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A Dropout Annoyance Measuring Apparatus “DAMA” to Check Magnetic Tapes*

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0 INTRODUCTION

The dropout phenomenon in magnetic recording has been discussed several times in this Journal. Two articles in particular gave information about the topic from a physical point of view.

Van Keuren [1] has examined dropouts from an instrumentation approach and compared the effectiveness of various methods of treating and handling magnetic tapes before and after recording to minimize dropouts. Dropouts are defined and detection equipment is described.

Using optical, electrical, and microchemical techniques Comstock et al. [2] identified substances producing dropouts on instrumentation tape. These findings are correlated with measured electrical losses to provide source identification of foreign substances present. Instruments used to evaluate tape condition and provide real-time monitoring in the field are also described.

The subjective appreciation and audibility of dropouts, especially in magnetic recordings of music, were estimated by Commerci [3] and Admiraal et al. [4].

In a series of listening experiments in which the most vulnerable situation was simulated, that is, the type of music, the playback conditions, and the highly discriminating listeners cooperated to yield high annoyance ratings, “worst case” criteria were obtained by Cardozo and Domburg [5].

On the basis of their perceptual investigations a dropout annoyance measuring apparatus (DAMA) has been designed, which is discussed here. The instrument is in use at several tape manufacturing factories.

1 BACKGROUND

Irregularities in the magnetic material of tapes are among the reasons why a tone of, say, 1000 Hz, recorded with a constant amplitude, will not be heard as a tone of constant loudness when reproduced. Sometimes the loudness briefly weakens. This is called a ‘‘dropout.’’

It is possible to measure the objective value or capacity of a dropout by means of an electronic system. Investigations of the perceptual appraisal of dropouts have shown that characterizing a dropout by physical parameters is not a good basis for developing a dropout measuring instrument because of the perceptive aspect of the dropout, which can be described in terms of a quantity of annoyance or hindrance value h [5].

The present paper describes a dropout annoyance measuring apparatus (DAMA) based upon perceptual annoyance. It can be used for testing magnetic tapes which have been provided for the purpose with a carrier of the international measuring frequency of 3150 Hz at the nominal tape speed of 48 mm/s. For practical reasons the h values for this instrument are the quadruple of those mentioned in [5] (see Table 1).

An annoyance value of 1 indicates that although a slight decrease of loudness is heard, it is not experienced as annoying. It does not become so until h is equal to 2. The instrument should thus respond to eleven annoyance values for each individual dropout.

The depth of a dropout is the relation in decibels (regardless of sign) of the nominal amplitude D of the envelope of the carrier signal to the minimum amplitude d of this envelope during the dropout (Fig. 1).

The length or duration of a dropout is the time interval t between the moments at which the envelope has decreased

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to \(-3\,\text{dB}\) with respect to the nominal level.

The annoyance meter DAMA classifies the signal into periods or cycles of 20 seconds. After each cycle the instrument resets to zero automatically. The measuring time is the sum of a number of cycles. This number can be chosen at will.

To shorten the measuring time with this instrument the playback speed can be increased by the following factors: 8 times, 16 times, and 32 times. The various time intervals used in the instrument have to be matched to the playback speed. Since the time measurement is digital, carried out from a clock, the matching can be effected in a simple manner by switching to a suitable point of the frequency divider following the clock.

The perceptual experiments of [5] have shown the following results:

1) A dropout shorter than 10 ms causes no annoyance, regardless of the depth.
2) Penalty points are to be added in cases where more dropouts occur within the cycle time of 20 seconds.

In the instrument these penalty points are realized as

1) Penalty pool: each dropout after the first with an \(h\) value of 4 or more counts as an extra point added to the \(h\) counter.

2) Rolling pool: for two dropouts within 1 second with an \(h\) value of 2 or more (short roll) two extra points are added to the \(h\) counter. For three dropouts three points are added to the \(h\) counter, and for four or more dropouts (longer roll) four points are added.

The total \(h\) value during 20 seconds is thus the sum of the greatest \(h\) measured for an isolated dropout plus the sum of all penalty points and the sum of all rolling points.

Consider the following example. In one period of 20 seconds there are dropouts with these annoyance values: \(h = 4, h = 3 \text{ and } h = 5\) within 1 second and finally \(h = 9\). What is the total annoyance value?

1) The maximum annoyance value for an isolated dropout is \(h = 9\).
2) Penalty pool: two dropouts, with \(h \geq 4\) after the first result in two extra points.
3) Rolling pool: within 1 second two dropouts with \(h \geq 2\) result in two extra points.

