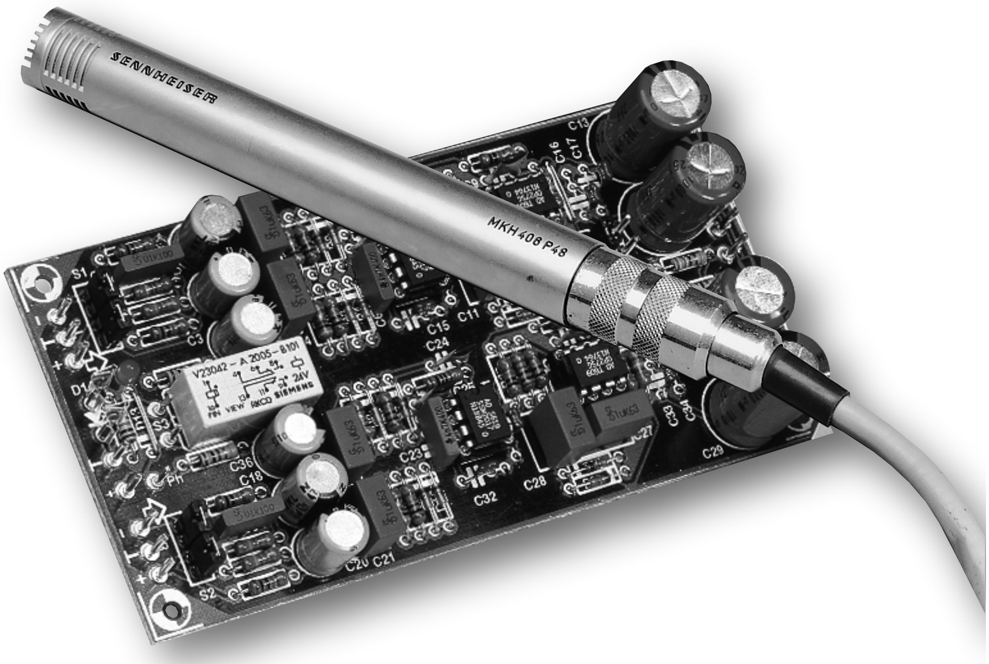
stereo microphone amplifier

with balanced inputs and phantom power supply



The magnification of very weak audio-frequency signals is and remains a precarious affair. That is why a microphone amplifier good enough for professional applications must have balanced inputs and indisputably good specifications. Foremost, of course, is the faithful transducing of sound. Although this is a subjective aspect, it is confidently expected that the design of the amplifier described here will satisfy even professional audio engineers and technicians. It is a stereo model with integral phantom power supply for electret microphones.

Design by J Brangé

INTRODUCTION

There are not all that many good methods to amplify the very small a.f. output signals of a microphone without affecting the quality of the input sound. One of the best is undoubtedly that in which a balanced instrument amplifier, discrete or integrated, is used.

Today, the accent in design is on integrated circuits, ICs, rather than on discrete transistors. One of the many a.f. ICs in the gamut of Analog Devices is the SSM2017, which is eminently suitable for use in a balanced microphone amplifier. This operational amplifier has a small noise factor and low total harmonic distortion, combined with a large bandwidth and high slew rate. Also, its amplification may be set within wide limits.

CIRCUIT DESCRIPTION

From the foregoing, it is clear that basing the design of the microphone amplifier on an SSM2017 is a sound decision. The circuit diagram in **Figure 1** may look extensive, but it should be borne in mind that it concerns a stereo circuit. This means that there are two of every device and component with the exception of those in the power supply. The following description will be limited to the left-hand channel.

The microphone is connected to the balanced input amplifier, IC_1, via terminals L+ and L–. The facility for short-circuiting R_1 and R_2 is provided for cases in which the circuit is to be used as a line amplifier. The switches are then open to provide an attenuation of 10 dB. When the circuit is used as microphone amplifier, the resistors are short-circuited. So, if use as a line amplifier is not envisaged, the switches and R_1, R_2 may be replaced by a wire bridge.

