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Telemetry/Alarm Bridged Service (TABS) Overview

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Table of Contents

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1. GENERAL

1.1. Purpose of Document

The purpose of this document is to provide information to users of Telemetry/Alarm Bridged service and to designers and manufacturers of terminal equipment that will interface with the service. Service offerings are described and transmission performance is specified in terms of parameter limits. Interface specifications and network descriptions are also given.

1.2. Service Description

Telemetry/Alarm Bridged Service (TABS) is a private line data service that is designed for applications in which a master station exchanges voiceband data information with a number of remote stations on a multipoint basis.

Alternate voice service and DC continuity are not available. the service allows two-way transmission between the master station and the remote stations, but no direct transmission is available between remote stations.

TABS is a generic term used to describe a multipoint low-speed data offering. The data transmission rate, dependent upon customer provided equipment and the specific multipoint configuration selected, is generally 400 baud or less.

The bridged network service within the TABS offering utilize unique circuit designs producing multipoint data networks that are not available through traditional two-wire designs. These special designs utilize specific Telco provided equipment or design approaches which may not be compatible with all existing two-wire transmission devides.

The bridging configuration available in Ameritech as a TABS network is termed “Split Band Active”. A full description follows.

2. SERVICE ARCHITECTURE

2.1. General

A Split-Band, active bridging arrangement provides for a four-wire (master station) frequency-split common port and multiple two-wire (remote station) ports and is intended for application in multiport voice-frequency data or tone signaling arrangements. Two-way (polling) communication between the master station and each remote station is intended. The Split-Band bridging system can accommodate 128 two-wire ports.

All 128 two-wire ports may be distributed from a system located in a single office or be distributed over several telephone serving offices.

The multi office design is provided using full bandwidth (300 to 3000 Hz) channels for the primary link (between the user control location and the primary bridge) and all secondary links (between a primary bridge and any secondary bridge). The conbination of primary and any secondary links is referred to as the backbone circuit. The primary bridge may be thought of as a hub from which all secondaries radiate. The bridging system is equipped with a set of filters, one being a high pass and the other a low pass.

2.2. Bridging with Filters

The filters in the bridge divide the voice band into two portions and applied to the 2-wire facility from the bridge to the remote stations. One portion of the voiceband is used for signaling from the master station toward the remotes. And the other portion is used for responses from the stations back toward the master.

A number of standard filter sets are available for use with specific Split-Band bridging terminal equipment. (See Table A). Because each filter set is designed to meet specific noise and cross talk considerations, Telco will not mix a filter from one set with a filter from a second set. Should an additional filter set be required for a Split-Band bridge application, the vendor of the Telco provided equipment has to agree to make such a filter set available. Telco, being dependent upon vendors of such equipment, cannot independently make such a decision to provide a non-standard filter set. Depending upon vendor response and wuantities of required units, the use of a non-standard filter set could result in high user cost. Should a new filter set be required, the user should discuss the feasibility of the application with local Telco engineering representatives.

Any of the standard sets available will control the amount of energy being returned to the control location (during an out going poll) to a value at least 20 dB less than the energy present during a response period.

The frequency response and envelope delay specifications of the resulting network cannot be readily specified due to the presence of the filters. However, terminal equipment manufacturers using this bridging configuration have not experienced operational difficulities due to the presence of the filters.

The following information reflects the worst case filter set test criteria, as established for bridge manufacturers acceptance testing, for the Telco provided equipment used to structure a Split-

Band bridging network. The filter set used represents the standard set of filters which have the closest 3dB cut off frequencies.

Filter Function	3dB Point	-30dB Point	Bandpass ± .5dB
Lowpass Filter	1370	1620	300 – 1000 Hz
Highpass Filter	1650	1310	1850 – 3000 Hz

Split-Band bridging is not designed to provide communications between two-wire stations served by the network. Only transmission between the master location and individual two-wire remote stations is guaranteed. The electrical design of the Telco provided bridging equipment results in a minimum of 20 dB of loss between any of the two-wire port terminations (actual loss between two wire ports may be in excess of 40 dB).

