THE FLUTTER STORY BOOK

All recording systems, analog and digital, that record on a moving storage medium must deal with a phenomenon known as flutter. In an ideal transport, the relative speed between the record/reproduce transducers (heads) and the tape or disk would be absolutely constant. In a real system, however, several imperfections of the transport can produce small speed fluctuations that are known as flutter.

These speed disturbances produce contaminating sideband frequencies in the audio program which are not at all related to the music frequencies. At low frequencies these sidebands are perceived as cyclic pitch changes. At higher disturbance frequencies the sidebands become so numerous and widespread that the perception is both an increase in background noise which depends upon the signal and a masking or 'veil' which destroys the crispness of the recording. This loss of crispness due to 'scrape flutter' is perhaps the major factor in determining the overall subjective sound of a specific brand and model of tape recorder. Indeed, the fact that digital audio recorders normally suppress these flutter effects by digital timebase correction leads to the 'openness' of digital recordings.

Speed disturbances can be easily measured by recording a constant frequency tone on the recorder, and then measuring any variations in frequency due to speed change that occur on playback with a flutter meter. The disturbances measured by the flutter meter fall into several major categories:

1. Eccentricities and disturbances due to bad bearings. The upper frequency limit for rotational eccentricities is usually 30 Hz, the speed of an 1800 RPM capstan motor. If the eccentricity is caused by a distortion in the round shape of the rotating element, such as a clump of dirt on a capstan shaft, then flutter components at several harmonics of the rotational rate will also be present.

Ball bearings will also produce flutter components above the rotational rate due to the small balls within the bearing which are spinning faster than the bearing rotational rate. Once again, a pit in the ball will produce flutter at several harmonics of the ball rotation rate.

2. Tension variations due to varying dragging brakes or tape scraping against a reel flange will produce low frequency flutter. Drag can also be created by improperly slit tape that binds periodically in the tape guides or by bad splices that ooze adhesive onto adjacent layers of tape.

3. Servo motor oscillations and torque variations can produce speed disturbances at rates up to 1000 Hertz. The usual point of servo oscillation is near the frequency at which the servo loop gain goes to unity. Since the servos are intended to remove disturbances out to at least 100 Hz, the gain does not fall to unity until several times this highest working frequency. Video and timecode audio machines that require active speed control from a video sync or SMPTE track are prone to servo irregularities.

4. Vibrational resonances of the tape excited by the tape scraping against stationary surfaces on guides and heads can produce flutter frequencies up to 5000 Hz. The tape is an elastic filament under tension, much like the string of a violin. As the tape slides across the stationary guides and faces of the heads on a transport, resonant vibrations are excited within the tape - much like stroking a violin bow across the violin string. The dominant frequency of vibration is determined by the mass, tension and unsupported length of the tape.

Since the tape mass and desired tension are not very 'negotiable', many machines minimize these scrape flutter disturbances by reducing the unsupported length of tape. Rollers are added to the tape path to absorb vibrational energy from the tape. To function properly, these rollers must be in firm contact with the tape and must be virtually friction-free. Any slippage whatsoever turns the energy absorber into an energy generator.

Repositioning a scrape flutter idler after cleaning can be a very tedious task. The design of the tape path usually allows only a few degrees of tape wrap around the idler. If the wrap is excessive, the tape will be lifted away from the record and play heads; if the wrap is insufficient, the tape will slip on the idler. The only accurate method to align the idler is to directly measure the amount of scrape flutter and the stability of the high frequency record/play response of the recorder.

The Altair Tape and Transport Diagnostic System greatly simplifies the task of repositioning the scrape flutter idler. The Altair unit provides both a direct of readout of scrape flutter content up to 5000 Hz and an Amplitude Modulation detector that measures the amplitude stability of the signal. The Altair meter will typically indicate a drop in the scrape flutter reading of approximately 50% when the idler begins making proper tape contact. This reading should be re-checked after the idler mounting screw is tightened.

Items 1 and 2 above can be measured with any conventional flutter meter with response out to 200 Hz. The servo oscillations of Item 3 require extended range meter that measure to 1000 Hz. Item 4 requires extremely high perfomance that is physically beyond the capability of any meter using a 3150 Hz test tone. The only audio instruments capable of scrape flutter measurements are the Altair Tape and Transport Diagnostic System and the Audio Precision System One 'High Band' flutter option (which was derived from the Altair technique.) The Altair unit is unique is providing Amplitude Modulation testing for tape dropout detection and tape-to-head contact evaluation.

The following case histories illustrate some of the problems that are commonly encountered in the testing of tape transports. Note that only the Altair Tape and Transport Diagnostic System permits the direct measurement of normal flutter, scrape flutter, and amplitude modulation (dropouts) for making these tests. No other audio flutter meter measures the scrape flutter band in the critical range of 3000-5000 Hz, and only a few instruments include the region of 200-1000 Hz where servo problems live.

Case 1. Scenario - Customer dissatisfied with subjective sound of a new Ampex MM1200 2-inch recorder. Conventional flutter reading for 250 Hz bandwidth was just barely within specification at .08%. Manufacturer claimed everything was OK since the machine was within spec.

