Sound Talk®

Scotch Magnetic Tape

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HIGH FREQUENCY BIAS REQUIREMENTS FOR MAGNETIC TAPE RECORDING

Magnetic recording tape provides a superior method for the permanent recording of information, but it is limited by the natural phenomena of magnetic properties. Fortunately, the shortcomings created by this magnetic phenomena can be compensated for by the use of electronic measures. This bulletin will make no attempt to explore the mathematical or theoretical realms of magnetic recording, but will present a simplified explanation of high frequency bias, its requirements and limitations, and methods of adjustments.

Every magnetic medium exhibits a non-linear characteristic because the magnetization, resulting from an exposure to a magnetic field (such as that produced by the recording head), is not directly proportional to the strength of the field. This non-linear characteristic, if not corrected, would result in severe distortion of the audible recorded information. The use of a high frequency bias current; applied through the recording head, is the standard method of compensating for the non-linearities in the transfer of electro-magnetic signals onto magnetic recording tape.

The high frequency bias signal is usually generated by an oscillator circuit in the recorder electronic system and is added to the signals generated by the microphone or supplied by the recorder input circuits. The bias is a high frequency, usually 30 to 100 kHz (KiloHertz), which is above the range of hearing. Therefore, during playback of only the bias signal, one would not hear or identify any tones which would identify its presence. By adding the bias signal to the audio signal, a resultant signal is produced (Fig. 1). In most recorders, the two signals are simply combined without any form of modulation. The resultant signal is what the record head inductively converts from electrical signals into magnetic fields which influence the magnetic tape.

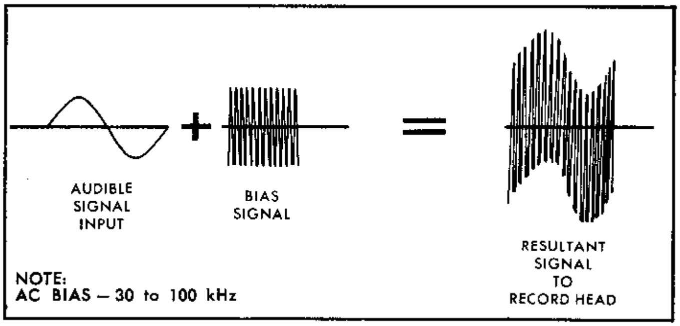

FIGURE 1. PRODUCTION OF RESULTANT SIGNAL

As previously stated, every magnetic medium exhibits a non-linear characteristic. This non-linearity is best illustrated by the Transfer Characteristic Curve which is mathematically derived from a family of hysteresis loops (Figure 2). The hysteresis loops and transfer curve indicate the degree of tape magnetization which results from an exposure to a magnetic field such as that produced by the record head. The transfer curve also indicates that the non-linearities exist only at the extremely low signal level (center portion of the curve) and at the very high signal levels (saturation areas) which are at the extreme ends of the curve. The remainder of the curve is relatively straight and allows linear and proportional transfer of magnetic signals.

