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# Interface and Performance Specifications for Digital Video Transport Service at the DS3 Rate

Technical Reference

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# INTERFACE AND PERFORMANCE SPECIFICATIONS FOR DIGITAL VIDEO TRANSPORT SERVICE AT THE DS3 RATE

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# INTERFACE AND PERFORMANCE SPECIFICATIONS FOR DIGITAL VIDEO TRANSPORT SERVICE AT THE DS3 RATE

## 1. Introduction

### 1.1 General

This document provides interface and performance specifications for the encoding and transport of System M−NTSC video signals at the DS3 rate. This service is offered by BellSouth to Interexchange Carriers (ICs) and End Users (EUs) for both interLATA access and for point−to−point service within a LATA. For interLATA access, BellSouth provides the digital facilities from the EU's Network Interface (NI) within the LATA to the IC's point of termination (POT). For intraLATA service, BellSouth provides facilities end to end.

**Except where noted herein,** this service supports video signal performance within the objective limits of BellSouth's Commercial Quality (TV3) Video Service. The delivered video signal is expected to be visually comparable to Broadcast Quality (TV1) video, but with less stringent objective criteria. Traditional analog measurements will either underestimate or overestimate the relative picture quality delivered by this system. Subjective evaluation of picture quality is the suggested method of picture evaluation for compressed video.

This BellSouth Technical Reference supplements BellSouth private line video service capabilities as described in BellSouth Technical Reference TR 73557, Issue C, March 1994. It offers modifications where necessary, and adds specifications appropriate to a digital interface.

### 1.2 Purpose

This document provides the interface specifications and transport requirements for private line video signals compressed into a 44.736 Mbit/sec (DS3) signal transmitted over various digital transmission facilities in the BellSouth Region. The video compression is accomplished by a coder. Signal decompression and restoral of analog is accomplished by a decoder. The requirements provided herein will insure interoperability of video coders/decoders in the BellSouth Network.

### 1.3 Applicability of Coding Specifications

**It should be noted that parts of the described coding/decoding system are the intellectual property of Northern Telecom. It is not necessary that other manufacturers adopt the described processes exactly if other approaches will yield compatible devices. Where necessary, however, Northern Telecom has agreed to license its technology under reasonable terms and conditions. <u>The securing of this and any other Intellectual Property Rights shall be the sole responsibility of the user.</u> Prospective manufacturers of codecs designed to these requirements are directed to Northern Telecom for details.**

## 2. Service Description

Private Line Video Services (TV3) are full or part time channels used exclusively for transmission of standard format video and associated audio signals within a LATA. The Private Line Video Services described herein accommodate System M–NTSC video signals and up to four associated audio signals per video signal. Transport will be via digital techniques over a mix of basic facilities. These services may be provided between an End User (EU) and an Interexchange Carrier (IC), or between two End Users (EU) within the same LATA.

This service provides digital transport of private line video signals at the DS3 rate. Two one–way services may be combined to provide two–way, fully interactive video services. These services may be terminated in a BellSouth DS3 Digital Cross–Connect System (DCS) to provide hubbing arrangements.

The service has two options for channel terminations. One channel termination option provides an analog video and audio interface. The other channel termination option provides a digital interface. Each DS3 digital video circuit requires at least one analog interface. With an analog interface, video coding and/or decoding will be performed by BellSouth. With a digital interface, such coding/decoding must be performed by the customer.

## 3. Video Codec Overview

Hardware used to convert an analog video signal into a recoverable digital equivalent are known as video coders. The simplest such devices sample the analog video signal at a rate high enough to recover the highest frequency information it is designed to transmit, and directly encode each sample according to an agreed upon plan. A pulse code modulation (PCM) coder might sample the analog video signal at 14.32 MHz ($4f_{SC}$ = 4 times sub–carrier frequency of 3.58 MHz). The samples must be quantized with 9 bit accuracy. The compatible video decoder would reverse this process to restore the original analog signal.

The information rate of the above uncompressed PCM coding system is 128.88 Mbps (14.32 MHz times 9–bits/sample). Adding system overhead yields a transport rate of approximately 140 Mbps. Although such a system can deliver excellent television quality, this bandwidth is not required for non–broadcast quality video and is currently expensive to transport on BST's digital network. Some signal compression is therefore desirable.

Recent advances in video and audio signal processing have made it possible to provide picture quality visually comparable to analog broadcast standards through coders/decoders (codecs) operating at rates as low as DS3. Although these codecs use a multiplicity of techniques to eliminate redundant information, most depend upon either discrete cosine transform (DCT) or differential pulse code modulation (DPCM) for their primary processes. This service is based on a unique form of DPCM encoding.

The basic architecture for coding and decoding is presented in Figure 1. In this architecture, the analog video input at the coder must correspond to the EIA RS–170–A for M–NTSC interlace system. This analog signal is filtered, clamped and sampled per Section 4.1 of this Document. The sampling is at 4 times the sub–carrier frequency to generate an orthogonal signal quantized with 9–bit PCM in the pre–processing stage of the coder. The orthogonal signal is subsampled at two times the sub−carrier frequency using a field quincunx (QT) pattern and the QT signal is encoded using a predictive 6−bit DPCM technique with channel adaptation to compensate for transmission errors. Active video information not transmitted as a result of the subsampling process is restored through interpolation techniques. As an aid to interpolation, a correction signal is derived and encoded into a serial block quantization signal.

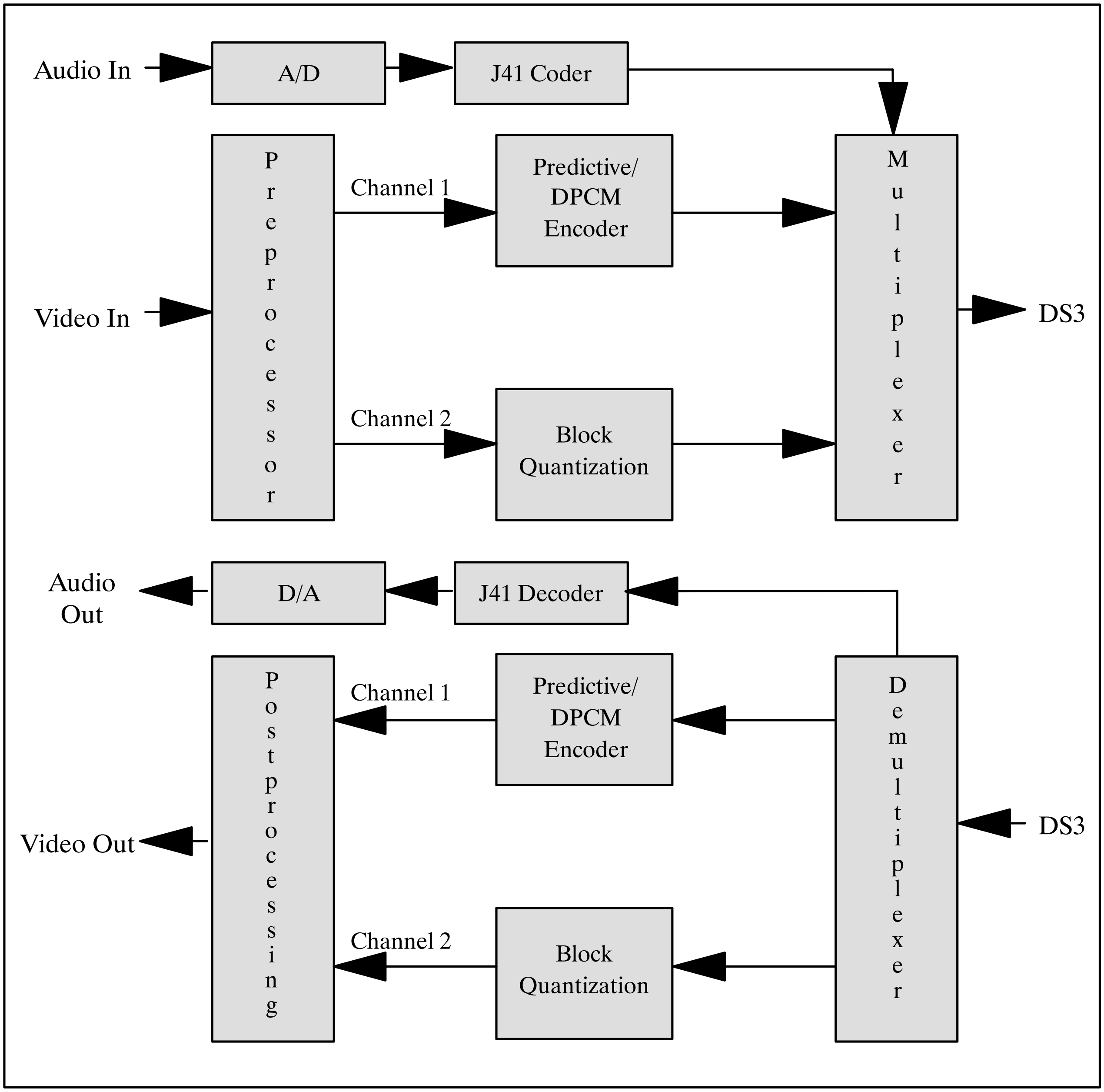



**Figure 1 − Two Channel Architecture for Coding of Video Signals**

The coding of the audio signals is accomplished in compliance with CCITT Recommendation J41. For each companded audio word (11 bit), a parity bit is included for error detection. Up to 4 audio signals are combined together to generate a DS1 signal. The generation of the DS1 signal is fully described in Bellcore Technical Reference, TR−TSY−000431, **15kHz Digital Audio Terminal for Program or Television − Requirements and Objectives**, Issue 1, October 1987 and CCITT Recommendation J41, **Characteristics of Equipments for Coding Analogue Sound Programme Signals**, 1984. This DS1 signal is converted into 6−bit words for multiplexing. This 6−bit DS1 signal is also buffered and delayed to ensure lip sync with the video.

The 6−bit audio words and the 6−bit DPCM words described above are multiplexed together as shown in Figure 1 with framing information using one of four possible time slot formats described in Section 6 of this document. The 6−bit time slot information stream is combined to the serial block quantization channel to create a 7−bit stream. The 7−bit stream is fed to a scrambler to provide immunity against transmission errors and multiplexed with a M2−3 multiplexer in such a way that the bit which carries the serial block quantization channel is mapped to DS2 group 1 of the M2−3 mux, while the combined audio/video 6−bit time slot will be mapped to DS2 groups 2 to 7.

## 4. Video Signal Processing

### 4.1 Analog Video Interface to Digital Mapping

#### 4.1.1 Analog Video Input/Output

The analog video input (at the coder) and output (at the decoder) shall comply to the EIA RS−170−A, **Electrical Performance Standards − Color Television Studio Facilities**, November 1977 for the M−NTSC video signal.

#### 4.1.2 Low Pass Filtering

The analog video input shall be filtered prior to digitization to remove high frequencies that might cause aliasing during the A/D process. A typical filter might have the following characteristics:

| | |
|---|---|
| Passband: | 4.2 MHz |
| Stopband: | > 45 dB from 6 MHz to 100 MHz |

At the receiver an equivalent filter with sin(x)/x compensation is desirable after the D/A conversion.

#### 4.1.3 Sampling Parameters

The basic sampling parameters of the analog video shall be as follows:

| | |
|---|---|
| Sampling Frequency: | $4f_{SC}$ (14.32 MHz) |
| Sampling Structure: | Orthogonal |
| Sampling Phase: | Locked to the burst at $0^0$ phase |

| | |
|---|---|
| Number of Samples per line | 910 |
| Number of Samples per active line | 758 (centered in the active video area) |
| Number of Samples in the Horizontal Blanking Interval (HBI) | 152 |

### 4.1.4 Analog to Digital Conversion

The relationship between video signal levels (nominal values) and the 9 bit quantization levels shall be as follows:

| | | |
|---|---|---|
| Sync level (−40 IRE) | – | 8 |
| Blanking level (0 IRE) | – | 120 |
| White level (100 IRE) | – | 400 |

Other levels may be obtained by using the following equation:

9−bit level = 2.8 x IRE level + 120

### 4.1.5 Time−Stamp Bit Generation

The time−stamp bit shall be generated at the coder for accurate clock recovery at the receiver. A counter shall count every $2f_{SC}$ (2 times 3.58 MHz) clock pulse. Whenever the count starts at 0 and reaches 454, another free−running counter clocked at half of the DS3 clock rate shall be reset. At the moment when the half−DS3 counter is reset, the negation of the LSB of this counter shall be the time−stamp bit (i.e., if the count = 1420, the time stamp bit shall be represented by 1. If the count = 1421, it will be a 0). Bit 2 of the very last word of every line shall be used to convey this bit information as shown in Figure 11. The repetition rate of this time−stamp bit is the video line rate (about 15.734 kHz).

## 4.2 Video Pre−Processing

### 4.2.1 Video Segmentation

The coding algorithm shall compress the video information by segmenting the signal into the following components which have different characteristics:

(1) The active video (758 pixels/line, lines 22 to 262 in the first field and lines 285 to 525 in the second field) where one can assume temporal and spatial correlation;

(2) The horizontal blanking interval (HBI),(152 pixels/line, lines 10 to 262 in the first field and lines 273 to 525 in the second field) which is easily predictable;

(3) The pre−equalizing pulses, serration pulses, and post−equalizing pulses (910 pixels/line, lines 1 to 9 in the first field and lines 264 to 272 in the second field) which are deterministic;

(4) VITS, Teletext and the like (758 pixels/line, lines 10 to 21 in the first field and lines 273 to 284 in the second field) where only horizontal correlation can be assumed.

### 4.2.2 QT Subsampling

The video signal shall be 2:1 horizontal subsampled by using a field quincunx (QT) pattern. The subsampled pattern, as shown in Figure 2, takes place by keeping every other pel.

