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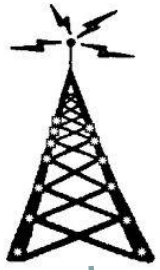
Video and Audio Genlock using IEEE-1588

WSTS June 2014

Broadcast Studio Setup

Broadcast Studio Setup

Monitoring



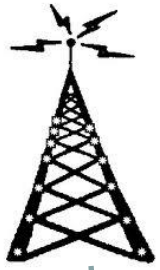
SWITCHER

Outputs

Sources

Broadcast Studio Setup

Monitoring



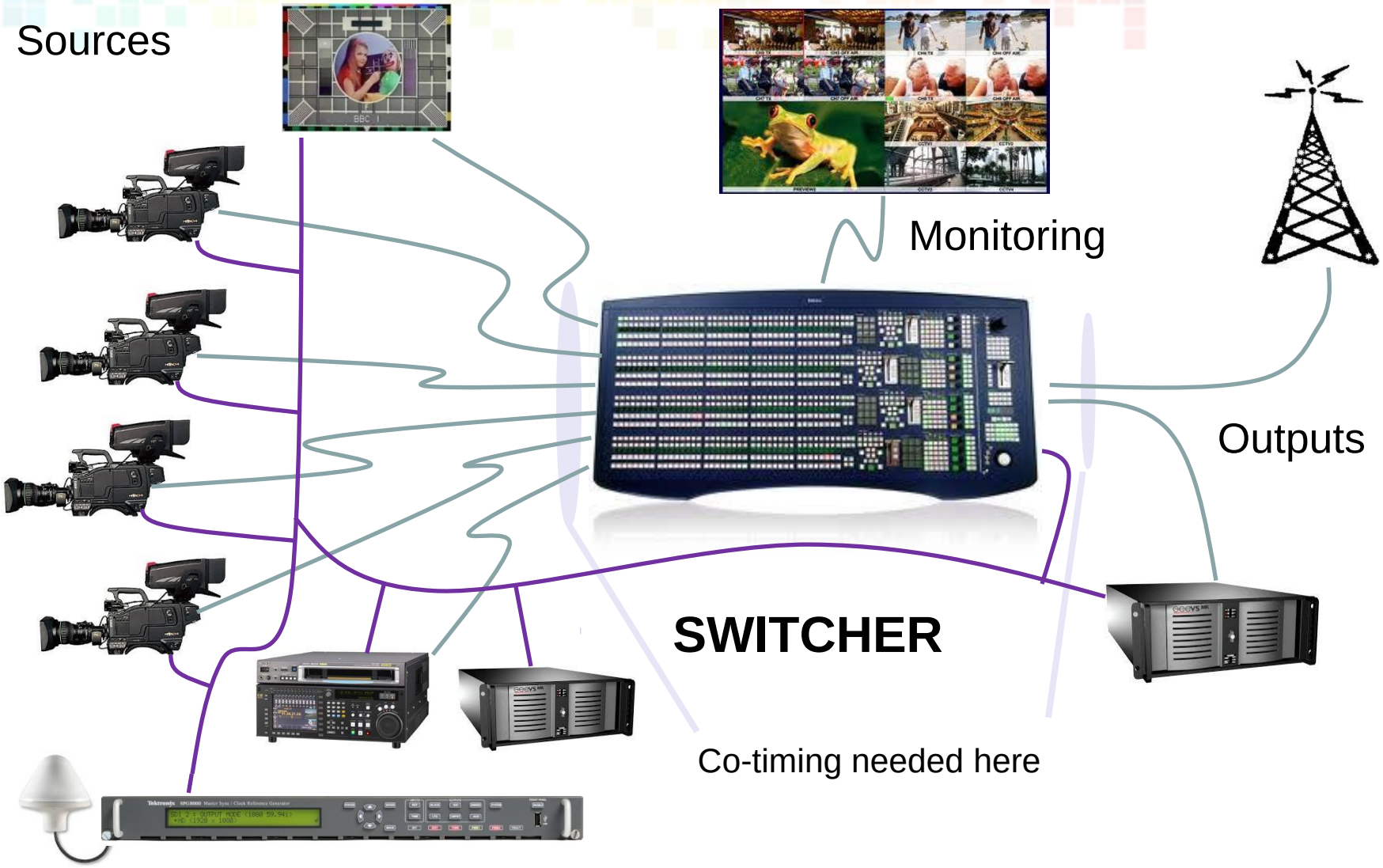
SWITCHER

Outputs

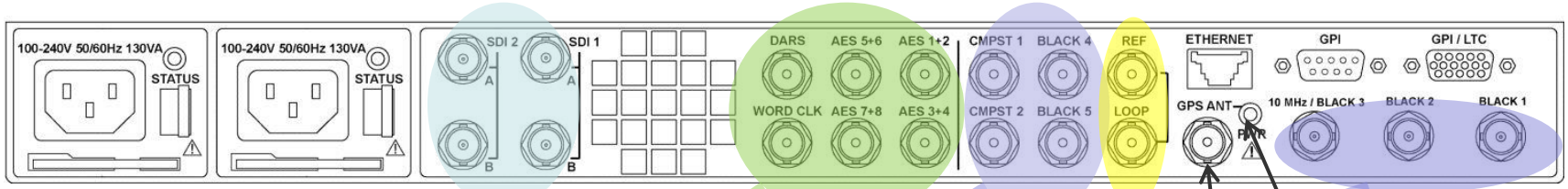
Sources

Co-timing needed here

Broadcast Studio Setup



Master Sync Pulse Generator



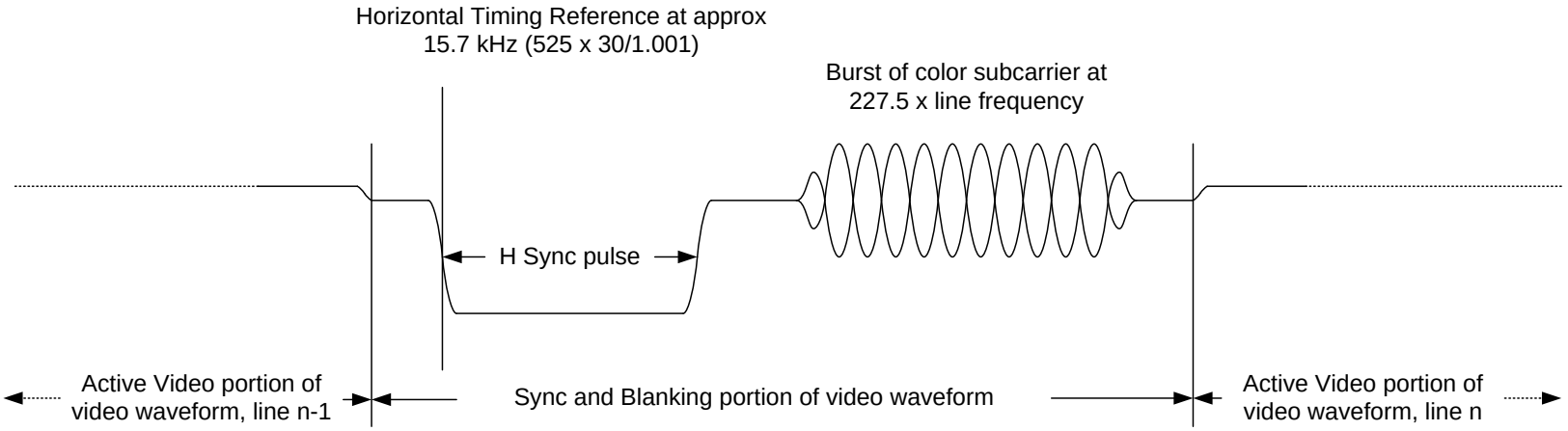
- Serial Digital Video
- Audio Reference (AES)
- Analog Video Reference
- Input Analog Video Reference (for slave mode)

