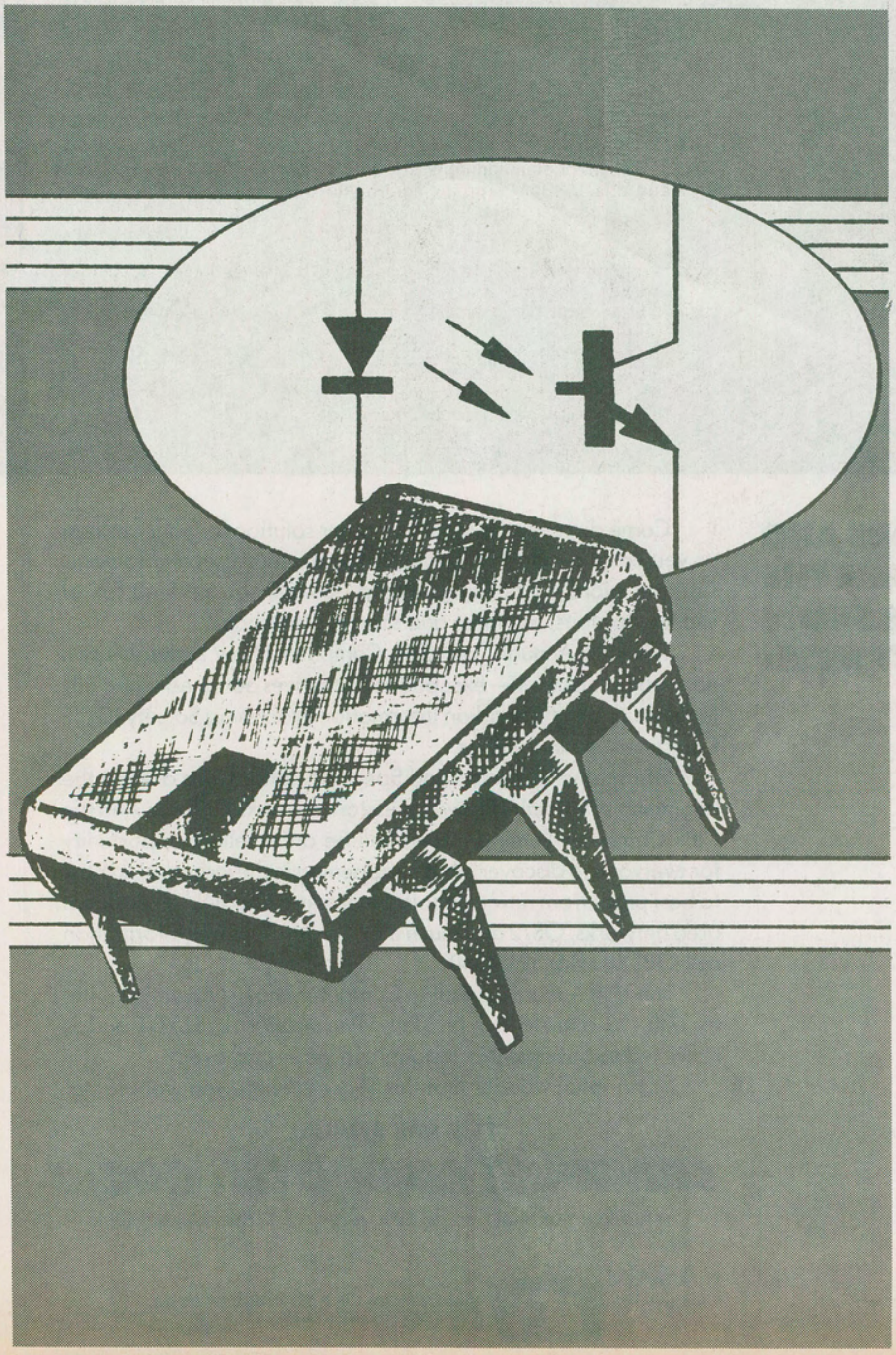
Isolink

Circuit connections without contact.

ANDY FLIND



The Isolink conducts voltage signals from DC to around 30kHz between its input and output terminals. "Amazing", you might say, "but surely two bits of wire can do that?"

Well, yes, but the Isolink does offer some significant advantages over wire. For a start, it will withstand high voltages between the input and output connections without passing current, allowing measurements to be made on normally inaccessible circuits such as those connected directly to live AC mains.