2.3. Network Transmission

The design objective for a Split-Band bridging network results in a channel which provides a four-wire master station termination having a 600 ohm impedance. The data signal level, used to poll the network, is 0 dBm (.774 VRMS across 600 Ohms). A remote location response appears on the receive side of the four-wire interface and will have a nominal energy level of -16 dBm (.123V RMS across 600 Ohms).

All remote two-wire locations will be provided using a passive interface and shall provide a nominal 600 Ohm impedance. the transmit signal level used to communicate with the master location is 0 dBm (.774 V RMS across 600 ohms). Communications generated at the master location will be received at all remote locations at a nominal signal level of 16 dBm (.123V RMS across 600 ohms).

The Telco implementation of a Split-Band bridge design results in a full bandwidth four-wire back-bone circuit (primary and any secondary trunking). The filters used in the primary as well as secondary bridges define the specific frequency response of the resulting network. The Telco end-to-end design objectives, excluding the action of band splitting filters are as follows.

Loss @ 1004 Hz	16dB
Envelope delay	Not specified (varies by facilities & filters)
Signal to noise Ratio	Equal to or better than 24dB
Impulse noise	15 hits in 15 min. At a level of 74 dBmc
Maximum bit rate	400 bits per second (filter dependent)
Frequency Response	500 – 2800 Hz –4 to +14dB* (Excluding Filter Characteristics) @ 1004 Hz

*+ means more loss

2.4. Master Station Interface

The Master Station interface will consist of a four wire (separate transmit and receive terminations) circuit interface. The termination and source impedance appearing at the interface shall be 600 ohms ± 10%. The maximum user transmit signal level is 9 dBm as averaged over a 3 second measurement period. The instantaneous transmit level shall not exceed + 13dBm.

Signals appearing on the receive transmission pairs shall have a nominal level of -16dBm. Every effort shall be made to provide the interface using circuit designs which do not require local power. However, should a design requiring local power be required it is the users responsibility to provide either 117 volts 60Hz AC or 24 volts DC. Should 24V DC be provided, the maximum current demand of the interface shall not exceed 240 MA. The long term curent requirement shall average 60 MA.

The interface is provided with a “loopback” feature. The purpose of the “loopback” is to facilitate remote testing by Telco to the interface. the period of maximum current demand of the interface occurs only during the operation of the “loopback” test.

The design used to provide master station network interface can provide manual customer control of a normally tone aactivated test feature used by Telco. Manual loopback control provides security against accidental or purposeful operation of the tone energized loopback. If manual control is requested, it is required that the locations served by manned on a 24 hour basis and that the user will, upon Telco request, activate the loopback feature

2.5. Remote Station Interface

All remote locations shall consist of a passive two-wire interface having a nominal impedance of 600 ohm. The 1004 Hz loss objective between any remote location and the primary location is 16dB. The direction of transmission from a remote will be towards the primary location. Communication between remote locations is not provided.

3. END-TO-END TRANSMISSION PARAMETERS

The end-to-end channel established between the master station and each of the remote stations will meet certain parameter limits and specifications. These parameters are discussed in the following sections. An understanding of the parameters is necessary to determine the effect of the channel on the user's end-to-end signal and to determine the constraints on that signal.

3.1. Voiceband Interface Parameters

The voiceband interface parameter specifications are influenced by two considerations: electrical protection of the telephone network and its operating personnel, and standardization of private line design arrangements.

3.2. Terminal Impedance and Balance

The recommended impedance of data terminal equipment is 600 ohm ± 10 % resistive over the voiceband. The designer of the user's terminal equipment should be aware that it is in the best interest of the user that this impedance is utilized. The impedance of the Telco test equipment used for installation tests and trouble tests is 600 ohms resistive. Channels lined up using 600-ohm terminations should be used with 600-ohm terminations to assure transmitted and received signal power is as specified. It should be noted that this does not necessary imply that the Telco facilities will, of themselves, present an impedance of 600 ohms to the user's terminal equipment. At the master station the termination will always present an impedance of 600 ohms. At the remote station, however, the impedance presented by ther termination from the CSU (Channel Service Unit) may vary significantly with frequency, and also may depend on the length and type of facility used in the local loop plant. However, these factors do not prevent the parameter limits from being realized as long as the user's terminal equipment meets the 600 ohm recommendation.

