

SMPTE RECOMMENDED PRACTICE

Production Timing and
Synchronization for Stereoscopic
(S3D) or Multi-Camera Array



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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 its Standards Operations Manual.

SMPTE RP 2076-1 was prepared by Technology Committee 32NF.

Intellectual Property

At the time of publication no notice had been received by SMPTE claiming patent rights essential to the implementation of this Engineering Document. However, attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. SMPTE shall not be held responsible for identifying any or all such patent rights.

Introduction

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

Stereoscopic (S3D) or Multi-Camera Array imaging systems deliver two or more images to a downstream process that may be used for depth information (segmentation, S3D) or increased spatial or temporal resolution.

To maintain the fidelity of S3D or Multi-Camera Array images when captured as individual images, it is critically important that the temporal alignment of the images be maintained at all times. Loss of alignment between the images will result in the degradation or complete destruction of the stereoscopic or Multi-Camera Array image.

1 Scope

This document specifies the synchronization of two or more cameras in a Stereoscopic (S3D) or Multi-Camera Array moving image camera systems.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:"

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword "reserved" indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword "forbidden" indicates "reserved" and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; Tables shall be next; then formal languages; then figures; and then any other language forms.

3 Normative References

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

SMPTE ST 12-1:2014, Time and Control Code

SMPTE ST 274:2008, Television — 1920 × 1080 Image Sample Structure, Digital Representation and Digital Timing Reference Sequences for Multiple Picture Rates

SMPTE ST 296:2012, 1280 × 720 Progressive Image 4:2:2 and 4:4:4 Sample Structure — Analog and Digital Representation and Analog Interface

SMPTE ST 318:2015, Synchronization of 59.94- or 50-Hz Related Video and Audio Systems in Analog and Digital Areas — Reference Signals

SMPTE ST 352:2013, Payload Identification Codes For Serial Digital Interface

SMPTE ST 2051:2014, Two-Frame Marker for 48/(1.001)-Hz, 50-Hz, and 60/(1.001)-Hz Progressive Digital Video Signals on 1.5 Gb/s and 3 Gb/s Interfaces

SMPTE ST 2059-1:2015, Generation and Alignment of Interface Signals to the SMPTE Epoch

4 Terms and Acronyms

For the purpose of this document, the following terms and definitions apply.

4.1 Camera

As defined here for this document, a *camera* includes the lens and all associated equipment required to create digital representations of moving images. The *camera* is generally capable of stand-alone operation.

4.2 Camera Systems

As defined here for this document, a *camera system* consists of all *cameras* and their associated equipment to create S3D content or for computational light field image processing.

4.3 Coincident in Time

With respect to dual image signals for stereoscopic television, this means that not only are the two image signals “genlocked”, but they represent the same moments in time for the image displayed.

4.4 Genlock

Abbreviation of “[sync] Generator Lock.” Genlock is a technique for locking a device’s internal sync structures (and thus image structures) to a common external reference (a “sync generator”).

4.5 Multi-Camera Array

Two or more cameras aligned to capture a single scene coincident in time for downstream light field image processing.

4.6 S3D Image Content

Image content, which results in the viewing of a scene with the perception of depth to the observer.

4.7 Stereoscopic

Relating to the use of binocular vision to create the perception of depth in an image.

4.8 Stereoscopic 3D S3D

Acronym for Stereoscopic (3D).

5 Stereoscopic (S3D) or Multi-Camera Array System Synchronization

A Stereoscopic (S3D) or Multi-Camera Array system should maintain synchronization of all cameras during the capture time period. This may be accomplished by locking all cameras to a master sync generator. This sync generator may be an external device or a sync signal generated from one of the cameras. (As seen below in Figure 1.)

Cameras shall support a genlock method that will maintain temporal coincidence in time between all cameras within a camera system. Signal timing of the camera system shall not change or drift over the time of capture.

