

AMPEX

1280067-01

HBR-3000i

**High Bit Rate Digital
Recorder/Reproducer
With ECC**

**Signal Electronics
Adjustment Manual**

ISSUED 1 SEPTEMBER 1983

Note: Asterisk denotes pages affected by latest change.

LIST OF EFFECTIVE PAGES

This manual consists of 24 pages, comprised as follows:

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A	Original		
i and ii	Original		
1 thru 20.....	Original		

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HBR-3000i SIGNAL ELECTRONICS

ADJUSTMENT

1. GENERAL

This manual contains information on adjustment procedures for digital and analog channels of the HBR-3000i system. Transport adjustment procedures, such as reel and capstan servo alignments, etc., are included in the tape transport adjustment manual. Table 1 lists the test equipment required for the adjustments.

2. SYSTEM ADJUSTMENT CONSIDERATIONS

Correct adjustment of the signal electronics of a high bit rate recorder/reproducer is extremely important to attaining the best bit-error-rate (BER). A major part of this adjustment is concerned with the analog signal electronics that handle the data as it goes to and comes from the magnetic heads. Bias level, record level, reproduce amplitude equalization and reproduce phase equalization all need special consideration. (These adjustments are not made to the same criteria for digital recording as they are for analog instrumentation recording.) Auxiliary (analog) channels must also be adjusted for optimal response, and require the special considerations outlined in the portions of this manual concerned with analog signal adjustments (paragraphs 15 and following).

3. Bias Level and Record Level Requirements

Bias is always set to a slight over-bias condition. (This means that bias is increased until the output of an upper bandedge signal passes a peak and is slightly reduced in level by increasing the bias level.) Record level is set as high as practical, but always below saturation level.

4. Reproduce Equalization Requirements

In digital recording, again in contrast to analog data recording, phase equalization is considerably more important than amplitude equalization. Flat amplitude vs. frequency response is not required.

5. DIGITAL SIGNAL SYSTEM ADJUSTMENTS

For correct results, these adjustments must be performed in the order given. Internally generated test signals can be applied to the digital signal system when the mode select bay (MSB) NORMAL/TEST switch is in the *in* position. The TEST lamp lights. User-supplied data cannot be recorded in this mode.

6. Encoder Clock Symmetry

The clock symmetry adjustment is located on the encoder PWBA (see figure 1). The adjustment is initially made with test signals and should be checked and readjusted as needed with a user-supplied clock prior to recording user-supplied data.

- a. Lower the digital process bay (DPB) front panel for access to the adjustments.
- b. Supply the clock signal to be used for the adjustment.
- c. Connect an oscilloscope probe to the encoded data output of channel 1 (TP1 of the encoder PWBA). Trigger the oscilloscope internally to display an "eye" pattern, as shown in figure 2.

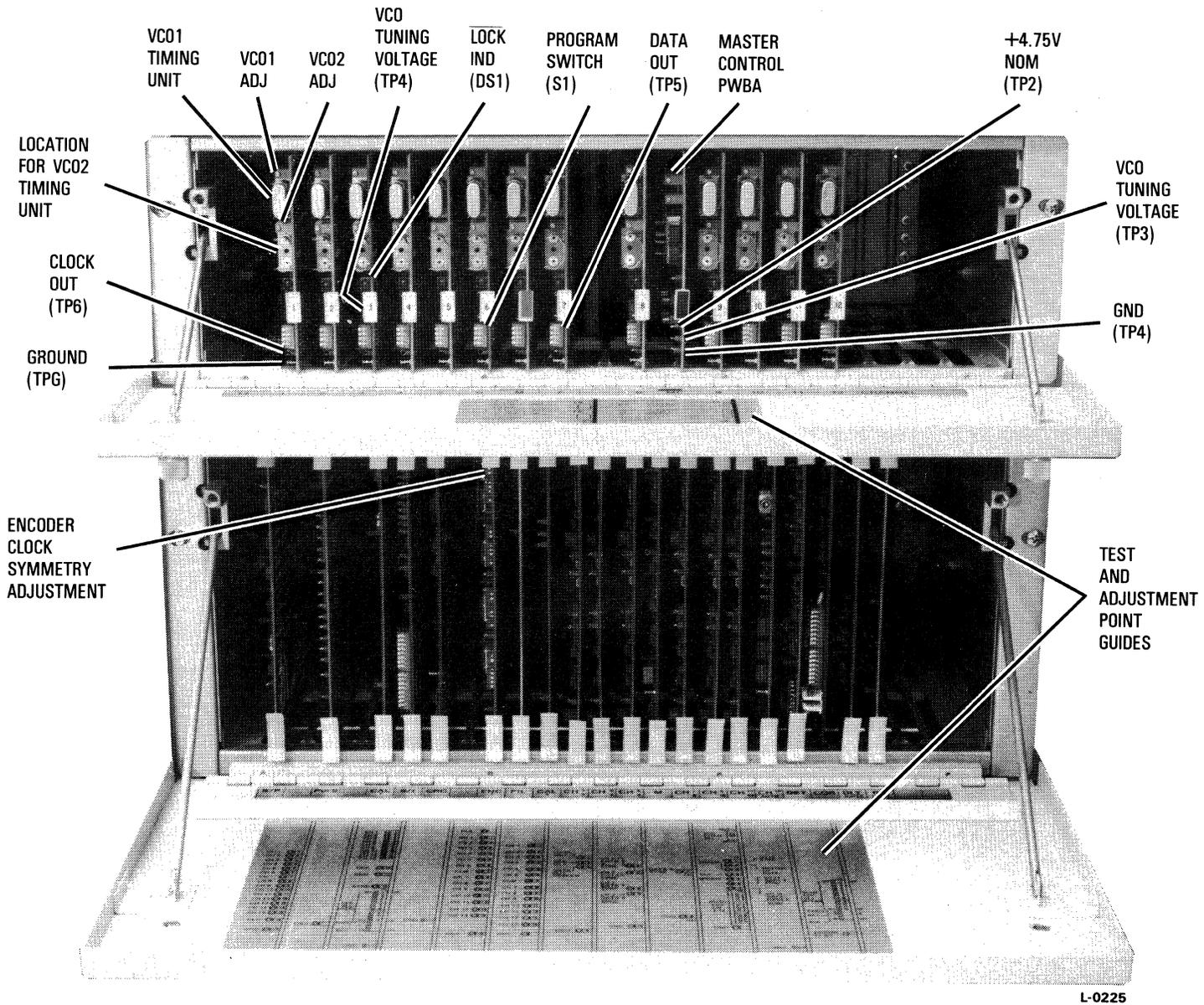


Figure 1. Bit-Sync and Digital Process Bays

Table 1. Test Equipment and Extender

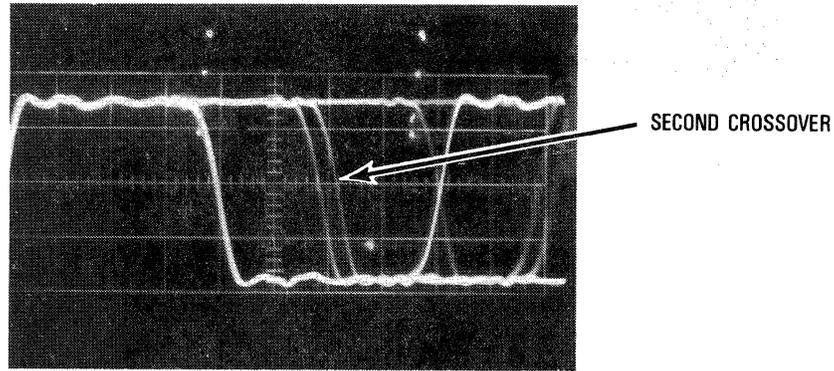
ITEM	TYPE
Oscilloscope	Tektronix 465 (or equivalent)
Digital voltmeter (DVM)	Fluke 8000A (or equivalent)
Signal generator (used only if analog channels are adjusted)	Hewlett-Packard 209A (or equivalent)
AC electronic voltmeter (EVM)	Hewlett-Packard 3400A (or equivalent)
Wave analyzer (selective voltmeter)	Hewlett-Packard 312B (or equivalent)
Extender board	Ampex 1256253-01

