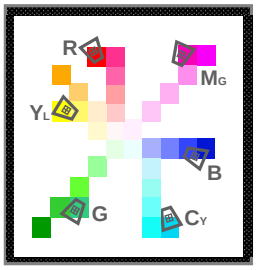
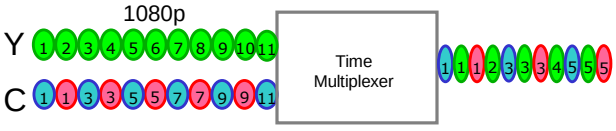
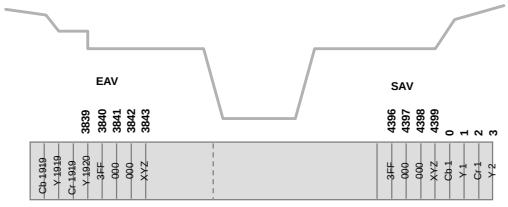
Section 10 – K-Frame Appendix







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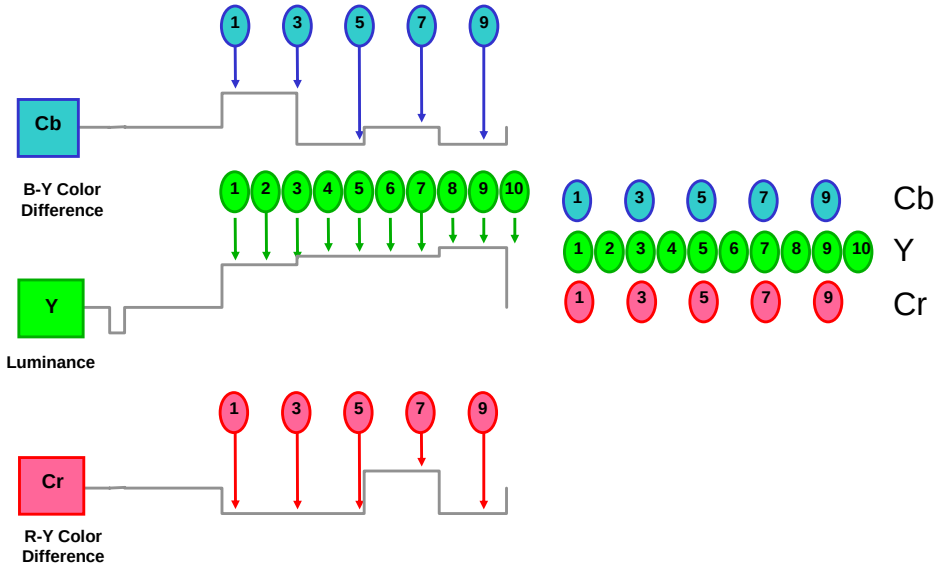
Digital Video

- Sampling
- Luminance and Chrominance
- Multiplexing
- De-multiplexing
- Luminance Levels
- Chrominance Levels
- Active Video
- Horizontal Blanking
- Serialization
- NRZI
- Eye Pattern
- HANC

Component Analog Video Sampling



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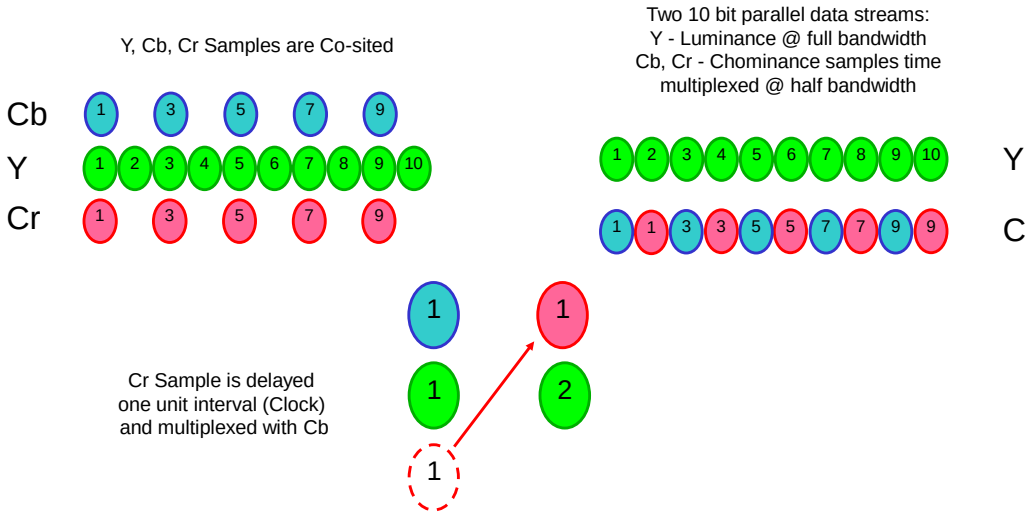
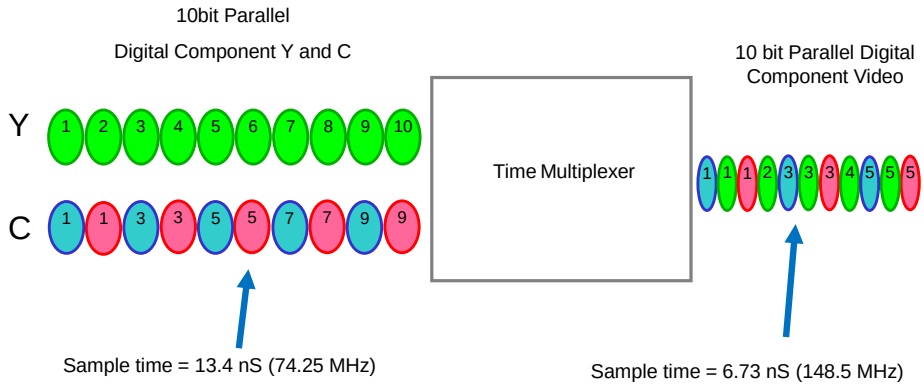
Component Luminance and Chrominance



Digital Multiplexing



Note: All values are for 1080i/60

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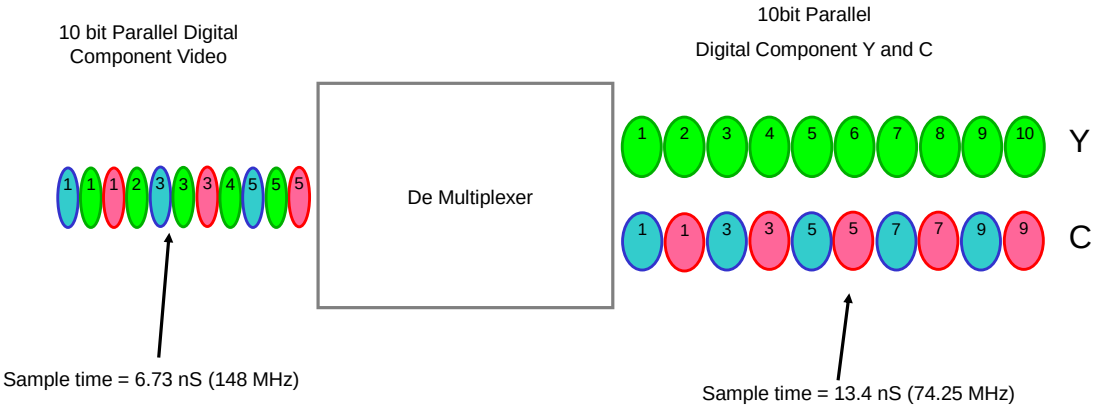
Digital De-Multiplexing



