



AEROSPACE INFORMATION REPORT

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A TECHNIQUE FOR NARROW BAND ANALYSIS OF A TRANSIENT

1. INTRODUCTION

It is often desirable to have a "narrow band analysis" at a particular instant during a transient signal, in order that a more complete picture may be drawn regarding the discrete tone content of the signal at that particular instant. For example, this data is useful and sometimes necessary when analyzing the noise from an aircraft flyover in cases where the customary 1/3 octave analysis of the complete flyover has not yielded sufficiently detailed information. The standard method of analyzing tape recorded signals of only a few seconds duration is the "loop method." The magnetic tape is cut and spliced to form an endless loop, and the loop is replayed with the aid of a tensioning device (see Fig. 1). Difficulty arises with transient signals when the length of tape required to make a loop covers a time over which there is a considerable variation. The principle of the system described herein is that of expanding the time-base of the signal to a point at which there is a length of tape sufficient to make a loop across which the signal is sensibly constant. Although the method is one which has been used specifically for the analysis of aircraft flyover noise, it could equally well apply to other transient signals.

2. CONFIDENCE LIMITS

With conventional narrow band analysis of a nominally constant noise signal, the indicated sound pressure level at any particular frequency can be significantly different to the true level. The confidence one can have that the true level will lie within a given deviation from the indicated level depends on the bandwidth of the analyzer filter and the duration of the noise sample used. This is explained in Reference 1, which provides a table of confidence limits.

With the narrow band analysis of a transient signal, the freedom of choice of sample duration is restricted by the need to concentrate the analysis over a very small time interval. The degree of confidence, therefore, tends to be reduced relative to that with the more common analysis of nominally constant signals.

For this reason, the general adjuncts of Reference 1 should be especially borne in mind when interpreting transient analyses.

3. EQUIPMENT REQUIRED

- 3.1 2 tape recorders, with a minimum performance of: two speeds with a 2:1 ratio, at which the frequency response is flat between 40 c/s and 12 Kc/s.
- 3.2 1 narrow band frequency analyzer with associated paper trace recorder.

4. PROCEDURE

- 4.1 First, determine the length of the minimum loop which can be handled by the machine in question. (See Fig. 2; here, the tape deck unit is used in a horizontal attitude, and a free standing pulley is used to bring the loop length down to 25 in. : i. e., 1.67 seconds at 15 in./sec.)
- 4.2 Record the transient signal on magnetic tape.
- 4.3 Produce a paper trace of the recorded signal by replaying it into the pen recorder.
- 4.4 Mark the point requiring analysis on this trace (see Fig. 3), and equally spaced about this point mark the time corresponding to the minimum loop previously determined.

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- 4.5 Arrange the equipment as in Fig. 4, and re-record only the section marked on the above trace by watching the pen recorder and operating the switch at the appropriate points. The tape produced to be called "Tape A."
- 4.6 Make a re-recording of Tape A and halve the time-base (double the speed) by replaying Tape A on one machine, and recording on the other machine at twice the tape speed. The tape produced is to be called "Tape B."
- 4.7 Make a re-recording of Tape B and again halve the time-base by replaying Tape B from one machine and recording on the other machine at twice the tape speed. The tape produced is to be called "Tape C."
- 4.8 Carry out further speed doublings in a similar manner, as are demanded by the signal to be analyzed, the result being:

Tape A time-base = 1 x true time.
Tape B time-base = 2 x true time.
Tape C time-base = 4 x true time.
Tape D time-base = 8 x true time.
Tape E time-base = 16 x true time.
Etc.

Each of these tapes comprises a portion bearing the relevant signal with blank portions before and after.

The number of successive double-speed re-recordings can be chosen to approach as nearly as required an instantaneous spectrum.

- 4.9 With the final tape, locate and mark the ends of the portion bearing the signal. Fold the tape with the end marks coincident and cut out the center portion with a length corresponding to the minimum loop. Form a loop with this portion.
- 4.10 From a replay of this loop at the higher tape speed, re-record a long length of tape at the half-speed. The length of tape required should be ample enough to allow a series of successive half-speed re-recordings of a number corresponding to the first series of double speed re-recordings in order to culminate in a true time-base tape of sufficient length to form a manageable loop.
- 4.11 Carry out the series of successive half-speed recordings to arrive at a tape of true time-base.
- 4.12 Form a loop from the tape, and replay the loop to obtain a narrow band analysis. The writing speed and paper speed of the recorder should be selected to provide the desired smoothness of trace and corresponding degree of accuracy.

5. EXAMPLE

Using the typical flyover in Fig. 5, analyses with a 1/12 octave bandwidth analyzer were obtained using the above procedure.

The first was after only one double-speed re-recording and subsequent re-conversion to a true time-base. The second was after two successive double-speed recordings and re-conversion, the third after three, and the fourth after four.

In this example, three successive re-recordings are sufficient to obtain a satisfactory narrow band analysis, no further improvement being afforded by proceeding to four.

6. FOOTNOTES

- 6.1 Each re-recording increases the tape surface noise (i. e. , decreases the signal to noise ratio).
- 6.2 Each halving of the tape speed loses the lower octave of the signal below the lower limit of the frequency response; hence, a machine meeting the minimum frequency response limitations (40 c/s to 12 Kc/s) loses all signal below 315 c/s after being expanded 16 times (i. e. , four series of expansions). Any improvement in the lower end of the frequency response gives a pro-rata improvement as regards loss of signal.
- 6.3 Recordings need not be re-converted to true time for final analysis (using steps 4. 10 and 4. 11 above), but it is advantageous to do so for ease of comparison with other data and narrow band analyses.
- 6.4 The number of steps in the procedure can be reduced by using tape recorders with a speed ratio of 4:1 providing the frequency response is adequate.
- 6.5 The final tape loop analyzed is, of course, a number of identical short duration samples joined end to end. On the question of confidence limits (see Reference 1), the significant duration is that of the repeated short duration sample, not that of the complete loop.

7. REFERENCE

W. J. Galloway, "Frequency Analyses of Short Duration Random Noise."
(SOUND; Vol. 1, No. 6; 31-34; November-December 1962).

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