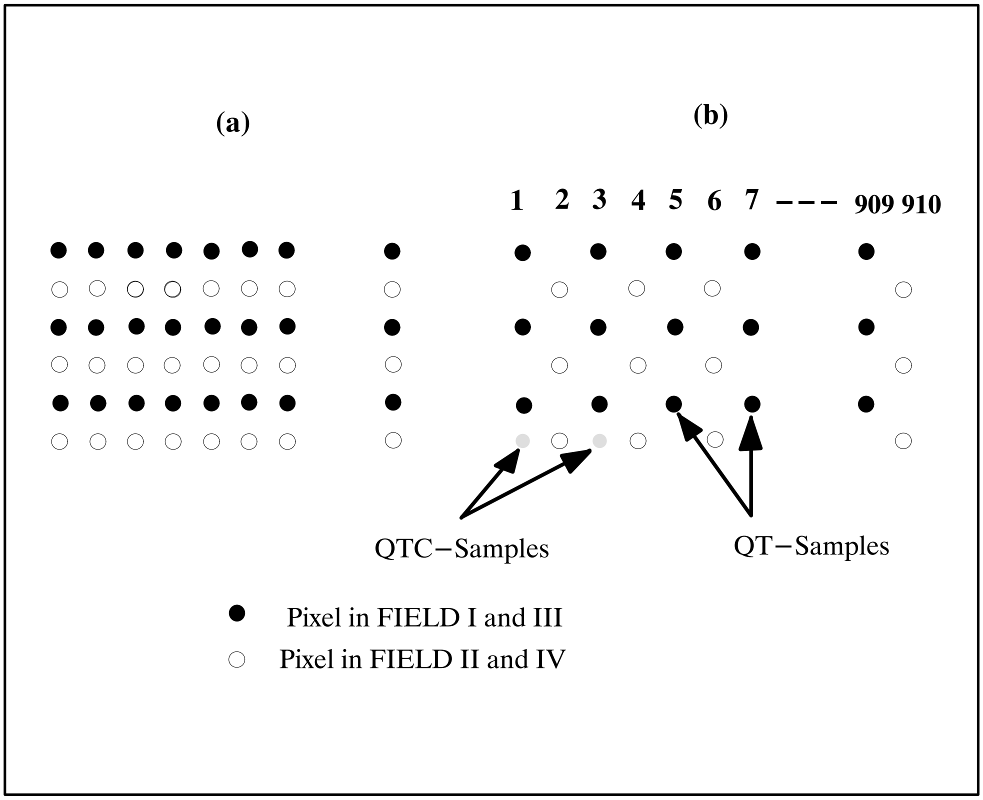



**Figure 2 − Subsampling Pattern**

Within a field, the pels kept by the decimator are vertically aligned, producing an orthogonal pattern. From field to field, the sampling phase is offset by one pel; thus, the pels kept in one field are aligned with the pels discarded in the previous and following fields. The subsampling phase changes from field to field, generating a field quincunx pattern. The odd pels (1,3,5,...,909) of each line are kept in fields I and III while the even pels (2,4,6,...,910) of each line are kept in fields II and IV. Two $2f_{SC}$ streams are generated by the 2:1 subsampling. The first stream is QT information (pels transmitted in the given field) and the second stream is the QT complimentary (QTC) information (pels discarded).

### 4.3 Video Coding Algorithm

The digitized NTSC composite video signals shall be processed to reduce the bit rate by using a two−channel coding architecture. The architecture for coding the active video segments is shown in Figure 3.

### 4.3.1 First Channel Encoding

#### 4.3.1.1 Coding of Lines 1 to 9 and of the Horizontal Blanking Interval (HBI)

**(1) Equalizing and Serration Pulses**

The equalizing pulses (lines 1,2,3,7,8,9 in field I or III, and corresponding lines in field II or IV) as well as the serration pulses (lines 4,5,6 in field I or III, and the corresponding lines in field II or IV) are processed in the following way and shown in Table 4.1. One line of equalizing pulses and one line of serration pulses is sent per field. In field I or III, one equalizing pulse line shall be sent during time slot 1, while one serration pulse line is sent during time slot 4. In field II or IV, one equalizing pulse line is sent during the second half of time slot 263 and first half of time slot 264, while one serration pulse line is sent during the second half of time slot 266 and first half of time slot 267.

Only the QT information (455 pels) of the equalizing and serration pulses is transmitted. The QT information is encoded 6 bit PCM with a quality equivalent to 7 bit PCM by dropping the 2 lsb's (least significant bit) and the msb (msb is never active during these intervals) from the 9 bit PCM signal.

**(2) Horizontal Blanking Interval (HBI)**

To render the compression algorithm more efficient, the horizontal blanking intervals (HBI) shall be transmitted a limited number of times per field. The QT information corresponding to the HBI shall be represented by 76 pels. The QT information shall be encoded 6 bit PCM with a quality equivalent to 7 bit PCM by dropping the 2 lsb's and the msb from the 9 bit PCM signal. In addition to line 1, 4 (and the corresponding lines in the other fields) where the HBI shall be transmitted as part of the serration and equalizing pulses, the HBI is always transmitted for lines 10, 11 and the corresponding lines in the other fields as these lines are the two first HBI of the field that contain the two phases of the color burst. Other HBI's shall be transmitted to regularize the buffer content.

#### 4.3.1.2 Coding of the Active Lines and of Lines 10 to 21

The 379 QT pixels representing the Vertical Blanking Interval (VBI) and active video information (lines 10 to 262 and the equivalent lines in the following fields) are coded in 6−bit DPCM mode incorporating circuitry for transmission of error mitigation. The block diagram is shown in Figure 3 for coding of the active lines and in Figure 7 for coding of lines 10 to 21. As it can be seen, the first channel coding is equivalent for these two picture segments. The DPCM predictor is the fourth previous reconstructed pel (when the signal is sampled at $4f_{SC}$). The DPCM Prediction errors are non−uniformly quantized with 6 bits using Table 4.2. Only the positive halves are tabulated. The negative halves are the mirror images of the corresponding positive ones and are represented in 2's complement format. For robustness against transmission errors, a reset is done at the beginning of each active line by setting to "128" the prediction value of the two first samples of the line to be DPCM encoded.

Table 4.1: Relationship Between the Video Lines and the Time Slots

| Time Slot | Flag Code | Coding | Data | Line No. | Reconstruction of (QTC) Pels |
|---|---|---|---|---|---|
| 1 | SOF | 7–bit PCM quality | QT | equalizing pulses | QTC restored from past information |
| 2 | X | 6–bit PCM | QTC | 273 to 284 | ... |
| 3 | X | 6–bit PCM | QTC | 273 to 284 | ... |
| 4 | SYNC | 7–bit PCM Quality | QT | serration pulses | QTC restored from past information |
| 5 | X | 6–bit PCM | QTC | 273 to 284 | ... |
| ... | ... | ... | ... | ... | ... |
| 9 | X | 6–bit PCM | QTC | 273 to 284 | ... |
| 10 | SYNC | 6–bit DPCM | QT | 10 | QTC info transmitted in time slots 264SH to 266FH, 267SH to 272FH |
| 11 | SYNC | 6–bit DPCM | QT | 11 | QTC info transmitted in time slots 264SH to 266FH, 267SH to 272FH |
| 12 | X | 6–bit DPCM | QT | 12 | QTC info transmitted in time slots 264SH to 266FH, 267SH to 272FH |
| ... | ... | ... | ... | ... | ... |
| 21 | X | 6–bit DPCM | QT | 21 | QTC info transmitted in time slots 264SH to 266FH, 267SH to 272FH |
| 22 | X | 6–bit DPCM | QT | 22 | 3–D Interpolation filter |
| 23 | X | 6–bit DPCM | QT | 23 | 3–D Interpolation filter plus second channel |
| ... | ... | ... | ... | ... | ... |
| 262 | X | 6–bit DPCM | QT | 262 | 3–D Interpolation filter plus second channel |
| 263 | X | 6–bit DPCM | QT | 263FH | 3–D Interpolation filter |
| | – | 7–bit PCM quality | QT | equalizing pulses | QTC restored from past information |
| 264 | SYNC | | QT | equalizing pulses | |
| | | 6–bit PCM | QTC | 10 to 21 | ... |
| 265 | X | | | 10 to 21 | |
| | | 6–bit PCM | QTC | 10 to 21 | ... |
| 266 | X | | | 10 to 21 | |
| | | 7–bit PCM quality | QT | 10 to 21 | QTC restored from past information |
| 267 | SYNC | | QT | 10 to 21 | |
| | | 6–bit PCM | QTC | 10 to 21 | ... |
| 268 | X | | | 10 to 21 | |
| | | 6–bit PCM | QTC | 10 to 21 | ... |
| 269 | X | | | 10 to 21 | |
| | | 6–bit PCM | QTC | 10 to 21 | ... |
| 270 | X | | | 10 to 21 | |
| | | 6–bit PCM | QTC | 10 to 21 | ... |
| 271 | X | | | 10 to 21 | |
| | | 6–bit PCM | QTC | 10 to 21 | ... |
| 272 | X | | | 10 to 21 | |
| | | 7–bit PCM quality | QT | 272SH | Copy of QT samples |
| 273 | SYNC | 6–bit DPCM | QT | 273 | QTC info transmitted in time slots 2,3,5,6,7,8,9 of next frame |
| 274 | SYNC | 6–bit DPCM | QT | 274 | QTC info transmitted in time slots 2,3,5,6,7,8,9 of next frame |
| 275 | X | 6–bit DPCM | QT | 275 | QTC info transmitted in time slots 2,3,5,6,7,8,9 of next frame |
| ... | ... | ... | ... | ... | ... |
| 284 | X | 6–bit DPCM | QT | 284 | QTC info transmitted in time slots 2,3,5,6,7,8,9 of next frame |
| 285 | X | 6–bit DPCM | QT | 285 | 3–D Interpolation filter plus second channel |
| ... | ... | ... | ... | ... | ... |
| 525 | X | 6–bit DPCM | QT | 525 | 3–D Interpolation filter plus second channel |

**Note: X = SYNC, VIDAUX or VIDEO formats per the selection rules defined in Section 6.2.**

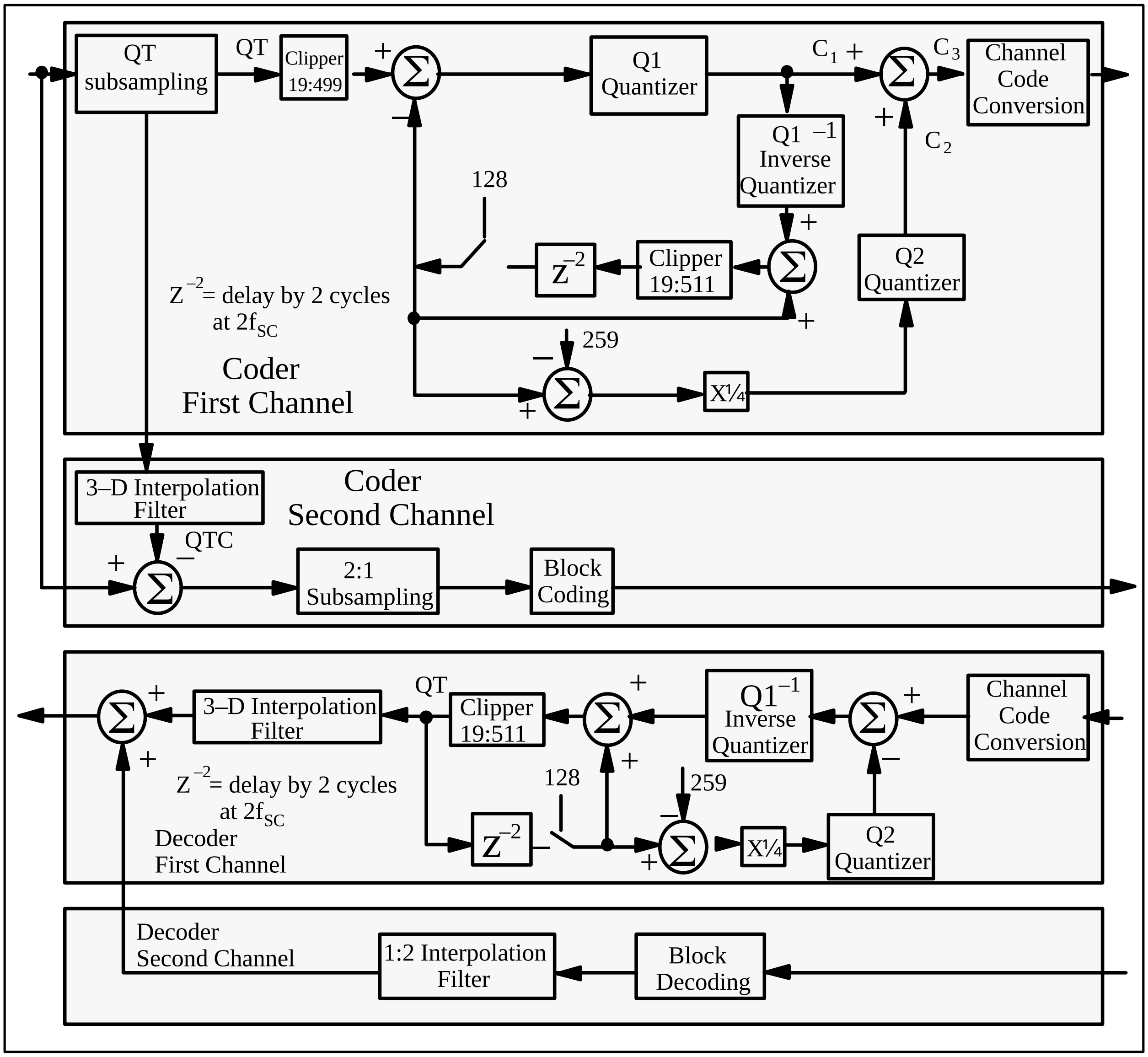



**Figure 3 − Details of the Video Coding Algorithm for Active Video Segments**

The second loop adds another channel code $C_2$ (Table 4.3) to $C_1$. The Q1 and Q2 Tables are designed such as the summation of $C_1$ and $C_2$ is also included between −31 and +31. The design of Tables Q1 and Q2 also assume that the input signal is clipped between levels 9 and 499 and the prediction signal is clipped between the levels 19 and 511. If the system works in an error free environment, the second loop has no effect. If transmission errors occur, the effect is that the error will decay and will be invisible after a few pels.