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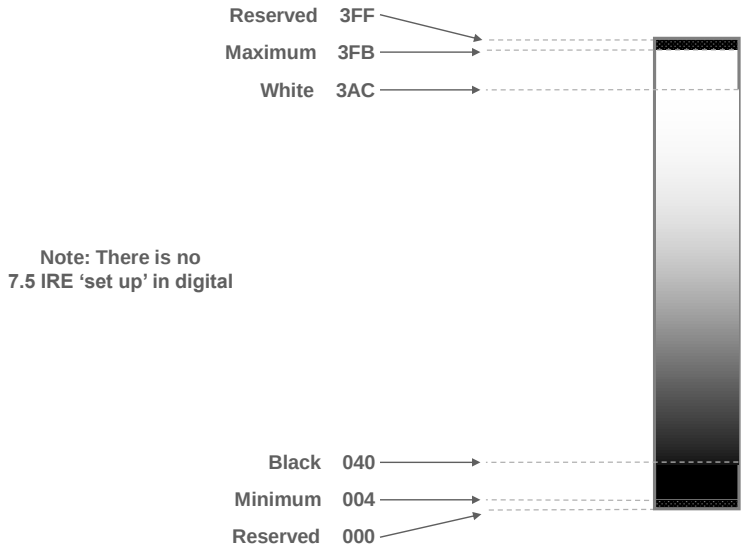
Digital Luminance Levels



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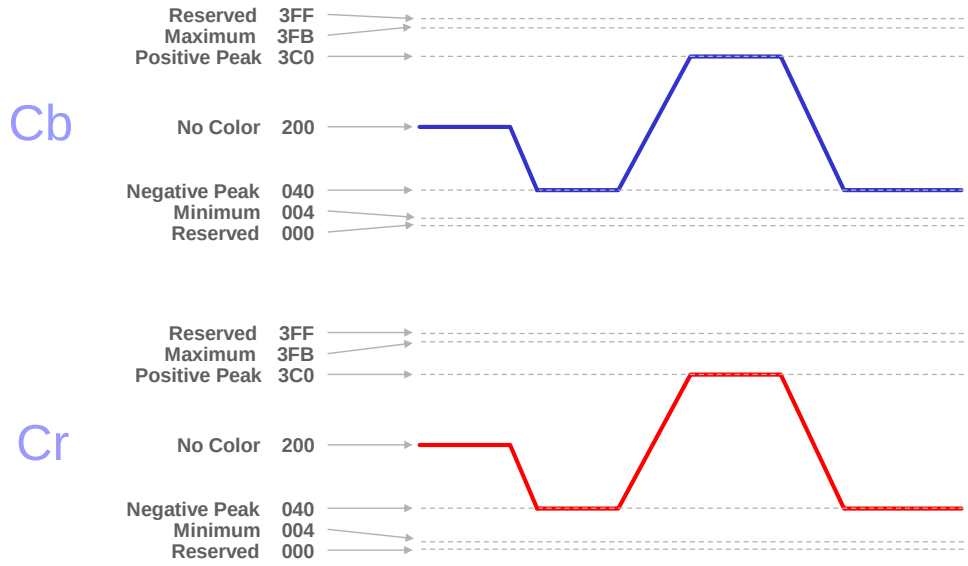
Digital Chrominance Levels



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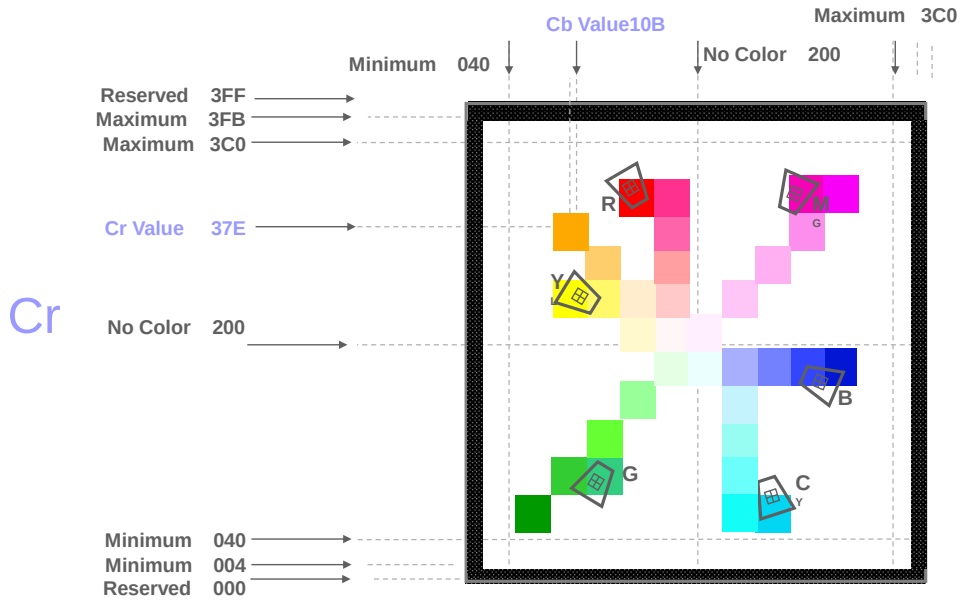
Digital Vector Representation



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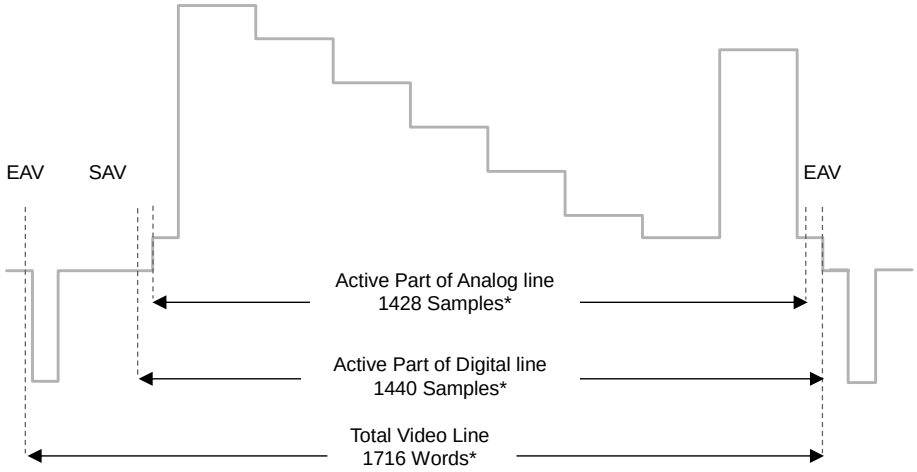
Active Video (SD)