GPS input

Control/monitoring network interface

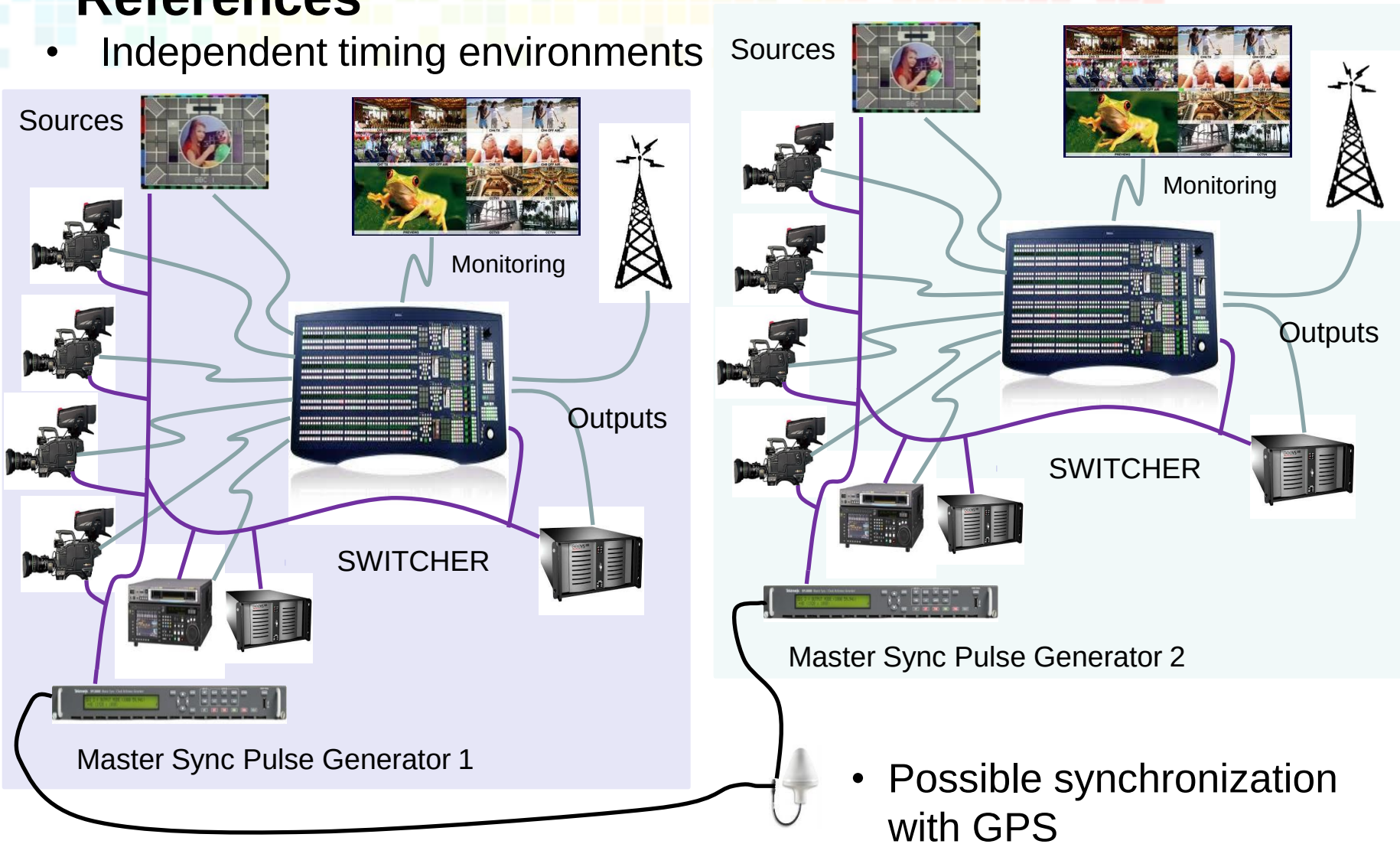
Black & Burst

- NTSC signal with no active video content
  - PAL signal for 50 Hz countries
- Horizontal Sync pulses at fH = 15.734…kHz
  - Actually 525 x 30 / 1.001 Hz
- A burst of color subcarrier on each line at 227.5 fH
- Modified sync pulses at 60/1.001 Hz for Vertical timing
  - Alternate V Syncs at different phases wrt H Sync to indicate Field 1 / Field 2 in interlaced system
- An H Sync:



Multi-Format Facility – Separate References

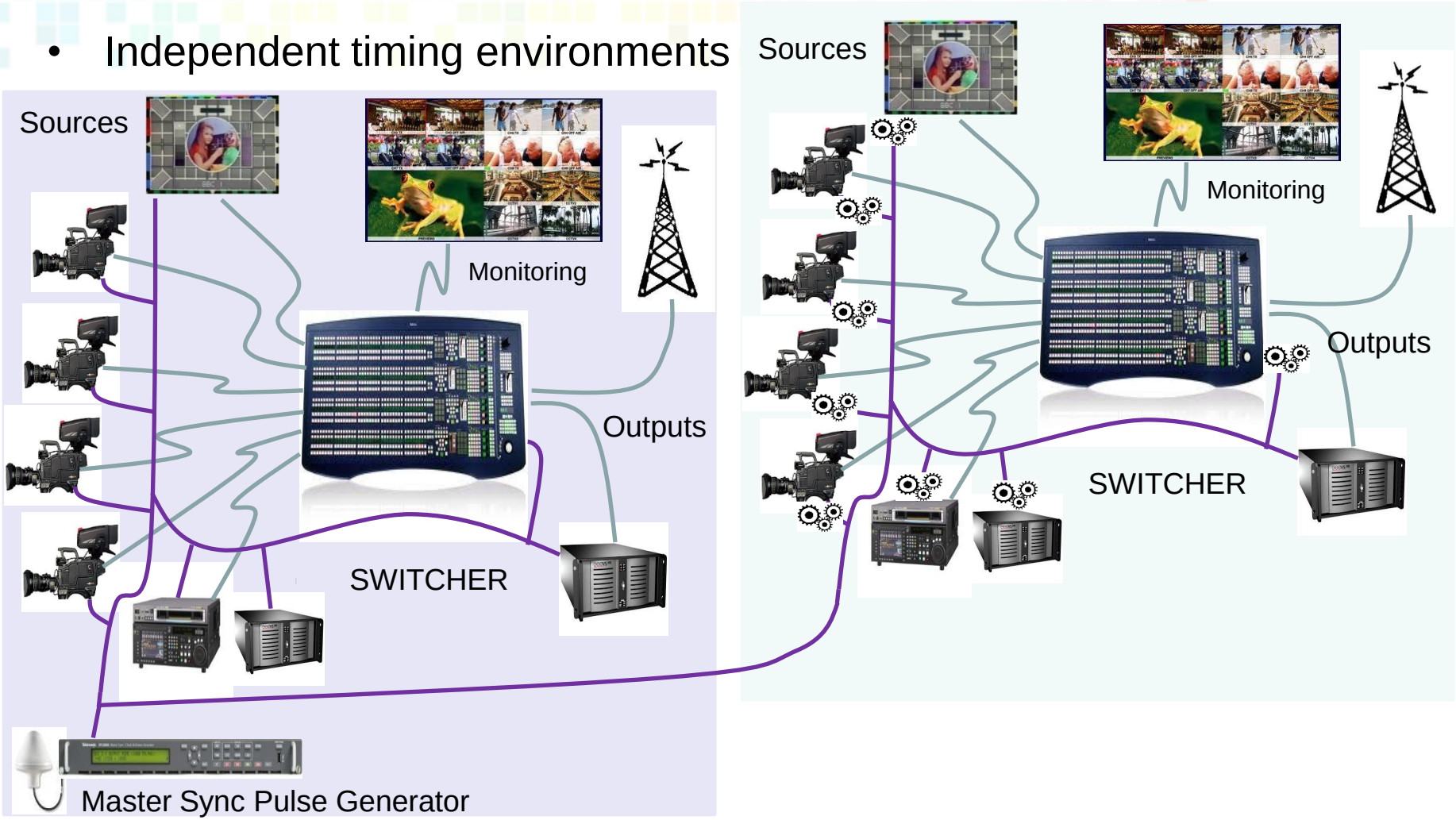
- Independent timing environments



- Possible synchronization with GPS

Multi-Format Facility – Single Reference

- Independent timing environments



Media Timing Requirements

- Media signals are periodic
  - Video frames
    - 24, 25, 30, 50, 60 frames per second
    - 24/1.001, 30/1.001, 60/1.001 frames per second
    - Higher frame rates coming – 100, 120, 120/1.001
  - Audio samples
    - 48 kHz, 96 kHz
    - Occasional use of 32 kHz and 44.1 kHz
    - Very rare use of 48/1.001 kHz

Media Timing Requirements – Media Frame Generation

- They are nominally all frequency synchronised
  - although the ratios are sometimes a bit weird between different formats
    - HD to SD clock ratio is 11:2
      - This works for integer frame rates, e.g. 25, 50
    - Add in 1/1.001 factor and this becomes 500:91
      - This works for 1/1.001 frame rates, e.g 29.97, 59.94
  - "Nominally" synchronised as synchronisation between facilities has traditionally not been a requirement
    - But it is becoming progressively more important
    - Big events, e.g. the Olympics, may be edited and switched many miles from where they are shot, and then be sent live around the world

