Magnetic Recorder Testing with a Flux Loop

In our search for ways of dividing the magnetic recording and reproducing process into smaller, more easily diagnosed components, the flux loop is an extremely powerful tool that permits separating tape-related problems from electronic circuitry problems.� Considering a cost of only a few cents to make a flux loop compared to a wealth of information obtained regarding the performance of the recorder, the flux loop is certainly an overlooked bargain.

Some skeptics may question the need for the flux loop.� After all, doesn't the standard procedure of aligning playback level and equalization with a test tape cover all of the potential sources of problems?� The answer is "Yes, but all too well."� The test tape includes all errors of the playback system together.� Poor tape-to-head contact, errors due to head gap deterioration or head misalignment, and electronic gain and equalization frequency response anomalies could all be responsible for any noted discrepancies.� How can we determine which is which?

Another serious disadvantage of using the standard alignment tape as the sole test criterion is that we may not notice errors in the magnetic interface which gradually creep into the system due to aging and wear.� Frequent realignment of the machine hides small incremental changes that may be indicators of pending catastrophic failures.� If the machine is aligned frequently, only small, unnoticed changes will be required during each alignment session.� Within a short time, however, these small alignments add up to a major error.

A good example of a creeping error is gap erosion of a ferrite head.� The erosion is a gradual process, but most users suddenly "discover" the problem only when it causes serious response or noise problems.� Periodic checks with a flux loop can spot erosion before major errors develop.� When the problem is severe enough to require attention, preventive maintenance to relap the head can be scheduled at a convenient time that avoids interruptions in studio schedules.� (See �Maintenance Procedures for Ferrite Heads� at www.manquen.net for more details.)

Frequency and Wavelength Basics

To understand the unique benefits of the flux loop we must first explore what is happening at the gap of a head as a tape passes over the head gap.� The signal that is recorded on the tape is actually variations in the magnetic polarity and strength of the magnetic particles on the tape.� Each of the microscopic magnetic particles is a small magnet that contributes either one unit of North or South polarity magnetism (magnetic flux.)� A visual analog would be a black-and-white picture of a picket fence in a newspaper.� The newspaper picture is composed of an array of black and white dots.� Gray "halftones" are created by varying the density of the black dots.� The image of the fence is composed of a repeated pattern of alternating white and black areas.�

�� Figure 1.�

We could describe the "pitch" of the fence by measuring either the number of fence pickets per inch or the distance from picket to picket.� The number of pickets per inch is the "spatial (derived from 'space') frequency" or how many times an event occurs per unit of distance.� If the width of the pickets is cut in half so that the number of pickets per inch is doubled, the spatial frequency is also doubled.� "Wavelength" is the distance from a reference point on one picket to the equivalent reference point on the adjacent picket.� Spatial frequency and "wavelength" are alternate descriptions of the same characteristic - wavelength is pickets per inch, which is the reciprocal of the spatial frequency in inches per picket.

Our magnetic recording also has wavelength and spatial frequency attributes for the recorded signals.� Higher pitched sounds have shorter wavelengths and higher spatial frequencies.� The key factor is that the wavelength and spatial frequency are <u>determined by the speed of the tape</u>.� If we pass a blank tape over a record head that is being excited by a sinewave signal, a sinusoidally varying magnetic signal is impressed upon the tape.� The length of one complete sinusoid on the tape is the recorded wavelength of that signal, and this length is determined by the speed of the tape when it was passing over the record head.

When we pass the recorded tape over the playback head at a given speed, we produce a time-varying signal in the playback head.� The faster the tape moves, the more sinusoidal cycles per second.� The temporal (derived from 'time') frequency of the signal in Hertz or cycles per second is found by multiplying the spatial frequency by the tape speed:

Temporal frequency(Hz) = Spatial frequency(Wavelength) x Speed of propagation

or

Events per second = events per distance� x� distance per second

The magnetic head complicates our problem by having both spatial frequency response characteristics and temporal frequency response characteristics.� Spatial effects include gap length loss, low frequency contour effects, spacing loss, fringing, and thickness loss.� Temporal effects include head resonance and inductive voltage rise at 6 dB per octave.� The flux loop is our key to separating the spatial and temporal effects, but we must perform two sets of tests to fully characterize the spatial and temporal effects.

Table 1

<u>Spatial Effects</u>	<u>Temporal effects</u>
Gap length loss	6 dB/octave inductive voltage rise
Spacing loss	Head resonance
Coating thickness loss	Head inductance
Fringing	
Low frequency contour effects	

The Flux Loop "Transformer"

First, we can use the flux loop to inject a signal directly into the magnetic head by transformer action.� The flux loop serves as the primary coil of the transformer; the windings within the magnetic head are the secondary coil of the transformer.� The resulting transformer no longer has any *spatial* frequency or wavelength characteristics because nothing is moving.� The position of the flux loop coil (and the magnetic structure of the head core which is serving as the transformer core) determines the degree of coupling between the primary and secondary coils, but this coupling is constant for all temporal frequencies in Hertz.� **The frequency response of the flux loop is not affected by mechanical misalignment of the flux loop on the head**.� The level may change, but the frequency response is unchanged.

