MURIDEO®

SEVEN GENERATOR

Professional Audio/Video Testing Device for HDMI 2.0, eARC, Latency & Calibration

An Approved Test Device for Dolby Audio™

Audio Testing Guide

(Version 1.0)

Introduction to Testing Audio and Video Signals with the SEVEN Generator, Including Dolby Audio and Dolby Vision

The SEVEN Generator is a feature rich device perfect for testing a wide arrange of Audio and Video signals through three interfaces:

HDMI - High Definition Multimedia Interface – TX & RX
ARC - Audio Return Channel – TX & RX
eARC - Enhanced Audio Return Channel – TX & RX

SEVEN Generator Capabilities and Features

HDMI Specification Interoperability

HDMI 1.3,1.4,2.0(a/b)
HDMI ARC 1.4b, 2.0(a/b)
HDMI 2.1 (Limited)
HDMI eARC 2.1

Generator Capabilities and Features

1. Supports output of IEC 61937 bitstreams at IEC 60958 frame rates of 48 and 192 kHz – via HDMI, ARC, and eARC
2. Supports output of IEC 61937 bitstreams at IEC 60958 frame rates of 705.6 and 768 kHz – via HDMI, ARC, and eARC
3. Generates audio InfoFrames for a given IEC 60958/61937 bitstream
4. Generates audio and video streams in sync with regard to the beginning of the respective video stream – via HDMI
5. Continuously generates audio test streams over HDMI & ARC and eARC
6. Generates continuous signals (looped) for Dolby Digital, Dolby Digital Plus, Dolby TrueHD, and Dolby MAT Video content via HDMI and eARC
7. Generates continuous signals (looped) for Dolby Digital, Dolby Digital Plus via ARC
8. Control interface allows user to select audio test stream for playback.

Device Under Test Audio/Video Capabilities Parsing Features

- Displays full E-EDID information in human readable format
- Parses the SAD (Short Audio Descriptors) for Dolby Digital, Dolby Digital Plus, Dolby TrueHD, and Dolby MAT
- Parses the SAD for information about Dolby Atmos support and indicates to the user whether Dolby Atmos is supported over HDMI.
- Displays the audio and video latency values from the Vendor Specific Data Block (VSDB) over HDMI.
- Sends a <Request SAD> CEC message, reads, and displays <Report SAD> CEC message from an ARC receiver device under test in a human-readable format.
- Parses the SAD for Dolby Digital and Dolby Digital Plus from a connected downstream ARC device and indicates their presence to the user.
- Parses the SAD for information about Dolby Atmos support and indicates to the user whether Dolby Atmos is supported over ARC.
- Retrieves and displays the contents of the Capabilities Data Structure of a device under test connected via eARC, including the Dolby SAD and the Dolby Vendor Specific Audio Data Block (VSADB), in a human-readable format.

- Parses the SAD for Dolby Digital, Dolby Digital Plus, Dolby TrueHD, and Dolby MAT from a connected downstream eARC device and indicates their presence to the user.
- Parses the SAD for information about Dolby Atmos support and indicates to the user whether Dolby Atmos is supported over eARC.

HDMI 2.1 Testing

- Implements an HDMI source interface in compliance with version 2.1 of the HDMI specification.(*Available for HDMI 2.1 SEVEN Generator Upgrade*)
- Implements an eARC TX interface in compliance with version 2.1 of the HDMI specification.
- Provides controls to select an audio test stream for playback.

Introduction to SEVEN Generator Test Functions

SEVEN Generator analyzer functions include tests for the following interfaces:

1. HDMI
2. ARC
3. eARC

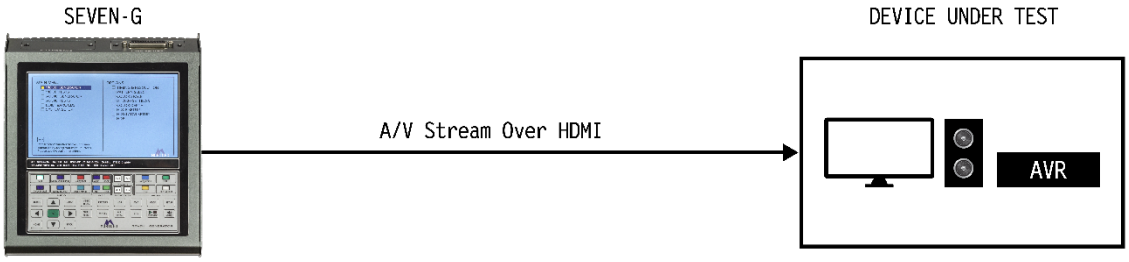
Tests Include:

1. HDMI Input for ARC and eARC
2. HDMI Output for AV signal generation
3. E-EDID and Capabilities data structure control
4. Audio Analysis – pop/click latency
5. CEC exchange and logging
6. Automation – via API
7. Pass-through monitoring via Protocol Analyzer and Data Logger
8. Offline testing capabilities

SEVEN Generator is an approved device for Dolby Audio and is able to generate AV streams for testing AV synchronization.

