Engineering Standard

SAES-T-556 31 March, 2002

Circuit Quality and Performance

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Previous Issue: 28 February, 1999 Next Planned Update: 1 December, 2006
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1 Scope

1.1 This Saudi Aramco Engineering Standard (SAES) defines the parameters associated with circuits used for data communication and specifies the standards to which dedicated, switched and supervisory (low speed signalling) channels are to be planned and commissioned, in terms of those parameters.

1.2 This SAES will be a reference document for engineers involved in the planning of data communications circuits and networks and for technicians concerned with the provision, commissioning and maintenance of such circuits and networks.

2 Conflicts and Deviations

2.1 Any conflicts between this standard and other applicable Saudi Aramco Engineering Standards (SAESs), Materials System Specifications (SAMSSs), Standard Drawings (SASDs), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Consulting Services Department (CSD) of Saudi Aramco, Dhahran.

2.2 Direct all requests to deviate from this standard in writing to the Company or Buyer Representative, who shall follow internal company procedure SAEP-302 and forward such requests to the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

3 References

All referenced Specifications, Standards and Codes, Forms, Drawings and similar material shall be of the latest issue (including all revisions, addenda and supplements) unless stated otherwise. Applicable references are listed below:

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 Standard

SAES-T-004 *Bibliography - Communications*

3.2 Industry Codes and Standards

International Telecommunication Union-Telecommunication

Bell System Std C2 *Conditioned Voiceband Circuit*

4 General

4.1 Section 5 of this standard defines terms and parameters in common usage. The definitions are based upon those given in the bibliographic references quoted in SAES-T-004.

4.2 Section 6 specifies three standards for dedicated circuits. The first operating at 2400 to 9600 bit/s, and the second for 300 to 1200 bit/s, over voiceband channels. The third is for baseband transmission over local cable.

4.3 Recognizing that until a collection of empirical data is available, a switched circuit is very difficult to specify, Section 7 details the parameter values that may be associated with a typical connection.

4.4 Section 8 specifies the standard for supervisory (low speed signalling) channels.

4.5 Section 9 specifies signal levels and system loading.

4.6 Wherever ITU-T Recommendations are quoted, these shall be taken as agreed at the 1980 Plenary Assembly (Yellow Book) or the latest revisions of ITU-T.

5 Definitions

5.1 Distortion

5.1.1 **Envelope (or Group) Delay Distortion**: When a complex signal is transmitted through a system the envelope of the signal will appear to have suffered a delay. Envelope Delay Distortion is defined as the maximum variation in Envelope Delay over a band of frequencies. Envelope Delay itself is the slope of the phase characteristic with respect to frequency, at any particular frequency.

Envelope Delay Distortion is usually quoted in milliseconds, relative to a frequency at which it has a minimum value (often 1,8 kHz for voiceband circuits).

5.1.2 **Harmonic Distortion**: Often referred to as non-linear distortion, it refers to the generation of unwanted signal components of the transmitted signal. It is usually confined to the second and third harmonics and measurements of these are referred to the power of the fundamental. Main sources are electronic components in voiceband circuits.

5.1.3 **Intermodulation Distortion**: This is caused by non-linearities in terminal equipment and line amplifiers of FDM systems. The contribution of these at VF (and thus to Harmonic Distortion) is usually negligible.

5.1.4 **Quantization Distortion**: This is caused by the quantization of a voiceband signal prior to transmission over digital lines. C-notched noise measurement incorporates this.

5.1.5 **Phase Intercept Distortion**: Independant of frequency and time, this can be considered as an "initial phase offset" common to all signals passing over a carrier system. It is overcome in practice by modem design.

5.1.6 **Attenuation/Frequency Distortion**: This is the variation of loss with frequency over a particular channel. Ideally loss should be independant of frequency and equalization provides a close approximation.

5.2 Equalization

5.2.1 **Equalization or Conditioning**: is the process of inserting analogue filters into a circuit such that the characteristics of the line or channel are complemented in order to compensate for attenuation/frequency and envelope delay distortion.

5.2.2 **Automatic and Adaptive Equalization**: Methods by which digital filters which are usually built into the modem achieve the equalization required. Either by sending a training pattern prior to data being sent (automatic) or by continually adjusting during transmission (adaptive) in order to precisely match the filter to the line or circuit characteristics. Many modems use a combination of the two methods.

