ROSTEC ASD24

High Precision Sync Reference Generator

Technical/user manual

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ASD24 Reference Generator

Features

- Easy and intuitive no-nonsense user interface
- Real time read-out of status on a bright OLED display
- 1 External sync input, BNC connector, 1.5 kohm
- 2 Video sync outputs. BNC connectors, 75 ohm
- 6 Word clock outputs, BNC connectors, 75 ohm
- 1 AES 11 output. XLR male connector, transformer balanced 110 ohm
- 1 S/PDIF output. RCA connector, 75 ohm
- 14 External sync input reference frequencies
- 24 Video sync output formats, SD and HD
- 16 Word clock output frequencies
- 6 AES/SPDIF output frequencies
- All possible combinations between input and output formats and frequencies are allowed and valid!
- Automatic delay calculation ensures correct alignment between video frame, word clock edge and AES/SPDIF block start (see Appendix section)
- HD video output tri-level sync
- SD video output negative going sync
- Video test pattern, color bar for SD formats, hatch pattern (grid) for HD formats.
- Grade 1 internal oven reference crystal oscillator. accuracy 0.1 ppm (0.1 x 10E-6), 0 – +50 deg.C
- Synchronizing to standard word clocks, 10 MHz GPS (atomic clocks) and 2.048 MHz E1 / 1.544 MHz T1 telecom clocks
- External sync input accepts from 0.5 to 10 Volts.
- External sync Input has a "sweet spot" detector, providing auto slicing and signal clean-up for safe and jitter-free synchronization.
- Fly-wheeling and soft glide when switching between external and internal sync reference, providing continuous outputs without gabs or drop-outs.
- Extremely low output jitter and wander, typically less than 80 psec RMS
- Exceptional high immunity against jitter and digital noise from computer work stations.
- Linear low noise analog power supply.
- Inputs and outputs are ESD protected to 23 kV peak IEC 61000-4-2 and 15 A surge IEC 61000-4-5.
- Sturdy steel metal casing, electrically and magnetically screened.
- Stand-alone desktop, half size 19” standard.
- Compact size: 210mm x 210mm x 42mm
- Affordable price.

General description

The ASD24 is a high performance, high precision Digital Reference Generator designed to operate as master synchronization source in film/video/audio recording and post production environments.
It generates 24 different SD and HD video sync formats, 16 word clock frequencies and 6 AES3/SPDIF digital audio formats.
It features a high accuracy oven crystal oscillator, which is used as the main internal reference. The ASD24 can run on the internal reference, or it can be synchronized to 13 different external house clocks, which is relevant in large scale installations.

The user interface is simple, informative and easy-going. The status of the unit is displayed in real time on the bright OLED display, and all functions are controlled by four tactile push-buttons on the front panel.
(see front panel quick guide)

ALL combinations between input sync, video format, word clock frequency and AES/SPDIF sample rate are allowed and valid. The internal locking mechanism keeps all signals in an iron grip, with a correct mathematical relationship that cannot be broken apart. The resulting flexibility is astounding. There are a total of 4992 combinations, and they are all allowed, precise and mathematically correct.

Note that ASD24 does NOT use the problematic and inaccurate approximation techniques found in DDS (direct digital synthesis) or fractional n-dividers. These techniques will invariable lead to noisy and jittery output signals.

The architecture of the ASD24 is based on multiple SAW oscillators (surface acoustic wave), firmly bound together by phase locked loops and hardware synchronous counters. This topology maintains total and accurate control of the relationship between all signals, so no drift between video and audio is possible. ASD24 always maintains the correct relationships between all signals, like cogs in a gearbox!

Also, the ASD24 uses a low noise linear analog power supply for a radiation-free and quiet electrical internal environment, resulting in clean low-noise and low-jittery outputs.

Video Sync Outputs

The Video Sync outputs are available on two BNC connectors on the back panel. The outputs are individually buffered, 75 ohms and SMPTE/EBU standard amplitude when terminated. The signal is DC coupled with blanking level at zero Volts (black level).

The video sync format is selected by the pushbuttons on the front panel. While selecting, both frame rate and the relevant SMPTE/EBU standard are displayed.
After selecting is done, pressing the enter key will bring back the display to top level, where an overview of all parameters are displayed (input, video, clock, lock etc.)

24 different SD and HD formats are available (see the Appendix for the available formats).
All components of the video sync signal are digitally synthesized from the same master clock, making the relationship between sync, sub carrier, luminance and chrominance fixed and temperature independent.
Digital filters are employed on the individual components before they are summed to a composite video signal.
Analog filters are used to remove any digital artifacts that may cause aliasing in digital video equipment.
Slew rate limiting of the sync pulses is used for both SD and HD formats.
An undershoot limiter is placed right after the digital filters to prevent synchronization problems. The limiter level is preset to -1.5 IRE below black level.

Video test patterns are available, and can be selected by the pushbuttons on the front panel. Color bar for SD formats and hatch pattern (grid) for HD formats.

Word Clock Outputs

The Word Clock outputs are available on six BNC connectors on the back panel. The outputs are individually buffered, 75 ohms and TTL level.

The word clock frequency is selected by the pushbuttons on the front panel. While selecting, the chosen frequency is displayed. Everything else is blanked out.
After selecting is done, pressing the enter key will bring back the display to top level, where an overview of all parameters are displayed (input, video, clock, lock etc.)

16 word clock frequencies are available (see the Appendix for the available formats).
When an integer relationship between video frame rate and clock frequency exists, the rising edge of the word clock is aligned to the video frame start.

AES outputs

The AES output is available on a standard male XLR connector on the back panel.
The AES output is 110 ohms, transformer balanced and 5V PP when terminated (full swing buffers).
The AES sampling frequency follows the selected word clock output frequency.

Note: The AES output sampling frequency is limited to a max of 192 kHz, When the word clock frequency is selected to a higher frequency than this limit, the AES output sampling frequency continues to run at 192 kHz at 48 kHz based clock frequencies, or continues to run at 176.4 kHz at 44.1 kHz based clock frequencies.

6 AES sampling frequencies are available (see the Appendix for the available formats).
When an integer relationship between video frame rate and AES block frequency exists, the rising edge of the AES block start (Z-preamble) is aligned to the video frame start,
When an integer relationship between video frame rate and AES sampling frequency exists, the rising edge of the AES sample start (X-preamble) is aligned to the video frame start

Observe that some commercially available AES receiver chips in budget equipment exhibit lock problems when subjected to a "black" AES signal..
The issue is overcome by setting the first eight audio data bits to 1 and the remaining sixteen bits to 0 in the AES audio signal. This gives a DC offset in the audio signal of –90 dBFS (0.2 mV with reference to +18 dBu). Standard digital audio input circuits easily accommodate this DC offset, and the scheme efficiently eliminates any lock problems.

