IMPULSE NOISE

GENERAL INFORMATION

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1. GENERAL

A. Introduction

1.01 This section contains general information about impulse noise. Its purpose is to provide an understanding of the characteristics, source, measurement, and mitigation of impulse noise.

1.02 ➧This section is reissued to change information defining impulse noise and its characteristics.➧

1.03 The word "noise" is usually used to label those disagreeable or distracting sounds which are present at times in a telephone conversation and which the listener would rather not hear. As such, it is an acoustical term difficult to describe either qualitatively or quantitatively, although descriptive words such as hiss, click, rumble, crash, pitch, loudness, etc, are often used. The total noise that reaches the ear of the listener affects the degree of annoyance and the intelligibility of received speech.

1.04 Impulse noise consists of short-duration pulses of unwanted signals which occur in a somewhat random pattern in the transmission medium. In the telephone network, transients, generated by switching operations and lasting for less than 1 to a few milliseconds, constitute the largest source of impulse noise.

1.05 For years the type of noise of interest on telephone channels has been ***message circuit noise***. This noise is measured with instruments (3-type noise measuring sets) which are constructed to enable reasonably good correlation between the reading obtained and the annoyance of the noise during a telephone conversation. Fluctuations of the reading during a measurement are either ignored or mentally averaged by the observer, depending upon their frequency of occurrence and their magnitude. With the introduction of data transmission on the telephone network, the high amplitude excursions of the noise waveform were viewed as a ***new*** kind of noise, primarily because they were generally not annoying in voice communication. Also, it was recognized that no meaningful measure of these excursions could be obtained with the standard 3-type noise measuring sets. The term ***impulse noise*** was applied to these high excursions and new instruments (the 6-type noise measuring sets) were designed to measure them.

B. Impulse Noise Versus Message Circuit Noise

1.06 Typical oscillograph noise waveforms from a random noise generator and from a telephone channel are shown in Fig. 1. Each trace is 200 milliseconds long and both have the same rms value. The upper trace is from the noise generator. The lower trace is from a telephone channel. The occurrence of two ***impulses*** is shown near the left end of the lower trace. It is primarily the occurrence of such impulses that makes real channel noise decidedly different from band-limited white Gaussian noise (the upper trace).

1.07 Noise in a group bandwidth photographed for 50 milliseconds is shown in Fig. 2a. In this case, the impulse noise is readily apparent because of the relatively wide bandwidth. Figure 2b shows the noise in a voice bandwidth channel and illustrates one of the impulses. If a large sample of impulses (about 200 or more) is taken from a given channel, the average spectrum appears to be approximately the shape of the channel gain-frequency characteristics, as illustrated in Fig. 3.

1.08 The increased use of computers and automatic data processing systems in the commercial, industrial, and military areas has substantially increased the demand for greater varieties of data service and data transmission channels. This expansion, with its attendant requirement for a variety of speeds and channel usage times, has encouraged the development of service offerings that use the regular switched-message telephone network in establishing communication channels.

1.09 Expanded utilization of the telephone network for data service made it necessary for requirements to be devised which would optimize transmission channel performance for both data and voice communication, especially with regard to impulse noise. For example, impulse noise commonly encountered near switching offices may produce clicks which are subjectively acceptable in voice communication unless the power of the impulse becomes unusually large. With data communication, however, impulse noise is a serious problem because the bit durations are short (for example, 0.8 millisecond in a 1200-bit frequency shift serial system). If impulse noise hits are of sufficient magnitude and occur very often, they can seriously increase the error rate of a data communication system.

2. IMPULSE NOISE CHARACTERISTICS

A. Definition of an Impulse

2.01 In measuring impulse noise, a definition is needed to distinguish an impulse from continuous background noise. A critical level or ***threshold*** is specified, and any disturbance which exceeds this threshold is considered impulse noise, regardless of its time duration (up to about 50 milliseconds). ➧The threshold is a power level in dBrnc set on the 6-type noise measuring instrument. The noise measuring set counts excursions above this preset threshold. The threshold is only one element of the measure of impulse noise; the number of counts and the length of time involved in counting are also necessary to identify a performance level or requirement.➧

2.02 ➧Impulse noise is characterized by short (usually less than 4 ms) bursts of unwanted