- d. Adjust symmetry-adjust R12 at the top of the encoder PWBA until the oscilloscope display shows the second crossover as a single line (see figure 2).

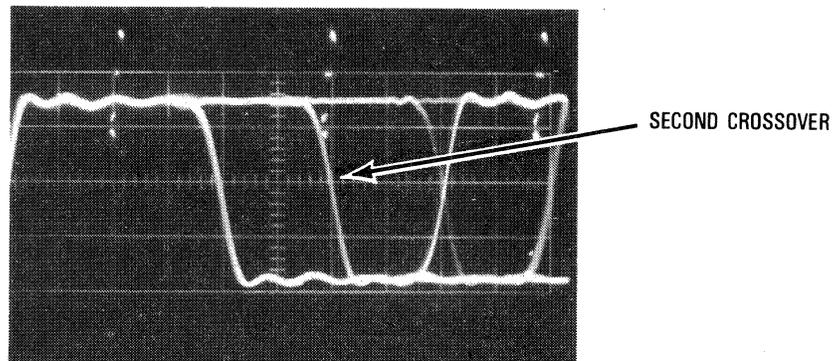
7. Head Azimuth Adjustment

The reproduce head azimuth is set as follows:

- a. Set MSB switches as follows:
 1. MODE CLOCK @ 120 IPS to 04.000 MHz or the 120 IPS equivalent of the highest operating clock rate of the system.
 2. NORMAL/TEST *in*.
 3. RAN/FIX INHIBIT *in*.
 4. SERIAL/PARALLEL *in*.
- b. On the transport control panel, select the 120 IPS pushbutton.
- c. Select forward record mode.
- d. Monitor the reproduce output of the master channel at TP5 (signal) and TP6 (ground) on the front of the master-channel reproduce amplifier PWBA.
- e. Adjust the azimuth adjustment screw on the reproduce head assembly containing the head track for the master channel. On 28-channel systems this is the odd-numbered head. On 14-track systems it is the even-numbered head. (The odd-numbered head is the one that the tape reaches first in forward operation.) Adjust the azimuth for maximum output of the reproduce signal.



A. SYMMETRY MISADJUSTED



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B. SYMMETRY CORRECTLY ADJUSTED

Figure 2. Encoder Clock Symmetry Adjustment Waveforms

- f. Check other channels across the same headstack (odd or even, as in step *e*). If their output levels do not peak at the same azimuth setting, make a compromise setting among the different channels, or one that favors the greatest number of channels.
- g. Repeat steps *d*, *e*, and *f* for the other headstack (the even numbered headstack in 28-channel systems, the odd in 14-channel systems). Use a convenient center track for the first check.

8. Record and Bias Level Adjustment

The record mode adjustments need be made only when going to a higher packing density than the one for which the system was last adjusted. Do not perform these procedures if the same or lower density is to be used, unless there is difficulty in getting good recordings.

The record adjustments are made with clock input only. With the setup made in paragraph 7, *a*, select 60 IPS at the transport control panel.

- a. Place the recorder in the record mode. The incoming test clock controls the transport tape speed.

- b. With an AC electronics voltmeter (EVM), monitor the reproduce output of the track to be adjusted at TP5 (signal) and TPG (ground) on the front of the direct reproduce amplifier PWBA. (Figure 3. Also refer to the track number on the label on the reproduce bay [REP bay].)
- c. To make the bias level adjustments, adjust the record level control of the selected channel for a maximum (peak) output, then reduce (CCW) the level approximately 6 dB. The controls are on the front of the headdresser PWBA as shown in figure 4. (The headdresser PWBA's are located adjacent to the head assemblies on the tape transport.)
- d. Adjust the BIAS LEVEL control of the record headdresser for the track being adjusted. To be sure the channel is underbiased at the beginning of this adjustment, decrease (CCW) the bias level until the reproduce output level begins to drop. Then increase the bias level until the output level reaches a maximum (peak) as monitored at TP5 on the reproduce amplifier. Further increase the bias level for a drop in output of 1 dB (overbias).
- e. To adjust the record level, increase the setting of the record level control (CW) until the peak is reached. Then, if the packing density is in the normal range, 26.6 to 33.3 kb/i, decrease the setting (CCW) to 1 dB down. If the packing density is below 26.6 kb/i, decrease the setting (CCW) 2 dB below the peak.
- f. Repeat the steps above for all of the digital tracks that are to be adjusted, including the master channel.
- g. If no further adjustments are to be made, return the system to the normal mode (NORMAL/TEST switch on the MSB).

9. Reproduce Adjustments

The seven-speed reproduce-amplifier adjustments are as follows. A common technique is to start making the adjustments in record/reproduce mode. If a relatively high tape speed is being used, and the tape runs out before all channels are adjusted, the tape is rewound and then run in reproduce mode for further adjustments until all channels are complete. Using this technique, it is safest to adjust the master channel first, so that a valid master channel clock is present to control the capstan when operating in the reproduce mode. Other approaches are equally usable, and may be selected according to the convenience of the user. The adjustments may be made using random data or pseudorandom-word (test) data. The following procedure is an example using pseudorandom-word (test) data.

- a. Use the test setup of paragraph 7,a and 8, except set the RAN/FIX INHIBIT switch to *out*.
- b. At the righthand end of the MSB panel, be sure the lower row of BITE switches is *out* (the normal position for internally generated test signal).
- c. At the transport control panel, 60 IPS.
- d. With an oscilloscope, monitor the output of the reproduce amplifier for the track being adjusted. TP5 is signal, TPG is ground (see figure 3).
- e. Simultaneously record and reproduce the pseudorandom test data. Adjust the oscilloscope to display the eye pattern (see figure 5). If necessary, adjust the reproduce amplifier output level (R64) for a nominal 2.8V P-P.