The master station and remote station are designed to provide balanced terminations to the Telco facilities. The customer equipment may be balanced or unbalanced; however, balanced is usually preferred to minimize local (on premises) noise interference.

3.3. In-Band Data signal Powers

The maximum allowable transmitted signal power for an end-to-end data signal, averaged over any 3-second interval, is 0 dBm (as measured across a 600 ohm resistor). In meeting the 3-second average power, the absolute instantaneous power shall not exceed the average power by 13 dB. Hence, at the 0 dBm transmit point the instantaneous signal power must not exceed + 13 dBm (3.46 volts peak across 600 ohms resistive). The total power specification applies in the voiceband below 3995 Hz. All signal energy, spurious or otherwise, must be included when determining whether the transmitted power specification is met. The dc requirement is that the user's terminal should cause no more than one miliampere dc to flow through the voiceband channel termination.

At the master station, the nominal 1004 Hz received data signal power is -16 dBm based on a transmitted power of 0 dBm at the remote station.

3.4. Test Signal Power

Test signals applied by the user must not exceed 0 dBm. A test signal with power well below 0 dBm (<30dB) may give erroneous results because of nonlinear channel response with changes in signal power.

3.5. Out-of-Band Transmitted Signal Powers

Out-of-band signals are defined (when part of voiceband transmission) to be in either of two regions, above 3995 Hz or below 300 Hz. The limits on out-of-band signal power are applicable to the transmitted signal power at the Telco interface. The out-of-band signal power limits are required to protect Telco personnel from hazardous current or voltage and to prevent interference with other services carried on Telephone Comany facilities.

Out-of-band signals shall be limited in accordance with FCC Regulation Part 68.308. To summarize this document, the criteria for short duration RMS powers are:

1. The power in the band from 3995 Hz to 4005 Hertz shall not exceed -18 dBm.

2. The power in the band from 4K Hz to 10 kHz shall not exceed -16 dBm.

3. The power in the band from 10K Hz to 25 kHz shall not exceed -24 dBm.

4. The power in the band from 25K Hz to 40 kHz shall not exceed -36 dBm.

5. The power in the band above 40 kHz shall not exceed -50 dBm.

3.6. Bandwidth Parameters

The bandwidth parameters (attenuation and envelope delay) provide an indication of the usable bandwidth of a channel. A summary of these limits is given in Table D along with a summary of the facility parameters discussed in Section 3.3. Limits for parameter values given in Table D are provided for information purposes only. In some cases the information on the bandwidth and facility parameters is based on limited studies, and some changes may result as new information becomes available. To avoid the need to disrupt the service each time a station is added, these parameters are not measured on an end-to-end basis at installation. The limits given in Table D are based on the combined effect of individual sections.

3.7. Attenuation Distortion (Loss vs. Frequency)

One requirement for the end-to-end channel to provide distortionless transmission is that all signal frequencies experience the same loss in traversing the channel. Typical channels, however, have variation in loss with frequency. To control the magnitude of this variation, attenuation distortion limits are specified.

Attenuation distortion is the difference in loss at one frequency with respect to the loss at a Reference frequency. It is specified by placing a limit on the maximum loss at any frequency in a specified band of frequencies, with respect to the loss at a reference frequency. The reference frequency established in this country is 1004 Hz. The limit for attenuation distortion on the end-to-end channel is -4 to +4 dB in the 504 - 2804 Hz band. Note that “+” means more loss than the loss at 1004 Hz.

3.8. Envelope Delay Distortion

Another channel requirement for distortionless transmission is a linear phase versus frequency characteristics. The end-to-end channel will typically only approximate such linearity over the voiceband. Measuring the phase versus frequency channel characteristic directly is difficult because of problems in establishing a phase reference. However, a usable approximation to the derivative of phase with respect to frequency, called envelope delay, can be more easily measured. The maximum variation in envelope delay over a band of frequencies is called envelope delay distortion (EDD). The limit on envelope delay distortion for the end-to-end channel not including the filter, is 1750 microseconds over the 804-2604 Hz band. (83-1/3 Hz modulating frequency used for the measurement).