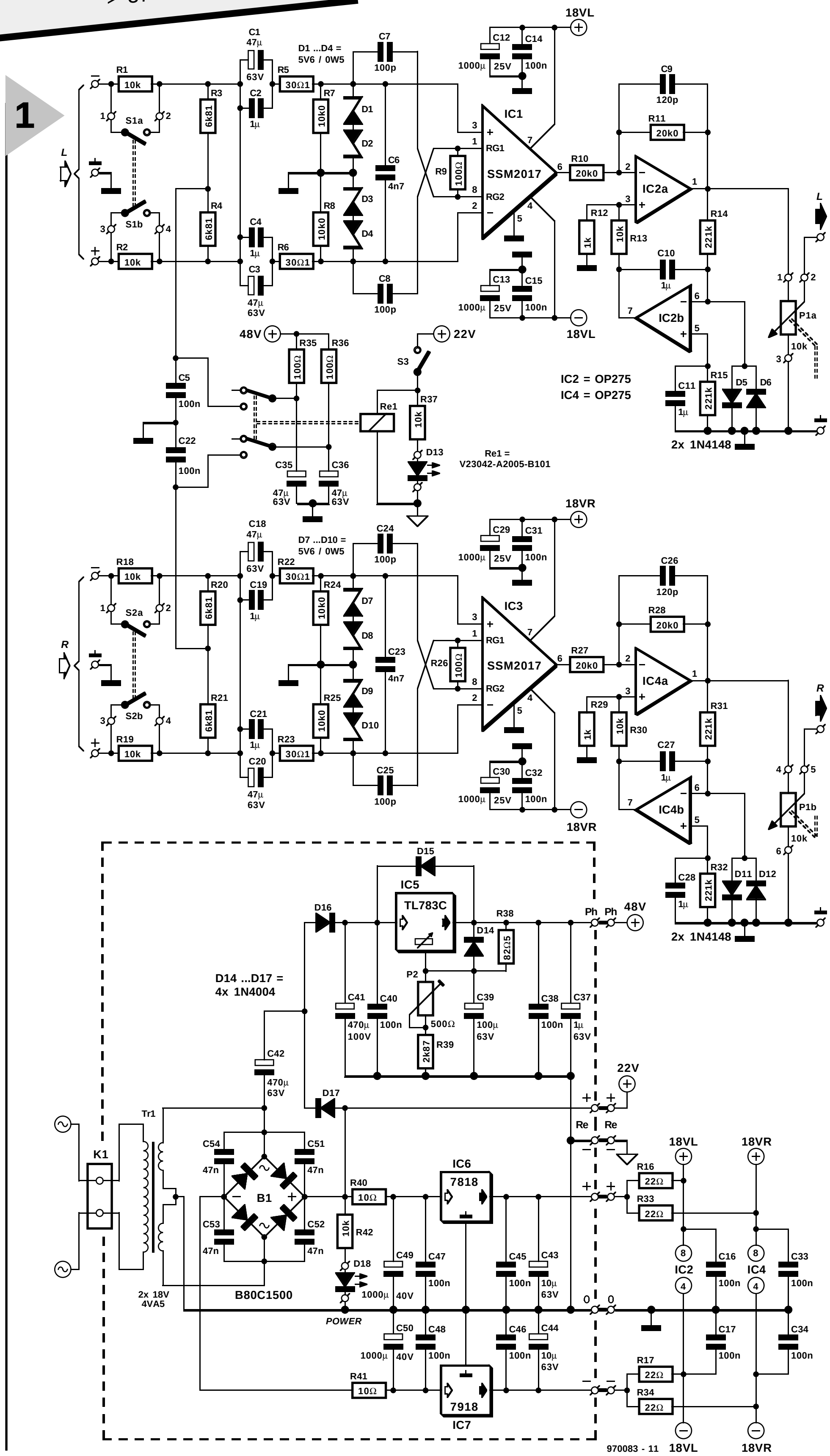
The supply voltage needed by electret microphones is provided via a phantom line. This means that the signal lines are used for carrying the supply voltage, which is, of course, not applied to the amplifier input. The volt-

Features

(measured with an input signal of 2 mV into 50 Ω)

Signal-to-noise ratio		>74 dB (BW 22 kHz linear)
Total harmonic distortion (20 Hz–20 kHz)		<0.03% (BW 80 kHz)
Channel separation	(20 Hz)	120 dB
	(1 kHz)	95 dB
	(20 kHz)	83 dB
Bandwidth		> 60 kHz (source 50 Ω)
		> 37 kHz (source 600 Ω)

Figure 1. Circuit diagram of the stereo microphone amplifier, which is based on an SSM2017 operational amplifier from Analog Devices.



