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# Summary of Claims & Features

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**TruColor™**, Specification originally published in 2012 – A **Luma/Chroma** matrix with **RGB** weighting that produces an even stair step **Luma** signal when the 'Wh**Y**C**Cy**Gr**Mg**R**d**B**Bk**' color bars are generated. When the **U&V Chroma** signal levels are adjusted and combined in quadrature they produce an equilateral hexagon on the Cartesian grid (vector scope), optimizing **Chroma** signal levels. The **I&Q** channels are positioned  $\pm 45^\circ$  away from the **U&V** channels. The hue of TruColor's **I** channel is  $< 2\frac{1}{5}^\circ$  away from NTSC's **I** channel hue of #**FC6600** and TruColor's **Q** channel's hue of #**E700FB** is  $< 4\frac{1}{8}^\circ$  away from the **Green-Magenta** axis. This **RGB** weighting provides a better orthochromatic **B&W** visual representation to the eye than the panchromatic weighting used in most image file formats while also offering a symmetrical color wheel with the axes spaced  $60^\circ$  apart and of equal level, the same as the panchromatic weighted images. This lends its self to very similar **YUV** color processing used in the panchromatic image formats.

**3:1 Interlace** – Inverting the **Luma** on every other field line will produce a full frame of lines that will have every other line inverted also. Any PLL mis-tracking producing minor DC bias offsets causing intensity variations between lines will cancel out visually. Using sequential color where only one channel of color information is sent per **Luma** line the **U&V** channels will alternate in both field and frame lines just as the alternating **Luma** does. In both a field and frame the color information is evenly distributed and after the 1<sup>st</sup> field has been received a full color image at  $\frac{1}{3}$  resolution will be displayed. The non-current color channel per **Luma** line will be acquired from a 1:1 average of two lines, above and below. As the 1<sup>st</sup> field is being received the lines for the other two fields will be temporarily interpolated from the 1<sup>st</sup> field of lines in a 2:1 mix ratio so all lines will be displayed as the image is being drawn from top to bottom. The color information for the lines in the other two temporary fields will also be interpolated in an optimized ratio for best accuracy. As the 2<sup>nd</sup> field is being received interpolated lines in the 2<sup>nd</sup> field will be replaced and the additional color information will be applied and re-calculated for all fields. As the 3<sup>rd</sup> field is being received the update process will repeat and produce full resolution as the 3<sup>rd</sup> field is being drawn. This sequential **Luma/Chroma** arrangement is usually referred to 4:2:0 but since the **U&V** channel alternation is on a per line basis for a full frame it is better referred to as 4:2:1. This arrangement produces a fair quality image early on during reception. A 3:1 interlace produces an image in 3 passes and dropouts within a field can be concealed by interpolating the loss from the other 2 fields. This can naturally happen on the fly by not replacing the temporarily interpolated areas where dropouts occur making those interpolations permanent.

**Inverting Luma** – Adding 2 or 3 adjacent **Luma** lines in a field with a  $\frac{1}{2}:\frac{1}{2}$  or  $\frac{1}{4}:\frac{1}{2}:\frac{1}{4}$  ratio will cancel out almost all **Luma** leaving an average DC error from PLL mis-tracking. This error can then be applied to correct both **Luma** & **Chroma** offset errors.

**Inverted U Channel** – Inverting the **Chroma U** channel in relation to the **V** channel during transmission will only cause saturation changes in the **I** channel but not the hue if a DC tracking error is present. The DC error will cause both  $-U$  &  $V$ , between where **I** is located, to increase or decrease in unison. However for the **Q** channel the hue will be primarily affected with some minor saturation changes. This is more desirable than having the **I** channel affected in this way as a  $\pm 15^\circ$  change in **Q** can produce visually noticeable differences that should be the most tolerable whereas  $-Q$  errors are much less noticeable for the same amount of error. The test pattern has **Q** &  $-Q$  colored squares with additional squares at  $\pm 15^\circ$  &  $\pm 30^\circ$  hue deviations.

