Engineering Standard

SAES-T-830 31 December, 2003

Voice Frequency Loop Transmission Objectives

Saudi Aramco DeskTop Standards

Table of Contents

1 Scope

This standard prescribes minimum mandatory requirements governing transmission objectives for voice frequency loop and defines the parameters associated with circuits used for voice frequency transmission.

2 Conflicts and Deviations

Any deviations, providing less than the mandatory requirements of this standard require written approval as per Saudi Aramco Engineering Procedure SAEP-302.

3 References

The selection of material and equipment, and the design, construction, maintenance, and repair of equipment and facilities covered by this standard shall apply with the latest edition of the references listed below, unless otherwise noted.

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedure

SAEP-302	*Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement*

Saudi Aramco Engineering Standards

SAES-O-100	*General Requirements, Safety and Security*
SAES-T-634	*Communications - Cable Testing and Identification*

3.2 Industry Codes and Standards

American National Standards Institute

ANSI C2	*National Electrical Safety Code (NESC)*

National Fire Protection Association

NFPA 70	*National Electrical Code (NEC)*

4 Definitions and Terms

Attenuation (Loss): The inherent characteristics of telephone copper cable cause performance difficulties as the circuits are extended over distance. Increase electrical resistance along with shunt capacitance, capacitive and inductive reactance cause loss of

power. The loss, or attenuation, is greater over long distances. Attenuation is usually expressed in decibel (dB).

Attenuation Distortion: Attenuation distortion is the variation in attenuation (loss) relative to that at 1000 Hz.

Circuit: In telephony, sound is carried over an electrical circuit from a calling party through a communication office, where it is switched out to the called party.

Crosstalk: Crosstalk is the disturbance (specifically speech disturbance) in one circuit from signals in another circuit. Intelligible crosstalk occurs when some of the words in a conversation can be understood by a person using another circuit. Intelligible crosstalk is objectionable because it interferes with privacy.

Delay Distortion: Distortion is an unfaithful reproduction of signals due to changes occurring in the waveform of the original signal. Delay distortion is the delay at one frequency relative to that at another frequency. In a telephone channel the reference frequency is often taken as 1700 or 1800 Hz. In any channel the reference frequency may be taken as the frequency of minimum delay.

Echo: A wave which has been reflected or returned with sufficient magnitude and delay to be perceived.

Echo Return Loss (ERL): is a measure of the difference in level between the echo returned and the original signal for frequencies between 500 Hz and 2500 Hz. Singing return loss (SRL) is a measure of the difference in level between the echo returned and the original signal for frequencies between 200 Hz and 500 Hz and between 2500 Hz and 3000 Hz. Poor return loss causes singing or near singing of amplifiers as well as echoes which can be objectionable if the magnitude is high enough and the delay long enough.

Envelope Delay: Envelope delay is another parameter which is considered to be more useful than delay distortion. Envelope delay takes in account the rate of change of phase versus frequency. EDD (envelope delay distortion) is the maximum difference or deviation of envelope delay between any two specified frequencies.

Frequency: Frequency is measured in units called Hertz (Hz). One Hz is one cycle per second.

Impulse Noise: Impulse noise is any burst of noise that produces a voltage of more than 12 dB above the steady state noise, and is typically of 5 microseconds duration. Sources of impulse noise include lightning surges, switching transients and surges on power lines which induce surges in telephone circuits.

Network: Network is a physical structure of paths or channels over which information can be moved.

Objectives: Objectives are the recommended operating limits for circuits or equipment in order to keep overall performance at a desired level.

Resistance: Property of a conductor which determines the current which will flow through it when a particular voltage is applied. In electrical circuit, the greater the resistance between two points the greater the drop in voltage.

Singing Return Loss: A loss due to impedance mismatch particularly at the junctions between interconnected circuits.

Slope: Slope is loss at 2800 Hz relative to that at 1000 Hz. Normally, in a voice channel the loss at 2800 Hz is greater than at 1000 Hz.

User Loop: The user loop is the circuit or transmission path between the station apparatus and its local serving office. In outside plant terms the user loop is considered to be the circuit from office MDF (Main Distribution Frame) to the station protector.

Varistor: A variable resistor. A device which does not have a linear resistance characteristic.