The capacitance between input and output, due mainly to stray coupling, is less than 10pF. As this presents an impedance greater than 300 megohms at 60Hz it enables investigation of sensitive battery-powered circuitry by mains powered test gear with virtually no coupling of hum.

This has obvious applications in many areas of electronics, but should be of especial interest to biofeedback enthusiasts. The prototype was in fact designed to assist with the development of a brainwave monitor circuit.

Optoisolator

An optoisolator device was chosen as the basis for this project as it offers efficient signal transfer with low supply current. Most other methods require tens of milliamps (at least) of transmitter drive current, and it was intended from the outset that this circuit would be battery powered.

Another factor in this choice was avoidance of the need to encode signals for transmission. Fibre optic and infrared systems usually employ frequency or pulse width modulation, but these involve an extra oscillator which might interfere with sensi-

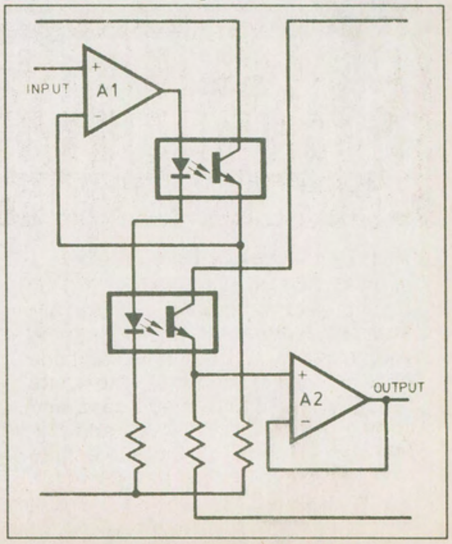


Fig. 1. Simplified representation of the optolink circuit stage.

tive biofeedback circuitry. Although optoisolators are not totally linear, the problem is quite easily overcome, as will be seen.

A simplified version of the circuit appears in Fig. 1. The input is applied to one side of amplifier A1. The output from this amplifier is routed through the input LEDs of two similar opto isolators in series, so that both receive exactly the same current, and feedback taken from the output of one of them is fed back to A1. This enables the amplifier to compensate for most errors in the isolator response, so both of the isolator outputs should be accurate copies of the input. The signal from the second isolator is buffered by A2.

Circuit Description

Of course, it's not quite that simple, as a glance at the full circuit diagram (Fig. 2) of the Isolink will show. To begin with, the input may be alternating voltage. There must therefore be a quiescent current in the isolators which can both rise and fall, and the input and output "grounds" must be placed somewhere between the supply rails. IC1b with resistors R3 and R4 set the input ground to about 1V.

Stability caused a few design headaches. There seems to be a brief delay between the application of a signal to an isolator input and its appearance at the output, possible due to charge storage in the transistor. At any rate, if the transistor is the sole source of feedback the circuit bursts into uncontrollable oscillation, so much HF feedback is provided from the input side through capacitor C1.

As it is taken after the LEDs, at least their errors will be compensated for. Low frequency and DC feedback is derived entirely from an isolator output, so the performance here is excellent and even temperature-induced drift is mostly cancelled out.

The isolator type specified for this project has a stated transfer ratio of 100%, meaning that for each milliamp of input a milliamp should be conducted by the output transistor. In practice there is a fair degree of variation between individual devices, so preset adjustment is necessary to compensate for this.

Starting with the high frequency compensation, if the ratio between the two feedback paths is adjustable, it is possible to trim the circuit for optimum high frequency response. This is carried out by preset VR1 which varies the ratio between the return resistances from the isolator inputs and the transistor in IC2.

Next, the transfer ratios of the two isolators probably won't be exactly the same, so gain adjustment with preset VR3 sets the correct output level. The "ground" connection on the output side is also offset to permit negative signal swings and, as the DC outputs of the two isolators are unlikely to be exactly the same, preset VR2 gives a small range of compensatory adjustment.

Power Supply

Regulated supplies are essential for both sections of the circuit, these being provided by two 5V 100mA "78" series regulators. As the circuit is battery operated, a warning of impending supply failure on either side is a worthwhile addition.

Two 3130 op amps, IC3 and IC7, compare voltages derived from the battery and the stabilized 5V rails. With the resistor values given, the LEDs will light when the supply voltage has dropped to about 8V.

