"Good" and "Bad" Modifications to OPTIMOD-FM Model 8000A

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It has come to our attention that there are a large number of suggested modifications for the 8000A floating around the industry. The purpose of this white paper is to try to clarify which modifications are legitimate, and which will simply result in a degraded 8000A.

In general the "good" modifications either update the unit with IC's that were unavailable or unproven when the 8000A was designed, or else change the loudness/brightness/distortion tradeoff designed into the 8000A to make it more suitable for a given format or special situation.

The "bad" modifications usually result from ignorance or naivete. They are often IC replacements that either make no audible improvement or actually degrade certain aspects of the unit's performance (noise, or stability of 38kHz suppression, for example). Other modifications may result in the 8000A's performing poorly in high RF environments, or in other problems that were not immediately apparent to the engineer who first developed the modifications.

IMPORTANT!

IF ANY MODIFICATIONS ARE MADE, IT IS PARTICULARLY IMPORTANT TO FOLLOW WORKMANSHIP STANDARDS DESCRIBED ON P. V-4 OF YOUR **OPERATING MANUAL** ("Replacements of Components on Printed Circuit Boards").

IC Replacements

In certain times past, an almost hysterical concern was expressed over "Transient Intermodulation Distortion." This is distortion caused by the signal's being subject to slope overload or "slewrate limiting."

The 8000A, even in its earliest version, never subjected the signal to actual slewrate limiting anywhere in the circuitry. However, at certain points in the circuitry, the signal came close enough to the slewrate limit point to possibly induce "sub-slewing" TIM.

Before doing any modifications, it is useful to see if a signal degradation is due to audibly perceived TIM, or simply to the high frequency limiting and clipping required to accommodate the signal to the 75µs preemphasis while retaining competitive loudness. The latter is far more likely to be what you are actually hearing.

The best way to test this is to remove the 8000A from service. Place it in the production studio or other environment that has a good monitor system and that permits accurate A/B comparisons between the processor's input and its output. Connect the TEST jacks on the rear panel of the 8000A to the monitor switching system through a pair of *accurate* 75µs deemphasis networks. Play demanding music through the 8000A, and adjust the audio drive level into the unit about 2dB below the level where the meter first exhibits gain reduction. Put the 8000A in PROOF mode, defeating all HF limiting and clipping. *CAREFULLY* match monitoring levels between the console output and the 8000A output. (If levels are unbalanced by only a few tenths of a dB, this can introduce an apparent quality change.) What you are hearing when you switch to the de-emphasized 8000A output is now *only* the effects of any TIM or other distortion in the circuitry; your ear is not being fooled by processing effects or level imbalances. If you hear a significant degradation in TEST mode, and if you are convinced that you are not hearing the effects of the input transformers, then proceed with the chip changes. Otherwise, leave well enough alone!

To avoid any possibility of sub-slewing TIM, later production units of the 8000A were fitted with faster chips that had been introduced since the original 8000A design, and that had proven to be reliable. The

chips may be field-retrofitted into the *audio processing* part of the 8000A *only* (up to the "Audio Test Jacks"). Retrofitting the stereo generator demands that it be realigned. Most stations don't have the time, experience, or proper test equipment to do this right.

IMPORTANT

IF YOU REPLACE *ANY* CHIP AFTER THE 30MZ HIGHPASS FILTER (IC203, 204) MEASURE THE 38 KHZ SUPPRESSION ON YOUR CALIBRATED STEREO MONITOR, AND PERFORM THE "TOUCHUP ALIGNMENT" PROCEDURE ON P. A-1 OF YOUR **OPERATING MANUAL** IF SUPPRESSION IS LESS THAN –45DB.

4558: All 4558 dual opamps may be replaced with Texas Instruments TL072 or National LF353. The Signetics NE5530 is not recommended because it has a class-B-input stage.

Very early units used 1556 single opamps in a number of sockets. These may be replaced (in the audio processing section only) with Texas Instruments TL071 or National LF351. The Signetics NE530 is not recommended. (NOTE: middle-period 8000A's used RCA CA3140's in these sockets. These are fully adequate, and no benefit would result from their replacement.)

709: The uA709 opamps should not be replaced. They were chosen for low noise. In their specific circuit configuration, they do not suffer from slewrate limiting, crossover distortion, or other problems sometimes attributed to them. (A pulldown resistor to the –15 volt rail forces their output transistors into class-A operation.)

301A: The 301A's are compensated for a slewrate of 5V/µs. This is fully adequate and there is no need to replace these chips.

Input Transformer

It has been suggested that the input transformer be replaced with a differential amplifier. This is OK, provided that you know what you are doing. Any replacement must be a *fully balanced* instrumentation amplifier-type circuit with less than –123dBm equivalent input noise. In practice, such a circuit can be built with NE5532 or NE5534 opamps.