The total annoyance value at the end of the cycle time is
\[h_t = 9 + 2 + 2 = 13.\]

2 OPERATIONS OF THE INSTRUMENT\(^1\)

The signal \(v_1\) with the above-mentioned measuring frequency of 3150 Hz can be attenuated with potentiometer \(P\) and is then amplified approximately 25 times (see the block diagram of Fig. 2). The signal is fed to two peak rectifiers:

1) With an RC time of 1000 ms, indicated by capacitor \(C_s\). This dc voltage hardly responds to dropouts and follows only slow variations of \(v_1\); the slow dc voltage \(V_s\) or reference voltage. With attenuator \(P\) this voltage is set to 2 V (100%), to be read on voltmeter \(M\).
2) With an RC time of 3 ms, indicated by capacitor \(C_r\). This dc voltage is so fast that it is able to follow the envelope of a dropout, assuming that its duration is longer than 10 ms.

These time constants have to be matched to the selected tape speed. This is done by switching capacitors \(C_s\) and \(C_r\). In the block diagram switch \(S\) is set to the nominal tape speed at which the above-mentioned time constants are applicable.

All other times in the apparatus are generated by digital means. From a central clock with a frequency of 32 kHz a division to 16 kHz is first made with a flipflop, after which further divisions are made to 8 and 1 kHz by means of a 4-bit binary counter. The latter frequency gives the repetition time of 1 ms, which is standard for measurements at the nominal tape speed.

3 MEASUREMENTS OF DROPOUT DEPTH

With the aid of a number of voltage comparators VC3—VC26 the fast dc voltage \(V_f\) is compared with a number of threshold levels, given by the indices in decibels and tapped from the reference voltage \(V_s\). Thus by comparing the fast dc voltage not with fixed thresholds but with levels proportional to the reference voltage, slow variations in the amplitude of \(v_1\) of the order of approximately 1 dB are compensated.

The comparator VC3 serves for determining the duration

\(^{1}\) Patents are pending.
Fig. 2. Block diagram of dropout annoyance measuring apparatus DAMA.
of the dropout which is defined as the time interval between the two -3 dB (70%) points of the dropout.

The information from the other comparators (VC4-VC26) is stored in dropout depth memory DM, composed of three 4-bit S-R registers. The outputs of those comparators that respond to the dropout are high and are thus inscribed in the memory. This is reset when the signal again becomes higher than 70% (-3 dB) of its nominal value.

As described below, the outputs of the dropout depth memory are connected to the inputs of an h matrix.

4 THE TIME CLASSIFIER

The pulse train to the parent contact of switch S3 is fed to decimal counter DC I. As long as the depth of the dropout remains above the 70% or -3 dB level, the output of VC3 is low. Consequently the counter is reset and cannot count.

If the depth of the dropout is below the 70% level at the first -3 dB point, the voltage at the reset input is high. From that moment t0 counter DC I starts counting pulses. Upon a count of 10 pulses, that is, after 10 ms, the counter returns to zero, triggering the second counter DC II, which is now set to position 1.

The binary output Qs is then high. Coupled to DC II is the decoder, which converts the binary input information into the decimal output information to lines a, b, and c. Line a is low during the time of 10 - 20 ms. If the reset voltage at input R of 1 and II remains high long enough, then 20 ms after the moment t0 counter II is set to position 2, whereupon output 1 of the decoder becomes high and its output 2 low.

After 30 ms output 3 of the decoder goes low, after 40 ms output 4, and after 50 ms output 5. Since outputs 2, 3, and 4 are interconnected, line b is low during the time interval of 20 - 50 ms after t0a, and line c is low for time intervals longer than 50 ms. Lines a, b, and c are the time inputs of the h matrix.

The highest position of counter DC II is 5 because DC II is blocked in this position via the C7 input. At the end of the dropout, DC I and DC II are reset.

5 LOGIC WITHOUT INTERACTION BETWEEN DROPOUTS

Switch S6 of the rolling pool and S9 of the penalty pool are situated in the system as illustrated in the block diagram of Fig. 2. If during the first measuring cycle of 20 seconds the most annoying dropout had a depth of, say, 6.7 dB and a duration of 35 ms, then according to Table 1 its annoyance value h was 3. Thus at the end of the cycle the seven-segment numerical indicators must display the numeral 3.

If a dropout of 6.7 dB appears, the outputs of comparators VC4, VC4.9, VC5.5, and VC6.2 go successively high, causing the flipflops of the depth memory, denoted by the indices, to switch over. At the end of the dropout the flipflops which have switched over are reset at the moment of the second -3 dB crossing via the output of VC3.

The combination of length and depth as a perceptual value, as mentioned in Table 1, is represented in the instrument as an h matrix, consisting of a crossboard of X and Y wires, in which gates are mounted at certain crossings to correspond with Table 1.

As can be seen from the diagram, all outputs of the h matrix are connected to the set inputs of register HR, consisting of three shift registers. The matrix output h = 2 is divided between two set inputs of register HR. This is done because the value h = 1 in the matrix is not coded (see Table 1).

Thus during the entire measuring time of 20 seconds the h register stores the maximum annoyance value. In the event, for example, of a succession of dropouts with h values of 2, 3, and 2, the first three flipflops remain set until the end of the measuring cycle.