Sample Use Cases:

1. **Basic Setup**
   - The Seven Generator is used to test A/V Sync of the DUT (Device Under Test). See diagram below:



2. **Using the SEVEN Generator as an A/V Sync Pattern Generator.**
   - The SEVEN Generator provides IEC 61937 audio streams containing beeps and video containing flashes (black frames with a white rectangle in the center of the image). The SEVEN Generator continuously outputs synchronized beeps and flash frames over HDMI.
   - The audio streams are in the following Dolby Audio formats:
     - Dolby Digital
     - Dolby Digital Plus
     - Dolby Metadata-enhanced Audio Transmission (MAT) with PCM and Dolby TrueHD
   - The audio signals are streamed in sync with uncompressed video frames in an AV sync pattern generated by the SEVEN Generator
   - Test patterns for AV sync testing:

Part 1 Part 2 “Cornerbox_UHD” test pattern

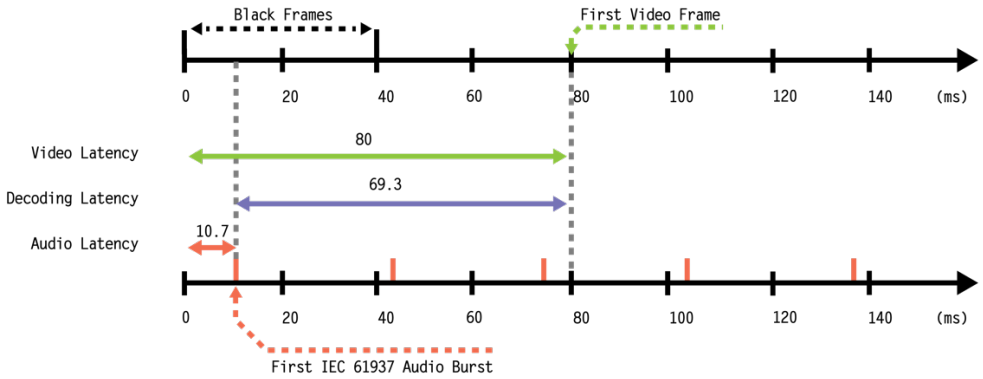
   - The test pattern alternates between part 1 to part 2 and creates the “Cornerbox_UHD” or “Cornerbox_FHD” test patterns
   - The AV Sync patterns are located on the SEVEN Generator under Audio Tests>Sync & Latency – there are separate tests for HDMI, ARC and eARC
   - The stream generated by the SEVEN Generator loads a pattern frame or flash which is then synchronized with and audio beep. The flash and beep is generated continuously at 1 second intervals – the corner box pattern is used to fill the gaps between the flashed.
   - The test patterns for this function can be used in SDR (Standard Dynamic Range) in HD and UHD and Dolby Vision in HD and UHD.

3. A/V Sync Test Signals

- The SEVEN Generator contains IEC 61937 audio streams containing beep sounds at regular intervals:
  - Looped - AV Sync – Contains streams in various Dolby audio formats for playback in a loop. These streams can be used to detect sync issues for longer periods of time. The length is calculated based on the sampling frequency, the frame size of the codec, the interval between beeps, and the rate of video frames per second.
  - Non-Looped AV Sync – Contains streams with the same properties above but are 120 seconds long – these can be used for short AV sync tests.
- Steam properties:
  - The beep is close to 1 second depending on the video frame rate
  - The channel configuration is 2.0 for channel based and 5.1.2 for object based signals.
- Supported Dolby audio formats include:
  - Channel Based:
    - Dolby Digital
    - Dolby Digital Plus
    - Dolby MAT with PCM
    - Dolby MAT with Dolby TrueHD
  - Object Based:
    - Dolby Digital Plus
    - Dolby MAT with PCM
    - Dolby MAT with Dolby TrueHD
- The audio test signals support the following video frame rates:
    - Directly: 23.976, 24, 25, 29.97 and 30 Hz
    - Indirectly: 50, 59.94, 60, 100, and 120 Hz
- Video flashes – the SEVEN Generator generates a video stream of interlaced test patterns where the flash pattern occurs in sync with audio beeps.
  - The frames are generated at a constant rate equal to:
    - Video Frame Interval = Flash Interval in Seconds * Video FPS
      - Video frame interval is the number of seconds between flashes
      - Video FPS is the video frame rate
    - The flash interval in the streams is 1 second, the actual interval depends on the video frame rate for which the stream was generated and is always equal to an integer number of video frames – See table below:

Video Frame Rate (fps)	Flash Interval (video frames)	Flash Interval (milliseconds)
23.976	24	1001
24	24	1000
25	25	1000
29.97	30	1001
30	30	1000
50	50	1000
59.94	60	1001
60	60	1000
100	100	1000
119.88	120	1001
120	120	1000

4. **AV Synchronization on output**
    - The SEVEN Generator outputs synchronized A/V HDMI by default and provides controls in the Sync & Latency function to both video and audio (add or subtract delay in milliseconds)
    - The SEVEN Generator supports the following modes for AV synchronization:
        - Default – no audio or video delay – this can be used to measure the actual video latency in the DUT
        - Offset – adjust audio and video offset in 1 millisecond intervals. This can be used to calculate a value to use when compensating for audio or video delay.
    - Example in figure below, decoding delay for video at 25 fps and channel-based Dolby Digital Plus



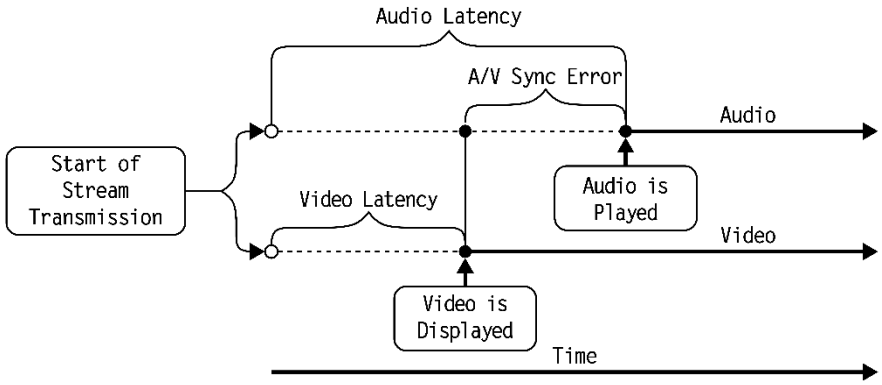
5. **Adjusting AV offset in 1 millisecond steps**

- The SEVEN Generator allows you to adjust the audio and video offset in 1 millisecond steps – you can adjust the audio and video together or separately.
- On the SEVEN Generator – Select AV Sync & Latency>Audio Stream Start Adjust – you can increase or decrease audio or video delay in 1ms steps.

6. **Basic audio test signals**

- The SEVEN Generator contains audio streams in the IEC 61937 format, which can be used for testing downstream devices connected via HDMI or ARC. These signals are stored on the SEVEN Generator and output in a loop.
- The streams are located on the SEVEN Generator under Audio>Audio Generator>Dolby Audio Generator. Streams carry a 1KHz sinewave for all full-bandwidth channels and a 100 Hz sinewave for the LFE channel.
- To output the streams on the SEVEN Generator select from the Dolby Audio Generator
- Basic audio test signals are available for all Dolby audio formats & configurations

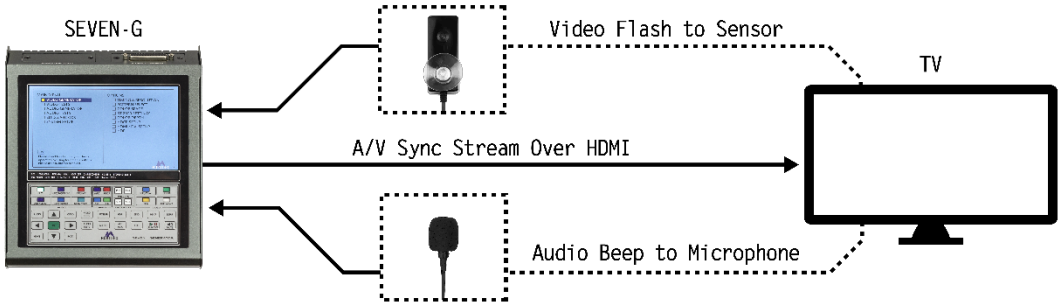
7. **Measuring AV sync and latency**
    - Processing AV signals on different pieces of equipment can introduce AV sync issues. It is important that regardless of the equipment in the connected system that there is no latency as this negatively impacts the end user experience.
    - This diagram below explains how A/V sync issues are caused, many people refer to this as lip-sync issues:



- **AV sync error (lip sync)** – AV synchronization errors or lip sink errors is the delay of the audio signal in relation to the video signal or visa versa – measuring on the SEVEN Generator is a simple process that provides delay in millisecond based on calculating the time between the flash and beep generated and measured by the SEVEN Generator.
- **Latency** – Audio latency is the time delay (in millisecond) between the moment the stream leaves the generator and is measured by the SEVEN Generator's microphone. The latency measurement helps to determine the delay introduced by the DUT.
- **AV sync and latency testing on the SEVEN Generator** – The SEVEN Generator provides latency and AV sync tests for all Dolby codecs

