MTR-90II AUDIO ALIGNMENT

Audio alignment on the MTR-90II is a simple, straightforward procedure similar to alignment on other tape machines. Section 4 of the owner's manual provides an excellent description of this procedure. Although the steps detailed here are similar, some extra explanation is provided to clarify the procedures. Before proceeding with the audio alignment, verify that the transport alignment is correct. Please read the entire procedure through once before adjusting anything. This procedure assumes that the technician is familiar with the use of the test equipment detailed below.

Any audio tape recorder is essentially a storage device. Program material is stored on the tape (whether digitally or in analog form) and retrieved with - we hope - nothing added or taken away. No storage medium is perfect; hence, we have error correction for digital storage media, and other techniques for analog longitudinal tape recording to make the output as faithful to the input as possible. Some of these techniques are the use of high-frequency AC bias to transfer the program to tape in a linear fashion, phase correction circuitry to compensate for phase shifting of the program after equalisation, pre-emphasis and de-emphasis to an accepted set of standards, etc.

To properly perform the audio alignment of the MTR-90II, the following tools are recommended:

1/ An oscilloscope; preferably dual trace, but single trace will do. The bandwidth should be at least 1 MHz;
2/ A small screwdriver;
3/ A good quality AC voltmeter or dBm meter. Any of the Fluke DVMs will do with the 8060A being especially nice;
4/ A low distortion AC signal generator, with frequencies from 20Hz. to 30KHz;
5/ A source for square waves at approximately 1KHz and (optionally) 10KHz. Most oscilloscopes have a square wave output on the front panel for calibrating X10 probes; with a few clip leads and a 1/4" phone plug, this can be used;
6/ A master alignment tape for the standard of your choice. The alignment tape should be a real alignment tape from a reputable source such as MRL or STL; a <u>copied alignment tape cannot be used with integrity</u>.
7/ A known good reel of recording tape of your choice.
8/ A head demagnetizer , some head cleaner, and cotton swabs.
9/ (Optional) A distortion analyzer.
10/ Appropriate test cables.

PRELIMINARY STEPS

Before beginning any alignment, clean and demagnetize the tape path. Otari recommend the use of a 99% isopropyl alcohol solution for cleaning the heads and guides. Make sure the solution you use is 99%, as weaker solutions have water, oil, and other additives that leave harmful residues on the heads and guides. If a 99% solution is hard -to find, the use of a pure freon (such as the Ultimedia tape head cleaner) is highly recommended. This is a non-flammable liquid which is also safe for plastics.

The demagnetizer used should be an Annis Han-D-Mag or equivalent. Do not use an inexpensive hi-fi type demagnetizer, as this could permanently magnetize the heads. Never turn on or turn off the power to the demagnetizer unless it is at least three to four feet (1 - 1-1/2 meters) away from the tape machine. Always turn off the power to the tape machine before using the demagnetizer. Follow the procedure in section 4.2 of the MTR-90 manual to demagnetize the heads.

The following preliminary adjustments need only be done once to any machine upon initial setup, or if it is suspected that the adjustment in question has been improperly done. WARNING: SEVERAL STEPS IN THIS PROCEDURE REQUIRE THE REMOVAL AND RE-INSERTION OF CIRCUIT CARDS. <u>ALWAYS TURN OFF THE POWER TO THE MTR-90 BEFORE REMOVING OR INSERTING A CIRCUIT CARD.</u> FAILURE TO HEED THIS WARNING WILL CAUSE CATASTROPHIC FAILURE OF CRITICAL COMPONENTS AND COULD CAUSE A SESSION TO BE CANCELLED!

One of the unique features of the MTR-90II is the <u>all-input jack</u> on the front of the BIAS CONTROL card. This allows routing an input signal to all channels simultaneously. To match the input level of this jack to the normal operating level of the machine, extend the BIAS CONTROL card and proceed as follows:

1/ Apply a 1kHz, +4dBm signal to the channel 1 LINE INPUT connector on the rear of the machine. On the REMOTE SESSION CONTROLLER, select the ALL INPUT mode.

2/ Monitoring the channel 1 LINE OUTPUT with a dBm meter or A.C. voltmeter, adjust the MONItor level control on the front of the channel 1 AUDIO card for a reading of +4dBm.

3/ Using the appropriate test cable, apply a 1kHz, +4dBm signal to the jack on the front of the BIAS CONTROL card.

4/ Still monitoring the output of channel 1, adjust VR5 on the BIAS CONTROL card for a reading of +4dBm.