Table 4.2: Q1 Table (Channel Code and Representative Value)

| Input Range of Prediction Error From | To | 6–bit Channel Code ($C_1$) | Representative Value of Prediction Error |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 |
| 2 | 2 | 2 | 2 |
| 3 | 4 | 3 | 3 |
| 5 | 6 | 4 | 5 |
| 7 | 8 | 5 | 7 |
| 9 | 11 | 6 | 10 |
| 12 | 14 | 7 | 13 |
| 15 | 18 | 8 | 16 |
| 19 | 22 | 9 | 20 |
| 23 | 27 | 10 | 25 |
| 28 | 32 | 11 | 30 |
| 33 | 38 | 12 | 35 |
| 39 | 44 | 13 | 41 |
| 45 | 51 | 14 | 48 |
| 52 | 59 | 15 | 55 |
| 60 | 67 | 16 | 63 |
| 68 | 77 | 17 | 72 |
| 78 | 87 | 18 | 82 |
| 88 | 98 | 19 | 93 |
| 99 | 110 | 20 | 104 |
| 111 | 123 | 21 | 117 |
| 124 | 137 | 22 | 130 |
| 138 | 153 | 23 | 145 |
| 154 | 169 | 24 | 161 |
| 170 | 187 | 25 | 178 |
| 188 | 206 | 26 | 196 |
| 207 | 226 | 27 | 216 |
| 207 | 226 | 27 | 216 |
| 227 | 248 | 28 | 237 |
| 249 | 272 | 29 | 260 |
| 273 | 298 | 30 | 285 |
| 299 | 511 | 31 | 311 |

**NOTE:** **Only the positive half is listed. The negative half is identical to the positive half except for the sign**

Table 4.3: Q2 Table (Channel Code)

| Input Range of Prediction Value From | To | 6–bit Channel Code ($C_2$) |
|---|---|---|
| 0 | 0 | 0 |
| 1 | 3 | 1 |
| 4 | 6 | 2 |
| 7 | 9 | 3 |
| 10 | 12 | 4 |
| 13 | 15 | 5 |
| 16 | 18 | 6 |
| 19 | 21 | 7 |
| 22 | 25 | 8 |
| 26 | 29 | 9 |
| 30 | 32 | 10 |
| 33 | 35 | 11 |
| 36 | 38 | 12 |
| 39 | 40 | 13 |
| 41 | 43 | 14 |
| 44 | 45 | 15 |
| 46 | 47 | 16 |
| 48 | 48 | 17 |
| 49 | 50 | 18 |
| 51 | 51 | 19 |
| 52 | 53 | 20 |
| 54 | 54 | 21 |
| 55 | 55 | 22 |
| 56 | 56 | 23 |
| 57 | 57 | 24 |
| 58 | 58 | 26 |
| 59 | 59 | 28 |
| 60 | 63 | 31 |

**NOTE: Only the positive half is listed. The negative half is identical to the positive half except for the sign.**

The channel code “$C_3$” (i.e., the summation of $C_1$ and $C_2$) might emulate the flag−sign value (hexadecimal value “3F”) during the coding of the video information. To reduce the possibility of this emulation occurring, all channel codes with a sign bit set will have their amplitude bits inverted at the coder. Since the channel code “−32” (100000 in two’s complement) is not existent in the DPCM error concealment loop, the channel code conversion will not create code “111111”.

At the decoder the inverse process is performed. To recover the $4f_{SC}$ from the QT pels a 3D interpolation filter must be used. The impulse response of a suitable digital filter is represented by the following Matrix:

$$\frac{1}{16}\begin{bmatrix} 0 & -2 & 0 & 4 & 0 & -2 & 0 \\ 1 & 0 & 7 & 16 & 7 & 0 & 1 \\ 0 & -2 & 0 & 4 & 0 & -2 & 0 \end{bmatrix}$$

The filter is equivalent to a 2−D filter operating in the 45° plane with respect to the vertical−temporal plane. The first row of the filter coefficients in the matrix is applied to the 262nd previous line, the second row is applied to the current video line, and the last row is applied to the 262nd following line as shown in Figure 4:

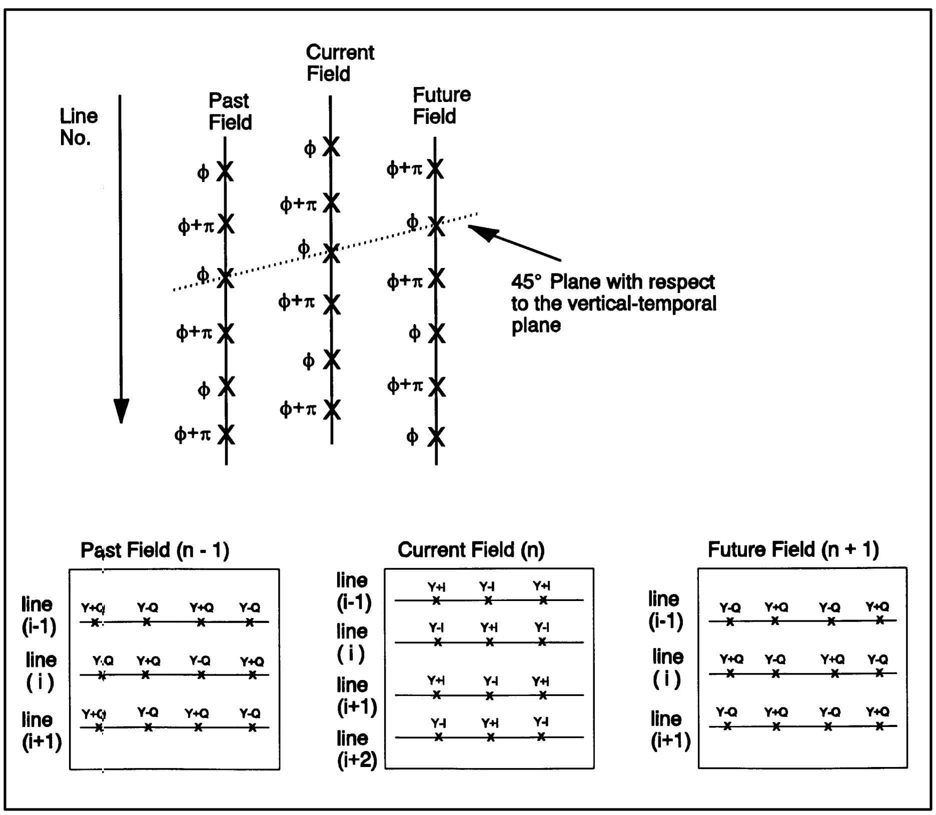



**Figure 4 − Region of Operation for the 3−D Interpolation Filter**

### 4.3.2 Second Channel Coding

#### 4.3.2.1 Coding of the Active Video Lines

At the coder, the 379 QTC samples of the active video line are recovered using a 3−D interpolation filter (Figure 3). A correction signal is then generated by subtracting the reconstructed QTC pels from the original pels. The use of a high−order interpolation filter to reconstruct the QTC samples limits the bandwidth of the correction signal to the 3 − 4.2 MHz band. For this reason, the correction signal is 2:1 subsampled, resulting in a $1f_{SC}$ subsampled QTC error signal of 180 samples per line as shown in Figure 5. These 180 samples of this $1f_{SC}$ signal are then block encoded.

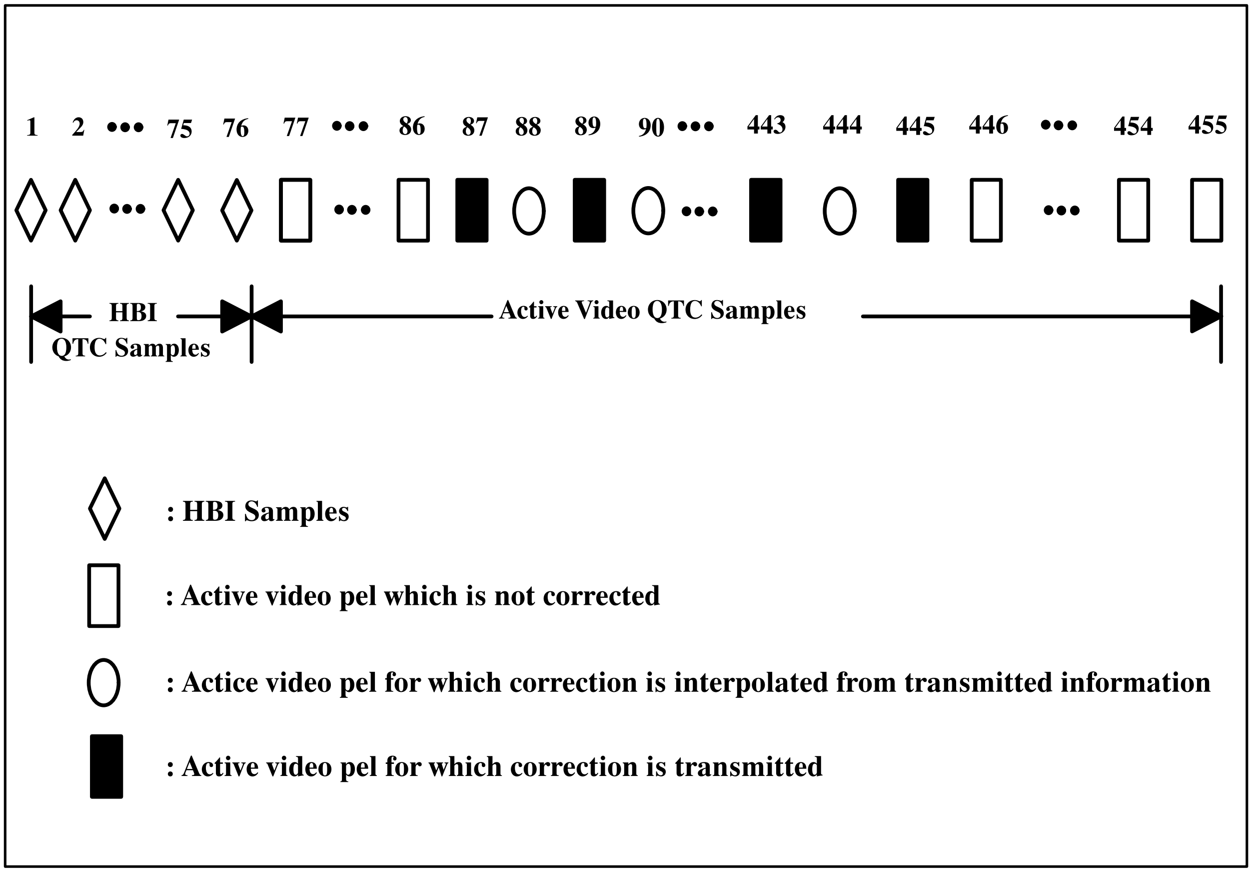



**Figure 5 − Pels Coded by the Block Encoding Technique**

The adaptive block coding technique uses the structure depicted in Figure 6. The 180 transmitted QTC samples are divided in 20 blocks of 9 errors each. Each block of 9 errors is coded into 4 words of 5 bits each for a total of 20 bits/block. The fourth word represents the amplitude of the block correction by a value "a" while the 3 other words represent the signs (i.e. −, 0, +) of the incremental errors, taken 3 at a time. The associated sign configuration is depicted in Table 4.4. The bits come in with the MSB first, so that "b0" is the MSB of Word 1 and "b4" its LSB. Correction starts on line number 23 in the odd fields (I and III) and on line number 285 in the even fields (II and IV).

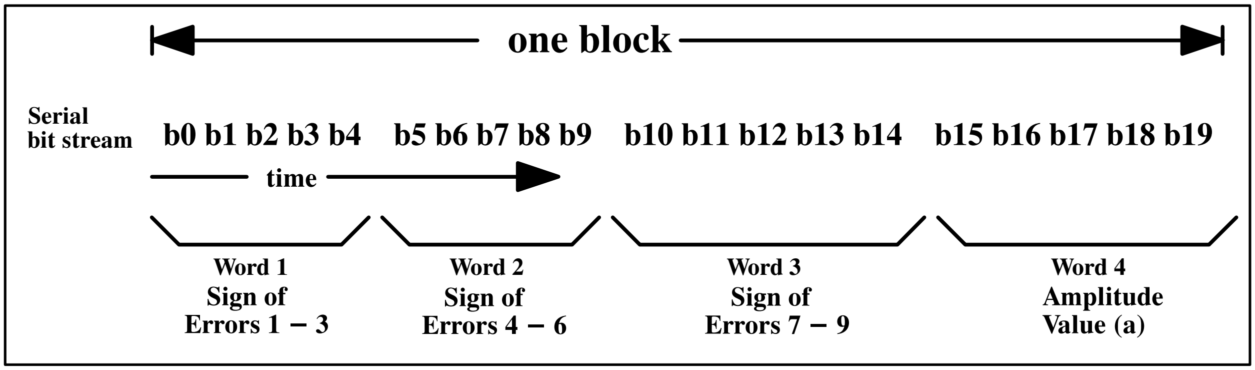



**Figure 6 − Block Coding Technique**

Table 4.4: Sign Table

| First Sign | Second Sign | Third Sign | 5 Bits Sign Channel Side Data |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 0 | + | 1 |
| 0 | 0 | – | 2 |
| 0 | + | 0 | 3 |
| 0 | + | + | 4 |
| 0 | + | – | 5 |
| 0 | – | 0 | 6 |
| 0 | – | + | 7 |
| 0 | – | – | 8 |
| + | 0 | 0 | 9 |
| + | 0 | + | 10 |
| + | 0 | – | 11 |
| + | + | 0 | 12 |
| + | + | + | 13 |
| + | + | – | 14 |
| + | – | 0 | 15 |
| + | – | + | 16 |
| + | – | – | 17 |
| – | 0 | 0 | 18 |
| – | 0 | + | 19 |
| – | 0 | – | 20 |
| – | + | 0 | 21 |
| – | + | + | 22 |
| – | + | – | 23 |
| – | – | 0 | 24 |
| – | – | + | 25 |
| – | – | – | 26 |

Each block is encoded with an adaptive three−level quantization (levels +a, 0, −a). A different value of (a) is chosen for each block to minimize the maximum absolute error over the block of interpolation errors and the value (a) is non−uniformly coded with five bits.