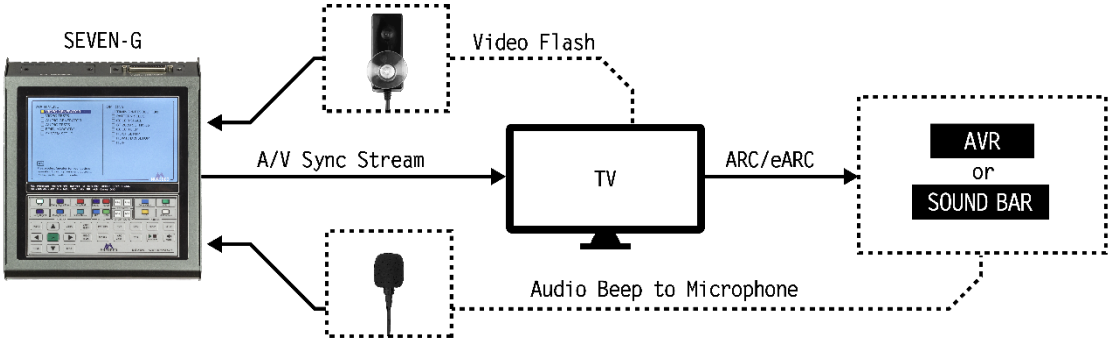
8. **A/V Sync Use Cases** – The following pages provide some sample use cases for testing latency in HDMI source, sink and repeaters as well as use cases for ARC and eARC device interfaces.

    - A/V sync single DUT – Sending AV streams to a single device via HDMI. This test involves measuring the time span between the beeps coming from the TV speakers and the video flashes on the display. Shown in this diagram below



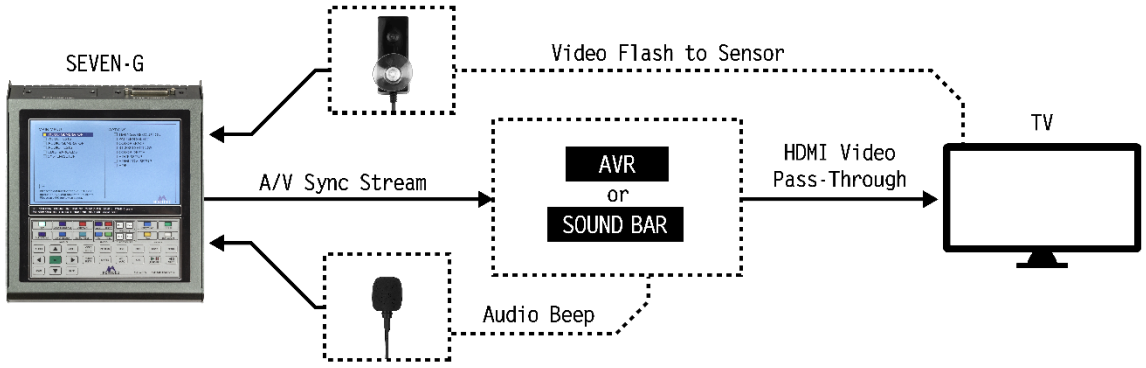
        - SEVEN Generator Menu Navigation Steps:
            1. Audio Tests
            2. Sync & Latency
            3. AV Latency
            4. Press OK to run the test – The length of stream is 120 seconds pressing OK during the test re-runs the test from the beginning
            5. Evaluate the difference between your video and audio signal on the SEVEN Generator's display
            6. Re-run as necessary – Place the mic close to the speaker for best results

    - AV sync TV/AVR (repeater) example – Most home entertainment systems include repeaters like an AVR and/or matrix switch. In this example the SEVEN Generator sends audio and video over HDMI to a downstream device like a TV. The TV/downstream device sends only the audio stream over ARC or eARC to an AVR, soundbar or matrix switch. The SEVEN Generator measures the time span between the video flashes on the display and the beeps coming from the speakers connected to the AVR, shown this this diagram below:



- In this use case the audio may be delayed due to processing time in the AVR or TV. TV and audio equipment manufacturers should test their product and minimize delay
- SEVEN Generator Menu Navigation Steps:
    1. Audio Tests
    2. Sync & Latency
    3. AV Latency
    4. OK to run

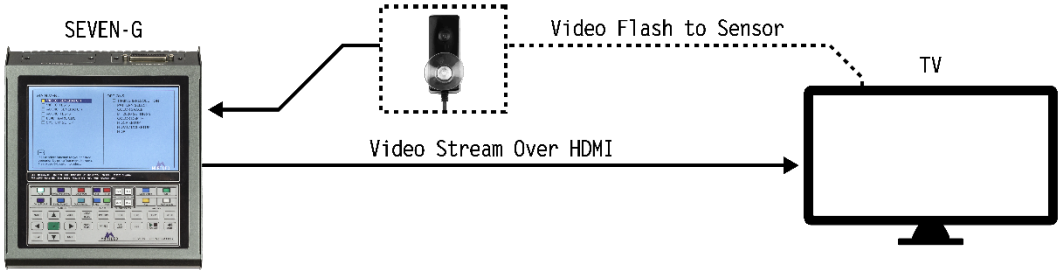
- AV sync AVR (repeater)/TV example – In this example the video is passed to the TV from the AVR or soundbar or another repeater. Shown below in this diagram:



- In this use case the audio may be delayed due to processing time in the AVR or TV. TV and audio equipment manufacturers should test their product and minimize delay.
- SEVEN Generator Menu Navigation Steps:
    1. Audio Tests
    2. Sync & Latency
    3. AV Latency
    4. OK to run

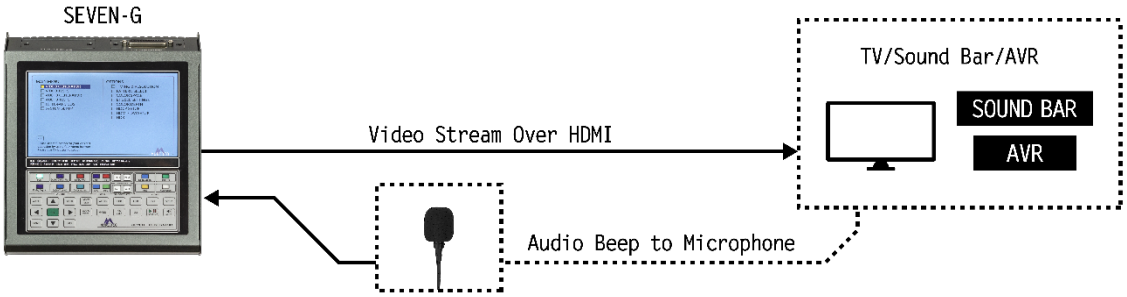
9. Latency use Cases/Examples

- The SEVEN Generator is capable of measuring latency in a variety of use cases – some examples are shown below
- AV latency measurement use cases for single DUT – measuring latency helps to identify/correct delay processing in a single connected DUT. TV shown below in the diagram:



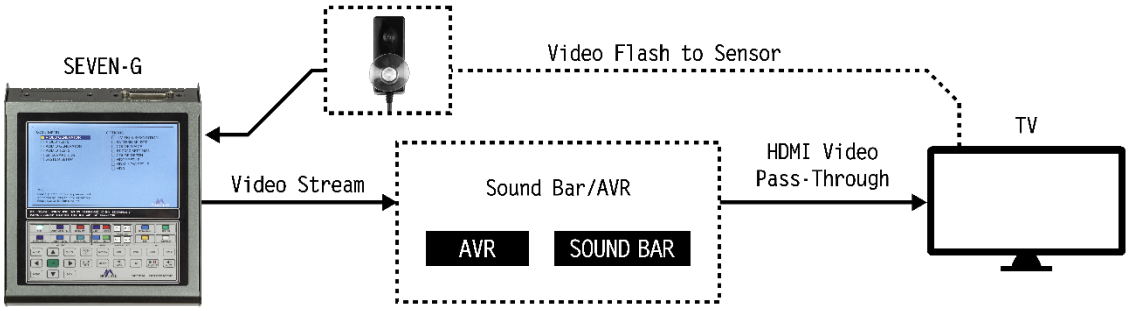
  - Video delay testing of single DUT
  - SEVEN Generator Menu Navigation Steps:
    1. Audio Tests
    2. Sync & Latency
    3. AV Latency
    4. OK to run
    5. Note: Only need to connect photo diode sensor near TV speaker

- Measuring latency over the Audio only pathway only helps identify/correct delays in processing an audio signal. DUT shown below being tested for audio latency only.



  - Audio delay testing for single DUT
  - SEVEN Generator Menu Navigation Steps:
    1. Audio Tests
    2. Sync & Latency
    3. AV Latency
    4. OK to run
    5. Note: Only need to connect microphone near TV speaker, soundbar or AVR speakers.

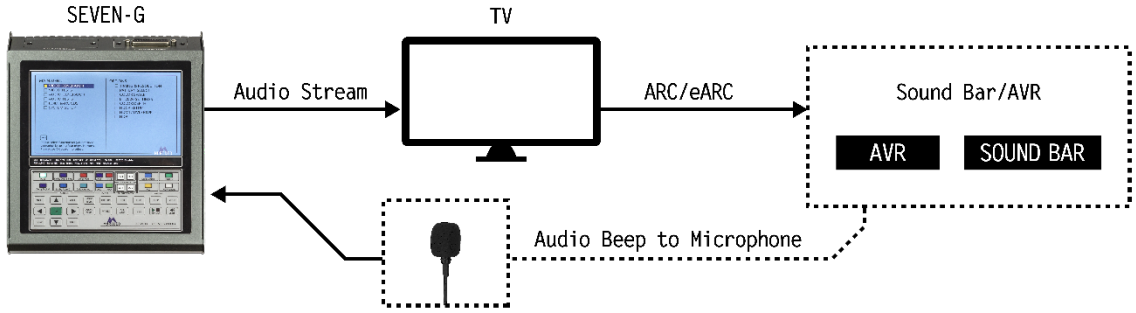
- Latency measurement example for a sound bar/AVR pass-thru to a TV



  - Video delay testing AVR pass-through
  - SEVEN Generator Menu Navigation Steps:
    1. Audio Tests
    2. Sync & Latency
    3. AV Latency
    4. OK to run
    5. Note: Only need to connect microphone near TV speaker.