5/ Leaving the oscillator connected to the ALL INPUT jack, monitor the output of each audio channel in turn. On each of the AUDIO cards, adjust the MONItor control for a reading of +4dBm on the corresponding output.

6/ The next two adjustments on the BIAS CONTROL card set the master bias and erase levels. Monitor TP 1 with an oscilloscope. If a X10 probe is being used, remember to adjust the compensation capacitor. Set the BIAS POSITION switch on the front of the card to position 1. Adjust BIAS trimmer 1 on the front of the BIAS CONTROL card for a display of 5 volts peak to peak (5V p-p).

7/ Monitor TP 2 with the oscilloscope. Adjust VR4 for a display of 5 volts peak to peak (5V p-p).

8/ Turn off the power and reinsert the BIAS CONTROL card in the card cage. Leave the oscillator (+4dBm, 1kHz) connected to the ALL INPUT jack. Turn on the power.

9/ The VU meters on the MTR-90 should be indicating 0 VU. If adjustment is required, open the VU meter panel by removing the 3 allen head screws along the upper edge of the panel and pivoting the the panel down to horizontal position. The trimpots are in groups of eight behind the meters and are numbered left-to-right as VR101, VR201, VR301, etc.

10/ The last preliminary adjustment sets the erase voltage on each individual audio card. Since the erase voltage level affects the gapless punch-in, punch-out timing and the overall noise level of the machine, this step is critical. Experience has shown that it is also necessary. To begin, turn off the power and extend the first audio channel card. Turn on the power and move the swing-arms on the transport to the upper position until they lock. Use a couple of Sharpie pens or "greenie" screwdrivers to hold the arms in the middle of their travel while you press the STOP button. This simulates a reel of tape being loaded on the machine. Alternatively, a reel of scrap tape could be used. Arm the channel in RECORD READY using the session controller. Place the machine in RECORD by pressing the RECORD and PLAY buttons. Using the oscilloscope, monitor TP2 on the audio card. Use the GROUND test point next to TP2 for the probe ground. Adjust VR401 (located near the bottom of the board) for a display of 2.6 volts peak to peak (2.6V p-p). Turn off the power, re-install the audio card and extend the next card. Repeat this step for the remaining channels.

NORMAL ALIGNMENT

The normal alignment procedures below should be performed on an as-needed basis. This will vary depending on your situation. Generally speaking, audio alignment will be checked before each recording session. Normal alignment on the MTR-90II is a straightforward procedure similar to that used for any audio tape machine.

To begin, clean and demagnetize the tape path. The first step is verifying the azimuth of the record and reproduce heads. Technically, azimuth is defined as the absolute perpendicularity of the head gap relative to tape travel. This definition works well for a full-track monaural head, but falls short when applied to a multi-track head. When a multi-track head is manufactured, the individual gaps of each track are not always in perfect alignment. This phenomenon is known as gap scatter, and causes relative phase (time) errors between tracks. Azimuth adjustment on a multi-track machine is the minimizing of the effects of gap scatter, and there are several methods available.

Remove the four 3mM hex-head screws holding the head cover and remove the head cover. Refer to the diagram and locate the 2.5mM hex-head azimuth adjusting screw for each head. Load the alignment tape and locate the 1kHz section. Connect the output of track 2 to the vertical input of the oscilloscope. If your oscilloscope is dual trace, connect track 2 to vertical input channel 1. Now connect the output of track 23 (or track 15 if the machine is a 16 track) to the external horizontal input of the oscilloscope. If your oscilloscope is dual trace, connect track 23 (15) to vertical input channel 2. Put the oscilloscope in the X-Y display mode.

With the machine in REPRO mode, play the 1kHz section of the alignment tape. Turn the azimuth adjusting screw on the REPRO head until the pattern on the oscilloscope indicates 0 degrees phase error (see diagram). Switch the monitor to sync mode (SEL-REP) and adjust the azimuth of the RECORD head in the same way. Advance the alignment tape to the 8kHz section and play the tape. First in sync mode and then in repro, fine-adjust the azimuth screw of each head for the least phase error. As a final check, repeat the procedure using the 16kHz section of the alignment tape. If the tones are not steady on the VU meters, either the wrap, zenith or penetration of the heads will need adjustment. This procedure is covered under the Service and Repair sections. Once the azimuth has been set, the electronics can be adjusted.