An example of the quantization method is given by the following:

$$\hat{e} = \begin{bmatrix} 0 & \text{if} & |e| & < & T \\ a & \text{if} & e & \geq & T \\ -a & \text{if} & e & \leq & -T \end{bmatrix}$$

where the goal is to minimize the maximum absolute error given by the following equation:

$$\max_{i \varepsilon [1,9]} |e_i - \hat{e}_i|$$

An example of the quantization value (a) may be determined by the following method:

$$L = \max_{i \varepsilon [1,9]} |e_i|$$

In this example, the threshold “T” is defined as:

$$T = \min_{|e_i| > L/3} |e_i|_{i \varepsilon [1,9]}$$

and the representative value (a) is equal to the quantized value of (L + T)/2 using Table 4.5. For example, if the block of errors $e_i$ is:

$$\{-5,7,-4,-5,-9,1,0,5,-2\}$$

Then,

$$L = 9$$
$$L/3 = 3$$
$$T = 4$$
$$a = \text{Table } 4.5 \left[ \frac{L+T}{2} \right]$$
$$a = 8$$

Therefore, for the previous example, the representative values $\hat{e}_i$ for the block of errors are:

$$\{-8,8,-8,-8,-8,0,0,8,0\}$$

and the resulting errors ($e_i - \hat{e}_i$) are:

$$\{3,-1,4,3,-1,1,0,-3,-2\}$$

Table 4.5: Five Bit Quantizer for the Representative Value (a)

| Error (9 Bits) | Code (5 Bits) | Quantized Representative Value (a) | Error (9 Bits) | Code (5 Bits) | Quantized Representative Value (a) |
|---|---|---|---|---|---|
| 0 – 5 | 0 | 4 | 88 – 95 | 16 | 92 |
| 6 – 9 | 1 | 8 | 96 – 103 | 17 | 100 |
| 10 – 13 | 2 | 12 | 104 – 111 | 18 | 108 |
| 14 – 17 | 3 | 16 | 112 – 121 | 19 | 116 |
| 18 – 21 | 4 | 20 | 122 – 131 | 20 | 126 |
| 22 – 25 | 5 | 24 | 132 – 141 | 21 | 136 |
| 26 – 29 | 6 | 28 | 142 – 151 | 22 | 146 |
| 30 – 35 | 7 | 32 | 152 – 161 | 23 | 156 |
| 36 – 41 | 8 | 38 | 162 – 171 | 24 | 166 |
| 42 – 47 | 9 | 44 | 172 – 181 | 25 | 176 |
| 48 – 53 | 10 | 50 | 182 – 193 | 26 | 188 |
| 54 – 59 | 11 | 56 | 194 – 205 | 27 | 200 |
| 60 – 65 | 12 | 62 | 206 – 217 | 28 | 212 |
| 66 – 71 | 13 | 68 | 218 – 229 | 29 | 224 |
| 72 – 79 | 14 | 76 | 230 – 241 | 30 | 236 |
| 80 – 87 | 15 | 84 | 242 – 511 | 31 | 248 |

At the decoder, the inverse process of the encoder is performed. The error signal is decoded and interpolated to regenerate the QTC signal at $2f_{SC}$. An example of a high−pass interpolation filter at the decoder to regenerate the missing pels is shown in the following equation.

$$h(n) = \frac{1}{8}[1, 0, -5, 8, -5, 0, 1]$$

The second channel is then combined to the first channel as shown in Figure 3 to create the high quality video signal.

#### 4.3.2.2 Coding of Lines 10 to 21

Detail of the video coding algorithm for lines 10 to 21 is presented in the Block Diagram of Figure 7. The first channel encoding is identical to the coding of the active video shown in Figure 3. However, the second channel coding in this figure is different from that shown in Figure 3 because it takes into consideration the correlation in the Vertical Blanking Interval (VBI) segment.

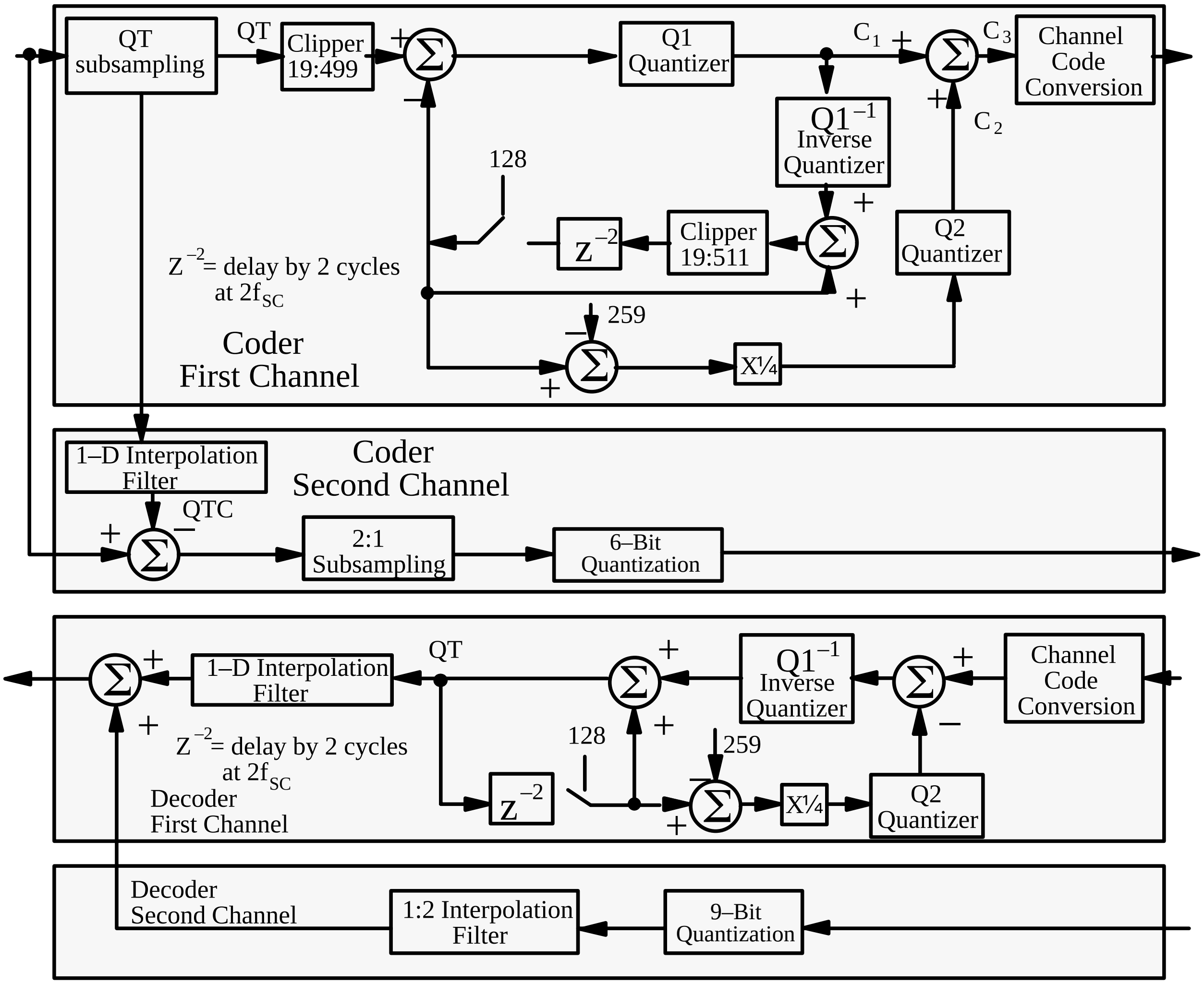



**Figure 7 − Details of the Coding Algorithm for Lines 10 to 21**

At the coder, the QT pels are filtered with a low pass interpolation filter such as one shown below to recover the 0 to 3 MHz band of the QTC pixels:

$$H(z) = -\frac{1}{64}z^{-7} + \frac{1}{16}z^{-5} - \frac{11}{64}z^{-3} + \frac{5}{8}z^{-1} + 1 + \frac{5}{8}z^{1} - \frac{11}{64}z^{3} + \frac{1}{16}z^{5} - \frac{1}{64}z^{7}$$

The reconstructed QTC pels are then subtracted from the original QTC pels and the resulting signal, which has energy in the higher frequency band (3 MHz and above), is rounded to the nearest 6−bit level (2's complement). The six−bit signal is then 2:1 subsampled resulting in a stream with 196 pels. Figure 8 presents the 196 QTC pels which are transmitted. This Figure shows additional pels transmitted at the edges of the block to eliminate the edge effect that would have been produced by the interpolation filter.

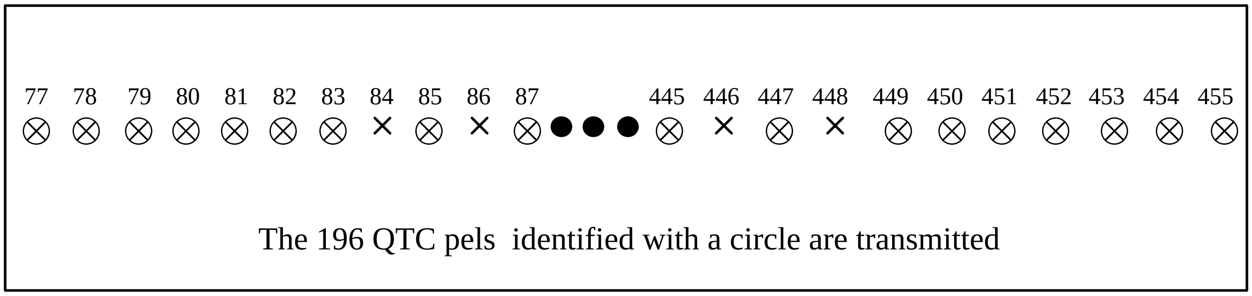



**Figure 8 − QTC Pels Encoded for Lines 10 to 21 (second channel)**

The 196 QTC pels for lines 10 to 21 are the carried in time−slots 2, 3, 5, 6, 7, 8 and 9 per Figure 9:

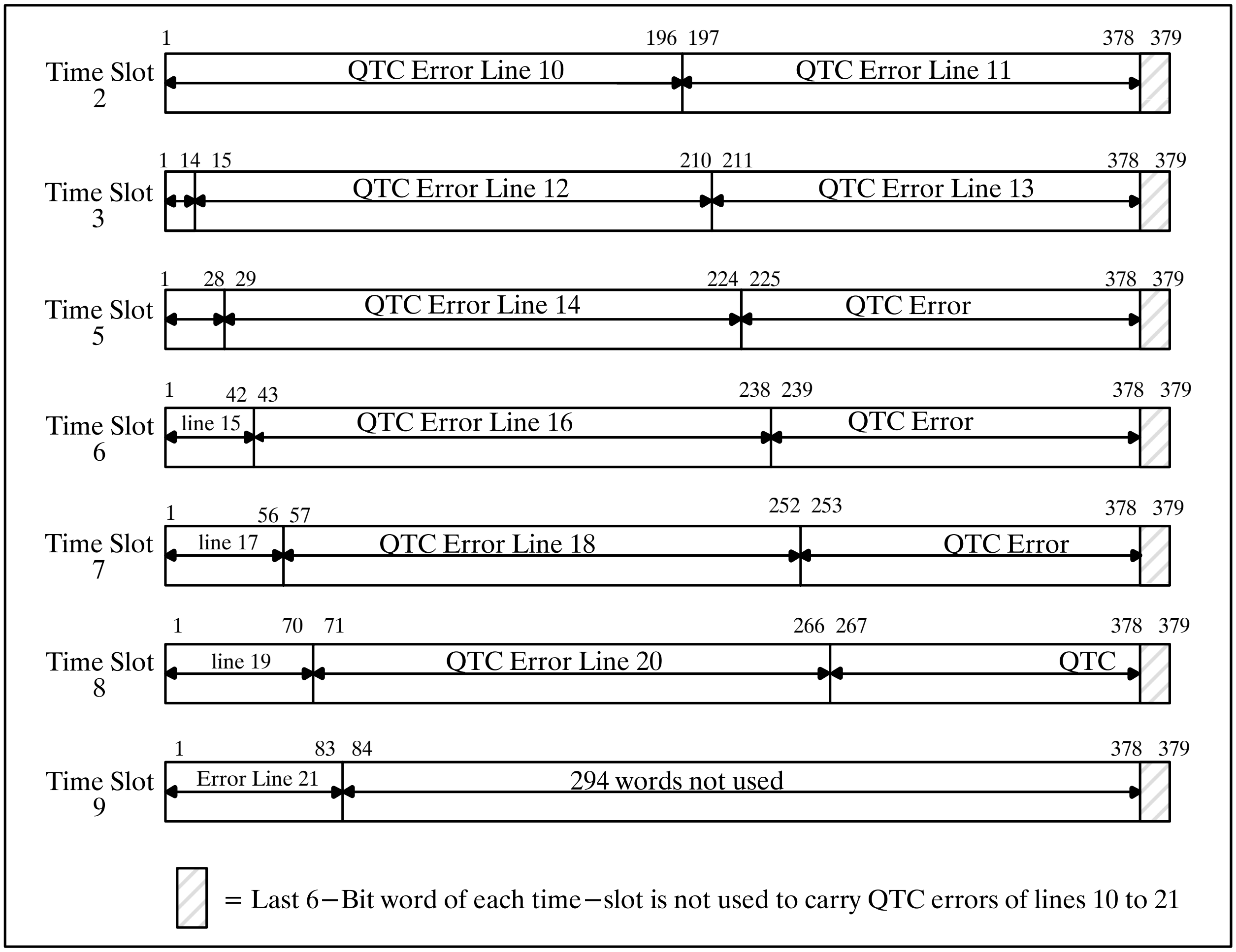



**Figure 9 − Time Slot Assignment of QTC Information for Lines 10 to 21**

## 5. Audio Signal Processing

The audio analog/digital (A/D) and digital/analog (D/A) subsystems perform the analog pre−processing, post−processing, and digitization. The subsystems should format/deformat the audio data in conformance to the new CCITT Recommendation J41 for multichannel sound. For each companded audio word (11 bit), a parity bit shall be included for transmission of error detection. The 12−bit samples that are produced are at a sampling rate of 32 kHz to generate a 384 kbit/s stream per audio channel. This will allow up to four audio channels to be combined together to create a 1.544 Mbit/s stream. This DS1 signal format shall conform to Bellcore Technical Reference TR−INS−000342, Issue 1, February 1991:

| | |
|---|---|
| DS0 channels 1−6 | 15 kHz audio − left stereo |
| DS0 channels 7−12 | 15 kHz audio − right stereo |
| DS0 channels 13−18 | 15 kHz audio − separate audio program |
| DS0 channels 19−24 | six DS0 channels for voice or data or another 15 kHz audio channel |

The DS1 signal shall be converted to 6−bit parallel stream as depicted in Figure 10 for multiplexing onto the DS3 bit stream. The 6−bit words shall be stored in a buffer, and recalled and combined to other signals in groups of 24 six−bit words when slots are made available. The audio buffer should also perform delaying functions to ensure lip−sync with the video signal. The audio delay should be programmable (in steps of 2 msec or less) to ensure that lip−sync can be established with 1 msec.