* Values for 525 Formats

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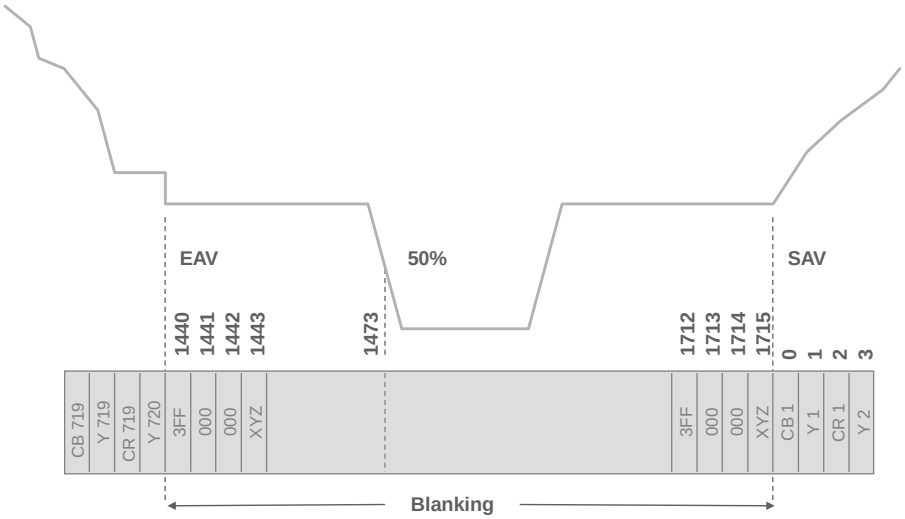
Horizontal Ancillary Period (HANC)



* Values for 525 Formats

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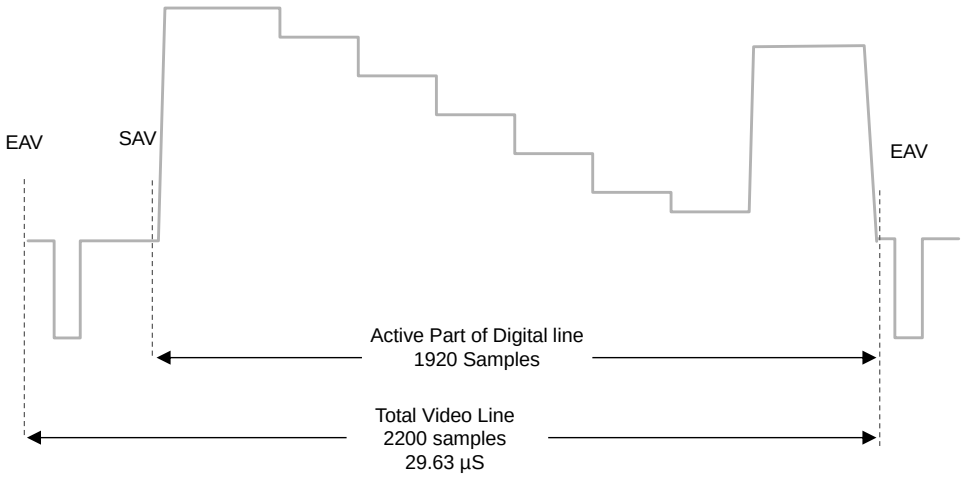
Active Video (HD)



Note: Values for 1080i/60 Format

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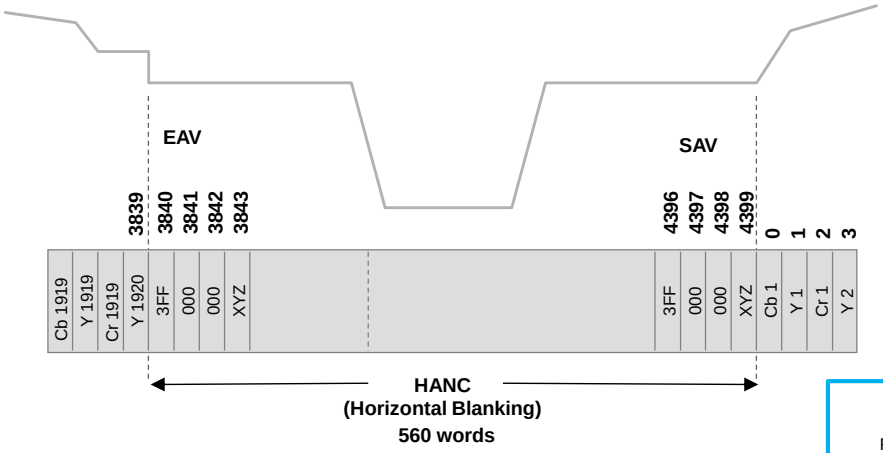
Horizontal Ancillary Period (HANC)

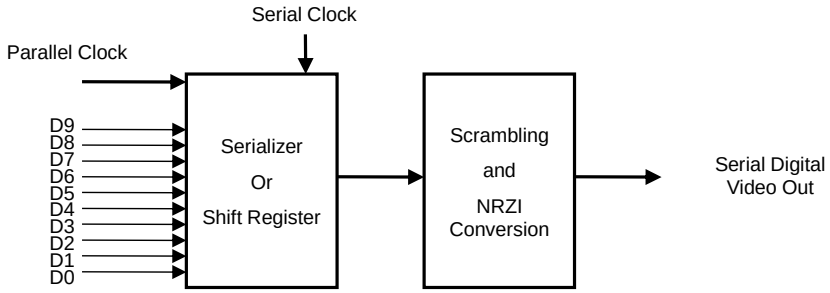


Note: Values for 1080i/60 Format

XYZ bits

MSB = 1
SAV = 0, EAV = 1
Field 1 = 0, Field 2 = 1
Blanking = 0, Active = 1
P3 = 0
P2 = 0
P1 = 0
P0 = 0
= 0
LSB = 0

Parallel to Serial Conversion



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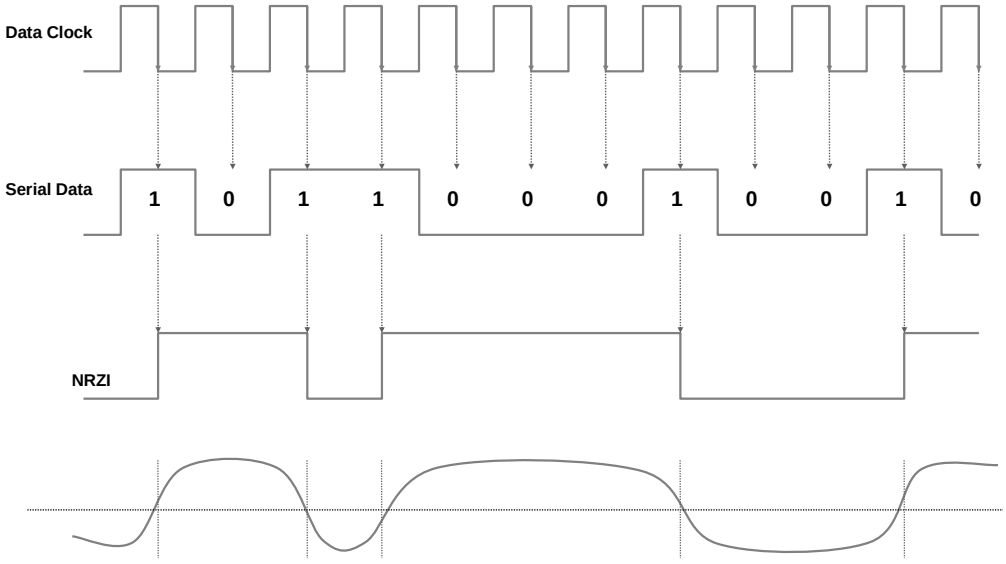
Serial Digital NRZI Conversion



