EG 40-2002

SMPTE ENGINEERING GUIDELINE

Conversion of Time Values Between SMPTE 12M Time Code, MPEG-2 PCR Time Base and Absolute Time

1 Scope

This guideline specifies a set of formulas for converting between SMPTE 12M time code, MPEG-2 systems layer program clock reference (PCR) time base, and absolute time. Included are formulas for converting SMPTE 12M time address values and MPEG-2 PCR time base values to absolute time, and formulas for converting SMPTE 12M time address values directly to/from MPEG-2 PCR time base values. Absolute time conversion formulas may be useful for converting between different frame rates of SMPTE 12M time code; e.g., a 24-fps SMPTE time code running at 23.976 fps could be converted to true time and then to a 29.97 drop frame SMPTE time code value.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this guideline. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this guideline are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

SMPTE 12M-1999, Television, Audio and Film — Time and Control Code

SMPTE 339M-2000, Television — Format for Non-PCM Audio and Data in AES3 — Generic Data Types

ITU-T H.222.0 | ISO/IEC 13818-1, Information Technology — Generic Coding of Moving Pictures and Associated Audio: Systems

3 Arithmetic operators

The arithmetic operators used in the conversion formulas are defined as follows:

+	Addition
–	Subtraction
x	Multiplication
/ or —	Division
%	Modulus operator
int(x)	Largest integer not greater than x
ceil(x)	Smallest integer not less than x

Approved August 5, 2002

4 Basic conversion formulas

The following formulas define the conversion between SMPTE 12M time code time-address values and the MPEG-2 PCR time base values, referred to as PCRtb. The resulting PCR time base value may or may not be equal to the *program clock reference base* (PCRB) counter used in the MPEG-2 transport system; however, it will always be synchronous with the actual PCRB counter, differing by a constant. The formulas given here are limited to the resolution of the PCRB counter that is 1/300 of the MPEG-2 system clock frequency of 27 MHz (i.e., 90 kHz). Conversion to the full PCR counter resolution is not considered in these formulas. Time values are in units of seconds.

4.1 Conversion of SMPTE 12M time-address value to absolute time

These formulas presumes an alignment between midnight (time zero) and time-address 00:00:00:00. For systems with an integer number of frames per day, this alignment may be achieved and maintained. For systems with a noninteger count of frames per day, such as with 29.97-Hz frame rates, there will be a daily phase variation between midnight and time-address 00:00:00:00.

4.1.1 General

$$\text{time} = \left(\frac{\text{frame\_count}}{\text{frame\_rate}} \right)$$

where:

frame_count = total number of elapsed frames since time address 00:00:00:00

4.1.2 23.98... frames/sec non-drop frame

$$\begin{aligned} \text{time} &= \left(\frac{1}{24} \times \frac{1001}{1000} \right) \times (\text{frames} + 24 \times (\text{seconds} + 60 \times (\text{minutes} + 60 \times \text{hours}))) \\ &= \left(\frac{1001}{24{,}000} \right) \times (\text{frames} + 24 \times \text{seconds} + 1440 \times \text{minutes} + 86{,}400 \times \text{hours}) \end{aligned}$$

4.1.3 24 frames/sec

$$\begin{aligned} \text{time} &= \left(\frac{1}{24} \right) \times (\text{frames} + 24 \times (\text{seconds} + 60 \times (\text{minutes} + 60 \times \text{hours}))) \\ &= \left(\frac{1}{24} \right) \times (\text{frames} + 24 \times \text{seconds} + 1440 \times \text{minutes} + 86{,}400 \times \text{hours}) \end{aligned}$$

4.1.4 25 frames/sec

$$\begin{aligned} \text{time} &= \left(\frac{1}{25} \right) \times (\text{frames} + 25 \times (\text{seconds} + 60 \times (\text{minutes} + 60 \times \text{hours}))) \\ &= \left(\frac{1}{25} \right) \times (\text{frames} + 25 \times \text{seconds} + 1500 \times \text{minutes} + 90{,}000 \times \text{hours}) \end{aligned}$$

4.1.5 29.97... frames/sec drop frame

$$\text{time} = \left(\frac{1}{30} \times \frac{1001}{1000}\right) \times \begin{pmatrix} \text{frames} + 30 \times (\text{seconds} + 60 \times (\text{minutes} + 60 \times \text{hours})) \\ -2 \times \text{minutes} + 2 \times (\text{int})\left(\frac{\text{minutes}}{10}\right) - 108 \times \text{hours} \end{pmatrix}$$

$$= \left(\frac{1001}{30{,}000}\right) \times \left(\text{frames} + 30 \times \text{seconds} + 1798 \times \text{minutes} + 2 \times (\text{int})\left(\frac{\text{minutes}}{10}\right) + 107{,}892 \times \text{hours}\right)$$

