

Demagnetizing A Tape Recorder¹

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The Talkback column of *db Magazine*, on page 2 of the 1987 March/April issue, published some answers to readers' questions about demagnetizing tape recorder heads. This brought a flood of comments and further questions to the Editor. So he asked me "is there any technical basis for a procedure for demagnetizing tape recorder heads?" Here is what we think we know.

1 WHAT GETS MAGNETIZED IN A TAPE RECORDER?

Anything that contains iron, nickel, or cobalt is probably ferromagnetic, which means that it can become magnetized.

But the magnetic field decreases rapidly with spacing, so our concern with magnetization can usually be limited to only those things which directly contact the tape — heads, guides, and the capstan shaft.

The materials used to make head cores and shields are very low remanence (that is, they would make terrible permanent magnets), but if they are subjected to a high magnetizing field they do retain enough magnetization to affect a tape recording.

The guides and capstan shaft are subject to the constant abrasive wear from the tape running over them, so they *must* be wear-resistant. What is non-magnetic and wear resistant? Ceramics are used and Pyrex glass is used, but most often guides and capstan shafts are made of "non-magnetic stainless steel." As with the head material, "non-magnetic" only means that you would not intentionally use the material to make a permanent magnet. It does not mean that it has no remanence at all!

Another source of unwanted magnetic field in a tape recorder could be current flowing in an electrical conductor. It takes a current of 300 A to make a field of 2.5 kA/m (10 % of the tape coercivity — the least that could affect a recording) at a distance of about 20 mm away from the conductor. Such currents are never found in a tape recorder, so we won't further consider the field from a conductor. Yet more sources could be solenoids and transformers. We have not measured their fields, but we do not believe that they produce large enough leakage fields to be a problem.

2 HOW DO HEADS AND GUIDES GET MAGNETIZED?

Certainly there is an obvious way to magnetize a head, guide, or capstan shaft — touch it with a permanent magnet, such as a magnetized screwdriver.

The capstan shaft runs down into the motor "works" which is a veritable hotbed of magnetic fields. But they are *alternating* fields in many studio recorders; and even in dc motors, the magnetizing path through the capstan shaft would seem to be very inefficient. So I would not expect the motor to magnetize the capstan shaft.

You can also magnetize a head by passing direct current or a large unidirectional current pulse through it. How could this happen? Testing continuity with an ohmmeter is one way. But tape recorders in normal use do not have magnetized screwdrivers poked into them, and the heads are not continuity tested. Things *do* get magnetized, but how? That is one of the great mysteries of tape recording.

It may happen that an associated amplifier draws current through the head, either all of the time, or during power-up or power-down. We have had reproducing-head magnetization that seemed — as best we could find — to be caused by occasional current pulses from an integrated-circuit pre-amplifier on power-up or power-down (this was a home-built pre-amp, not a commercially-manufactured unit). This is difficult to analyze, because it happens only rarely. But once can be enough to magnetize the head.

If you find an answer, please tell me! Suffice it to say that I have observed "mysterious magnetization" and I'll bet that you have too.

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3 SO WHO CARES ABOUT A LITTLE MAGNETIZATION?

We all do! Magnetization can produce high second-harmonic distortion in your recordings. It can produce clicks at tape splices. It can produce low-frequency noise (rumblings and poppings), and high-frequency noise (hiss). It can partially erase the recorded signals — especially the short recorded wavelengths (that is, the high frequencies, especially at slower speeds).

4 HOW DO I KNOW IF I HAVE MAGNETIZATION?

If the magnetization is bad, you have already heard some or all of the effects just listed. But you really want to eliminate the magnetization *before* you ruin a recording session or an existing master tape, not afterward.

Finding out what is magnetized, how much it is magnetized, and why it is magnetized, will take much longer than the actual demagnetizing. So if you are the usual busy maintenance engineer, you will probably just demagnetize without worrying about scientific analysis. But, for the curious...

The list of magnetization effects can be broken in two categories — magnetization in recording, and magnetization in reproducing.