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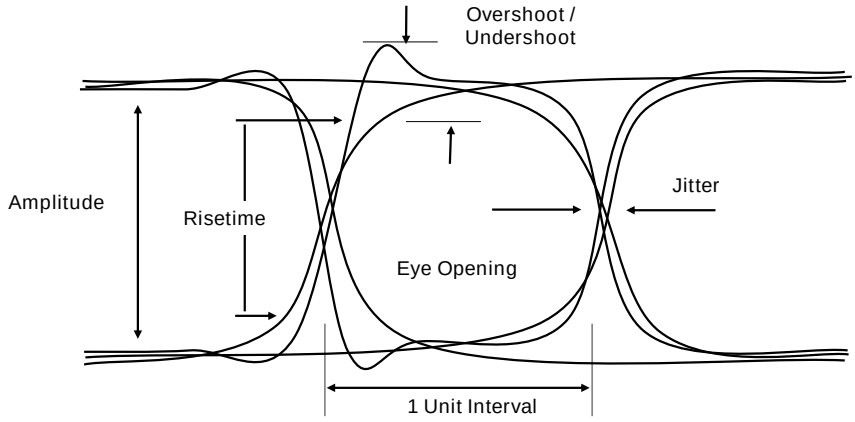
Serial Digital Eye Pattern



Parameter	Unit ratio	270 Mbps	1.485 Gbps
Amplitude	1 +/- .2	800 +/-160 mV	800 +/-160 mV
Overshoot	+/- .2	+/-160 mV	+/-160 mV
Pulse Width	1	3.7 nS	670 pS
Jitter	+/- .2	+/- 740 pS	+/- 134 pS
Risetime	.2 - .8	740 pS	134 pS

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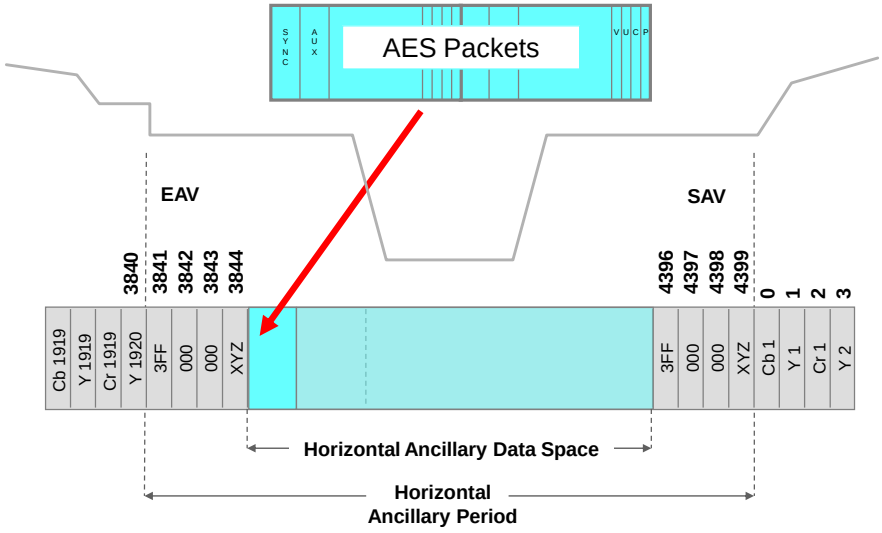
Digital Video HANC - AES Embedded Audio



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Digital Video SMPTE 424M Standard

- SMPTE 424M is a standard which expands upon SMPTE 259M, 259M, 344M and 292M, allowing for bit-rates of 2.970 Gbit/s and 2.970/1.001 Gbit/s over a single-link coaxial cable
- These bit-rates are sufficient for 1080p video at 50 or 60 frames per second
- The signal formats carried over SMPTE 424M are specified in SMPTE 425M
- Within this standard there are two formats known as Level A and Level B
  - The Level A format is a full format transport of a 1920 x 1080 progressive frame with the frame rate of 50 or 60 Hz
  - The Level B format is a multiplexing scheme where two streams of 1920 x 1080 interlaced 50 or 60 Hz video is transported over a 3G SDI link

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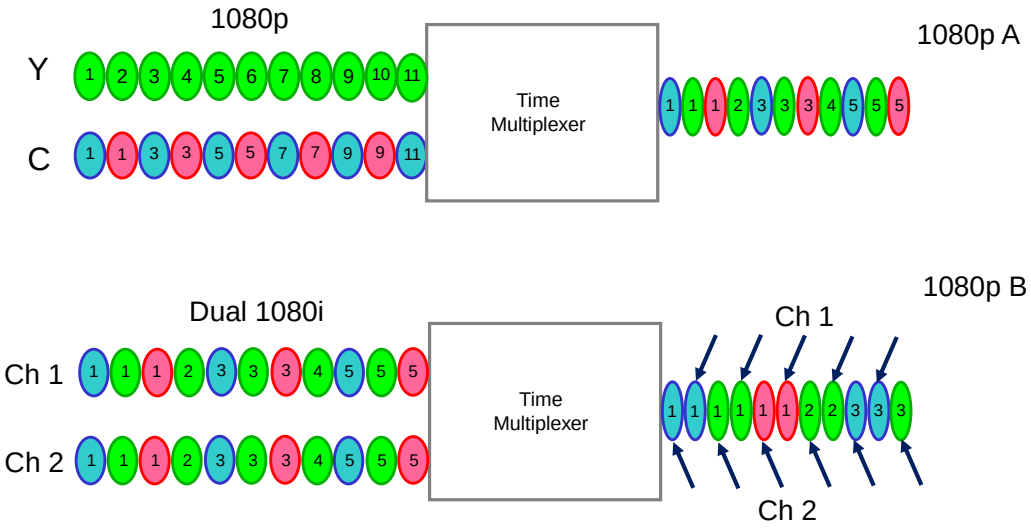
This standard is part of a family of standards that define a Serial Digital Interface commonly known as 3G-SDI

Several manufacturers are supporting only one or the other.

Note that currently SONY Cameras who only support 3G SDI Level B.

Digital Video SMPTE 424M Standard



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The basic difference therefore between the two standards is that the 1080p-A standard is a full 1080p format, whereas the 1080p-B standard is in fact 2 1080i signals (V/V or V/K) multiplexed together.

Video over IP

SMPTE 2022-6

- Ethernet format
- Video over IP standards
- Synchronization
- Switching of streams and Lost Packets
- Embedded Audio
- TICO compression

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Ethernet Streaming

The K-frame modular I/O card accommodates Incoming Ethernet streams that must match the format of the switcher and be synchronous to the switcher reference

Ethernet Streams that are not synchronous to the Switcher will act just like non-synchronous SDI signals do and drift vertically up or down depending on the clock rate difference between the 2 signals

Ethernet streams that are not of the same format will also be treated like an SDI signal of the wrong format

There is no Frame synchronization or format conversion of incoming streams

How is SDI video encapsulated into the Ethernet packets?

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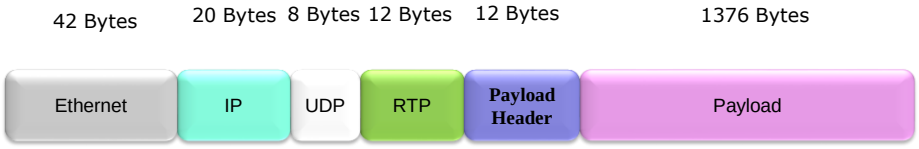
Ethernet Packets

1. Ethernet (Layer 2) 42 Bytes
   Uses standard Ethernet addressing (MAC address) for source and destination packets
2. IP - Internet Protocol (Layer 3) 20 Bytes
   IP Addressing
3. UDP - User Datagram Protocol (Layer 4) 8 Bytes
   Connectionless transmission protocol (requires no handshaking) and so allows transmission to multiple locations



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TCP IP is not used as it has no time relationships between packets. This may produce packet loss but reduces the time delay in waiting for missing packets.