The first step will set the reference fluxivity in reproduce mode. Fluxivity is a measure of the magnetism on the tape and is commonly measured in nanoWebers per square meter, or "nWb" for short. The original Ampex flux reference was 185nWb at 700Hz. As tape and tape recorders got better, higher flux references began to be used - all referenced to the original 185nWb. The relationship between fluxivity on the tape and output level from the head is linear. To find the difference in decibels between two flux levels, use the formula:

$$dB = 20\log\,(\text{Flux } 2/\text{Flux1}).$$

For example, the difference in decibels between 250nWb and 360nWb is

$$\begin{aligned} dB &= 20\log\,(360/250) \\ &= 20\log\,(1.44) \\ &= 20\,(0.1583625) \\ &= 3.2 \end{aligned}$$

or approximately 3dB above 250nWb which is approximately 3dB above 185nWb. These are the most common flux references in use. When engineers call for "+3", they are referring to a record level of 250nWb at 1kHz (261nWb at 700Hz). A record level of "+6" refers to a flux level of 360nWb at 1kHz (371nWb at 700Hz). NOTE: DO NOT CONFUSE RECORD LEVEL ON THE TAPE WITH THE TAPE MACHINE'S NOMINAL OUTPUT LEVEL (USUALLY +4dBm FOR PROFESSIONAL MACHINES AND -10dBV FOR SEMI-PRO MACHINES)!

Two different fluxivity measurement standards are in existence. The numbers above are derived using the NAB "short-circuit" flux method. The IEC uses an "open-circuit" method for flux measurement which gives a number ten-percent higher than the NAB number. Conversions between the two methods are straightforward. Thus:

$$(\text{flux IEC}) - .10(\text{flux IEC}) = \text{flux NAB}.$$

For an IEC flux level of "320"nWb, the NAB equivalent is 288nWb (approximately "+5" over 185nWb).

Select ALL REPRO on the remote control. Play the 1kHz section of the alignment tape and adjust the REPRO GAINs for the appropriate level. If the reference fluxivity of the alignment tape is 250nWb, for a record level of 250nWb adjust the REPRO GAINs for a reading of 0VU on the meters. If the reference fluxivity of the alignment tape is 250nWb, for a record level of 360nWb adjust the REPRO GAINs for a reading of -3VU on the meters. In other words, if the record level is being increased, the reproduce level must be decreased a corresponding amount so that the net change in output level is 0dB. Note the level achieved in this step.

Advance the alignment tape to the 10kHz section. Play the tape and adjust the REPRO EQ to obtain the same reading on the VU meters as in the previous step. If the machine is in low speed (15 ips) use the REPRO LOW SPD EQ. If the machine is in high speed (30 ips) use the REPRO HI SPD EQ.

Select ALL SEL-REP on the remote control and repeat the last two steps using the SYNC GAIN and SYNC EQ controls. When the last channel has been completed, remove the alignment tape from the machine and put it away.

Thread a reel of recording tape (of the manufacture and type you will be using for your session) on the machine. NOTE: If this reel is being used for the session, it is strongly recommended that the session tones and record pad be placed at the end (tail) of the tape rather than at the beginning (head). In this way you will avoid accidental erasure of your program material. Using the oscillator, insert a +4dBm, 1kHz sine wave in the TEST SIGNAL jack on the front of the BIAS CONTROL card. If the machine is connected to a mixing console, the test signal could also be routed to the inputs from the console's oscillator. On the remote control, select ALL INPUT. Verify that the meters read 0VU. If adjustment is required, repeat steps 1-5 of the PRELIMINARY ADJUSTMENTS.

The next step sets the bias on each channel to allow bias adjustment from the master bias trimmers. Place all tracks of the machine in the record mode and select ALL REPRO on the remote control. On each channel, turn the BIAS control counterclockwise until the signal disappears; then turn the BIAS clockwise until the signal on the VU meter reaches a peak. If the signal is off the scale of the VU meter, turn the RECORD GAIN counterclockwise until the VU meter indicates approximately 0VU. Continue turning the BIAS control clockwise until the signal on the VU meter is one-half deciBel below the peak. Repeat this adjustment for all channels. NOTE: The peak at 1kHz is a broad, smooth peak. It is possible on the MTR90 to increase the bias until the waveform is distorted. When this happens, the 1kHz peak will be very sharp and the signal will have higher than normal distortion. For this reason, the bias should be adjusted as described, i.e.: by turning the control counterclockwise first and then gradually increasing the bias to observe the first peak. This step need only be done once for any machine. After this, bias for all tracks may be adjusted simultaneously using one of the master bias trimmers on the BIAS CONTROL card.

