correctly orientate

SPECIFICATION

Operating voltage:	7-15V DC (9V nominal)
Current consumption:	7·5mA @ 7V 8·5mA @ 9V 12mA @ 15V <25mA maximum (under short circuit/fault conditions)
Input impedance:	500kΩ
Output impedance:	200Ω (Link output) 150Ω (Differential Mic XLR output) 75-0-75Ω (Balanced Mic XLR output)
Gain:	7:1 reduction (–16·9dB) on Balanced Mix XLR output, Unity gain (0dB) Link output
Bandwidth:	Unlimited audio spectrum
PCB dimensions:	80 × 100mm
Boxed unit dimensions (WHD):	109 × 52 × 93mm

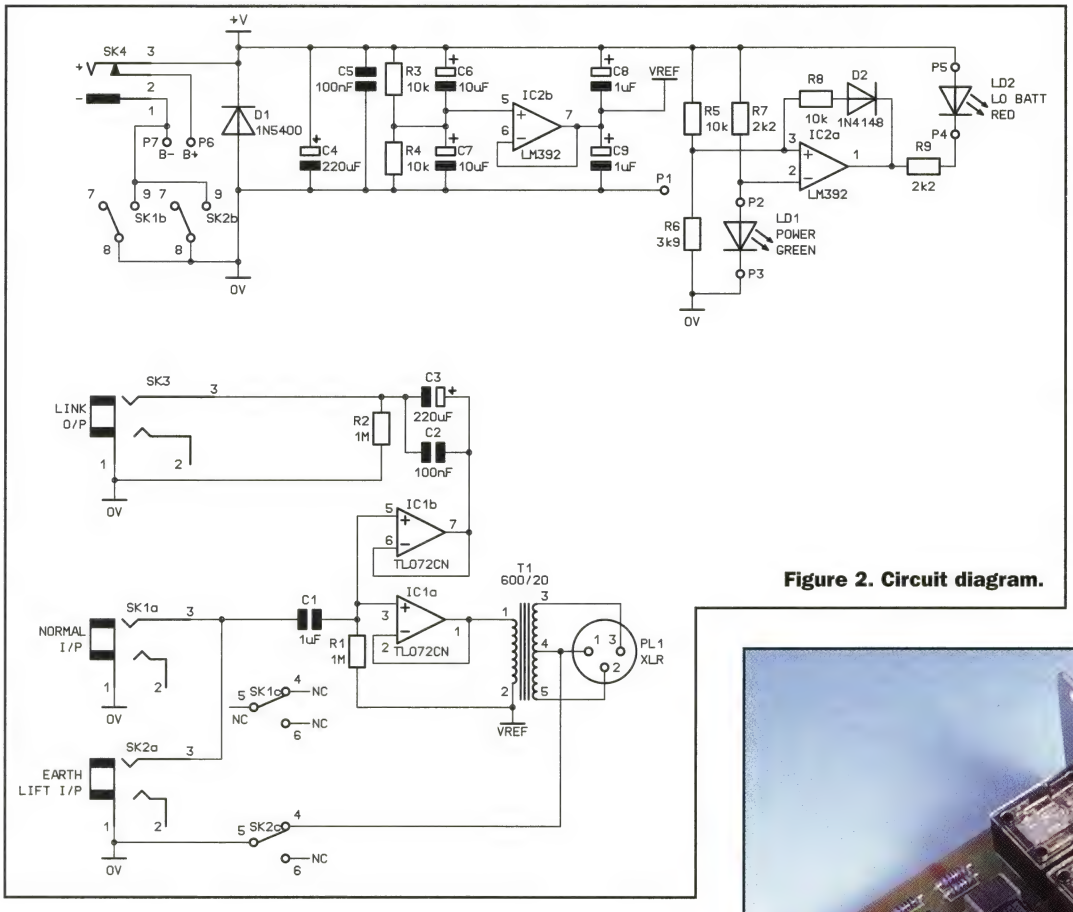


Figure 2. Circuit diagram.

the polarised devices, i.e. electrolytic capacitors, diodes and ICs; the ICs should be inserted into their sockets last of all, ensuring the identification notch/dimple/spot aligns with the holder/PCB legend.

Preform and fit the two LEDs (Green on the innermost and Red on the outermost part of the board) fully into the PCB (note orientation, short lead is cathode/K). The LED lenses should protrude over the edge of the PCB.