Be particularly careful about compromising the RF suppression of the unit when this is done. If your 8000A is located in a high RF field, be prepared to fail, and make sure that you can restore the original RFI protection if you can't get the instrumentation amplifier to work without buzz, noise or other RF problems.

A Painless Way to Defeat the AGC

Stations using external processing ahead of the 8000A may want to operate with the 8000A's own high frequency limiter and/or broadband AGC defeated. The HF limiter control loop senses the peak level of the *entire* pre-emphasized signal, and not just the high frequencies. The preceding broadband AGC precisely controls the low frequency levels presented to the HF limiter, preventing it from being activated by low frequencies. Therefore, to avoid having the HF limiter punch gross holes in the high frequency response due to overdriving with low frequency material, the HF limiter *must* be defeated if the broadband AGC is defeated. In turn, this means that you must rely on the external processing to control the HF energy applied to the 8000A's clippers to prevent audible sibilance splatter or other HF distortion.

To defeat the broadband AGC, simply remove IC202 and IC208 from their sockets. To defeat the HF limiter, remove IC213 and IC214 from their sockets.

High Frequency Limiter Headroom Modification

The more headroom between the broadband limiting threshold and the HF limiting threshold, the less hard the HF limiter will work, and the brighter the sound will be. On the other hand, loudness will decrease.

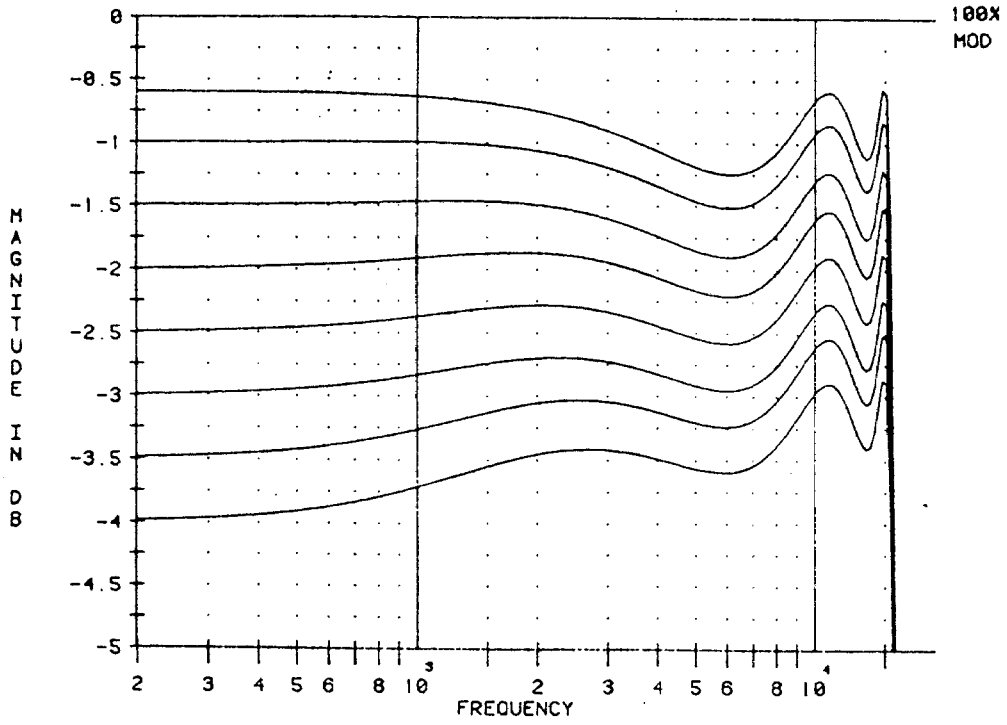
The adjustment in the 8000A is a carefully considered “commercial” compromise between loudness and brightness. However, stations wishing to give up loudness to achieve more brightness can change the value of R239, 240. These resistors pass the unpreemphasized component of the signal through to IC209B, IC210B. Adjusting their value therefore adjusts the preemphasis headroom without disturbing critical source and load impedances in the circuitry.

The appropriate values of R239, R240 for various amounts of headroom are as follows:

Headroom	R239, R240
1.0dB	12.4K
1.5dB	13.0K
2.0dB	14.0K
2.5dB	14.7K
3.0dB	15.4K
3.5dB	16.2K
4.0dB	17.4K

All resistors should be 1/8 watt 1% metal film RN-55D-style.