5.3 Error Rate

5.3.1 **Bit Error Rate**: The number of bits transmitted in error divided by the number of bits transmitted.

5.3.2 **Block Error Rate**: A block is a number of bits, the number being dependant upon the transmission protocol in use. The Block Error Rate is the number of blocks transmitted with one or more bits in error divided by the total number of blocks transmitted, for a given block length (i.e., number of bits per block). The block length should be quoted.

5.4 Hits and Dropouts

5.4.1 **Phase Hits**: Sudden uncontrolled changes in the phase of the transmitted signal. Such occurrences may include:

- The signal jumping to a new phase and then returning after a few ms.
- The signal jumping to a new phase and then returning after about 25 ms.
- The signal jumping to a new phase and remaining there.
- The signal continually changing phase over a period which may exceed 1 s.

5.4.2 **Gain Hits**: Sudden uncontrolled changes in the gain or loss of a channel. These usually last longer than impulse noise spikes, typically 4 ms or longer.

5.4.3 **Dropouts**: Large reductions in channel gain, usually greater than l2 dB for 10 ms or longer duration, in extreme cases resulting in an open circuit. These are usually caused by deep fading of radio facilities or component failure.

5.5 Incidental Modulation

Any unwanted AM, FM or PM imposed upon the signal. This includes Phase Intercept Distortion, Frequency Shift, Phase Jitter, Incidental AM, Phase Hits, Gain Hits and Dropouts.

5.6 Interference

5.6.1 **Crosstalk**: The interference resulting from coupling from other channels, or coupling of the "go" signal to the "return" signal within the same channel.

5.6.2 **Single Tone Interference**: Unwanted steady tones that may appear on channels.

5.6.3 **Echo**: Impedance mismatches may cause echoes to be returned to the transmitter (talker echo) or the receiver (listener echo). See also Return loss.

5.7 Jitter

5.7.1 **Amplitude Jitter**: Often called Incidental Amplitude Modulation, this consists of low index Double Sideband modulation of voice-band signals.

5.7.2 **Phase Jitter**: Various sources may cause the instantaneous phase of a signal to "jitter" at rates usually less than 300 Hz.

Typical sources are D.C. power supply ripple appearing in the master oscillator stages of carrier systems, ringing current and incomplete filtering of sidebands in carrier systems. The most common jitter frequencies are 20 Hz (ringing current) and 60 Hz (power) together with the second through fifth harmonics of these.

5.8 Loss

5.8.1 **Insertion Loss**: The loss occurring due to the insertion of either a circuit component or the entire circuit. It is usually measured at a particular frequency.

5.8.2 **Loss Variation**: Short term loss variation occurs for less than a few seconds and can be brought about by AGC action on carrier system amplifiers or standby facility switching. Long term loss variation covers periods up to several months and occurs due to component aging, amplifier drift and temperature.

5.8.3 **Return Loss**: The ratio of the power at a single frequency placed on the 4-wire receive side to the resulting power at that frequency appearing on the 4-wire transmit side, where a 4-wire circuit interfaces to a 2-wire circuit, at a 2 W/4 W terminating set or hybrid.

5.9 Frequency Response

The variation of loss and envelope delay with frequency of a channel. Characterized in terms of the amplitude/frequency distortion and envelope delay distortion.

5.10 Frequency Shift

Often referred to as Frequency Error or Re-inserted Carrier Error, this is the constant change in all voiceband frequencies resulting from the slight difference in modulating and demodulating carrier frequencies associated with carrier telephony systems.

5.11 Noise

5.11.1 **C-Message Noise**: This is the Bell System near-equivalent to ITU-T Psophometrically Weighted Noise (Recommendation 041).

Both are weighted measurements of the background or idle noise on a channel in the absence of a signal. The weighting used is provided by a filter of defined characteristic which differs slightly between the two standards quoted.

5.11.2 **C-Notched Noise**: This is the Bell System measurement method for assessing noise on a channel when a signal is present. Basically a holding tone is transmitted which is removed by a notch filter at the receiver while measuring other C-message noise.

5.11.3 **Impulse Noise**: This is characterized by large 'spikes' or impulses in the total noise waveform and arises from electrical storms and crosstalk from other systems such as make-and-break contacts.