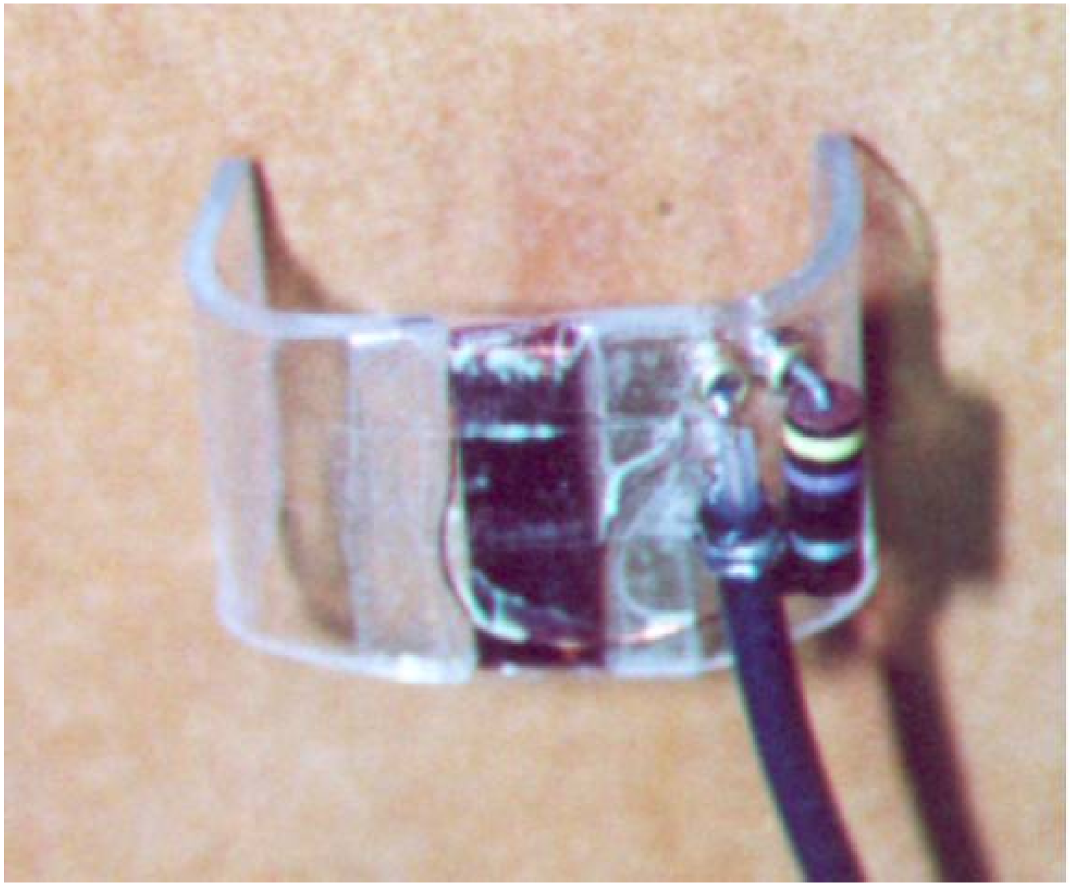


Figure 2. A basic flux loop

For convenience, we can control the frequency response of the device driving the flux loop to generate the flux that would be created by an ideal alignment tape.� The shaping of the frequency response of the driver with an equalizer is referred to as equalizing the flux loop.� With an equalized loop we can run frequency response sweeps of the reproduce channel to determine the response characteristics of the head, preamp, and equalizers for known amounts of flux in the head core at various frequencies.� The "equalized flux loop" thus permits us to adjust the reproduce chain to match the ideal characteristics of a theoretical ideal alignment tape, yielding a nominally flat frequency response.

Since a properly equalized flux loop will inject correct flux levels over a wide frequency band, we can use more complex input signals such as square waves and bursts.� These complex signals provide greater insight into the dynamic response capabilities of the reproduce channel than simple sinewaves.� Reproduce head damping, for example, is easily adjusted with square wave excitation.

Comparing Ideal with Actual

But this is only half of the puzzle.� We must now determine how the head converts real-world spatial recordings on a recorded tape into magnetic flux within the head core.� For this part of the investigation, we replace the direct excitation of the flux loop with a standard alignment tape played at the appropriate speed.� Since the alignment tape recording is based upon the same international standards that were used to construct the equalizer for the flux loop, we expect the same performance from the alignment tape as we noted with the equalized flux loop.�

Any discrepancies between the response we predict from the flux loop and the measured response from the test tape are due to the spatial response errors at the tape/head interface.� This would include such factors as head azimuth misalignment, poor tape-to-head contact, and gap erosion.� If all is well, the errors will be small; but if a problem exists the errors may be large.� The nature of the errors, such as the range of frequencies or the rate of change - 6 dB/octave, etc., will generally indicate the nature and source of the problem.

Figure 3.� Flux loop and test tape responses

Constructing a Very Basic Flux Loop

Now that we have examined the "why" of using a flux loop, the next step is to closely explore how to build and use a flux loop.� First we will explore the construction and use of the simplest form of flux loop.� Following that, we will explore loop construction techniques and custom equalizers that make the use of a flux loop more convenient.

A very simple flux loop can be constructed from a length of enameled magnet wire and some sticky tape.� Start with a length of approximately 10 feet of #28 - #36 gauge enameled magnet wire.� Smaller wire permits packing more turns of wire into the active area at the magnetic gap, but the smaller wire is also more fragile.� For a 2" tape machine, wrap approximately 20 turns of wire around 3 or 4 outstretched fingers to form a loop which is at least 2" across.� Remove the loop from your fingers and wrap the side with the loose wire ends with masking or Scotch mending tape to avoid unraveling.

Figure 4. Making a simple flux loop

The loose ends must be stripped of insulation with a knife or sandpaper so that test leads to an oscillator can be affixed.�

Since the short length of magnet wire will be a virtual short circuit to the oscillator which drives the loop, connect the loop to the oscillator through a series resistor of 50 to 600 ohms.� A small value of the series resistor is desirable to maximize the current in the loop and thereby maximize the output from the head and preamp, but the oscillator must not be be overloaded.� To determine the appropriate value, connect an oscilloscope and distortion analyzer across the output of the oscillator that is driving the loop.� Select decreasing values of resistor while checking for distortion and amplitude accuracy at high frequencies.� The selected resistor value should be the minimum value that maintains a clean signal at all frequencies.� If the oscillator/resistor combination does not provide at least 5 mA of flux loop current, insert a small headphone or loudspeaker amplifier between the oscillator and the loop.

Before physically attaching the loop to the head, test the oscillator and loop for constant current performance by attaching a voltmeter across the series resistor.� The current through the loop is directly proportional to the voltage across the series resistor.� Sweep the oscillator across the entire audio band and note any deviations from flat response.� These deviations can be used later to correct any readings made while the flux loop is driving the head.

One side of the loop of wire can now be attached to the face of the reproduce head with a strip of tape.� Align the turns of wire to run from top to bottom of the head along the line of the reproduce head gap, with the loops extending beyond the edge tracks for best uniformity.� The reverse side of the coil can dangle out in space or be secured to the face of the head.� Keep the reverse side at least .1" from the gap area so that the desired flux in the gap area is not canceled by the field from the reverse side.

Although our simple loop will certainly inject flux into the reproduce head, we note two glaring construction shortcomings.� First, the loop is not very durable and handling may damage the fragile loop.� Second, the positioning of the loop on the face of the head is not repeatable.� We will describe more construction techniques for durable loops that can be attached with good repeatability in a later section.

