Phantom Power

Simple Solution or Convenient Compromise?

Any engineer who has spent hours hooking up tube mics to power supplies realizes what a time saver phantom power is. It's convenient to plug in a mic and have it immediately powered up. And what an ingenious solution it is too, using the audio cabling to carry the power for the mic. It seems like a perfect system. Or is it?

Most of us don't spend a lot of time thinking about phantom power. Unless you're plugging in ribbon mics, you may not even notice if it's on or off. Let's talk about this most common microphone powering system, its history, implementation and whether it's everything we think it is.

From whence came the phantom?

Phantom power, or simplex power as it was called, originated back in the early days of the telegraph industry. According to Chris Woolf of Rycote "Telegraph engineers realized that they could treat a balanced pair as a single conductor and, using a separate ground, create an additional circuit without any extra wires." Pretty neat trick, eh? According to Greg Gualtieri of Pendulum Audio (www.pendulumaudio.com), the Bell System then adapted it to power the carbon mics and ringers for the original telephones. The beauty of the system was that it worked with only two wires coming into the home, and no separate ground was needed and the voltage was low enough not to pose a threat to customers. It was a pretty elegant solution.

Put a phantom powering schematic diagram here, based on the one I sent him.

Fast forward to 1966. Ribbon mics, dynamics and powered tube mics are the mainstay of the recording industry. But a new type of mic, the solid state mic, has appeared on the scene. In order to power these mics, without using an individual supply like each tube mic requires, Neumann GmbH considers two alternatives: T-power (or AB or parallel power) and Phantom power. Since you likely never have heard of the first one, it should be pretty evident which system won. (A-B Power, which uses 12V, is still commonly used in the television and motion picture industries today.) While experiment with powering systems, Neumann consider different voltage standards as well. Oliver Archut, of AMI Tab-Funkenwerk (www.tab-funkenwerk.com) who hails from "the old country," recounts it this way. Neumann considered many different voltages, from 12, 24, 48 all the way up to 103V. The primary goal was trying to implement the new standard without having to change the existing infrastructure of cables, connectors, etc. The design engineers realized that higher voltages would be better, but an order from the Norwegian Broadcasting Network cinched the standard. The Norwegians were changing all their mics to solid state and wanted to power them with their existing 48V system that would also be safe for the technicians. So Neumann filled that order and we've had 48V phantom power ever since. According to Archut, we got the best of the worst.

Why would anyone think that 48V phantom power is a problem? It always seems to work and is easy to use. It's a standard, right?

Convenience or Fidelity?

According to many preamp and microphone designers I have spoken with, the decision to use 48V phantom was a "compromise of convenience," not sonic fidelity. (Does that sound familiar?) According to Archut, the German Institute of Broadcast Technology (IRT or Institut für Rundfunk GmbH, the audio gurus in Germany from 1940 to 1975), rejected Neumann's +48V phantom system because it was a sonic compromise. They never adopted it. Ever heard of a Neumann U77 or KM74 (kin to the ubiquitous U87 and KM84)? These were the non-phantom powered versions of the same mics that used standalone power supplies. You may wonder, as I did, how could this system be such a compromise when everyone in the world has adopted it and it seems to work fine.

There are several inherent problems with the phantom powering system as it pertains to high fidelity audio. First 48V is too low. The original preference from Neumann was a system with 70-80V. 48 volts, in the opinion of the mic manufacturers I've spoken with, is inadequate for the polarization voltage of (non electret) condenser mics. While 48V is considered adequate for the head amp (the amp inside the mic that interfaces the mic element with the outside world), it doesn't have enough juice for the capsule.

Standard? Which one?

Another problem is that some manufacturers don't adhere to the 48V standard for phantom power. Phantom voltages of 12, 15, 18, or 24V are not uncommon. Even one of the most prolific console manufacturers has a phantom system that only puts out 41V. Why is that a big deal? If manufacturers are making consoles with 15V phantom, then the mic manufacturers are compelled to make sure their mics work in the greatest number of situations, so they aim for the lowest common denominator in order to not lose sales. They have to make sure their mics will still work even running on 15V power. That in turn means compromises in the design stage. Not just for cheap mics but for every mic that might get plugged into a 15V supply, which is usually everything they make. Do you want a mic that is designed to work even on the lowest possible voltage or one that is optimized for the best sound?