6 Dedicated Circuits

6.1 Voiceband Circuits

Two types of circuits are specified. The first is a Bell Standard C2-conditioned circuit which may be used for higher speed operation where a high standard of conditioning is a requirement. The second is an unconditioned circuit primarily for lower speed operation. It is possible with an appropriate modem, to achieve speeds up to 4800 bit/s and may be greater, over an unconditioned circuit. The type of circuit selected for a particular application will depend upon the choice of modem.

6.2 Test Level Points

A Test Level Point (TLP) is a reference level which is numerically equal to the level at that point of a standard 1 mW test tone (0 dBm) applied at a point of zero relative level in the circuit. In the data circuits detailed in this section, the zero relative level point is the transmit output of the modem and the TLP levels elsewhere in the circuit signify the levels which will be measured at those points when a 0 dBm test tone is applied to the circuit from the point where the modem transmit is applied, i.e., the user's location. In data circuits, all measurements are made at data level, which is 13 dB below TLP, i.e., -13 dBmO. In the voiceband dedicated circuits detailed, a point-to-point circuit is designed to have a nominal loss of O dBm end-to-end. Therefore, at the modem, the transmit level is -13 dBm (which, since this is OTLP may also be written -13 dBmO). At the MOD IN jack of a 4-wire carrier system it will also be -13 dBmO but this is by convention a - 16 TLP so the level measured will be -29 dBm. At the DEMOD OUT jack (a +7 TLP) the measured level will be -6 dBm (i.e., -13 dBmO) and at the far end modem receive (O TLP) the measured level should be -13 dBm. An overall tolerance of ± 2 dB is permitted on the measured values. Multipoint circuits will be similar except that the overall loss between the instation modem and any outstation spur is designed to be 3 dB to compensate for branching points.

6.3 C2-Conditioned Voiceband Circuit

These circuits shall use conventional telephone plant and equipment and shall be presented as 4-wire circuits, either point-to-point or multi-point. The conditioning requirements shall comply with Bell Standard C2. All loss, attenuation/frequency and envelope delay distortion figures quoted are those permissible between the end points of the circuit.

6.3.1 Loss: The nominal insertion loss of the circuit shall be 0 dB ± 2 dB at 1004 Hz for point-to-point circuits and 3 dB ± 2 dB at 1004 Hz for multipoint circuits, in the 4-wire mode. The short term loss variation shall be no greater than ± 3dB.

The long term loss variation shall be no greater than ± 4 dB.

6.3.2 Attenuation/Frequency Distortion: Relative to the loss at 1004 Hz, the loss at other frequencies shall be as follows:

- 300 Hz to 500 Hz -2 dB to + 6 dB (+ indicates more loss)
- 500 Hz to 2.8 kHz -1 dB to + 3 dB
- 2.8 kHz to 3.0 kHz -2 dB to + 6 dB

6.3.3 Envelope Delay Distortion: Relative to the minimum delay, the variation at other frequencies shall be as follows:

- 500 Hz to 600 Hz 3.0 ms
- 600 Hz to 1 kHz 1.5 ms
- 1.0 kHz to 2.6 kHz 0.5 ms
- 2.6 kHz to 2.8 kHz 3.0 ms

6.3.4 Frequency Error: This shall be no greater than + 5 Hz, between two ends of the carrier section of the circuit.

6.3.5 Single Tone Interference: This shall be at least 3 dB below the C-message noise limits.

6.3.6 Harmonic Distortion: The relationship between the power of the fundamental and the power of the harmonics shall be as follows:

- Fundamental to Second Harmonic 25 dB minimum
- Fundamental to Third Harmonic 30 dB minimum

6.3.7 Phase Jitter: This shall be no more than 10 degrees peak-to-peak in the worst case.

6.3.8 Phase Hits: There shall be no more than 15 occurrences of phase hits in excess of 10 degrees peak-to-peak over any 15 minute period.

6.3.9 Gain Hits: There shall be no more than 15 occurrences of gain hits in excess of 2 dB with reference to the received signal level over any 15 minute period.

6.3.10 Dropouts: There shall be no more than 50 interruptions or dropouts of duration in excess of 10 ms over any 24 hour period at a threshold of -12 dB, with reference to the received signal level.