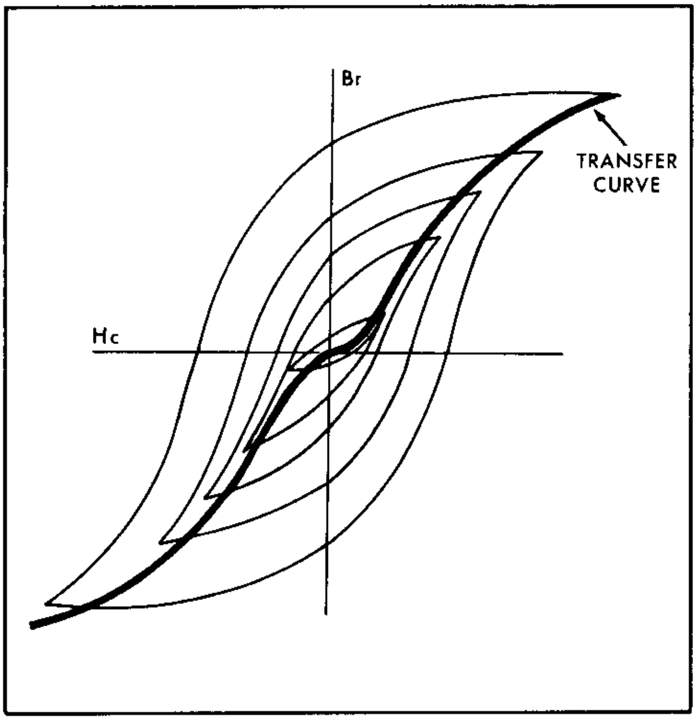

FIGURE 2. TRANSFER CURVE DERIVED FROM A FAMILY OF HYSTERESIS LOOPS

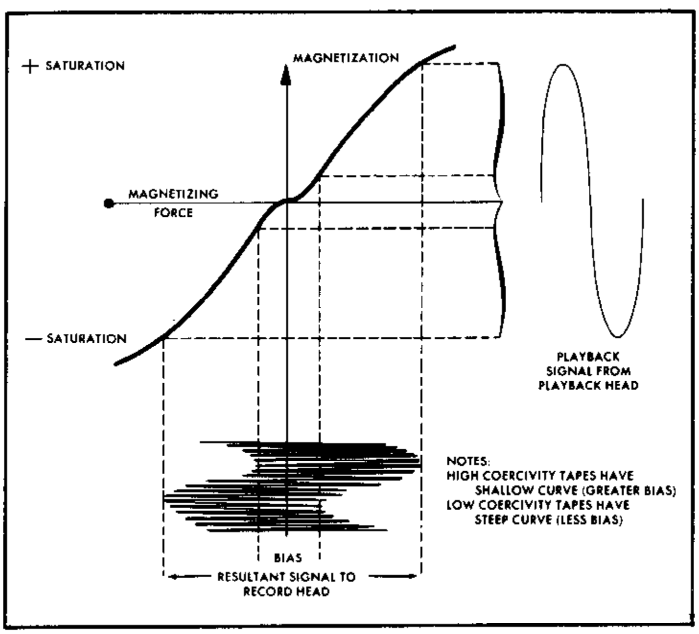

FIGURE 3. RECORDING TAPE TRANSFER CURVE

The transfer curve shown in Figure 3 illustrates the resulting tape magnetization from a magnetic signal generated by the record head. The curve is typical of those for recording tape and no attempt is made to show non-linearities and signal losses created by either the record head or recorder electronic systems.

As the magnetizing force increases (greater record head output in terms of magnetic flux field intensity) the resulting tape magnetization also starts to increase. Notice that the vertical segments of the transfer curve are relatively straight. It is within these straight segments of the curve that undistorted recording takes place. The straight segments indicate that a linear and proportional relationship exists between a given input and the resulting output. This relationship may change for different types of tape because of differences in the magnetic properties exhibited by various oxide coatings.

The straight portions of the curve continue until either saturation in the positive or negative directions occurs. At the saturation points, no effective additional tape magnetization will ocur even if the magnetizing force continues to increase. Recording into the saturation levels may produce distortion, tape noise, and reduce frequency response.

To visualize the recording process, the transfer curve illustrates the resultant signal waveform (sum of bias and input signals), and its transfer across the curve to form the recorded signal waveform (Figure 3). Observe that the signal with bias essentially bridges the "zero-point" and the low signal response portion. The bias position across the curve allows the signal changing portions of the input waveform to fall onto the linear segments of the curve.

The shift of the input waveform across the transfer curve to form the recorded signal waveform shows that the non-linear segment is essentially removed by the bias signal, and the recorded signal is relatively distortion free. Also, it can be visualized that either a low or high bias condition will drive the signal onto the non-linear segments of the curve and will cause distortion.

With a low bias condition, (Figure 4) the low level input signals may fall into the "zero-point" region and either may be severely distorted or not be reproduced. In a high bias condition, (Figure 5) the high frequency response will decrease. The high frequencies will distort sooner or go into saturation because of a phenomenon called "self-erasure" which will be discussed in a future *SOUND TALK*. Also, the signal-to-noise ratio may be reduced causing undesirable tape noise.