Testing with a wideband flutter meter yields .08% for 250 Hz bandwidth, but rises to .2% when the measurement bandwidth is increased to 5 kHz. Listening to the demodulated output of the flutter meter on the studio monitors reveals that the dominant contributor is not random scrape flutter components, but rather a sustained medium frequency tone, indicating a constant oscillation. With the aid of an oscilloscope the oscillation is determined to be 360 Hz and is synchronous with the AC mains.

The culprit is instability in the motor drive amplifier for the supply spindle motor. The Ampex MM1200 , which uses AC torque motors for spooling, controls the motor torque by modulating the amplitude of the line voltage applied to the motor. Excessive harmonic distortion in the modulator produces torque pulsations at the frequencies of the line harmonics. In this case the sixth harmonic of the mains is the culprit.

Case 2. Scenario - Routine inspection of an MCI JH110B 1/4" transport yields acceptable low-frequency flutter readings of .06%, but the scrape flutter readings are .14%. Since this transport is equipped with a scrape flutter idler, the scrape flutter reading should typically be below .08%. The scrape flutter idler appears to be turning normally, but stalling the idler yields virtually no change in reading.

The idler mounting screw was loosened and the idler repositioned for slightly more penetration into the tape. The scrape reading dropped to .o7%. However, when the mounting screw was cinched down for a 'final tightening', the reading popped up to the previous level. A repeat of the idler placement sequence yielded the same result. Apparently, the head of the mounting screw caused the idler to 'walk' away from the tape slightly when the screw was tightened.

To overcome this 'walking', the idler was pushed out slightly farther than the minimum required distance, and the allowed to walk back to the desired final position. The scrape flutter meter readings and the demodulated output on a monitor are the only reliable method of setting the idler.

Excessive penetration of the scrape flutter idler could lift the tape away from the record and reproduce heads, causing signal instabilities at high frequencies. The AM measurement mode of the Altair meter permits direct measurement of these instabilities so that an appropriate compromise between idler slippage and head liftoff can be achieved.

On numerous occasions, scrape flutter idlers that appeared to be rotating properly have been found to be slipping. Any slippage whatsoever will completely inhibit the transfer of vibrational energy from the tape into the mass of the idler, rendering the idler ineffective. The next case history illustrates that placement isn't the only possible culprit.

Case 3. Scenario - A Studer transport yields adequate low-frequency flutter readings, but excessive scrape readings. The scrape flutter idler is observed to be turning, but stalling the idler with the tip of a screwdriver yields virtually no change in reading.

When the idler was removed and cleaned, a deposit of grease pencil wax was discovered in the bearing. The extra bearing friction created by the wax caused slippage between the tape and idler surface.

Although the manufacturers of magnetic tape maintain an amazingly high quality standard, all manufacturers make some bad tape. When this inferior product reaches the customer, the cost to the customer can be very high. A typical example follows.

Case 4. Scenario - At the beginning of a multitrack recording session the first playbacks yield an unacceptably noisy signal. An hour of studio and musician time is lost while various mikes and console modules are changed and the recorder re-aligned. Finally, when a new roll of tape is tried, the problem disappears.

A post mortem of the bad reel of tape gave interesting results. Using the AM test capability of the Altair meter, a good roll of tape yielded an AM reading of .55%. The bad roll of tape, on the other hand, produced and AM level of 1.5% - nearly 3 times or 10 dB higher. The meter readings from the bad tape were very unstable, with frequent peaks that drove the meter off scale. When the demodulated signal was routed to the monitor speakers, the AM noise sounded much like popcorn popping.

These noise bursts were being created by small imperfections in the uniformity of the magnetic coating. Possible sources are inadequate mixing of the oxide prior to coating, dirt or other contaminants within the mix, or coating and processing problems that contaminate the surface of the tape.

The standardized test method for testing and specifying modulation noise performance requires that a known amount of DC current be injected into the record head during testing. The user, on the other hand, has tape machines that are designed not to pass any DC due to amplifier voltage offsets that might produce AM tape noise! The audio industry would be better served by an AM test method that could be conveniently used in the field on common equipment.

The test method used by the Altair meter provides the same type of information as the DC tests, but uses a high frequency audio signal to excite and test the tape particles. A very useful result is that the same signal on the tape can be used to test flutter, AM and dropouts, speed and high frequency record equalization. This one signal, placed at the head of the reel with the level set and low frequency tones, can serve as a 'rosetta stone' for later reference.

A quick check of the AM and flutter content during the normal alignment and 'toning' sequence provides confidence that the transport is performing properly and that at least the tested area of the tape is within acceptable AM limits. Although this spot check at the beginning of the reel is by no means completely comprehensive, it will uncover most reels that suffer from bad processing.

P.S. For you digital recorder owners who are snickering to yourselves that you are so clever to avoid all of these problems by investing in digital machines, think again! Although the digital playback electronics contain a digital timebase corrector to *minimize the effects of flutter, the digital tape transport still suffers from all of the above shortcomings. In fact, the problems may be even worse due to the short wavelengths and narrow tracks required for high density digital data. When the flutter on the digital machine exceeds the correction range of either the data detector or the timebase corrector, the result will not be easily recognized flutter, but rather data errors which may well drive the recorder into hysteria. How do you test the transport for flutter due to worn parts? One way is to use an analog cue track on the digital deck to test just the transport. This technique has been applied to several digital recorders, including the ubiquitous ADAT.*

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