AMPEX

MAGNETIC TAPE TRENDS

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I. INSTRUMENTATION TAPE DROPOUTS

Instrumentation recording applications are moving into the area of higher frequencies and shorter wavelengths, and along with this growth is an increasing requirement for a basic understanding of tape dropouts. TRENDS issue No. 3 discussed the nature of computer tape dropouts, and in this issue we will investigate some of the general, underlying principles of instrumentation tape dropouts.

Instrumentation recording techniques differ greatly from computer techniques. Because of the nature of the data to be captured, the majority of all instrumentation systems employ an analog approach to recording, and computers use digital format. Dropouts and their effect on the computer electronics are quite obvious. A self contained, discrete bit of information may be lost due to a dropout which renders the associated data meaningless. For this reason, it is imperative that reliable computer tapes be 100% tested and certified error free. Instrumentation tape dropouts, although more subtle in their effect on the total information, are also most important and must be adequately controlled.

At this point the difference between computer dropouts and instrumentation dropouts should be clarified. A digital dropout is any tape phenomena that produces a reduction or loss in signal below a preset level (usually 50%). Any individual bit that suffers this effect is classified as a dropout. If a system is operating at 800 BPI, a loss of signal for any one of the 800 bits of information recorded on each inch of the tape would constitute a dropout.

An analog instrumentation dropout must have another parameter defined to properly classify it. This additional parameter is time - the duration of the reduction in signal. Quoting from W-T-0070, paragraph 4.5.3.4.2 - "Dropout counting for tape speed of 60 inches per second - a 70,000 cps signal shall be recorded at a constant level such that on playback it will be between 40 and 50 db above the noise level. The bias level

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shall be adjusted to that value which is optimum for the tape being tested. The recorded signal shall be reproduced. All discontinuities in output which for a period of 40 microseconds or more are equal to or exceed a 60% decrease in the average output shall be counted."

Although the preceding description of an instrumentation tape dropout is the definition provided by MIL standards, it does not necessarily classify all the dropout specifications throughout the industry. Any specific instrumentation installation may set forth its own specifications on dropout classification. However, for any instrumentation dropout specification to be meaningful, it must not only define the minimum level of a signal, it must also specify the duration of the reduction.

Analog recording and reproducing, by its very nature, is relatively insensitive to instantaneous losses in signal. The original data is still preserved, and may be interpreted quite accurately despite the presence of a few instantaneous discontinuities in the waveform. This is made possible through the use of sophisticated electronics and proper application of ingenious recording and analyzing techniques. For this reason, W-T-0070 (paragraph 3.7.3) allows 4 dropouts per nominal 100 feet of instrumentation tape. A tighter specification than this is actually unnecessary for practically all instrumentation applications of today. That is to say that very little will be gained in the overall performance of an instrumentation installation by specifying analog instrumentation tape that is free from all dropouts. This would increase the tape cost by a significant factor, and would be usually impossible to justify.

As in the case of computer tape dropouts, instrumentation tape dropouts are due primarily to the presence of foreign particles on the tape surface. Obviously, oxide voids on the tape will also cause dropouts, but with the present state of the art in precision tape manufacture, it is indeed rare to run into this phenomena. The foreign particles may be nodules of oxide that have been improperly dispersed during manufacture, or clumps of oxide shed that have been redeposited onto the tape, or any particle of dust, lint, or matter that is present in the vicinity of the tape handling mechanism. The present trend to conductive coatings on tape will undoubtedly improve their performance heretofore affected by the static buildup of an electrical charge which enhanced the tapes affinity for attraction of foreign particles.

As the tape passes over the head, any embedded particle in the tape surface will lift the tape from the head. Under certain tape speed and tensioning conditions, "tape flap" will occur. This is the condition where the tape actually flaps, or bounces away from the head after the embedded particle has passed the head. The signal drops drastically as a result of this tape to head separation. The relation of loss in signal, wavelength, and tape to head separation is expressed in the formula -

$$\text{db loss} = \frac{55\,d}{\lambda}$$

Where d = tape to head separation

λ = wavelength

It is readily apparent that even the smallest particle will significantly reduce the output as it pulls the tape away from the head. Base material deformations will also cause dropouts. If the deformation is such magnitude to reflect through to the oxide coating side, a loss in signal will occur as the deformed portion of the tape moves past the heads.

Sometimes the last few layers of a tape wound on an NAB hub will carry the imprint of the threading slot, and as many as 10 or 15 layers of tape will contain the resulting dropouts. Winding under improper tensions, or long term storage under adverse conditions will accelerate this effect. However, it may be minimized by being careful when threading NAB reels, and rewinding and storing tapes under controlled conditions. (See Tape TRENDS No. 2, July 1963). The use of precision reels will eliminate the threading slot deformation problem entirely.

Markers of any and all description (such as slips of paper, Mylar, etc.) should never be inserted into a tape pack for purposes of identifying or marking positions of the tape. This will deform the tape and will ultimately cause dropouts. Proper tape handling techniques should always be observed. The tape should never be handled in such a way that the fingers come in contact with the edge of the tape pack. The reels should never be handled by using their edges as a sole support.