Thoroughly check your work for misplaced components, solder whiskers, bridges and dry joints. Finally, clean all the flux off the PCB using a suitable solvent.

Box Construction

Refer to Figure 4, showing the exploded assembly diagram.

Note that the specified casing has pre-punched front and rear panels, requiring no further drilling. Care should be taken during assembly, however, to avoid damaging the silk-screen printed legends on the panels.

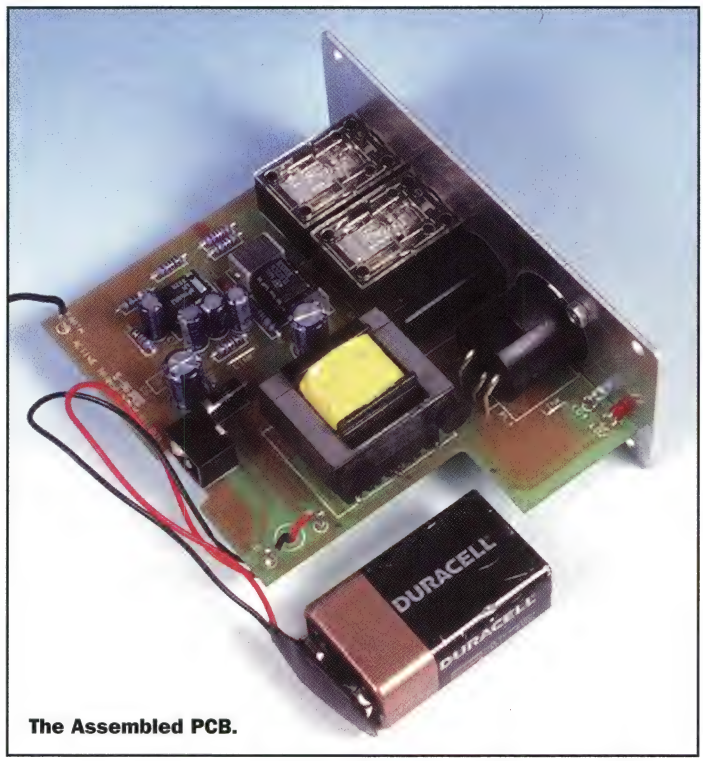
The XLR socket must be fitted to the front panel using the two screws, shakeproof washers and nuts, before soldering the socket to the PCB. Use the nuts supplied with the jack sockets to secure the PCB to the front panel; do not overtighten.

The four small rubber feet supplied should be fitted to each side of the transformer, stuck together in pairs (one above the other), to hold the battery firmly in place, and to prevent the metal case of the battery from coming into contact with the transformer pins.

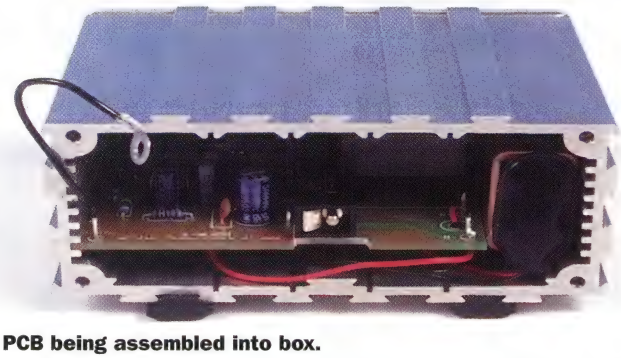
Ensure that the rubber grommet is fitted in the central hole of the rear panel, preventing the power supply plug outer (+V) connection from being shorted out against the casing (0V). Fit two lengths of rubber strip into the outermost grooves in the box base; use a little contact adhesive for permanent fixing. Test the module BEFORE fitting it into the enclosure.

Testing

See Figure 5 for typical application wiring details. The best way to test the unit is to use it! However, if you have a multimeter, a variable power supply, a signal generator and an oscilloscope, it is worthwhile bench testing it to ensure it is fully functional.



The Assembled PCB.



PCB being assembled into box.