6.3.11 C-Message Noise: The maximum level at the modem receiver shall be 50 dBrncO.

6.3.12 C-Notched Noise: This shall be at least 24 dB below the received 1004 Hz test tone power.

6.3.13 Impulse Noise: There shall be no more than 15 counts over any 15 minute period at a threshold of 68 dBrncO.

6.3.14 Signal to Quantizing Noise Level: At least 24 dB.

Commentary Note:

This figure is incorporated within the C-notched noise requirement.

6.3.15 Signal to Listener Echo Ratio: The first listener echo shall be at least 12 dB below the signal level for a terminal impedance of 600 ohms.

6.3.16 Crosstalk Attenuation: At least 45 dB.

6.3.17 Signal to Noise Ratio: The minimum signal to noise ratio for operation at 9600 bits/s is 24 dB, if using DPSK 8 phase and 2 amplitude level modulation.

6.3.18 Bit Error Rate: This shall be a maximum worst case value of 1 bit in error for every 10^6 bits transmitted.

6.4 Unconditioned Voiceband Circuit

These circuits shall use convertional telephone plant and equipment and shall be presented as 4-wire circuits, either point-to-point or multipoint. All loss, attenuation/frequency and envelope delay distortion figures quoted are those permissible between the end points of the circuit.

6.4.1 Loss: The nominal insertion loss of the circuit shall be 0 dB ± 2 dB at 1004 Hz for point-to-point circuits, and 3 dB ± 2 dB at 1004 Hz for multipoint circuits, in the 4 wire mode. The short term loss variation shall be no greater than ± 3 dB.

The long term loss variation shall be no greater than ± 4 dB.

6.4.2 Attenuation/Frequency Distortion: Relative to the loss at 1004 Hz, the loss at other frequencies shall be as follows:

- 300 Hz to 500 Hz -3 to +12 dB (+ indicates more loss)
- 500 Hz to 2.5 kHz -2 to + 8 dB
- 2.5 kHz to 3.0 kHz -3 to +12 dB

6.4.3 Envelope Delay Distortion: Relative to the minimum delay, the variation at other frequencies shall be as follows:

- Below 800 Hz Not specified
- 800 Hz to 2.6 kHz 1750 microseconds
- Above 2.6 kHz Not specified

6.4.4 Signal to Noise Ratio: The minimum signal to noise ratio for operation at 1200 bits/s is 14 dB, if using FSK modulation.

6.4.5 The parameter limits in paragraphs 6.3.4 through 6.3.16 and paragraph 6.3.18 are also applicable to this circuit type.

6.5 Baseband Circuits

This type of circuit is for use in connection with unamplified, short distance data transmission using baseband techniques over unloaded local line plant. It shall be presented 4-wire.

6.5.1 Loss: The insertion loss shall not exceed 37 dB at 10 kHz measured between 140 ohm terminations.

6.5.2 Idle Noise: The idle noise shall not exceed 27 dBrn (-63 dBm) when using 3 kHz flat weighting and a 140 ohm termination, measured at the user's location.

6.5.3 Impulse Noise: The impulse noise threshold shall be 14 dB below the received 1004 Hz test tone level and no more than 15 counts shall exceed this threshold in any 15 minute period, measured at the user's location, with 3 kHz flat weighting.

6.5.4 The transmission distance achievable by baseband transmission techniques is dependant upon the modulation technique, the gauge of the conductors and the transmission speed.

6.5.5 Since baseband modems operate only over local line plant, using a wide bandwidth, no special conditioning is required and no additional parameters other than those specified in Section 6.5 are relevant.

6.6 Specially Engineered Circuits

Any dedicated data circuit required which does not fall into any of the categories specified in Sections 6.3, 6.4, 6.5 or 6 shall be designated as a circuit requiring special design and shall be referred to Communications Planning and Engineering Department.

7 Switched Circuits

7.1 This section gives guidance as to the values of some of the parameters which may be obtained over a dial-up connection. It must be appreciated that these represent typical values obtained by measurement. In many cases, the values obtained will be a considerable improvement, particularly on short distance circuits, but busy hour conditions on long distance circuits may give worse figures. The choice of modem will influence greatly the overall performance.