4.1.6 29.97... frames/sec nondrop frame

$$\text{time} = \left(\frac{1}{30} \times \frac{1001}{1000}\right) \times (\text{frames} + 30 \times (\text{seconds} + 60 \times (\text{minutes} + 60 \times \text{hours})))$$

$$= \left(\frac{1001}{30{,}000}\right) \times (\text{frames} + 30 \times \text{seconds} + 1800 \times \text{minutes} + 108{,}000 \times \text{hours})$$

4.1.7 30 frames/sec

$$\text{time} = \left(\frac{1}{30}\right) \times (\text{frames} + 30 \times (\text{seconds} + 60 \times (\text{minutes} + 60 \times \text{hours})))$$

$$= \left(\frac{1}{30}\right) \times (\text{frames} + 30 \times \text{seconds} + 1800 \times \text{minutes} + 108{,}000 \times \text{hours})$$

4.2 Conversion of absolute time to MPEG-2 PRCtb value

$$\text{PCRtb} = \text{int}(\text{time} \times 90{,}000) \% 2^{33}$$

(Since the PCRtb is based on a 33-bit digital counter and the absolute time value can exceed this limit, a correction has been included that constrains the PCRtb value to 33-bits.)

4.3 Conversion of SMPTE 12M time-address value to MPEG-2 PCRtb

4.3.1 General

$$\text{PCRtb} = \left(\frac{\text{frame\_count}}{\text{frame\_rate}}\right) \times 90{,}000$$

where:

frame_count = total number of elapsed frames since time address 00:00:00:00

4.3.2 23.98... frames/sec nondrop frame

$$\begin{aligned}\text{PCRtb} &= \text{ceil}\left(\frac{1001}{24000}\times 90{,}000\times(\text{frames}+24\times(\text{seconds}+60\times(\text{minutes}+60\times\text{hours})))\right)\\ &= \text{ceil}\left(1001\times\frac{15}{4}\times(\text{frames}+24\times\text{seconds}+1440\times\text{minutes}+86{,}400\times\text{hours})\right)\\ &= \text{ceil}\left(1001\times\frac{15}{4}\times\text{frames}\right)+90{,}090\times\text{seconds}+5{,}405{,}400\times\text{minutes}+324{,}324{,}000\times\text{hours}\end{aligned}$$

4.3.3 24 frames/sec

$$\begin{aligned}\text{PCRtb} &= 3750\times(\text{frames}+24\times(\text{seconds}+60\times(\text{minutes}+60\times\text{hours})))\\ &= 3750\times(\text{frames}+24\times\text{seconds}+1440\times\text{minutes}+86{,}400\times\text{hours})\\ &= 3750\times\text{frames}+90{,}000\times\text{seconds}+5{,}400{,}000\times\text{minutes}+324{,}000{,}000\times\text{hours}\end{aligned}$$

4.3.4 25 frames/sec

$$\begin{aligned}\text{PCRtb} &= 3600\times(\text{frames}+25\times(\text{seconds}+60\times(\text{minutes}+60\times\text{hours})))\\ &= 3600\times(\text{frames}+25\times\text{seconds}+1500\times\text{minutes}+90{,}000\times\text{hours})\\ &= 3600\times\text{frames}+90{,}000\times\text{seconds}+5{,}400{,}000\times\text{minutes}+324{,}000{,}000\times\text{hours}\end{aligned}$$

4.3.5 29.97... frames/sec drop frame

$$\begin{aligned}\text{PCRtb} &= 3003\times\left(\begin{array}{l}\text{frames}+30\times(\text{seconds}+60\times(\text{minutes}+60\times\text{hours}))\\ -2\times\text{minutes}+2\times\text{int}\left(\frac{\text{minutes}}{10}\right)-108\times\text{hours}\end{array}\right)\\ &= 3003\times\left(\text{frames}+30\times\text{seconds}+1798\times\text{minutes}+2\times\text{int}\left(\frac{\text{minutes}}{10}\right)+107{,}892\times\text{hours}\right)\\ &= 3003\times\text{frames}+90{,}090\times\text{seconds}+5{,}399{,}394\times\text{minutes}\\ &\quad+6006\times\text{int}\left(\frac{\text{minutes}}{10}\right)+323{,}999{,}676\times\text{hours}\end{aligned}$$

4.3.6 29.97... frames/sec nondrop frame

$$\begin{aligned}\text{PCRtb} &= 3003\times(\text{frames}+30\times(\text{seconds}+60\times(\text{minutes}+60\times\text{hours})))\\ &= 3003\times(\text{frames}+30\times\text{seconds}+1800\times\text{minutes}+108{,}000\times\text{hours})\\ &= 3003\times\text{frames}+90{,}090\times\text{seconds}+5{,}405{,}400\times\text{minutes}+324{,}324{,}000\times\text{hours}\end{aligned}$$