Voice Frequency Bandwidth: The human voice is capable of producing sound of various tones. In telephony, the normal voice frequency band is 300-3000 Hz. This 300-3000 Hz band is used because 90% of all the speech intelligence is included in that band. The edges of the bandwidth are considered to be where the loss is 10 dB more than at 1000 Hz. Refer to Figure 1 for a possible bandwidth.

Units of Transmission Measurements:

Decibel: The decibel is the standard unit for expressing transmission gain or loss and relative power ratios. The decibel is one tenth the size of a Bel, which is too large a unit for convenient use. Both units are expressed in terms of the logarithm to the base 10 of a power ratio, the decibel formula being: $dB = 10 \log_{10} (P_1/P_2)$.

Watt: A Watt is defined as the unit of power dissipated in a 1 ohm resistor with 1 ampere of current flow, or the power dissipated in a 1 ohm resistor when 1 volt is applied. When powers are related to a 1 watt reference, they are expressed in dBw.

Milliwatt (10^{-3}): When powers are related to a 1 milliwatt reference, they are expressed in dBm. By definition dBm is used to express quantities of power in decibel form with reference to 1 milliwatt.

Reference Noise (rn): Reference noise is that magnitude of circuit noise which will produce a reading on a circuit noise meter equal to one picowatt (10^{-12} watts)

of electric power at 1000 Hz. This is also equals 10^{-9} milliwatts (-90 dBm), and is designated as 0 dBrn.

dBrn: Decibels above reference noise is a measurement of the magnitude of noise above the reference level.

dBrnC: A letter or a number following dBrn refers to the weighting at which the measurement is made. dBrnC refers to dB above reference noise, using the C Message weighting filter on the noise measuring set.

5 Design

5.1 Loss

5.1.1 Maximum loss at 1000 Hz shall not exceed 8.5 dB.

5.1.2 If user loops are also used for data transmission the general loss objective given in paragraph 5.1.1 may not be satisfactory and the specific requirement for the data circuit shall then dictate the loss limit.

5.2 Loss Versus Frequency

The loss versus frequency objectives for subscriber loops are as follows:

5.2.1 Bandwidth

The bandwidth shall fall between 300 Hz and 3300 Hz.

Commentary Note 5.2.1:

The lower cutoff frequency applies to electronically derived (originated from a switch using solid state devices) circuits only. Voice frequency cable pairs do not have a lower cutoff frequency since the loss of a cable pair decreases below 1000 Hz.

5.2.2 Slope

a) For long voice frequency cable pairs, slope shall not exceed 6 dB.

Commentary Note 5.2.2 (a):

The loss at 2800 Hz shall not be more than 6 dB greater than the loss at 1000 Hz. Refer to Figure 2.

b) For conditioned (circuits with voice frequency repeaters) long voice frequency cable pairs, slope shall not exceed 2.5 dB.

Commentary Note 5.2.2 (b):

Circuits used for data transmission may require equalized gain to improve slope of the cable pairs.

5.3 Noise - Steady State

Noise level at the user set shall not exceed 20 dBrnC.

Commentary Note 5.3:

The Measurement of Noise

Noise on telephone circuits is measured using weighting filters which weight the noise reading to correspond to subjective effect of noise on voice communication. The weighting filters used 4 KHz voice circuits are the C-message and 3 KHz Flat weighted filters.

a) C-Message Filter

This filter is used to measure noise which affects mainly voice communications and is not particularly relevant to data transmission.

b) 3 KHz Flat Filter

This filter more nearly approximates the response of modems. Compared to the C-Message filter, it allows the low frequency noise contribution to be measured.

c) Noise with Tone

Some element of the telecommunication network such as compandors and quantizers are only active when a signal is present. Their noise contribution cannot be measured unless a tone is sent to activate them. A 1010 Hz test tone is usually sent and a notch filter in the test set removes the tone prior to noise measurement. The noise filter in this case consists of a C-Message filter with a superimposed notch filter and is often referred to as a C-Notch filter.

5.4 Crosstalk

5.4.1 The objective for user loops is that crosstalk index shall not exceed 0.1 for 99% of circuits.

Commentary Note 5.4.1:

The cosstalk index is the percent probability of a telephone user hearing one or more intelligible crosstalk words during one call.

5.4.2 Crosstalk coupling loss at 1000 Hz shall be a minimum of 77 dB when measured at either end of a user loop.

5.5 Echo and Return Loss

The return loss for loops when measured against 900 ohms + 2 µF shall be:

a) ERL - minimum 8 dB

b) SRL - minimum 5 dB

Commentary Note 5.5:

Echo can occur at a 4-wire to 2-wire junction or in a 2-wire user loop at impedance irregularities. The extent to which echo is objectionable depends on the magnitude and echo delay of the echo compared to the original signal.

