MACKIE®

Balanced Lines, Phantom Powering, Grounding, and Other Arcane Mysteries

LOUD TECHNOLOGIES INC.

Balanced Lines

Balanced lines offer increased immunity to external noise (specifically, hum and buzz). Because a balanced system is able to minimize noise, it is the preferred interconnect method, especially in cases where very long lengths of cable are being used. A long unbalanced cable carries with it more opportunity for noise to get into a system – having balanced inputs means very little noise will enter the system via snakes and other cables that typically must run a long length. But regardless of length, balanced lines are best.

Phantom Powering and Microphones

History

Condenser (capacitor) microphones differ from dynamic and ribbon microphones because they are not self-generating. That is, they cannot generate electricity in response to an impinging sound wave. A condenser microphone modifies an external source of electricity to reflect the effects of a sound wave striking its diaphragm.

Dynamic and ribbon microphones use magnetism to generate electricity in response to a sound wave: they are self-generating. Furthermore, both of these types of microphones are inherently low-impedance devices. It is possible to connect a dynamic microphone element directly to a balanced, low-impedance mixer input. Many commercially made dynamic microphones do just that.

On the other hand, a condenser microphone is an inherently high-impedance device. How high? Verrrrrry high. On the order of a billion ohms (1 Gigaohm). This is high enough that the inherent capacitance of a foot of shielded cable would audibly reduce the output of the microphone. All condenser microphones have an impedance converter, in the form of a vacuum tube or field-effect transistor (FET), built into the microphone and located extremely close to the microphone element. The impedance converter and the microphone element itself require an external power source.[1]

PHANTOM POWER DO & DON'T CHART

DO	DON'T
If you are plugging in a condenser microphone, do verify that your microphone can be phantom powered.	Don't worry about your other microphones as long as their outputs are balanced and floating.
Ensure that the microphone's output is low impedanced, balanced, and floating. This is especially important for vintage ribbon microphones like the RCA 44BX and 77DX.	Don't connect microphones or devices that do not conform to the DIN 45 596 standard.
Mute the sound system when turning the phantom power on or off, or when connecting or disconnecting microphones. If you forget, the resulting loud POP may be your last.	Don't connect A-B or T-system microphones (another remote powering system) without suitable adaptors.

1. To be strictly correct, electret condenser microphones are a bit different, as the microphone element does not require a power source for operation (it is more or less permanently self-polarized). Regardless, the impedance converter still requires an external source of power.

What is it, exactly?

The obvious external power source for any modern microphone is a battery. About the only electronic advantage that a battery has is that its output is pure DC. The only other advantage is to the battery company – you have to keep on buying them.

Tube microphones require several different voltages for operation. This invariably means a multiconductor cable and nonstandard (not XLR) connectors. A tube microphone will always have an associated external power supply.

In the late 1960's, Neumann (you know, the folks that brought you the U47 and U87 microphones) converted its microphones to solid-state, adopting a system of remote powering that they called, and trademarked, Phantom Powering. Because of the trademark, some manufacturers use terms like Simplex Powering, etc. Over the years, the trademark has become genericized and now refers to any device that is powered according to DIN standard 45 596 (or maybe it's DIN standard 45 595, we're not exactly sure…).

So, why "Phantom" Powering? Because (like the Phantom in the old comic strip) it's there when you need it, and invisible when you don't. This technology is not new; it actually predates rocket science. Like many other things in audio, it was brought to you by the telephone company, who used it to get an extra circuit from a pair of wires. In effect, so does your phantom powered microphone.

What is important is: phantom powering is a compatible system. Your dynamic/ribbon microphones as well as your condenser microphones work side-by-side, from the same microphone inputs, without further thought on your part.

Technically speaking, phantom powering refers to a system in which the audio signal is applied to the balanced line in differential-mode, and the DC power is applied common-mode. The audio travels via pins 2 and 3, the power travels between pins 2 and 3 simultaneously, and pin 1 is the ground for both audio and power.

Microphones that do not require power simply ignore the DC present between pin 2/pin 3 and pin 1. If you measure with a voltmeter between pin 2 and pin 3, you will read 0 Volts DC. This is what your dynamic microphone sees. Measuring between pin 2 and pin 1, or between pin 3 and pin 1, you will read the phantom power voltage, usually 48V, without a microphone connected. The dynamic microphone, as well as your balanced mixer input, ignores this voltage.

Lately, the term phantom power has been perverted to refer to any remote powering system. In the strict sense of the DIN standard, this is not true. Furthermore, microphones or transducers that claim to use this system are not compatible with the DIN standard and will almost certainly be damaged if connected into such a system. Fortunately, these systems use tip-ring-sleeve phone plugs or miniature XLR connectors and they are usually associated with instrument pickup applications.[2]

Phantom powering is defined in DIN standard 45 596 or IEC standard 268–15A. Your Mackie Designs mixer conforms to this standard.

What works?

To be compatible in a phantom powered system, a device (microphone, preamp with a microphone-style output, or direct box) must have a balanced and floating, low-impedance output. This includes all microphones commonly used for sound reinforcement and recording, such as the Shure SM58, SM57, Electro-Voice RE-15, RE-16, RE-20, ND series, Beyer M160, M500, AKG D224, D12, D112, and *many* others.

If you are fortunate enough to own any tube condenser microphones, such as the AKG C12, Neumann U47 or U67, these microphones may be connected in a phantom powered system and will operate without regard to the presence or absence of phantom power. They will always require their external power supply (which must be plugged in and turned on).

2. There is another remote powering system called A-B or T-system powering. It uses pins 2 and 3 to carry both power and audio. It is not compatible with dynamic microphones or phantom-powered microphones.