As tape is used, normal oxide buildup occurs at various machine points such as guides and heads. For optimum performance this oxide buildup should be removed regularly, at least once after each complete pass of the reel of tape. Precautionary methods of cleanliness should be taken in all areas where tape is used and handled. The amount of dust particles in the air is directly related to the number of dropouts experienced. The expense of an environmentally controlled tape installation will be more than justified by the immediate increase in efficiency over that realized in a dusty atmosphere.

Since proper tape performance is highly dependent upon tape to head contact, the machine should be checked periodically to insure that its performance is according to machine specifications. This is particularly important in areas such as the braking and tensioning systems.

Many times skew or misaligned guides will manifest themselves as excessive dropouts in the tape, and it is necessary to isolate the malfunction to properly analyze the problem. Almost every fault in a tape installation will initially manifest itself as a tape defect, so a basic understanding of the inherent nature of tape dropouts is necessary for effective trouble-shooting.

Conclusive tests have revealed that FM recording techniques are no less prone to dropouts than direct methods. The actual FM recording process on the tape itself is done in a direct manner, so it will also be affected by instantaneous loss of signal. However, due to the manner in which the FM recording is demodulated and handled by the electronics, the final result appears to be independent of dropouts. Regardless of the actual recording technique employed, the general rules of good machine maintenance, proper care and handling of the tape, and a clean, controlled atmosphere apply to all installations where optimum tape performance is desired.

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II. GLOSSARY OF TAPE TERMS

INSTRUMENTATION

ANALOG RECORDERS — Devices designed to record continuously variable functions in which the recorded information has a direct relationship to the input information.

BIAS — A high frequency signal supplied to the record head to compensate for the hysteresis effect of tape, to improve the linearity of the system. It is usually much higher in frequency than the highest frequency to be recorded.

CARRIER FREQUENCY — The frequency of the system at rest or with no input. This frequency is generally deviated in amplitude, frequency, or by interruption to impose recoverable data into the system. The carrier frequency is usually much higher than its modulating frequencies.

CHANNELS — Separate data origination sources. This is not necessarily a separate tape track, since numerous channels may be recorded on one tape track by various multiplexing techniques.

DECIBEL (db) — Logarithmic expression of a power voltage, or current ratio. $db = 10 \log \frac{P1}{P2} = 20 \log \frac{E1}{E2} = 20 \log \frac{I1}{I2}$

DRIFT — Tape velocity deviations from nominal velocity occurring at frequencies below 0.1 cps.

WOW — Tape velocity deviations from nominal velocity occurring at frequencies between 0.1 and 10 cps.

FLUTTER — Tape velocity deviations from nominal velocity occurring at frequencies above 10 cps.

DYNAMIC RANGE — The ratio of the maximum signal which can be recorded (at a given level of distortion) to the minimum signal which can be recorded (determined by the inherent noise level of the system) over a narrow frequency range. Over a broader band spectrum, this is better known as signal-to-noise ratio. Generally the noise figure is unweighted with a recorded signal.

DROPOUT — An instantaneous reduction in signal below some given level. In the case of analog dropouts this is usually defined both as to length of time as well as amplitude.

SATURATION	That point in a magnetic material where an increase in the magnetizing force will not cause an increase in magnetic intensity to be exhibited by the sample under test.
H	Magnetizing force measured in Oersteds
B	Magnetic intensity measured in Gauss.
RETENTIVITY (Br)	Remanence of magnetization. The amount of magnetization or flux density remaining in a magnetic material after the magnetizing force has been increased to saturation and returned to zero. (see fig. 1)
Bmax	Maximum magnetization a given material is capable of supporting. Occurs at saturation, (see fig. 1).
SQUARENESS FACTOR	Ratio of Br to Bmax
COERCIVITY (Hci)	The magnitude of magnetizing force required to reduce the remanence to zero. (see fig. 1)
HYSTERESIS	The inherent characteristic of a ferro-magnetic material for the magnetic intensity to lag the magnetizing force.
DEGAUSS	The act of reducing all residual magnetization to a given object to zero.
PRE-EMPHASIS	Peaking or increasing system gain at the high frequency end to compensate for inherent, system recording losses, and in some cases at the low frequency end also.
POST EMPHASIS	Increasing gain at lower frequencies to compensate for inherent, system recording losses.
ERASURE	Clearing magnetic tape of all previous signals and data preparatory to recording new information, i.e., reducing both B & H (external) to zero in gradually decreasing amounts. The same as degaussing.
LIVE DATA	Data in electrical form, hence reproducible and completely flexible as to further use.
FREQUENCY MODULATION (FM)	A modulation technique whereby a center carrier frequency is shifted or deviated by the signal to be recorded, thus recording the original data in a reproducible form.
CARRIER FREQUENCY DEVIATION (FM)	The swing or deviation of the center carrier frequency caused by a signal being recorded using FM techniques.
MODULATING FREQUENCY (FM)	The signal which represents the data being imposed on the carrier frequency.