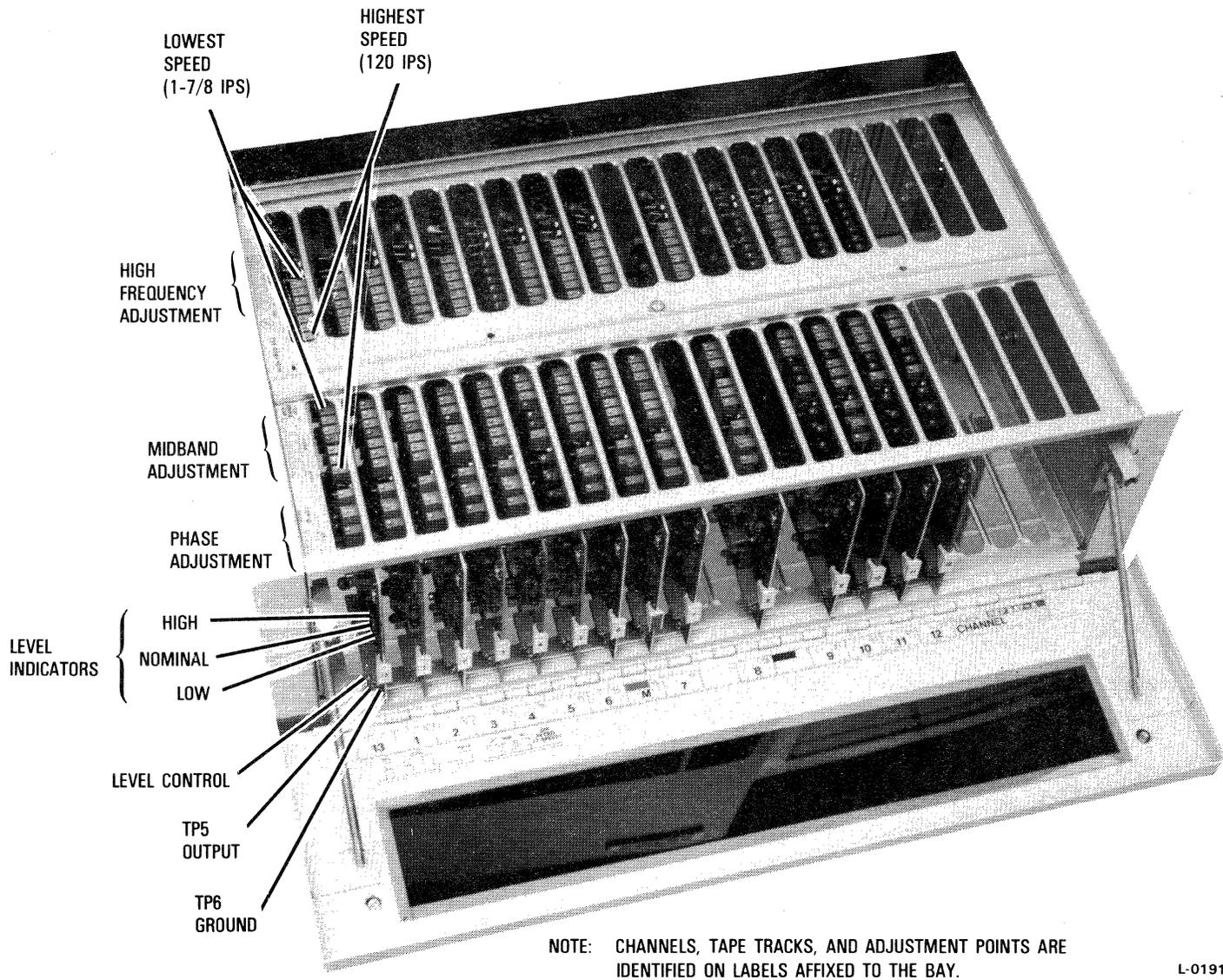
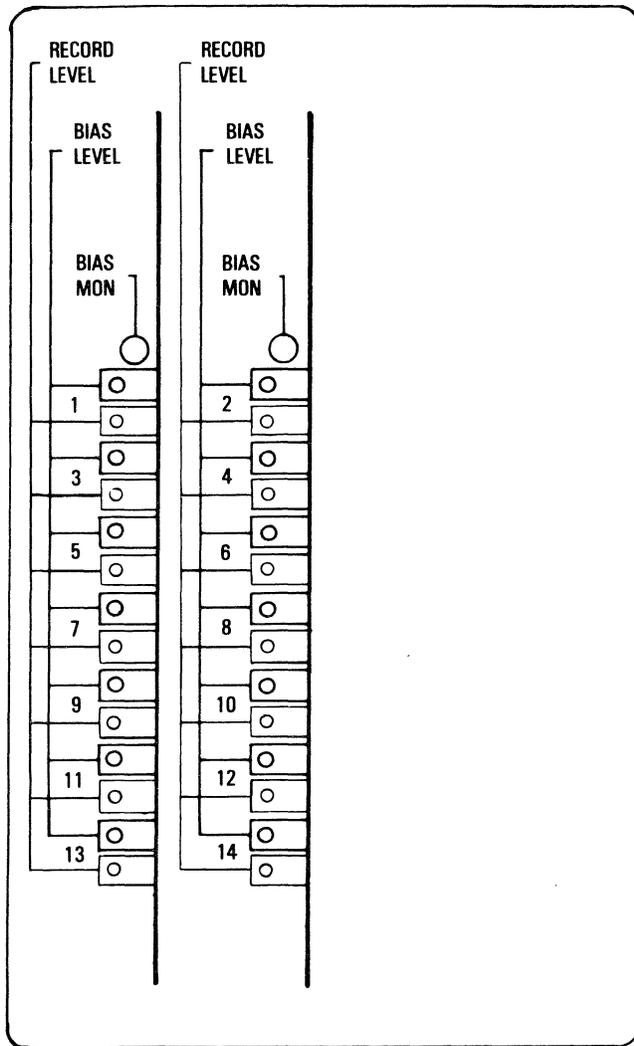
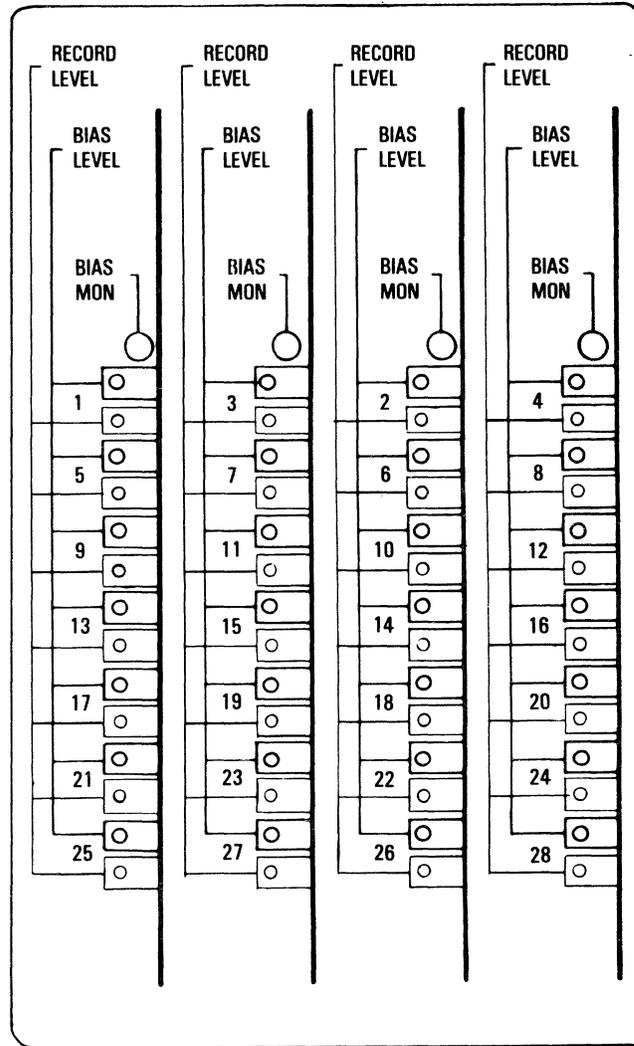


