Why Many Condenser Mics Are Too Bright and Sibilant

September 04, 2015 by Michael Joly Engineering

It's a common complaint on gear forums - "My condenser mic is too bright and sibilant!"

There's a good reason. Many new, inexpensive, large diaphragm condenser (LDC) mics use the wrong capsule and circuit combination. A particular capsule and circuit type are used together to reduce manufacturing costs - not because they sound good together.

Before I describe how perfectly fine capsule and circuit types can produce excessively bright and sibilant mics when used together, I'll back up and talk about analog audio noise reduction. We need to understand the design of the venerable Neumann K67 capsule used in the U 87 microphone - because misuse of the K67 type capsule creates excessively bright and sibilant LDC mics.

The Need For Noise Reduction -

Unlike modern 24 bit digital recording and transmission with a theoretical 144 dB dynamic range, early AM broadcast transmissions had a dynamic range of 30 dB. This meant a signal to noise ratio of only 24 dB (allowing for 6dB of peak amplitude above

average level).

A 24 dB signal to noise ratio is quite poor - voices are intelligible, but shrouded in noise. So early recording and broadcast equipment designers sought ways of improving the limited S/N ratio available at the time.

These designers were aware that speech and music has less energy in the high frequency range relative to the low and mid frequency range. In other words, the energy distribution found in speech and music declines with frequency. This fact offers an opportunity.

Declining amplitude vs. frequency makes it possible to add high frequency equalization during recording or broadcast (commonly known as high frequency pre-emphasis) without overloading the recording or transmission medium.

Upon reception of the broadcast, or playback of the recording, the high frequencies are attenuated by a “de-emphasis” circuit in the receiver or “record player”. This high frequency de-emphasis restores the original timbre balance of the program material and simultaneously attenuates the noise of the recording or transmission medium. Thus analog “pre-emphais / de-emphasis” noise reduction was born.

In later years, complimentary pre-emphasis / de-emphasis noise reduction would be augmented with dymanic range “companding” (encode compression followed by decode expansion) as found in the Dolby and dBx noise reduction systems. This allowed for even more S/N ratio improvement. But in this article we’re concerned only with high frequency pre-emphasis and the need for complimentary de-emphasis.

Fast forward to the Neumann U 47, U 67 and U 87 microphones - After the success of the U 47 and M 49 microphones with pop singers like Nate King Cole, Frank Sinatra and Barbara Streisand, Neumann answered a need for a mic that could handle a new, louder genre - rock n’ roll, but also offer an improved signal to noise ratio for those quieter genres as well.

Neumann engineers noticed young rock n’ rollers worked very close to their vocal mics to gain intimacy and presence. Of course working a cardioid condenser like the

U 47 at close range can produce too much bass proximity effect. So the U 67 was designed to have less bass boost, when worked close, compared to the U 47 worked at the same distance.

And to push the technical envelope further, Neumann developed a microphone topology that would improve the S/N performance of their newest mic, the U 67, compared to the U 47 - they used a high frequency pre-emphasis / de-emphasis noise reduction strategy within the U 67 (and later, within the U 87).

To achieve HF pre-emphasis, Neumann designed a new capsule, the K67, with a built in HF boost. The capsule itself provided HF pre-emphasis of program material. The HF-boosted signal from the K67 capsule was then fed through the tube impedance converter stage and then on to the output transformer of the U 67 mic where HF de-emphasis via negative feedback and low pass filtering restored the original timbre balance of the program material and simultaneously attenuated tube noise.

A similar HF pre-emphasis / de-emphasis topology was used in the subsequently introduced U 87 microphone - the most recorded microphone in the history of pop music. It is the ubiquity of the U 87 and its status as a “go to” microphone that set the stage for the excessively bright mics that would appear later on.

Mis-application of the Neumann K67 type capsule -

Let’s take our time machine back to cold war era China - set the controls for Beijing, 1952.

Chinese condenser mic manufacturing in China started when then East German microphone engineers (the “Gefell branch” of the Neumann family) introduced Neumann capsule and mic designs to the Chinese as part of a technology exchange program between those comrade countries.