These changes will disturb the preemphasis curve slightly. The graph included with this monograph gives the expected de-emphasized frequency response of the 8000A system for the various reisistor values tabulated assuming that P205, P206 were optimally adjusted for the original value of 11.8K. It can be seen that in the worst case (4.0dB headroom), the preemphasis rises by about 1.1 dB at 15kHz.



8000A FREQUENCY RESPONSE AS HF LIMITER HEADROOM IS CHANGED

In many cases, this will not cause unsatisfactory sound quality or difficulties in meeting FCC Proof of Performance requirements. However, if you wish to restore the preemphasis to a maximally flat condition, this can be done by sweeping the system and readjusting P205, P206 for equiripple response (similar to the "0.6 dB" curve in the graph). With the rear-panel TEST jacks in NORM, observe the output of the rear panel TEST jacks through a *precision* 75µs deemphasis network. Note that the networks in most modulation monitors are designed for aural monitoring only, and are insufficiently accurate for this adjustment! (A precision network can be built by connecting a 7500 ohm 1% resistor from the network's input to its output, and then shunting the output with a 0.01 mfd 1% capacitor. No lower impedance than 1 megohm should load the network.)

Clipping Level

We do not recommend lowering the clipping level (by readjusting P311) to achieve more clipping. This will result in severe "sibilance smear" with certain voices, and will increase distortion to objectionable levels.

"Classical Music" Modification

This modification was developed specifically for classical music broadcasters, and is applicable to "Beautiful Music" or other formats where low fatigue, low distortion, and listenability over extremely long periods are particularly important. It combines slowing the AGC (to "slower than slow") and increasing the high frequency limiter headroom somewhat to reduce HF limiting and clipping. After modification, the 8000A should be operated with the RELEASE TIME control fully clockwise ("Full Slow")

To perform this modification:
1. Change the value of C268 from 4.7 mfd/15V ±10% dipped tantalum to 15 mfd/15V ±10% dipped tantalum.
2. Change the value of R239 and R240 from 11.8K 1/8w ±1% metalfilm to 12.7K 1/8w ±1% metalfilm (RN55D-style).

Filter Modifications

There is a considerable misunderstanding of the operation of the 8000A overshoot-compensated lowpass filters. Briefly, this system works by applying about 2dB excess preemphasis before the first set of clippers. This preemphasis is 95.5µs. The preemphasis is then reduced to the standard 75µs by means of shelving filter R325, R327, R329, C317 in the left channel and corresponding network in the right channel. The transient response of this shelving filter interacts with the response of the 15kHz lowpass filter to virtually eliminate overshoot.

OVERSHOOT CONTROL OR PREEMPHASIS CORRECTION IS *NOT* ACHIEVED BY MEANS OF SLEWRATE LIMITNG, as some have stated.

There are *no* recommended filter modifications. Some have advocated lifting C317 to defeat the shelving filter. This compromises the overshoot control (and therefore the dynamic separation). It makes the sound brighter by turning the 8000A into a shelving equalizer. However, at proof time, you will find that the system is no longer flat—it is producing 95.5us preemphasis instead of the required 75µs.

Stereo Generator

A number of minor, evolutionary changes have been developed over the course of 8000A production at the factory. These do not affect audible performance of the stereo generator, and need not be installed in the field.

All stereo generators, from the very first, produce outstanding separation "stock" (typically better than 50dB throughout the spectrum). IT IS EASY TO MESS UP THE ALIGNMENT OF THE STEREO

GENERATOR, PARTICULARLY WITH UNAUTHORIZED MODIFICATIONS. LEAVE YOUR STEREO GENERATOR ALONE, AND IT WILL WORK JUST FINE FOR YOU!

That's All, Folks!

Any other modifications that you have heard about have not reached the factory for evaluation and we can therefore not recommend them. Evaluate *any* modification carefully. The 8000A was not a causally conceived design – there are many things happening that aren't externally obvious, but that can be disturbed by thoughtless changes. If in doubt, leave it alone!

In particular, if you want to try using "premium" opamps, be very careful to verify that they do not ring, oscillate, or add noise. Some premium opamps with bipolar inputs have very high input currents, and this can increase offset voltages at the amplifiers' outputs. Because these amplifiers are designed to produce low noise when their inputs see very low source impedances, they can produce unexpectedly high noise if placed in a circuit with higher than optimum source impedance.

Further, if the gain-bandwidth product of any replacement opamp is significantly higher (or stability margin is lower) than the originals, this can cause oscillation because of circuit board layout, insufficient power supply bypassing, or capacitive loading.

Finally, several opamps (the 709's and 301's) are externally compensated appropriately for their closed-loop gains. Replacing these opamps with internally compensated opamps will probably require removing the compensation components from the PCB unless you know with certainty that at least one lead of each compensation component is connected to a true "no connect" pin on the replacement opamp.

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