Application Report
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Phantom Power with Operational Amplifiers

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ABSTRACT

Phantom power is a technique often seen in professional audio equipment to provide power to a microphone or other active signal sources, using the same connections that carry the audio signal. For this application an XLR cable carries a 12-V, 24-V, or 48-V phantom power to the microphone as well as carrying the differential output signal to an operational amplifier. This app report focuses on 48-V phantom power for audio applications.

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Trademarks

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1 Why is it Called Phantom Power?

The two pins that carry the differential audio signal, the 'hot' and 'cold' pins on an XLR, are set to the same potential. Therefore, a balanced dynamic microphone would not be effected by the phantom power because the equal voltages on the hot and cold pins have no current flow between the two pins. This is referred to as phantom power because the voltage does not affect the devices that are not using the supplied power.

2 Microphones

Microphones convert sound waves into electrical signals through the help of a transducer element. The transducer element for a dynamic microphone has a diaphragm, voice coil, and magnet. The voice coil is connected to the diaphragm and runs through the magnet. As the diaphragm moves up and down the voice coil generates varying levels of current. For this reason a dynamic microphone does not require phantom power.

The transducer element in a condenser microphone is composed of a diaphragm and backplate. Both of these elements must be electrically charged for the microphone to work. However, the condenser microphone, in most cases, does not provide this electrical charge and the power must be sourced from an external supply. This is where the phantom power comes into play.

Phantom power is commonly used with condenser microphones, and with DJ controllers, mixers. control surfaces and other audio equipment that is associated with condenser microphones. Phantom power eliminates the need to connect a battery source to your microphone or to run a secondary power cable to the microphone.

3 How Phantom Power Works (Supply Side)

The input circuitry of a typical mixing console includes the phantom-power-injection circuitry and an instrumentation amplifier. Both signal conductors are connected to the 48-V phantom power supply through 6.8-kΩ resistors. These resistors limit current in the event of a wiring fault, and they must be well matched to maintain good common-mode rejection and noise immunity. Usually a switch is provided on the mixer to allow for the phantom power to be turned off or on as desired. Capacitors on the inputs of the amplifier block the DC common mode voltage from the phantom power source. The 3.3-kΩ resistors on the input of the amplifier provide a path for the bias current to flow to ground. By changing the value of R_G the gain of the amplifier can be controlled.