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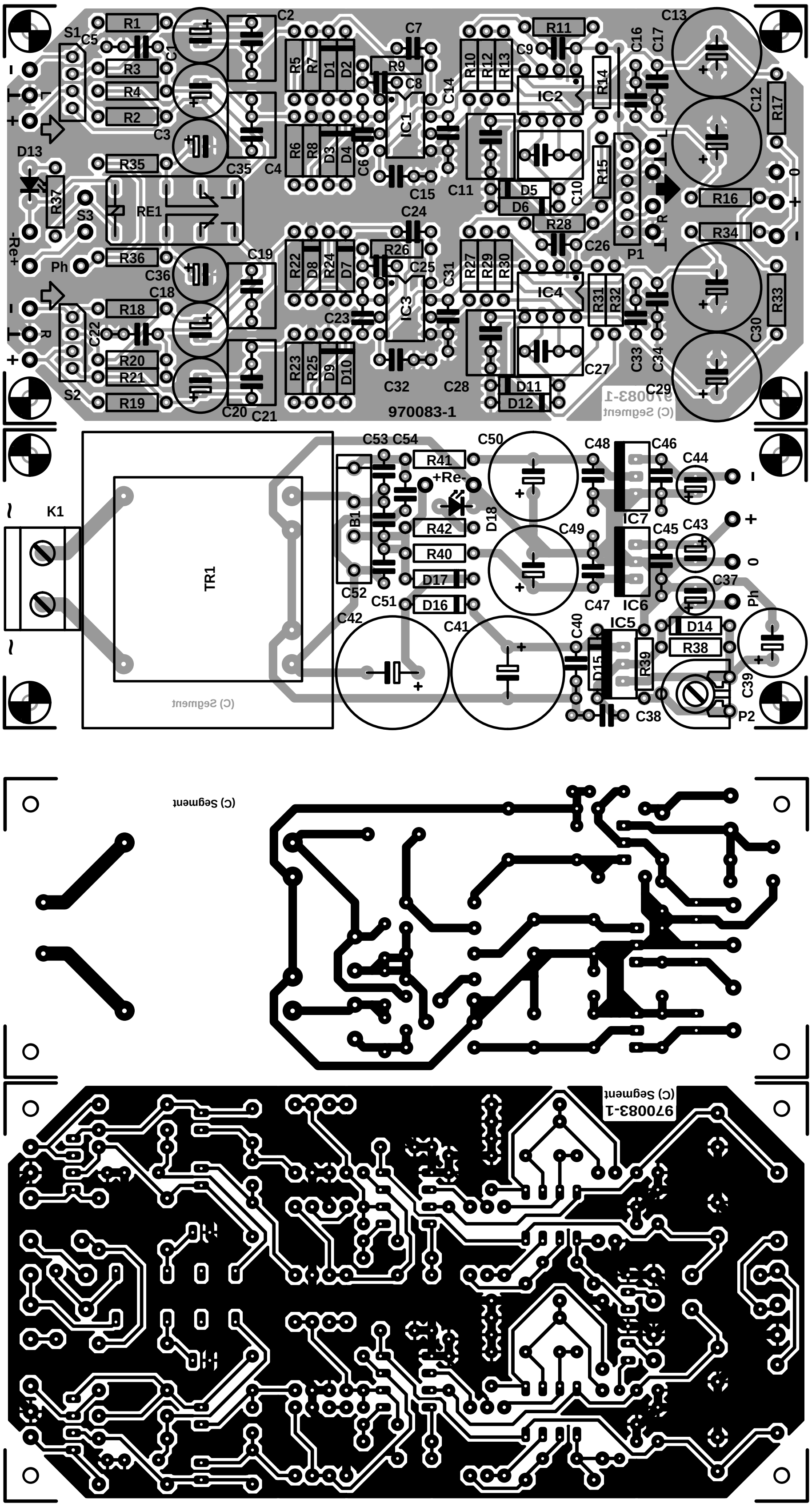

Figure 2. The printed-circuit board is in two parts to enable the amplifier and power sections to be kept isolated.

Parts list

Resistors:

R_1, R_2, R_7, R_8, R_{13}, R_{18}, R_{19}, R_{24}, R_{25}, R_{30} = 10.00 kΩ, 1%
R_3, R_4, R_{20}, R_{21} = 6.81 kΩ, 1%
R_5, R_6, R_{22}, R_{23} = 30.10 Ω, 1%
R_9, R_{26} = 100 Ω, 1%
R_{10}, R_{11}, R_{27}, R_{28} = 20.00 kΩ, 1%
R_{12}, R_{29} = 1.00 kΩ, 1%
R_{14}, R_{15}, R_{31}, R_{32} = 221 kΩ, 1%
R_{16}, R_{17}, R_{33}, R_{34} = 22 Ω
R_{35}, R_{36} = 100 Ω
R_{37}, R_{42} = 10 kΩ
R_{38} = 82.50 Ω, 1%
R_{39} = 2.87 kΩ, 1%
R_{40}, R_{41} = 10 Ω
P_1 = 10 kΩ, log, stereo potentiometer
P_2 = 500 Ω preset potentiometer