10. AV latency use cases for systems with more than one device

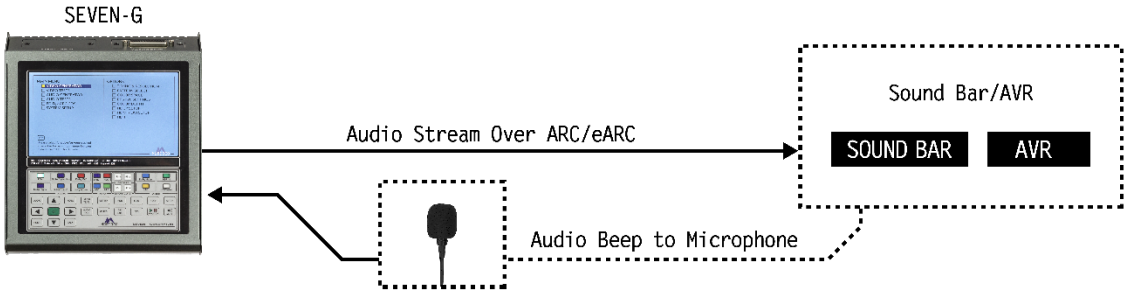
- The SEVEN Generator can be used to test intermediate devices like TVs and projectors that can transfer AV signals over ARC or eARC. This test involves measuring latency for the entire system and for the single intermediate device.
- Latency measurement example for a TV connected to a sound bar/AVR via ARC or eARC hown below in the diagram:



- Measurement of the latency of the entire system (processing chain) is performed the same way as for a single device. The AV delay is measured from the moment the signal leaves the SEVEN Generator until a beep and flash is displayed on the last device in the system.
- To measure the latency for the intermediate device (like a TV) you will measure the latency of the device connected via ARC or eARC – The SEVEN Generator and the intermediate device must have the same properties.

- SEVEN Generator steps:
  - SEVEN Generator Menu Navigation Steps:
    1. Audio Tests
    2. Sync & Latency
    3. AV Latency
    4. OK to run
    5. Note: Only need to connect microphone near TV speaker.

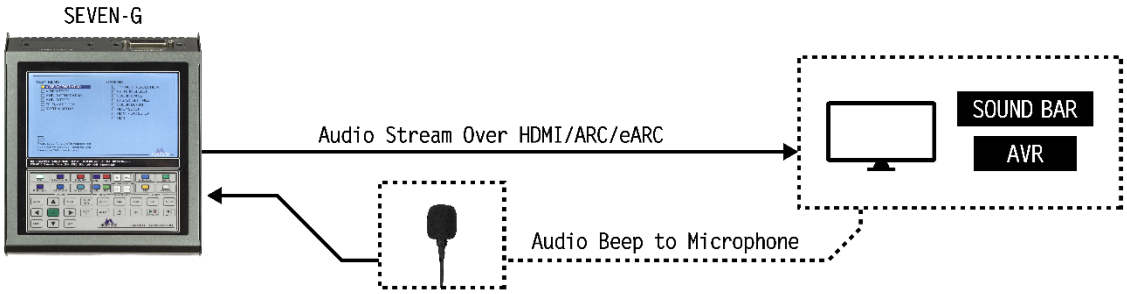
- Audio latency measurement for a sound bar or AVR connected via ARC or eARC, shown below in the diagram



- To calculate the latency of the intermediate device substract the latency for the device connected via ARC or eARC from the latency of the entire system (end to end).
  - SEVEN Generator Menu Navigation Steps:
    1. Audio Tests
    2. Sync & Latency
    3. ARC or eARC Latency (make sure to turn on ARC/eARC port on the SEVEN Generator)
    4. OK to run
    5. Note: Only need to connect microphone near AVR or sound bar speakers

11. Audio transition testing

- (Note – this will be a 2020 firmware update) – Verifies that the DUT connected via HDMI, ARC or eARC does not introduce audible gaps or glitches when a change of format occurs
- Below showing the set up for Audio Transition Testing