Chinese mics of this era, built by the grand daddy of Chinese mic manufacturers - Beijing 797 Audio, were U 87 clones that used the K67 type capsule and proper HF de-emphasis circuit.

Time travel forward to the home recording era of the early 2000s. With the burgeoning of home recording, many Western "re-branders" and re-sellers of Chinese-built mics demanded lower prices from their Chinese suppliers in order to hit the very low price points demanded of them by major retailers like Guitar Center and its Musician's Friend division.

One way to reduce mic manufacturing cost is to eliminate the expense of a high quality output transformer. The circuit can be changed to a much less expensive transistorized, transformer-less topology and a substantial manufacturing cost eliminated.

More fine German engineering goes to China - enter Schoeps

Looking to replace expensive microphone output transformers, Western re-branders of Chinese mics hit upon the proven transformer-less circuit developed by Schoeps - the German manufacturer of premium microphones.

This clever, transformer-less, flat frequency response circuit (no HF de-emphasis network) was simplified somewhat and put into service in almost every low cost, Chinese-built condenser mic model.

But ... mics built using the flat response Schoeps circuit also used the now-standard K67 type capsule with its built-in HF pre-emphasis. The result - thousands upon thousands of excessively bright and sibilant mics.

The Schopes circuit, as fine as it is, does not provide HF de-emphasis (this circuit was designed to be used with capsules without a pronounced HF peak at 7-8 kHz and sounds wonderful with non-peaked capsules).

When a K67 type capsule is coupled to the Schoeps type circuit the result is brighter and more sibilant sound than what Neumann created with its own K67 capsule mics (U 67 and U 87) that used HF de-emphasis.

Let's recap the sequence of events that brought us to today's excessively bright and sibilant LDC mics.

Neumann developed the K67 capsule with a HF peak to provide the pre-emphasis portion of a noise reduction circuit (which would be de-emphasized at the output stage of the mic).

Cold war era German engineers introduced the K67 capsule and U 87 circuit to Chinese manufacturers who then made accurate U 87 clones.

Pressured by Western companies to reduce manufacturing cost of K67 type capsule mics, Chinese companies began making mics with a low cost circuit that did not have the HF de-emphasis needed to restore proper timbre balance of program material. Result - mics that are too bright and sibilant with an 8dB peak right in the middle of the sibilance range of 7-8 kHz.

For years inexpensive mics have been derided by recordists as “cheap Chinese junk” and have blamed the quality of the Chinese-built K67 type capsules. This blame, and the reason for excessive brightness has been misplaced.

The truth of the matter is, the Chinese-built K67 type capsules are decent copies of the Neumann K67 capsule design (and these capsules can be built to very tight tolerances and quality control standards if one is willing to pay the Chinese manufacturers to do so. But low end re-branders are not willing to do this).

The Chinese manufacturers only produced what their Western clients wanted - inexpensive K67 type mics. The cheapest way to do this was to eliminate an expensive microphone output transformer and use a low cost transistorized circuit instead (and yes, use lowest cost parts like cheap ceramic and electrolytic capacitors - even in critical signal path locations).

Apparently the Western re-branders didn’t care (or didn’t even know) there was a mismatch between the K 67 type capsule with its HF boost and the flat response Schoeps type circuit. It appears that offering $100 “looks like a U 87” mics trumped offering mics that actually adhered to the U 87 frequency response (not too mention parts quality and assembly quality control standards).

What to do about LDC mics that are too bright.

There are two possible solutions - change the circuit or change the capsule. Let's look at both approaches.

If a mic's stock K67 type capsule is kept in place in a flat response Schopes type circuit mic, and one wants to hear a traditional U 87 timbre balance, then the mic's circuit needs to be changed. High frequency de-emphasis achieved through the use negative feedback and low pass filtering - as is done in the U 67 and U 87, must be retrofit to the mic.

To restore proper timbre balance requires a precise, complimentary notch filter designed to attenuate the unique peak of the K67 type capsule. A low pass filter (HF roll off) or simple capacitor value change will not suffice.