An even greater difficulty with this simple coil of wire is that the loop is not equalized.� If we sweep across the frequency spectrum, we will note that the response of the reproduce channel will be flat only in a narrow region near 400 Hz.� The culprit is the frequency response correction curve of the appropriate reproduce equalization standard.� For example, the NAB 15 in/s standard requires a frequency boost of 6 dB per octave above 3180 Hz and a frequency rolloff below 50 Hz.� The high frequency portion is required to correct for wavelength losses resulting from coating thickness loss.� The low frequency portion complements an equal but opposite boost of low frequencies generated by the record equalizer.� This matching low end boost and cut, which originated in the early days when tubes had large amounts of low frequency flicker noise, serves to roll off reproduce amplifier noise at low frequencies, but the consequence is a decrease of low frequency headroom.

The reproduce channel output when using our flux loop can be made flat by changing the flux loop current to compensate for the reproduce channel characteristics.� By applying a cut at the high frequencies to simulate the coating thickness loss and a boost at the low frequencies to match the record equalizer boost, we will achieve an overall flat frequency response from the reproduce channel.� The cut and boost can be generated by an equalizing circuit when using a fixed amplitude source, or through an equalizer file on a software-driven signal source such as the Audio Precision System One.� We will explore both methods here.

Equalizing Circuits

Of the requirements for low end and high end compensation, the easier task is to build a circuit which rolls off at high frequencies to match the appropriate standard.� Building a low frequency boost circuit is complicated by the limits of how far down in frequency the circuit can continue to boost.� We begin with the assumption that the oscillator is an ideal 600 ohm source at all frequencies.� Since the inductance of the flux loop is negligible at audio frequencies, our flux loop presents a load of 100 ohms resistive due solely to the buildout resistor.� We will strive for a 50 Hz boost as used in NAB 7.5 in/s and 15 in/s and compact cassette equalizations with no more than .2 dB error at 50 Hz.�

A low frequency shelving circuit can provide our desired results if we utilize 8 dB of net boost with the components shown.� This passive circuit has 1.1 dB of error at 30 Hz.� Reducing the error requires more than 8 dB boost, but more boost means more current flows into the shelving capacitor and less current flows into the flux loop.� Since we are usually struggling to get adequate current into the flux loop, more boost is a poor compromise.

(Fortunately the AES 30 in/s and CCIR 7.5 and 15 in/s standards have a flat low end that does not require this low frequency boost.)

On the high frequency end, we will complete our example with the 3180 Hz roll off of the NAB 7.5 in/s and 15 in/s reproduce standards (which are identical.)� A capacitor will be added across the oscillator to pull the output down 3 dB at 3180 Hz.� A value of 1.5 μF gives the desired result.

Figure 5. A flux loop equalizer for 15 in/s NAB equalization

The circuit can now be built and tested.� For the NAB 50/3180 Hz curves, a good reference point is 400 Hz, the mean (geometric midpoint) of the lower and upper corner frequencies.� With the voltage across the oscillator at a nominal reference of 0 dB on the metering device, 3180 Hz should be -3 dB and 50 Hz should be +2.8 dB for our circuit.� Refer to the enclosed graph for additional details.

The loss in this passive equalizer restricts our testing to values near nominal operating level for typical oscillators.� If we wish to examine the reproduce chain near the clipping point of tape, we will require much more drive current.� This can be achieved with a small power amplifier driven by our passive equalizer.� We must remember to load the equalizer with 100 ohms to replace the flux loop.� The flux loop is attached through a current limiting resistor of less than 100 ohms to the output of the power amplifier.�

Caution is required when using a power amplifier to drive the flux loop.� Since the wire coil has poor heat dissipation capability, excessive drive to the loop can cause enough heat in the loop to damage the loop or create a hazard to the user or the tape transport being tested.� Select the amplifier maximum output level and current limiting resistor value to keep the flux loop temperatures cool enough to avoid discomfort when touched with a finger.� Also use a current limiting resistor with a generously sized wattage rating so that the resistor will not overheat and become a burn hazard to the operator.

(Since the power amplifier will have relatively high input impedance, the equalizer values can be scaled appropriately for smaller values of capacitors and larger resistors.� Remember to add a resistor in series with the oscillator to scale the source impedance by the same ratio as all of the other components.� Check the frequency response at the output of the power amplifier using the test values given above.)

When working with a programmable source, the oscillator amplitude can be automatically equalized with an equalization file.� The Audio Precision System One DOS software can be used to generate an appropriate flux loop equalization file using the BASIC program �EQCREATE.BAS� on the TEST and EQ disk.� Insert the following lines for Line 500:

For NAB 7.5 and 15 ips equalization

500�

Enter 50 usec when prompted by the program.

For IEC 7.5 or 15 ips or AES 30 ips equalization

500

Enter 70 usec for 7.5 ips, 35 usec for 15 ips or 17.5 usec for 30 ips

A modified program for generating flux loops is listed at the end of this paper.� This program prompts the operator for the type of low end � flat or 3180 usec boost � and the appropriate high-end time constant.

The appropriate EQ file must be �attached� to the test file and the EQSINE option selected to activate the �equalized� generator test mode.

For most loops, a suitable load for the System One generator can be achieved with a 50 ohm 1 watt resistor in series with the flux loop.� Set the Oscillator output impedance to 50 ohms balanced grounded.�

For high level testing, the System One generator�s maximum output current is doubled when the generator is configured as �unbalanced�.� For one of the sample loops used to gather data for this paper (a 20 turn loop that is 1� high and incorporates a 50 ohm buildout resistor), the �25 ohm unbalanced� configuration permits operation up to approximately 8 Volts RMS across the generator output terminals (12 V RMS of generator source voltage before the 25 ohm generator buildout resistor.)� Slightly higher operation would cause the generator �Overload� flag to appear.� This voltage corresponds to 160 mA RMS through the loop, which is equivalent to a reference fluxivity of approximately xx nanowebers/meter.� In comparison, the long-wavelength saturated fluxivity of GP9 tape is approximately yy nanowebers/meter.