Note that the 3130's have no compensation capacitors, this being unnecessary in a switching comparator application. Also there are no series limiting resistors in their outputs, as these effectively limit the current to about 8mA anyway.

Construction

Despite the apparent complexity this circuit is quite simple to construct on a small printed circuit board. The component layout and full size copper foil master pattern is shown in Fig. 3. Sockets are recommended for all ICs except regulators IC4 and IC8, as this assist the test procedure. The PCB has been designed to accept 8-pin sockets for the isolators although these are 6- pin devices, the reason being that 6-pin sockets are fairly hard to find. The isolators are fitted at the tops of these, leaving the bottom two holes unused. Do not fit any ICs at this stage as they will be added later whilst setting up.

The LEDs can be connected to leads just long enough for the final installation in the case. Lengths of screened lead can be connected to the input and output points at this stage, long enough to allow easy ac-

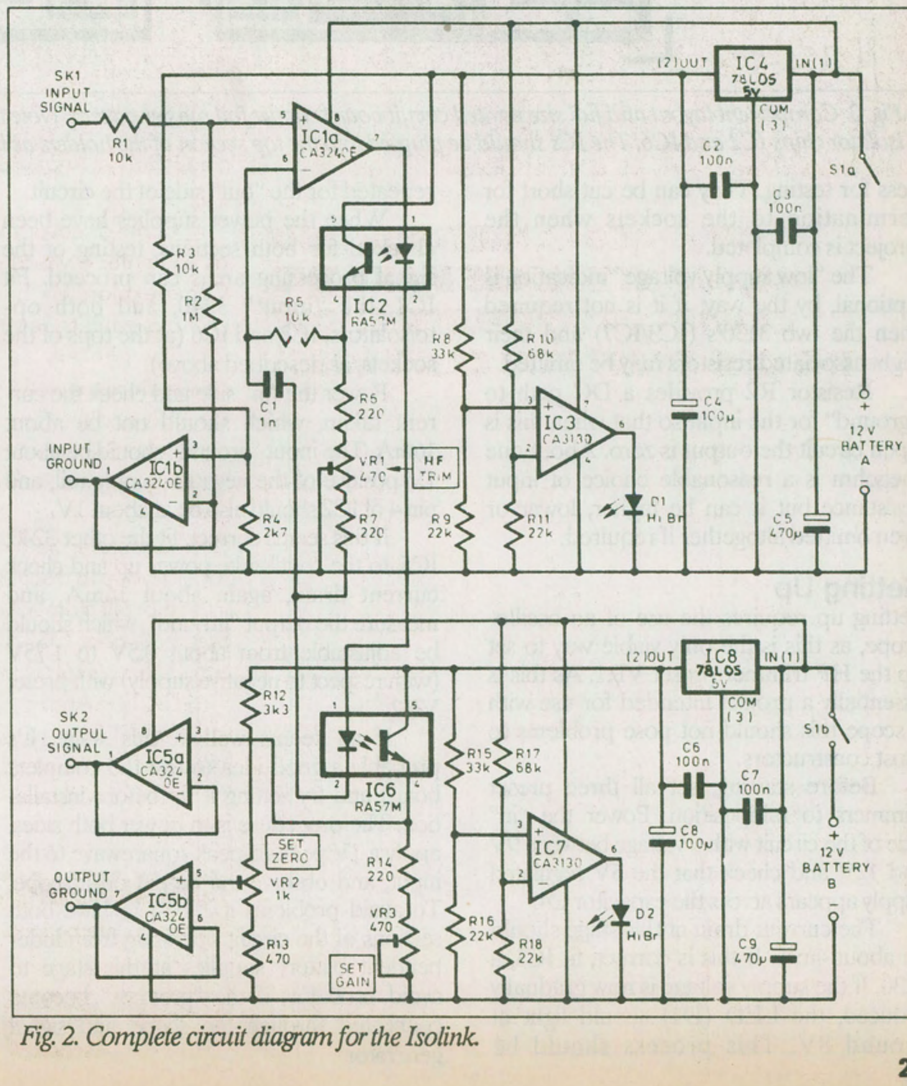


Fig. 2. Complete circuit diagram for the Isolink.