**Time Compressed Chroma** – The **Chroma** signals will be time compressed requiring only  $\frac{1}{2}$  the samples required for the **Luma** per line. During image sampling for transmission the Chroma DotClock will run at  $\frac{1}{2}$  speed of the **Luma** DotClock. During transmission it will produce the same bandwidth as the **Luma** but its transmission period is only  $\frac{1}{2}$  the length of the **Luma**. During reception the **Chroma** sample rate will run at  $2 \times$  **Luma** sample rate to acquire the same number of pixels per line as the **Luma**. This accounts for the '2' in the 4:2:1 **Luma/Chroma** ratio. This is mostly Prior Art.

**Armstrong PM via QAM** – FM is normally used for SSTV modulation to benefit from the capture effect and noise immunity over AM. For Fast Scan TV AM is normally used with good results. With AM the sideband energy resembles the modulating signal with no harmonics generated providing greater image detail within the same bandwidth. Both FM and linear PM produce multiple harmonics requiring a wider bandwidth for the same sideband energy compared to AM. For single tone modulation both FM and PM with the same modulating index produce identical sideband harmonics. One is the integral or derivative of the other. The drawbacks to FM are that the modulation index and S/N decrease as the modulating frequency increases versus PM and is why pre-emphasis is used with FM. Above the pre-emphasis corner frequency the sideband energy starts to resemble that of PM so why not use PM instead. FM has a triangular noise spectrum while PM has a rectangular one. These are well known modulation characteristics and Prior Art.

The goal is to create an angle modulated signal with the sidebands of AM, a rectangular noise spectrum, and also benefit from the capture effect and noise immunity of a limited signal. Using Armstrong PM and not limiting it prior to transmission will produce AM sidebands but also produce a non-linear phase modulation term. In the receiver it can be limited to remove the AM components to benefit from the capture effect and noise immunity but the phase output is non-linear.  $\tan\theta$  is the correct transfer curve. There are analog circuits that can produce the benefits of a limited signal and output  $\tan\theta$  in the process, shown later. The  $\tan\theta$  curve is symmetrical across the modulation range and the phase deviation curve resembles the exposure density curve of film with a larger toe and shoulder with a gradual transition, not unlike that of Tri-X, for the **Luma**. For the **Chroma** gamma is applied during transmission and

removed during detection. This phase deviation curve is also similar to  $\mu$ -Law or A-Law non-linear compression used in telephony which can be of benefit here also. Armstrong PM is generated using QAM by modulating the 'Q' vector with the signal and the 'I' vector with a DC level for carrier. The  $90^\circ$  phase differential between I & Q vectors is what creates the phase term. For DSP after detecting the I & Q signals the limited signal benefiting from the capture effect and noise immunity can be calculated as  $\tan[\arctan(Q/I)]$ .

**Master Clock & Pilot Tone** – At the receiver the master clock operates at  $8\times$  the Pilot tone which is transmitted on the 'Q' channel during the Sync pulses on the 'I' channel. Using a PLL a  $\div 8$  of the master clock is checked against the incoming pilot tone and kept in sync via the loop filter. All timing intervals are defined by a multiple of a cycle of the pilot tone and synchronization checked at every Sync pulse. **Chroma** is sampled at the master clock rate for RX, and the **Luma** is  $\frac{1}{2}$  of that. If the master clock has a wide enough tracking range to follow any Doppler shift then everything will stay well synced since it is checked at the beginning of each horizontal line.

**Data Header** – Previous SSTV systems used a VIS code for identification of different systems and modes. After the beginning tone I guess having a VIS signal modulated in the typical manner would be the norm but having an additional data header is of great benefit. For a system to be dynamically configured on the fly to transmit and receive various image sizes at various speeds within different bandwidths this information must be provided before the image portion is transmitted. Also descriptive information about the image content is also needed. This could amount to a sizable chunk of text and a robust and efficient codec may be needed. QAM32 modulation may be sufficient but using QAM16/COFDM (think DRM) may offer a better solution. The default character set is ASCII with UTF-8 being optional.

It is the goal of this document to share this exercise in defining an analog SSTV system and hybrid digital processing with the open source community. Whether or not this will result in a new analog format being created and used at least it is here for a history lesson and education. On the chance that there may be new and creative ideas introduced here that are of some value the viewing license wrapper that has been used is intended to prohibit proprietary interests from claiming sole ownership and/or restricting free use of said ideas. The usual path in protecting ideas are patents, which are costly to obtain within a broken system and in the words of Arthur C. Clark, "A License to be Sued". This is the spirit of this wrapper with the intent in which it has been written. IANAL so the letter of the wrapper may not be perfect.