Magnetization in recording occurs because of unidirectional magnetization at a point where an alternating magnetic bias field is present. Such a point would be at the recording head, the erasing head, or both². This magnetization causes high second-harmonic distortion, high recorded background noise — mostly rumblings and poppings — and clicks at splices.

Magnetization in reproduction occurs because of unidirectional magnetization at a point where there is no alternating bias field, such as the reproducing head, guides, and capstan shaft. It causes increased noise — mostly high-frequency noise, and erasure of signals — mostly high-frequency signals.

These effects directly suggest the tests that you can perform.

4.1 Recording tests would be as follows:

Distortion test: Record a mid-frequency test signal (any frequency in the 250 Hz to 1000 Hz range) having low distortion (less than 0.2 % second harmonic distortion) at

² The unidirectional field could come from the earth's field of around 50 microtesla, tho the recording head shield should reduce or prevent this. Yet another source of unidirectional field in the recording and erasing process is an asymmetrical biasing or erasing current waveform. This may be a high harmonic (such as the 10th harmonic) "blip" on the wave.

normal recording level³, using normal bias, and measure the second harmonic distortion of this recording. If the second harmonic distortion exceeds 0.5 %, then there is probably a magnetization problem. (You will need a sharply tuned filter such as a wave analyzer or at least a 1/3-octave spectrometer for this measurement. A Total Harmonic Distortion meter is completely useless here — its indication is derived mostly from third harmonic distortion, background noise, and bias leakage.)

Pop and thump test: Record a "blank" tape with normal bias. Increase the playback gain so you can clearly hear the noise. Listen to the playback of the noise. If you hear "popping and thumping" noises, you probably have a magnetization problem. This is not a very repeatable test because the "popping and thumping" are also very much a function of the blank tape itself. So a "bad" tape on a "good" recorder may sound rather like a "good" tape on a "bad" recorder. Therefore this test may be difficult to use. I have said "listen" rather than "measure with a voltmeter" for two reasons: First, not all studios own a voltmeter that will read levels down to the -50 dB to -80 dB range that we are measuring here. Second, your ear can tell the difference between hiss, rumble and thumps, bias leakage, etc., but a voltmeter can't tell the difference unless you filter the noise first, and have the right averaging time in the rectifier.

Splice click test: Take the recording mentioned just previously and splice a 10 mm length of non-magnetic (paper or plastic) leader into it. For best effect make a 90° (not 45°) cut, and be sure the splicer is not magnetized. Play through this splice. If you hear distinct clicks when the splice passes the reproducing head, you have a magnetization problem. With a storage oscilloscope you could make quantitative measurements.

4.2 Reproducing tests are easy enough if the magnetized element is "downstream" of the reproducing head, because reproduction *during recording* would give a reference condition (the tape has not passed the magnetized surface) but rewinding and reproducing again would give the measurement after the tape has passed the magnetized element.

Noise-increase test: Record a "blank tape" as above. Turn up the reproducer gain so you can hear the noise. First listen to the mid- and high-frequency hiss *as you make the recording*. Then rewind and play the tape several times. If the hiss increases with number of plays, then something is magnetized.

High-frequency erasure test: Record a high frequency (16 kHz at 7.5 in/sec, at about -10 dB), and (as above) play during recording, then rewind and play several times. See if the recorded level remains constant for all of these playbacks. It is not unusual to see the level at this wavelength drop a few

³ Unlike the third harmonic distortion, which is a function of the square of the signal amplitude, the second harmonic distortion due to the unidirectional magnetization is essentially independent of the signal amplitude.

tenths of a decibel on repeated playings (attributed to magnetostriction, and commonly called “bending loss”), but if the level of the recording drops more than about 0.5 dB with several playings, then magnetization is likely.

If, on the other hand, the reproducing head *is* magnetized, then even the first playback may be noisy and erased. In this case, you have to make a first recording that may already be noisy and erased. Then demagnetize the reproducing head, and make a second recording. Compare the noise level and high-frequency response of the first and second recordings. If they are the same, you didn't need to demagnetize the reproducing head. If the second recording has less noise and a higher level than the first, you did need to demagnetize the head.