SPDIF output

The SPDIF output is available on a RCA connector on the back panel. The output is 75 ohm, 0.5V when terminated.
The SPDIF output is a downscaled mirror image of the AES output, which means that channel status info reports professional use and copying allowed. As such it is technically not a real consumer SPDIF format, but the differences are irrelevant for synchronization purposes.
(The SPDIF and AES block structure and protocol is identical. Only channel status reporting differs)

External Sync Input

The external sync input is available on a BNC connector on the back panel. The input is unterminated 1.5 kohm, and has a nominal sensitivity of 0.5 V. Max level is 10V, AC as well as DC.
The sync Input features a "sweet spot" detector, which performs auto slicing and signal clean-up. The detector automatically selects the most useful part of the incoming signal, thus providing safe and jitter-free synchronization.
Schmitt trigger and pulse shaper functions make the input compatible with both square wave and sine wave signals.

The sync input accepts 13 standard clock frequencies (see the Appendix for the available formats). The various clock frequencies can be selected as the source by the push buttons on the front panel. While selecting, the chosen frequency is displayed. Everything else is blanked out.
When INTERNAL is selected, the input signal at the BNC connector is ignored, and the unit will run on its internal crystal oscillator reference.
After selecting is done, pressing the enter key will bring back the display to top level, where an overview of all parameters are displayed (input, video, clock, lock etc.)

Internal Crystal Oscillator Reference

The heart of the ASD24 is a high grade crystal oscillator built into a temperature controlled oven together with all the necessary voltage references and regulators for its operation. This scheme results in an excellent frequency stability over the specified temperature range, and is far superior to a standard temperature compensated crystal oscillator. The frequency accuracy is better than 0.1 ppm from 0 to +50 C. The factory adjustment is typically 0.05 ppm at 25 C.
The ASD24 always uses this oscillator as the central reference for all Video, Word and AES/SPDIF outputs, no matter whether the generator runs on its own, or if it is locked to an external sync source.
The sync input is meant to be used with an ultra high accuracy house clock, typically derived from a GPS disciplined Rubidium or Cesium oscillator, if such is available. When the generator locks to the external sync, it simply tunes the internal crystal oscillator to the exact frequency of the incoming reference. The incoming sync accuracy is then directly transferred to all outputs, independent of which format is chosen.

For example, when the generator is synchronized to an external GPS disciplined Atomic Clock with an accuracy of 1/1.000.000 ppm, ALL OUTPUTS will have an accuracy of 1/1.000.000 ppm.

Further, the generator does not jump into lock, but glides softly until a perfect lock is achieved. If the external sync signal is lost or discontinued, the generator softly glides back to the internal reference, and while it is gliding back and fort between sync sources, it continues to supply uninterrupted outputs. No interruptions, no disturbances.

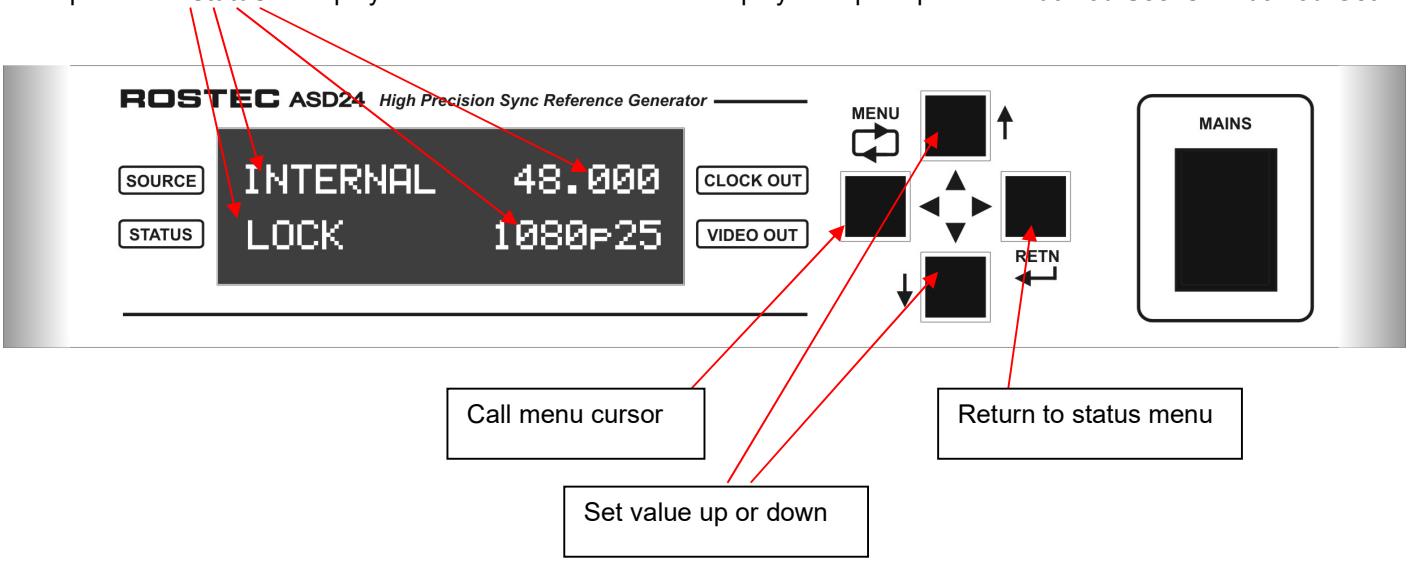
This locking mechanism is based upon an extensive sync safety philosophy. The circuit performs input sync "de-bouncing" which efficiently absorbs sync dropouts by means of an intelligent fast reacting input detector and a unique soft gliding principle.

Video sync is always generated directly by the internal crystal oscillator reference. Word clock, AES and SPDIF signals are generated by a separate crystal oscillator block, which is permanently locked to the video encoder by means of a high precision low jitter phase locked loop. When the video format is changed, the clock, AES and SPDIF outputs always follow with the correct mathematically relationship between video frame rate and clock frequency. Video, Clock, AES and SPDIF are bound together like cogs in a gearbox, always correct, never wanders off.