To extract the test pattern at the end of this pdf highlight image and copy to clipboard then paste into image editor and save image as .png or .bmp in 24-bit.

C-QUAM® is a registered trademark of Motorola.

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# Not So Slow Scan TV / Broadband Fax

The method for transmitting images via slow scan TV is usually done sequentially with the color components sent separately from the intensity compared to Fast Scan TV where the **Luma** & **Chroma** are sent simultaneously per horizontal line, e.g. NTSC & PAL. One system though sends the two color channels separately in time along with each **Luma** line sending only ½ the number of vertical lines of color providing ½ the vertical resolution, e.g. SÉCAM. A newer analog color system sends all three components separately in a sequence, e.g. MAC.

NTSC – National Television Standards Committee (RCA) using QAM for Chroma.

PAL – Phase Alternating Line (Telefunken of Germany) NTSC Variant

SÉCAM – Séquentiel Couleur Avec Mémoire (France)

MAC – Multiplexed Analog Components (Europe)

So what would be a good name for this which resembles PAL, SÉCAM & MAC in many ways? A portmanteau of the above?

SeMACCMaM – Sequential Multiplexed Analog Component Color Matrix And Memory Pronounced 'See Mac Mam', what a mouthful.

Maybe PASÉMAC – Phase Alternating Séquential Multiplexed Analog Color.

That's a bit much also ... Whatever. Is analog modulation passé now? Maybe not.

Most of the **Luma/Chroma** SSTV systems use the luminance weighting values of:

$$Y = 0.299 \times \text{Red} + 0.587 \times \text{Green} + 0.114 \times \text{Blue} \text{ and scaled } C_B = (B - Y), C_R = (R - Y)$$

**TruColor™** will be used since it produces an equilateral hexagon on the VectorScope.

$$\overline{0.285714} + \overline{0.571428} + \overline{0.142857} = 1$$

$$\lambda = 2 \times \text{Red} \div 7 + 4 \times \text{Green} \div 7 + \text{Blue} \div 7$$

$$U = \sqrt{3} \times (B - \lambda) \div 2 ; V = R - \lambda$$

Scaling applied for Armstrong PM:

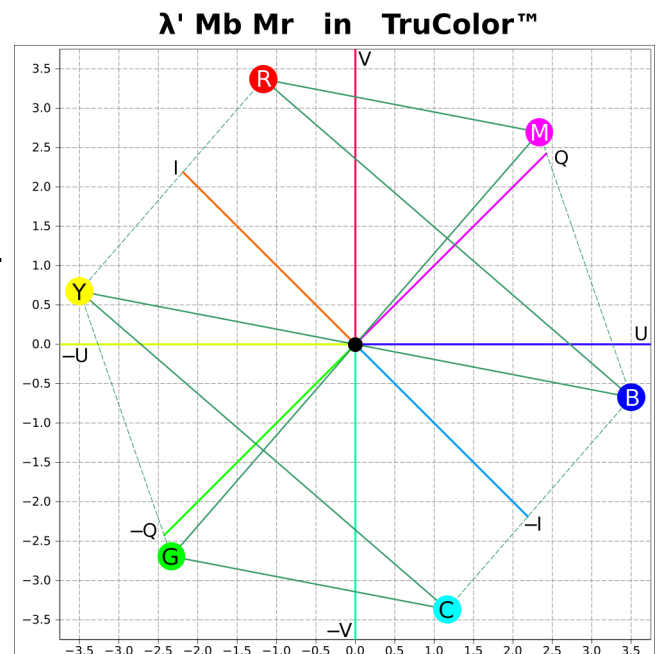
$$M_\lambda = 2 \times \text{Red} + 4 \times \text{Green} + \text{Blue} - 3\frac{1}{2} ; 0-1 \text{ ea.}$$