Note that on a multi-channel recorder it is probable that the magnetization problems will be different on the different channels. So all tests have to be done on every channel that you care about. This may be a blessing in disguise, because you may find that some channels are not magnetized, and serve as reference for the magnetized channels.

5 MAGNETIZING AND DEMAGNETIZING

There are two concerns when using a demagnetizer: First, is the field from the demagnetizer strong enough to demagnetize the heads and guides? And second, when is it far enough away so that you can shut it off without re-magnetizing the heads and guides?

Demagnetizing: If the demagnetizer is to demagnetize the core laminations, then the field that it produces must be large enough to cause the induction (flux density) in the core to approach saturation. When saturation approaches, the head output voltage waveform becomes distorted. But by this time the output voltage level is about 50 dB greater than the maximum output from tape, and the playback head preamplifier will surely be completely overloaded. Thus to perform this test you must disconnect the head and connect it directly to an oscilloscope input, and look for distortion in the waveform.

Now another measurement complication arises: the head output voltage is the derivative of the core flux. The effect is that when the core flux is sinusoidal, the output voltage is also sinusoidal. But when the flux becomes a square wave, the head output voltage becomes a series of “spikes,” and there's no way to tell just how near you are to core saturation. The “fix” for this is to build an integrating amplifier⁴. When the head output voltage is fed through an integrator, the integrator output voltage has the same waveform as that of the core flux. Therefore the 'scope waveform will show a flat-topped wave when the core saturates.

For rough estimation purposes, you can look at the head output voltage directly on an oscilloscope. Turn the head demagnetizer on, and bring it to a point about 20 mm away from the head. You should see a sinusoidal wave on the

'scope. Then bring it closer, eventually touching the core with the demagnetizer pole tips. As you bring it closer, you should come to a point where the waveform on the 'scope begins to look distorted. The sinusoid will turn into more-or-less spikes. When you begin to see spikes, the core is saturating, and the head will be magnetized if you switch the demagnetizer off, or demagnetized if you move the demagnetizer away from the head before switching it off.

Remagnetizing: So...you ask “how far away from the head do I have to be before I turn off the demagnetizer?” The magnetics textbooks get pretty vague here. They tell us that a field that produces less than about 10 % of the saturation induction will not produce permanent magnetization. If you measure the actual head output voltage level at the onset of non-linearity, and compare it with the level from a test tape (at the same frequency), you will see that the level difference is about 60 dB, which corresponds to an induction not 10 % of saturation, but just one-hundredth of that, which is 0.1 % of saturation. Put another way, it seems intuitive that the magnetization on ordinary recorded tapes will not permanently magnetize the heads, so the same field from a demagnetizer should not permanently magnetize the heads either.

Now this gets to be a measurement that you can easily do for yourself: Take a reproducer that is calibrated so that normal recording level of around 250 nWb/m gives a reference (0 dB) indication on the volume indicator of the reproducer. Turn on your head demagnetizer, and bring it closer to the heads, until the volume indicator reads around 0 dB. (With our particular demagnetizer and heads this condition corresponded to a demagnetizer-to-head spacing of about 70 mm. You will probably find a similar distance.) Now at this distance, nothing you do to turn off the demagnetizer or move it still farther away can possibly produce a high enough field to magnetize the heads.

Perhaps someone will say, “Ah, but when you switch the field off suddenly, a spike is produced.” It is true that the head *output voltage* will have a spike because the output voltage is the derivative (rate of change) of the magnetic field. But there is *no spike in the magnetic field itself* — it just falls to zero. You can confirm this for yourself. Connect a loudspeaker to the tape recorder output. Position the demagnetizer about 70 mm from the reproducing head. Switch it on and off, and listen for loud clicks. You won't hear any, and this means there are no large magnetizing pulses that could magnetize the head.

6 CONCLUSION ABOUT REMAGNETIZING:

Once the demagnetizer is around 70 mm away from the head, it doesn't matter how you move it around and turn it off.

PS It is possible for a ferrite erasing head to be permanently magnetized enough to record “dc noise” onto the tape. The only solution in this case may be to replace the erasing head.

⁴ Contact MRL for information if you want to build such an integrating amplifier.