Media Frame Labelling – Time Code

- Time code is a time label attached to each video frame
  - It currently counts hh:mm:ss:ff up to 40 fps and up to 24 hrs
  - You may have seen it burnt in to you tube videos
  - Capability needed for higher frame rates
- Drop Frame or not
  - The 1/1.001 frame rates have a formula to skip some codes in order to keep Time Code roughly in line with real time. It still drifts a bit, so:
- Time of day to jam Time Code to Local Time
  - Once a day in the wee small hours Time Code is jammed back to real time. Different facilities have different preferences for this time
- No Standard Reference
  - Some users have midnight as the “all zeros” reference
  - Some start all clips at a fixed time, say 1hr, or 10 hrs
  - A standard reference including date would be very beneficial

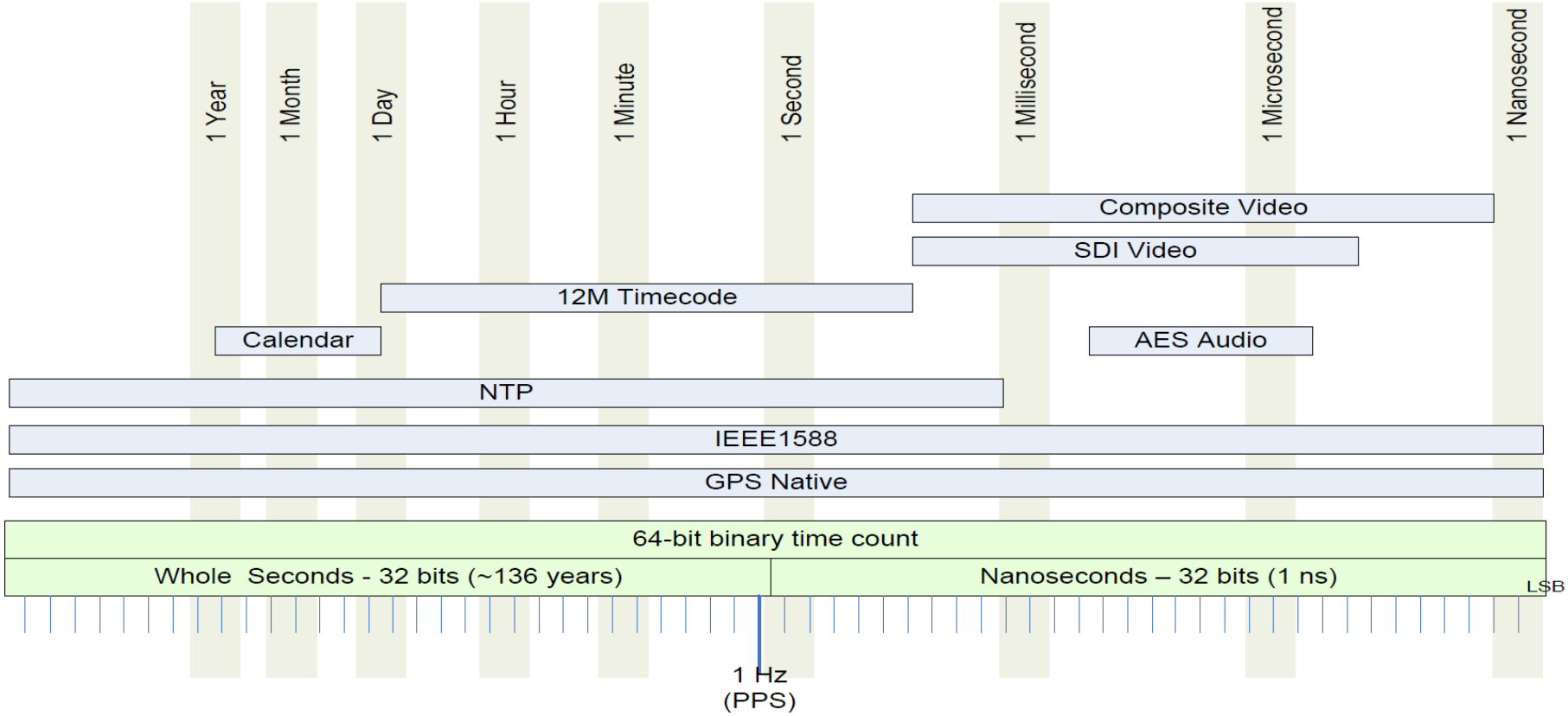
NETWORK USAGE IN BROADCAST

Network Usage in Broadcast

- All equipment has a network interface for control and monitoring
- Growing use of high speed network interfaces for transport of essence (media)
- Why require a separate infrastructure just for synchronisation?
- PTP looks to have the capability to satisfy the broadcast requirements