Front panel quick guide

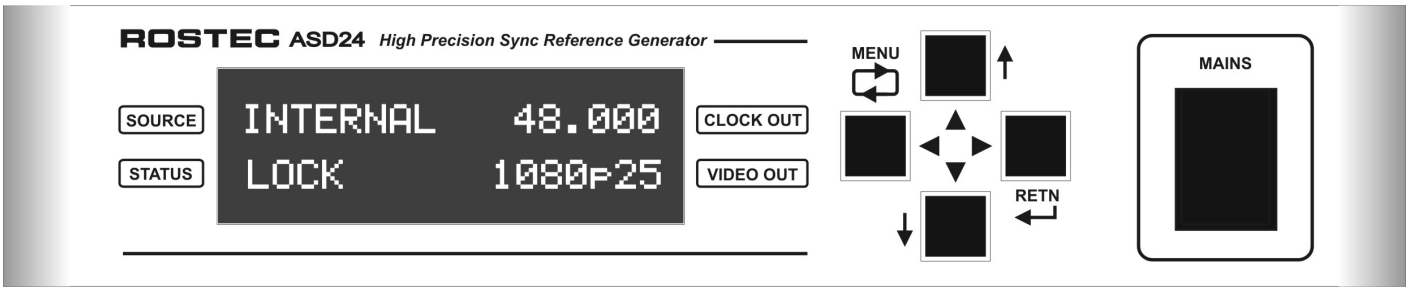
Status menu (default at power on):

The operational **status** is displayed at the four corners of the display. The principle is **"What You See Is What You Get"**



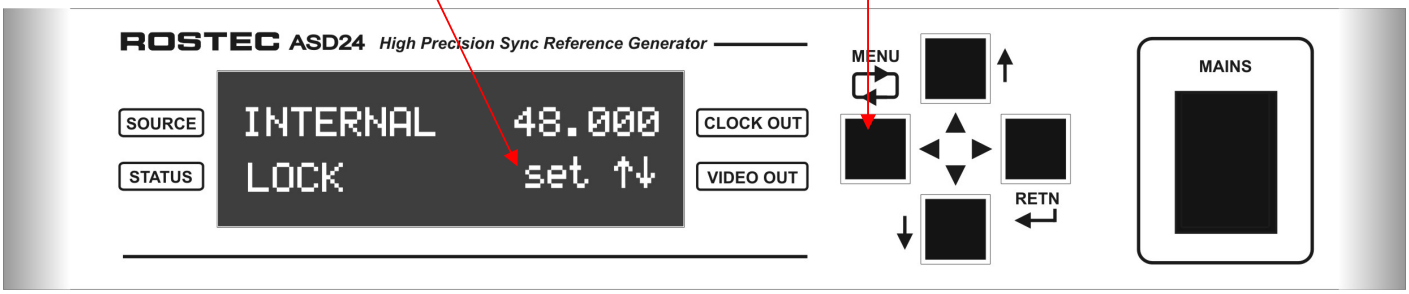
How to change video parameter (example):

Step 1: For example, you start with this status menu:



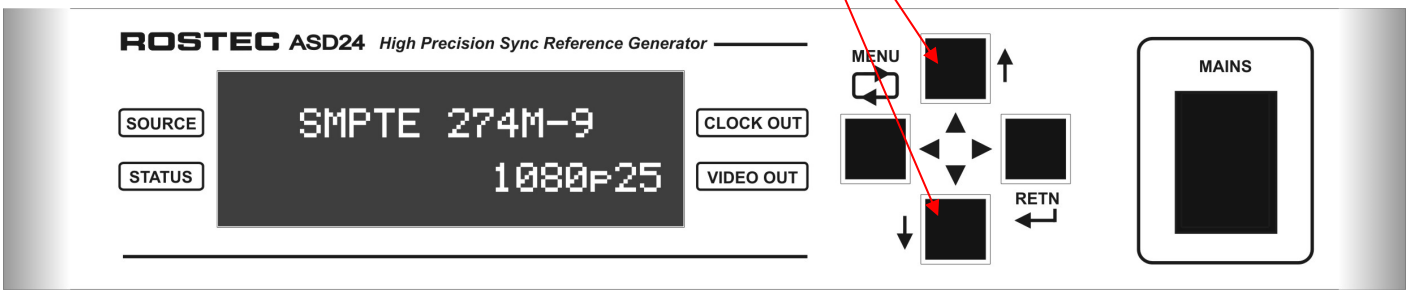
Step 2: Press the MENU button

Observe that the settings cursor appears. If you want the cursor to appear at another position, just press the MENU button again. The cursor will change its position between the four corners of the display.
The cursor arrows indicate that you can now change the value at the cursor position with the arrow buttons. If you don't wish to change anything, just press RETN to return to the status menu.



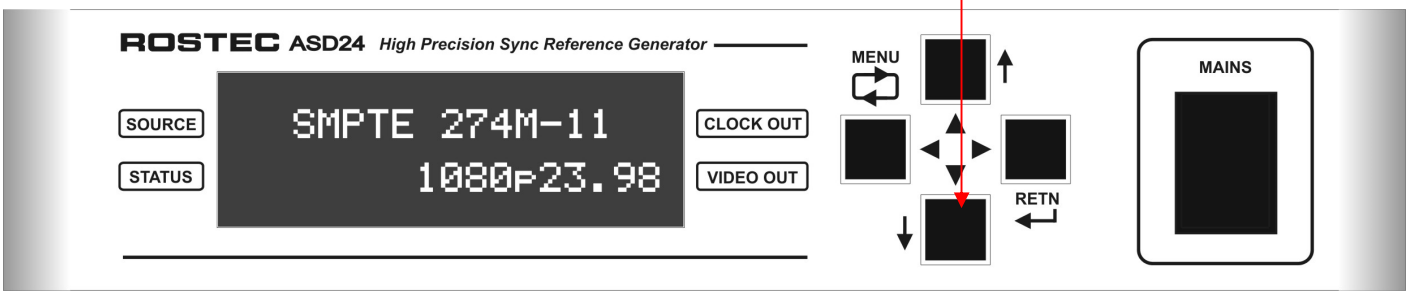
Step 3: Press one of the ARROW buttons. It doesn't matter which one.

Observe that the current parameter at the cursor position is displayed.
Video standard and video format are shown. Everything else is blanked out.