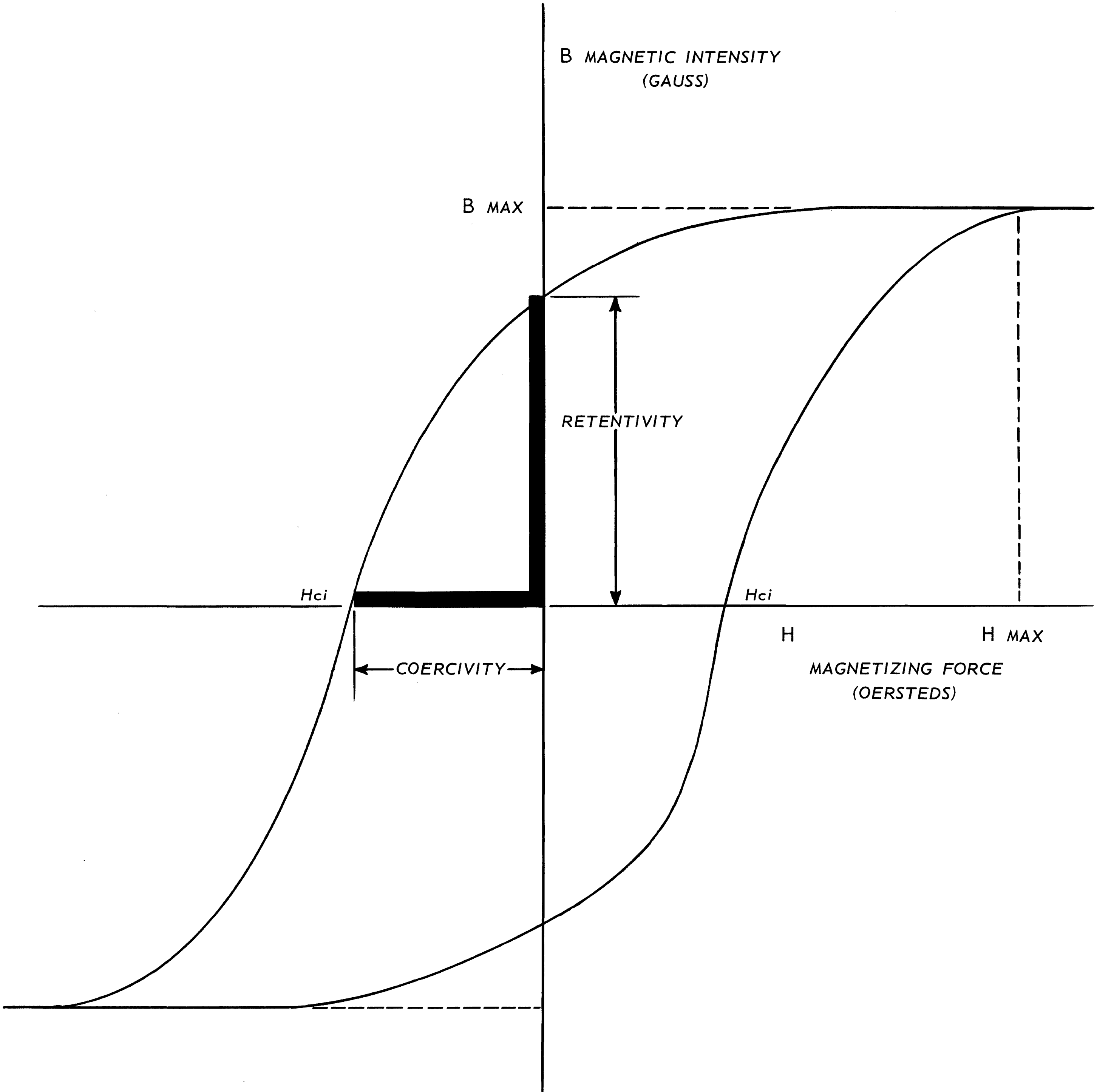
B MAGNETIC INTENSITY
(GAUSS)
B MAX
RETENTIVITY
Hci
Hci
H
H MAX
COERCIVITY
MAGNETIZING FORCE
(OERSTEDS)

FIG. 1

MODULATION INDEX (FM)	The ratio of carrier frequency deviation to modulating frequency.
DEVIATION RATIO (FM)	This is the modulation index for a maximum value of modulating frequency.
PERCENTAGE DEVIATION	The ratio of modulating frequency to center carrier frequency expressed in per cent.
TRANSDUCER	A device that converts data from its natural form (such as a weight, physical vibration, etc.) into an electrical signal for purposes of recording on magnetic tape.
SENSITIVITY	The tape output at a relatively long wavelength usually 7.5 or 15 mils. This is usually expressed as a relative sensitivity relating to some reference such as another tape, i.e., BuShips standard reference tape as specified in MIL-T-21029A and MIL-T-22756A.
RESPONSE	Tape output expressed in db difference compared to a given reference tape, or in most cases, to the sensitivity of the same piece of tape at various recording wavelengths.
PRINT THROUGH	The transfer of a signal from one layer of tape onto an adjacent layer. Usually expressed in db lower than the signal which caused the phenomena.
ANCHORAGE	Pertains to the adhesive quality of the oxide coating to the tape backing material. This is as opposed to cohesion qualities of the coating itself which is the determining factor on relative wear.