A few comments on setting the record bias are in order. The purpose of record bias is to transfer the audio spectrum

(20Hz to 20kHz) to tape in the most linear portion of the transfer curve for that particular tape. Several factors influence the location of the optimum point on the curve. Some of these factors are the size and density of the magnetic particles on the tape, the bias frequency, the wavelengths of the program material (related to tape speed), the track height, and the record head gap width. Without knowing all of these factors and how they relate mathematically, the engineer must often rely on printed tables or hit-and-miss experience to set the bias. Using a slight overbias of a mid-frequency signal works for all tapes, all tape machines, and all speeds. Experiment has shown that this method consistently yields the lowest noise and distortion figures. If a distortion analyzer is available, it can be used to set the bias for the lowest third harmonic distortion at 3.3kHz (the third harmonic of 3.3kHz is - surprise!- approximately 10kHz), but this method requires more time and does not yield appreciably better results.

Once the bias is set, select ALL INPUT on the remote control and verify that the VU meters still indicate 0VU at 1kHz. Place the machine in RECORD and select ALL REPRO on the remote control. Adjust the REC GAIN trimmer on each audio card for a reading of 0VU on the corresponding meter.

Next, select 10kHz sine wave on the oscillator. On the remote control, select ALL INPUT and verify that the VU meters indicate 0VU. If not, adjust the output of the oscillator for a 0VU indication. With the machine in RECORD, select ALL REPRO on the remote control. Adjust the REC EQ control (HI SPD EQ for 30 ips; LOW SPD EQ for 15 ips) on each audio card for a reading of 0VU on the corresponding meter.

The last adjustment is the PHASE compensation. When a group of frequencies (for example, 20Hz - 20kHz) goes through an equalization circuit, a shift in phase occurs. In the analogue recording process, the amount of phase shift at different frequencies is affected by, among other things, the bias setting and the equalization adjustment. To compensate for this, Otari have provided a PHASE compensation circuit.

To adjust the PHASE, insert a 1kHz square-wave at the TEST SIGNAL jack on the BIAS CONTROL card. The level on the VU meters should be approximately -5VU to avoid tape saturation. Select ALL INPUT on the remote control and monitor the output of track one with the oscilloscope. Note the shape of the square wave. Place the machine in the RECORD mode and select ALL REPRO on the remote control. Adjust the PHASE compensation trimmer (the top one for 30ips; the bottom one for 15ips) until the square wave in

REPRO most closely resembles the square wave in INPUT. Repeat this step for the remaining tracks.

At this point, if desired, the LOW FREQuency compensation can be adjusted. For most applications, the fixed low frequency compensation characteristic will prove adequate. To select fixed compensation place the LOW FREQ COMP switch on the front of the BIAS CONTROL card in the OFF position. This disables the LOW FREQ trimmers on the individual audio cards. To provide adjustable compensation, turn this switch ON.

To adjust the LOW FREQ trimmers, insert a 100Hz (or 50Hz) sine wave at +4dBm into the TEST SIGNAL jack, and select ALL INPUT on the remote control. Verify that the VU meters indicate 0VU. Place the machine in RECORD and select ALL REPRO on the remote control. Adjust the REPRO LOW FREQ trimmer on each audio card for a reading of 0VU on the corresponding meter. Record a few minutes of signal, and rewind to the starting point. On the remote control select ALL SEL-REP. Play the tape and adjust the SYNC LOW FREQ trimmer on each audio card for a reading of 0VU on the corresponding meter.

This completes the audio alignment.

Order of Adjustments.

ONE-TIME ONLY PRELIMINARY ADJUSTMENTS

1/Input unity gain
- a/Insert 1kHz at +4dBm in channel 1
- b/Monitor ALL INPUT
- c/Adjust MONitor for +4dBm at chan 1 out
- d/Insert 1kHz at +4dBm in TEST SIGNAL jack
- e/Adj VR5 on BIAS card for +4dBm at chan 1 out
- f/Adj each MONitor for +4dBm at each output.