PTP in Broadcasting

- PTP has range and precision to cover all media requirements



SMPTE Standardisation

- SMPTE (Society of Motion Picture and Television Engineers) is standardising a PTP profile to replace analog based genlock
- SMPTE ST 2059-1 is the timing standard including calculation methods
  - It defines the phase of all media signals relative to the epoch
  - It also includes the equations to work out signal phase at any time
- SMPTE ST 2059-2 is the PTP profile
- These standards are now well on the route to publication
  - Significant changes are now unlikely
- SMPTE Engineering Guidelines – kicking off now
  - Introduction to PTP
  - Time discontinuities
  - Migration guide
  - Best practice for large networks

SMPTE PTP Profile Details

- Timing accuracy 1us
- Lock time 5s
- Mix of multicast and unicast
  - Required message transport modes for Announce, Sync and Follow_Up messages: multicast
  - Permitted message transport modes for Announce, Sync and Follow_Up messages: unicast
  - Delay_Req messages may be multicast or unicast.
  - Pdelay_Req messages may be multicast or unicast.
  - Pdelay_Resp and Pdelay_Resp_Follow_Up messages shall be unicast.
  - Management messages may be multicast or unicast. Replies to management messages shall be unicast.
- TimeSource can be locked, unlocked or “once locked”
  - Unlocked and once locked are for applications where the master’s frequency is referenced to incoming media
  - Each of these has its own ClockClass

SMPTE PTP Profile Details – TLV Packets

- Metadata for Local Time calculation
  - Leap seconds
  - Daylight Savings
  - Time Zone
- Metadata for Time Code generation
  - Local time vs PTP time
  - Drop Frame or not
  - Time of day to jam Time Code to Local Time

SMPTE Timing Standard

- Epoch is 1970-01-01T00:00:00TAI
- All signals aligned at the epoch
  - Audio clocks at 32 kHz, 44.1 kHz, 48 kHz, 96 kHz, 192 kHz....
    - Blocks of 192 audio samples
  - Video frames at all frame rates
    - Blocks of 2 or 4 video frames arising from the relationship with the colour subcarrier in analog colour systems (NTSC and PAL)
    - Blocks of 5 frames arising from the relationship between audio samples and some video frames
- For each video frame type there is a defined alignment point, based on the start of the vertical flyback time for an analog transport of the video signal
  - Equivalents have been invented for formats that were never analog

GETTING FROM PTP TO VIDEO AND AUDIO

Video Clock requirements

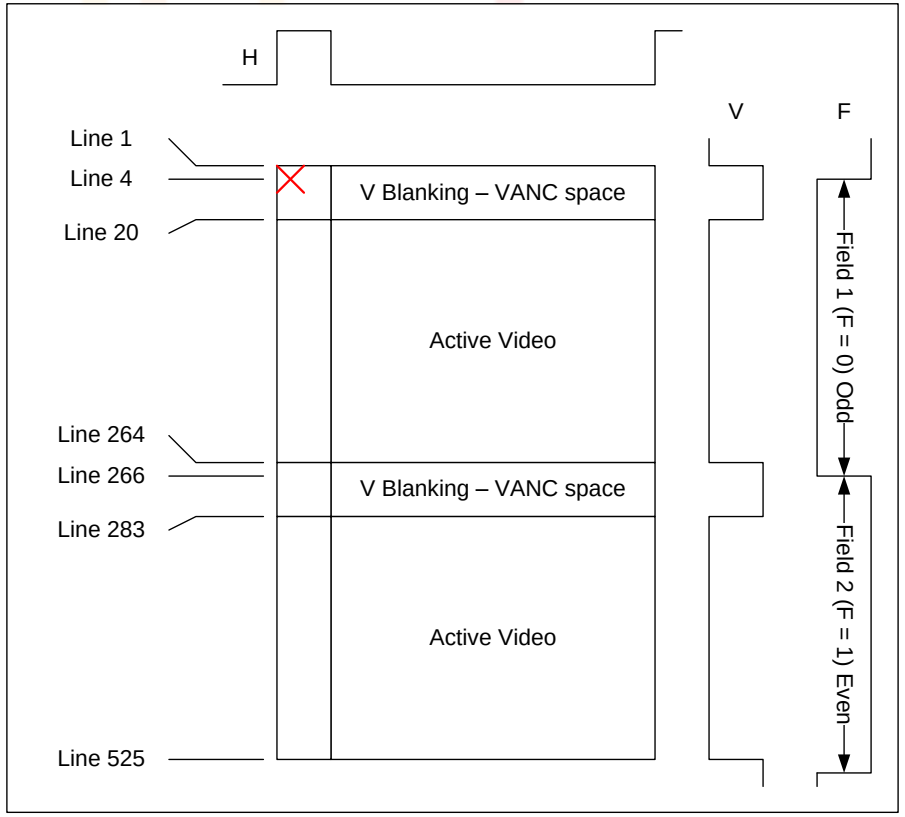
- Sampling Frequencies:
  - 13.5 MHz
  - 74.25 MHz
  - 74.25/1.001 MHz = 74.175824*175824 recurring*
  - 148.5 MHz
  - 148.5/1.001 MHz = 148.351648*351648 recurring*
- Jitter needs to be sub 80ps p-p above 100kHz
- Jitter needs to be sub 600ps p-p above 10Hz
  - This is actually the jitter requirement for the serial clock that is generated from the parallel clock, but parallel to serial clock PLLs do not have great jitter rejection below 10 or 20 MHz, so it's a good idea for the parallel clock to be this good.
- Sampling Clock is epoch aligned