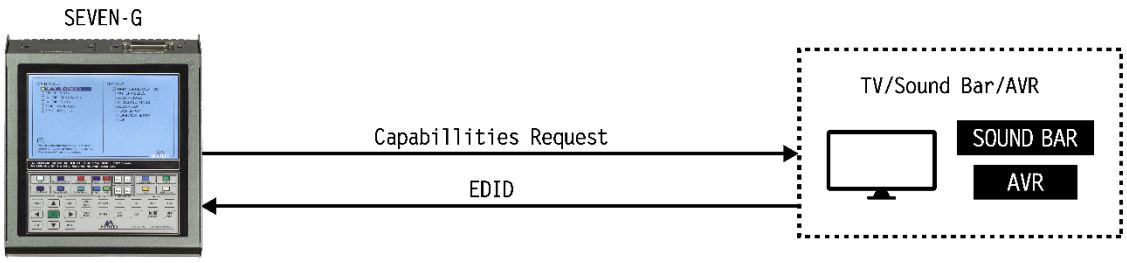
- The following are audio transition types that the SEVEN Generator is capable of testing for:
    - Audio format change ex. DD+ to DD MAT
    - Codec mode changes (with and without Atmos):
        - Object based MAT to Dolby MAT
        - Object Dolby Digital Plus to channel-based Dolby Digital Plus
    - Channel mode changes – 2.1 to 5.1 channel configurations
    - Sampling rate changes

12. Device Capabilities Parsing

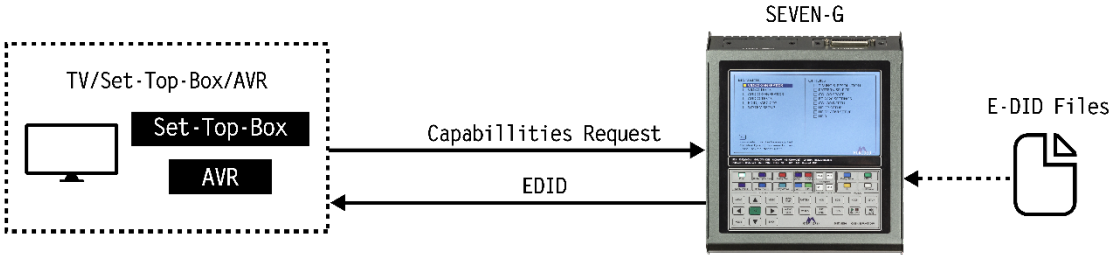
- Capabilities capture in HDMI varies depending on the interface – HDMI uses E-EDID, ARC uses CEC messaging, and eARC uses CDS (capabilities data structure). For all three interfaces the SEVEN Generator captures the SAD (short audio descriptor) – a three-byte structure defined in CTA-861 that indicates the type of audio supported, specific codec, maximum channels, sampling frequency, and any codec specific information that is available.

13. E-EDID – HDMI

- The SEVEN Generator reads the E-EDID to verify that downstream DUT indicates its capabilities correctly. The E-EDID test on the SEVEN Generator returns the SAD and vendor specific audio data block (VSADB) from the downstream DUT connected via HDMI and displays the information in human readable format to verify that the correct information is received.
- E-EDID testing examples – The SEVEN Generator is used to verify that a sink DUT correctly signals its AV capabilities AND that the source interprets the information correctly and send the video and audio in the proper formats.
- E-EDID info is returned the SEVEN Generator during any hot plug event for verification that capabilities are transferring properly
- Below diagram shows signal flow for EDID

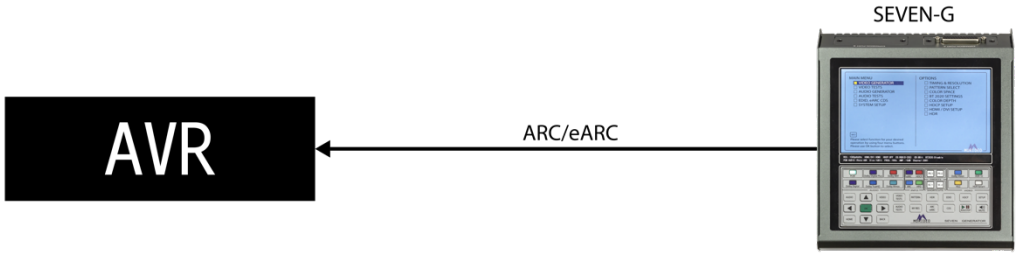


- The SEVEN Generator allows the user to load and store captured E-EDIDs. The SEVEN Generator also allows the user to select from pre-defined E_EDIDs and allows the user to modify the E-EDID file to simulate various configurations of the sink device. Once captured – the SEVEN Generator can transmit the selected capabilities to the upstream device.
    - SEVEN Generator Menu Navigation Steps:
        1. Select EDID
        2. Sink Device EDID
        3. Note: must use PC to store and recall EDIDs – there is some limited storage on-board the SEVEN Generator.