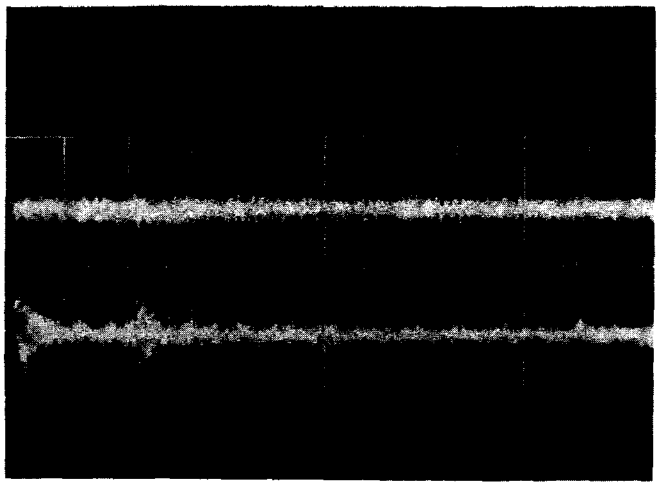

Fig. 1—Random Noise and Telephone Channel Noise

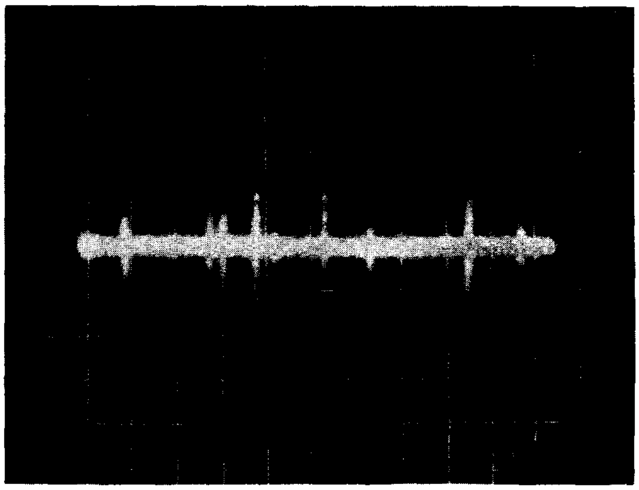

Fig. 2a—Noise in a Group Bandwidth

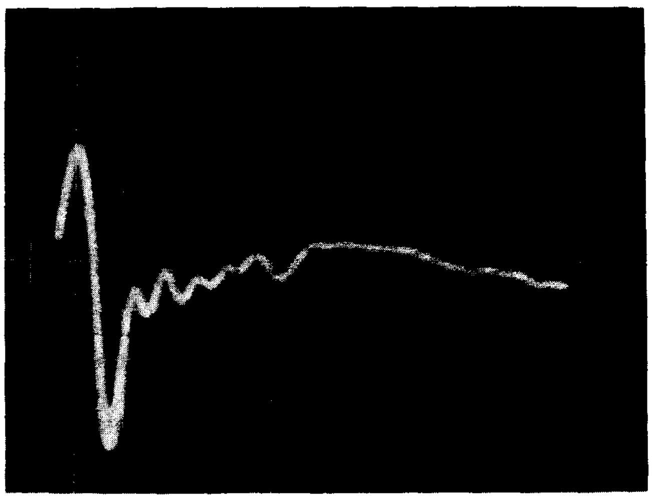

Fig. 2b—Noise in a Voice Bandwidth Channel

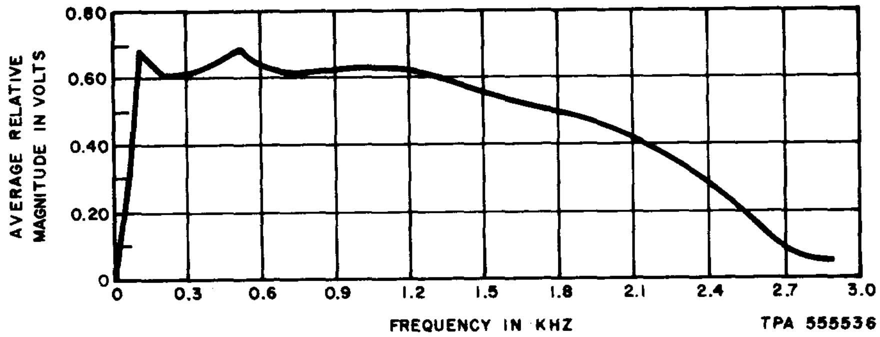

Fig. 3—Average Spectral Content of About 200 Impulses From a Single Telephone Channel

high-energy signals. It is most commonly generated in switching machines by the collapse of fields around relay coils. There are, however, several other sources.◆

2.03 ◆The waveform of an impulse is pictured in Fig. 2b. Impulse noise is measured with an instrument which responds to the noise waveform whenever the waveform exceeds an adjustable level. The response is to register one count on an electromechanical counter. These counts are accumulated over a test interval, thus giving an indication of impulse noise activity in the circuit under test.◆

