Signal Line Tester

PROJECT

If you're a PA person, here's an incredibly simple device to prevent embarrassment when all you can give them is the sound of silence. Design by Vivian Capel.

THIS PROJECT came about as a result of a very unfortunate incident. The author was in charge of a large public-address system that had been temporarily installed to cater for a public meeting with an audience of several thousand. There were spare microphones, spare inputs on the mixer, and to make quite sure, a spare mixer under the bench. Very little really could go disastrously wrong — but it did! Part way through the main speech everything went dead. Calm and reasoned diagnosis was employed (it wasn't really, but I couldn't admit to blind panic). Finally, after what seemed an age of silence from the speaker and murmurings from the audience, the fault was revealed as a dead short across the audio cable between mixer and amplifier rack.

Thus the fault-warning unit here described was conceived, embarrassment being the mother of invention! The idea was to constantly monitor the condition of a signal cable; if it should go either short-circuit or open-circuit, an appropriate LED would immediately light up to indicate what had happened.

The device could be used not only for public address applications, but any situation where a vulnerable signal cable needs protection by constant monitoring. A security intercom or telephone link, for example, could be monitored to reveal a fault or tampering as soon as it occurred, and avoid the need for frequent testing.

Requirements

To utilize the device successfully, the normal signal for which the cable is used must be AC. Furthermore there must be a DC path or load resistor at the far end of the cable to pass the small open-circuit mode sensing current. The input to the amplifiers or other equipment at the far end must be AC-coupled; otherwise the input stages could be affected by the DC monitoring potentials. As a rule, these conditions are met in most slave amplifiers by the input gain control and following coupling capacitor. Should the capacitor come first, a load resistor must be added across the input socket.

In considering the design, several features were deemed desirable. First, the value of the load terminating the line should not be critical. While false indications can be obtained under extreme load conditions with the circuit eventually evolved, there is a wide latitude in load values and no false alarms will be obtained within the specified limits. The nominal load for which the circuit was designed is 10k, but variations up to 20k and down to under 1k0 can be tolerated. This will accommodate most applications, but other values could be obtained by changing the values of the three resistors from those given.

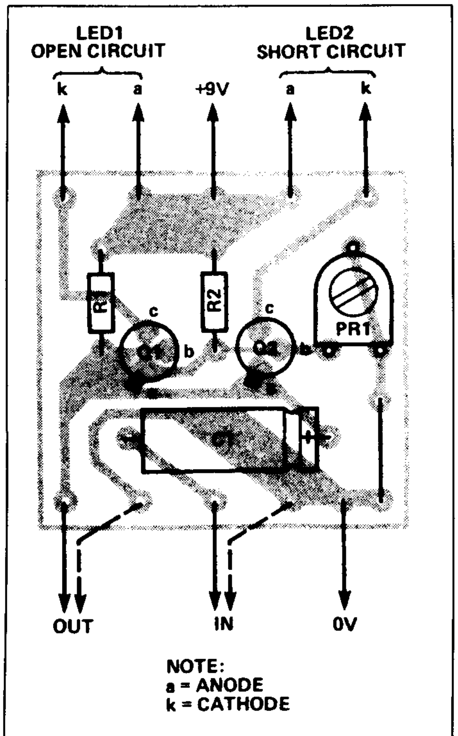

Fig. 1. Component overlay for the line checker. The line below PR1 may be replaced by a resistor — see text.

Second, the circuit must take very little current, as it is active for the whole time the mixer is switched on. A current of 1 mA was stipulated as the maximum allowable in the quiescent mode. This meant that few active components could be used, and that they had to be non-conducting until a fault condition occurred.

Third, the unit should be as simple as possible; far too many electronic circuits at present are needlessly complicated. In this case simplicity was pursued not merely for its own sake but as a fundamental necessity for fault monitoring equipment. It has to have a high degree of reliability if it is to be depended upon, and every extra component is one more that could itself break down.

HOW IT WORKS

The circuit diagram is shown in Fig. 1: we will consider the operation of the open-circuit indicator first. The emitter of Q1 is taken to the junction of R2 and PR1 which have values of 10k and 1k0 respectively, so the emitter is at a potential of one-tenth of the supply. The base of Q1 is connected to the junction of R1 (100k) and the load, which is nominally 10k; hence it too is at one-tenth of the supply voltage. Therefore there is no forward bias on Q1 as the base and emitter are at about the same potential, so no current passes through it and the LED in its collector circuit.