Figure 3. Reproduce Amplifiers in Reproduce Bay



14 TRACK

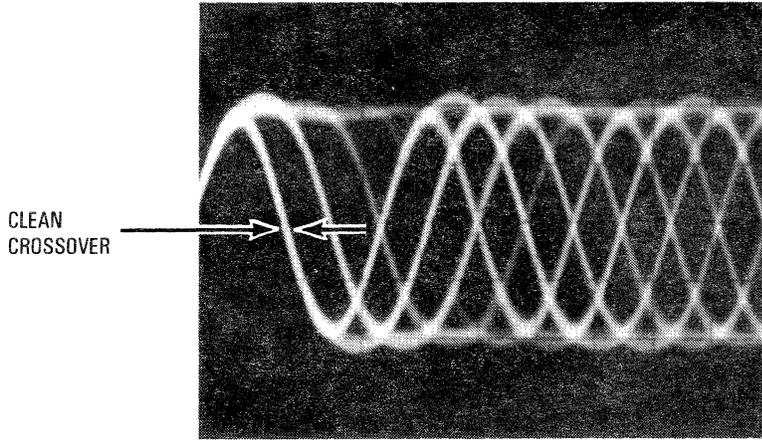


28 TRACK

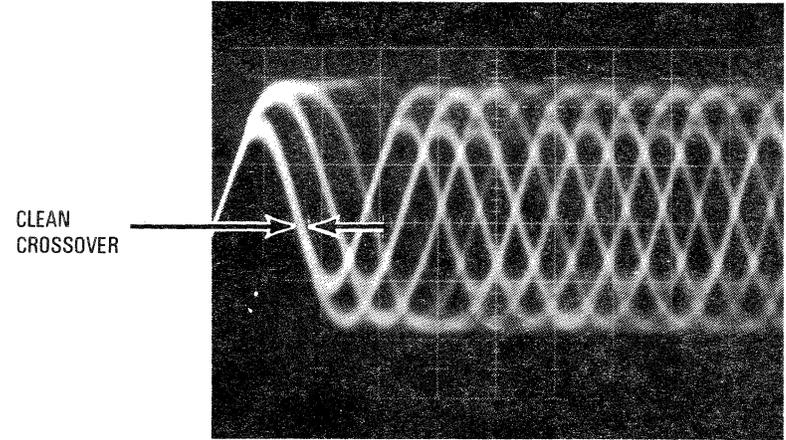
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NOTE: NUMBERS ARE *TRACK* NUMBERS.

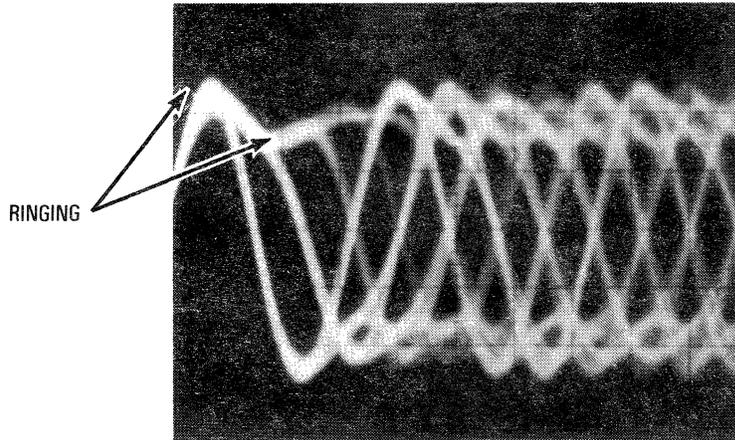
Figure 4. Bias and Record Level Adjustments



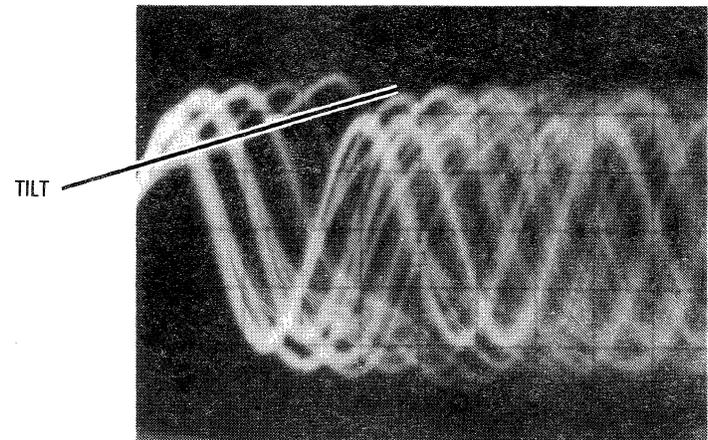
A. CORRECT ADJUSTMENTS,
26.6 kb/i PACKING DENSITY



B. CORRECT ADJUSTMENTS,
33.3 kb/i PACKING DENSITY



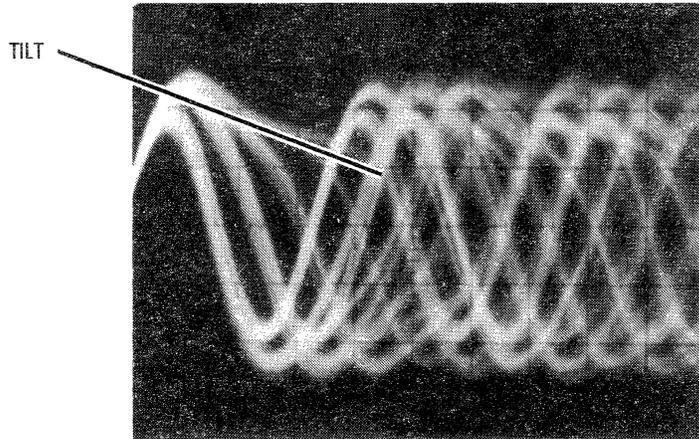
C. HIGH BAND MISADJUSTED
(TOO MUCH HIGH BOOST)



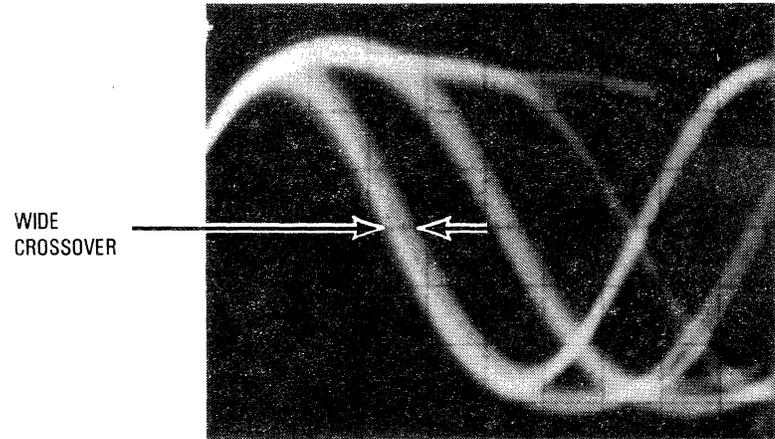
D. PHASE CONTROL MISADJUSTED

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Figure 5. Reproduce Amplifier Output Waveforms (TP5) (Sheet 1 of 2)