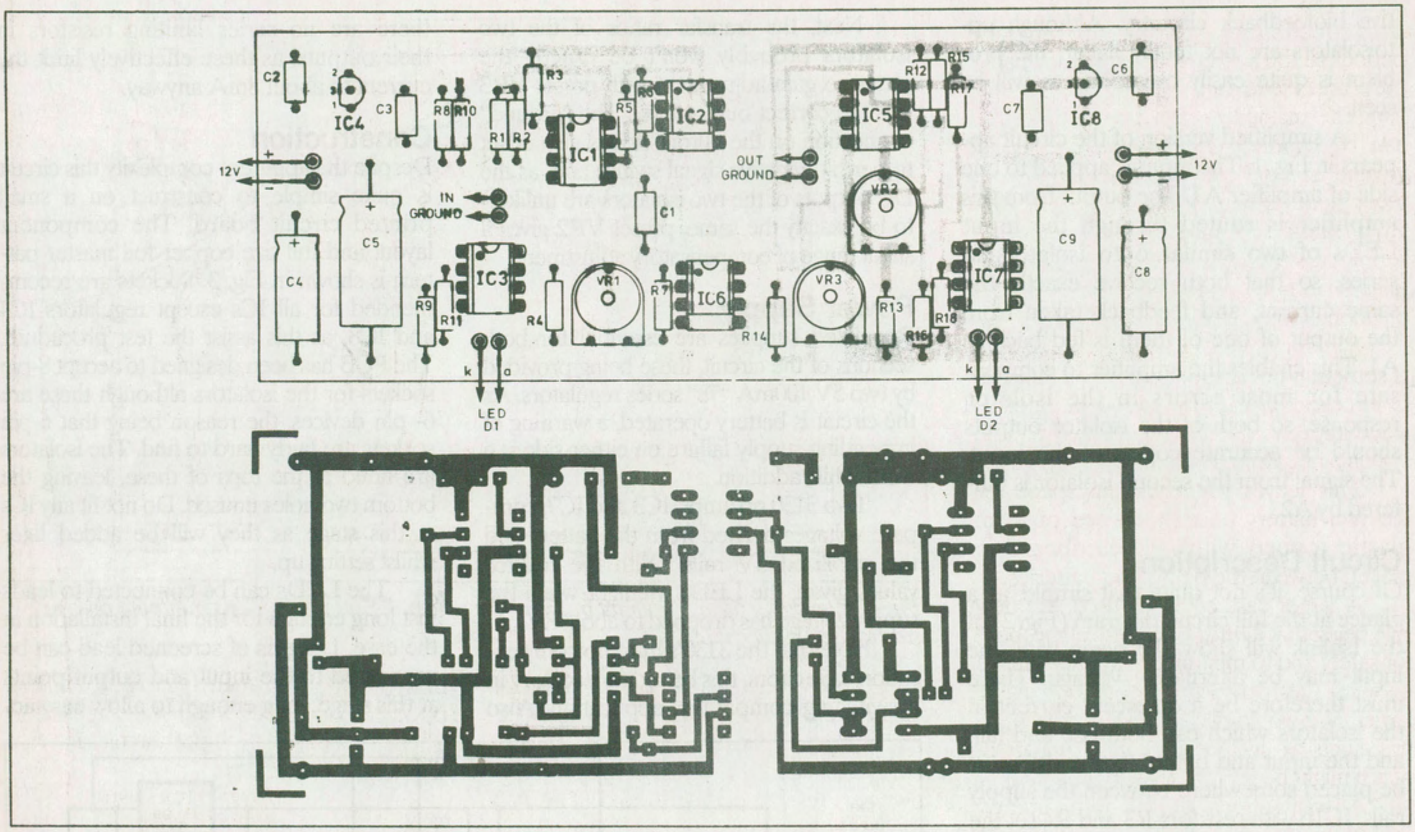


Fig. 3. Component layout and full size printed circuit board copper foil master pattern. Note that 8-pin IC holders have been used for the isolator chips IC2 and IC6. The ICs should be plugged into the top section of the holders as indicated.

cess for testing. They can be cut short for termination to the sockets when the project is completed.

The "low supply voltage" indication is optional, by the way; if it is not required then the two 3130's (IC3/IC7) and their eight associated resistors may be omitted.

Resistor R2 provides a DC path to "ground" for the input so that when this is open circuit the output is zero. About one megohm is a reasonable choice of input resistance but it can be higher, lower or even omitted altogether if required.

