

SMPTE ENGINEERING GUIDELINE

Conversion of Time Values Between SMPTE 12-1 Time Code, MPEG-2 PCR Time Base and Absolute Time



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Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally-recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE's Engineering Documents, including Standards, Recommended Practices, and Engineering Guidelines, are prepared by SMPTE's Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU.

SMPTE Engineering Documents are drafted in accordance with the rules given in Part XIII of its Operations Manual.

SMPTE EG 40 was prepared by Technology Committee 33TS.

Introduction

This section is entirely informative and does not form an integral part of this Engineering Document.

This Engineering Guideline provides a set of formulas for common time related conversions in the hope that implementers will do these calculations in a similar and interoperable manner.

An earlier revision of this document used the term "absolute time" to refer to time that may be more clearly termed "local wall clock time." This is the time of day in the local time zone typically measured by "the clock on the wall" and not necessarily tightly tied to an International standardized time reference (UTC, GPS, etc.).

Other SMPTE Engineering documents may provide for defined calculations to convert "local wall clock time" to an International standardized time reference (UTC, GPS, etc.).

1 Scope

This guideline specifies a set of formulas for converting between “SMPTE 12M time code” (correctly SMPTE ST 12-1 time code), MPEG-2 systems layer program clock reference (PCR) time base, and local wall clock time. Included are formulas for converting SMPTE ST 12-1 time address values and MPEG-2 PCR time base values to local wall clock time, and formulas for converting SMPTE ST 12-1 time address values directly to/from MPEG-2 PCR time base values. Local wall clock time conversion formulas are useful for converting between different frame rates of SMPTE ST 12-1 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. Finally, a discussion of how ST 12-1 time code may be carried within the coded video structures of both MPEG-2 and MPEG-4 AVC is provided.

2 Informative References

Note: All references in this document to other SMPTE documents use the current numbering style (e.g. SMPTE ST 12-1:2008) although, during a transitional phase, the document as published (printed or PDF) may bear an older designation (such as SMPTE 12M-1-2008). Documents with the same root number (e.g. 12-1) and publication year (e.g. 2008) are functionally identical.

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 ST 12-1:2008, Television — Time and Control Code

SMPTE ST 339:2008, Format for Non-PCM Audio and Data in AES3 — Generic Data Types

Recommendation ITU-T H.222.0 | ISO/IEC 13818-1, Information Technology — Generic Coding of Moving Pictures and Associated Audio: Systems, (2007)

Recommendation ITU-T H.262 | ISO/IEC 13818-2, Information Technology — Generic Coding of Moving Pictures and Associated Audio: Video, (2000)

Recommendation ITU-T H.264 | ISO/IEC 14496-10, Information technology — Coding of audio-visual objects — Part 10: Advanced Video Coding, (2010)

3 Definitions and Acronyms

local wall clock time: This is the time of day in the local time zone typically measured by “the clock on the wall” and not necessarily tightly tied to an International standardized time reference (UTC, GPS, etc.).

AVC: An abbreviation for Advanced Video Coding, documented in ISO/IEC 14496-10.

GPS: An abbreviation for Global Positioning System.

MPEG-2: A suite of standards distributed as parts under the identifier ISO/IEC 13818. Part 1 is MPEG-2 Systems. Part 2 is MPEG-2 visual (video coding).

MPEG-4: A suite of standards distributed as parts under the identifier ISO/IEC 14496. Part 2 is MPEG-4 visual. Part 10 is AVC.

PCR: An abbreviation for Program Clock Reference. (Note: See ISO/IEC 13818-1.)

UTC: An abbreviation for Coordinated Universal Time.

WWV: The call sign of the United States National Institute of Standards and Technology's (NIST) HF ("shortwave") radio station in Fort Collins, Colorado.

4 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

5 Basic Conversion Formulas

The following formulas define the conversion between SMPTE ST 12-1 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.

This document does not account for the existence of frame rates greater than 30 Hz. Section 12 of SMPTE ST 12-1 provides the necessary constraints for utilization of SMPTE ST 12-1 time code time-address values with 50-Hz and 60-Hz progressive scanning systems. The reader is cautioned that many applications of this guideline may require attention to video system frame rate before doing a calculation related to time code.

The reader's attention is called to the discussion regarding the required precision of these calculations which is found in the second "Note" within Section 5.1.2 of SMPTE ST 12-1.

5.1 Conversion of SMPTE ST 12-1 Time-Address Value to Local Wall Clock Time

These formulas presume 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.

5.1.1 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

5.1.2 23.98... frames/sec non-drop frame

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

5.1.3 24 frames/sec

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

5.1.4 25 frames/sec

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

5.1.5 29.97... frames/sec drop frame

$$\begin{aligned}\text{time} &= \left(\frac{1}{30} \times \frac{1001}{1000} \right) \times \left(\text{frames} + 30 \times (\text{seconds} + 60 \times (\text{minutes} + 60 \times \text{hours}))) \right. \\ &\quad \left. - 2 \times \text{minutes} + 2 \times \left(\text{int} \left(\frac{\text{minutes}}{10} \right) - 108 \times \text{hours} \right) \right) \\ &= \left(\frac{1001}{30,000} \right) \times \left(\text{frames} + 30 \times \text{seconds} + 1798 \times \text{minutes} + 2 \times \left(\text{int} \left(\frac{\text{minutes}}{10} \right) - 108 \times \text{hours} \right) \right)\end{aligned}$$

5.1.6 29.97... frames/sec nondrop frame

$$\begin{aligned}\text{time} &= \left(\frac{1}{30} \times \frac{1001}{1000} \right) \times (\text{frames} + 30 \times (\text{seconds} + 60 \times (\text{minutes} + 60 \times \text{hours}))) \\ &= \left(\frac{1001}{30,000} \right) \times (\text{frames} + 30 \times \text{seconds} + 1800 \times \text{minutes} + 108,000 \times \text{hours})\end{aligned}$$

5.1.7 30 frames/sec

$$\begin{aligned}\text{time} &= \left(\frac{1}{30}\right) \times (\text{frames} + 30 \times (\text{seconds} + 60 \times (\text{minutes} + 60 \times \text{hours}))) \\ &= \left(\frac{1}{30}\right) \times (\text{frames} + 30 \times \text{seconds} + 1800 \times \text{minutes} + 108,000 \times \text{hours})\end{aligned}$$

5.2 Conversion of Local Wall Clock Time to MPEG-2 PCRtb 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 local wall clock time value can exceed this limit, a correction has been included that constrains the PCRtb value to 33-bits.)

5.3 Conversion of SMPTE ST 12-1 Time-Address Value to MPEG-2 PCRtb

5.3.1 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

Note: In the formulas below, 3750 = 90,000 ÷ 24 and 3600 = 90,000 ÷ 25.

5.3.2 23.98... frame/sec nondrop frame

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

5.3.3 24 frames/sec

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

5.3.4 25 frames/sec

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

5.3.5 29.97... frames/sec drop frame

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

5.3.6 29.97...frames/sec nondrop frame

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

5.3.7 30 frames/sec

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

5.4 Conversion of MPEG-2 PCRtb Value to Local Wall Clock Time

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