4.3.7 30 frames/sec

$$\begin{aligned}\text{PCRtb} &= 3000\times(\text{frames}+30\times(\text{seconds}+60\times(\text{minutes}+60\times\text{hours})))\\ &= 3000\times(\text{frames}+30\times\text{seconds}+1800\times\text{minutes}+108{,}000\times\text{hours})\\ &= 3000\times\text{frames}+90{,}000\times\text{seconds}+5{,}400{,}000\times\text{minutes}+324{,}000{,}000\times\text{hours}\end{aligned}$$

4.4 Conversion of MPEG-2 PCRtb value to absolute time

$$\text{time}=\left(\frac{\text{PCRtb}}{90{,}000}\right)$$

4.5 Conversion of absolute time to SMTPE 12M time-address value

4.5.1 General

$$\begin{aligned}\text{frame\_count} &= \text{int}(\text{frame\_rate}\times\text{time})\\ \text{hours} &= \text{int}\left(\frac{\text{frame\_count}}{\text{frame\_rate}\times 60\times 60}\right)\%24\\ \text{minutes} &= \text{int}\left(\frac{\text{frame\_count}-\text{frame\_rate}\times 60\times 60\times\text{hours}}{\text{frame\_rate}\times 60}\right)\\ \text{seconds} &= \text{int}\left(\frac{\text{frame\_count}-\text{frame\_rate}\times 60\times(\text{minutes}+60\times\text{hours})}{\text{frame\_rate}}\right)\\ \text{frames} &= \text{frame\_count}-\text{frame\_rate}\times(\text{seconds}+60\times(\text{minutes}+60\times\text{hours}))\end{aligned}$$

(Since the absolute time value can exceed 24 hours, while values of SMPTE 12M time-address must be constrained to be < 24 hours, a correction has been included in the following formulas that generate the hours values.)

4.5.2 23.98... frames/sec non-drop frame

$$\text{frame\_count} = \text{int}\left(24 \times \frac{1000}{1001} \times \text{time}\right)$$

$$\text{hours} = \text{int}\left(\frac{\text{frame\_count}}{24 \times 60 \times 60}\right) \% 24 = \text{int}\left(\frac{\text{frame\_count}}{86{,}400}\right) \% 24$$

$$\text{minutes} = \text{int}\left(\frac{\text{frame\_count} - 24 \times 60 \times 60 \times \text{hours}}{24 \times 60}\right) = \text{int}\left(\frac{\text{frame\_count} - 86{,}400 \times \text{hours}}{1440}\right)$$

$$\text{seconds} = \text{int}\left(\frac{\text{frame\_count} - 24 \times 60 \times (\text{minutes} + 60 \times \text{hours})}{24}\right)$$

$$= \text{int}\left(\frac{\text{frame\_count} - 24 \times 60 \times \text{minutes} - 24 \times 60 \times 60 \times \text{hours}}{24}\right)$$

$$= \text{int}\left(\frac{\text{frame\_count} - 1440 \times \text{minutes} - 86{,}400 \times \text{hours}}{24}\right)$$

$$\text{frames} = \text{frame\_count} - 24 \times (\text{seconds} + 60 \times (\text{minutes} + 60 \times \text{hours}))$$

$$= \text{frame\_count} - 24 \times \text{seconds} - 24 \times 60 \times \text{minutes} - 24 \times 60 \times 60 \times \text{hours}$$

$$= \text{frame\_count} - 24 \times \text{seconds} - 1440 \times \text{minutes} - 86{,}400 \times \text{hours}$$

4.5.3 24 frames/sec

$$\text{frame\_count} = \text{int}(24 \times \text{time})$$

$$\text{hours} = \text{int}\left(\frac{\text{frame\_count}}{24 \times 60 \times 60}\right) \% 24 = \text{int}\left(\frac{\text{frame\_count}}{86{,}400}\right) \% 24$$

$$\text{minutes} = \text{int}\left(\frac{\text{frame\_count} - 24 \times 60 \times 60 \times \text{hours}}{24 \times 60}\right) = \text{int}\left(\frac{\text{frame\_count} - 86{,}400 \times \text{hours}}{1440}\right)$$

$$\text{seconds} = \text{int}\left(\frac{\text{frame\_count} - 24 \times 60 \times (\text{minutes} + 60 \times \text{hours})}{24}\right)$$

$$= \text{int}\left(\frac{\text{frame\_count} - 24 \times 60 \times \text{minutes} - 24 \times 60 \times 60 \times \text{hours}}{24}\right)$$

$$= \text{int}\left(\frac{\text{frame\_count} - 1440 \times \text{minutes} - 86{,}400 \times \text{hours}}{24}\right)$$

$$\text{frames} = \text{frame\_count} - 24 \times (\text{seconds} + 60 \times (\text{minutes} + 60 \times \text{hours}))$$

$$= \text{frame\_count} - 24 \times \text{seconds} - 24 \times 60 \times \text{minutes} - 24 \times 60 \times 60 \times \text{hours}$$

$$= \text{frame\_count} - 24 \times \text{seconds} - 1440 \times \text{minutes} - 86{,}400 \times \text{hours}$$