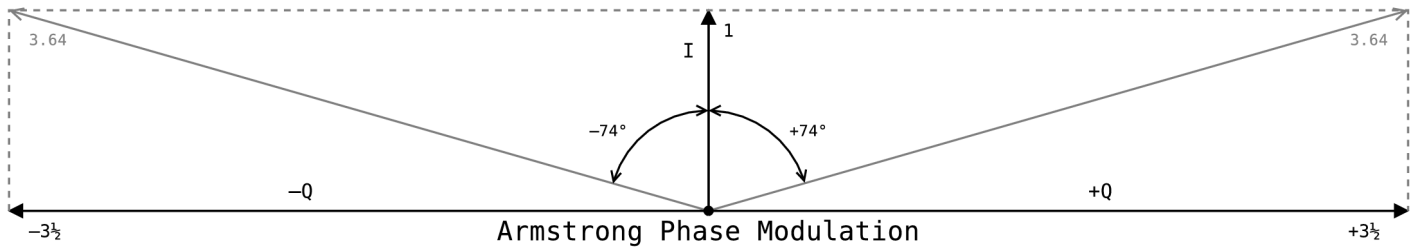
$$M_B = K \times -U$$

$$M_R = K \times V$$

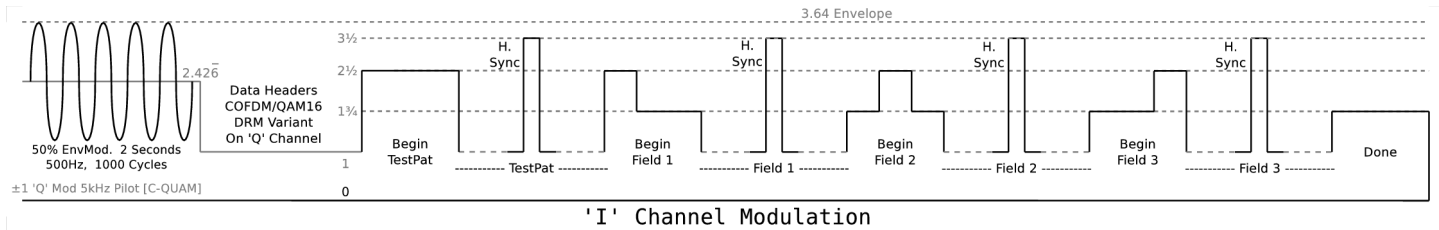
$$K = 4.715 \quad (4.71502719838196)$$

The graph to the right shows the **Chroma** signal as displayed on a VectorScope. It produces an equally level and spaced color circle, unlike NTSC or PAL, and better than **Y'CB<sub>R</sub>**. **I** & **Q** are located equidistant from **U** & **V** at 135° & 45° respectively.





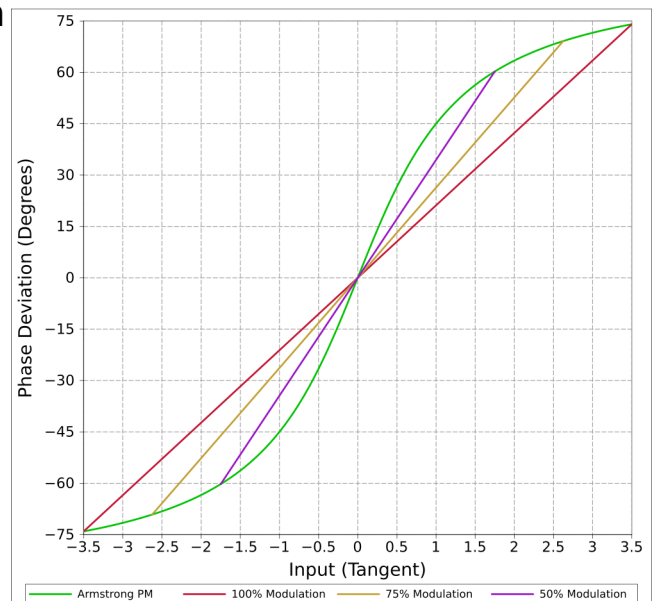
In the image above is the phase deviation graph during **Luma** & **Chroma** modulation. While the 'I' channel remains static with a DC carrier level of 1 the 'Q' channel when modulated by  $M_\lambda$ ,  $M_B$  &  $M_R$  will peak at  $\tan(\pm 74^\circ) = \pm 3\frac{1}{2}$  producing a peak envelope modulation of 3.64.