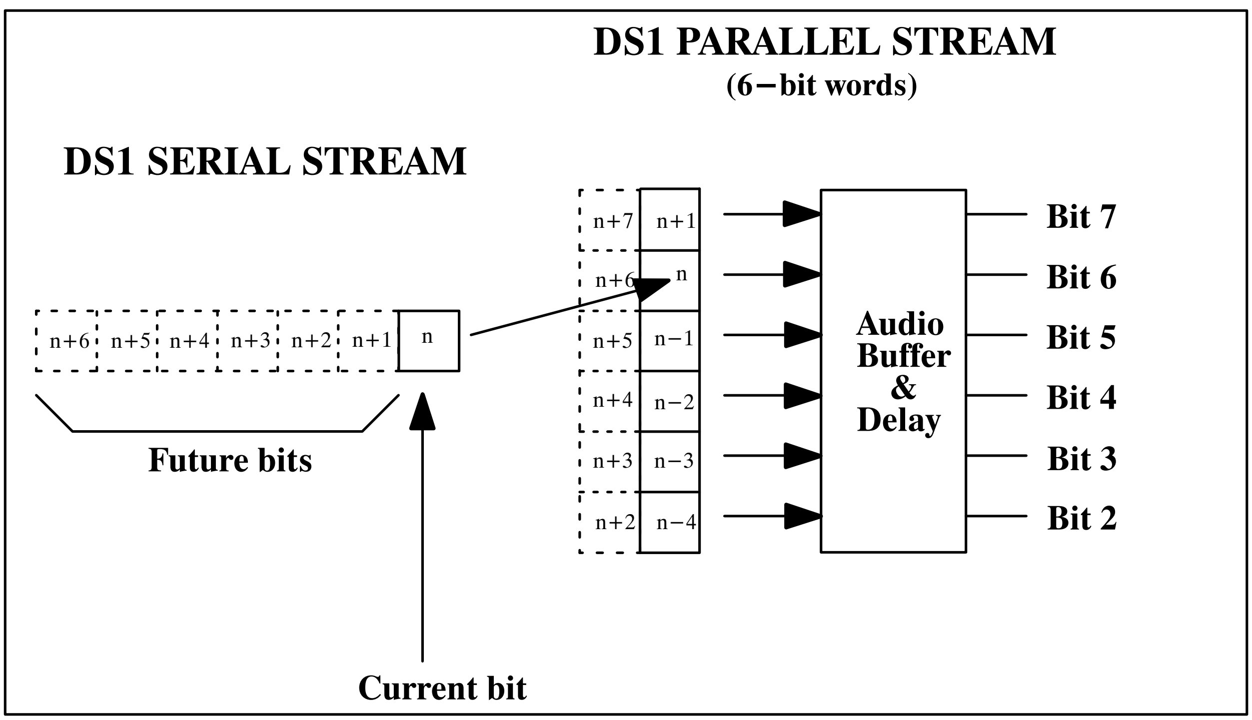



**Figure 10 − Serial to Parallel Conversion for the Audio Information**

# 6. Multiplexing

## 6.1 Time Slot Formats

A time division multiplex first combines the 6−bit audio stream, the 6−bit video stream, and inserts flagging information into time slots.

The time slot formats are presented in Figure 11. Four different formats are specified. Each time slot starts with a flag sign (hex “3F”) and is immediately followed by two other 6−bit words which define the time slot format being used. The flag sign is a distinctive codeword which cannot be emulated by coded video information. The reason for doing this is to limit the one’s density, and to accelerate the resynchronization during power−up and after a loss of synchronization. The lsb of the last 6 bit word of each line shall be used to carry the time code information.

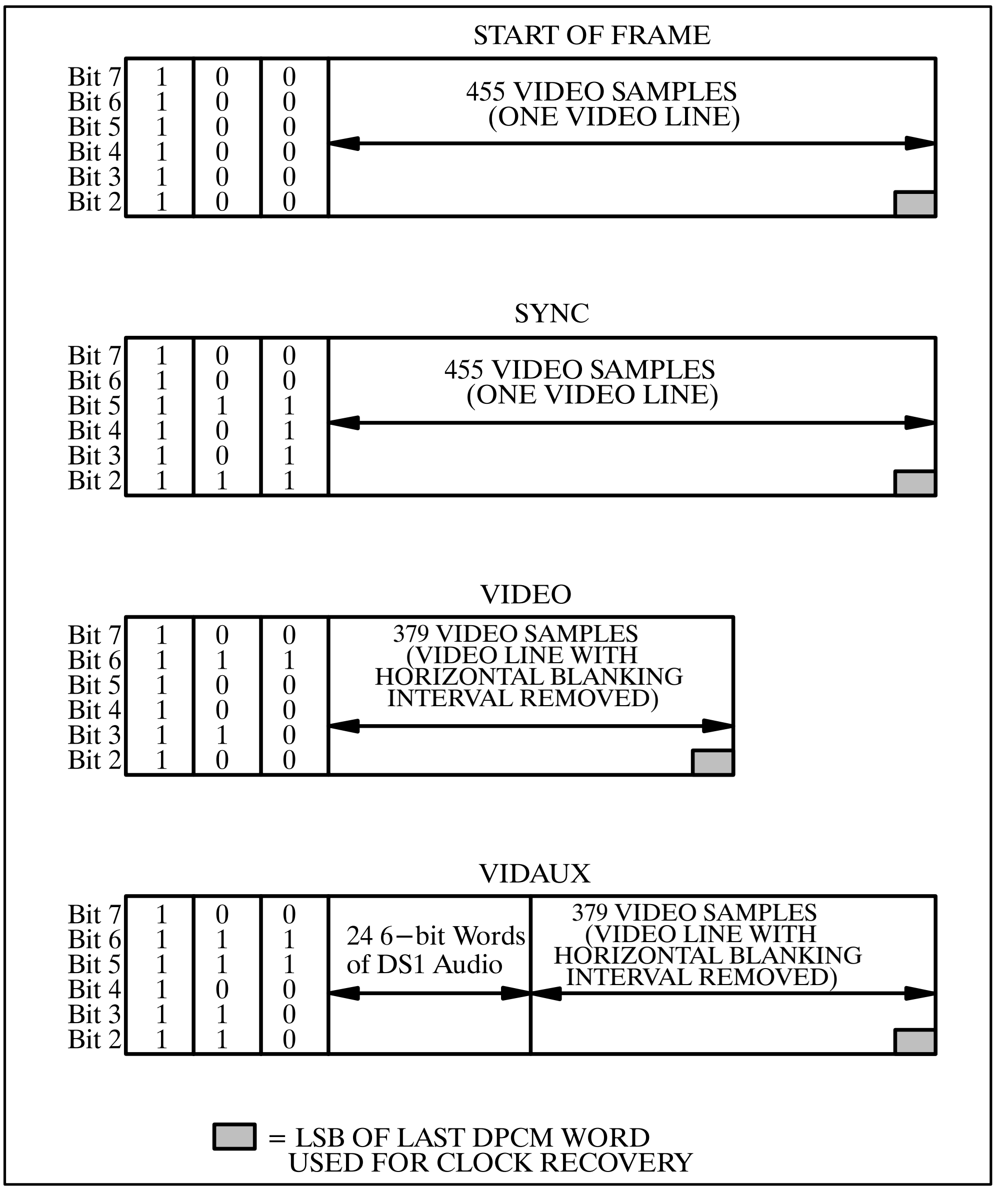



**Figure 11 − Time Slot Formats**

| | |
|---|---|
| SOF (Start of Frame): | Indicates a new frame (selected only at line 1 of fields I and III), the horizontal blanking interval is transmitted, the corresponding time slot shall be 458 words long. |
| SYNC: | Indicates that the horizontal blanking interval (HBI) is transmitted, the corresponding time slot shall be 458 words long. |
| VIDEO: | Indicates that the horizontal blanking interval (HBI) is removed, the corresponding time slot shall be 382 words long |
| VIDAUX: | Indicates that the horizontal blanking interval (HBI) is removed, and that 24 six bit words of the DS1 audio information follow, the corresponding time slot shall be 406 words long. |

The arrangement of the data that follow the three flag words shall be:

| | |
|---|---|
| DS1 audio signal: | Bits 2 to 7 of the 24 six bit words shall be inserted serially in DS2's #2 to 7, respectively, for 24 consecutive DS2 slots. Bit 2 shall correspond to the lsb of the 6−bit word and bit 7 shall correspond to the msb. |
| HBI: | Bits 2 to 7 of the 76 six bit PCM words (7−bit PCM quality) shall be inserted serially in DS2's #2 to 7, respectively, for 76 consecutive DS2 time slots. Bit 2 shall correspond to the lsb of the 6 bit word and bit 7 shall correspond to the msb. |
| Serration and Equalizing Pulses: | Bits 2 to 7 of the 455 six bit PCM words (7−bit PCM quality) shall be inserted serially in DS2's #2 to 7, respectively, for 455 consecutive DS2 slots. Bit 2 shall correspond to the lsb of the 6 bit word and bit 7 shall correspond to the msb. |
| Time Slots where encoding is 6−bit DPCM | Bits 2 to 7 of the 379 six bit DPCM words shall be inserted serially in DS2's #2 to 7, respectively, for 379 consecutive DS2 slots. Bit 2 shall correspond to the lsb of the 7−bit word and bit 7 shall correspond to the msb. |

### 6.2 Procedures for Time Slot Format Selection

The procedures for selection of a time slot format are listed below sequentially:

(1) If video line number = 1; Then Format SOF shall be selected and then END

(2) If video line number = 4, 10, 11, 264, 273 or 274; Then Format SYNC shall be selected and then END

(3) If the DS2 FIFO contains less than 128 words; Then Format SYNC shall be selected and then END.

(4) If at least 24 six−bit audio words are present in the buffer; Then Format VIDAUX shall be selected and then END.

(5) Format VIDEO is selected and then END

### 6.3 Multiplexing of First and Second Channel

The second channel is a continuous channel which starts on the 4th word of the time slot 22 and 285 and is not aligned with the information in the first channel. The information in the second channel is delayed by approximately one field. Time slots 22 to 262 carry a correction signal for lines 285 to 525 of the previous field (241 X 400 bits long) while time slots 285 to 525 carry a correction signal for lines 23 to 262 of the previous field (240 X 400 bits long). This correction signal is aligned to bit 1 of the DS2 − DS3 multiplexing structure.

### 6.4 Bit Scrambler and Descrambler

The 7−bit stream (6−bit PCM/DPCM/Audio and the 1 bit block quantization signal) shall go through a bit scrambler at the coder before being multiplexed at DS3 level. The purpose of this scrambler is to spread the flagging information in the DS3 serial stream. As a consequence, short transmission burst errors will not corrupt the flagging information. A descrambling process is done at the decoder. The Scrambler delays DS2 group 7 by 6 bits and DS2 group 6 by 5 bits and so on as shown in Figure 12.

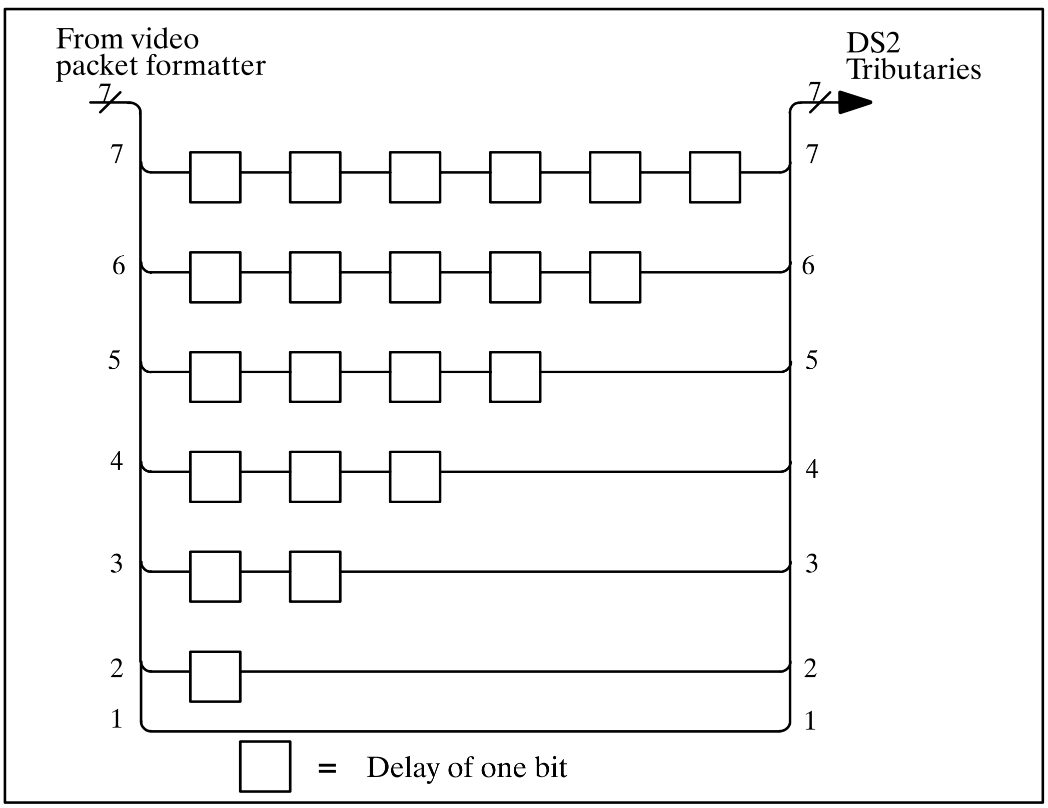



**Figure 12 − Bit Scrambler**

### 6.5 Multiplex Framing Structure

The 7−bit stream out of the scrambler shall be read at the DS2 rate and fed to a M2−3 multiplexer. The M2−3 multiplexer shall combine the seven 6.312 Mbit/s streams using the normal DS3 structure shown in Figure 13 with the normal DS3 framing as specified in ANSI Standards, ANSI T1.107−1988 and ANSI T1.404−1989. Framing overhead (F, M, X and P bits) is required and timing must be maintained within rate and tolerance specification.

