

Bulletin	Ampex 351 bias upgrade (does not apply to electronics with Catalog Numbers 30960-11 or -12)
Date	2021 Jan 12
Revision	2
Total pages	3

Problem

Most Ampex 351 recorders do not have enough erase/ bias current to accommodate modern tape formulations.

Fix

Substitute a 12BH7 tube in place of the 12AU7A and make minor circuit changes. NOTE: See *Exceptions* below.

Disclaimer

While the procedures shown here will increase the amount of erase/bias current available, they are not guaranteed to upgrade the Ampex 351 electronics for use with *all* modern tape formulations.

Overview

In magnetic recording, a high-frequency oscillator is required to generate both erase and bias current (100 kHz was typical for older Ampex recorders, including the model 350 and 351). While in record mode, the electronics uses most of this high-frequency current to erase the tape. At the same time, a smaller amount of this current is combined with the audio signal at the record head to ensure a low-distortion recording.

When the Ampex 351 was introduced in 1958, magnetic tape available at that time required much less current for full erasure (and sufficient record bias) than many tape formulations available today. These newer formulations offer improved performance in terms of output, noise, and high frequency response but a stock 351 electronics typically is unable to provide the required erase/bias current.

Tape recorders designed in the late 1940s required powerful erase/bias oscillators to overcome the relatively inefficient erase and record heads used at that time. As tape heads improved, less erase/bias current was required.

The Ampex 350 (made between 1953 and 1957) typically has enough erase/bias current for most modern tape formulations. In contrast, the Ampex 351 typically does not. The reasons are the use of different erase/bias transformers and different oscillator tubes.

The Ampex 350 used an efficient toroidal erase/bias transformer. However, these transformers are difficult to wind and therefore relatively expensive. In contrast, the 351 (with exceptions noted later) used an inefficient air-core erase/bias transformer. The change (according to former Ampex engineers) was done to reduce cost. When the Ampex 351 was introduced in 1958, the reduced erase/bias current available was adequate for most tape formulations then in common use.

Exceptions

Two variants of the Ampex 351 electronics did use a more powerful erase/bias oscillator—these are the catalog number 30960-11 and 30960-12 (these numbers are on small identification plates on the rear of the electronics chassis). These variants were designed for use with Ampex 300-3 and 300-4 multichannel recorders.

Two significant changes were made to the erase/bias circuit with these models. Specifically, a different record board using a plug-in toroidal bias transformer was used in place of the soldered-in air-core transformer and a 12BH7 tube was used in place of the 12AU7A.

Acknowledgments

Full-Track Productions would like to thank Robert Cochran (Downers Grove, Illinois) for writing the draft of this bulletin.

IMPORTANT NOTICE AND TERMS OF USE

Full-Track Productions is not liable for any damage or injury that may result from inappropriate use of information in this document—always refer service to qualified personnel. Contents of this document copyright © 2005-2021 by Full-Track Productions, all rights reserved. This bulletin may be distributed only if reproduced in its entirety (including this notice) without any alteration whatsoever. No fee may be charged for this bulletin nor for any information detailed here.

Required Parts

- 12BH7 vacuum tube
- 68 pF mica capacitor (300V minimum rating)
- 1000 pF mica capacitor (300V minimum rating)
- Type **BA9SF-WW-6VAC** LED replacement for #47 or #1847 incandescent lamps (two required) used in the VU meter; warm-white color recommended*
- 750Ω or $1K\Omega$ one-watt resistor (optional)

Procedure

- 1) Remove ac mains power from the electronics assembly.
- 2) Replace the 12AU7A (V6) with a 12BH7.
- 3) Carefully remove the VU meter face and replace the two lamps with appropriate LED replacements (see note below).
- 4) Install the 1000 pF capacitor in parallel with the erase trimmer (C33 on the rear panel).
- 5) Using a vacuum-desoldering tool, carefully remove the 33 pF capacitor which is in parallel with the bias trimmer (C13 on the rear panel).
- 6) Now install the 68 pF capacitor in place of the 33 pF cap you just removed. Keep in mind that an exact value is not critical (anything near 68 pF is fine); the new capacitor simply increases the adjustment range of the bias-adjustment circuit.
- 7) For enhanced reliability and smoother adjustment of the Bias Cal potentiometer R24, install a one-watt 750Ω (or $1k\Omega$) resistor in parallel with this potentiometer.