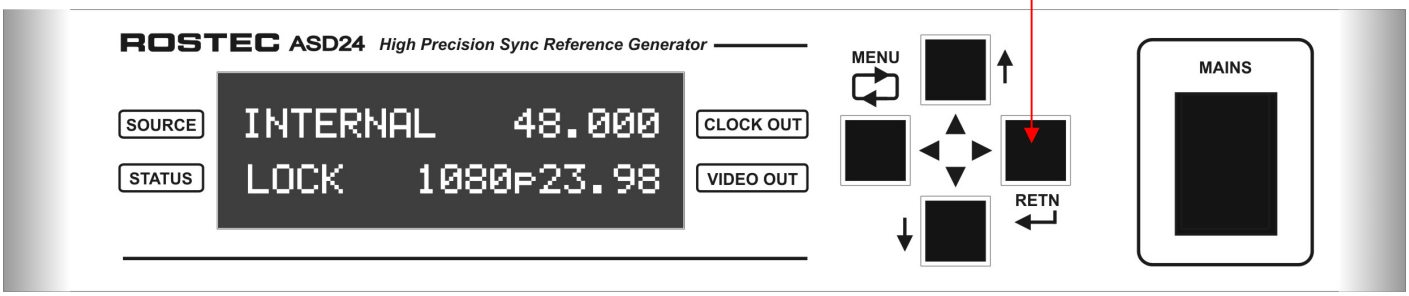
Step 4: Press the DOWN ARROW button (two times in this example)

The video standard changes from SMPTE 274M-9 to SMPTE 274M-11, and video changes from 1080p25 to 1080p23.98.
You can press up/down arrow buttons repeatedly to scroll though the list of formats.



Step 5: When you are satisfied with your choice, press the RETN button

The unit will return to the status menu and show you an overview of your settings.
Remember that pressing RETN will always bring you back to the status menu.
No need to worry about saving. The unit automatically saves your setting when you change anything.



SOURCE:
INTERNAL: The unit runs on the internal oven crystal clock oscillator.
44.1 kHz to 10 MHz (see Appendix for list)**:** Enabling external synchronization at the selected frequency.

CLOCK OUT:
44.1 kHz to 6.144 MHz (see Appendix for list)**:** Shows the selected word clock output frequency. It also shows the sampling frequency for AES and SPDIF outputs. However, the sampling frequency for AES and SPDIF is limited to a maximum of 192 kHz (see details in the Appendix).

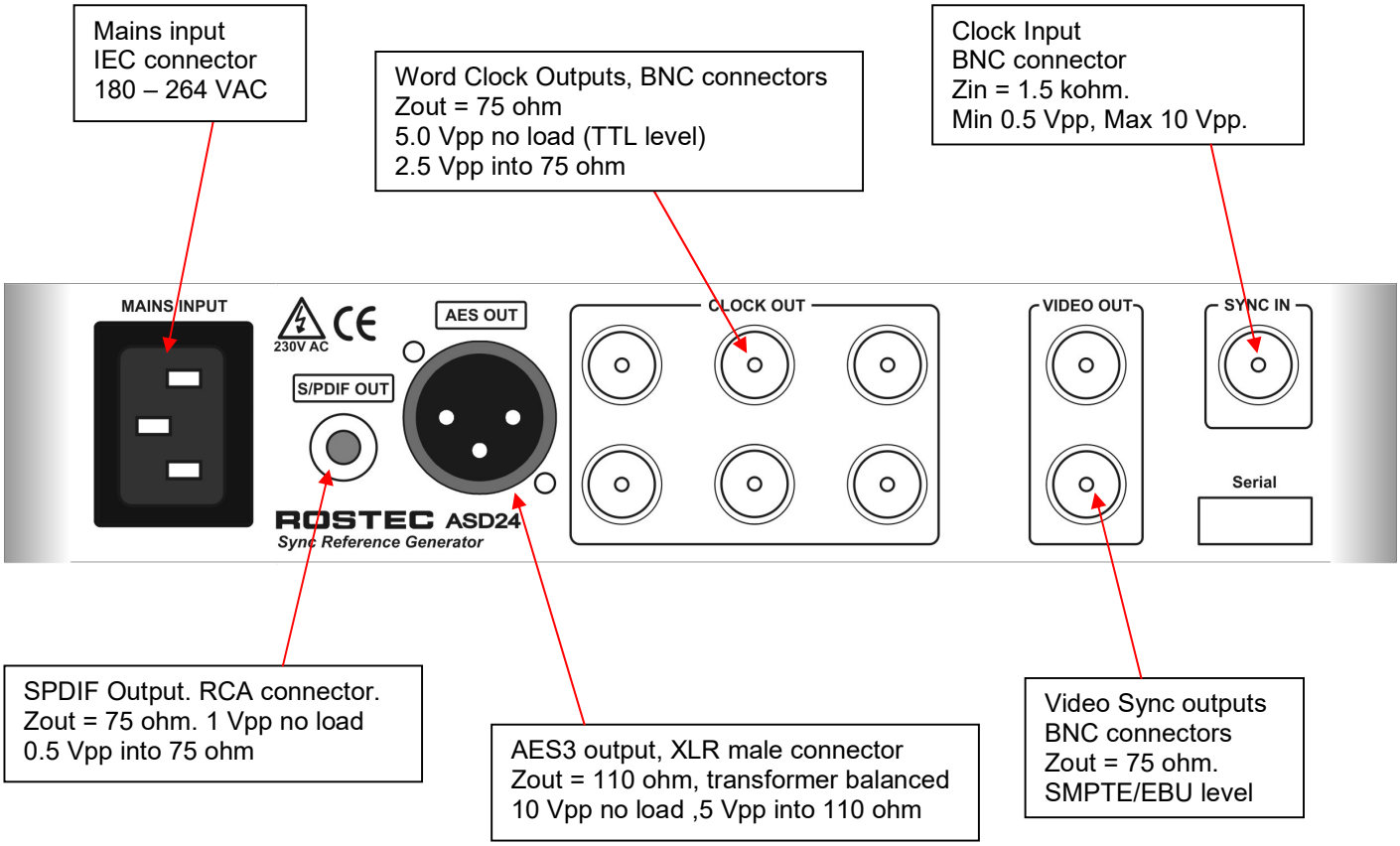
VIDEO OUTPUT:
SD and HD Video formats (see Appendix for list)**:** Shows the selected video format.

STATUS:
Shows the status of the unit: When the unit runs on INTERNAL, the status is shown as LOCK. When a change of video format or clock frequency is made, the unit will briefly display WAIT until all phase locked loops have settled. Typically this will last for less than 1 second.
When any external sync is selected (44.1 etc.) and no input sync is present at the BNC connector at the back, the unit will display - - - - to indicate that no external sync is present. When the incoming sync is at a valid frequency, the unit will perform a phase lock and display LOCK.

OBS: When the incoming sync is invalid, for example if it is at a different frequency than the SOURCE setting, the unit will not lock, and the display will show ERROR.