What doesn't work?

The list is short:

1. Microphones with unbalanced outputs.
2. Microphones with grounded center-tapped outputs. Many old ribbon microphones were supplied connected this way. Have a technician lift the ground from the center tap.
3. High-impedance microphones.
4. Microphones that exhibit leakage between pin 2 or pin 3 and pin 1. These microphones will sputter and crackle when phantom power is applied and will work fine when you turn off the phantom power. Get the microphone repaired.

Do's and Don'ts of Fixed Installations

If you install sound systems into fixed installations, there are a number of things that you can do to make your life easier and that increase the likelihood of the sound system operating in a predictable manner. Even if you don't do fixed installations, these are good practices for any sound system, installed.

1 Do use foil-shielded snake cable for long cable runs. Carefully terminate each end, minimizing the amount of shielding removed. Protect the exposed foil shield with shrink sleeving or PVC sleeving. Prevent adjacent shields from contacting each other (electrically). Use insulating sleeving on the drain wire (the one that connects to pin 1) to prevent it from contacting the connector shell.

2. Don't connect the XLR connector shell to pin 1 of the XLR connector (unless necessary for RFI shielding). Doing so is an invitation for a ground loop to come visiting.
3. Do ensure that your speaker lines and AC power lines are physically separated from your microphone lines.
4. If you use floor pockets, use separate pockets for inputs and speakers, or put the connectors on opposite sides of the box so that they may be shielded separately.
5. If your speaker lines run in the open, they should be twisted pairs, at least 6 twists per foot. Otherwise, run the speaker lines in their own conduit. (Of course, conduit is not too practical for portable systems, heh-heh.)
6. Minimize the distance between the power amplifiers and the speakers.
7. Use heavy gauge, stranded wire for speaker lines. Ideally, the wire resistance should be less than 6% (0.5dB power loss) of the load impedance. Remember that the actual run is twice as long as the physical length of the run. See below.

Maximum wire run in feet for 0.5 dB power loss				
wire gauge	res. per 1000 ft.	2 Ω	4 Ω	8 Ω
10	1.00	60	120	240
12	1.59	40	75	150
14	2.5	24	48	95
16	4.02	15	30	60

8. Ensure that the electrician uses the star-ground system for the safety grounds in your electrical system. All of the audio system grounds should terminate at the same physical point. No other grounds may come in contact with this ground system.
9. Ensure that the AC power feeds are connected to the same transformer, and ideally, the same circuit breaker.
10. Walk outside – look at the horizon, see any radio towers? Locate potential sources of RF interference and plan for them before you begin construction. Know the frequency, transmitter power, etc. You can get this information by calling the station. Remember that many broadcast stations change antenna coverage pattern and transmitter power at night.
11. Don't use hardware-store light dimmers.
12. Don't allow for anything other than microphone inputs at stage/altar locations. Supplying line inputs at these locations is an invitation for misuse. Make all sources look like microphones to the console.
13. Balance (or at least impedance balance) all connections that are remote from the console's immediate location.
14. If you bridge an amplifier, don't use ¼" phone plugs for speaker connectors.

Grounding

Grounding exists in your audio system for two reasons: product safety and noise reduction. The third wire on the power cord exists for product safety. It provides a low-resistance path back to the electrical service to protect the users of the product from electrical shock. Hopefully, the resistance to ground through the safety ground (third wire) is lower than that through the user/operator to ground. If you remove this connection (by breaking or cutting the pin off, or by using a 'ground cheater'), this alternate ground path ceases to exist, which is a safety hazard.

The metal chassis of the product, the ground connections provided by the various connectors, and the shields within your connecting cables provide a low potential point for noise signals. The goal is to provide a lower impedance path to ground for noise signals than through the signal wiring. Doing so helps minimize hum, buzz, and other extraneous non-audio signals.

Many "authorities" tell you that shields should only be connected at one end. Sometimes this can be true, but for most (99%) audio systems, it is unnecessary. If you do everything else correctly, you should be able to connect every component of your audio system using standard, off-the-shelf connecting cables that are available at any music store.

Here are some guidelines:

1 All return lines to the stage should be balanced. At a minimum, they should be impedance balanced. Remember that you can balance a line by inserting a piece of equipment in-line that has a balanced output.

2. Run your own AC power wiring from the stage for the mixer and related equipment. Don't use the "conveniently located" receptacle thoughtfully provided by the management for your use. You have no idea how it's wired or grounded.

3. Carry an outlet tester, available at any well-stocked hardware store. Use it to tell you if the outlet you're about to plug into is wired correctly. Consider it cheap insurance.

4. If you carry enough equipment that you need to wire directly into the electrical service, then use a voltmeter to ensure that the line voltage is correct, then use the outlet tester mentioned in #3, above. Do this before you connect any of your audio equipment. Chances are that your 120V gear won't be too happy if it sees 220V for any length of time.

5. Cables that are too long are less likely to pick up hum if you uncoil them in their entirety, and then find a place to stow the excess. Leaving the excess coiled only helps the cable pick up hum more efficiently.

6. Don't run unbalanced lines to or from the stage. It's not the impedance, it's the fact that they're unbalanced. It's a good idea to use a direct box to make the unbalanced source look like a microphone.

7. For really extreme cases, you may need to insert 1:1 or isolation transformers into each return line from the front-of-house location to your amp racks.

8. Don't cut the third pin off of the power cord. Carry some ground-lifter adapters and use them only when you have to plug into an ancient two-wire outlet.

9. If you bundle your cables together, don't bundle AC wiring and audio wiring together. Bundle them separately.

10. If your sound system insists on humming, you may need to teach it the words.

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