As it is a connectionless protocol there is no way to ask for missing packets either.

RTP protocol favors timeliness over reliability. Some packet loss is acceptable to ensure the timeliness of the stream being received.

UDP

4. RTP – Real Time Transport Protocol (Layer 5) 12 Bytes
   - Provides a Timestamp to allow packets to be resynchronized to external clock
   - In the case of Video this clock is the Video clock
   - Used to provide the information for the reordering of the data packets
5. Payload Header (12 Bytes)
6. Payload – Video Signal 188-1376 Bytes
   - The actual data being transmitted
   - With video streams a single payload of 1376 bytes is a very small part of an image

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User Datagram Protocol (UDP)

- Provides an alternative protocol to TCP
- UDP is a connectionless protocol

Provides only limited error checking of TCP

Provides a faster communication path

Error checking can be done at higher levels

Does not provide for re-sequencing of data

- Important for large networks
- Can make connections unreliable

Synchronization

1. RTP allows the stream to be synchronized to a real time clock
2. Adding a frame buffer to perform synchronization would add significant delay to the stream
3. The timing window in the K-frame is extended by adding a buffer of 1 horizontal line to the incoming streams
4. There is an additional 8 packet FiFo that adds a timing window to the stream
5. One Ethernet packet is about ¼ line at 1080p 59.94

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Switching and lost packets

1. If signals are switched synchronously as in SDI there should be no interruption in the video
2. Dropped packets will cause a loss of data similar to an interruption of the signal in SDI
3. A loss of signal will cause vertical lines on the screen again similar to a loss of an SDI signal

Audio Encapsulation

1. Audio in the HANC period is encapsulated along with the video in the stream
2. When it is extracted from the Ethernet stream the Audio can be used in the same way as regular SDI
3. However Audio is not extracted on the Modular I/O cards supported by the K-frame.

SMPTE 2022 Standards

ST 2022-1:2007 "Forward Error Correction for Real-Time Video/Audio Transport Over IP Networks" defines row/column FEC (Forward Error Correction) for IP video streams. Along with Section 2, this standard has been widely implemented. Row/Column FEC works by grouping IP video packets into logical rows and columns, and then appending one FEC packet to each row and each column. In the event that one packet is lost from a row or a column, the data in that packet can be perfectly recreated using the contents of the FEC packet in conjunction with the other packets in the row or column. This method works quite well, and allows the packet stream to survive lengthy bursts of lost packets.

ST 2022-2:2007 "Unidirectional Transport of Constant Bit Rate MPEG-2 Transport Streams on IP Networks" specifies how constant bit rate compressed video signals that are encoded within MPEG-2 transport streams are encapsulated into IP packets. This standard covers the transport layer (RTP and UDP) as well as comments about timing and buffer sizes.

ST 2022-3:2010 "Unidirectional Transport of Variable Bit Rate MPEG-2 Transport Streams on IP Networks" defines IP packets for variable bit-rate MPEG-2 TS streams that are constrained to have a constant bit rate between PCR messages (called piecewise-constant).

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SMPTE 2022 standards

ST 2022-4:2011 "Unidirectional Transport of Non-Piecewise Constant Variable Bit Rate MPEG-2 Streams on IP Networks" is similar to Section 3, except that it removes the constraint on bit rates.

ST 2022-5:2012 "Forward Error Correction for High Bit Rate Media Transport Over IP Networks" expands on Section 1 to allow larger row/column FEC combinations to support signals with bit rates up to 3 Gbps and beyond. A minor revision to this standard is scheduled to be published in 2013 by SMPTE.

ST 2022-6:2012 "Transport of High Bit Rate Media Signals over IP Networks (HBRMT)" specifies a way to transport high bit-rate signals (including uncompressed 3 Gbps 1080p video) that are NOT encapsulated in MPEG-2 transport streams.

2022-7 (approval pending) "Seamless Protection Switching of SMPTE ST 2022 IP Datagrams" describes a way to send two matching streams of packets from a source to a destination over different paths, and have the receiver switch automatically between them. This allows a perfect video signal to be reconstructed at the receiver as long as both paths do not fail simultaneously.

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SMPTE 2022 - 6

The modular I/O boards in a K-frame, S-series or V-series frame allow integration of IP based signals with an SDI based switcher

What formats are supported?

480i (525), 580i (625), 720p, 1080i, 1080p and 4K

Requirements for Modular I/O:

Kayenne Modular I/O IP boards do not do format conversion

Signals must be of the same format as the switcher (ie 1080i)

Signals must be Synchronous - There is no frame synchronization

The K-Frame and S-series support SMPTE 2022-6 which does not use FEC

K-frame only supports Unicast point to point transmission

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What is 4K - UHD

1. What is the 4K standard?
2. What is UHD?
3. 4096 x 2160 or 3840 x 2160?
4. 4K as used in a switcher is 3840 x 2160
5. Transmission can be either:
   a. Quad Link - 4 quadrants – simultaneously
      i.e. 4 - IP streams or 4-HDSDI signals at 1080p

   b. Dual Pixel Interleave
      1,1,2,2,1,1,2,2 and 3,3,4,4,3,3,4,4 on 2 simultaneous streams

   c. Compression - TICO (Tiny Codec) 4k in a 3Gb signal (4:1 compression)

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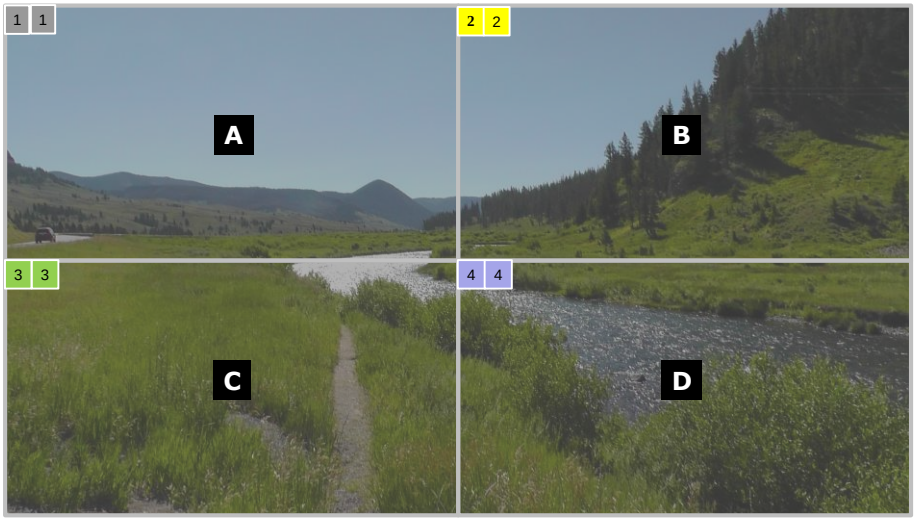
4096 x 2160 is the standard (2048 x 1080)

4K Quadrants = (3840 x 2160)