There is a hidden setting in the STATUS position (the only one in the unit): Press the menu button until the settings cursor is at the STATUS position, and then press the up- or down arrow. You will then be presented with the choice TS OFF or TS ON. This setting controls the Test Signal embedded in the video output: Color bar for PAL and NTSC formats, hatch pattern (grid) for all other formats.
This feature is meant as a test tool for tracking down problems in installations. It is irrelevant for synchronization purposes.

Back panel quick guide



All Inputs and outputs are ESD protected to 23 kV, IEC 61000-4-2 and 15 A surge, IEC 61000-4-5.

Electrical and mechanical specifications

Sync Reference input
- Clock input, 1.5 kohm unbalanced, unterminated, 1 x BNC connector
- Input level 0.5 V - 10 V PP, square or sine
- Input reference: INTERNAL and 13 external clock frequencies (see Appendix)
- Clock input capture range: +/- 80 ppm.
- Lock time approx: 0.4 - 0.6 sec.

Video Sync Output:
- Video Sync Output, 75 ohm, SMPTE/EBU level, 2 x BNC connectors, individually buffered
- SD bi-level, negative going sync.
- SD, colorbar test pattern (selectable)
- HD tri-level sync
- HD, hatch test pattern (selectable)
- 24 Video Sync output formats and frame rates (see Appendix)

Word Clock Output:
- Word clock output, 75 ohm, 6 x BNC connectors, individually buffered
- Output level 5 Volt PP no load, (TTL level). 2.5 Volt PP into 75 ohm
- 16 word clock output frequencies (see Appendix)

AES output:
- AES3 format, transformer balanced, 110 ohm, 1 x XLR Male connector
- Output level 10 Volt PP no load, 5 Volt PP into 110 ohm (full swing buffer)
- 6 AES3 output frequencies, following the word clock frequencies (see Appendix)

SPDIF output:
- SPDIF output format, 75 ohm, 1 x RCA female plug
- Output level 1 Volt PP no load, 0.5 Volt PP into 75 ohm
- 6 SPDIF output frequencies, following the word clock frequencies (see Appendix)

Clock system:
- Internal GRADE 1, oven crystal oscillator.
- Accuracy: Factory calibrated to 0.05 ppm @ 25 deg C
- Temperature stability: +/- 0.1 ppm from 0 degC to +50 deg C.
- Ageing: 1 ppm per year.
- Internal crystal oscillator jitter: 2.4 ps rms.
- Video sync output jitter and wander: 80 ps RMS
- Word clock output jitter and wander: 80 ps RMS
- AES/SPDIF output data jitter and wander: 80 ps RMS.

Power supply:
- Linear analog, passively cooled, high power, very low noise.
- Thermally and overload protected.
- Mains voltage: Nominal 230 VAC, range 180 - 264 VAC 50-60 Hz (115 VAC version available by request).
- Power consumption: 10 Watts.

General:
- Sturdy steel casing, magnetically and electrically screened. Size 210 mm x 210 mm x 42 mm.
- All signal inputs and outputs are ESD protected to 23 kV 15 A surge (IEC61000-4-2 and IEC61000-4-5).

Appendix

Sync references (SOURCE on the front display)

1. INTERNAL internal oven crystal oscillator
2. 44.1 kHz standard audio sampling frequency
3. 48 kHz standard audio sampling frequency
4. 88.2 kHz standard audio sampling frequency
5. 96 kHz standard audio sampling frequency
6. 176.4 kHz standard audio sampling frequency
7. 192 kHz standard audio sampling frequency
8. 352.8 kHz audio sampling frequency from future audio equipment
9. 384 kHz audio sampling frequency from future audio equipment
10. 705.6 kHz audio sampling frequency from future audio equipment
11. 768 kHz audio sampling frequency from future audio equipment
12. 1.544 MHz clock from T1 Telecom systems
13. 2.048 MHz clock from E1 Telecom systems
14. 10 MHz clock from GPS receivers, rubidium oscillators, cesium oscillators (AKA atomic clocks)

Word Clock Output frequencies (CLOCK OUT on the front display)

1. 44.1 kHz standard audio sampling frequency
2. 48 kHz standard audio sampling frequency
3. 88.2 kHz standard audio sampling frequency
4. 96 kHz standard audio sampling frequency
5. 176.4 kHz standard audio sampling frequency
6. 192 kHz standard audio sampling frequency
7. 352.4 kHz audio sampling frequency for future audio equipment
8. 384 kHz audio sampling frequency for future audio equipment
9. 705.6 kHz audio sampling frequency for future audio equipment
10. 768 kHz audio sampling frequency for future audio equipment
11. 1.4112 MHz audio sampling frequency for 1-bit converters
12. 1.536 MHz audio sampling frequency for 1-bit converters
13. 2.8224 MHz mostly for test bench or lab work
14. 3.072 MHz mostly for test bench or lab work
15. 5.6448 MHz mostly for test bench or lab work
16. 6.144 MHz mostly for test bench or lab work

AES/SPDIF Outputs (follows CLOCK OUT on the front display)

1. 44.1 kHz standard audio sampling frequency
2. 48 kHz standard audio sampling frequency
3. 88.2 kHz standard audio sampling frequency
4. 96 kHz standard audio sampling frequency
5. 176.4 kHz standard audio sampling frequency
6. 192 kHz standard audio sampling frequency

Note: The AES output sampling frequency is limited to a max of 192 kHz, When the word clock frequency is selected to a higher frequency than this limit, the AES output sampling frequency continues to run at 192 kHz at 48 kHz based clock frequencies, and continues to run at 176.4 kHz at 44.1 kHz based clock frequencies.