The EDD characteristics will differ from the 1750 microsecond limit by the additional distortion created by the band splitting filters. The frequencies at which EDD is most pronounced occur near and beyond the filter cut off frequency.

3.9. Facility Parameters

The facility parameters covered in this section represent potential impairments to a data signal that is transmitted over the end-to-end channel. In all cases the facility parameters exhibit some variation over a period of time. There is little information an the amount of time variability of these parameters. The parameter limits, unless otherwise stated, apply to measurements of steady-state phenomena and the measurements generally last less than one minute.

Transient phenomena (impulse noise, phase hits, gain hits, and dropouts) are measured over longer periods and such events meeting certain criteria may be counted. The results of either steady-state or transient measurements may vary by time of day, day of week, season of year, or according to some other time dependency. In the face of this uncertainty, an attempt made is to determine the conditions representative of the channel during normal operation.

3.10. 1004 Hz Receive Level Variation

Short term loss variation may be caused by dynamic regulation of carrier system amplifiers. Switching to standby facilities and some maintenance activities. “Short term” is meant to be a few seconds or less. Short term variations are considered to be gain hits, gain changes, or dropouts.

Long-term variations are primarily caused by temperature changes affecting locatl plant; component aging, amplifier drift, and other phenomena also ontribute. “Long term” is meant to be periods of days, weeks, or even longer. Long-term variations should not exceed ± 5 dB with respect to the nominal receive level.

3.11. C-Message Noise

C-message noise is a weighted measurement of the background noise on a channel in the absence of a signal. It is measured with an RMS-responding noise measuring set equipped with a C-message filter.

This weighting offers less than 5 dB attenuation in the 600 - 3000 Hz band of interest for most end-to-end data transmission, and sharply attenuates low frequency components, such as 60 Hz and its lower harmonics, and high frequency components above 3200 Hz. Substantial low frequency noise components may be masked in measuring message noise by the attenuation of the C-message filter below approximately 500 Hz. In particular, 60 Hz and its harmonics up to 300 Hz may be present at relatively high levels. The C-message moise limit specified in Table D is particularly important for modems operating without continuously present received signals since they apply tot he channel in the idle (no signal) condition.

3.12. C-Notched Noise

The C-message noise described in Section 3.3.2 often is not the principal noise experienced when a signal is present. Quantizing noise in digital carrier systems and the effect of compandors in both digital and some analog systems result in signal dependent noise. Thus, the ratio of the received power of a 1004 Hz test tone to the received C-message noise power is not a reliable indication of the signal-to-noise ratio.

C-notched oise is a measure of the amount of noise on a channel when a signal is present. In making this measurement, a single frequency “holding tone” is applied at the transmitting end of the channel to act as a signal. This tone operates compandors and other signal-dependant devices, and thus simulates a data signal. At the receiving end, the tone is removed by a narrow band elimination filter (notch fiber) and the noise is then measured through a C-message filter. The ratio of the received 1004 Hz test tone power to the C-notched noise power is indicative of the signal-to-noise ratio on the channel. The limit for the received 1004 Hz power to C-notched power ratio is a minimum of 24 dB.

3.13. Impulse Noise

Impulse noise is characterized by large peaks, or impulses, in the total noise waveform. It is measured with an instrument which counts impulses greater than a selected threshold value, using a counter having a maximum counting rate of approximately seven counts per second. Measurements are made through a C-message filter. A holding tone is transmitted and notched out at the receiver to activate any compandored facilities in the channel.

The usual impulse noise measurement involved counting the number of noise peaks exceeding a threshold numerically 6 dB below the received 1004 Hz test tone power.

In addition, there are limits of 18 counts in 15 minutes at a threshold 2 dB below the received 1004 Hz test tone power, and 10 counts in 15 minutes at a threshold 2 dB higher than the received 1004 Hz test tone power. These additional limits are designed to cover cases where impulses of realatively high power would interfere substantially with data transmission but the channel would pass the single threshold test.