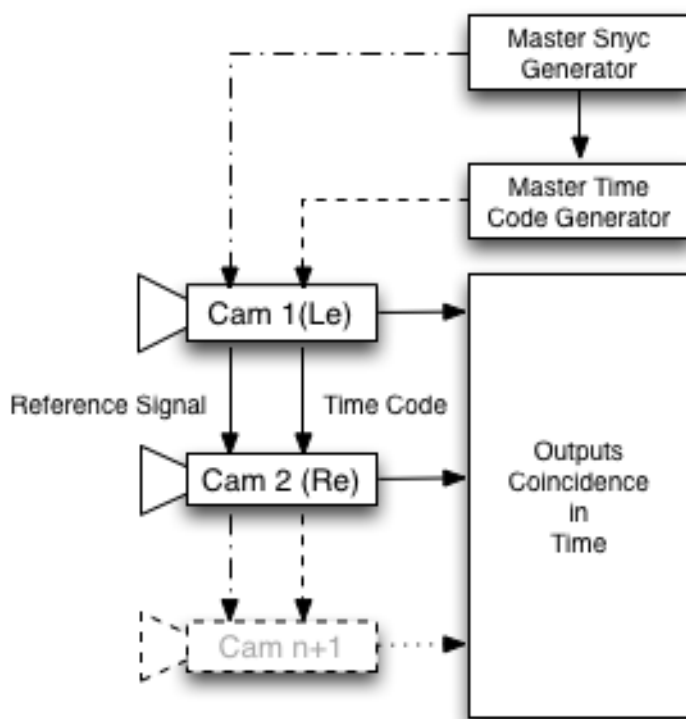


Figure 1 – Example Camera System (Informative)

5.1 Genlock Signals

Cameras shall support at a minimum one of the following reference signals; SMPTE ST 318, SMPTE ST 274, SMPTE ST 296 or SMPTE ST 2059-1 allowing the cameras within a camera system to be synchronized.

At applicable frame rates, camera systems generating progressive image formats above 30 fps shall maintain two-frame alignment as per the definition in SMPTE ST 2051.

5.2 Synchronized Shutter

Cameras shall have the ability to synchronize the shutter timing such that each sensor in the camera system is exposed coincident in time.¹

6 Image Alignment

Each individual camera image derived from a camera system shall maintain the temporal alignment appropriate to the S3D or Multi-Camera Array system in use with all other camera images derived from the camera system. Cameras within the camera system should use a similar scanning method and should maintain synchronization with the use of a genlock signal.

¹ Cameras generally use a mechanical or electronic shutter system or a combination of the two depending on the frame rate of capture. An electronic global shutter method can produce better results for some post-production processes as compared to a rolling shutter method.

This alignment shall be maintained throughout the camera system, without change or drift during the time of capture of moving images. This alignment shall be maintained and preserved to the recording device as a part of the camera system or the output of the camera system.²

7 Image Identification

7.1 Time Stamping

The camera system should have the ability to sequentially time stamp each image frame at the time of capture at each camera so that the camera's output image frames may be identified later on in post-production. This time stamp should conform to SMPTE ST 12-1.

This time stamp should be temporally coincident across all cameras in the camera system. This may be accomplished by using an external time code generator that is locked to the camera system's synchronization or by using one of the cameras internal time code generator to provide a master time code reference to slave all other camera internal time code generators in the camera system.

7.2 Support of Camera Identification

The identification of each camera should be embedded into the output file metadata or SDI signal for downstream processing or post-production processes. This can be accomplished using the SMPTE ST 352 Payload Identifier channel assignment. Ch. 1 for Left Eye (Le) or Camera 1, Ch. 2 for Right Eye (Re) or Camera 2, Ch. 3 for Camera 3 and so on.³

² For optimum results, fixed offsets or temporal delays between each of the images need to be avoided. If this is unavoidable, a fixed offset that does not change over time can be used provided it can be recognized by the downstream systems required to process the images.

³ SMPTE RDD 18 provides a documented KLV approach.

Bibliography (Informative)

SMPTE ST 2059-2:2015, SMPTE Profile for Use of IEEE-1588 Precision Time Protocol in Professional Broadcast Applications

SMPTE RDD 18:2012, Acquisition Metadata Sets for Video Camera Parameters