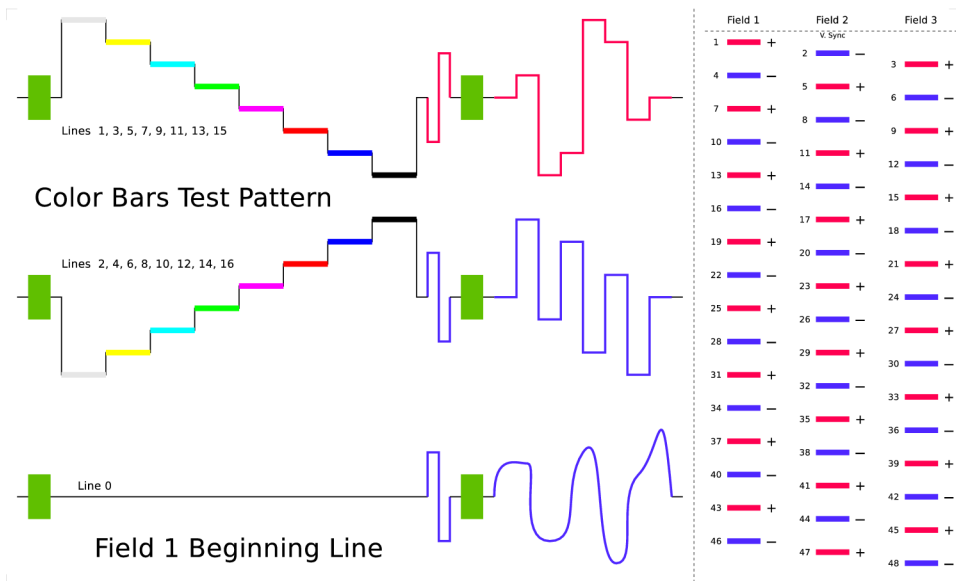
In the image above is the starting tone which modulates the envelope at 50% with a peak at 3.64 and with a frequency of  $\text{Pilot} \div 10$  for 1000 cycles while the Pilot tone is modulated at  $\pm 1$  on the 'Q' channel. C-QUAM is used for the start tone since the PLL has yet to acquire carrier lock and the envelope should carry a clean tone while also having the 'Q' channel carry the Pilot tone. The same circuit that detects  $\tan\theta$  for the **Luma** & **Chroma** will also detect the C-QUAM 'Q' channel if the envelope signal is supplied to the decoder in place of the un-modulated carrier levels used during image transmission. Next is the data header preceding the field marker castle pulses on the 'I' channel. The castle pulses will have a two level modulation at  $1\frac{3}{4}$  &  $2\frac{1}{2}$  providing the field ID depending on which position the peak is at. The 1<sup>st</sup> all high pulse precedes several progressive lines of color bars test pattern before the 1<sup>st</sup> field pulse arrives. A 'Pad' or two will precede all Field pulses. The 'I' channel is at  $3\frac{1}{2}$  for the horizontal sync and produces the maximum envelope modulation of 3.64 with the pilot tone added. During all sync pulses the pilot tone is modulated at  $\pm 1$  on the 'Q' channel.

To the right is the **Luma** & **Chroma Modulation Transfer Curve** in **Green** showing the familiar 'S' curve similar to the exposure density of film and gamma correction for **Chroma** modulation. The  $\pm 100\%$  **Red** linear line represents maximum modulation while the  $\pm 75\%$  **Gold** line modulation is where the majority of **Luma** image modulation will occur and the  $\pm 50\%$  **Purple** line is where the majority of **Chroma** modulation will be. Only a minimum amount of image information exceeds the  $\pm 75\%$  modulation levels where it starts to compress a lot.