If the load now goes open circuit, the positive voltage on Q1 base rises since it is no longer tied down, so Q1 becomes forward biased, and current flows through LED1, illuminating it. Current limiting is provided by PR1 in the emitter circuit, which safeguards LED1.

The short circuit detector is built round Q2. The base of this transistor is taken to the R2-PR1 junction, and is at one-tenth of the supply; Q2 emitter is connected to the junction of R1 and the load, and so it too has base and emitter at the same potential and is cut off. Should the load become short circuited, the emitter voltage drops to zero which means there is a positive bias on the base. Therefore Q2 conducts and LED2 lights to indicate a short. Although there is no current-limiting resistor in series with LED2, the bias on the transistor can be adjusted by PR1 to give the correct current and desired illumination.

Note that neither fault condition affects the warning circuit of the other. If the load is short-circuited, Q1 base drops to 0 V while its emitter is still positive, so it is driven even further into cut-off. Similarly, if the load becomes open-circuit, the emitter voltage of Q2 rises above that of its base.

The capacitor C1 blocks DC from the sending equipment, should there be any, from upsetting the operation of the warning circuits and vice versa. It also prevents any DC path in the output of the sending device from shunting the load and rendering the open-circuit test ineffective.

Construction

The original circuit was built into the mixer and powered from the mixer batteries, but construction and housing is by no means critical and almost any convenient form can be used. Input and output sockets can be standard jacks, Cannon XLR plugs or any suitable terminations appropriate for the equipment involved.

Before applying the battery voltage make sure that the variable preset PR1 is fully advanced so that maximum resistance is in circuit. If it should be fully the other way there will be no limiting resistance for LED1 and it could be destroyed. If preferred, the value can be split between a 500R preset and 560R fixed resistor for the sake of safety. Once set, the preset should not require readjustment, and so can be sealed with a spot of paint.

Connect a 10k load resistor across the output socket. If one is already fitted across a switched jack socket, this will not be necessary. On applying the supply, both LEDs should remain off. Disconnect the load and LED1 should light up. Now short-circuit the output; LED1 should go out and LED2 illuminate. It will be found that one LED is brighter than the other due to the differences in the h_{fe} of the resistors. Adjusting PR1 will produce equal brightness, so repeat the open-circuit and short-circuit test and adjust PR1 each time until the desired illumination is achieved. Decreasing the value darkens LED2 and brightens LED1 and vice versa.

Check that both LEDs are off with loads of 20k and 1k0. If LED 1 glimmers at 20k increase the value of R1 to 120k or even more if required. This may be necessary if Q1 has an exceptionally high h_{fe}.

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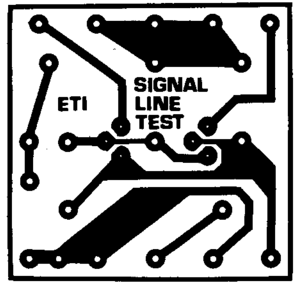

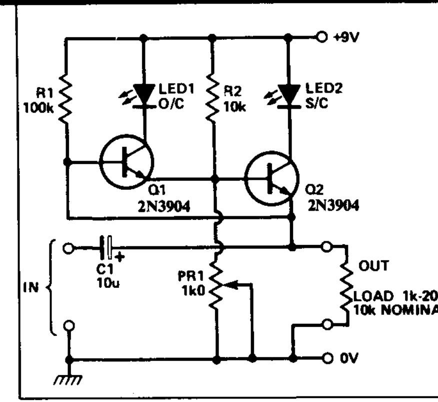

Fig. 2. Circuit diagram of the signal line tester.

PARTS LIST

Resistors (all ½ W, 5%)

R1	100k
R2	10k

Potentiometer

PR1	10k miniature horizontal trim-pot

Capacitor

C1	10*u* 25 V axial electrolytic

Semiconductors

Q1,2	2N3904 or equiv.
LED1,2	3 mm red LED

Miscellaneous

PCB; case and sockets (if built separate from audio equipment).