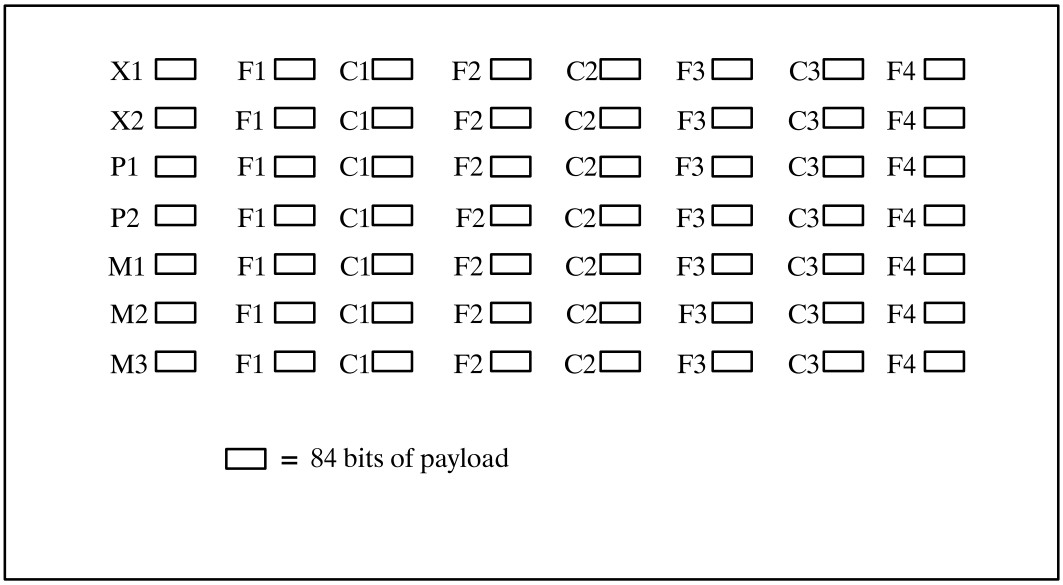



**Figure 13 − DS3 Format**

The stuffed bit position for each DS2 never carries valid information and should be ignored at the receiver. The stuffed control bits ($C_{ij}$ where i = {1, 2, ..., 7} and j = {1, 2, 3}) in the DS3 frame are ignored by the decoder. The correction signal (bit 1) is resident in the DS2 group #1 and the Video/Audio (bit 2−7) are resident in the DS2 groups #2 to #7 respectively.

### 6.6 Transmission Error Handling

Transmission errors that might occur are handled directly by the coding algorithm according to the following:

- Flagging information is sent three times during the 6−bit words following the flag sign (Figure 11). A majority decision is done at the receiver to recover the proper time slot format. The scrambler (Figure 12) increases the distance between the flagging information sent in the DS3 serial stream. This will allow the DS3 serial stream to handle longer bursts of errors without corrupting the flagging information.

- A reset is done on the DPCM loop at the beginning of each video line (Figure 3).

- The addition of the error mitigation loop as shown in Figure 3.

- Error concealment may also be implemented at the decoder by detecting errored channel codes.

- The second channel carries information for a very small segment of the picture (18 pixels). The effect produced by transmission errors remains concentrated on these 18 pixels. A reset is automatically done on the following block. As correlation is extremely high in a typical picture, the second channel basically carries small errors and the change in a sign due to transmission errors is imperceptible.

## 7. X−Bit Information

### 7.1 Overview

The X−bits in the DS3 stream may be used by the coder to carry information relative to the alarms and status information between codecs as shown in Figure 14. This information is used to provide end−to−end status to the monitoring equipment.

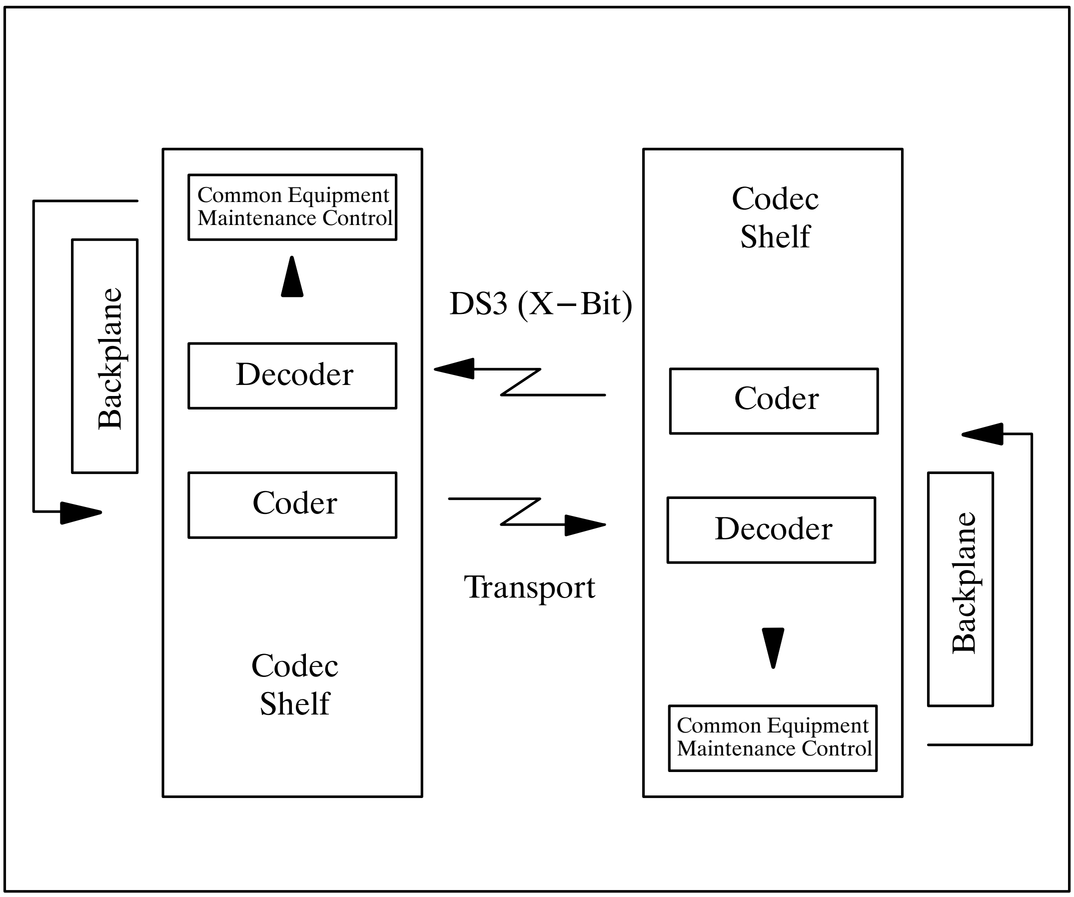



**Figure 14 − (X−Bit) Channel Data Direction**

Details of the implementation applied to codes provided by BellSouth are given in Sections 7.2 and 7.3. Other implementations are expected to comply only with the test functions of Audio/Video loopback, and then only if a two way system is envisioned.

## 7.2 Packet Framing

Information on the X−Bit channel is carried on small variable length packets (Figure 15). Each packet has a maximum length of 256 bytes of payload. The payload is framed by specific start and end bytes and the integrity is verified by cyclic redundancy check.

| Dle | Stx | Payload | ... | ... | Crc–1 | Crc–2 | Dle | Ext |
|---|---|---|---|---|---|---|---|---|

**Figure 15 − (X−Bit) Packet Structure**

Not to restrict the content of the payload a {Dle} byte occurring in the payload is sent as a pair {Dle,Dle}. The framing bytes are the usual ANSI defined characters shown in Table 7.1.

Table 7.1: ANSI Framing Bytes

| Bytes | Hex Value | Meaning |
|---|---|---|
| DLE | 10 | Data Link Escape |
| STX | 02 | Start of Text |
| ETX | 03 | End of Text |

The CRC is the 16−bit ITU−T defined cyclic redundancy check for the following polynomial equation:

$$CRC = x^{16} + x^{12} + x^{5} + 1$$

This equation is fully described in the International Standards, ISO 3309, **Information Processing Systems − Data Communications − High Level Data Link Procedures − Frame Structure**, 1984.

## 7.3 Payload Content of the X−Bits

The packet content is described in BNF−like (Backus−Nohr−Form) notation:

- Bytes with specific values are denoted by their hexadecimal representation as 0xNN.
- Database points (e.g. *Audio_chip_failure*) take on only bit values {0,1}. “0” indicates negation of the database point meaning (e.g. *Audio_chip_failure* = 0, means that the audio chip has not failed).
- Sets of possible values are denoted by curly braces with ellipsis indicating obvious sequence range.
- Concatenation is denoted by the comma “,”.
- “Or” is denoted by the “/”.
- Repetition is denoted by start “*”, followed by repetition count.

The only 2 types of packets sent over the X−Bit channel are the loopback request packet and the database packet.

| | |
|---|---|
| *Payload :=* | *Loopback/Database* |
| *Loopback :=* | *0xF0,Loopback_request* |
| *Database :=* | *Alphabetic,Alphabetic,Numeric,Numeric,Unit Database* |
| *Alphabetic :=* | *{A,B,...,Z}* |
| *Numeric :=* | *{0,1,...,9}* |
| *Unit Database :=* | *Decoder/Coder* |

*Decoder :=* *Audio_chip_failure,Audio_ram_failure,Audio_fifo_failure*
’ *Power_failure,Battery_A_failure,Battery_B_failure*
’ *No_video,Broadcast_circuit_failure*
’ *Video_ram_failure,Video_fifo_failure,Video_dram_failure*
’ *Digital_audio_failure,J81_chip_failure,Frame_store_failure*
’ *DSP_failure,Xilinx_failure,Unused_point * 16,Loopback_enable*
’ *Freeze_on_video_loss,B8ZS_AMI,LBO2,LBO1,LBO0*
’ *Digital_analog_audio,Audio_frame_loss,Mcu_dead,Audio_AIS*
’ *External_boot,Monitoring_video,Frame_store_equipped*

’ *No_external_broadcast,Video_sync_loss_pre_process*
’ *Front_end_dead,Video_sync_loss_post_process*
’ *Decoding_mode_1,Decoding_mode_0,DS3_clock_loss*
’ *DS3_frame_loss,DS3_parity,DS3_parity_div8,DS3_blue*
’ *DS3_all_ones,DS3_degraded,Unused_point * 101*
’ *Loopback_control,,Digital_analog_control,,Broadcast_control,*
’ *B8ZS_AMI_control,Impedance_2,Impedance_1,Impedance_0*
’ *Frame_store_control,Disable_black,Unused_point * 62*
’ *Unit_fail_alarm,DS3_alarm_indication_signal*
’ *DS3_fail_alarm,DS3_alarm_indication_signal*
’ *Video_sync_loss_alarm,Unit_on_status,Black_active_status*
’ *Lamptest_status,Audio_channel_active_status*
’ *Video_pattern_generation_control,Pattern_1,Pattern_0*
’ *Freeze_control,Loopback_control,Unused_point * 7*

*Coder := Audio_failure,Audio_ram_failure,Audio_fifo_failure*
*, Power_failure,Battery_A_failure,Battery_B_failure,No_video*
*, Broadcast_failure,Video_ram_failure,Video_fifo_failure*
*, Unused_point,Dsp_failure,Xilinx_failure,Unused_point * 19*
*, Loopback_sense,Unused_point,B8ZS_AMI,Encoding_mode_1*
*, Encoding_mode_0,Loopback_request,Digital_analog_audio*
*, Audio_frame_loss,Mcu_dead,Audio_ais,External_boot*
*, DS1_loss,Unused_point,Broadcast_equipped,No_video*
*, Front_end_dead,45_meg_lock,Video_overload_check*
*, Unused_point * 110,Digital_analog_control,Mode_1,Mode_0*
*, 45_meg_lock_control,B8ZS_AMI_control,Mode_1,Mode_0*
*, Unused_point *4,No_video_mask,Front_end_dead_mask*
*, Unused_point * 59,Unit_fail,Video_failure,Video_sync_loss*
*, Unit_on,Unused_point *4,Lamptest,Unused_point * 4*
*, Loopback_request,Loopback_status,Unused_point * 8*

## 8. Video Signal Specifications

Analog video signal inputs and outputs of the service are System M−NTSC composite television signals, 75 ohms, unbalanced with input return loss greater than 30 dB. When both ends are analog, the objective performance specifications provided in BellSouth Technical Reference TR 73557, Issue C, 1994 will apply except for the signal−to−noise ratio where the supported specification will be 56 dB. When one end is digital, overall performance is dependent upon the device performance of the customer−provided codec. In this case, the service limits are objectives only. BellSouth will work with the customer as necessary to provide the best possible performance.