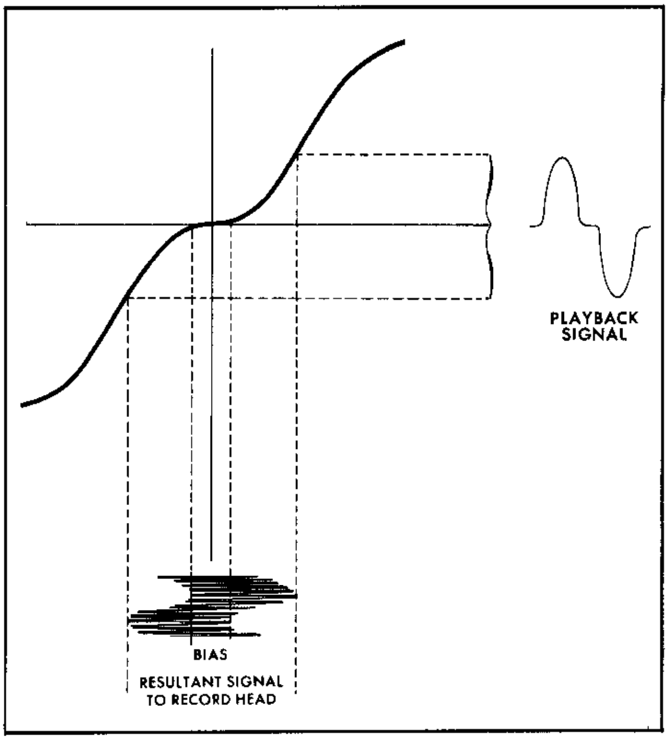

FIGURE 4. UNDER BIAS CONDITION

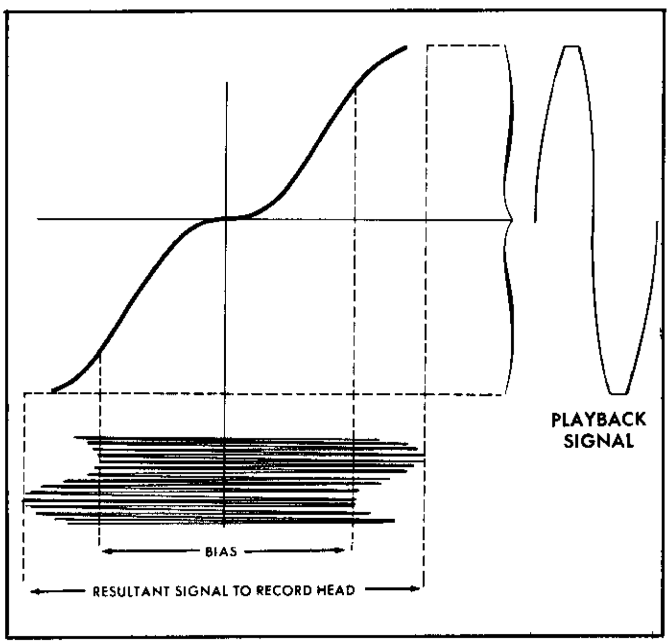

FIGURE 5. OVER BIAS CONDITION

The transfer curve is typical of most magnetic recording tapes but each particular type of tape will exhibit different slope, "zero-point" region, as well as different saturation peaks. The differences of the curve shapes are created by the individual magnetic properties exhibited by each tape type. As the shape of the curve changes so do the bias requirements.

A low coercivity tape has very steep linear segments and will require less bias current. On the other hand, a high coercivity tape has relatively shallow linear segments which require a greater bias current input. Because of the differences in tape magnetic properties the slope of the curve changes and the proper bias level required to eliminate distortion will change accordingly.

To evaluate the changes of bias requirements involved with different types of tape, the tape's wavelength response must be considered. Bias current is required to eliminate distortion but is also directly involved with frequency response and output. In terms of response and output, the bias requirement is related to tape construction such as; type and thickness of coating, quality of oxide dispersion forming the coating, and smoothness of the coating surface.

As a general rule, high frequency response can be improved by using a tape with a high coercivity oxide, relatively thin coating depth and a smooth (specially prepared) coating surface. These improvements of high frequencies may have an opposite effect for the low frequencies to the extent that they may not be reproduced with the same efficiency. This situation becomes apparent in the bias curves (Figure 6).

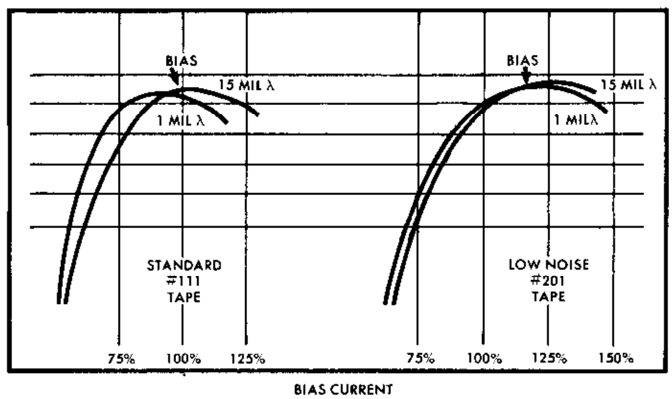

FIGURE 6. BIAS CURVES

Because of the slight differences that may occur in the reproduction of the different frequencies, the actual bias setting is of a selective nature. The ideal situation would be one where the bias setting is at the point of peak output for all frequencies. Note that a bias setting is easily accomplished for the low noise tape as shown in the bias curves (Figure 6). For this particular tape both the high frequency (1 mil wavelength) and the low frequency (15 mil wavelength) output peaks coincide with each other allowing the bias setting to be at the overall output peak.