At the end of the 20 seconds the central control unit in the apparatus causes the contents of the h register to be transferred serially to the h counter. The h register is thereby set to zero, and the h counter now contains the total annoyance value determined in the preceding measuring cycle. Further particulars are given in Section 7.

6 THE LOGIC WITH INTERACTION BETWEEN DROPOUTS

6.1 Penalty Pool

Each dropout after the first with an h value equal to 4 or more must yield an extra penalty point per cycle. This is achieved as follows.

Switch S3 is depressed. Flipflop D4b has already been reset by the central control unit. Upon the first dropout with an h value equal to 4 or more the output h = 4 of the matrix is high and remains so until the end of the dropout at the second -3 dB point. At that moment D4b is set and its output Q connected with input C8 of an AND gate in delay generator TU 30 μs, goes high.

When a second dropout with a value h ≥ 4 arrives, input G3 again goes high. This triggers delay generator TU 30 μs, which in turn, after a delay of 30 μs, triggers the one-shot flipflop OS 2μ. The output pulse from this flipflop is added to the h counter via the OR gate D9a.

Upon every subsequent dropout within 20 seconds with an h ≥ 4 an extra pulse is added in this way to the h counter.

At the end of the measuring cycle D4b is reset by the central control, causing the line marked “measurement,” connected to input R, to go low.

6.2 Rolling Pool

If, within 1 second, two dropouts with an h value equal to 2 or more occur, then two penalty points are added to the h counter, three dropouts give three penalty points, and four or more give four penalty points to the h counter. This takes place as follows.

Switch S5 is depressed. The data input D of shift register D7 is now high, and is thus able to respond to information at the T input. Flipflop D4a changes over upon the occurrence of the first dropout with a value h ≥ 2. Its output Q now goes high, thereby unblocking:

1) Shift register D2 (owing to the “high” level at the input T the unused output Qs goes high), and
2) Decade counter D9. This now starts counting pulses of 100 ms. After 10 pulses, that is, after 1 second, the counter resets flipflop D4a, which in turn resets the decade
counter and the shift register.

If, within 1 second, a second dropout with \( h \geq 2 \) occurs, output \( Q_d \) of shift register \( D_2 \) goes high. This triggers a one-shot flipflop \( OS_{2\mu} \) and a monostable flipflop \( TU_{15\mu} \), which in turn triggers after \( 15\mu s \) the OS \( 2\mu \) flipflop coupled to it. Both one-shot flipflops OS \( 2\mu \) are connected with inputs of the OR gate \( D_9a \). Upon the second dropout within 1 second with an \( h \) value of 2 or more, two extra pulses are added in this way to the \( h \) counter.

If three dropouts occur, then upon the arrival of the third the output \( Q_e \) goes high, thereby triggering the one-shot flipflops OS \( 2/\mu \), which again adds an extra pulse to the \( h \) counter. Finally upon four dropouts or more, output \( Q'_d \) of shift register \( D_2 \) also goes high, as a result of which a further one-shot flipflop OS \( 2/\mu \) is triggered, which sends a fourth pulse to the \( h \) counter.

7 THE CENTRAL CONTROL

During the measuring time of 20 seconds the control unit is not active. After the end of this time the "20-sec" line goes low and thereby activates the control via switch \( S_4 \). This signal is derived from the clock after division by 20 000.

The first task of the control unit is to block the measurement. This is done via the "measurement" line on gate \( D_9b \). Next the control unit carries out a fixed program consisting successively of the following:

1) Empty the \( h \) register via the "shift" line. At output \( Q \) of the \( h \) register as many pulses appear as flipflops have been set. These are added to the \( h \) counter via the OR gate \( D_9a \). The maximum capacity of this counter is 99.
2) Waiting via the "busy" lines until any peripherals connected are ready to receive the new \( h \) value.
3) Transmitting via the "latch" line the \( h \) value from the \( h \) counter to the buffer memory.
4) Resetting the \( h \) counter via the "reset" line.
5) Sending via the "start" line a signal to the peripheral equipment that a new \( h \) value is present.
6) Unlatching the measurement via the "measurement" line and starting the 20-second measuring cycle again.

The control unit now goes nonactive for another 20 seconds. The time in which no measurements are made varies between 200 and 600\( \mu \)s, irrespective of the position of the tape speed switch \( S_{a-b-c} \). After a stop signal has been presented, the apparatus completes the measurement on which it is working and then stops. The stop signal and also the starting signal can be given by means of a push button or via a connected peripheral unit.

Finally it is possible to measure the annoyance value of each separate dropout immediately after it occurs. For this purpose switch \( S_4 \) is turned to the left to a position marked "singular" on the apparatus. The central control unit now starts immediately upon observation of a dropout. The \( h \) register thus contains in this case only the annoyance value of this particular dropout.

8 REFERENCES