Capacitors:

C_1, C_3, C_{18}, C_{20}, C_{35}, C_{36} = 47 µF, 63 V, radial
C_2, C_4, C_{10}, C_{11}, C_{19}, C_{21}, C_{27}, C_{28} = 1 µF, metallized polyester (MKT), pitch 5 mm or 7.5 mm
C_5, C_{22} = 0.1 µF
C_6, C_{23} = 0.0047 µF
C_7, C_8, C_{24}, C_{25} = 0.001 µF
C_9, C_{26} = 0.12 µF
C_{12}, C_{13}, C_{29}, C_{30} = 1000 µF, 25 V, radial
C_{14}–C_{17}, C_{31}–C_{34}, C_{38}, C_{45}–C_{48} = 0.1 µF, ceramic
C_{37} = 1 µF, 63 V, radial
C_{39} = 100 µF, 63 V, radial
C_{40} = 0.1 µF, metallized polyester (MKT), 100 V
C_{41} = 470 µF, 100 V, radial
C_{42} = 470 µF, 63 V, radial
C_{43}, C_{44} = 10 µF, 63 V, radial
C_{49}, C_{50} = 1000 µF, 40 V, radial
C_{51}–C_{54} = 0.047 µF, ceramic

Semiconductors:

D_1–D_4, D_7–D_{10} = zener 5.6 V, 500 mW
D_5, D_6, D_{11}, D_{12} = 1N4148
D_{13} = LED, high efficiency, red
D_{14}–D_{17} = 1N4004
D_{18} = LED, high efficiency, green

Integrated circuits:

IC_1, IC_3 = SSM2017 (Analog Devices)
IC_2, IC_4 = OP275G (Analog Devices)
IC_5 = TL783C (Texas Instruments)
IC_6 = 7818
IC_7 = 7918

Miscellaneous:

K_1 = two-pin terminal block, pitch 7.5 mm
S_1, S_2 = double-pole on switch (or wire bridge – see text)
S_3 = single-pole on switch
B_1 = B80C1500 bridge rectifier
Re_1 = 22 V relay, 2 contacts
Tr_1 = mains transformer, 2×18 V secondaries, 4.5 VA
PCB Order no 970083-1 (see Readers services elsewhere in this issue)

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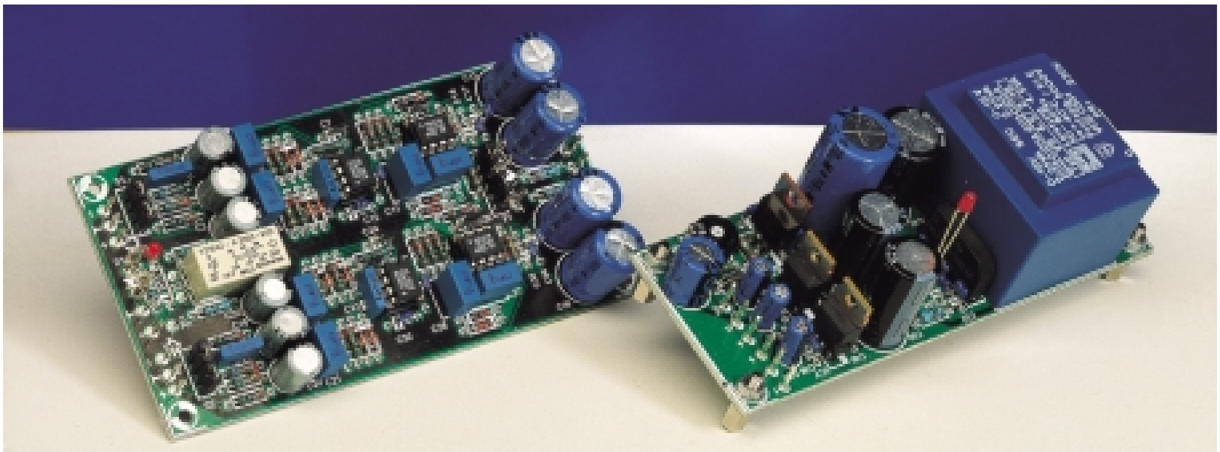

Figure 3. In the prototype, S_1, S_2 and P_1 have been omitted deliberately – see text.

age is 48 V and is linked to the input lines via relay Re_1, which is controlled by S_3. Network R_{35}-C_{35} provides additional smoothing of the supply line. The supply voltage is applied to the balanced microphone lines via potential divider R_3-R_4. RF decoupling is provided by C_5. The lighting of diode D_{13} indicates that the supply is on.