Simply rolling off the top end of a K67 capsule type mic leaves the 7-8 kHz K67 type capsule peak intact relative to the frequencies above and below (because the capsule's peak is a higher Q - a narrower bandwidth - than a low Q, simple RC low pass filter) — the mic will sound simultaneously dull on top (due to low pass filtering) but still have an offending 8 dB @ 7-8 kHz peak standing above the neighboring frequencies.

Proper modification of a flat response Schoeps circuit requires extensive and costly parts and labor changes - a nearly complete point-to-point, hand-soldered rebuild of the circuit in fact. This can be an a amusing and educational DIY project - there is a whole website devoted to such projects.

If a recordist was to retain the services of a professional electronics tech with familiarity with microphone circuits, the cost based on current bench tech rates to accomplish this change, to a single mic, would be exorbitant. Correct, (not taking any short cuts such as "cap swaps" in other words) professional re-design and re-build of a Schoeps type circuit is not really a cost effective solution for owners of these types of mics.

Beyond the costs involved, there is another compelling reason to leave the flat response circuit in place - sonic purity.

The flat response Schoeps type circuit has far lower phase shift than a Neumann style

high frequency de-emphasis type microphone circuit. The result, as noted by the legendary, late, microphone modifier Stephen Paul (in his seminal Mix Magazine article from the late 1980's, now sadly missing missing from the Mix Magazine website), is a smoother, less “fatiguing” / less “processed” sounding microphone. Minimal phase shift (no negative feedback, minimal band pass filtering) circuits are preferred by many listeners - the top was settled in favor of minimal phase shift circuits in the audiophile community years ago.

A better approach - change the capsule.

Given the expense associated with changing a flat response Schoeps type circuit into a Neumann U 87 HF de-emphasis type circuit, and given that the Schoeps type circuit is a proven design with lower phase shift and a less “processed” and more relaxed sound than a traditional U 87 pre-emphasis / de-emphasize circuit topology, it makes economic and sonic sense to keep the Scheops circuit intact and replace the K67 type capsule with a capsule designed to operate into a flat response circuit.

Unlike the K67 type with its pronounced HF peak, the earlier Neumann K47 type capsule has a much flatter response with just a broad and gentle presence “mound” in the upper midrange. A Neumann K47 capsule used with the flat response U 47 circuit is largely responsible for much of the “sound” of popular music recorded from the 1950’s to the present day.

Do It Yourself (DIY) Capsule Swap?

Lately, low cost Chinese K47 type capsules have appeared on the market and are being sold to DIY’ers as drop in replacements for K67 type capsules. If only it were that simple. It is true these DIY K47 type capsules have the correct frequency response to be coupled to the flat response Schoeps circuit. But in many cases, the Schopes type circuit also has a “voltage doubler” network (a means of raising capsule diaphragm polarization voltage to increase sensitivity and S/N within the mic). The voltage doubler circuit creates excessive polarization voltage for many DIY K47 type capsules.

The voltage doubling network is a clever and useful circuit - but it must be matched to a capsule that can support the higher diaphragm polarization voltage. The K67 type capsule commonly found in Schoeps type circuit mics with voltage doublers will support the higher polarization voltage.

But many DIY K47 type capsules will not support the higher polarization voltage found in inexpensive mics that use voltage doubler circuits. The diaphragm of these K47 type capsules will be partially, or in some cases, completely sucked onto the capsule backplate - distorted and thin sound with reduced output level is the result.

I've had many folks write to me asking for help troubleshooting their DIY K47 capsule installation. After I ask which capsule they used, and which mic they put it in, they are dismayed to learn they cannot simply drop that particular K47 capsule into that particular mic - without reducing the capsule polarization circuit in the mic in order to have this voltage fall within the maximum safe capsule polarization spec for their particular capsule.

Changing the mic to a K47 type capsule will correct a stock K67 type capsule / Schoeps type circuit mic's timbre balance. But the replacement K47 capsule will only function properly if it is designed to work with a correctly calibrated voltage doubler circuit.

I hope this has helped explain why so many low cost mics are too bright and sibilant in the 7-8 khz region and what can be done to improve them. - Michael Joly