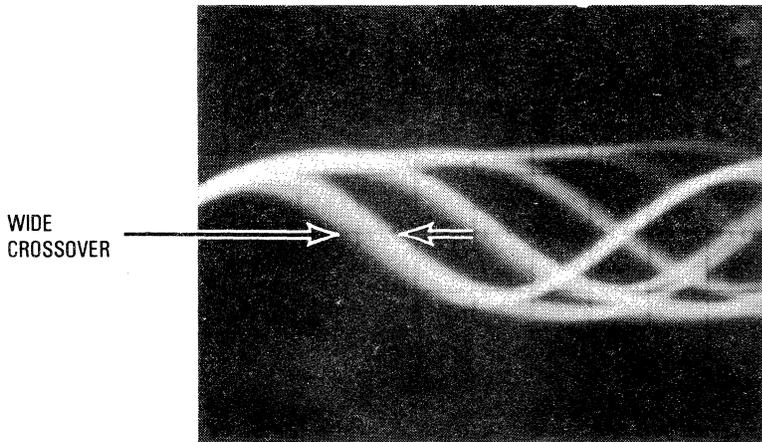


E. PHASE CONTROL MISADJUSTED



L-0192-2

F. MIDBAND ADJUSTED,
TOO HIGH GAIN



G. MIDBAND ADJUSTED,
TOO LOW GAIN

Figure 5. Reproduce Amplifier Output Waveforms (TP5) (Sheet 2 of 2)

- f. Adjust the low-/mid-range potentiometer (R12 to R18) for the tape speed selected to produce the cleanest zero-crossing of the first negative-going transition.
- g. Adjust the high-frequency potentiometer (R5 to R11) for the most even amplitude across the display which does not degrade the clean zero-crossing. At high packing densities (33.3 kb/i), high frequencies may be as much as 6 dB down from nominal mid-band level. (See figure 5B.)
- h. Adjust forward phase control R19 for the cleanest overall eye pattern. (In most systems, the reverse phase control is not used.)
- i. Make minor readjustments of any or all of the controls for the best compromise of clean first crossover, most even amplitude consistent with the clean first crossover, and overall clean pattern. Reset the output level for 2.8 V P-P.

NOTE

If difficulty is encountered in achieving satisfactory equalization, refer to paragraph 8-10 in section 8 of the system manual, and be sure that the system programming is correct.

- j. Repeat all but the phase adjustment for any other tape speeds below 60 IPS to be used. Then at 120 IPS, repeat the entire procedure, using separate phase adjustment R20 and adjustable inductor L7 in the high-frequency equalizer. L7 is adjusted along with the 120 IPS potentiometer for best eye pattern.
- k. Repeat for all digital channels to be adjusted.

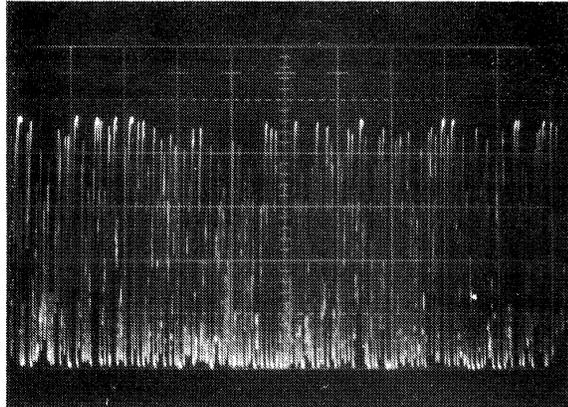
10. Bit-Sync Decoder Adjustments

To perform the several adjustments for the bit-sync decoder PWBA, refer to figures 1 and 6, and prepare the system as follows:

- a. Select E-E mode on the MSB. Supply normal or test clock at the intended operating frequency. Select the appropriate speed switch at the tape transport.
- b. Assure that the PWBA is correctly programmed. (Jumper E1 to E3 and switches S1-1 through S1-4 open.)
- c. Perform the master control preliminary adjustment.

11. Master Control Preliminary Adjustment. The master control adjustment provides a single control for resetting the center frequency of all bit-sync VCO 1's and a second control for VCO 2's. To make the preliminary adjustment, proceed as follows:

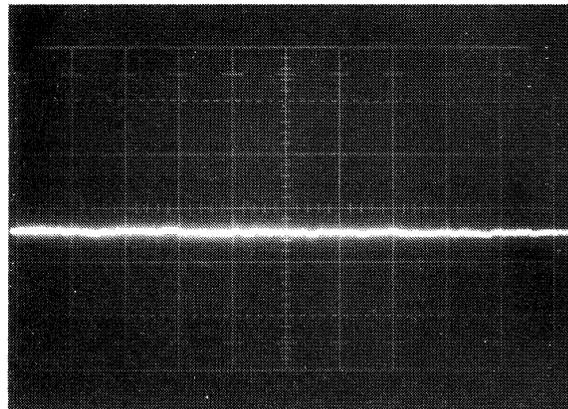
- a. Press switch S1-A, on the master control PWBA in the bit-sync decoder bay (BSB), *in* to the DISABLE position.
- b. With power off, extend the master control PWBA on extender 1256253, and restore power.



OUT OF ADJUSTMENT

VCO TOO HIGH
1 V/DIV
5 ms/DIV

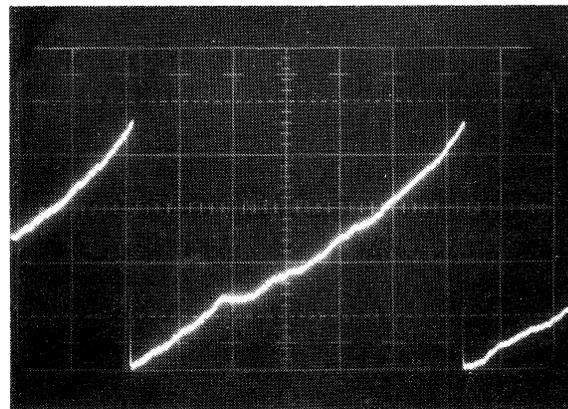
— 0 VDC



NORMAL SETTING

VCO CORRECT
1 V/DIV
5 ms/DIV

— 0 VDC



OUT OF ADJUSTMENT

VCO TOO LOW
1 V/DIV
5 ms/DIV

— 0 VDC

L-0227

Figure 6. Typical 5 Mb/s Data Bit-Sync Adjustment Waveforms (TP4)

- c. Connect a DVM to TP1 and adjust R11 for $5.0\text{ V} \pm 0.1\text{ V}$.
- d. Connect a DVM to TP2 and adjust R14 for $4.75\text{ V} \pm 0.05\text{ V}$.
- e. Return the PWBA to its normal position.
- f. Press switch S1-A *out* to the ENABLE position. Set S1-B *out* for the VCO 1 position, and adjust R18 (VCO 1 adjust) for the same voltage as was set in *c* above ($4.75\text{ V} \pm 0.05\text{ V}$).
- g. Set S1-B *in* for the VCO 2 position and adjust R20 (VCO 2 adjust) for the same voltage as was set in *c* above ($4.75\text{ V} \pm 0.05\text{ V}$).