4.5.4 25 frames/sec

$$\text{frame\_count} = \text{int}(25 \times \text{time})$$

$$\text{hours} = \text{int}\left(\frac{\text{frame\_count}}{25 \times 60 \times 60}\right)\%24 = \text{int}\left(\frac{\text{frame\_count}}{90{,}000}\right)\%24$$

$$\text{minutes} = \text{int}\left(\frac{\text{frame\_count} - 25 \times 60 \times 60 \times \text{hours}}{25 \times 60}\right) = \text{int}\left(\frac{\text{frame\_count} - 90{,}000 \times \text{hours}}{1500}\right)$$

$$\text{seconds} = \text{int}\left(\frac{\text{frame\_count} - 25 \times 60 \times (\text{minutes} + 60 \times \text{hours})}{25}\right)$$

$$= \text{int}\left(\frac{\text{frame\_count} - 25 \times 60 \times \text{minutes} - 25 \times 60 \times 60 \times \text{hours}}{25}\right)$$

$$= \text{int}\left(\frac{\text{frame\_count} - 1500 \times \text{minutes} - 90{,}000 \times \text{hours}}{25}\right)$$

$$\text{frames} = \text{frame\_count} - 25 \times (\text{seconds} + 60 \times (\text{minutes} + 60 \times \text{hours}))$$

$$= \text{frame\_count} - 25 \times \text{seconds} - 25 \times 60 \times \text{minutes} - 25 \times 60 \times 60 \times \text{hours}$$

$$= \text{frame\_count} - 25 \times \text{seconds} - 1500 \times \text{minutes} - 90{,}000 \times \text{hours}$$

4.5.5 29.97... frames/sec drop frame

$$\text{frame\_count} = \text{int}\left(30 \times \frac{1000}{1001} \times \text{time}\right)$$

$$\text{hours} = \text{int}\left(\frac{\text{frame\_count}}{30 \times 60 \times 60 - 108}\right) \%24 = \text{int}\left(\frac{\text{frame\_count}}{107{,}892}\right) \%24$$

$$\text{minutes} = \text{int}\left(\frac{1}{1800} \times \left(\begin{array}{l}\text{frame\_count} + 2 \times \text{int}\left(\dfrac{\text{frame\_count} - (107{,}892 \times \text{hours})}{1800}\right) \\ - 2 \times \text{int}\left(\dfrac{\text{frame\_count} - (107{,}892 \times \text{hours})}{18{,}000}\right) - 107{,}892 \times \text{hours}\end{array}\right)\right)$$

$$\text{seconds} = \text{int}\left(\frac{1}{30} \times \left(\begin{array}{l}\text{frame\_count} - 30 \times 60 \times (\text{minutes} + 60 \times \text{hours}) \\ + 2 \times \text{minutes} - 2\,\text{x}\,\text{int}\left(\dfrac{\text{minutes}}{10}\right) + 108 \times \text{hours}\end{array}\right)\right)$$

$$= \text{int}\left(\frac{1}{30} \times \left(\begin{array}{l}\text{frame\_count} - (30 \times 60 - 2) \times \text{minutes} - 2 \times \text{int}\left(\dfrac{\text{minutes}}{10}\right) \\ - (30 \times 60 \times 60 - 108) \times \text{hours}\end{array}\right)\right)$$

$$= \text{int}\left(\frac{1}{30} \times \left(\text{frame\_count} - 1798 \times \text{minutes} - 2 \times \text{int}\left(\frac{\text{minutes}}{10}\right) - 107{,}892 \times \text{hours}\right)\right)$$

$$\text{frames} = \text{frame\_count} - 30 \times (\text{seconds} + 60 \times (\text{minutes} + 60 \times \text{hours}))$$
$$+ 2 \times \text{minutes} - 2 \times \text{int}\left(\frac{\text{minutes}}{10}\right) + 180 \times \text{hours}$$

$$= \text{frame\_count} - 30 \times \text{seconds} + (30 \times 60 - 2) \times \text{minutes} - 2 \times \text{int}\left(\frac{\text{minutes}}{10}\right)$$
$$- (30 \times 60 \times 60 - 180) \times \text{hours}$$

$$= \text{frame\_count} - 30 \times \text{seconds} - 1798 \times \text{minutes} - 2 \times \text{int}\left(\frac{\text{minutes}}{10}\right) - 107{,}892 \times \text{hours}$$