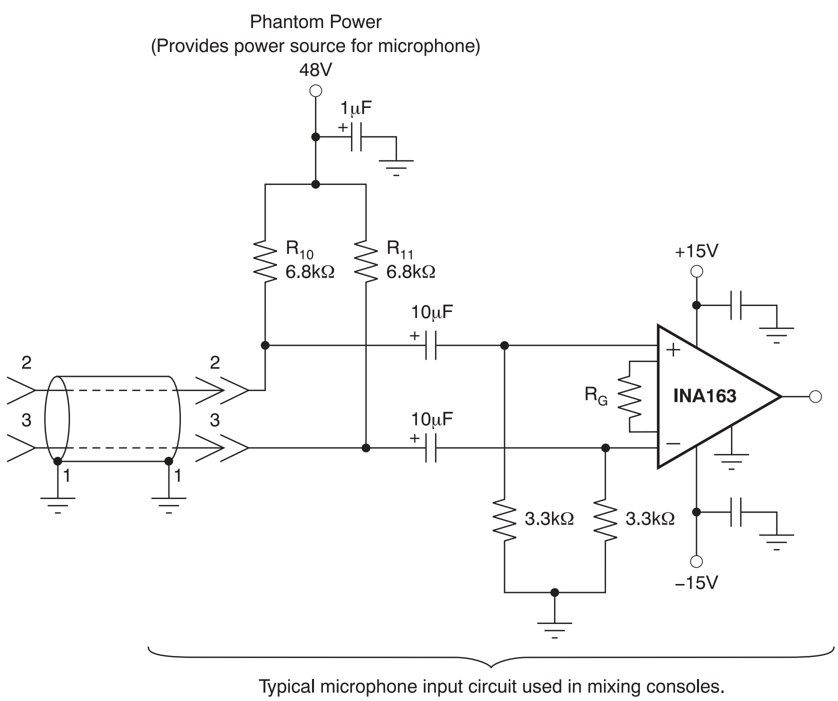

Figure 1. Supply Side

4 How Phantom Power Works (Load Side)

The schematic of a typical phantom-powered electret microphone is shown in Figure 2. Resistors R8 and R9, combined with Zener diode D1, create a simple voltage regulator, dropping the 48-V phantom power to around 5 V to power the op amps in the microphone. Capacitors C2 and C3 isolate the op amp outputs from the 48-V phantom power, while maintaining signal coupling at AC. Here the OPA1671 serves as a single-ended input to a differential output amplifier with a 6-dB gain. The common-mode bias for the two op amps is provided by the DC voltage developed across the electret microphone element.

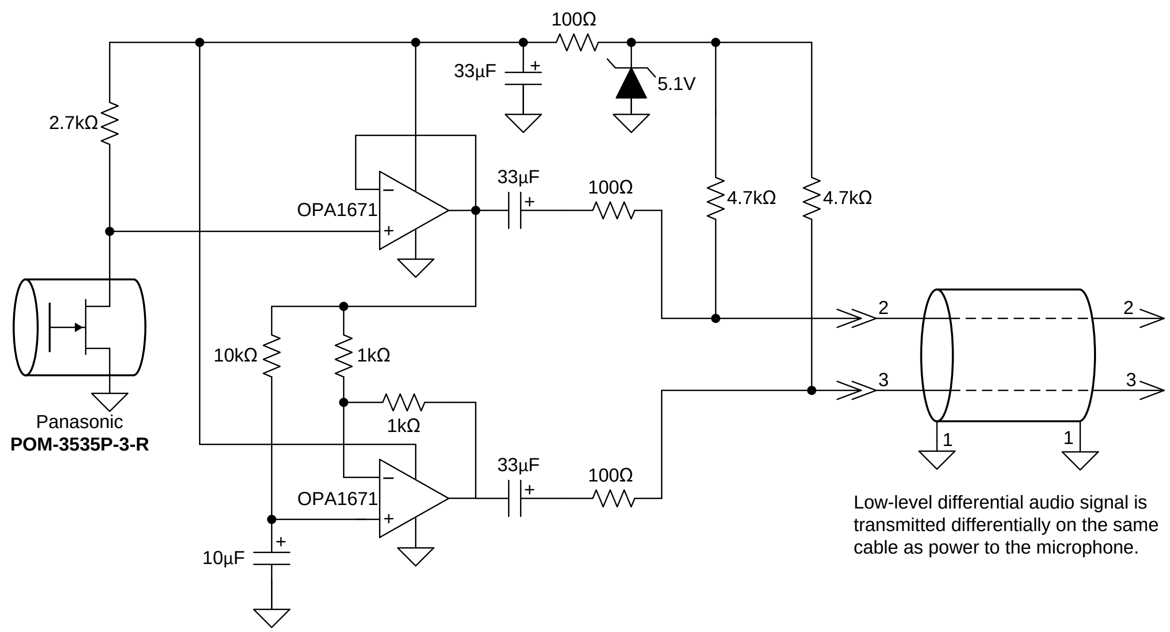

Figure 2. Load Side

Table 1. TI's Electret-Mic Audio Amplifiers

DEVICE	OPTIMIZED PARAMETERS
OPA1671 1.7 V < V_S < 5.5 V	GBW: 12 MHz, 5 V/µs, 0.00035% THD + N at 1 kHz, 6 nV/√Hz, RRIO
OPA1692 3.5 V < V_S < 36 V	Burr-Brown™ Audio, 140 dB CMRR, 23 V/µs, 4.2 nV/√Hz, RRIO
OPA1678 4.5 V < V_S < 36 V	GBW: 16 MHz, 9 V/µs, 0.0001% THD + N at 1 kHz, 4.5 nV/√Hz, RRO

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (November 2018) to A Revision **Page**

- Changed "OPA2376" to "OPA1671" in *Section 4* and Figure 2 3
- Added Table 1 3

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