In the case of the standard tape, the high and low frequency (short and long wavelength) output peaks do not coincide at maximum output. The bias setting could be at either output peak or at the mid point. In normal recorder adjustment however, the bias setting most often used is at the output peak of the longer wavelengths. This setting is justified because the greater percentage of recorded information is in the low or mid-range portion of the frequency spectrum. To compensate for any unbalance in response output, the equalization settings of the recorder are adjusted until the overall output frequency response is flat.

TYPICAL BIAS ADJUSTMENT PROCEDURE

The bias settings shown in the illustration indicate only a relative bias level comparison between two different types of tape. The percentage value relationship will generally hold true for most recorders. Specific information on bias adjustment or settings is impossible to enter into here because of the large variety of recorders in use. Most recorders have their own individual requirements and specifications for bias current (or voltage) adjustments. If a bias level adjustment is attempted – care should be taken to assure correct settings and the recommendations of the recorder manufacturer must be precisely followed.

As mentioned in the preceding paragraphs, the low-midrange frequency (longer wavelengths) output peak is generally used to obtain the most desirable bias setting. The normal adjustment frequency (for 7½ inches/sec. tape speed) is 500 to 1000 Hz. This audio signal is available from an audio, function, or signal generator which most electronic repair facilities have available.

The following adjustment of recorder bias is typical of many machines now in use. For stereo machines, the adjustment procedure must be repeated for both channels. Before attempting any adjustment, be sure that the machine is operating properly, the record and playback heads are clean and in good condition, and thoroughly review the manufacturer's service manual. The bias adjustment range, location, and function of controls, and the operation and scale of the output meters (VU meters) must be understood. Since the bias setting is determined by the type of recording tape, establish the basic type of tape most often used in your particular recorder. Prepare the machine for normal recording at 7½ ips with a low signal level input (approximately 20 db below tape saturation).

Set "Gain," "Record Volume," or "Level" adjustments low to avoid the possibility of recording in the saturation levels. Adjust the signal generator (1000 Hz signal source) for a low voltage output and connect to the recorder input terminals. If the recorder is a 3-head type, while recording the 1000 Hz signal, listen to the recorded signal. Slowly increase the bias current (or voltage) and observe any increase of output as indicated on the VU meters. An increase of intensity of the playback signal should also be heard. Continue to adjust the bias, starting at low output, until the maximum output signal is observed. Continue to increase bias until the maximum output signal is observed. Continue to increase bias until the output begins to drop, indicating an over-bias condition (Figure 6), and return the bias setting to the point of maximum output.

If the recorder is a 2-head type, the set up procedure is similar except that a series of short recordings, each with a change in bias current (or voltage), is made and played back. A simple method is to voice identify the recording segment and bias setting and record the 1000 Hz signal for 10 seconds, readjust the bias current and record and identify another segment. Repeat this procedure for low to high bias current (or voltage). Then play back all the recorded segments noting which one has the greatest fidelity and intensity, and set the bias accordingly.

The recommended bias setting for most recorders is where maximum output is indicated for the 1000 Hz signal. This setting coincides with the low frequency (long wavelength) output peak as shown in the response curve illustrations.

After the correct bias adjustment is obtained, a corresponding equalization control adjustment may, in some cases, be required to compensate for differences in overall response. Usually a simple listening test of recorded material will determine if the overall response is correct.

SUMMARY

High frequency bias current to the recording head is required because of the non-linear characteristic exhibited by most magnetic media. Its major purpose is to compensate for these non-linearities and allow distortion-free recording. Correct bias setting allows undistorted recordings on magnetic tape to the limits established by the record head or the recorder electronics. Proper bias adjustment also assures a better signal-to-noise ratio and optimum frequency response. Maximum performance and fidelity are direct results of high frequency bias.

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