Current Vs flux levels

Almost any loop of wire in front of a reproduce head gap can be used to determine the relative frequency response of the reproduce chain.� The wire loop can be held in place with cellophane or masking tape or even a rubber band.� If, on the other hand, the loop is to be used to accurately set the reproduce chain gain, the wire must always be in the same physical position each time the loop is attached to the head.� This higher degree of placement accuracy typically requires a snap-on holderA flux loop with known characteristics can be used as a rough amplitude reference.� For example, assume that testing shows a certain preset value on the oscillator driving the flux loop produces 0 VU on a properly aligned machine.� If the loop attachment mechanism provides repeatable positioning, the flux loop can then be used in the future to set the 0 VU level on that same machine if the oscillator is set to the same reference value.�

The relative output of a typical flux loop may be helpful in determining the amount of drive required for a given application.� The following values were determined with a flux loop of 20 turns of #32 wire wound as a tightly stacked single layer.� A 1/4" stereo recorder was aligned with a 250 nW/m 15 in/s NAB standard alignment tape for 0 VU at 500 Hz, then the flux loop was placed on the reproduce head.� The current of xx mA RMS in the flux loop was measured for 0 VU output at 500 Hz.� (Note that 500 Hz tones from full track test tapes may have a slight fringing error of a few tenths of a dB.� This error is negligible in this application.)

Constructing a Durable Flux Loop

Two types of self-aligning flux loops can be easily constructed.� The most common type grabs onto the sides of the head with fingers.� An alternate style locks into the tape guides.� Either style will work adequately if the flux loop conductors are held firmly and repeatably against the reproduce head gap.

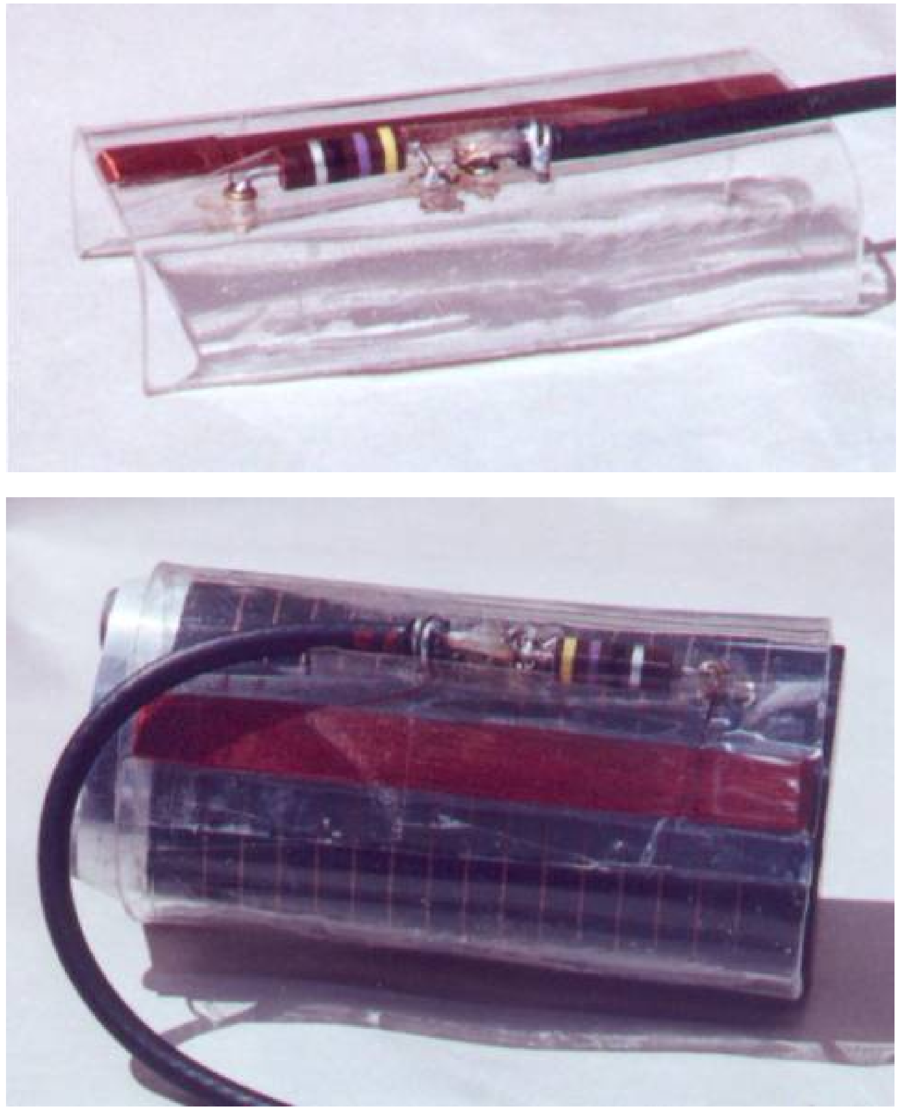


Figure 6. A snap-on flux loop for 2-inch tape

A simple loop with clamping fingers can be constructed with a small piece of 1/16" plastic sheet.� Suitable sources include the plastic stock used for modeling at a hobby store, a storage box for a CD or compact cassette, or the plastic sheets used for fluorescent fixture lenses.� For the sake of this example we will use a cassette box to build a loop for use on an Ampex 2" tape deck.� The plastic yoke should be slightly wider than the tape, approximately 2 1/4", but must be narrow enough to fit inside any head shields.� We will build a U-shaped loop that will have sides of approximately 1" length to grab the head.� Since the head is approximately 1" wide, we will need a plastic sheet which is 2 1/4" x 3".� For our example, we cut the hinged cover of an old compact cassette box with an Xacto knife to make a plastic blank with our required dimensions.�

Once we have cut the plastic to size, we must make a form for molding the plastic to the desired U-shaped contour.� A block of wood cut to the width of the head and 1" longer than the loop height is an excellent form.� For our example, the wood block is������ .