Video Sync Output Formats (VIDEO OUT on the front display)

Video	Standard	Format	Frame rate	Field rate
1. PAL B	PAL B 25i	interlaced	50.00000000 Hz	25.00000000 Hz
2. NTSC	NTSC 29.97i	interlaced	59.94005994 Hz	29.97002997 Hz
3. 525p 59.94	ITU-BT 1362	progressive	59.94005994 Hz	
4. 625p 50	ITU-BT 1362	progressive	50.00000000 Hz	
5. 720p 23.98	SMPTE 296M-8	progressive	23.97602398 Hz	
6. 720p 24	SMPTE 296M-7	progressive	24.00000000 Hz	
7. 720p 25	SMPTE 296M-6	progressive	25.00000000 Hz	
8. 720p 29.97	SMPTE 296M-5	progressive	29.97002997 Hz	
9. 720p 30	SMPTE 296M-4	progressive	30.00000000 Hz	
10. 720p 50	SMPTE 296M-3	progressive	50.00000000 Hz	
11. 720p 59.94	SMPTE 296M-2	progressive	59.94005994 Hz	
12. 720p 60	SMPTE 296M-1	progressive	60.00000000 Hz	
13. 1035i 29.97	SMPTE 240M	interlaced	59.94005994 Hz	29.97002997 Hz
14. 1035i 30	SMPTE 240M	interlaced	60.00000000 Hz	30.00000000 Hz
15. 1080i 25	SMPTE 274M-6	interlaced	50.00000000 Hz	25.00000000 Hz
16. 1080i 29.97	SMPTE 274M-5	interlaced	59.94005994 Hz	29.97002997 Hz
17. 1080i 30	SMPTE 274M-4	interlaced	60.00000000 Hz	30.00000000 Hz
18. 1080p 23.98	SMPTE 274M-11	progressive	23.97602398 Hz	
19. 1080p 24	SMPTE 274M-10	progressive	24.00000000 Hz	
20. 1080p 25	SMPTE 274M-9	progressive	25.00000000 Hz	
21. 1080p 29.97	SMPTE 274M-8	progressive	29.97002997 Hz	
22. 1080p 30	SMPTE 274M-7	progressive	30.00000000 Hz	
23. 1080psf 24	ITU-R BT.709-5	interlaced	48.00000000 Hz	24.00000000 Hz
24. 1080psf 23.98	Non Standard	interlaced	47.95204795 Hz	23.97602398 Hz

As a general rule, standard video equipment use only the frame rate information in the video sync signal to synchronize their respective systems. The line pulses are ignored.
This means that a HD interlaced format can synchronize equipment running a progressive scan format at the double of the field rate of the interlace format.

1035i 29.97	can synchronize 1035p 59.94	at 59.94005994 Hz
1035i 30	can synchronize 1035p 60	at 60.00000000 Hz
1080i 25	can synchronize 1080p 50	at 50.00000000 Hz
1080i 29.97	can synchronize 1080p 59.94	at 59.94005994 Hz
1080i 30	can synchronize 1080p 60	at 60.00000000 Hz

There are however exceptions from this rule. Some specially dedicated industrial cameras use the line pulses for control of shutter speed and timing, and may not accept an interlaced sync to synchronize a progressive format.
Also, equipment that use auto-detect on the sync input to determine which system video format to run, may cause issues.

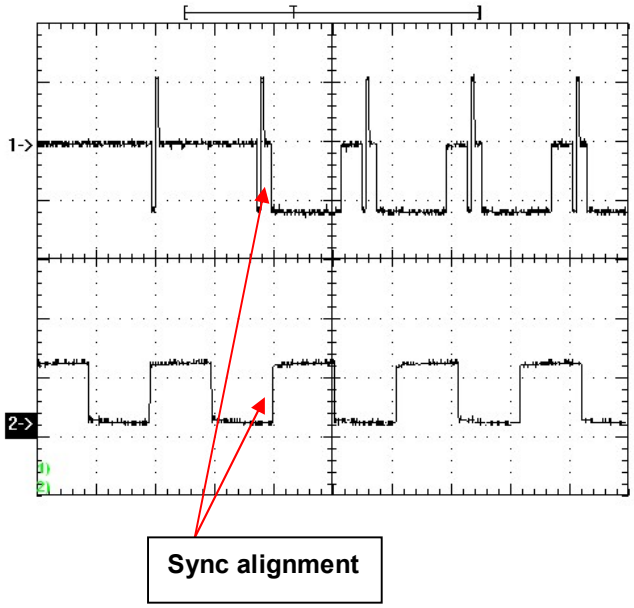
Technical Section

Position lock vs. frequency lock

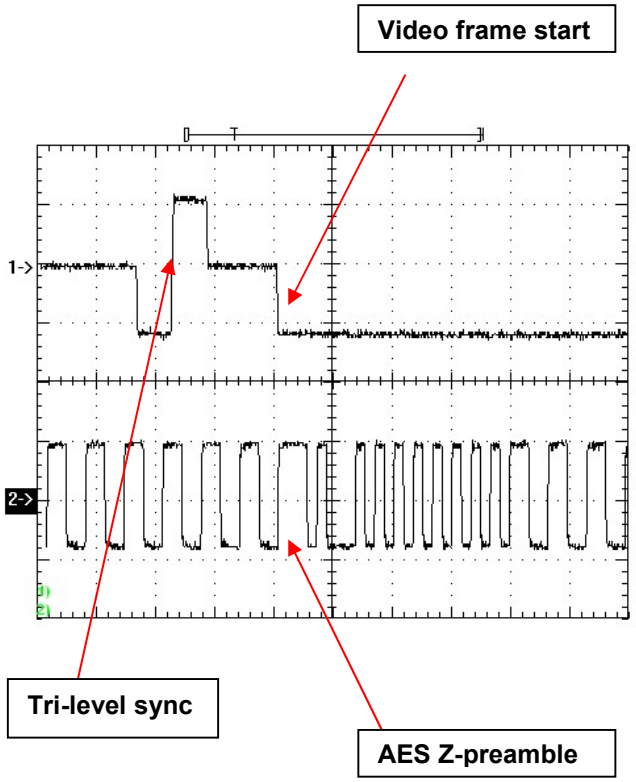
The ASD24 will perform a position lock between different signal formats whenever the mathematical relationship between the waveforms allows for it. However, a position lock is not always possible. When the mathematical relationship between signals has no simple common denominator, the ASD24 performs a frequency lock by using a complex algorithm involving hardware synchronous counters and phase-locked loops. The result is always 100% mathematically precise, with no approximation and with no drift.

A good example of a frequency lock is a Word clock at 44.1 kHz synchronizing to a 525 lines progressive scan video. The frame frequency is 59.94 Hz, giving 735.735735 Word pulses for every frame.
The ASD24 does not give up on these two seemingly incompatible formats. It performs a mathematical calculation, finds a common denominator and performs a phase lock that will yield a perfect lock between the two frequencies.

A *position* lock between two different formats is conceptually straight forward to understand. An example can be seen on the scope snapshot below.
The Word clock is at 48 kHz (lower trace) and the video signal is a 1080i 25Hz HD Video (50 Hz frame frequency). There are 960 clock pulses for every video frame, so the signals fit nicely into each other.
This makes it possible for the ASD24 to perform a precise alignment of the leading edge of the word clock and the frame start of the 1080i video.