12. Data Rate (VCO) Adjustment. To perform the data rate adjustment, proceed as follows:

- a. Using S1-B on the master control PWBA, select the VCO to be adjusted. VCO select pushbutton S1-B selects VCO 1's when out and VCO 2's when in (E-E mode only — when in TAPE mode, the VCO1/VCO2 switch on the MSB performs the selection).

NOTE

If there is more than one data rate at a given tape speed, be sure that the correct data rate is being fed to the encoder associated with the bit-sync decoder PWBA being adjusted.

- b. In the DPB, connect an oscilloscope probe to TP-CLK (uppermost TP) of the encoder PWBA. Adjust the oscilloscope time base for one full cycle of clock for 10 cm.
- c. Move the probe to CLOCK OUT test point TP6 of the bit-sync PWBA for channel 1. Adjust the applicable VCO potentiometer for one full cycle of clock displayed for 10 cm. Repeat for all channels. (If the correct frequency is known, the VCO can be adjusted by selecting FREQ on the MSB BITE and selecting the channel number with the thumbwheel switches in the DIAGNOSTIC/MODE SELECT controls. The VCO frequency is then displayed.)
- d. Connect the oscilloscope probe to TP4 on the bit-sync decoder, and adjust for a straight line having a +2.5 volt DC level (see figure 6). Repeat for all channels, and for the other VCO if applicable.

NOTE

The VCO-select pushbutton on the master control PWBA controls the VCO selection when in the E-E mode. When in the tape mode, the MSB VCO select controls the selection and disables the pushbutton on the master control PWBA.

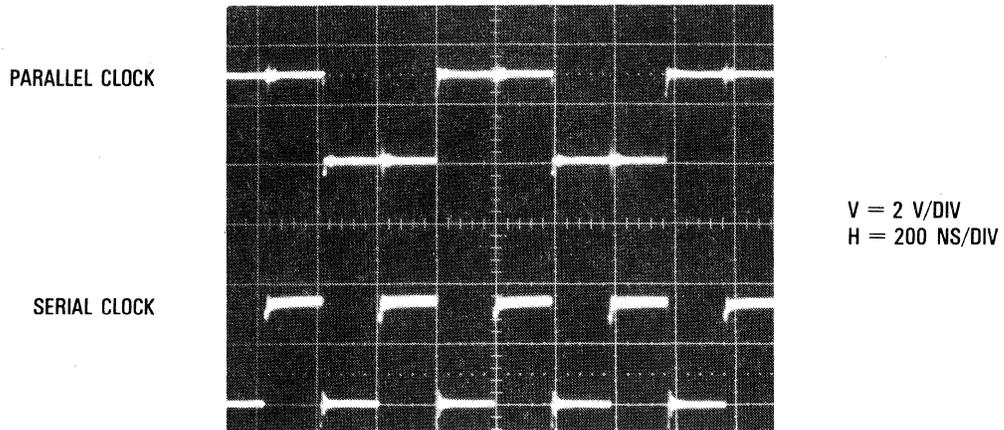
13. Master Control Readjustment. To accommodate a small change in the data rate, the master control voltage can be used to readjust all the bit-sync decoders simultaneously. The new clock and data must be applied to all channels, and all the steps in paragraph 11 must have been performed for the previous data rate. When these conditions are met, proceed as follows:

- a. In E-E mode, select VCO 1 or VCO 2 with S1-B on the master control PWBA.
- b. Monitor one of the bit-sync PWBA TP2 test points and adjust the applicable master control (VCO 1 or VCO 2) adjustment for a straight line having a +2.5 volt DC level (figure 6).
- c. The bit-sync decoder PWBA's are now adjusted for the new bit rate in use at all speeds of the tape transport. If the second VCO is to be used, repeat steps *a* and *b* above for the second VCO.

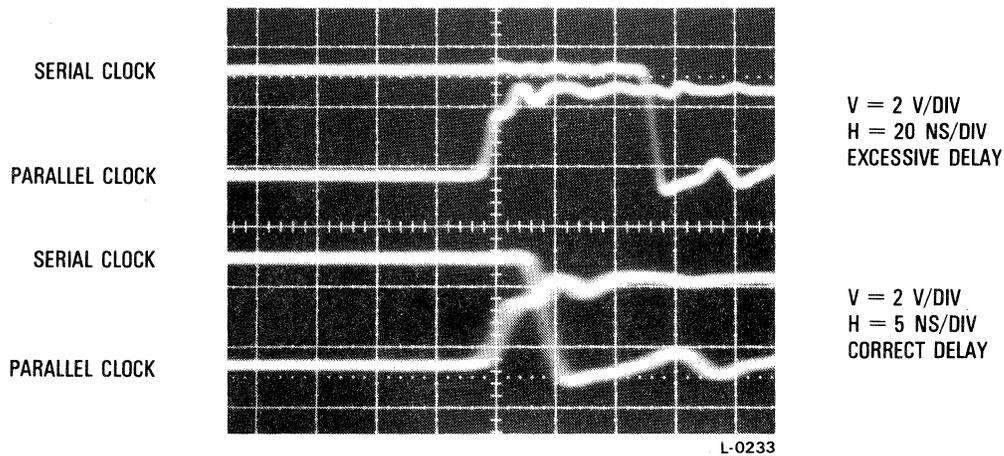
14. Delay Line Adjustment

The delay line adjustment is performed when the system density or data rate is changed, or in case of an unusually high error rate not attributable to other causes. To perform the delay line adjustment, proceed as follows:

- a. Examine the serial clock delay PWBA (its location is shown on the label of the DPB). If no jumpers are installed on the PWBA, install a jumper from E19 to E8 and one from E26 to E20. The E19 and E26 ends of the jumpers are fixed, the other ends are moved to different destinations to adjust the delay.
- b. Install the PWBA in the DPB and extend the parallel-to-serial converter on extender card 1256203.
- c. At the MSB, select serial and E-E modes. At the transport control panel, select 3-3/4 IPS.
- d. If the system is configured for a word-serial format, proceed to step *d*. If the system is configured for a bit-serial format, place a DIP clip on U12 of the p/s converter and with a dual-trace oscilloscope monitor pins 12 and 11. Pin 12 is the parallel clock and pin 11 is the serial clock. Proceed to step *e*.
- e. For the word-serial system, place a DIP clip on U29 of the p/s converter and with a dual-trace oscilloscope, monitor pins 2 and 3. Pin 2 is the parallel clock and pin 3 is the serial clock.
- f. The signals displayed on the oscilloscope should resemble figure 7A in type, with a number of serial clock cycles per parallel clock cycle that represents the divide-by-N programming of the system. Figure 7A shows the parallel and serial clocks for a divide-by-2 system.
- g. Adjust the oscilloscope to overlap and expand the traces and determine the direction and amount of adjustment to be made. The adjustment must bring the 50% point of the negative-going edge of the serial clock to within 5 (± 2.5) nsec after the 50% point of the positive-going edge of the parallel clock. It is important that the parallel clock lead the serial clock. The upper traces in figure 7B show too much delay (over 50 nsec). The lower traces in figure 7B show correct delay.
- h. Adjustment of the delay is made by jumper placement. There are two delay adjustments, coarse and fine:
 1. The coarse adjustment is 18 nsec per E-number change of the jumper destination.
 2. The fine adjustment is 6 nsec per 2 (even numbered) E numbers. (The fine adjustment change must be limited to even numbered terminals to maintain the correct clock phase.)
- i. To change the coarse adjustment, move the E19 jumper to a higher or lower destination E number. (E8 through E18.) To reduce the delay, move the jumper to a lower E number and to increase it, move it to a higher number. (E.g., to reduce the amount of delay by 18 nsec when the coarse jumper is from E19 to E12, move the jumper to E11.)