Greg Gualitieri commented "I don't know any recording gear manufacturer that would allow a third party to design the power supply for their gear. It's simply too important to the sound. So why should condenser microphones be any different?" So if the power supply is running at a a lower voltage, what impact does that have? First, headroom of the mic will be compromised from the stated spec. Distortion figures will likely increase. Noise figures may increase depending on the circuit design. The overall capabilities of the mic will be compromised. Is that what you want from your expensive condenser mic? So if a tube mic has a power supply designed specifically for it and solid state mics just get whatever phantom is available, how much of the difference we hear between tube mics and solid state mics is attributable to the differing power supplies? I don't know the answer to that question yet.

Oops! Don't forget the phantom.

For many console or preamp designs, the phantom power circuit is not given a lot of thought. It's just tacked on at the end. Archut observes that "phantom is treated as a stepchild." Why else would a console manufacturer have a 41V phantom supply instead of 48V? Because, instead of spending another $10 for a transformer with a 48V tap, they will use an inexpensive voltage doubler circuit on the ac voltage used for the+15V supply so that it can also be used for phantom, which results in 41V. But compromising the phantom voltage by 15% means starving the mic of the voltage it needs, which in turn means compromised headroom and distortion. Now multiply that by a dozen or more condenser mics and clearly you aren't getting the performance you expected from your condenser mics.

How about the power supply design itself? Does it have adequate reserves to handle as many condensers as you might plug in? When phantom power was first standardized, an upper limit of 2mA (milliAmps) of current was established as the guideline, but some mics today can draw as much as 10 mA. What if the designer spec'd the system to provide current for 20 condensers at 2mA each (40 mA), but you plug in 8 mics that each draw 10 mA? In a situation like a big explosive drum hit with kick, snare and cymbals, will that supply be able to provide all the current the mics need to keep up with the dynamics of the drummer? Maybe, maybe not.

One bad channel can spoil the whole bunch, girl...

What about the interaction between channels of the mixer? If one channel is shorted (Pin 2 or 3 to 1), say by a bad cable or mic, what happens to the current available to the other mics? If the power supply is not hefty enough to keep up, then every mic's performance will be compromised. And you may not even be using that mic or that channel. It's just sitting their draining the power supply reserve.

Did you know that every time that a condenser mic is plugged into a phantom powered input with a transformer that there is a short duration microblast of voltage that is destroying the insulation of the transformer's secondary? I surely didn't. According to Archut, the transformer dies over time due to this action which takes place multiple times a day in most studios. He should know. He rewinds transformers for vintage preamps, like the Telefunken V72 and V76s. "People buy these vintage modules and strap a phantom supply on them (since they were designed without phantom) and then wonder why they have to have the transformers replaced or rewound. I see it all the time."

When I first heard about this, at the Preamp Designer's Summit I hosted in Nashville last year, I was shocked. Since then, I have spoken to at least a dozen mic and preamp manufacturers who all agree that the phantom powering system that we now use is seriously compromised and that we pay for it with compromised sound. I was never aware that something so fundamental and commonplace as phantom power could be diminishing

my recordings from the time I plugged in a mic. As engineers, we spend so much time and energy sweating over all the details from mics to cables to connectors to preamps to converters to speakers to recorders to dither to jitter to clocks. Is it possible that a design decision made years ago and forgotten is compromising all the work that we do with condenser mics? I don't know about you, but I use a lot of condensers. Is there anything we can do about this?

What's a mic to do?