Below is an example of a position lock between an AES signal at 48 kHz sampling frequency (lower trace) and a Video signal at 1080i 25Hz (50 Hz frame frequency).
In this case, a position lock is possible. The AES signal consists of 960 samples pr. Video frame, and the structure of the AES signal is 192 samples pr block, which gives 5 blocks for every video frame, so everything fits nicely.
Observe that the video frame start is perfectly aligned with the AES block start (Z-preamble).



The AES recommendation states that the time difference between video frame start and AES block start should be less than 1 usec.

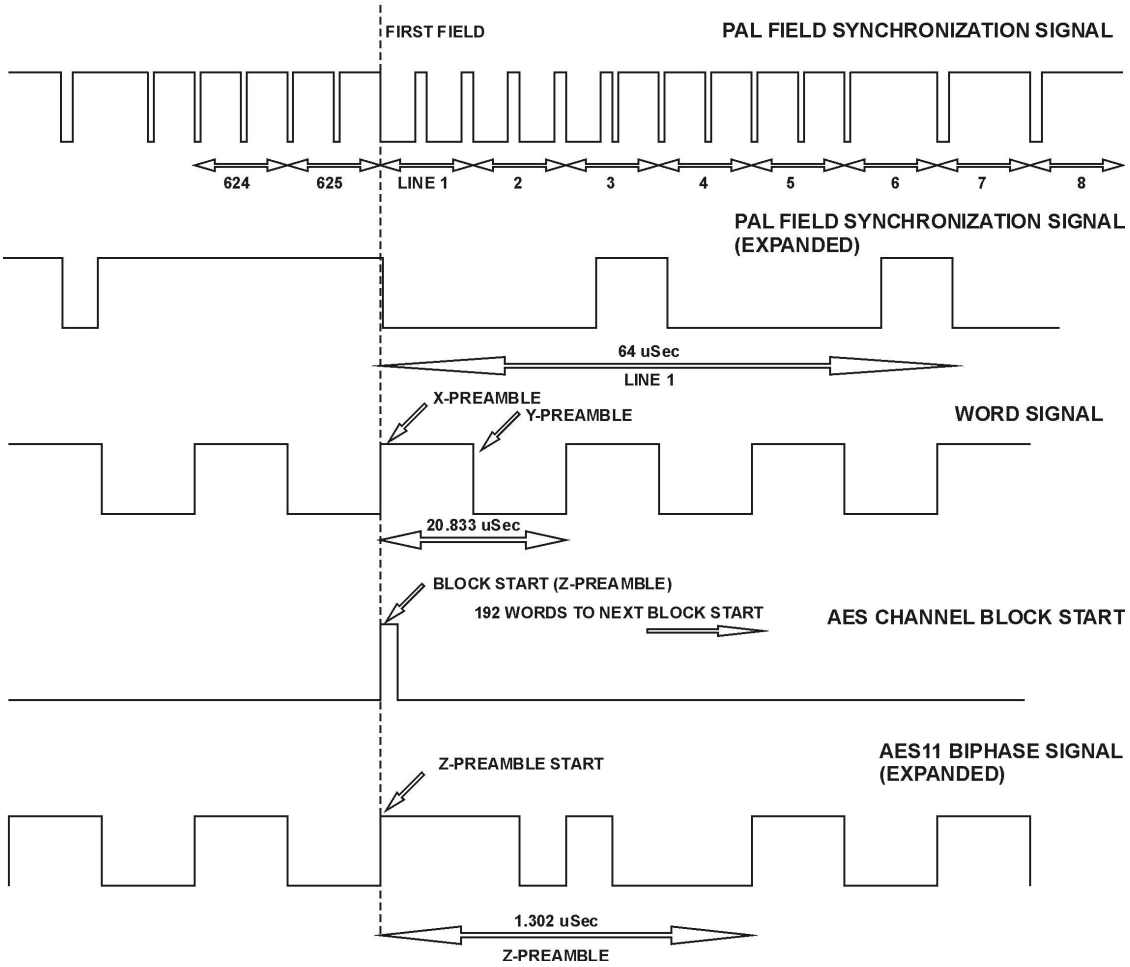
The ASD24 aligns these start positions within one clock cycle at 27 MHz, i.e. less than 37 nsec. The time difference is negligible and simply due to component tolerances and variation in component parameters. The time difference is fixed. It does not wander and it does not jitter outside the specified performance parameters!

The example below shows an overview of the relationship between Video, Word and AES as stated in the AES recommendation. The example uses a standard PAL B, a 48 kHz clock and an AES at 48 kHz sample rate. The illustration shows the position lock of the ASD24. The leading edge of the clock, the leading edge of the AES block and the frame/field start of the video signal are all aligned in time. This applies to the video formats used in the EU region.

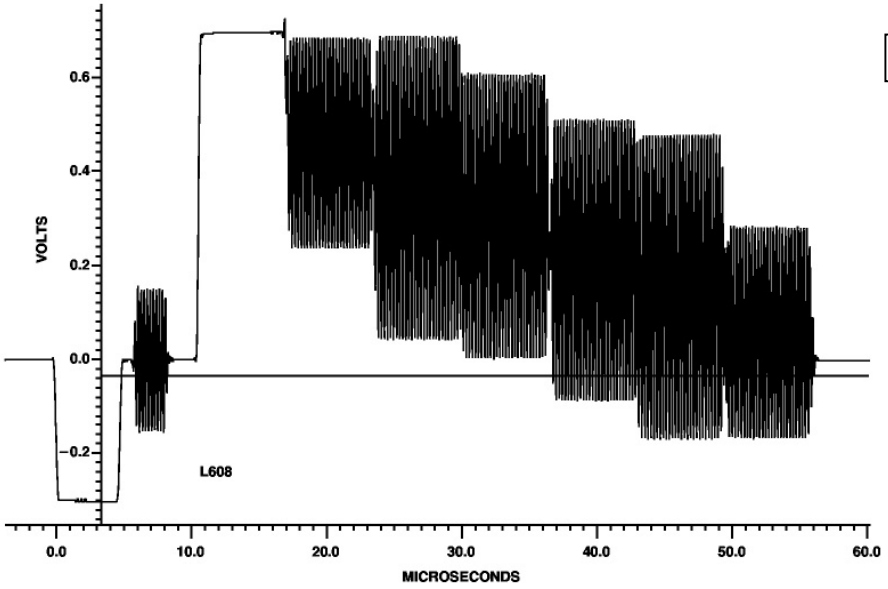
Video formats used in the NTSC regions (Americas, USA, Japan etc.) have a more complex frequency relationship to Word and AES, and in these instances the ASD24 will use frequency lock to achieve synchronization to the video frame.