5.6 Impedance

Electronically derived (originated from a switch using solid state devices) circuits shall have a 900 ohm impedance.

Commentary Note 5.6:

The choice of user loop impedance is based on impedance of existing equipment and cable pairs as described in the following:

a) The telephone set has an impedance of approximately 600 ohms but varies with frequency and magnitude of the current.

b) Non-loaded cable, which accounts for the majority of short loops, has an impedance which varies with length, frequency and gauge.

c) H88 loaded cables have an impedance at 1000 Hz ranging from 1025 ohms for 19 gauge, 1045 ohms for 22 gauge, 1085 ohms for 24 gauge to 1170 ohms for 26 gauge.

5.7 Impulse Noise

The impulse noise shall be no more than 15 counts in 15 minutes at a threshold of 54 dBrnC when measured at the central office.

Commentary Note 5.7:

Impulse noise is usually not of much concern for voice transmission because the ear does not respond to very fast noise spikes, and varistors in the telephone set suppress large voltage surges. However, when user loops are used for data transmission impulse noise is important because it causes errors.

5.8 Delay Distortion

Envelope delay distortion shall not exceed 100 µs between any 2 frequencies over the band from 1000 Hz to 2400 Hz for data transmission at speeds greater

than 300 bits/second. No objective is specified for speeds under 300 bits/second or for speech transmission.

Commentary Note 5.8:

a) Speech signals are insensitive to delay distortion. However, voice channels which are suitable for speech transmission may be completely unsuitable for data transmission because of phase distortion and other characteristics.

b) As an example, the envelope delay of 24 gauge H88 loaded cable is as follows:

1) 1000 Hz = 81.6 µs/mile

2) 1600 Hz = 89.4 µs/mile

3) 2000 Hz = 97.3 µs/mile

4) 2400 Hz = 110 µs/mile

5.9 Nonlinear Distortion

Nonlinear distortion shall be at least 25 dB lower than the original signal.

Commentary Note 5.9:

a) Nonlinear elements in transmission equipment gives rise to harmonic and intermodulation distortion which are generally referred to as nonlinear distortion. The various products arising from nonlinear distortion add to the wanted signal and interfere with it as noise does. This distortion has a negligible effect on speech transmission, but it may impair data transmission.

b) Distortion is sometimes expressed as a percentage, in which case the relationship is dB = 20 $\log_{10}$ voltage ratio in percentage.

Example: 25 dB = 20 $\log_{10}$ (100%/5.6%)

or 25 dB = 5.6% distortion

5.10 Transmission Contrast

When changing from one type of facility to another, the loss of the user loop should not increase more than 3 dB.

Commentary Note 5.10:

When existing telephone facilities are replaced with another type of circuit, there can be a difference in transmission performance which may cause user complaints even though in both cases the circuits are within design limits. The transmission contrast which is most likely to cause complaints is a change in loss (e.g., If the existing circuit has a 2 dB loss, and the new circuit which replaces it has an 8 dB loss, it may cause user complaints even though in both cases the loss not exceed the design limit).

6 Installation

The installation of all cables shall comply with this standard, SAES-O-100, NFPA 70, ANSI C2, general requirements related to land use, clearances, road or pipeline crossings, etc.

7 Testing and Inspection

The testing and inspection of copper conductor cables shall be done in accordance with SAES-T-634. The Inspection Department shall be notified prior to the testing of copper conductor cables.

Revision Summary

31 December, 2003	Revised the "Next Planned Update". Reaffirmed the contents of the document, and reissued with minor changes to Section 2..