A. DIVIDE-BY-2 SYSTEM CLOCKS



B. OVERLAPPED, EXPANDED WAVEFORMS

Figure 7. Serial Clock Delay Adjustment

- j. To change the fine adjustment, move the E26 jumper to another *even-numbered* terminal. Again, move to a higher E-number to increase the delay and lower one to decrease it.
- k. At the transport control panel select the next higher speed, checking to see that the delay is still correct. Repeat for each speed selection up to 120 IPS. If the delay is not correct at a higher speed selection, it must be readjusted (probably with the fine adjustment) until it is correct. If a readjustment is made, recheck delay at all speed selections. Repeat until it is correct at all speed selections.
- l. When the delay is correct per step *k*, replace the p/s converter in its normal location, and record and reproduce serial data. If the system fails to lock up correctly when reproducing serial data, further adjustments of the delay may be required.

15. ANALOG ADJUSTMENTS (AUXILIARY CHANNELS)

The following paragraphs include adjustments for analog (auxiliary) channels, followed by performance checks intended to confirm the correctness of the adjustments. If there is any doubt that an auxiliary channel requires adjustment, make the performance checks in section 5 of the system manual.

16. Record/Reproduce Level Definitions

Normally, tape recorder/reproducer systems are calibrated for operating input and standard output levels of 1 V RMS. If, however, it is desired to recalibrate a system to different input and output levels (direct record input level and direct reproduce output level), the operator should refer to the procedures which follow.

The following definitions apply in the procedures given in this manual:

- a. Operating Input Level. Commonly 1 V RMS, but any selected data input level to a record amplifier (within the limits given in the system specifications) is known as the *operating input level* for the channel in which the amplifier is used.
- b. Normal Record Level. With an input signal at the *operating input level*, the record level control of the direct record amplifier is set to produce a signal which contains 1% third-order harmonic distortion at the output of the direct reproduce amplifier. This level is known as the *normal record level*. (Equivalent of "Normal Record Level" as defined in IRIG 106-80.)
- c. Standard Output Level. The reproduce output level control is normally adjusted to produce an output signal amplitude of 1 V RMS, as measured across the proper terminating impedance, when reproducing a signal recorded at *normal record level*. This output level is referred to as the *standard output level*. (Amplitudes other than 1 V RMS may be used, but degradation in signal-to-noise ratio or distortion may result.)

NOTE

After these adjustments are made, and with no changes in adjustment, applying an operating input level signal to the channel input produces the normal record level and standard output level. Any change in operating input level requires the adjustments to be made again if optimum system capabilities are to be maintained.

17. Prealignment Procedures

Prior to aligning auxiliary-channel signal electronics, proceed as follows:

- a. Connect test equipment (identified in table 1) as shown in figure 8.
- b. Be sure that auxiliary-channel programming is correct, per section 8 of the HBR-3000i system manual.
- c. Go on to the alignment procedures unless there is reason to believe that the controls are completely maladjusted (e.g., no output signal when recording and reproducing). In the latter case, proceed to step *d*.
- d. Set the following potentiometers to mid-range settings:
 1. On the headdriver PWBA, the record level potentiometer and the bias potentiometer, as called out on the chart on the inside of the head cover door. (See figure 4.)
 2. On the direct reproduce PWBA, output level potentiometer R64 (figure 3).

18. Alignment Procedures

When performance checks indicate the need, or if auxiliary-channel requirements are changed, the signal electronics in such channel(s) should be fully aligned. All procedures should be performed, in order, for all channels that need adjustment; and, as applicable, at all tape speeds that are to be used.

- a. Bias level
- b. Record level
- c. Reproduce level
- d. Equalizer adjustments

19. Bias Level Adjustment. To adjust the auxiliary channel bias, be sure the filter PWBA jumpering is correct, as detailed in section 8 of the system manual, and proceed as follows.

- a. By way of the AUX connectors on the rear of the DPB (input) and the BSB (output), connect the test equipment (figure 8) to the channel to be adjusted.
- b. On the MSB front panel, set the HBR/IRIG switch *in*.
- c. At the transport control panel, select 120 IPS tape speed.
- d. Set the signal generator for a 2 MHz sine wave at 1V RMS.
- e. Initiate forward record mode.
- f. While observing the output waveform on the oscilloscope, increase the record level until the waveform begins to clip or show other distortion, then reduce the level by 5 to 6 dB.