4.5.6 29.97... frames/sec nondrop frame

$$\text{frame\_count} = \text{int}\left(30 \times \frac{1000}{1001} \times \text{time}\right)$$

$$\text{hours} = \text{int}\left(\frac{\text{frame\_count}}{30 \times 60 \times 60}\right) \%24 = \text{int}\left(\frac{\text{frame\_count}}{108{,}000}\right) \%24$$

$$\text{minutes} = \text{int}\left(\frac{\text{frame\_count} - 30 \times 60 \times 60 \times \text{hours}}{30 \times 60}\right) = \text{int}\left(\frac{\text{frame\_count} - 108{,}000 \times \text{hours}}{1800}\right)$$

$$\text{seconds} = \text{int}\left(\frac{\text{frame\_count} - 30 \times 60 \times (\text{minutes} + 60 \times \text{hours})}{30}\right)$$

$$= \text{int}\left(\frac{\text{frame\_count} - 30 \times 60 \times \text{minutes} - 30 \times 60 \times 60 \times \text{hours}}{30}\right)$$

$$= \text{int}\left(\frac{\text{frame\_count} - 1800 \times \text{minutes} - 108{,}000 \times \text{hours}}{30}\right)$$

$$\text{frames} = \text{frame\_count} - 30 \times (\text{seconds} + 60 \times (\text{minutes} + 60 \times \text{hours}))$$

$$= \text{frame\_count} - 30 \times \text{seconds} - 30 \times 60 \times \text{minutes} - 30 \times 60 \times 60 \times \text{hours}$$

$$= \text{frame\_count} - 30 \times \text{seconds} - 1800 \times \text{minutes} - 108{,}000 \times \text{hours}$$

4.5.7 30 frames/sec

$$\text{frame\_count} = \text{int}(30 \times \text{time})$$

$$\text{hours} = \text{int}\left(\frac{\text{frame\_count}}{30 \times 60 \times 60}\right) \%24 = \text{int}\left(\frac{\text{frame\_count}}{108{,}000}\right) \%24$$

$$\text{minutes} = \text{int}\left(\frac{\text{frame\_count} - 30 \times 60 \times 60 \times \text{hours}}{30 \times 60}\right) = \text{int}\left(\frac{\text{frame\_count} - 108{,}000 \times \text{hours}}{1800}\right)$$

$$\text{seconds} = \text{int}\left(\frac{\text{frame\_count} - 30 \times 60 \times (\text{minutes} + 60 \times \text{hours})}{30}\right)$$

$$= \text{int}\left(\frac{\text{frame\_count} - 30 \times 60 \times \text{minutes} - 30 \times 60 \times 60 \times \text{hours}}{30}\right)$$

$$= \text{int}\left(\frac{\text{frame\_count} - 1800 \times \text{minutes} - 108{,}000 \times \text{hours}}{30}\right)$$

$$\text{frames} = \text{frame\_count} - 30 \times (\text{seconds} + 60 \times (\text{minutes} + 60 \times \text{hours}))$$

$$= \text{frame\_count} - 30 \times \text{seconds} - 30 \times 60 \times \text{minutes} - 30 \times 60 \times 60 \times \text{hours}$$

$$= \text{frame\_count} - 30 \times \text{seconds} - 1800 \times \text{minutes} - 108{,}000 \times \text{hours}$$

4.6 Conversion of MPEG-2 PCRtb value to SMPTE 12M time-address value

4.6.1 General

$$\text{frame\_count} = \text{int}\left(\frac{\text{frame\_rate} \times \text{PCRtb}}{90{,}000} \right)$$

Calculate hours, minutes, seconds, and frames as per formulas in section 4.5.1.

4.6.2 23.98... frames/sec nondrop frame

$$\text{frame\_count} = \text{int}\left(24 \times \frac{1000}{1001} \times \frac{\text{PCRtb}}{90{,}000} \right) = \text{int}\left(\frac{4}{15} \times \frac{\text{PCRtb}}{1001} \right)$$

Calculate hours, minutes, seconds, and frames as per formulas in section 4.5.2.

4.6.3 24 frames/sec

$$\text{frame\_count} = \text{int}\left(\frac{24 \times \text{PCRtb}}{90{,}000} \right) = \text{int}\left(\frac{\text{PCRtb}}{3750} \right)$$

Calculate hours, minutes, seconds, and frames as per formulas in section 4.5.3.

4.6.4 25 frames/sec

$$\text{frame\_count} = \text{int}\left(\frac{25 \times \text{PCRtb}}{90{,}000} \right) = \text{int}\left(\frac{\text{PCRtb}}{3600} \right)$$

Calculate hours, minutes, seconds, and frames as per formulas in section 4.5.4.

4.6.5 29.97... frames/sec drop frame

$$\text{frame\_count} = \text{int}\left(30 \times \frac{1000}{1001} \times \frac{\text{PCRtb}}{90{,}000} \right) = \text{int}\left(\frac{\text{PCRtb}}{3003} \right)$$

Calculate hours, minutes, seconds, and frames as per formulas in section 4.5.5.

4.6.6 29.97... frames/sec nondrop frame

$$\text{frame\_count} = \text{int}\left(30 \times \frac{1000}{1001} \times \frac{\text{PCRtb}}{90{,}000} \right) = \text{int}\left(\frac{\text{PCRtb}}{3003} \right)$$

Calculate hours, minutes, seconds, and frames as per formulas in section 4.5.6.