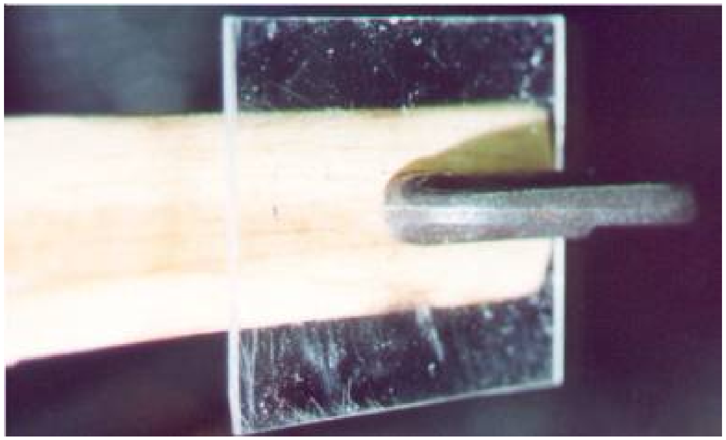
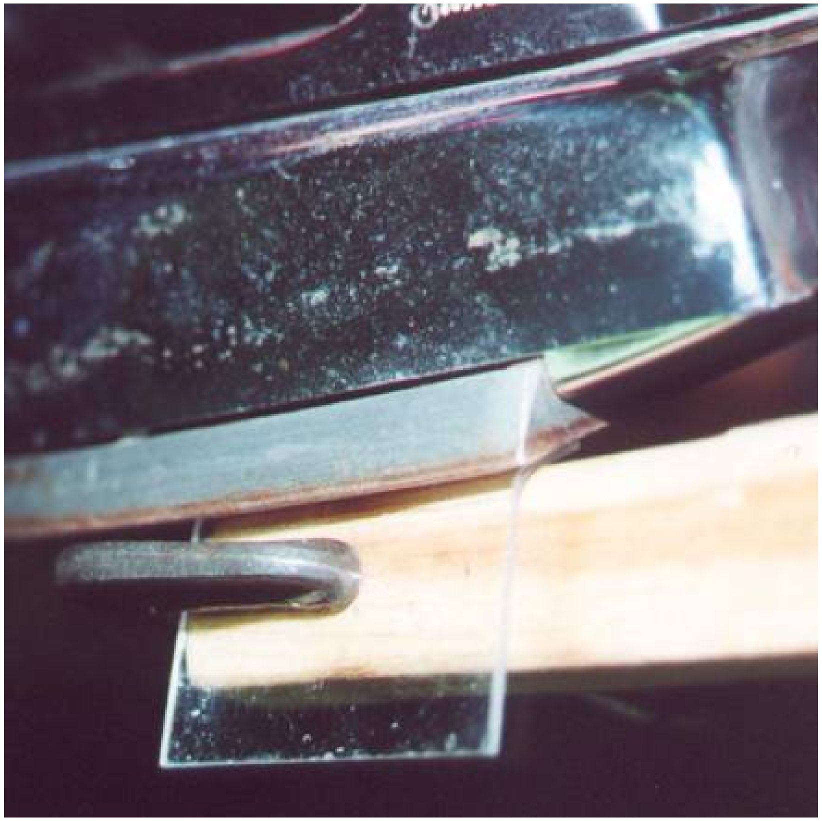


Figure 7. Plastic sheet clamped to wooden form

Make the form just slightly narrower than the head so that the molded plastic will grip the sides of the head firmly.� Since sharply bent corners will break easily, round the corners of the face of the block slightly with a file or sandpaper.

Clamp the block in a vise with the side that represents the face of the head pointing upwards.� Center the plastic sheet on the block with the finger extensions sticking out to the sides.� The author has tried several different methods of bending the plastic, with varied success.� Early attempts used a heat gun or propane torch, gently heating the plastic until the plastic became soft enough for the finger extensions to droop around the sides of the block.� An appropriate tool or an insulating glove was then used to firmly hold the fingers against the sides of the block while the plastic cools.� The problem with this method is that too much heat will distort the plastic.� Heat slowly for best results.



Figure� .� Forming the plastic yoke with an iron

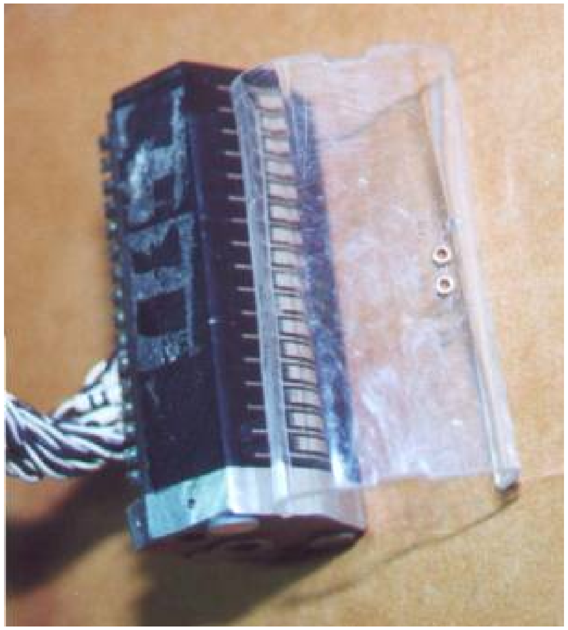
A more recent method is to use a conventional clothes iron or model airplane sealing iron as the controlled heat source.� The temperature of the iron is increased in steps until the plastic bends easily.� Rushing the process with insufficient heat and too much force on the plastic will break the plastic.

 ������������������������� 

Figure� .� Checking the plastic yoke after forming

Check the cooled plastic for a snug fit on the face of the head.� If necessary, modify the form or the process until a satisfactory fit is achieved.� (A slightly loose fit can be snugged up by putting layers of tape on the insides of the protruding fingers that clamp the loop to the head.)

Before winding the wire onto the plastic, we must prepare attachment terminals for the cable from the test oscillator and a winding trough for the magnet wire.� Leads may be attached by drilling holes in the plastic, gluing wires in place, using wire ties, or many other creative schemes.� The objective is to provide good strain relief so that the loop will last a long time.� The example� uses small riveted eyelets to secure the wires and a series dropping resistor.� (If you look carefully, you will note that the author initially forgot to include eyelets for the resistor, but added them after winding the coil.)



Figure� .� Yoke with notches for wire and eyelets for attaching cable

Winding the wire is simplified if notches are cut into the top and bottom edges of the plastic.� Use a small file or knife to cut notches approximately .2" wide centered where the gap of the head will align.� Start the winding by taping one end of the coil wire to the outer face of the plastic with enough service loop for attachment to the cable leads.� Begin winding the wire around the plastic from top notch to bottom notch, stacking adjacent layers snugly together.� When the notch is covered adequately, cut off and fasten the coil end with another piece of tape.