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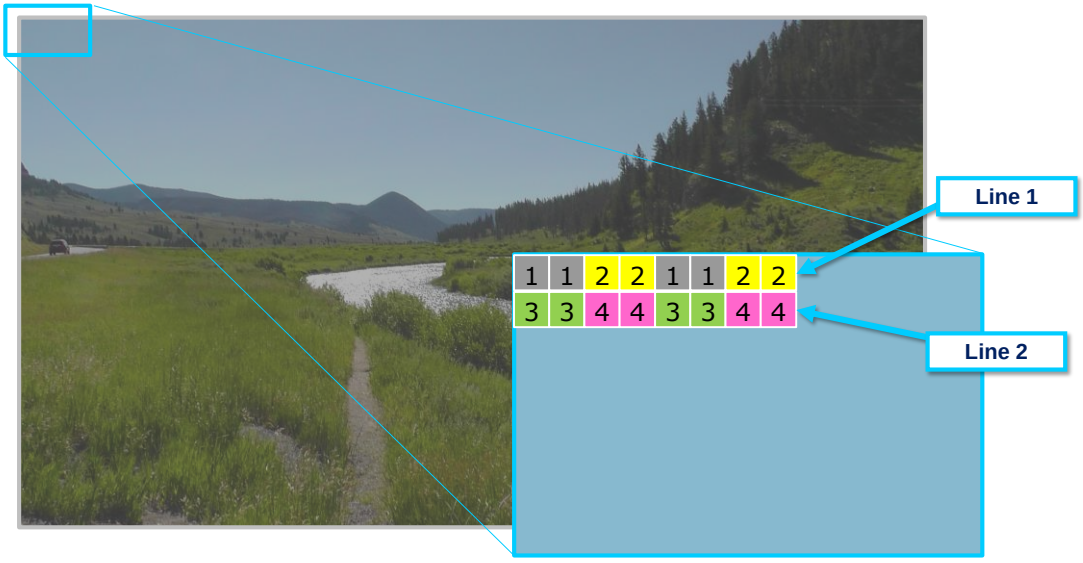
4096 x 2160 is the standard (4 quadrants @ 2048 x 1080)

4K 2SI - Sequential Interlace (3840 x 2160)



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Each box represents one pixel (Y Cr or CB combination) so 2 pixels = Cb,Y, Cr, Y

The streams are produced simultaneously, Stream 1,1,2,2,1,1,2,2 and 3,3,4,4,3,3,4,4 representing 2 lines scanning a complete 4K image.

TICO Compression

TICO Compression

Introduced by TICO at NAB 2015

1. This is a proprietary compression scheme that compresses a 12 Gbps 4K signal into a 10 Gbps Ethernet stream
2. It can also compress a 4K signal into a 3 Gbps stream for transmission over standard SDI infrastructure

It can be used over IP or SDI, In or Out

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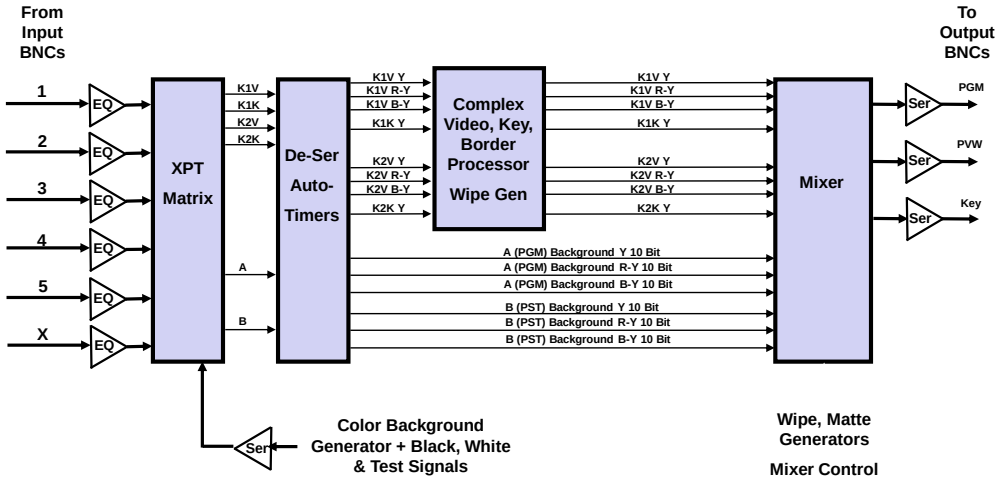
Compression adds a 5 line delay

Basic Switcher Functional Flow – Simplified Mix Effects



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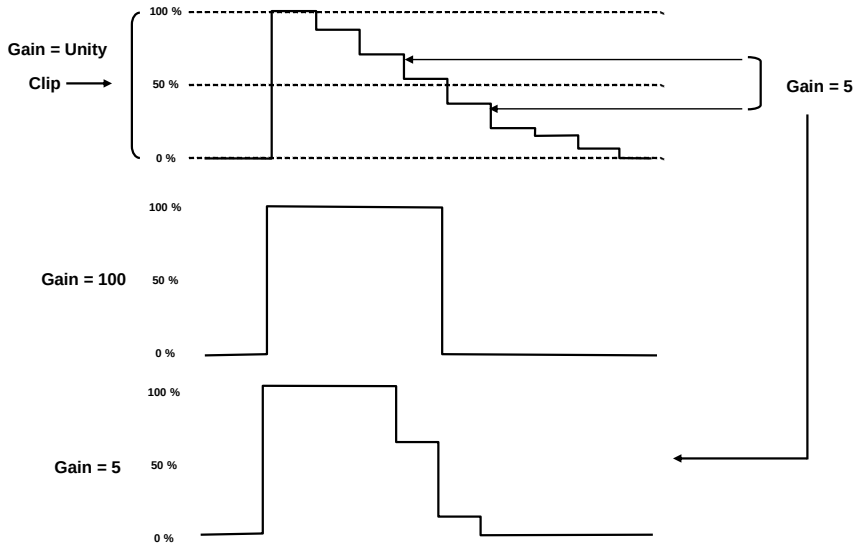
Keyer Controls - Clip and Gain



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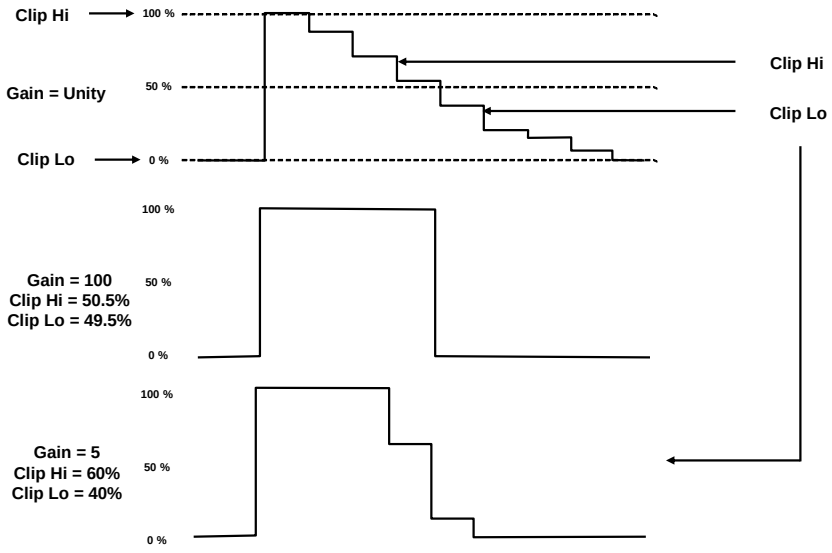
Keyer Controls - Clip Hi - Clip Lo