4.6.7 30 frames/sec

$$\text{frame\_count} = \text{int}\left(\frac{30 \times \text{PCRtb}}{90{,}000}\right) = \text{int}\left(\frac{\text{PCRtb}}{3000}\right)$$

Calculate hours, minutes, seconds, and frames as per formulas in section 4.6.7.

5 Conversion formulas with audio sample number extension

For time stamped audio elementary streams (SMPTE 339M), a time stamp value may contain a sample number extension to the SMPTE 12M time-address value. The sample number indicates which specific audio sample, relative to the start of the audio frame, aligns with the given 12M time-address value. This allows accurate calculation of an MPEG PCRtb value that matches the first sample of the audio frame.

The following formulas indicate modifications to the above conversion formulas when the sample number extension is factored into the calculations. The formulas assume an audio sample rate of 48 kHz for all video frame rates. The result of the calculations is a PCRtb value that corresponds to the time of the first sample in the audio frame (or audio access unit).

5.1.1 Conversion of SMPTE 12M time-address value with sample number to absolute time

Calculate time1 based on the formulas in section 4.1. Calculate a new time value that adjusts for the sample number value as follows:

$$\text{time} = \text{time1} - \left(\frac{1}{48{,}000}\right) \times \text{sample\_number}$$

The above conversion is valid for time code values greater than 00:00:00:00.

5.1.2 Conversion of SMPTE 12M time-address value with sample number to MPEG-2 PCRtb value

Calculate PCRtb1 based on the formulas in section 4.3. Calculate a new PCRtb value that adjusts for the sample number value as follows:

$$\text{PCRtb} = \text{int}\left(\text{PCRtb1} - \left(\frac{15}{8} \times \text{sample\_number}\right)\right)$$

The above conversion is valid for time code values greater than 00:00:00:00.

5.1.2.1 29.97... frame rate

For the 29.97 frame rate (drop frame or nondrop frame) the noninteger relationship between audio samples and video frames (8008 samples over 5 frames) will result in a slight discrepancy in the calculated value of PCRtb depending on the phasing of audio samples within a given frame. In most applications this discrepancy is negligible, however should a precise calculation be required the following formulas can be applied:

$$\text{PCRtb} = \text{int}\left(\text{PCRtb1} + \text{FFoffset} - \left(\frac{15}{8} \times \text{sample\_number}\right)\right)$$

where the value of FFoffset (Five Frame offset) is determined as follows:

```
if ((frame_count % 5) == 1)  {FFoffset = -1.125}
else if ((frame_count % 5) == 2)  {FFoffset = -0.375}
else if ((frame_count % 5) == 3)  {FFoffset = -1.5}
else if ((frame_count % 5) == 4)  {FFoffset = -0.75}
else  {FFoffset = 0.0}
```

The above offsets assume an alignment of audio samples and PCR values at time address 00:00:00:00. The conversion is valid for time code values greater than 00:00:00:00.

5.1.3 Conversion of absolute time to SMTPE 12M time-address value with sample number

Calculate a 12M_time_address1 value following the formulas in section 4.5. Calculate the final value of 12M_time_address and sample_number with the formulas below.

$$\text{if } \left(\text{time} - \left(\frac{\text{frame\_count}}{\text{frame\_rate}} \right) \right) == 0$$

{

sample_number = 0

}

else

{

$$12\,\text{M\_time\_address} = 12\,\text{M\_time\_address1} + 1\,\text{frame}$$

$$\text{sample\_number} = \text{int}\left(\frac{8}{15} \times \left(\left(\frac{\text{frame\_count} + 1}{\text{frame\_rate}} \right) - \text{time} \right) \right)$$

}

The above conversion is valid for time values within the first 24 hour time period relative to the corresponding time code (e.g., < 86,400 seconds for 30-Hz frame rate).

5.1.4 Conversion of MPEG-2 PCRtb value to SMPTE 12M time-address value with sample number

Calculate a 12M_time_address1 value following the formulas in section 4.6. Calculate the final value of 12M_time_address and sample_number with the formulas below.

```
if (PCRtb - (frame_count * (90,000/frame_rate)) == 0)
{
        sample_number = 0
}
else
{
```

$$12\,\text{M\_time\_address} = 12\,\text{M\_time\_address1} + 1\,\text{frame}$$

$$\text{sample\_number} = \text{int}\left(\frac{8}{15} \times \left(\frac{90{,}000 \times (\text{frame\_count} + 1)}{\text{frame\_rate}} - \text{PCRtb}\right)\right)$$

}

The above conversion is valid for PCR values within the first 24 hour time period relative to the corresponding time code (e.g., < 7,776,000,000 for 30-Hz frame rate).