Well, the good news is that there are options, although they're not easy or inexpensive. Probably the biggest proponent of increasing power voltage for mics is DPA (formerly B&K) with their high voltage powering system, spec'd at 130V. All of their studio mics use a 200V backplate voltage for the capsules, and some use a 130V supply for the head amp. By increasing the voltage available to the mic, they are able to take some already impressive specs for their 48V 4006 mic and make them even better in their 130V 4003 (Maximum output voltage 3.5V vs. 50V, headroom up from 14 dB to 25 dB, and maximum SPL handling up from 143 dB SPL to 154 dB SPL, respectively). According to DPA's Bruce Myers, DPA is the only manufacturer in the world making 130V mics. Many engineers who hear the difference become high-voltage converts and they've convinced several preamp manufacturers (Millennia, Grace, Avalon, along with DPA) to make preamps capable of 130V power for these mics. These mics use a modified 3-pin XLR so it is still a phantom configuration but you can't plug in a standard XLR cable and destroy your 48V mics. DPA also uses a 6-pin system for their 4041 series (130V preamp/200V backplate), which allows the audio to travel on dedicated lines while keeping the supply voltages on separate lines.

But are there other options, short of replacing your mics? Greg Gualtieri rebuilds his mics so that they use 5 pin XLRs so the power supply voltage doesn't have to piggyback on the audio lines. He also makes dedicated power supplies for his condensers, designed to satisfy their needs. He believes using dedicated supplies, just as we do with tube mics, can make a big sonic difference even staying at 48V. He has also been known to replace the head amp when he feels the original design was compromised to accommodate lower voltages. He believes that if mic manufacturers would quit compromising their designs to accommodate lower voltages than 48V, then maybe cheaper consoles and preamps with lower phantom voltages wouldn't be able to power some desirable microphones, and manufacturers would have to put in solid 48V supplies.

Oliver Archut's solution for transformer corruption, which he has adopted in all his preamps, uses a 48V power supply that ramps up slowly on power up and protects the output transformer from unnecessary stress and helps extend its life. "$25 worth of parts can save you a $300 rewinding fee." One other benefit is that you don't hear that huge pop in the speakers when you turn on phantom. He just wishes everyone else would follow his lead.

What about budget solutions?

So, you're convinced that our current system may be insufficient but you don't have the money to A) replace your mics, B) rebuild your mics or C) buy or rebuild your preamp collection. What else *can* you do?

There are three solutions that you might try, which are a little easier than Archut's initial suggestion. "If someone has a console with 41V phantom, they just need to dump it and get a different console." The first option is using standalone preamps with sufficient phantom powering. Quality preamps should not have compromised phantom supplies. But what if you need phantom for 24 mics? Then the option is to have a technician build a solid, high current capacity +48V power supply which can be added to your existing console. It will require modifying the internal wiring (not a lot) and another plug in the back of the console for the external phantom to come in. I have done this before and it is a very good option and not terribly time consuming or expensive. Finding someone qualified to do it should not be that difficult. The third option is to buy an external phantom supply that your microphones plug directly into and then the mic level audio goes straight to your console/ preamp. These standalone phantom supplies are readily available from companies like Audio-Technica, AKG, Shure, Neumann, Rolls, ART and Crown. They can be battery powered or AC powered and cost as little as $35, although the cheaper ones might not be an improvement over existing powering. (Some use 9V batteries for power.) A unit like the A-T 8056 (shown here) offers 120V powering, a highly regulated power supply, steel case to provide shielding from electrostatic interference, 4 inputs, +48V output at a current of 14mA per channel, and it costs about $150 (street price).

A-T 8056

Bio: Lynn Fuston is eager to get into the studio with some 130V mics and preamps and do some comparisons.

Sidebar 1

Our authorities this month include:

Oliver Archut
AMI Tab-Funkenwerk
www.tab-funkenwerk.com

Greg Gualtieri
Pendulum Audio
www.pendulumaudio.com

Bruce Myers
DPA Microphones
www.dpamicrophones.com

Chris Woolf
Rycote Microphone Windshields
www.microphone-data.com

Sidebar 2

If you are not familiar with the fundamentals of phantom powering, I'll go over them briefly. (This is not Electronics 101.) Balanced mics carry the audio signal on pins 2 and 3, with the ground on Pin 1. To get the voltage to the condenser mic without adding extra conductors in the cable or pins in the connector, phantom power applies +48V to both pins 2 and 3 through 6.81KΩ resistors. This way, when the preamp adds the opposite polarity audio signals from pins 2 and 3 together, the +48V is cancelled out, leaving just the audio. (See. That wasn't too painful.)