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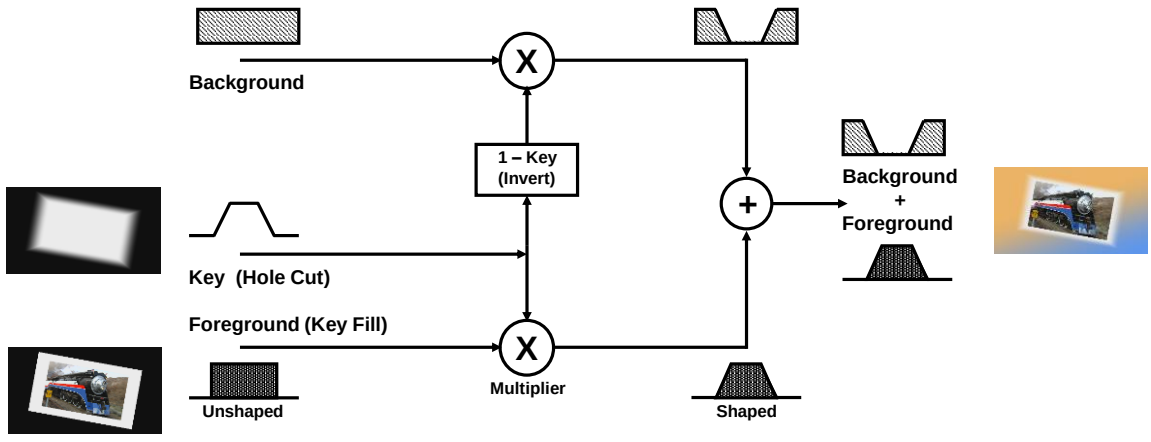
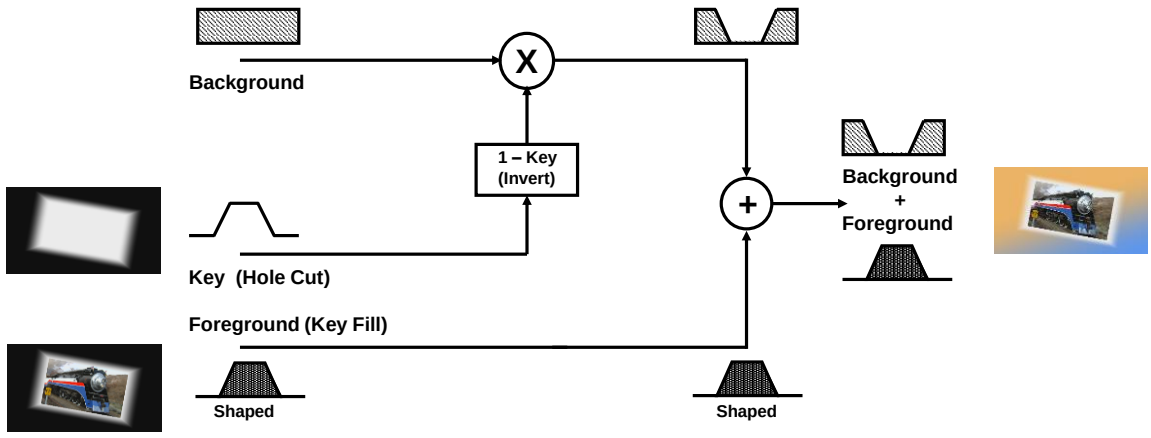
Unshaped Keyer Keying Operation



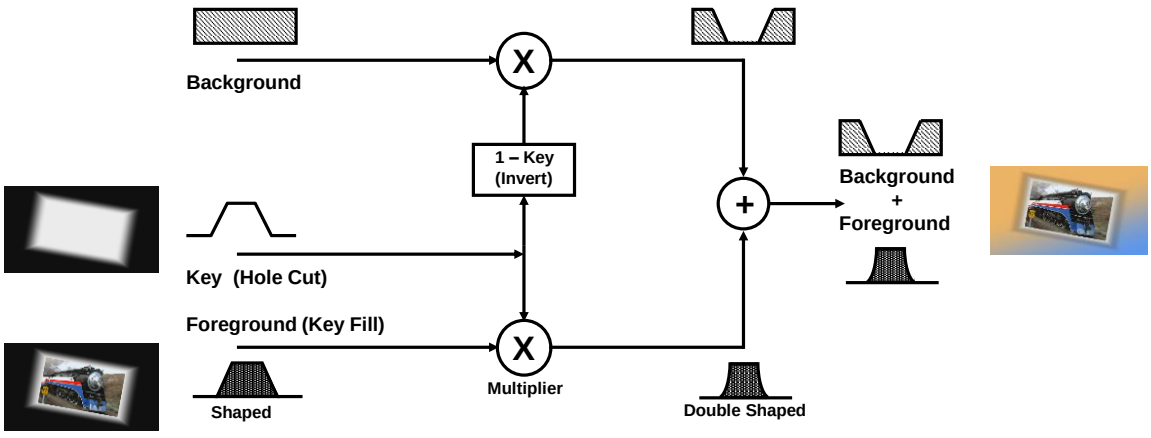
Multiplicative (Unshaped) keying operation

Shaped Keyer Keying Operation



Additive (Shaped) keying operation

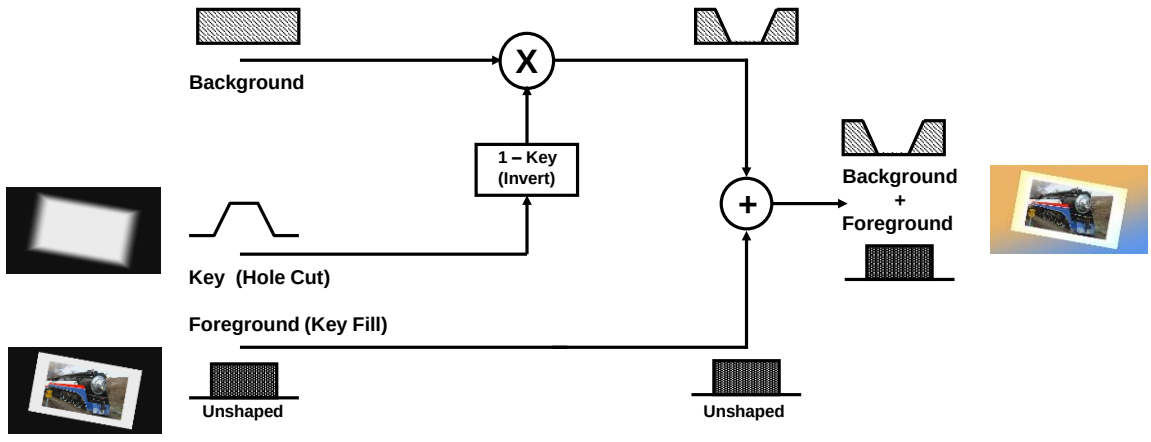
Incorrect Shaped Keyer Keying Operation



Shaping already shaped video (double multiply)