5.1.4.1 29.97... frame rate

For the 29.97 frame rate (drop frame or nondrop frame) the noninteger relationship between audio samples and video frames (8008 samples over 5 frames) will result in a slight discrepancy in the calculated value of the sample number depending on the phasing of audio samples within a given frame. In most applications this discrepancy is negligible; however, should a precise calculation be required, the following formulas can be applied:

if (PCRtb - ((frame_count/5) * 15015) == 0)

{

sample_number = 0;

}

else

{

$$12\,\text{M\_time\_address} = 12\,\text{M\_time\_address1} + 1\,\text{frame}$$

$$\text{sample\_number} = \text{int}\left(\frac{8}{15} \times ((3003 \times (\text{frame\_count} + 1)) - \text{PCRtb} + \text{FFoffset})\right)$$

if (sample_number < 0)

{

sample_number += 1602

12M_time_address = 12M_time_address + 1 frame

}

}

where the value of FFoffset (Five Frame offset) is as defined in section 5.1.2.1.

The above offsets assume an alignment of audio samples and PCR values at time address 00:00:00:00. The above conversion is valid for PCR values within the first 24 hour time period relative to the corresponding time code.

5.1.4.2 23.98... frame rate

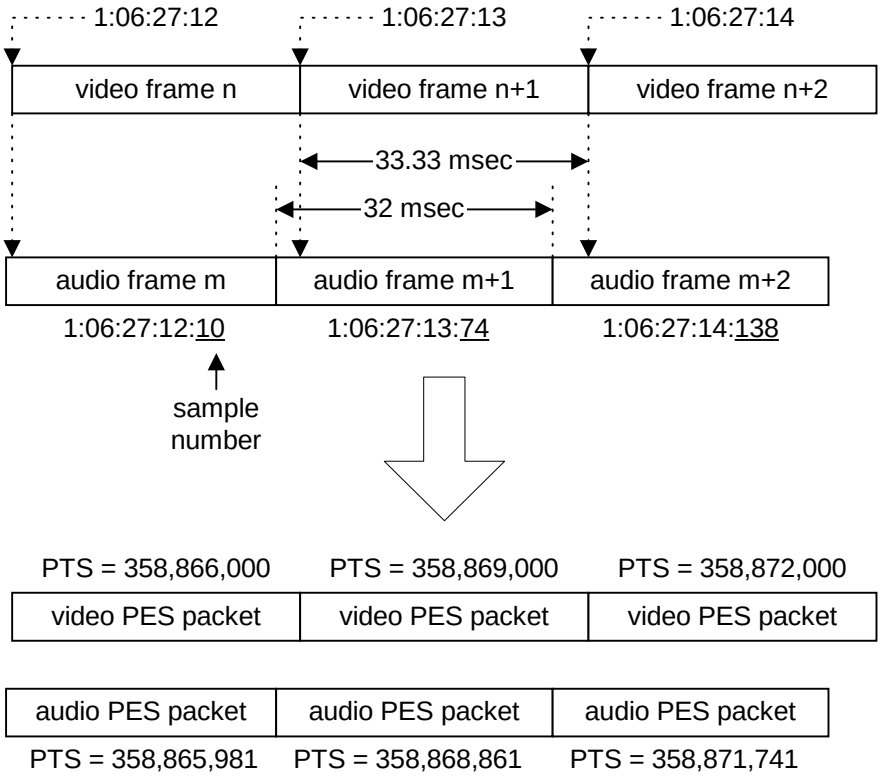
For the 23.98 frame rate, the noninteger relationship between audio samples and video frames (8008 samples over 4 frames) will result in a slight discrepancy in the calculated value of the sample number depending on the phasing of audio samples within a given frame. In most applications, this discrepancy is negligible; however, should a precise calculation be required, the following formulas can be applied:

```
if (PCRtb - ((frame_count/4) * 15,015) == 0)
{
        sample_number = 0;
}
else
{
        12 M_time_ address = 12 M_time_ address1 + 1 frame
        sample_number = int( 8/15 × ((3753.75 × (frame_count+1)) – PCRtb) )
}
```

The above offsets assume an alignment of audio samples and PCR values at time address 00:00:00:00. The above conversion is valid for PCR values within the first 24 hour time period relative to the corresponding time code.

Annex A (informative)
Example

The following shows example conversion calculations for a series of audio and video frames that are converted to/from MPEG-2 program elementary stream (PES) packets, each containing a presentation time stamp (PTS). This example assumes a video frame rate of 30 frames/sec and an audio frame size of 1536 samples at a 48 kHz sampling rate.