## 9. Audio Signal Specifications

The analog audio interface to the service shall have 600 ohm, balanced capability for up to four audio channels. The four audio channels shall be included in the DS3 channel along with the video information. Each audio channel shall be independent with a bandwidth of 15 kHz. Input and output analog audio specifications that will be required are specified in BellSouth TR 73557, Issue C, 1994.

## 10. Interface Specifications

### 10.1 Analog Video Input/Output

(1) M−NTSC Television interface which meets the EIA Specifications RS−170−A

(2) 75 ohm unbalanced

(3) BNC connector

## 10.2 Audio Input/Output

(1) 600 ohm balanced

(2) Absolute gain 0 dBm ± 0.1dBm @ 1 kHz nominal, 18dBm maximum with overload at 21 dBm

(3) Bandwidth 40 Hz to 15 kHz (+ 0.3 dBm @ − 1 dBm)

(4) Compression algorithm meets specifications depicted in CCITT Recommendation J41.

## 10.3 DS3 Interface

The codec shall interface at the standard DS3 digital rate. The signal shall conform to or exceed all the DS3 requirements specified in ANSI T1.404−1989, **Carrier−to−Customer Installation−DS3 Metallic Interface Specification.** These requirements are also defined in BellSouth Technical Reference TR 73501. The interface shall have the following characteristics:

(1) Payload Line Rate equal to 44.736 Mbits/sec ± 20 ppm

(2) Line Code is Bipolar with B3ZS

(3) Test Load is 75 ohms ± 5%, resistive

(4) Pulse Shape shall be defined as shown in Figure 16

(5) Pulse Amplitude shall be 0.36 to 0.85 V (peak) measured at the center of the pulse, scaled to fit the template in Figure 16

(6a) Pulse Power Level (for all ones transmitted pattern) shall be, in a 3 kHz band, centered at 22.368 MHz, the power level is between −1.8 and +5.7 dBm

(6b) Pulse Power Level (for all ones transmitted pattern) shall be, in a 3 kHz band, centered at 44.736 MHz: at least 20 dB below the level in the 3 kHz band centered at 22.368 MHz.

(7) Compatible with DS3 asynchronous M23 frame construction as shown in ANSI T1.404 and described in ANSI T1.107. Stuffing bits (C−bits) are ignored.

(8) Meets DSX3 interconnection specifications

(9) Interconnection at network Interface shall be SJA 44 Connector which are 75Ω coaxial TNC connectors (jack & plugs)

(10) Grounding arrangements shall comply with ANSI T1.404−1989

Customer provided coders should have a variable line build out (LBO) setting to accommodate cross−connect distances up to 450 ft for 728A cable or 250 ft for RG−59. Decoders should not require LBO since the levels and pulse shape should be accommodated for up to 450 ft with 728A cable and 250 ft with RG−59 cable from the network interface.

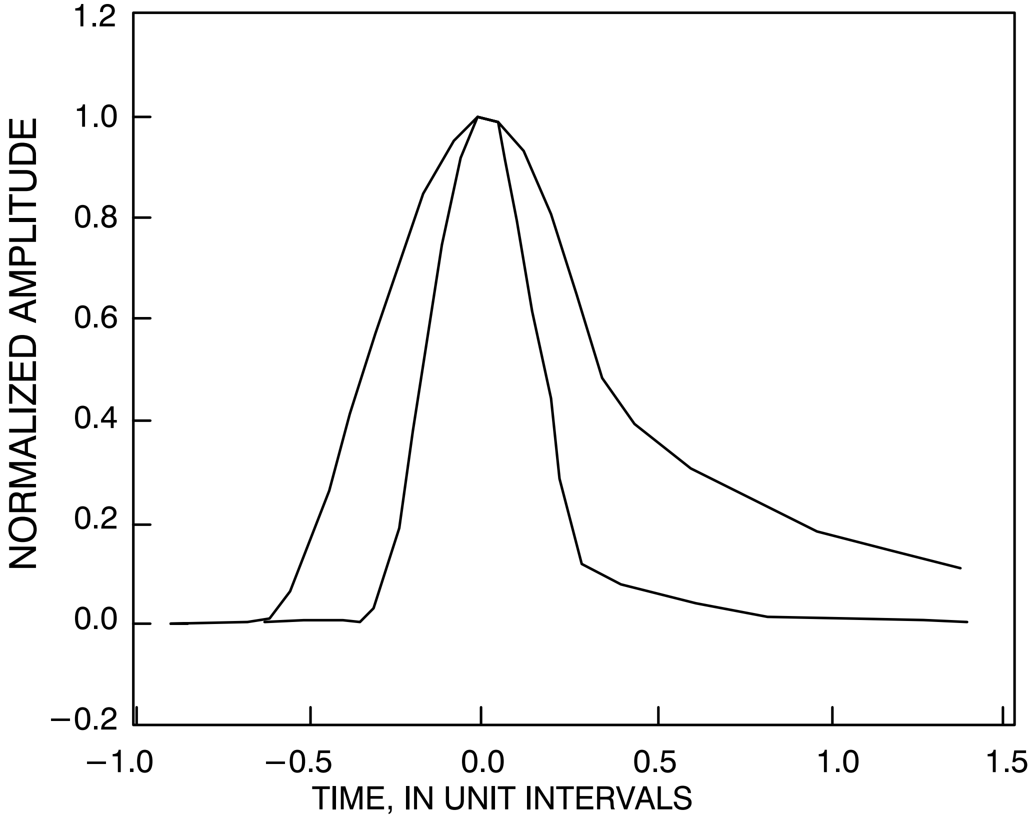
### 10.3.1 Timing

DS3 is an asynchronous format. Each coder is expected to rely on its own clock for generation of the output DS3 bit stream, subject only to the ±20ppm accuracy and subsequent jitter criteria. Each decoder is expected to recover the incoming bit stream as presented.

In a two−way system, clocking recovered by a decoder may be used to time outgoing signals.

### 10.3.2 Jitter

Jitter of the digital signals delivered to the NI shall be within the allowable range of ANSI T1.404−1989 for both network−delivered signals and for signals generated by customer equipment.




NI PULSE TEMPLATE BOUNDARIES

| CURVE | TIME UNIT INTERVALS | NORMALIZED AMPLITUDE |
|---|---|---|
| MAXIMUM CURVE | $T \le -0.68$ | 0 |
| | $-0.68 \le T \le 0.36$ | $0.5\left[1+\sin\frac{\pi}{2}\left(1+\frac{T}{0.34}\right)\right]$ |
| | $0.36 \le T$ | $0.05+0.407e^{-1.84(T-0.36)}$ |
| MINIMUM CURVE | $T \le -0.36$ | 0 |
| | $-0.36 \le T \le 0.28$ | $0.5\left[1+\sin\frac{\pi}{2}\left(1+\frac{T}{0.18}\right)\right]$ |
| | $0.28 \le T$ | $0.11e^{-3.42(T-0.3)}$ |

**Figure 16 − DSX−3 Isolated Pulse Template and Equations**

# 11. Access Service Channel and Interface Codes

## 11.1 General

Network Channel (NC) and Network Channel Interface (NCI) Codes are used to supplement ordering. These codes provide a shorthand notation of the interface and performance characteristics described earlier in this document. **This document may be referenced in specifying NC and NCI codes when ordering video services from the BellSouth Access Tariff.** The interface codes are described in this section.

**NOTE: Network Channel Codes (NC) and Network Channel Interface Codes (NCI) are currently not used to describe non−access services. Development of NC and NCI codes to describe non−access services is currently under study.**

## 11.2 Network Channel (NC) Code

The Network Channel code is an encoded representation used to identify both switched and non−switched channel services. It is a four−character code that consists of two (2) data elements: (1) Channel Service Code and (2) Optional Feature Code. The NC code describes the channel parameters. Table 11.1 Shows the format of the NC structure.

Table 11.1: Network Channel Code Format

| Field Identity | Network Channel Service Code | | Optional Feature Code | |
|---|---|---|---|---|
| Character Position | 1 | 2 | 3 | 4 |
| Code | A | A | A | A |

(1) The Network Channel Service Code is a two−character, alpha code that describes the channel service in an abbreviated form. The Channel Service code will typically be specified as the service code of the service. This code is always filled in.

(2) The Optional Feature Code is a Two−character alpha code for video service that represents the service quality and the C. O. option codes available for each channel service code. The Service Quality is an alpha code shown in the third position that describes the quality of the service channel. C. O. Option is an alpha code in the fourth position that describe Various combinations of the type of C. O. service requested (i.e., CO Bridging & Switching). The NC optional feature code field is always filled in. A hyphen (−) is used in position 4 of the NC to indicate the absence of features or options.

Allowable Network Channel (NC) Codes and combinations for this service are shown in the following Tables 11.2 – 11.4.

Table 11.2: Network Channel Service Code for Television Channel Service TV3

| Network Channel Service Code | LATA Service | Description |
|---|---|---|
| TZ | Access | Private Line Video |

Table 11.3: Service Quality

| Position | Character | Description |
|---|---|---|
| 3 | B | Commercial Quality Video |

Table 11.4: Central Office Option

| Position | Character | Description |
|---|---|---|
| 4 | – | NONE |
| | B | C.O. BRIDGED |
| | Q | B + S |
| | S | C.O. SWITCHED |

### 11.2.1 Network Channel (NC) Code Example

The NC code **"TZBS"** contains the following components:

(1) **TZ** – This two character Network Channel Service Code indicates that this television channel service is private line video.

(2) **B** – This character position indicates Service Quality. "B" indicates that this is Commercial Quality Video (TV3).

(3) **S** – This character position indicates C. O. Options. "S" indicates that this service is equipped for central office switching.

## 11.3 Network Channel Interface (NCI) Code

The Network Channel Interface (NCI) Code is an encoded representation used to identify five (5) interface elements located at a point of termination (POT) or customer location. The interface elements are (1) Total Conductors, (2) Protocol, (3) Impedance, (4) Protocol Options, and (5) directionality of transmission. Table 11.5 shows the format of the NCI code structure.

Table 11.5: Network Channel Interface Code Format

| Field Identifier | Total Conductors | | Protocol | | Imp | Del | Protocol Options | | | Del | Directionality Tx | Rx |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Character Position | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Code | N | N | A | A | N | | AN | AN | AN | | N | N |

**Note:** Imp = Impedance
Del = Delimiter − Required for overall code readability; generally a period (.) or a virgule (\,/)

(1) **Total conductors (character positions 1 and 2)** is a two−character numeric code that represents the total number of physical conductors (i.e., wires) required at the interface. This field is always filed. Total conductors are described in Table 11.6.

(2) **Protocol (character positions 3 and 4)** is a two−character alpha code that defines requirements for the interface regarding transmission. This field is always filled. The protocol combinations specified at the ends of a circuit need not be the same. However, only certain combinations are technically possible. Protocol codes (and associated options) are described in Table 11.7.

(3) **Impedance (character position 5)** is a one−character numeric code representing the nominal reference impedance that will terminate the channel for the purpose of evaluating transmission performance. This field is always filled. The impedance code is described in Table 11.8.

(4) **Protocol Options (character positions 7, 8 and 9)** is a one−to−three character numeric or alphanumeric code that describes additional features of the protocol to be used. Protocol option codes are always left−justified when fewer than three characters are specified. Protocol option codes are described in Table 11.7.

(5) **Directionality of transmission ( character positions 11 and 12)** is a two character numeric code indicating the direction of transmission. This code is described in Table 11.9.

Table 11.6: Total Number of Conductors

| Code | Number of Physical Conductors |
|---|---|
| 02 | 2 (One Way DS3 – 44.736 Mbps channel) |
| 04 | 4 (One or Two Way DS3 – 44.736 Mbps channel) |
| 10 | 10 (One–way video & four – 15 kHz audio channels) |

Table 11.7: Protocol Codes and Selected Options

| Code | Option | Definition |
|---|---|---|
| TV | | Analog Television Interface |
| | 15A | Video plus three or four (2–wire) 15 kHz audio signals |
| DS | | Digital Interface |
| | 44 | 44.736 digital channel including one compressed video signal and four 15 kHz audio signals |

Table 11.8: Impedance Code

| Code | Impedance |
|---|---|
| 6 | 75 ohms for analog or digital video |

Table 11.9: Direction of Service

| Code | Description |
|---|---|
| –0 | Transmit End |
| 0– | Receive End |

### 11.3.1 Network Channel Interface (NCI) Code Example

The NCI code **"10TV6.15A"** contains the following components:

(1) **10** – These two characters indicate the total number of physical conductors connected to the Network Interface. Ten conductors are shown.

(2) **TV** – These two characters indicate analog television and audio interface.

(3) **6** – This single character indicates the nominal reference impedance that will terminate the channel. As shown in Table 15, 75 ohms is the impedance.

(4) **"."** – This single character is the delimiter

(5) **15A** – These three alphanumeric characters indicate the optional protocol of the service provided at the Network Interface. As shown in Table 11.7, analog video plus three or four analog audio channels are provided at the Network Interface.

### 11.4 Compatible Interface Combinations for M−NTSC Television Signals Transported over DS3

Table 11.10 lists the compatible interface code combinations for this service.

Table 11.10: Interface Options

| Service Code | NC Code | End–User Interface | Interexchange Carrier Interface |
|---|---|---|---|
| TV3 | TZB | 10TV6.15A | 10TV6.15A |
| | | 10TV6.15A | 02DS6.44.0– |
| | | 10TV6.15A | 04DS6.44.0– |
| | | 10TV6.15A | 02DS6.44.–0 |
| | | 10TV6.15A | 04DS6.44.–0 |
| | | 02DS6.44.0– | 02DS6.44.–0 |
| | | 02DS6.44.0– | 04DS6.44.–0 |
| | | 02DS6.44.–0 | 02DS6.44.0– |
| | | 02DS6.44.–0 | 04DS6.44.0– |

## 12. Appendix

### 12.1 Glossary of Terms

#### 12.1.1 General

With the compression of video, new terms are being used to describe different aspects of the video associated with the compression processes that traditional terms associated with analog video are not able to describe. The following list of definitions is provided to familiarize the reader with the new terms and review some traditional terms associated with video. Not all of the listed terms are included in this document.