Audio Clock requirements

- Sampling Frequencies
  - 32 kHz
  - 44.1 kHz
  - 48 kHz
    - This is the predominant frequency
  - 96 kHz
  - 192 kHz
  - Processing equipment and audio serial interfaces typically use a multiple of these frequencies, e.g 128x
- Jitter is not well defined, but if it comes close to the video clock jitter it's fine
- Sampling Clock is epoch aligned

The Video Timing Environment

- Video is made up of Frames
- Each frame type has:
  - Active Video
  - Additional horizontal time
    - H blanking
    - H ancillary data space
  - Additional vertical time
    - V blanking
    - V ANC data space
  - An alignment point - X
    - Which aligns with the epoch
    - Based on analog sync times
- Some frames types are interlaced and consist of 2 fields (as shown) some are progressive



Frame Types

- Standard definition (SD)
  - 525 line 29.96 fps interlaced (59.94 fields per second)
    - Active area 720 x 483
  - 625 line 25 fps interlaced (50 fields per second)
    - Active area 720 x 575
- High definition (HD)
  - 1125 line 29.96 fps interlaced
    - Active area 1920 x 1080
  - 1125 line 25 fps interlaced
  - 750 line 59.94 fps progressive
    - Active area 1280 x 720
  - 750 line 50 fps progressive
  - 1125 line 24 fps progressive (movie production)
    - Active area 2048 x 1080
  - Frame rate multiples of the above

Frame Types - Continued

- 3G extensions to HD
  - 1125 line 50 fps progressive
  - 1125 line 59.94 fps progressive
- Ultra High definition (UHD)
  - 2250 line 59.94 fps progressive
    - Active area 3840 x 2160
  - 2250 line 50 fps progressive
  - 2250 line 24 fps progressive (movie production)
    - Active area 4096 x 2160
  - Multiples of the above
    - Half frame rate formats – 25 and 29.97 fps
    - Double frame rate formats – 48, 100 and 120 fps
      - 96 and 119.88 fps still under discussion
- The Message is: There are many video formats

The Audio Timing Environment

- The standard for broadcast audio is 48kHz sampling of up to 6 channels
- The audio sampling clock is epoch aligned
- Audio transport adds metadata with a 192 sample block length
- The 192 sample block is epoch aligned

A PTP GENLOCK

A PTP Genlock

- The PTP part
  - SMPTE profile support
  - SMPTE TLV extraction
- The Genlock part
  - Low Jitter Video Clock Generation
    - Not necessarily a multiple of 1Hz
    - Absolute frequency accuracy required
  - Programmable Video Format HVF Generation
  - Low Jitter Audio Clock and Block Generation
  - Epoch Alignment
    - With programmable offset for cable length compensation
- The Time Code part
  - Translation of TLV and Video frame information into Time Code
    - Including drop frame where necessary

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Thank You