7.2 Loss

The insertion loss may vary between 4 dB and 12 dB at 1004 Hz depending upon the length of the circuit. The short and long term variations should be no greater ± 4 dB.

7.3 Attenuation/Frequency Distortion

Relative to the loss at 1004 Hz, the loss at other frequencies should be of the following order:

Below 300 Hz	0 dB to in excess of + 10 dB	
300 Hz to 500 Hz	0 dB to + 8 dB	(+ indicates more loss)
500 Hz to 2.8 kHz	- 3 dB to + 10 dB	
Over 2.8 kHz	+ 3 dB to in excess of + 10 dB	

7.4 Frequency Error

Should be no greater than ± 5 Hz but may be in excess of this figure.

7.5 Envelope Delay Distortion

Relative to the minimum delay, the variation at other frequencies should be as follows:

500 to 600 Hz	0.2 to 2 milliseconds
600 to 1000 Hz	0.1 to 2 milliseconds
1000 to 2600 Hz	0.5 to 2 milliseconds
2600 to 2800 Hz	0.1 to 2 milliseconds

7.6 Single Tone Interference

Switched network conditions may given rise to in-band signalling tones either directly connected momentarily or by crosstalk at levels approaching the signal level.

7.7 Harmonic Distortion

Relative to the lower of the fundamental, the power of the harmonics could be as follows:

2nd harmonic : up to -20 dB

3rd harmonic : up to -20 dB

7.8 Phase Jitter

This may be within the range 0.2 to 5 degrees peak-to-peak but will frequently be in excess of 10 degrees on some connections.

7.9 Phase Hits

These may lie within the range of 5 to 30 over a 15 minute period but busy hour conditions may give rise to values in excess of 100, using a decision threshold of 10 degrees peak-to-peak.

7.10 Gain Hits

These may be within the range of 5 to 30 over a 15 minute period but busy hour conditions may give rise to values in excess of 200, using a decision threshold of ± 2 dB with reference to the received signal level.

7.11 Dropouts

The dial-up circuit adds the possibility of the exchange momentarily or permanently disconnecting the call, under a fault condition and dropouts may exceed 50 interruptions in excess of 10 ms over a 24 hour period, using a threshold of -12 dB with reference to the received signal level.

7.12 C - Message Noise

Busy hour conditions may adversely affect this reading to a considerable degree. Values should range between 15 dBrncO and 55 dBrncO depending upon the length of circuit and number of switching points in the connection.

7.13 C - Notched Noise

It is unlikely that the limit of a level at least 24 dB below the received 1004 Hz test tone power will not be met.

7.14 Impulse Noise

The switched network contributes a considerable amount of impulse noise due to switch operation and crosstalk within the exchange. Busy hour conditions greatly increase the number of noise spikes. Likely values range from 5 to 100 hits in 15 minutes at a threshold of 68 dBrncO.

7.15 Bit Error Rate

The switched telephone network will support both full duplex and half duplex data transmission. The rates in common use over a single dial-up line are 3200, 2400 and 1200 bit/s full duplex and up to 4800 bit/s half duplex. Bit error rates will vary with transmission speed and values of between 1 error in 10^3 bits transmitted and 1 error in 10^5 bits transmitted may be found. An accepted rate for dial-up circuits is 1 error in 10^4 bits transmitted.

7.16 Many of the other parameters specified in Section 4 such as Return Loss are, in the switched circuit case, dependant upon telephony network maintenance practices and standards.

8 Supervisory (or Low Speed Signalling) Circuits

8.1 These circuits provide 2-wire point-to-point metallic paths between any two locations served from the same Central Office. The standard only deals with maximum D.C. loop resistance and wire-to-wire capacitance. These circuits are not intended for speech use or for data transmission at frequencies above 30 Hz.

8.2 Such circuits will be suitable for a variety of intruder or fire alarms, relay operated devices or other equipments operated by a step change or D.C. reversals.

8.3 The D.C. loop resistance (i.e., the wire-to-wire resistance measured at one end when the other end is short circuited) shall not exceed 2 kilohms.