2.04 One of the characteristics of impulse noise is its time variability. When one is exposed to impulse noise measurements for the first time, the usual reaction is doubt that any single measurement made in the reasonably short time (5 to 15 minutes) can accurately represent the true impulse noise which occurs on a circuit over longer time intervals. ◆A typical sample of successive 5-minute measurements on a circuit might give rise to the following counts: 5, 8, 52, 6, 6, and 4. Thus, a single 5-minute measurement is not a very reliable indicator of the impulse noise activity on one channel. This is why 15-minute measurements are called for when measuring only one circuit. If several circuits in a common route are being measured, a 5-minute test on each of them is sufficient. In this case, the entire group of circuits is accepted if at least 50 percent of the measurements meet the stated objectives. This means that the entire group of circuits is acceptable from an impulse noise standpoint even though some of the measurements exceed the specified number of impulse noise counts.◆

2.05 The recommended interval now is *5* minutes or *15* minutes, as specified in the requirements. For any trunk, facility, or switching office, requirements have been established in terms of counts per minute at specified power levels. These requirements are given in Section 331-200-100.

B. Measurement Time Interval

2.06 Since most impulse noise arises from sources external to transmission systems, the noise appears on many channels within a common entity, such as a carrier facility, at the same time, although not necessarily at the same level. Thus, in measuring impulse noise in such situations, it is more significant to evaluate the entire facility at once than to measure a number of individual channels. Five minutes for each measurement has been found to be adequate when measuring in groups. Furthermore, evaluation of a group may be made by sampling techniques described in Section 331-200-100, thereby reducing overall test time.

2.07 When it is necessary to measure impulse noise on single communication channels, the measurement time interval is increased from 5 minutes to 15 minutes. This may result in a slightly low or high estimate, but the uncertainty is preferable to measuring for longer periods of time.

3. SOURCE AND MITIGATION

3.01 The following general sources introduce impulse noise in transmission circuits:

(a) Sources intrinsic to a system, such as switch contacts used to complete the connection;

(b) Noise induced through common leads (for example, battery supply and control leads);

(c) Induction from transients in other nearby equipment or from environmental factors such as electrical storms.

3.02 Some mitigative techniques aimed at eliminating and reducing impulse noise from the above source are appropriate filtering, shielding, balancing, maintaining of contacts, etc.

3.03 An important source of impulse noise is switching transients. These transients (or peaks of energy) are generated by connecting and disconnecting current or voltage in inductive (relay windings) or capacitive circuit elements in switching center equipment. These elements are used for dc telegraph, dial pulsing, switch hunting, reverse-battery supervision, and fast marker operations, and they can cause transients by seizure, disconnect, etc.

3.04 These switching transients couple to switching machines or cable by means of crosstalk or induction, either of which produces longitudinal voltages and currents on other circuits in the vicinity. The longitudinal components produce interfering effects (metallic currents) if there is common mode unbalance, mismatch, or lack of termination in the involved circuits. Unbalances are prevalent in battery-supplying relay windings, single-wire leads with ground return, and single-contact switching. An example of a unbalanced path is party-line ringing circuits in which ringing current is applied to only one side of a line.

3.05 Both disturbing and disturbed circuits usually interfere because they are unbalanced, poorly matched or terminated, or poorly shielded from each other. Both the noise influence and susceptibility may be reduced by one of the following methods:

(a) By balancing circuit elements and cable pairs, pairing up single-wire configurations, and closely pairing and twisting the two wires of the pair so that the fields associated with the outgoing and incoming wires cancel out.

(b) By choice of circuit devices.

(c) By providing the correct impedance matches and terminations and by reducing multiple appearances (bridged tap).

(d) By space-separating the disturbing and disturbed circuits and avoiding large differences in level between them, or by applying a metal shield to either. At voice frequency and cable carrier frequencies, the shield covering a pair of wires must be continuous and well-grounded at both ends, so that canceling current can flow in the shield. In the switching center, if the circuit is noisier with both ends of the shield grounded than with one end grounded, this is probably because the shield provides a low impedance path for stray noise currents. If this is the case, one end of the shield should be removed from ground or the stray current should be removed.

(e) By draining off the disturbed circuit through a center-tapped impedance to ground and by using longitudinal suppression coils.

(f) By adequately filtering switching office battery supplies.

(g) By using contact protection networks across relay windings which will substantially reduce the peaks introduced in the relay winding upon the collapse of its magnetic fields when current flow is interrupted to release the relay.

3.06 Appropriate design, correct installation, and continuing maintenance are important factors in controlling the generation and propagation of impulse noise.