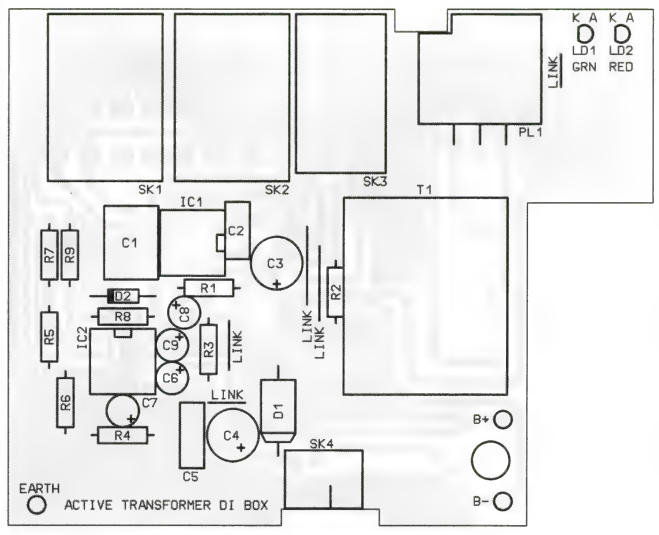


Figure 3. PCB legend and track.

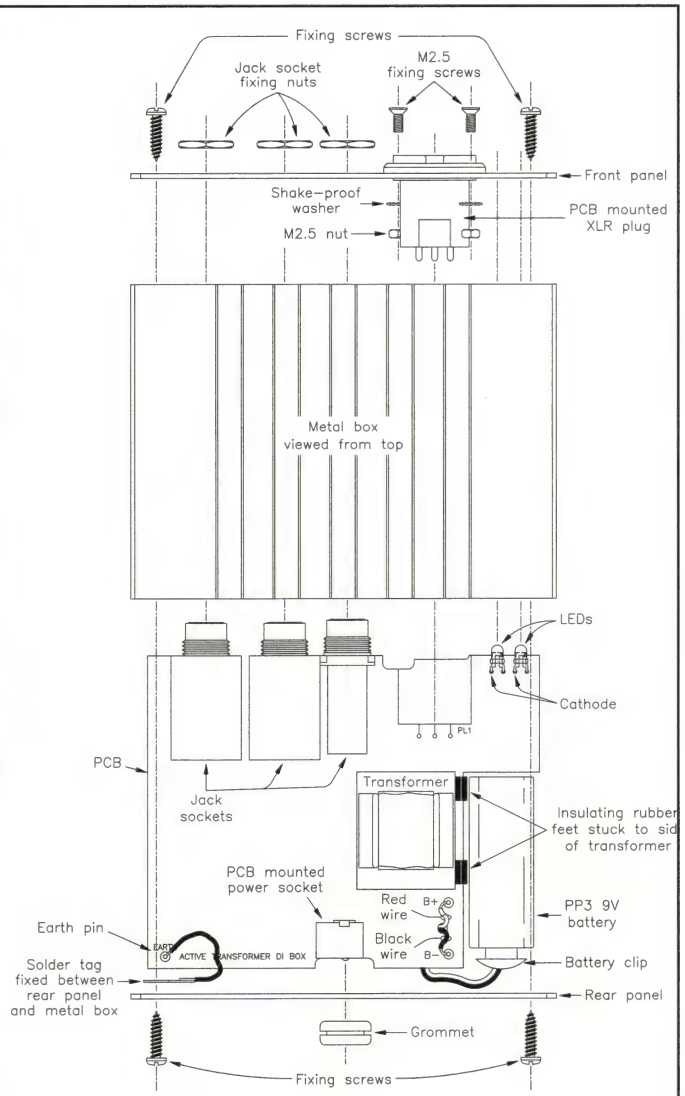


Figure 4. Exploded assembly diagram.

Set the meter to the continuity range and check that there is a connection between circuit ground and pin 1 of the XLR socket.

Set the PSU to +9V and current limit at 0·5A, then connect to the external power socket, SK4 (NOTE, the centre pin of the connector is (–) negative, and that a long reach connector must be used); both LEDs should be extinguished. Insert a jack plug into the 'Normal' input, the Green LED should illuminate; remove the jack plug and re-insert into the 'Earth Lift' input, whereupon the Green LED should again illuminate. Re-check the continuity between circuit ground and pin 1 of the XLR plug (while the jack plug is inserted), no continuity should be found.

Reduce the supply voltage until the red LED illuminates, which should be at approximately +7V. Apply a 4V Pk-to-Pk signal (or if you prefer, a 1·414V rms or +3dBV) to the 'Normal' input; monitor the 'Link' output; the signal should be just on the edge of clipping; also check the transformer in-phase and out-of-phase output signals on pins 2 & 3, respectively, of the XLR plug.