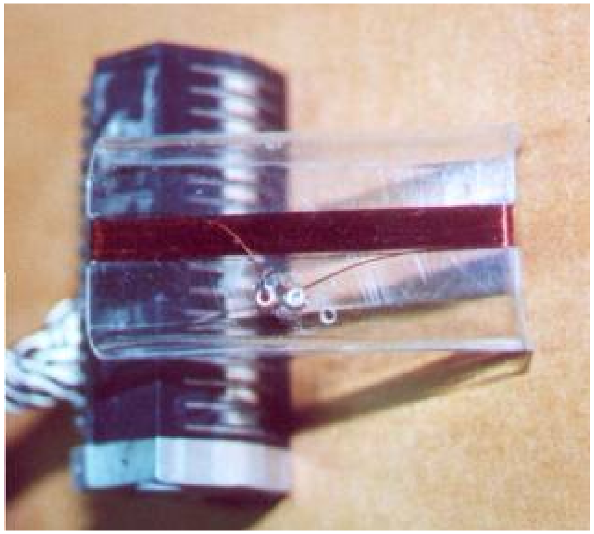
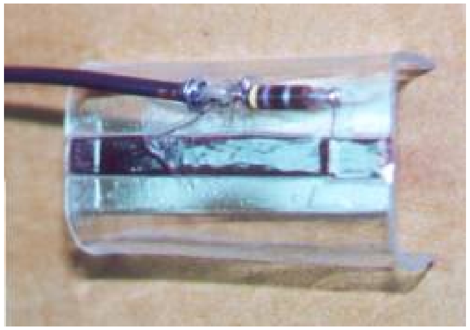


Figure 8. Winding the flux loop

Check the windings on the inside of the flux loop form to verify that all turns are flat with no crossings.� Cover these inner windings with one or two layers of tape such as packing tape to protect the wire from abrasion against the head during use.� This will also hold the wire while the ends are being attached to the cable leads.



Figure� .� The finished loop with tape added to protect the magnet wire

Remove the enamel insulation from the ends of the coil and attach the wires to the leads.� After the leads are attached, cover the back of the loop with tape.� The loop is ready for use.

Attach the appropriate connector to the other end of the cable.� Insert the connector into the equalizer or attach the buildout resistor if an equalizer is not being used. �(The buildout resistor can be permanently attached to the loop or incorporated into the driving device.)

Feed a sinusoidal signal into the loop and note the output on the test recorder.� Check the flux loop for repeatability by removing and reinstalling the loop two or three times.� The output should return to the original value within a few tenths of a dB if the loop is grabbing properly.� Check the frequency response of the drive circuit by monitoring the signal across the buildout resistor and loop with a meter.

Two final hints:�

���� Since flux loops are easy to make, build custom loops to fit all of your tape machines.� A snugly fitting flux loop is much more useful than an unmounted loop.

���� The U-shaped form of the loop makes the loop subject to breakage.� Create a storage box in which the loops will be adequately protected from abuse when not in use.

If you think the equipment required to drive a flux loop is excessive, try this solution.� Single chip VCO function generators with sinewave outputs are available with a 1000:1 sweep range that covers the entire audio band.� Such a chip could drive a flux loop equalizer.� The output of the equalizer can be buffered with a single chip current booster capable of 250 mA output current.� Power the oscillator and buffer from a "wall wart" modular power supply.� Now the entire package of flux loop, driver and power supply is quickly and easily carried from studio to studio and machine to machine.� Use an automated system with graphing such as an Audio Precision System One for detailed analysis and troubleshooting while using the portable box for day-to-day setups.

Figure 10. A self-contained equalized flux loop unit

How to use the loop

Now that we have constructed a flux loop, we can walk through an example of how to use the loop to test the output of a tape recorder.� As with many troubleshooting procedures, we will compare the actual performance with the expected performance.� But what is the correct expected performance?� Since manufacturers usually do not give us detailed performance data, we must build our own set of benchmarks to use during testing.�

The best reference for testing is the performance of the machine when it was new.� Assuming that the new machine worked properly, the "like new" performance represents what the machine can achieve without any degradation due to wear and aging.� If we note significant deterioration of performance compared to the original specifications, we would strive to correct the cause of the deterioration.� For our flux loop, this would mean determining the response characteristics of the machine when using the flux loop when the machine is new!�

If we are dealing with machines that have been around a while, we can only guess at nominal performance.� In the case of a flux loop, we can estimate the spatial and temporal losses that would occur.� The following 'rules of thumb' for studio recorders are adequate to get us started:

1.� The reproduce head gap length loss is typically less than 1 dB at 20 kHz for 15 in/s and .25 dB at 30 in/s for gaps up to 200 μin.� At 7.5 in/s a 100 μin. gap will also keep 20 kHz loss to less than 1 dB.

2.� Modern highly polished tapes running on an unworn head with adequate tape tension will typically have spacing loss of less than .7 dB at 20 kHz for 15 in/s.