Dark halo is always present around edge of key

Incorrect Unshaped Keyer Keying Operation



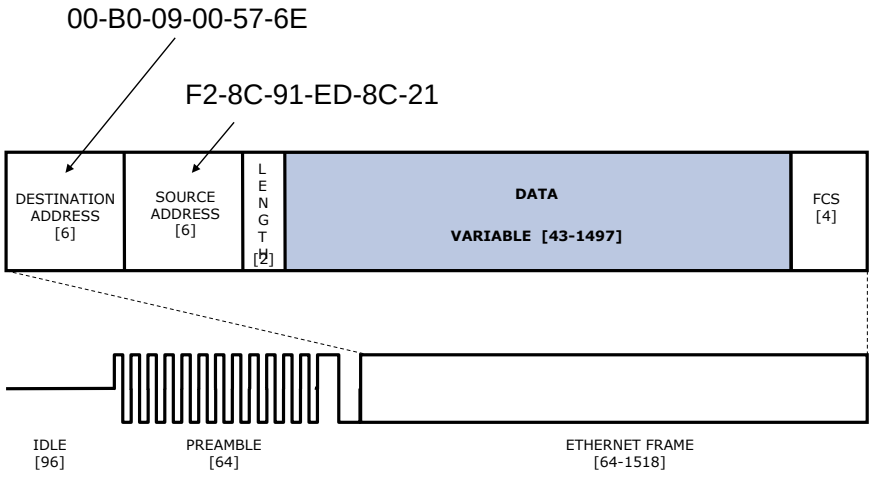
Unshaped video that is not being shaped

White halo is always present around edge of key

Ethernet Protocols

- Ethernet Frame
  - Source and Destination Addresses
  - IP Encapsulation
  - Negotiated Ethernet Frame Size 64 -1500 Bytes
- Collision Detection and Resolution
  - CSMA/CD 0 -102 mS retry
- Broadcast Addresses
- Address Resolution

Ethernet Frame



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IP Addressing

IP ADDRESS	192	168	0	122
SUBNET MASK	255	255	255	0
SUBNET	192	168	0	122

NETWORK ID HOST ID

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IP addresses are expressed in Dotted Decimal Notation.

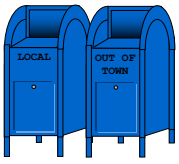
• Class A - This address uses the first byte for the network number and the remaining three bytes for the host number. The first byte ranges in decimal value from 1 to 127. A Class A address fits an Internet situation that has up to 128 networks and up to 16,777,216 hosts per network.

• Class B - This address uses the first two bytes for the network number and the last two bytes for the host number. The first byte ranges in decimal value from 128 to 191. A Class B address fits an intermediate situation with up to 16,384 networks and up to 65,536 hosts per network.

• Class C - This address uses the first three bytes for the network number and the last byte for the host number. The first byte ranges in decimal value from 192 to 223. A Class C address fits a situation with up to 2,097,152 networks, and less than 256 hosts per network.

IP Subnet Masks

NETMASK	255.255.255.0	11111111 . 11111111 . 11111111 . 00000000
SOURCE AD	192.168.0.240	10011000 . 10101000 . 00000000 . 11110000
DEST AD	192.168.0.126	10011000 . 10101000 . 00000000 . 01111110
RESULT		00000000 . 00000000 . 00000000 . XXXXXXXX
NETMASK	255.255.255.0	11111111 . 11111111 . 11111111 . 00000000
SOURCE AD	192.168.0.240	10011000 . 10101000 . 00000000 . 11110000
DEST AD	192.168.1.126	10011000 . 10101000 . 00000001 . 01111110
RESULT		00000000 . 00000000 . 00000001 . XXXXXXXX



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Subnet Mask separates the IP address into 2 parts, so that the Host can determine which part of the IP address identifies the network and which part defines to the local computers. On a Class C network, the first 3 sets of numbers are "blocked". Using the Subnet Mask, the IP address can be used to determine which packets belong on the local network and which do not. By combining the destination address with the Subnet Mask, a computer can recognize whether that address is on or off the local network (or segment). If it determines that the address is off the local network segment, the message will then be sent to the Default Gateway for forwarding beyond the local network. In order for this to be accomplished, the Default Gateway must have its own IP address on the local network. Local systems then send packets to that address for forwarding.

Address Resolution Protocol

- ARP Utilization Reduces Network Congestion
- Valid Entries are Maintained for 20 Minutes
- IP Address Resolution Sequence
  - Transmitting Station Sends ARP Request With Ethernet Broadcast Address
  - All Stations Must Listen
  - Targeted Station Responds With Ethernet Address
  - Transmitting Station Applies Discovered Ethernet Address to Packet

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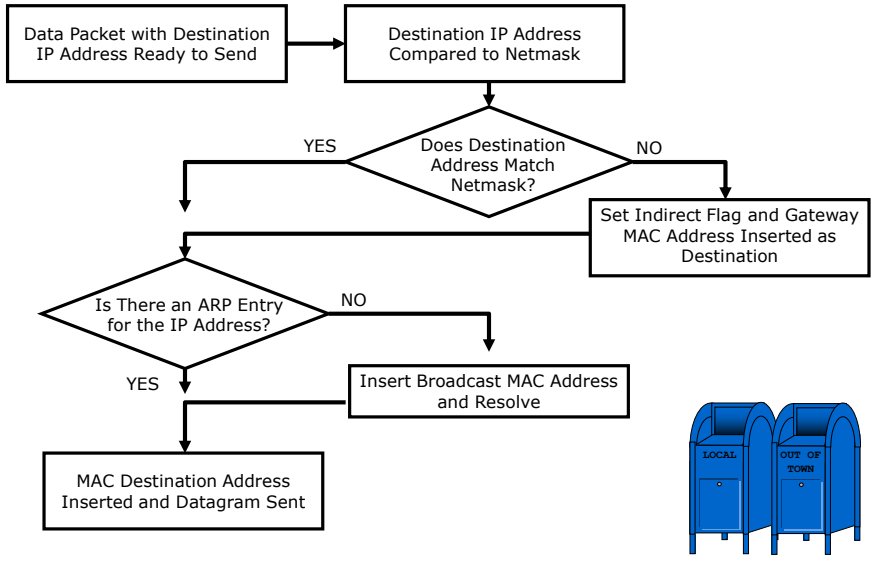
ARP Address Resolution Protocol - ARP requests must be sent as broadcasts. A device with the broadcasted IP address must respond with its Ethernet address. Most systems treat the ARP table as a cache, and will clear entries if they have not been used within a certain period of time.

IP Routing Operations



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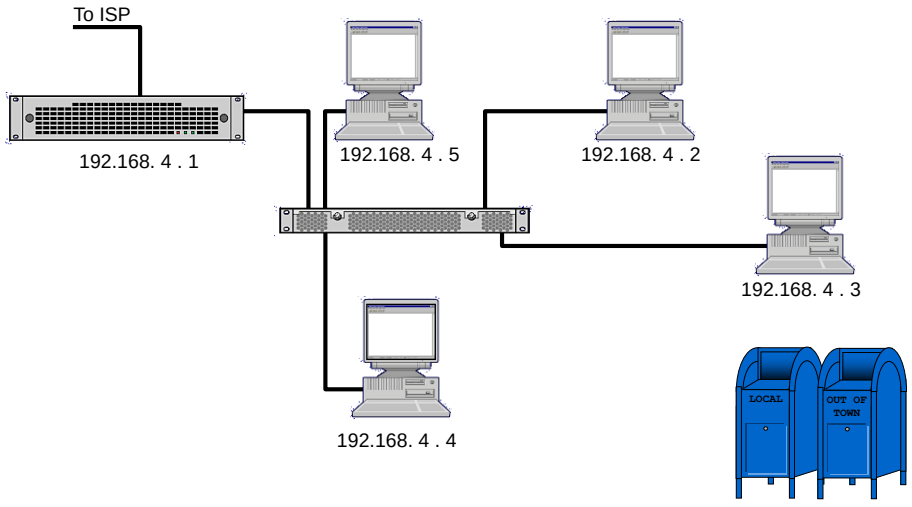
Gateway Routing



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