### 12.2 Common Definitions, Descriptions and Terminology

**Algorithm:** a set of rules to solving a problem in a finite number of steps, as for finding the greatest number divisor. A sequence of designing steps.

**Aliasing:** The undesirable "beating" effects caused by sampling rate being too low; also unpleasant stepped images when unfiltered non−horizontal lines are presented on raster lines of a TV system. Examples of aliasing are (a) temporal aliasing, e.g. Wagon Wheels apparently reversing direction, movement seen in standards converters with insufficient temporal filtering; (b) raster scan aliasing, which results in "twinkling" effects on sharp horizontal lines.

**Analog−to−Digital (A/D) Conversion:** The process of converting an analog signal into a digital signal.

**Anti−aliasing:** The smoothing and prevention of aliasing effects by filtering and other techniques.

**Artifact:** The imprecise term used to describe visible defects that result from a technical limitation. Artifacts cannot generally be quantified by traditional methods of evaluation.

**Aspect Ratio:** The ratio of picture width to picture height as transmitted. The Standard is 4:3 for 525–line System M–NTSC

**Average Picture Level (APL):** The average level of the picture signal during active scanning time integrated over a frame period and defined as a percentage of the range between blanking and reference white (expressed as a percentage or in IRE).

**Baseband Signal:** The band of analog frequencies occupied in the [video or audio] source signal before it is modulated by a broadband carrier system.

**Block Distortion:** Distortion of the received image characterized by the appearance of an underlying block encoding structure.

**Blurring:** A distortion, characterized by reduced sharpness of edges and spatial detail.

**Burned–In Image:** An image which persists in a fixed position on the video screen after the camera has turned to a different scene.

**Burst:** A phase–reference component of the color signal consisting of nine cycles of the sub–carrier frequency ($f_{SC}$ = 3.58 MHz) located on the back porch of each horizontal blanking interval

**Chrominance Signal:** That portion of the video signal which contains color information.

**Clamping:** A video–processing operation that provides a line–by–line correction of the video blanking or sync tip level to a fixed dc reference voltage. it is used for restoring the dc component of the video signal prior to processing circuitry such as clipping, blanking insertion, and gamma correction.

**Code Element:** The smallest unit to form a code word, in the case of binary coding: a bit.

**Code Word:** The block of a predetermined number of code elements, in the case of a word length with 8 bits a byte.

**Coding/encoding:** The process of converting quantizing signal values into coded words assigned to a defined code

**Coding:** The process of converting binary numbers of PAM samples (code words) into corresponding ternary or other multilevel digital signals acceptable to a transmission facility.

**Color Flicker:** An inconsistent or wavering of light which results from fluctuation of both Chrominance and luminance levels of intensity.

**Color Errors:** Distortion of all or a portion of the received image in which un–natural or unexpected hues occur.

**Component Video Signal:** The uncombined output of a video signal source device such as a digital camera to tape recorder, producing the primary colors of red, green and blue (RGB) that when combined produces all necessary picture information.

**Component Coding:** Coding of the three primary colors of an analog video signal that are converted into a digital signal format.

**Composite Video Signal:** The completed video signal that is the combined result of the primary colors of red, green and blue (RGB) producing all necessary picture information, such as with the NTSC or PAL formats. A composite video signal of standard amplitude, from correct sync to reference white level, should be presented between −40 and +100 units of the IRE scale on a waveform monitor.

**Composite Coding:** digitizing, where the complete analog color signal (composite color signal) is converted into a digital signal format.

**Compression Artifacts:** are introduced by filtering, conversion transformation, quantization and transmission compression. Loss of resolution, block errors, quantization noise, and block errors are typically observed as a result of these processes.

**Contour Distortion:** A visual defect arising from quantizing a picture. A gradual change of Chrominance and/or luminance between areas. These areas are replaced by a series of abrupt Chrominance and/or luminance changes.

**Differential Pulse Code Modulation (DPCM):** A pulse code modulation in which the coded value transmitted for each sample represents the quantized difference between the present sample value and the prediction value.

**Differential Gain:** The difference in gain of a video facility at the color subcarrier frequency between two luminance levels, from blanking to reference white level.

**Differential Phase:** The maximum difference in phase of a video facility at the color subcarrier frequency between two luminance levels, from blanking to reference white level.

**Digital Transport:** A portion of the telecommunications network using digital methods for the transmission of signals from one point to another to complete a transmission service channel. A transmission service channel may have one or more digital transport portions.

**Digital−to−Analog (D/A) Conversion:** The process of converting a digital signal into an amplitude−discrete signal.

**Discrete Cosine Transform (DCT):** See Transform Coding

**Distortion:** An undesired change in waveform of a signal while passing through a transmission system

**Edge Effect:** The overemphasizing of well defined objects from the addition of black or white outlines to the vertical edges of the objects. Examples of this phenomena are, trailing white, leading black around the outline of a figure in movement within a scene.

**Edge Business:** Distortion concentrated at the edge of objects, characterized by temporally varying sharpness or spatially varying noise. *Mosquito Noise* is an example of this impairment.

**Encoding:** see coding/encoding

**Entropy Coding:** See variable word length coding.

**Error Correction:** A technique of transmitting a small amount of redundancy to the coded information that can be used to restore the integrity of corrupted received data.

**Error Blocks:** A form of block distortion where one or more blocks in the received image bear no resemblance to the current or previous scene and often contrast greatly with adjacent blocks.

**Field:** A scan of the picture area once in a predetermined pattern.

**Forward Error Correction:** See error correction.

**Frame:** One complete picture consisting of two (more in some systems) fields of interlaced scanning lines. In the NTSC format, a frame consists of 525 horizontal lines of picture information. In the PAL format, 625 lines. (Non−interlaced systems may transmit 525 scan lines progressively (one after the other) in each full frame).

**Frame:** a set of consecutive time slots each consisting of definite numbers of coded words. The position of each time slot can be identified by reference to a frame alignment word.

**Ghost:** A shadow or weaker image in the television picture, typically offset to the left or right of the image within a scene.

**Grain or Graininess:** A uniform distribution of dark spots throughout the entire television picture from a motion picture film source. Hence the term should be limited (in the analog sense) to film or film reproduction.

**Granular Noise:** A visual defect caused by the quantizing errors with different coding, showing as fluctuations of the luminance and/or chrominance level − on uniform or nearly uniform parts of the video image.

**Image Persistence:** The appearance of earlier faded video frames of a moving and/or changing object within the current frame, e.g. an object that was erased continues to appear in the received video imagery.

**Inter−frame Coding:** A method of source coding; the temporal correlation of moving pictures is used for data reduction, in order to save transmission capacity.

**Interlaced Scanning:** Each frame is divided into two fields, with the even and odd lines scanned on alternate fields. To generate interlaced scanning, each frame must have an odd number of scanning lines. This causes the first lines of alternate fields to begin in the center of the picture, so that lines are interleaved. There are 525 scanning lines in each frame and 262½ lines in each field.

**Intra−Frame Coding:** A method of source coding applicable to still pictures or pictures that may be considered to be still, where the spatial correlation within a picture is used for data reduction, in order to save transmission capacity.

**IRE Standard Scale:** A linear scale for measuring, in arbitrary IRE units, the relative amplitudes of the various components of a television signal as shown in Table 12.1:

Table 12.1: IRE Standard Scale

| Level | IRE Units | Modulation, % |
|---|---|---|
| Zero carrier | 120 | 0 |
| Reference white | 100 | 12.5 |
| Blanking | 0 | 75 |
| Sync peaks (max. carrier) | –40 | 100 |

**Irrelevancy Reduction:** A method of reducing information where possible, only the relevant part of the information is transmitted. The irrelevancy reduction is irreversible.

**Jerkiness:** The original smooth and continuous motion is perceived as a series of distinct "snapshots".

**Jitter:** Short term variations of the sampling instants from ideal positions in time.

**Lip Synchronization (Lip Sync):** Synchronization of the sound portion (voice) with the visual portion (lip movement) of a video program.

**Luminance Signal:** That portion of video signal which contains the brightness information.

**Mosquito Noise:** Distortion typically localized to moving images within a scene, characterized by shimmering artifacts around edges and blotchy noise patterns superimposed over an object. It is a form of quantizing noise generated from block processing.

**Motion Artifacts:** In a video system, deteriorations of motion video that are caused by compression errors generated by a digital system. Motion artifacts primarily include the following impairments: ***Jerkiness, Blurring and Smearing, Edge Busyness (mosquito noise ), Block Distortion, Error Blocks and Image Persistence.***

**Motion Response Degradation:** The deterioration of motion video such that the received imagery has suffered a loss of spatial–temporal resolution.

**Motion Video:** Video imagery that conveys movement.

**Noise:** An extraneous electrical disturbance tending to interfere with the normal reception of a transmitted signal.

(a) ***Impulse Noise:*** Noise characterized by non–overlapping transient disturbances commonly introduced by mechanical devices such as switches, relays, etc.

(b) ***Random Noise:*** Band−limited noise generated from electron motion within resistive elements of electronic equipment. This noise is developed from a large number of minute current pulses occurring in a completely random sequence. Random noise appears as small gray, black, white or colored dots on the video screen and as a thickening of lines or as very fine spikes on a waveform monitor.

(c) ***Weighted Noise:*** Noise energy that has been shaped to meet the needs of power meters.

(d) ***White Noise:*** Random noise energy with all frequencies present.

**NTSC:** *National Television Systems Committee.* The color television system adopted by this committee is called the NTSC system.

**PAL:** *Phase Alternation Line*. A color television system developed and used in Germany and adopted by a number of other countries for use as a standard.

**Peak:** The highest amplified (point) of a waveform or voltage

**Pel:** see pixel.

**Pixel:** The picture element: one sample of digital picture information; it can refer to one individual example of luminance or Chrominance, or a collection both samples if co−located together producing one picture element.

**POTS:** *Plain Old Telephone Service.*

**Prediction:** The process used (e.g., DPCM) to determine a value from the values of samples that are in close proximity to a sample about to be prefigured (predicted). Sample values can be in horizontal, and/or vertical directions of image movement. Distinctions are made in one, two or three dimensional predictions.

**Pulse Code Modulation:** A method of source coding where the code words are obtained by sampling, quantizing and coding of the analog input signal.

**Quantizing Error/Noise:** Inaccurate digital representations of an analog signal. This error/noise condition occurs during the analog to digital transmission signal processing/conversion stage. Typically, the digital interpretation of video resolution is limited through the digital sampling of the analog video input signal.

**Quantizing:** The process of sampling an analog waveform to convert its voltage levels into digital data.

**Ringing:** is simulated by sharp edges with large color and brightness changes.

**RMS** ***(Root, Mean, Square):*** Measurement of *effective* (as opposed to *peak*) voltage of an AC periodic waveform, through one cycle. A sine wave is .707 times the peak voltage. This calculation is derived by any periodic waveform, it is the square root from the averages of the squares of the values through one cycle.

**Sampling:** A process of obtaining a series of discrete instantaneous values of a signal, usually at regular instants.

**Scene Cuts:** Video imagery where adjacent frames are not highly correlated.

**SECAM:** *Sequentiel Couleurs a Memoire.* A color television system developed and used in France and adopted by a number of other countries as their standard.

**Serial Transmission:** A transmission method of a digitally coded signal where only one single transmission path is used for the time sequential transmission of the code elements representing the code words of a digital signal.

**Signal–to–Noise Ratio (SNR):** Relative power of the signal to the noise in a channel.

**Smearing:** A localized distortion over a sub region of the image, characterized by reduced sharpness of edges and spatial detail.

**Smearing:** Blurring of vertical edges of images in a video picture. Smearing is shot–term streaking.

**Snow:** Light gray, white and dark gray or black spots distributed throughout a television picture. This term is used to indicate that a picture has very high noise degradation.

**Source Coding:** The coding of sample values of a picture signal, usually for the purpose of reducing redundancy and/or entropy of the signal.

**Spatial Application:** An application needing high spatial resolution, possibly at the expense of reduced temporal positioning accuracy (or increased jerkiness). Example spatial applications include the ability to read small characters and see fine detail in still video or motion video which contains a very limited amount of motion.

**Spatial Performance:** A measure of the ability of a video transmission system to accurately reproduce still scenes.

**Staircase Video Waveform:** A waveform consisting of a series of discrete steps resembling a staircase. In practical application, this is combined with blanking and synchronizing pulses.

**Still Video:** Video imagery that does not convey movement.

**Streaking:** A picture condition in which objects appear extended horizontally beyond their normal boundaries, usually seen on the vertical [streaking] outline of moving images within a scene.

**Temporal Application:** An application needing high temporal resolution (or reduced jerkiness), possibly at the expense of reduced spatial resolution. Example temporal applications include the ability to accurately distinguish such items as facial expressions and lip movements in face to face conference room settings – even though this may increase spatial distortion.

**Temporal Performance:** A measure of the ability of a video transmission system to accurately reproduce moving scenes.

**Tiling:** See Block Distortion.

**Transform Coding:** A method of coding a picture by dividing each picture into sub−pictures, performing a linear transform on each sub−picture and then quantizing and coding the resultant coefficients. Example: Discrete Cosine Transform.

**Transmission Service Channel:** A transmission service channel is the one−way transmission path between two designated points (analog in, analog out).

**Truncation:** The removal of lower significant bits, possibly leading to errors or unpleasant artifacts.

**VANDA:** A code word or acronym meaning video and audio combined.

**Variable Word Length Coding:** A technique for reducing the bit rate that exploits the physical properties of the quantized prediction error signal or quantized transform coefficients. This is achieved by assigning a lower number of bits for signal values with high frequency of occurrence and a larger number of bits for signal levels with a low frequency of recurrence.

**Video Teleconferencing/Video Telephony Service (VTC/VT):** The transmission of video signals capable of portraying motion and the accompanying audio signal(s) between two or more locations. typically using digital transmission facilities.

**Video:** The visually displayed images of motion scenes.

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