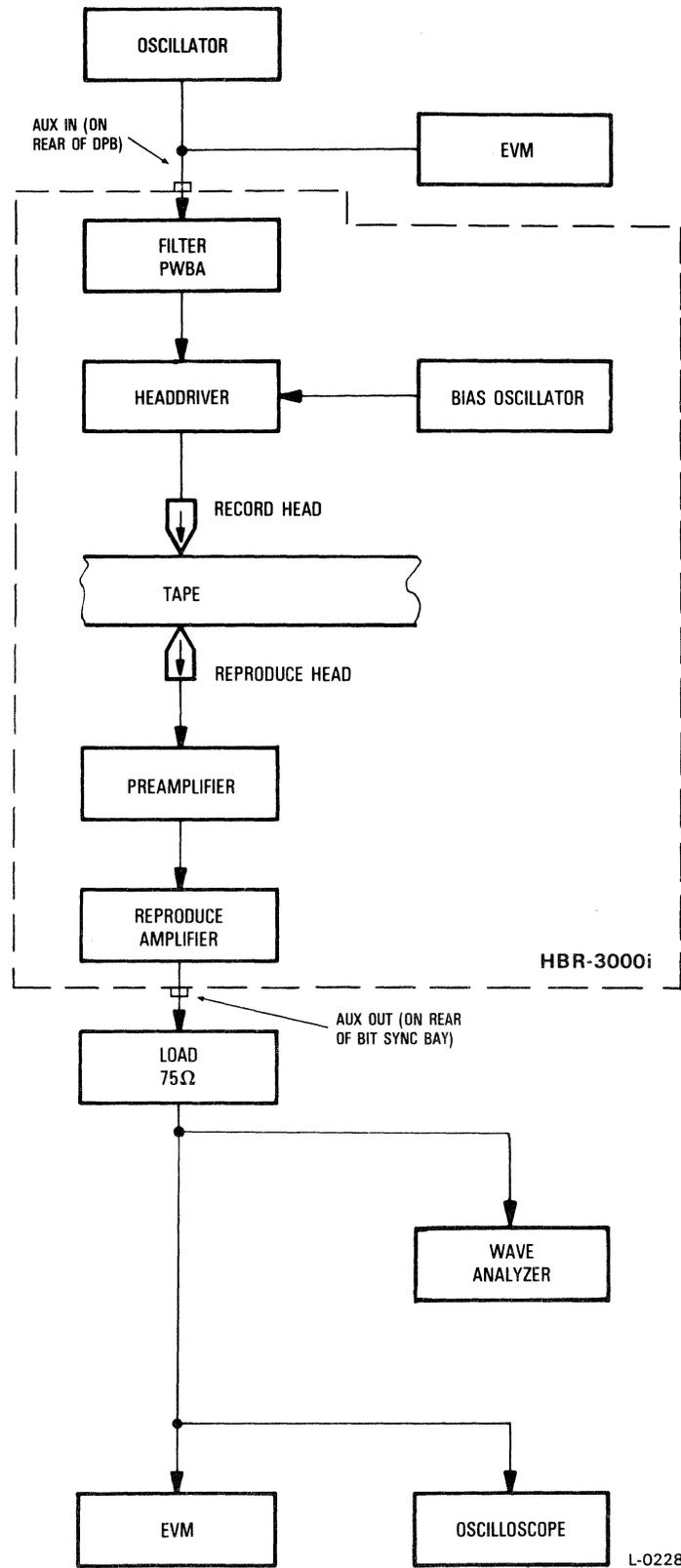


Figure 8. Direct Record/Reproduce System Test Setup

- g. Adjust the bias potentiometer for the channel for maximum signal output. (Make sure the signal does not clip or limit at any time.) When the output peak has been reached, adjust the bias potentiometer CW until the output of the channel drops 2 dB (overbias condition).
- h. Repeat this procedure for any other auxiliary channels that are to be adjusted.

20. Record Level Adjustment. This is the adjustment that sets the *normal record level* (1% 3rd harmonic distortion) when the input is at the *operating input level*.

- a. Set the oscillator to 600 kHz at the *operating input level* selected for the channel. Be sure to maintain this oscillator level throughout the record and reproduce level adjustments.
- b. Initiate record mode at 120 IPS. Adjust the reproduce amplifier level control (R21) to produce a reading of 1 V on the AC EVM at the output of the channel.
- c. Tune the wave analyzer exactly to the signal being reproduced and set it for zero (reference level).
- d. Retune the oscillator to 200 kHz. (Be sure the *operating input level* is maintained.) Increase the sensitivity of the analyzer, and fine-tune the oscillator until the analyzer is reading the 3rd harmonic of the input signal (maximum reading on the analyzer).
- e. If the 3rd harmonic is not down 40 (± 1) dB from the reference level, R15 of the record amplifier must be adjusted until it is. Adjusting R15 changes the output reference level as well as the level of the harmonic. Therefore, each time R15 is readjusted, the reproduce amplifier output level control (R21) must be readjusted to produce a reading of 1 V on the output EVM. Several repetitions of this may be necessary to produce a 40 (± 1) dB difference between the 200 kHz reference and its 3rd harmonic.
- f. Repeat this procedure for any remaining auxiliary channels to be adjusted.

21. Reproduce Level Adjustment. This procedure provides an approximately flat frequency response over IRIG bandwidths at IRIG speeds. Performance may be less flat at other than IRIG speeds. However, other adjustment procedures may be appropriate and optimum depending on the type of data being reproduced (i.e. voice or time code channels may be optimized by rolling off midband and bandedge adjustments to reduce bandwidth and increase signal-to-noise ratios. Other kinds of data may require different phase response and nonflat frequency response).

With the recorder and test equipment set up as above, Perform the reproduce level adjustment as follows:

- a. Set the oscillator to 10 kHz at the *standard record level*.
- b. Initiate the forward record mode at 60 IPS.
- c. Adjust R64, output level control, on the direct reproduce amplifier (figure 3) for the *standard output level* (1 V RMS).
- d. Set the oscillator to the 60 IPS reference frequency (see table 2) at the standard record level and adjust the midband adjust for the *standard output level*.
- e. Repeat step *d* for all other tape speeds.

Table 2. Reproduce Amplifier Adjustments

TAPE SPEED (IPS)	REFERENCE FREQUENCY (kHz)	MIDBAND ADJUSTMENT	UPPER BANDEDGE FREQUENCY	BANDEDGE ADJUSTMENT
120	200	R18	2 MHz	R11
60	100	R17	1 MHz	R10
30	50	R16	500 kHz	R9
15	25	R15	250 kHz	R8
7-1/2	12.5	R14	125 kHz	R7
3-3/4	6.3	R13	62.5 kHz	R6
1-7/8	3.1	R12	31.25 kHz	R5

22. Bandedge Adjustments. Perform the bandedge adjustments as follows:

- a. Initiate the forward record mode at 60 IPS.
- b. Set the oscillator to the upper bandedge for 60 IPS (see table 2) at the *standard record level*.
- c. Adjust the bandedge adjustment potentiometer (table 2) for an output level of 2 dB to 3 dB below the *standard output level*.
- d. Set the oscillator to the 60 IPS reference frequency (table 2) and adjust the midband adjust for the *standard output level*.
- e. Repeat steps *b* through *d* until the output is equal to the standard output level at the reference frequency and 2 dB to 3 dB below at the bandedge frequency.
- f. Repeat steps *a* through *e* for all other tape speeds to be used.
- g. Repeat the reproduce level and bandedge adjustments for all remaining channels to be used in analog mode.

23. Phase Adjustment (Pulse Optimization) Control. Phase linearity is required to permit the recording and reproduction of square waves with a minimum of overshoot and without significant degradation of amplitude response over a specific bandwidth. R19 (R20 for 120 IPS) is used to phase-equalize or phase-correct the nonsinusoidal signal from the reproduce heads, permitting the user to adjust the system for the best square wave.

With the recorder and test equipment set up as above, but with a square-wave signal from the generator, perform the phase adjustment as follows:

- a. To adjust for the best square wave where the frequency of the square wave is not known, proceed as follows:
 1. Initiate the forward record mode at the tape speed to be used.
 2. Set the square-wave generator to the reference frequency as shown in table 2.
 3. Adjust R19 (R20 for 120 IPS) for the optimum square wave as viewed on the oscilloscope.
- b. To adjust for the best square wave where the square-wave frequency is known, set the square-wave generator to the known frequency and adjust R19 (R20) for the optimum square wave out.

24. Bandedge Peaking Adjustment (Factory Adjustment). This adjustment is normally considered a factory adjustment and should not be changed in the field unless circuit components have been replaced or L7 was adjusted for a digital channel.

To make the bandedge peaking adjustment, proceed as follows:

- a. Connect the test equipment as shown in figure 8.
- b. Set the output of the oscillator to 2.1 MHz at 1/10 of the *operating input level*.
- c. Set the wave analyzer for 2.1 MHz.
- d. Turn R11, bandedge adjust, fully CW (multiturn potentiometer).
- e. Initiate the forward record mode at 120 IPS.
- f. Adjust inductor L7 for a maximum output on the wave analyzer using a nonmagnetic tuning wand.
- g. Readjust the bandedge adjustment per paragraph 22, *a* through *e*, above, at 120 IPS.