Slowly increase the supply voltage to +9V, and the red LED should extinguish at approximately +7·5V; there should also be a little more signal headroom.

Having completed the tests, install a fresh 9V PP3 battery (optional – preferably alkaline for long life), then fit and secure the module and panels to the enclosure with the screws provided (don't overtighten). Don't forget to fit the earth tag beneath the upper left-hand corner of the rear panel! The Active Balanced Line Transformer has now been fully tested and is ready for use. ELECTRONICS

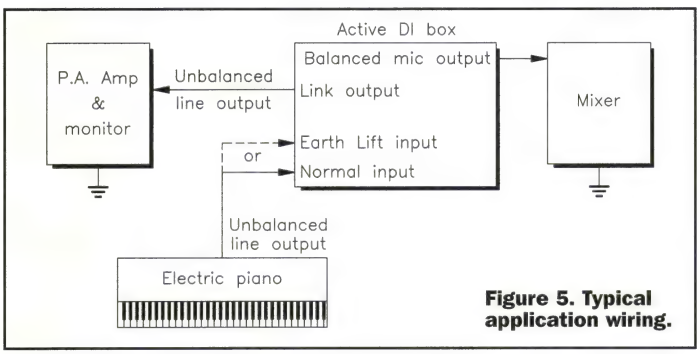


Figure 5. Typical application wiring.

PROJECT PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless Specified)

R1,2	1M	2	(M1M)
R3-5,8	10k	4	(M10K)
R6	3k9	1	(M3K9)
R7,9	2k2	2	(M2K2)

CAPACITORS

C1	1µF Polyester Layer	1	(WW53H)
C2	100nF Polyester Layer	1	(WW41U)
C3,4	220µF 16V Radial Electrolytic	2	(AT41U)
C5	100nF 16V Ceramic Disc	1	(YR75S)
C6,7	10µF 63V Radial Electrolytic	2	(AT77J)
C8,9	1µF 63V Radial Electrolytic	2	(AT74R)

SEMICONDUCTORS

D1	1N5400	1	(QL81C)
D2	1N4148	1	(QL80B)
LD1	3mm Low Current (2mA) Green LED	1	(CZ30H)
LD2	3mm Low Current (2mA) Red LED	1	(CZ28F)
IC1	TL072CN	1	(RA68Y)
IC2	LM392N	1	(UH32K)

MISCELLANEOUS

T1	Microphone Transformer 600/20	1	(FD23A)
SK1,2	PCB-mounting ¼in. Stereo Jack Socket with Switch	2	(FJ87U)
SK3	PCB-mounting ¼in. Stereo Jack Socket	1	(CX88V)
SK4	PCB-mounting Power Socket	1	(RK37S)
PL1	Low Cost XLR ACM-PC Socket	1	(KC56L)
	6·4mm Grommet	1	(JX65V)
	8-pin DIL Socket	2	(BL17T)
	PP3 Clip	1	(HF28F)
	Box Type CCN80	1	(YN50E)
	1mm PCB Pin	1 Pkt	(FL24B)
	M3 Solder Tag	1 Pkt	(LR64U)
	M2·5 6mm Countersunk Screw	1 Pkt	(BF39N)
	M2·5 Nut	1 Pkt	(JD62S)
	M2·5 Shakeproof Washer	1 Pkt	(BF45Y)
	Rubber Foot	1m	(XR93B)
	Stick-on Feet Small	1 Pkt	(FE32K)
	7/0·2 Wire 10m Green	1 Pkt	(BL03D)
	PCB	1	(GJ58N)
	Front Panel	1	(KV03D)
	Rear Panel	1	(KV25C)
	Instruction Leaflet	1	(XV98G)
	Constructors' Guide	1	(XH79L)

OPTIONAL (Not in Kit)

PP3 Battery	1	(JY49D)
9V Regulator	1	(BZ84F)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding optional) are available as a kit, which offers a saving over buying the parts separately.

Order As 95139 (Active Transformer DI Box) Price £32.99

Please Note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip, reel, etc.), the exact quantity required to build the project will be supplied in the kit.

The following new items (which are included in the kit) are also available separately, but are not shown in the 1996/97 Maplin Catalogue.

Active Transformer DI Box PCB **Order As 95140 Price £3.99**

Active Transformer DI Box Front Panel **Order As 95141 Price £2.69**

Active Transformer DI Box Rear Panel **Order As 95185 Price £1.99**