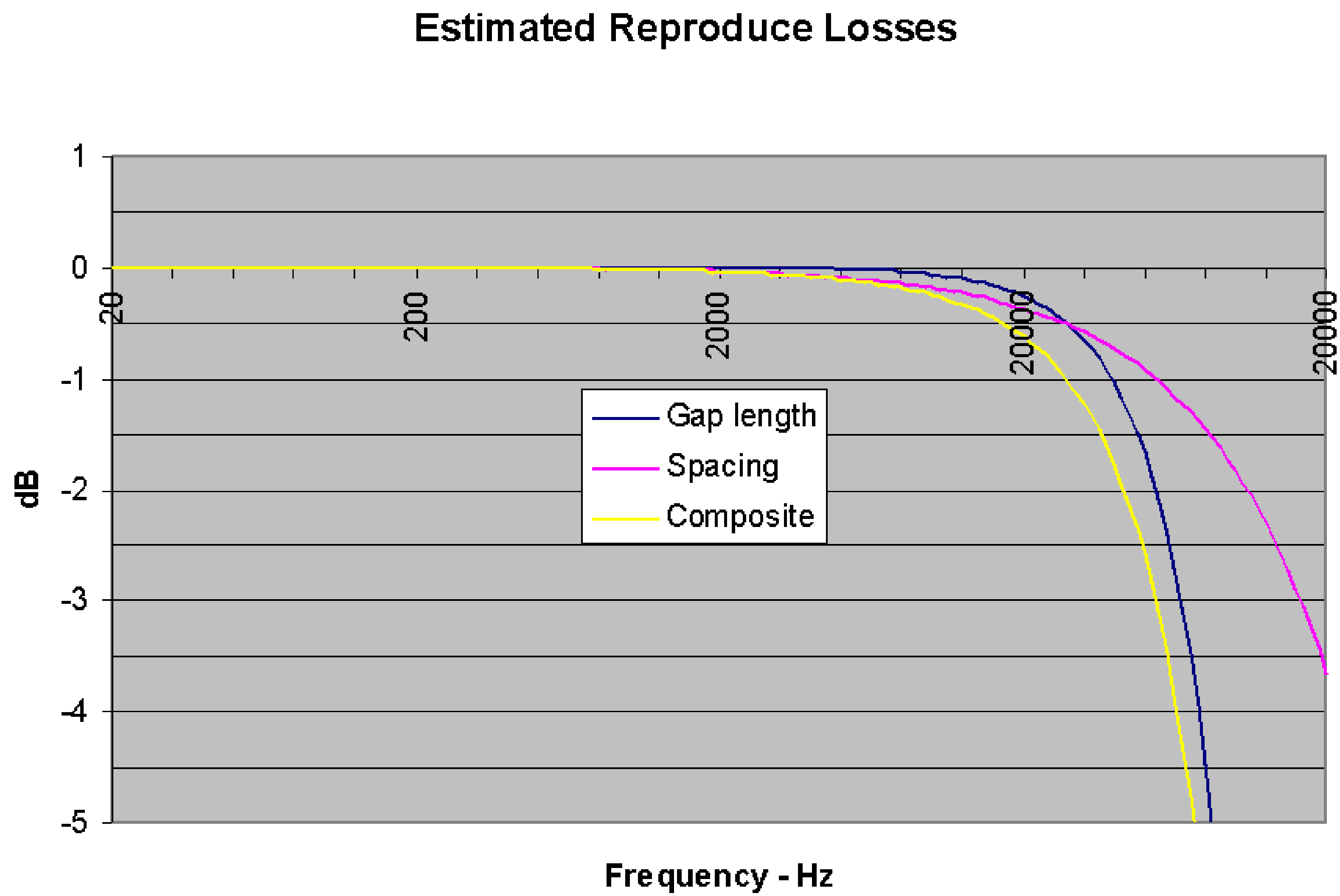


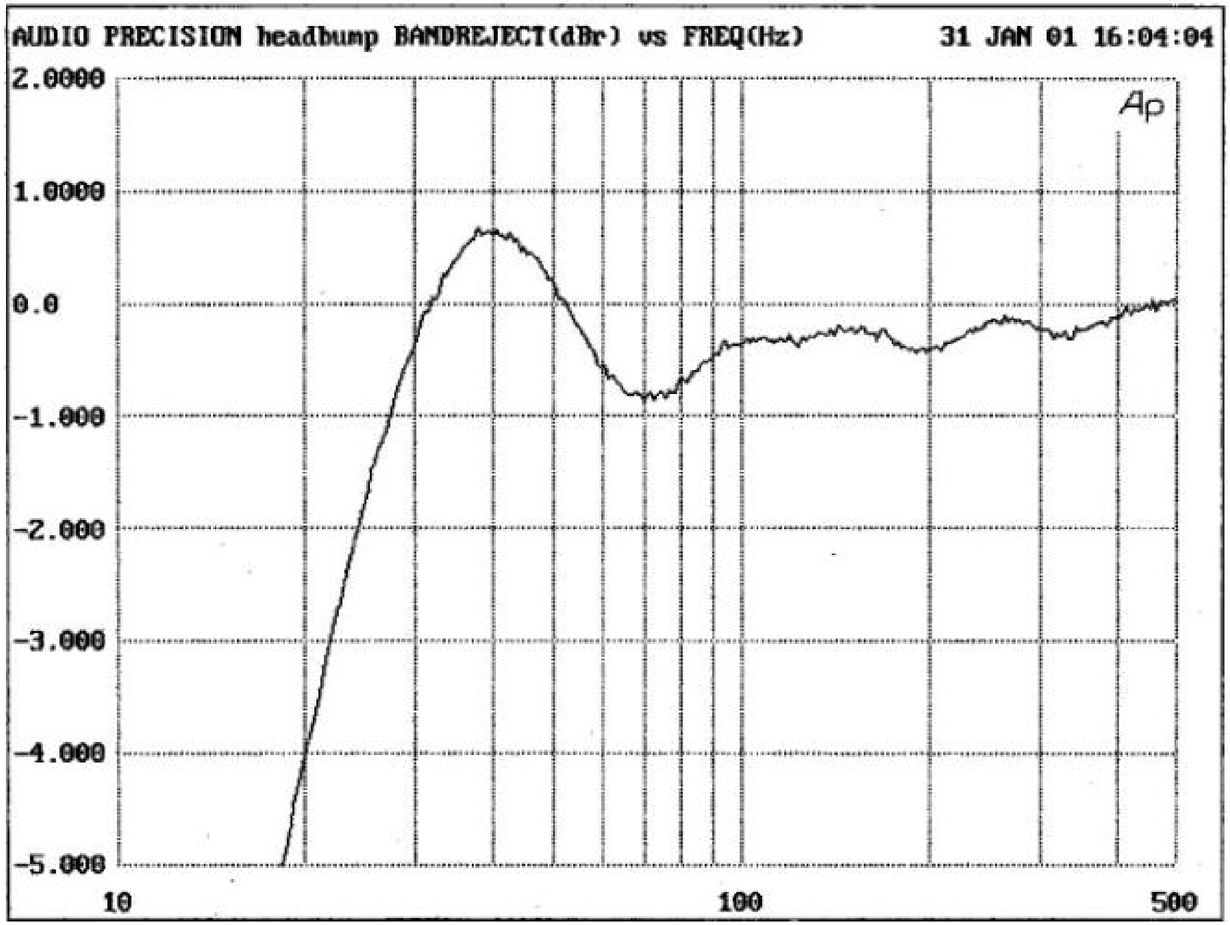
Figure 11. Typical gap length and spacing losses in a professional recorder (AG440 at 15 in/s with 10 uin. spacing)

3.� Azimuth errors should be eliminated by adjusting the reproduce head azimuth.

4.� Eddy current losses within the head core are insignificant in studio recorders at audio frequencies.� (This does not exclude eddy current effects at bias and erase frequencies in the record and erase heads.)

5.� Fringing can cause significant errors at low and mid frequencies if the recorded track is wider than the reproduce head core.� Full track alignment tapes fit this case.� Also note that the edge tracks will see less fringing than inboard tracks.