12M time code to MPEG-2 PCR time base conversion

video frame n time_code = 1:06:27:12
PCRtb = 3000 x 12 + 90,000 x 27 + 5,400,000 x 6 + 324,000,000 x 1
= 358,866,000
audio frame m time_code = 1:06:27:12:10
PCRtb = int(358,866,000 - (15/8 x 10)) = int(358,865,981.25)
= 358,865,981
video frame n+1 time_code = 1:06:27:13
PCRtb = 3000 x 13 + 90,000 x 27 + 5,400,000 x 6 + 324,000,000 x 1
= 358,869,000
audio frame m+1 time_code = 1:06:27:12:74
PCRtb = int(358,869,000 - (15/8 x 74)) = int(358,868,861.25)
= 358,868,861
video frame n+2 time_code = 1:06:27:14
PCRtb = 3000 x 14 + 90,000 x 27 + 5,400,000 x 6 + 324,000,000 x 1
= 358,872,000
audio frame m+2 time_code = 1:06:27:12:138
PCRtb = int(358,872,000 - (15/8 x 138)) = int(358,871,741.25)
= 358,871,741

MPEG-2 PCR time base to 12M time code conversion

video frame n PTS = PCRtb = 358,866,000
frame_count = int(358,866,000 / 3000) = 119,622
hours = int(119,622 / 108,000)%24 = int(1.11) %24 = 1
minutes = int((119,622 - 108,000 x 1) / 1800) = int(11,622 / 1800) = int(6.46) = 6
seconds = int((119,622 - 1800 x 6 - 108,000 x 1) / 30) = int(822 / 30) = int(27.4) = 27
frames = 119,622 - 30 x 27 - 1800 x 6 - 108,000 x 1 = 12
audio frame m PTS = PCRtb = 358,865,981
frame_count = int(358,865,981 / 3000) = int(119,621.99) = 119621
hours = int(119,621 / 108,000) %24 = int(1.11) %24 = 1
minutes = int((119,621 - 108,000 x 1) / 1800) = int(11,621 / 1800) = int(6.46) = 6
seconds = int((119,621 - 1800 x 6 - 108,000 x 1) / 30) = int(821 / 30) = int(27.36) = 27
frames = 119,621 - 30 x 27 - 1800 x 6 - 108,000 x 1 = 11 time_code = 1:06:27:11 + 1frame = 1:06:27:12
sample_number = int(8/15 x ((3000 x 119,621) - 358,865,981 + 3000))
= int(8/15 x 19) = int(10.1) = 10
video frame n+1 PTS = PCRtb = 358,869,000
frame_count = int(358,869,000 / 3000) = 119,623
hours = int(119,623 / 108,000) %24 = int(1.11) %24 = 1
minutes = int((119,623 - 108,000 x 1) / 1800) = int(11,623 / 1800) = int(6.46) = 6
seconds = int((119,623 - 1800 x 6 - 108,000 x 1) / 30) = int(823 / 30) = int(27.43) = 27
frames = 119623 - 30 x 27 - 1800 x 6 - 108,000 x 1 = 13
audio frame m+1 PTS = PCRtb = 358,868,861
frame_count = int(358,868,861 / 3000) = int(119,622.95) = 119,622
hours = int(119,622 / 108,000) %24 = int(1.11) %24 = 1
minutes = int((119,622 - 108,000 x 1) / 1800) = int(11,622 / 1800) = int(6.46) = 6

seconds = int((119,622 - 1800 x 6 - 108,000 x 1) / 30) = int(822 / 30) = int(27.4) = 27

frames = 119,622 - 30 x 27 - 1800 x 6 - 108,000 x 1 = 12

time_code = 1:06:27:12 + 1frame = 1:06:27:13

sample_number = int(8/15 x ((3000 x 119,622) - 358,868,861 + 3000))

= int(8/15 x 139) = int(74.1) = 74

video frame n+2 PTS = PCRtb = 358,872,000

frame_count = int(358,872,000 / 3000) = 119,624

hours = int(119,624 / 108,000) %24 = int(1.11) %24 = 1

minutes = int((119,624 - 108,000 x 1) / 1800) = int(11,624 / 1800) = int(6.46) = 6

seconds = int((119,624 - 1800 x 6 - 108,000 x 1) / 30) = int(824 / 30) = int(27.47) = 27

frames = 119,624 - 30 x 27 - 1800 x 6 - 108,000 x 1 = 14

audio frame m+2 PTS = PCRtb = 358,871,741

frame_count = int(358,871,741 / 3000) = int(119,623.91) = 119,623

hours = int(119,623 / 108,000) %24 = int(1.11) %24 = 1

minutes = int((119,623 - 108,000 x 1) / 1800) = int(11,623 / 1800) = int(6.46) = 6

seconds = int((119,623 - 1800 x 6 - 108,000 x 1) / 30) = int(823 / 30) = int(27.43) = 27

frames = 119,623 - 30 x 27 - 1800 x 6 - 108,000 x 1 = 13

time_code = 1:06:27:13 + 1frame = 1:06:27:14

sample_number = int(8/15 x ((3000 x 119,623) - 358,871,741 + 3000))

= int(8/15 x 259) = int(138.1) = 138

Annex B (informative)
Bibliography

SMPTE 170M-1999, Television — Composite Analog Video Signal — NTSC for Studio Applications

ITU-R BT.470-6 (11/98) — Conventional Television Systems