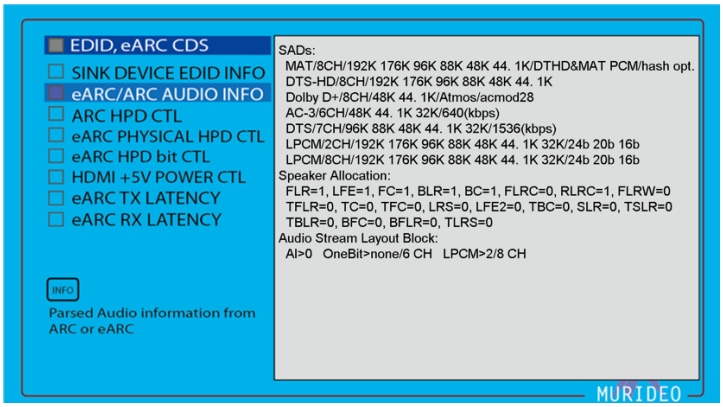


14. Capabilities Data Structure (CDS) for eARC interface

- The SEVEN Generator allows user to act as an eARC transmitter or receiver. The CDS is defined in the HDMI 2.1 standard for exchanging information about audio capabilities. The CDS carries the SAD and the VSADB and other information that is viewable on the SEVEN Generator.



- Steps on SEVEN Generator:
    1. Select EDID, eARC, CDS
    2. Press down one to eARC/ARC Audio Info



15. The SEVEN Generator interprets Dolby codec

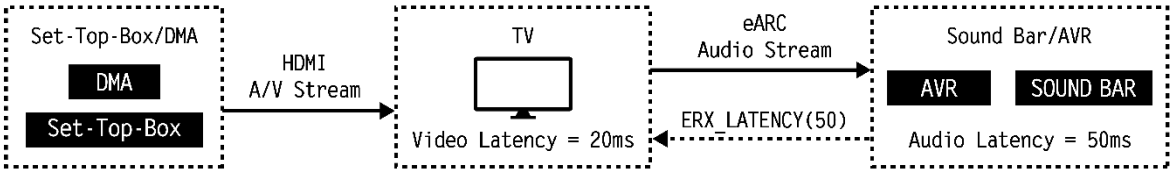
- The SEVEN Generator is able to interpret Dolby codec's specific information in the SAD and VSADB
- In the SAD – Short Audio Descriptor
    - Byte 1 - indicates max channels
    - Byte 2 – sampling frequencies supported
    - Byte 3 – Depends on the audio format
- Note: For detailed info see Dolby Audio and Dolby Atmos over HDMI specification, must be a Dolby partner and get document from Dolby.

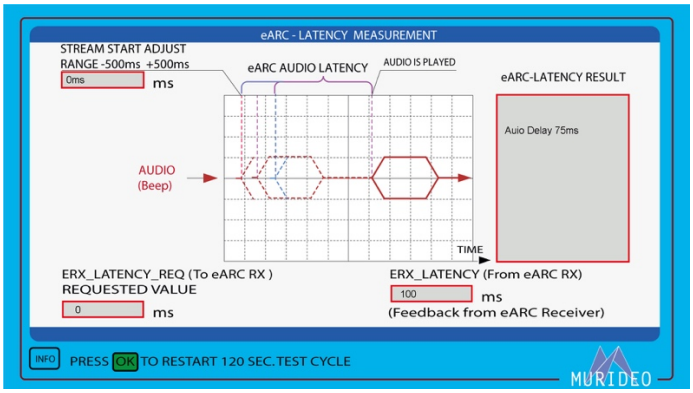
16. VSADB – Vendor Specific Audio Data Block

- The SEVEN Generator reads the VSADB and captures vendor defined audio capabilities of the sink for transmission to the upstream source.

17. eARC Audio Latency Control

- HDMI 2.1 introduces an audio latency control function for eARC and specifies audio latency control requirements and recommendations for eARC transmitters and receivers.
- The HDMI spec provides 2 options for implementing latency control for eARC
- The eARC receiver adjusts it's latency to be as close as the latency indicated in the transmitter.
- The eARC transmitter adjusts it's audio and video delay to the latency indicated by the eARC receiver.
- The following diagram indicates the recommended method for implementing latency for eARC
- Below is the recommended audio latency control behavior for eARC:





- To assist in testing that a DUT correctly implements eARC audio latency control, the SEVEN Generator includes an eARC interface that provides the following functions:
    - Reads the audio latency values from the ERX_LATENCY register from the receiver whenever the value changes
    - Provides controls to configure the requested audio processing latency indicated in the ERX_LATENCY_REQ register of the eARC receiver that is connected to the eARC transmitter.
    - SEVEN Generator Menu Navigation Steps:
        1. Audio Tests
        2. Sync & Latency Tests
        3. ARM eARC Latency
        4. Select Audio Signal you would like to test with
        5. Press “OK” to restart 120 second test cycle