3.14. Single Frequency Interference

Spurious single freqency tones may interfere with certain data signals, particularly narrowband signals which are frequency-division multiplexed onto the channel. Message circuit noise will be distributed across the voiceband, so the noise powe in each narrowband channel will be less than the total noise power, and the signal-to-noise ratio per channel may be quite adequate. If, however, a single-frequency tone of substantial power is present, it may interfere with one of the narrowband channels. The limit for single-frequency interference is that the noise contribution at any frequency should, when measured with C-message weighting, be at least 3 dB below the C-message noise power limit at the receiver.

3.15. Frequency Shift

Most long haul carrier systems operate in a single sideband suppressed carrier mode. Because the carrier is not transmitted and must be reinserted, there may be a slight difference in frequency between the modulating and demodulating carrier frequencies. The resulting frequency shift contributes a constant change at all frequencies in the voiceband.

Substantial frequency shift can degrade some data demodulation processes and can cause high distortion in narrowband frequency division multiplex systems. The limit on frequency shift is ± 5 Hz.

3.16. Phase Intercept Distortion

When a single sideband suppressed carrier transmission system is used, the phase of the reinserted carrier with respect to the phase of the modulating carrier is not controlled. The result in phase intercept distortion, which contributes a constant phase shift to all frequencies present in the end-to-end signal. It appears as the phase intercept at zero frequency on a graph of phase versus frequency for carrier-derived channels. Phase intercept distortion will affect any signal in which preservation of the phase relationships in the transmitted waveshape is important. A modern designed to operate cover a channel having frequency shift should not experience difficulties due to phase intercept distortion. Since modems can be designed to circumvent phase intercept distortio by frequency translation of baseband signals and local demodulation of carrier from the received waveform, no limit on phase intercept distortion exists and none is contemplated.

3.17. Phase Jitter

Various sources cause the instandaneous phase, or zero crossings, of a signal to “jitter” at rates normally less than 300 Hz. This phase jitter is typically caused by ripple in the dc power supply appearing in the master oscillator of long haul carrier systems and then passing through many stages of frequency multipliers. Some phase jitter occurs in short haul systems from incomplete filtering of image sidebands. Digital carrier systems also will exhibit phase jitter at certain input frequencies.

The most common jitter frequencies are 20 Hz (ringing current) and 60 Hz (commercial power), and the second through fifth harmonics of each of these.

Measurement of phase jitter is made with an instrument sensitive to frequencies within 300 Hz of an approximately 1004 Hz carrier. Noise may strongly influence this measurement, so phase jitter should be measured with a test tone at nominal data signal level. The limit for phase jitter is 15° peak-to-peak.

3.18. Nonlinear Distortion

Nonlinear distortion is that portion of the channel output which is a nonlinear function of the channel input. It is measured by transmitting four equal level tones, consisting of two pairs of tones, with a composite signal power equal to the nominal data signal level. Two of these tones are closely spaced around a center frerquency “A” (860 Hz) and the other two tones are centered around a center frequency “B” (1380 Hz). The second order distortion is determined from the B-A and B+A products while the third oder distortion is determined from the 2B-A product. The signal to second order distortion ratio limit is 25 dB and the signal to third order distortion limit is 28 dB.

3.19. Gain Hits and Phase Hits

Gain hits and phase hits are defined to be sudden changes in the amplitude or phase of a signal lasting for at least 4 milliseconds and returning to the original value within 220 milliseconds. Changes in amplitude or phase which last for more than 220 milliseconds are referred to as gain or phase changes. Changes that last for less than 4 milliseconds are classified as impulse noise. Limits for gain hits and phase hits are not specified; however, objectives for these parameters are:

- gain hits: - no more than eight in 15 minutes ± 3 dB
- phase hits: - no more than eight in 15 minutes ± 20 degrees

3.20. Dropouts

A dropout is a decrease in level (≥ 18 dB) which lasts for at least 4 milliseconds. Deep fading of radio facilities and defective components can cause dropouts. Since dropouts tend to be long, with more than 40 precent in excess of 200 milliseconds, they frequently are responsible for serious performance degraditions. Limits for dropouts are not specified; however, the objective is no more than two dropouts in 15 minutes.