Setting Up

Setting up requires the use of an oscilloscope, as this is the only viable way to set up the HF trimmer preset VR1. As this is essentially a project intended for use with a scope this should not pose problems to most constructors.

Before starting, set all three preset trimmers to midposition. Power the "in" side of the circuit with a voltage between 9V and 12V and check that the 5V regulated supply appears across the capacitor C4.

The current drain at this stage should be about 4mA. If this is correct, fit IC3, a 3130. If the supply voltage is now gradually reduced, the LED (D1) should light at around 8V. This process should be repeated for the "out" side of the circuit.

When the power supplies have been checked for both sections, testing of the signal processing areas can proceed. Fit IC1, the "input" 3240, and both optoisolators, IC2 and IC6 (at the tops of the sockets, as described above).

Power the "in" side and check the current taken, which should not be about 16mA. The input "ground" should be about 1V positive of the negative supply rail, and pin 4 of IC2 should also be at about 1V.

If this seems correct, fit the other 3240, IC5, to the "out" side, power up and check current drain, again about 16mA, and measure the output "ground", which should be adjustable from about 0.5V to 1.75V (with respect to negative supply) with preset VR2.

If all seems well at this stage, it's probably a good idea to test the complete board and try setting it up before installation. The procedure is to power both sides, apply a 1V peak-to-peak squarewave to the input, and observe the output on a scope. To avoid problems it is best to have both sections of the circuit operating from independent battery supplies at this stage to avoid problems if the "grounds" become connected through the scope and signal generator.

Preset VR1 is adjusted for best squarewave output; on one side there will be marked overshoot on the leading edges, on the other excessive rounding in both directions. This can be done at 1kHz, though the effect is easier to see at 10kHz.

Next, with frequency set to 1kHz, preset VR3 is adjusted for an output amplitude exactly equal to the input. Finally, with the signal removed, preset VR2 should be adjusted to remove any DC potential across the output.

As there is a fair degree of tolerance spread between individual optoisolators it may be worth swapping them over and setting up again to see which arrangement gives the best performance. This applies especially if VR1 or VR3 is near the end of its range when the settings appear correct. Experiments with four different isolators in the prototype produced overall frequency responses ranging from 10kHz to nearly 30kHz, so the benefit of some patient experiment is obviously worthwhile.

Interwiring

Most of the space is taken up by the battery packs. Batteries are a matter for the individual constructor; the circuit *will* operate from 9V, and indeed two 9V batteries could be used. However, as it is intended as a design tool it may be used for fairly long periods so the additional life given by packs of AA cells seems advisable.

The maximum signal amplitude that can be handled depends on the supply voltage and the characteristics of the optocouplers, and in the worst case a 1V RMS signal will start clipping when the supply falls to 8V. In view of this 12V supplies were fitted to the prototype with indication of impending failure at 8V.

Packing this lot into the specified case is something of a shoehorn job. The PCB is attached inside the top with double-sided tape, and the sockets, LEDs and switch S1 fit alongside it.

This leaves just sufficient space for the two battery packs. A piece of foam plastic topped with stiff cardboard is placed between the board and batteries.

A larger case could be used, the only rule being that it *must* be a plastic type, both for safety and to minimize stray capacitance between the two sections of the circuit. A larger case would allow the inclusion of extras such as switched input attenuation, which might be preferred by some users.

A final check of the adjustments should be carried out after completion. If the unit is to be used for safety isolation, a check with a "Megger" between input and output "grounds" is advisable to ensure the insulation is sound.

The Isolink is designed to handle signals up to about 1V peak-to- peak. The lower limit is governed by the inherent circuit noise, which is less than 5mV. The input impedance is about one Megohm, whilst the output impedance is low, a couple of hundred ohms.

The frequency range extends from DC to at least 10kHz, on the prototype it is around 30kHz. This means that most audio frequency signals will pass through it virtually undistorted, and squarewaves will still look reasonably square at 1kHz.

If it is required to handle larger signals a simple resistive attenuator can be used. The input is protected to some extent by the 10k resistor R1 and the internal protection diodes of IC1, but external diode protection is not provided as it was found that this caused some signal degradation. Suitable precautions should be taken to avoid possible overload where this might occur.