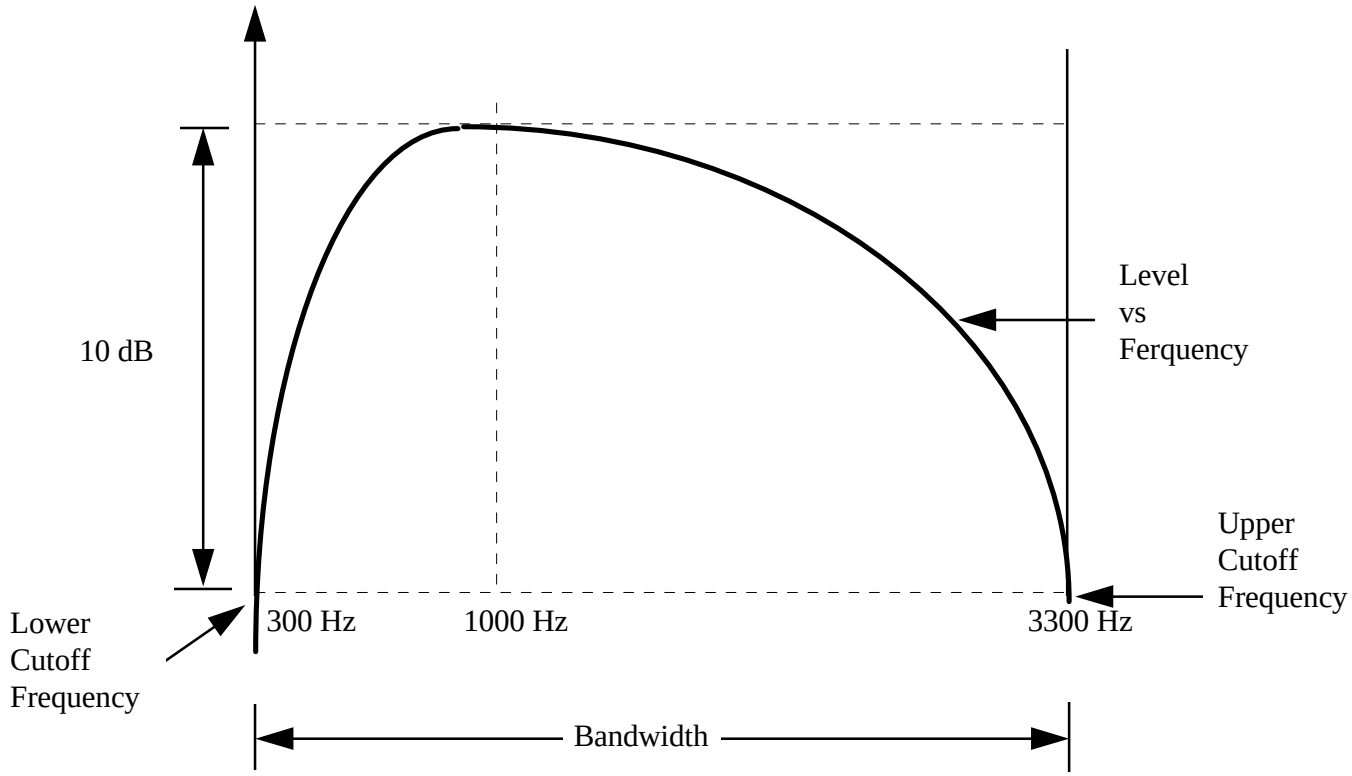

Figure 1 - Illustration of Bandwidth

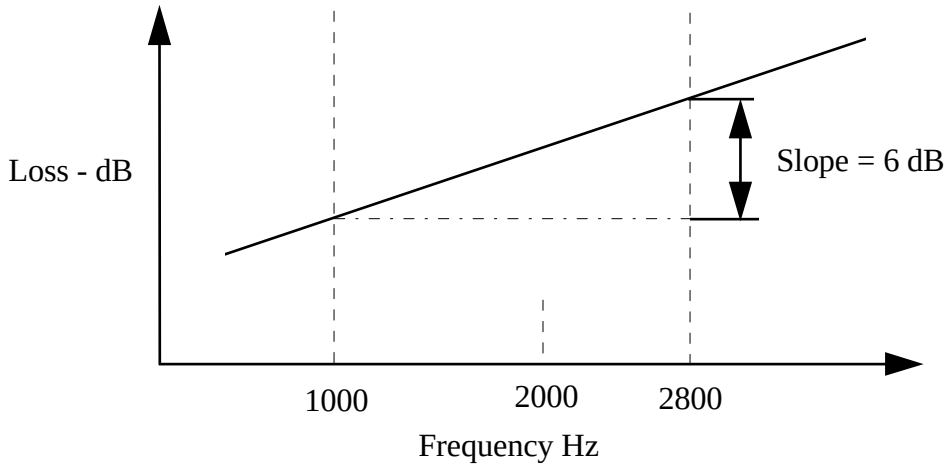

Figure 2 - Loss Versus Frequency for Cable Pairs