Capacitors C_1 and C_3 prevent any direct voltages from reaching the inputs of IC_1. They are bypassed for r.f. by C_2 and C_4.

Resistors R_5 and R_6, in conjunction with zener diodes D_1–D_4, suppress any peaks on the phantom supply lines that may be caused by the operation of S_3.

Resistors R_7 and R_8 form the input load of IC_1. As the pass-band of this IC is wide, it needs to be narrowed to reduce noise and distortion and also to largely suppress the effect of any r.f. radiation that may be present. The bandwidth is reduced by capacitors C_6–C_8, which must not be ceramic types.

One of the excellent features of the SSM2017 is that its voltage amplification is easily varied without affecting its input impedance and bandwidth. The amplification, α, is determined by the value of R_9 between pins 1 and 8. The relationship between these two quantities is given by

$$\alpha = (10^4/R_9) + 1.$$

With the value of 100 Ω specified for R_9 in the present circuit, this gives an amplification of ×100 (40 dB). For an amplification of ×31 (30 dB), the value of R_9 is 332 Ω, and for ×316 (50 dB), it is 31.6 Ω.

The output of IC_1 is applied to volume control P_{1A} via buffer amplifier IC_{2A}.This buffer is a special type of op amp, an OP275, which functions on the Butler amplifier principle. In this, a combination of bipolar and junction field-effect transistors is used to provide the low noise of the first and the speed and sound quality of the second. This arrangement results in a device with impressive specifications as regards noise contribution, distortion and slew rate.

The amplification of the buffer is set to unity with R_{10} and R_{11}.

The bandwidth of the buffer is limited by C_9.

To eliminate the fairly high offset (that is, imbalance) voltage produced by the SSM2017 (which may be as high as 200 mV, depending on the amplification), and since an electrolytic capacitor at the output was considered undesirable, integrator IC_{2B} is used. This op amp compares the potential at pin 1 of the buffer amplifier with that at its inverting input (pin 6). On the basis of this comparison, the integrator adjusts the input to the buffer in such a way that the overall offset voltage at the output is smaller than 1 mV at all times. Diodes D_5 and D_6 protect the integrator against high peak voltages.

POWER SUPPLY

The circuit needs three different supply voltages: a symmetrical one of ±18 V for IC_1–IC_4; a single one of 22 V for the relay; and a single one of 48 V for the microphone(s).

The ±18 V is provided by two voltage regulators, IC_6 and IC_7. The supply lines to the various ICs are bypassed for any noise and interference on the mains supply by resistors R_{16} and R_{17} and capacitors C_{12}–C_{17} (or R_{33} and R_{34}, and C_{29}–C_{34} in case of the right-hand channel).

The supply line for the relay is taken directly from the secondaries of the mains transformer since this need not be smoothed or regulated. Its level of 22 V is sufficient to drive the relay reliably.

Since the output of the mains transformer is not sufficient for directly generating the 48 V line for the microphone(s), a cascade network, D_{16}-D_{17}-C_{41}-C_{42} is used to boost the voltage across the bridge rectifier to about 70 V (open-circuit). This is reduced to +48 V by the combination of regulator IC_5 and preset P_2.

Diode D_{18} functions as on/off indicator.

CONSTRUCTION

It is obvious that in view of the very low a.f. input signal levels it is desirable to isolate the amplifier from the power supply, and this is why the printed-circuit board in **Figure 2** consists of two parts that should be separated before any construction work is commenced. In the final assembly, the two boards should be kept apart by at least 20 cm (8 in).

The construction itself is fairly straightforward, but a few points need to be borne in mind. Switches S_1 and S_2, if used, may be connected via 4-pin SIL headers.

In the same way, volume control P_1 may be connected via a 6-pin SIL header. Again, not everyone may deem this control necessary. When the amplification, and therefore the value of R_9 (and R_{26} in the right-hand channel), has been determined, the control is not really required, since the volume is set on the mixer panel or power amplifier. To enhance the signal quality it is then better to omit P_1 and, to protect the outputs, connect a 100 Ω resistor between pins 1 and 2 and 4 and 5 of the SIL connector.

It is advisable to house the power supply section in a well-insulated plastic (*Acrylonitrile-Butadiene-Styrene* – ABS) case.

The mains cable should be provided with a strain-relief.

The amplifier section is best housed in a metal case. The case should be connected to one of the earth connections on the amplifier board.

Finally, to keep any induced noise and interference to an absolute minimum, intertwine the three wires of the ±18 V line and earth, and the two wires of the +48 V line and earth.

[970083]