Sidebar 3 (optional)

For more information on this subject, check out:

Jörg Wuttke: The Feeble Phantom–http://www.microphone-data.com/pdfs/The%20feeble%20phantom.pdf

DPA Microphones: Hi-voltage vs. Conventional Powering Methods–http://www.dpamicrophones.com/page.php?PID=34

Chris Woolf: Microphone Powering–http://www.microphone-data.com/pdfs/Powering%20mics.pdf

A different opinion from Chris Woolf, just to keep things balanced and interesting:

The things to think about are both voltage ~and~ power. The 48V system was and is a compromise, but no more so than almost everything in electronics. If you use a 200V powering system you have to worry about safety and incompatibility. It also uses oodles of watts and is entirely impractical for use on location. P48 is remarkably good but, yes, you can pick a few holes if you want to.

The existence of consoles not providing adequate voltage or current to cope with a written standard (and it is absolutely defined) is a failure of customers as much as manufacturers. If you didn't buy one that complied, more fool you (I'm talking third party, not being personal!). One of my complaints is that buyers often display appalling judgement and don't read specs or demand them - this sort of thing is an excellent case in point. If all buyers only bought a mixer that had AES standard phantom power there wouldn't be any rubbish ones on the market. They buy cheap instead of wise, and they pay the price.

The only standard voltages are P48 and P12. The P24 version is obsolete. None of the other versions are graced with any legality. The non-standard high voltage DPA supply does allow extremely high SPLs but these are only possible with small diaphragm capsules. Large diaphragm capsules would be flapping on their back plates long before they reached those sort of levels. It's actually a hangover from B&K days when they used these sort of mics for measuring very high amplitude noises like gunshots. Mostly 150+dB SPL is not something we concern ourselves with very often because we probably wouldn't have any hearing left if we did.

The compromise of 48V is not as severe as all that either. Capsules are rarely biased directly. In practice a DC converter provides the 60V or whatever that is required allowing a well-stabilised supply that is not dependent on the actual volts delivered at the mic - which will more likely be 35-40V because of the potential divider action between the phantom resistors in the supply and the mic body. What is needed is enough volts to give the output amp rail room on Max SPL swings. With a Class A amp this must be enough for the overall peaks, positive to negative. Transformer output mics can't deliver as much wellie (*Editor: "level" for us non English-speaking Americans*) due to winding limitations so this is usually only a problem with bipolar output mics.

The power problem comes from the limiting resistors (6k8) which prevent excessive current (max 10mA). This also limits the power that the microphone can deliver into a line. Ideally the mic is low impedance and able to drive long cables - but Ohms law demands that low impedances must deliver more current to provide the same voltage. So good low Z output mics that are immune to long cable runs and dodgy mic pre input impedances also tend to want more power. 4mA is becoming common. A few still want the full 10mA but that is really asking for trouble.

The worry about damaging transformers with phantom is not that big a problem either. It is true that very old mic transformers with very fragile shellac insulation never expected to have any voltage stress on their windings. But it really only applies to a handful of antiques. 48V is not a vicious voltage and, delivered via current-limiting resistors, it doesn't strain many things. Indeed the presence of the 6k8 resistors means that there

is a marked ramping effect due to the mic powering capacitors charging whatever happens. You don't really need to pay for an exotic supply to do it.

The 5-pin approach doesn't fill me with much joy either. Good phantom is a very elegant technique that is hard to improve upon. If you looked at a Schoeps design that can work off P12 or 48 you might think "the original design was compromised to accommodate lower voltages". Believe me, it wasn't. The powering configuration senses the different powering requirements and changes its configuration. I think it's better to use a good P48 supply than to modify the mic to use an external supply with all the problems of grounds at different 0V references.

You can certainly find instances when mic powering is a problem - but you can also find a myriad of ones where the fundamental phantom is fine but the way the mic is cabled or split is actually causing the audible effects. As with all these things there is no better solution than to understand properly!