8.4 The wire-to-wire capacitance shall not exceed 2 uF. This would not normally be measured for each circuit.

8.5 These circuits can support non-simultaneous, bi-directional data transfer.

8.6 Other than meeting the requirements stated in paragraphs 8.3 and 8.4, no additional parameters are relevant.

8.7 If a low speed signalling channel requires to be extended beyond the coverage of the Central Office, a voiceband circuit and associated D.C./tone translation equipment will need to be provided as required. No conditioning of the voiceband channel should be necessary. Alternative methods could involve a form of multiplexing and a conventional voiceband data circuit and modem.

9 Signal Levels and System Loading

9.1 Signal Levels for Voiceband Dedicated Circuits

9.1.1 For frequencies in the band 300 Hz to 3.2 kHz, the power output of the modem to line shall comply with ITU-T Recommendation V2(A) i.e.:

9.1.1.1 The maximum power output of the modem to line shall not exceed 1 mW.

9.1.1.2 For systems transmitting tones continuously (e.g., FM or PM systems) the maximum power at the zero relative level point shall be -13 dBmO.

9.1.1.3 For systems not transmitting tones continuously (e.g., AM systems), the signal characteristic shall meet all of the following requirements:

i. the maximum value of the 1 minute mean power shall not exceed -13 dBmO.

ii. the maximum value of the instantaneous power shall not exceed a level corresponding to that of a 0 dBmO sine wave signal.

iii. the maximum signal power determined for a 10 Hz bandwidth centered at any frequency shall not exceed -10 dBmO.

9.1.2 This means that a voiceband modem connected to a 4-wire circuit shall be adjusted such that the transmit power level to line shall not exceed -13 dBm.

9.1.3 For frequencies above 3.2 kHz, the guidance given in Supplement No. 16 to the ITU-T Yellow Book Volume III shall be followed, in that the maximum power level of individual spectral components of the signal shall comply with Figure 1.

9.1.4 For frequencies below 200 Hz, the following shall be complied with:

i)	DC	:	150 V	60 mA maximum line current.
ii)	Up to 5 Hz	:	100 V rms	
iii)	6 Hz to 100 Hz	:	7 V rms	(without filter)
			25 V rms	(with 200 Hz low pass filter)
			75 V rms	(with 120 Hz low pass filter)
iv)	100 Hz to 200 Hz	:	3.5 V rms	(without filter)
			10 V rms	(with 200 Hz low pass filter)

9.2 Signal Levels for Baseband Dedicated Circuits

9.2.1 The maximum power output of the modem to line shall not exceed 1 mW (OdBm).

9.2.2 For frequencies below 200 Hz, the provisions of paragraph 9.1.3 shall be complied with.

9.3 Signal Levels for Voiceband Switched Circuits

9.3.1 The provisions of ITU-T Recommendation V2(B) shall be complied with, i.e.:

9.3.1.1 The maximum power output of the modem to line shall not exceed 1 mW at any frequency.

9.3.1.2 The provisions of paragraphs 9.1.1.2 and 9.1.1.3 shall apply.

9.3.2 For a switched circuit the zero relative level point (OTLP) is taken to be the central office MDF. This means that the power output from the modem to line may be greater than -13 dBm and if adjustment of power output is provided in the modem it should be arranged that the level measured at the MDF is 13 dBmO. This will compensate for local loop loss.

9.4 Signal Levels for Dedicated Supervisory Circuits

The provisions of paragraph 9.1.4 (i) through (iii) shall be complied with.

9.5 System Loading for Voiceband Circuits

9.5.1 Signal Levels: In accordance with ITU-T Recommendation V2, to ensure the correct loading of a multichannel FDM carrier system, provided that the proportion of channels used for non-speech applications in such a system is less than 50%, a mean power of -13 dBmO for each direction of transmission shall be allowable.

9.5.2 Effect of Filters: Channels 1 or 12 in any FDM group may be used for unconditioned circuits providing it is the only FDM channel in the routing. These channels shall not be used for conditioned circuits as they may introduce excessive envelope delay distortion, particularly when through-group filters are in use.

9.5.3 Group Loading: There shall be no more than 6 non-speech dedicated circuits assigned per 12 channel FDM group. This shall apply to all new assignments. Retrospective action may be advisable if excessive noise problems are encountered on existing systems.

9.5.4 Effect of Pilots: If a dedicated circuit (particularly a multipoint circuit) requires the tandem connection of FDM channels, the interference effect of the reference pilots of each system shall be considered, as follows:

9.5.4.1 For tandem connection where both systems use a 104.08 kHz pilot, channel 2 shall not be used in tandem with another channel 2.