2/Master bias level
- a/On BIAS card, in BIAS POSITION 1, adjust BIAS trimmer 1 for 5 volts p-p at TP1

3/Master erase level
- a/On BIAS card adjust VR4 for 5 volts p-p at TP2

4/VU meter calibration
- a/Insert 1kHz at +4dBm in TEST SIGNAL jack
- b/Adjust VR101, 201, 301, etc. on meter pcb for 0VU indication

5/Individual erase level
- a/Machine in RECORD, adjust VR401 on each AUDIO card for 2.6 volts p-p at TP2

NORMAL ALIGNMENT SEQUENCE

6/Azimuth adjustment
- a/Monitor REPRO, play 1kHz alignment tape, adjust repro head AZIMUTH screw for minimum phase error between tracks 2 and 23. Monitor SEL-REP and repeat for sync head.
- b/Repeat step "a" with 8kHz and 16kHz sections of alignment tape

7/Repro level
- a/Monitor REPRO, play 1kHz alignment tape
- b/Adjust each REPRO GAIN for 0VU or desired level

8/Sync level
- a/Monitor SEL-REP, play 1kHz alignment tape
- b/Adjust each SYNC GAIN for 0VU or desired level

9/Repro high frequency equalization
- a/Monitor REPRO, play 10kHz alignment tape
- b/Adjust each appropriate speed REPRO EQ to match 1kHz level

10/Sync high frequency equalization
- a/Monitor SEL-REP, play 10kHz alignment tape
- b/Adjust each appropriate speed SYNC EQ to match 1kHz level

11/Individual bias level

- a/Insert 1kHz at +4dBm in TEST SIGNAL jack
- b/Machine in RECORD, monitor REPRO
- c/Adjust each individual BIAS control for 0.5dB over the first peak
- d/Subsequent bias adjustment should be done from one of the MASTER BIAS trimmers on the BIAS card

12/Record level

- a/Setup as in last step
- b/Adjust each RECORD GAIN for 0VU

13/Record high frequency equalization

- a/Insert 10kHz at +4dBm in TEST SIGNAL jack
- b/Machine in RECORD, monitor INPUT, verify 0VU
- c/Monitor REPRO, adjust each appropriate speed RECORD EQ for 0VU

14/Record phase compensation

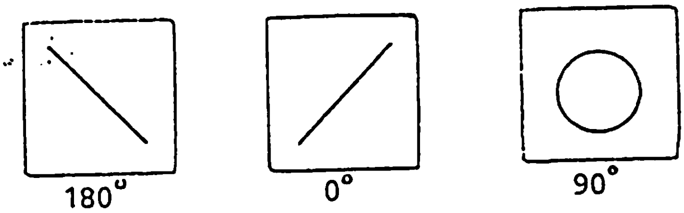
- a/Insert 1kHz square wave in TEST SIGNAL jack
- b/Machine in RECORD, monitor INPUT, then REPRO
- c/Adjust appropriate speed PHASE control for best square wave response (symmetrical ringing)

15/Repro low frequency compensation

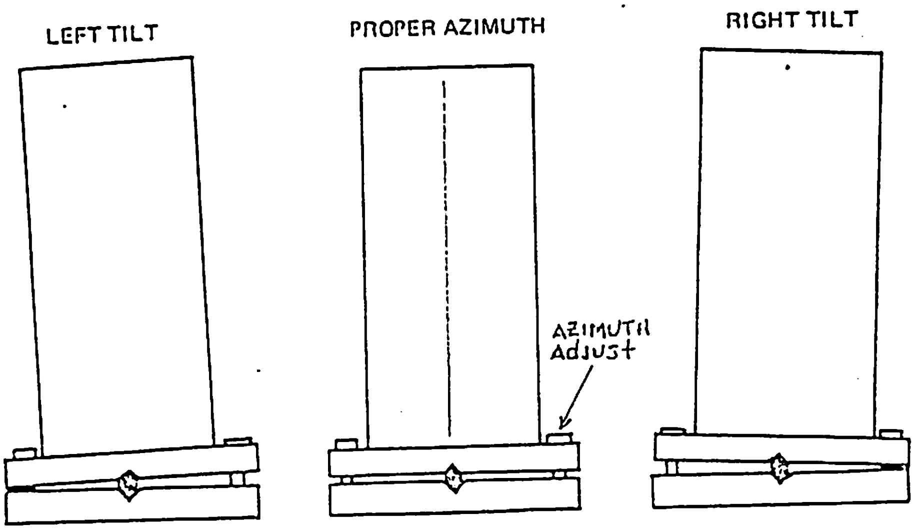
- a/Insert 50Hz <u>or</u> 100Hz, +4dBm in TEST SIGNAL jack
- b/Machine in RECORD, monitor REPRO
- c/Adjust each REPRO LOW FREQ control for 0VU

16/Sync low frequency compensation

- a/Setup as in last step, record a few minutes of signal
- b/Rewind to beginning, monitor SEL REP, play the tape
- c/Adjust each SYNC LOW FREQ control for 0VU.



Oscilloscope Phase Displays



TILT EXAGGERATED FOR ILLUSTRATING THE EFFECT

MTR-90 record and repro head azimuth adjustment.