3.21. Nonlinear Distortion in PCM Systems

Current Telecommunications short-haul digital carrier systems use pulse code modulation (PCM). In these systems a band limited analog voiceband signal is sampled 8000 times per second. The resulting pulse amplitude modulated (PAM) signals are interleaved with others on a time-division basis. Finally, each PAM sample is encoded into a discrete binary PCM signal to be transmitted over a digital line.

Representing the message by a discrete and, therefore, limited number of signal amplitudes is called quantizing. Quantizing inherently introduces an initial error in the amplitude and phase of the samples, giving rise to quantizing noise. The signal is then compressed and encoded. At the far end the signal is decoded and expanded. Once it has been encoded it can be transmitted over a ine using regenerative repeaters with little or no additional degradation.

Signal processing in PCM systems can give rise to a unique form of nonlinear distortion which has no direct counterpart in analog systems. The PCM processes involved in producing this distortion are sampling, quantizing, and mistracking of the instantaneous compandors.

The sampling process produces upper and lower sidebands (sometimes called aliases) about the sampling frequency and is harmonics. If the input signal is not sufficiently band limited (to half the sampling frequency or less), the lower sideband about the sampling frequency will overlap the baseband spectrum. That portion of the lower sideband which extends down into the baseband is known as fold-over distortion. As an example of this phenomenon, consider an input signal with significant out-of-band power, say at 6000 Hz. The 6000 Hz component will appear in the lower sideband about the 8000 Hz sampling frequency at 2000 Hz (8000-6000), which is near the middle of the baseband spectrum. Thus, it is to the equipment designer's advantage to limit out-of-band power to an acceptable level (this is also required to meet the network protection criteria discussed in Section 3.1).

In addition to fold-over distortion, any nonlinearities encountered after sampling will create intermodulation products from the baseband signal and its aliass and the sampling frequency and its harmonics. The primary sources of nonlinearities after sampling are quantizing and companding. Some of the intermodulation products created by these nonlinearities may appear as tones or noise at baseband frequences. For example, suppose a 2700 Hz input tone is transmitted. Then an alias of this input occurs at 5300 Hz (8000-2700). A nonlinear process may then produce distortion at the difference frequency of 2700 Hz (5300-2700). Notice that the 2600 Hz output is close to the 2700 Hz input. When the input frequency is a rational fraction of the sampling frequency, many of the resulting inband tones may coincide. For the fraction of 1/2 (2666-2/3 Hz), all the products in the baseband occur at 2666-2/3 Hz.

Other input frequencies for which many tones build up at relatively few inband frequencies are listed in Table C, along with the corresponding distortion output frequencies.

Table C assumes the input frequencies are rational fractions of the 8000 Hz sampling rate. If the input frequencies drift with respect to the sampling rate, sudden rising or falling of energy at the output frequencies may be observed as the rational fraction relationship appears and disappears. Since the sampling rate will vary slightly, this phenomenon may occur within a very narrow band (less than ±1 Hz) around the input frequencies listed in Table C.

Input frequencies which are very close to those listed in Table C, but not an exact rational fraction of the sampling frequency, will produce sidebands close to the output frequencies listed. The result is a beating effect about the output frequencies (which include the input frequency) that can cause significant distortion.

To reduce the probability of encountering significant distortion, it is suggested that the end-to-end signaling avoid schemes which generate high signal levels (such as carriers) within a few Hertz of the input frequencies of Table C.

3.22. Propagation Delay

The propagation delay of the end-to-end connections is not controlled. In particular, connections through different facilities and to different locations may have considerably different propagation delays, but these delays are related somewhat to the physical distance between end points of the connection.

Table E gives an estimate of some round trip propagation delays that might be encountered. These delays should only be considered as guidelines.

Table A

	Cut Off	Frequency (-3dB point)
Set 1	400 Hz (L)*,	1300 Hz (H)*
Set 2	1370 Hz (L)*,	1650 Hz (High)*
Set 3	1300 Hz (L)*,	1925 Hz H (H)*
Set 4	1460 Hz (L)*,	1810 Hz (H)*

* (L) = Low Pass
* (H) = High Pass

The high or low pass filter, from the available sets may be used in either direction of Transmission. The filters of any set are physically and electrically interchangeable.