Still, the ASD24 maintains position lock and perfect alignment between the clock leading edge and the leading edge of the AES signal. The clock and the AES signal are position locked together, and act as a group that is frequency locked to the video frame.

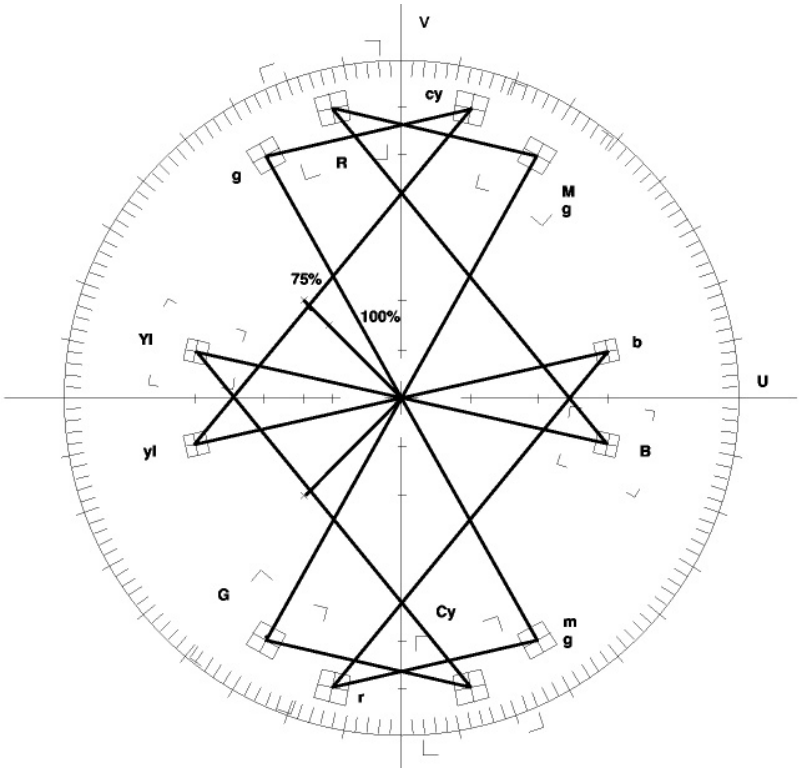
Note that at clock frequencies based on multiples of 44.1 kHz, the AES block start (Z-preamble) cannot be position locked to the word clock leading edge due to incompatible frequencies. In stead, the ASD24 chooses a position lock between the word clock leading edge and the AES sample (X-preamble)



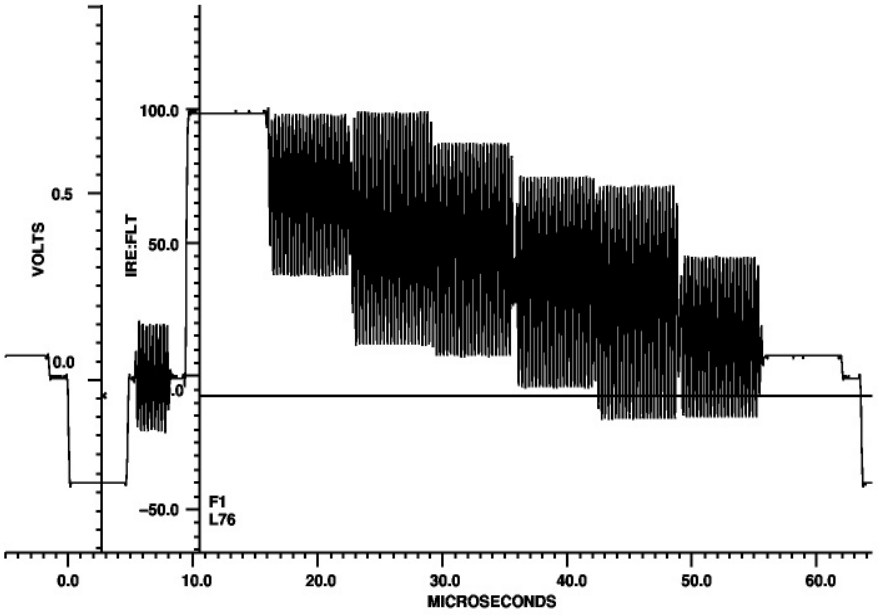
The PAL and NTSC video signals are of analog formats. Below are the test signals (can be selected on/off)



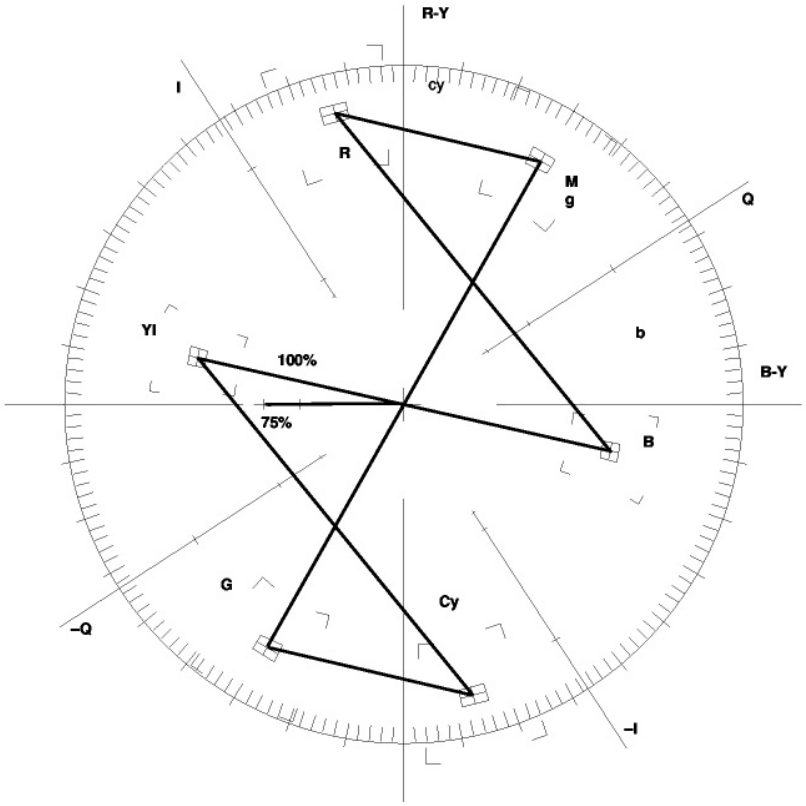
100/75 EBU PAL Colorbar



PAL vector plot



100/7,5/75/7,5 NTSC Colorbar



NTSC vector plot