6.� Contour effects dominate the low end response.� A test tape with spot tones does not give adequate information to properly characterize the low end response.� Record a frequency sweep on the machine and graph the reproduce curve to determine the shape of the response.� Then try to correlate the spot tones of the test tape with the corresponding points on the sweep.



Figure� .� Typical low frequency �head bumps� due to contour effect (AG440 at 15 in/s)

7.� Don't put too much faith in standard alignment tapes.� These tapes can be damaged or even wrong.� Watch out for the guy who recorded his own copy of a standard alignment tape so that he wouldn't wear out his original!� Also check the calibration curve that comes with some brands of alignment tapes to note the known errors in the tone levels.

Overall, the rules of thumb tell us that the high end response of a mastering recorder should be close to the theoretical values and the low end response from a test tape can be quite unreliable.� Since the flux loop does not have fringing and contour effects, the loop can give us a clear picture of the temporal response compared to the appropriate equalization standard.� We can then nudge the theoretical flux loop values slightly to minimize the actual errors due to contour effects.

We are now ready to proceed with actual testing.� First, we select the appropriate equalizer or equalization file to match the equalization standard in use.� We attach the flux loop to the reproduce head and drive the loop with a frequency sweep.� The results should be flat at the high end and flat except for any contour effect correction at the low end.�

For the first time through using a new flux loop we would note the discrepancies and adjust the high and low frequency equalizers to give flat response.� Remove the flux loop.� We will now use the ideal setup based upon the flux loop to check the response of the alignment tape.� Run the alignment tape, checking for any high frequency loss due to azimuth errors or poor tape-to-head contact by lightly pressing the tape against the reproduce head gap with a cotton-covered swab.� Graph the response difference between the flux loop and the alignment tape.� If the errors fall outside the rules of thumb listed above, we must search for the underlying problem.

Excessive gap length loss that could be caused by ferrite head gap erosion would show up as a loss that rapidly gets steeper at higher frequencies.� Spacing loss due to worn head faces would be a more gradual loss directly proportional to frequency.

Once we have determined that the machine is operating properly or corrected the reason for any anomalies, we are ready to pick flux loop reference values that can be used to test the state of adjustment of the recorder.� With the machine adjusted for nominal performance, use the flux loop to determine the response curve for flux loop excitation.� Save these values and use them when checking the performance of the recorder in the future.

The typical alignment procedure now boils down to two steps:

First, using the flux loop, align the equalizers to give the reference response curve.

Second, run the standard alignment tape to set the appropriate level and to <u>verify</u> that the off-tape response is correct.� There should be no need to reset any equalizer adjustments during this sweep, thereby eliminating repetitive shuttling of the alignment tape to tweak each equalizer pot.

This simple two step procedure is much faster than the conventional approach of using the alignment tape for adjustment *and* testing.� The alignment tape will also remain accurate for a longer period due to the reduced usage.

Flux Loops for Other Applications

In spite of the type of data encoded within the flux transitions on the tape, all types of magnetic recorders follow the same laws of physics.� The flux loop can therefore be generalized for use on virtually all digital, video and instrumentation tape and disc recorders.� The only requirement is that the reproduce or read signal must be accessible ahead of the signal processing circuits that extract the data from the analog waveforms coming off the tape.� Usually this is easily accomplished by monitoring the output of the analog repro or read preamp that boosts the signal from the head.� (Newer highly integrated designs may not include an appropriate test point.)

Two simple requirements apply to these generalized cases:

������������ 1.� The mechanical structure must repeatably hold a loop of wire in front of the head gap without damaging the head.� Loops for rotary heads and disk drives will be very different in construction from the analog audio loops described above, but the same principles apply.

������������ 2.� The drive electronics, cabling and flux loop must achieve the appropriate level, bandwidth and equalization for the application.� In some cases the range may exceed 100 MHz and may require breaking the spectrum into sub-bands.� For example, the highest frequency band may only be of interest to determine the resonance of the head, minimizing the equalization and flatness requirements.�

Other Uses for a Flux Loop

As we have already seen, the flux loop and head form a transformer.� We can reverse the transformer and use the flux loop as a receiving coil rather than as an excitation coil.� For example, we may wish to look at the flux being emitted from an erase head or a record head.� If we mount the flux loop at the gap of the head, a voltage will be generated in the loop by flux.� If we connect the loop connector to an oscilloscope or meter, we can observe and measure the flux output.�

Beware, however, of the 6 dB per octave rise that we will see from the loop.� For a constant flux amplitude, the voltage generated in the loop will double each time the frequency is doubled.� This will tend to accentuate harmonic distortion on a bias or erase waveform since the third harmonic will be magnified by a factor of three compared to the fundamental frequency component.�

One way to overcome this observation error is to integrate the flux loop output by connecting an RC lowpass filter to the meter or scope terminals.� The frequency range being observed will determine the size of the shunt capacitor and series resistor.� Too much integration with a large capacitor will unnecessarily reduce the size of the signal.�

As an example, if we wish to observe the 120 kHz bias waveform of a recorder, we could create a 60 kHz lowpass filter with a 10 kohm series resistor and a 330 pF shunt capacitor.� The skirt of the filter begins an octave before our test signal, assuring that the fundamental and all harmonics will be on a continuous �6dB/octave slope.� (The input resistance of the meter or scope should be several times larger than the filter�s series resistor.)

Figure 12. Using a flux loop to examine the erase flux waveform

When using the flux loop to observe the flux output of a record head, the bias signal can obscure the audio signal component.� A simple technique to remove the bias component is to use a distortion analyzer set to the bias frequency.� The analyzer notches out the bias, but leaves behind the audio signal and any distortion components of the bias.� A simple lowpass filter can be used to remove the bias distortion components.

The headroom of the record amplifier can be determined with this technique.� The flux level required to achieve the normal 0 VU level is first determined with the flux loop.� Next, the input signal is increased until the signal from the flux loop shows visible distortion.� (Beware that increasing the level by advancing the record gain adjustment of the recorder could possibly hide problems in any transformers or electronics that precede the gain pot.)� Check the headroom at low, mid and high frequencies since the record equalization changes the gain for different parts of the spectrum.

Back to top

PORTAL >> AUDIO - PENNY & GILES FADERS - TRAINS - FORUMS - SWAP STOP << PORTAL