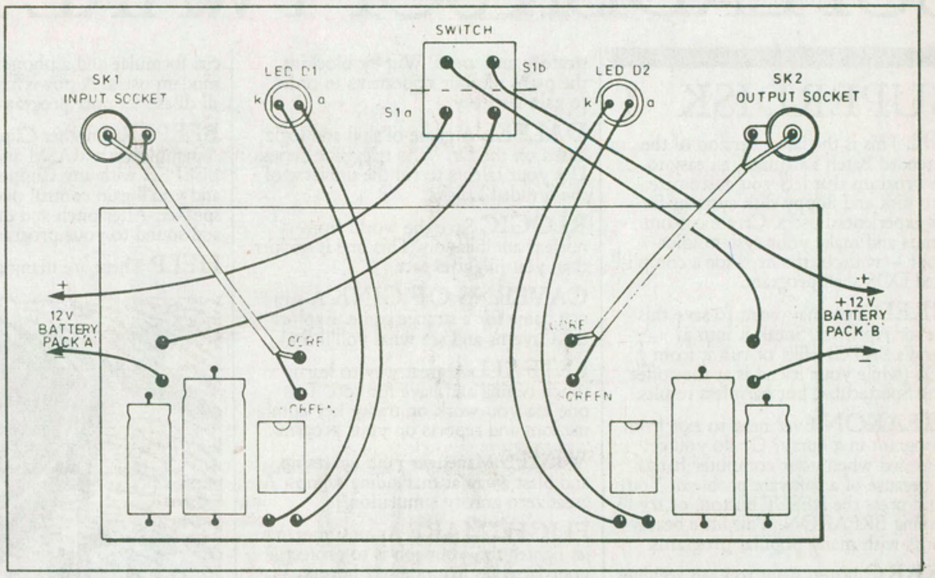


Fig. 4. Interwiring from the circuit board to the switch, LEDs and sockets mounted on one side of the plastic case.

In Use

The way in which Isolink should be used depends upon the actual application. The most obvious use is investigating signals in circuitry at potentials other than ground.

The optoisolators specified are quoted as "High Voltage", this being specified as 7500V peak, 5300V RMS. While it might be inadvisable to operate at this sort of voltage, it is quite in order to, for example, insert a low value resistor in the live lead of an AC appliance and, through Isolink, inspect the voltage developed across it with an grounded oscilloscope.

This will give an indication of the current flow. Similarly, low voltage signals in sections of high voltage circuitry could be measured. *Always be very sure you know what you are doing and check connections carefully before switching on* with this kind of work, though.

At a lower level, it can be used to take measurements across points that could otherwise be hard to access as neither end is grounded, and connecting them to ground through, say, the ground side of a scope would cause faulty operation or damage.

In the case of sensitive battery operated equipment, grounding of any point of the circuit will often introduce a high level of mains hum, making test measurements with mains-powered equipment difficult or even impossible. Biofeedback circuits are a classic example of this.

The stray capacitance between the two sections of the prototype was measured with a bridge and found to be in the region of 10pF, which will offer an impedance of more than 300M to 60Hz signals. This should greatly attenuate the hum problem, but the actual manner in which the Isolink is used should be considered carefully in such an application. If you are measuring a signal from your own body, for example, it would be better to place the isolator on your lap than on the workbench close to mains powered equipment, where it might pick up a lot of hum in the input circuit through capacitive coupling. ■

PARTS LIST

Resistors

R1,3,5 .... 10k
R2 .... 1M
R4 .... 2k7
R6,7,14 220
R8,15 .... 33k
R9,11,16,18 .... 22k
R10,17 .... 68k
R12 .... 3k3
R13 470

All 1% metal film

Potentiometers

VR1,3 470 submin horiz. preset
VR2, 1k submin. horiz. trim

Capacitors

C1 .... 1n
C6,7 .... 100n
C4,8 .... 100u axial elec. 10V
C5,9 .... 470u axial elec. 25V

Semiconductors

D1,2 .... LED red
IC1,5 .... CA3240E dual op amp
IC2,6 High-sensitivity, high voltage optoisolator, 4N35 or equivalent
IC3,7 .... CA3130 op amp
IC4,8 78L05 5V 100mA positive voltage regulator

Miscellaneous

S1 .... DPST toggle switch
SK1,2 .... chassis phono sockets

Case, 150 x 80 x 50mm; PCB; 8-pin DIP sockets; 12V battery holders (for 8 AA cells each); interconnecting wire, solder, etc.