Notes on LED replacement lamps

The 12BH7 requires twice the heater current of the 12AU7 (from 300 mA to 600 mA). To avoid unnecessary loading of the low-voltage winding of the Ampex 351 power transformer, it's a good idea to replace the incandescent VU meter lamps with low-current LEDs to compensate for the increased current draw.

The #47 (or #1847) meter lamps consume 150mA (total load of 300 mA). These LED replacements draw less than 50 mA total. Eliminating the incandescent lamps reduces power transformer loading to that typical with an unmodified electronics.

The preferred replacement lamp is the type **BA9SF-WW-6VAC** LED. This is a warm-white (2700K) 6-volt lamp that provides a pleasant appearance similar to an incandescent lamp. If the lamps are too bright, you can dim them slightly by installing an 82Ω (half-watt) resistor in series with the 6.3-volt feed to the meter lamps.

* As of this writing (January 2021), the following LEDs from SuperBrightLeds are recommended:

https://www.superbrightleds.com/moreinfo/miniature-and-subminiature-bulbs/ba9s-led-bulb-1-led-ba9s-retrofit -classic-car-bulb/4/#/attributes/10906

Oscillator Balance

For optimal noise performance, the bias oscillator must provide a symmetrical waveform to the record head. The requirement is that the second harmonic must be at least 50 dB below the fundamental frequency.

- 1) Connect a spectrum analyzer (or frequency selective voltmeter) to a convenient place to monitor the erase/bias signal; one place one place might be the connection between C13 and C33. You must use *a high-impedance X10 oscilloscope probe* to avoid loading the oscillator.
- 2) Thread tape onto the machine. Press PLAY and then RECORD.
- 3) While recording, note the level and frequency of the oscillator output (it should be around 100 kHz).
- 4) Now find the second harmonic (approximately 200 kHz) and note its relative level.
- 5) Adjust the **noise-balance control** (on the record board) until the second harmonic reads at its minimum level; with careful adjustment, it should be possible to achieve 55 or 60 dB down from the 100 kHz fundamental. (You may want to periodically check this as the oscillator tube ages.)

Erase Adjust

Adjust Erase C33 as shown in the Ampex 351 manual. This is a summary of the procedure:

- 1) If this is a stereo machine, *disconnect the bias-coupling cable to avoid interaction between the two channels*.
- 2) Thread tape onto the machine. Press PLAY and then RECORD.
- 3) Move the meter switch to ERASE.
- 4) Adjust the erase trimmer (C33 on the rear panel) to indicate the following readings on the VU meter: +1 dB (for a mono machine) or -1/2 dB (for a stereo machine).
- 5) For a stereo machine, repeat for the other channel until the VU meter indicates -1/2 dB.
- 6) Reconnect the bias coupling cable.
- 7) To check for sufficient erase current, record a 1 kHz tone at operating level (0VU) and erase the tape. The 1 kHz tone should be at least 60 dB down from the reference level (preferably 70 dB). You may need to increase erase current if you are not getting complete erase with your tape type (in that case, repeat the above procedure).

NOTE

If you increase erase current beyond the standard levels (shown in **step 4** above), eddy-current losses in the erase head may cause the head to overheat—the amount of heating is a function of the head construction and the amount of erase current used. Some aftermarket erase heads may tolerate more erase current than the original Ampex 351 erase head but there is no guarantee of this.

In normal operation, the erase head may become slightly warm after extended use. However, the head should never become uncomfortably warm; such overheating could damage the head or cause it to fail completely.

Record Bias Adjust

- 1) At 15 ips, record a 1 kHz signal at operating level (0VU).
- 2) While still recording, move the meter switch to PLAYBACK and adjust the playback volume so that the VU meter reads 0 VU or higher.
- 3) Adjust the bias control C13 for a peak indication. Then adjust the playback level to line up the VU pointer to a convenient scale marking (such as 0, +1, +2, or +3 dB) for better accuracy—this is because the VU meter is more accurate at the top end of its scale.
- 4) Now increase the bias level until the playback level drops one-quarter to one-half dB. If this is a stereo machine, repeat for the other channel.