9.5.4.2 For tandem connection where both systems use a 84.08 kHz pilot, channels 6 and 7 shall not be used in tandem with another channel 6 or 7.

9.5.4.3 For similar reasons, channel 11 of Group 5 in a supergroup shall not be tandem connected with channel 11 of another Group 5, due to the supergroup reference pilot of 547.92 kHz.

Revision Summary

31 March, 2002 Revised the "Next Planned Update". Reaffirmed the contents of the document, and reissued with no other changes.

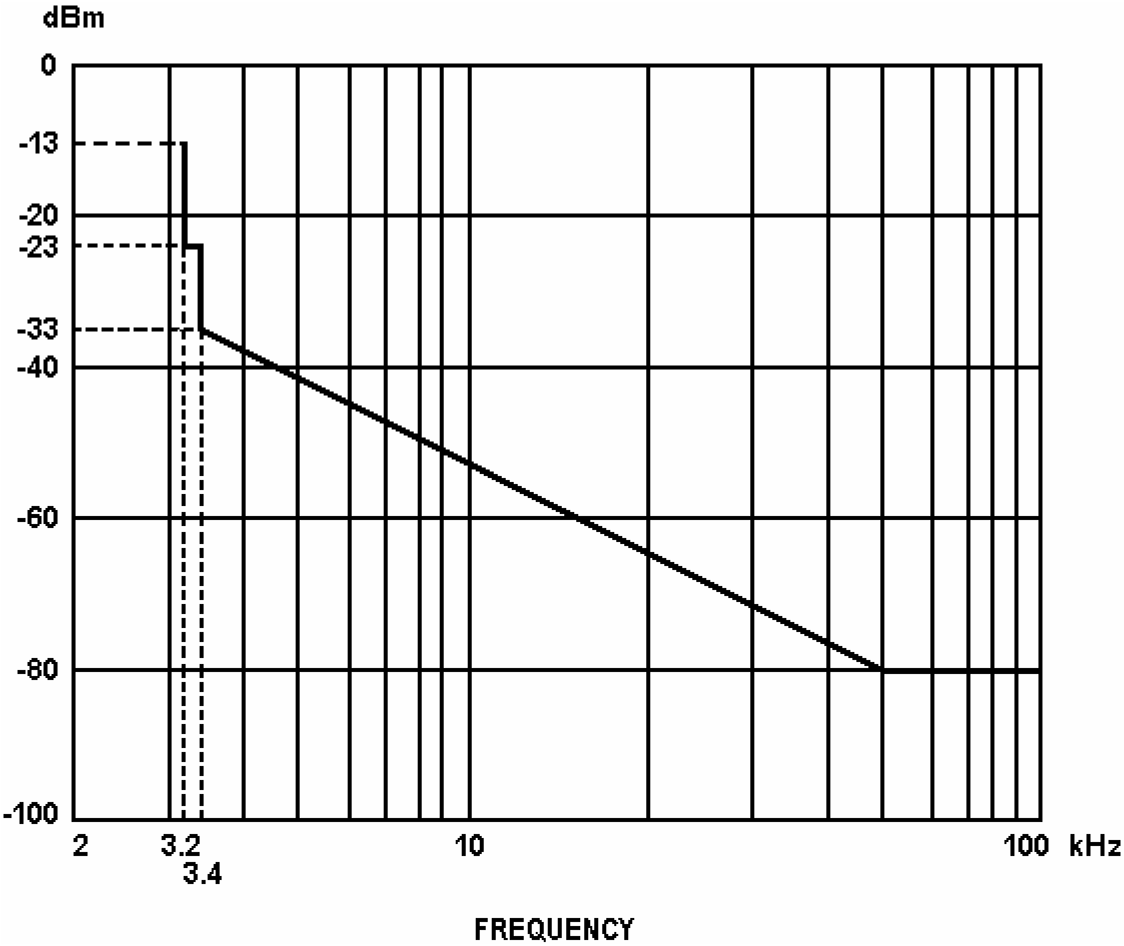

Figure 1 - Maximum Power Level of Individual Spectral Components Above 3.2 kHz of the Output Signal from Modems Connected to Voice Band Dedicated Circuits