Table B

Maximum Transmitted Signal Power For Each of N Channels
Such That the Combined Power From All N Channels is 0 dBm
(Assumes Uncorrelated Signals in Channels)

No. Of Channels	Per Channel Maximum RMS Power - (dBm)	No. Of Channels	Per Channel Maximum RMS Power - (dBm)
1	0		
2	-3.0	12	-10.8
3	-4.8	13	-11.1
4	-6.0	14	-11.5
5	-7.0	15	-11.8
6	-7.8	16	-12.0
7	-8.5	17	-12.3
8	-9.0	18	-12.6
9	-9.5	19	-12.8
10	-10.0	20	-13.0
11	-10.4	100	-20.0

Above table computed using the formula indicated 10 LOG⑩ (# of tone(signal) sources).

Table C

Input Frequencies Having Inband Distortion
Building Up At Relatively
Few Output Frequencies (PCM Systems)

Input Frequency (Hz)	Distortion Output Frequencies (Hz)*
800	800, 1600, 2400, 3200
888 8/9	888 8/9, 1777 7.9. 2666 2/3
1000	1000, 2000, 3000
1142 6/7	1142 6/7, 2285 5/7, 3428 4/7
1333 1/3	1333 1/3, 2666 2/3
1600	1600, 3200
1777 7/9	888 8/9, 1777 7/9, 2666 2/3
2000	2000
2285 5/7	1142 6/7, 2285 5/7, 3428 4/7
2400	800, 1600, 2400, 3200
2666 2/3	2666 2/3
3000	1000, 2000, 3000
3200	1600, 3200
3428 4/8	1142 6/7, 2285 5/7, 3428 4/7

* 0 Hz and above 3500 Hz excluded

Table D

Summary of End-To-End Bandwidth and Facility Parameter Limits

1.	Attenuation Distortion (Reference 1004 Hz)		
	504-2804 Hz	-4 to +14 dB*	
2.	Envelope Delay Distortion		
	804-2604 Hz	1750 Microseconds*	
3.	1004 Hz Loss Variation		
	long term	±6 dB	
4.	C-Message Noise		
	at 4-wire station termination	46 dBrnC	
	at 2-wire station termination	32 dBrnC	
5.	C-Notched Noise		
	1004 Hz signal to C-notched noise ratio	24 dB	
6.	Impulse Noise threshold with respect to received 1004 Hz test tone power	maximum counts above threshold allowed in 15 minutes	
		-6 dB	30
		-2 dB	18
		+2 dB	10
7.	Single Frequency Interference	at least 3 dB below C-message noise limits	
8.	Frequency Shift	±5 Hz	
9.	Phase Jitter	15° peak to peak	
10.	Nonlinear Distortion Four Tone Measurement Method		
	signal to 2nd order	25 dB	
	signal to 3rd order	28 dB	
11.	Phase Hits (objective)		
	no. of hits 20° in 15 minutes	8	
12.	Gain Hits (objective)		
	no. of hits 3 dB in 15 minutes	3	
13.	Dropouts (objective)		
	no. of dropouts in 15 minutes	2	

* Excluding characteristics of the filters used for the Split Band Offering.

Table E

Two Way Propagation Times for Various Network Elements

FACILITY TYPE		DELAY MICRO SEC/MI.
Interoffice Digital Carrier		16.6
Digital/Analog Conversion*		740.0
Optical Fiber		16.8
Radio Path		10.6
Local Loop#	Non Loaded - .082 uf/mi	68.0
	Loaded - .082 uf/mi	166.0

* Typical "D4" Telco Equipment. Values for "D5" equipment used in the network may be Up to 1,980 micro seconds.

Local Loop refers to metallic wire pairs used to connect the Customer to their local Telephone Company serving office. Values given (.082 uf/mi) are for 22 gauge wire.

Any questions regarding this document, please contact the APEx Help Desk at 847-248-4328.