### Modulation Transfer Curve

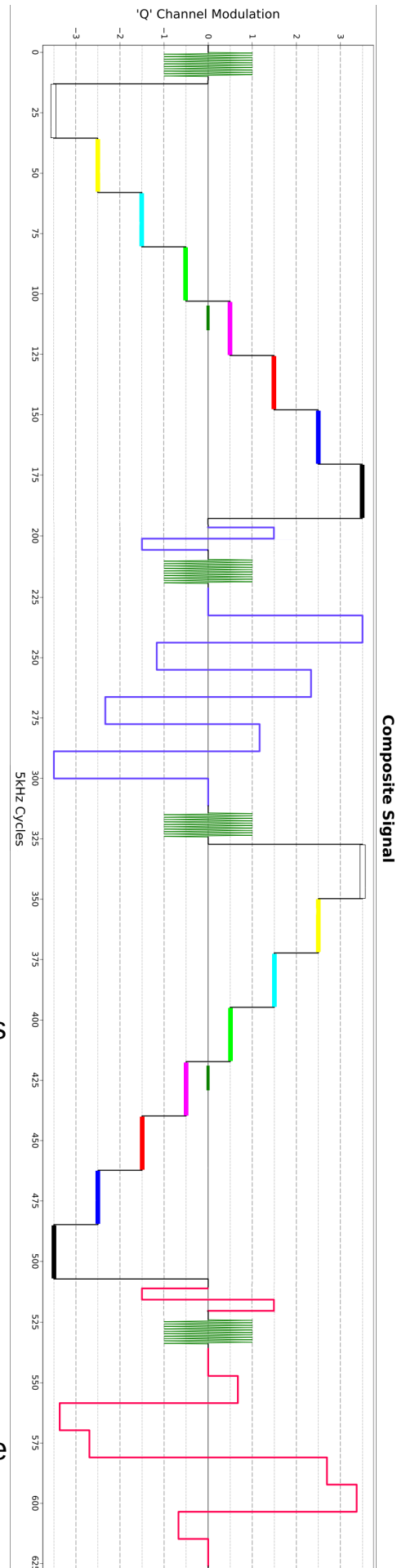


To the right, vertically displayed, is the detailed **Luma** and **Chroma** modulation for two lines. The 1<sup>st</sup> half has both the **Luma** and **U** channel inverted ( $\lambda - B$ ) and the 2<sup>nd</sup> half has the non-inverted **Luma** and **V** channel ( $R - \lambda$ ). At the beginning of each line are 10 cycles of the Pilot tone in **Green** for the horizontal sync. Preceding the **Chroma** signal, ahead of the sync tone, on the front porch of horizontal blanking, is the **Chroma** identification pulse. For the **U** channel it is a +|- order while for the **V** channel it is -|+. There is an even cadence to the horizontal sync pulses with a missing pulse in the middle of the **Luma** signal shown by the **Green** dash identifying that the next line will be a **Chroma** line and to check the front porch to identify which **Chroma** channel it is.



The 1<sup>st</sup> two lines in the image above represent the 16 lines of color bars preceding the 1<sup>st</sup> field sending both **Chroma** channels 8 times each. Upon reception this can be used for image quality analysis and to auto correct any errors. Line '0' of Field 1 is absent of any **Luma** but sends the **Chroma** signal for line 1 which will be averaged with the **Chroma** signal from line 2 for one of the channels while the other comes with line 1. An extra line will also be added to the end of Field 3 for the same reason. Field 1, 1+ #Lines ; Field 2, #Lines ; Field 3, #Lines +1. In the image above to the right is the **Chroma** channel order per line. Notice that for both field and frame it is an alternating pattern of both **-U** & **V** channels providing a fine and even distribution of the **Chroma** signal.

Note: In the vertical image to the right the timing scale accuracy varies some around the Chroma ID pulses but for all else it is scaled well.



## Video Bandwidth & Horizontal Period Determines Lines of Resolution

To determine the resolution from bandwidth and period looking at NTSC with its 330 lines and  $4\frac{1}{6}$ mHz bandwidth the horizontal period of active picture is needed. The full period of a horizontal line is  $1/15734\text{Hz} \approx 63.56\mu\text{s}$ . The horizontal blank is  $10.9\mu\text{s}$  leaving  $52.66\mu\text{s}$  for video modulation. There is also  $\sim 6\frac{2}{3}\%$  of over scan leaving  $\sim 49\mu\text{s}$  for active picture signal. How many cycles of  $4\frac{1}{6}$ mHz are in  $49\mu\text{s}$ ?  $1/4\frac{1}{6}\text{mHz} = 0.24\mu\text{s}$  and  $2 \times 49\mu\text{s} \div 0.24\mu\text{s} \approx 408$  lines. The  $2 \times$  is needed since one cycle represents two lines. This is the absolute maximum resolution available with  $<35\%$  of peak contrast at peak modulation. This is greater than 330 so the 330 spec is for a fairly respectable contrast although not at 100%. Or  $330 \approx \phi \times 49\mu\text{s} \times 4\frac{1}{6}\text{mHz}$  where  $330 \div 408 \approx 80.9\%$  and  $2 \times 0.809 \approx 1.618034\dots \approx \phi$  While this calculation uses  $\mu\text{s}$  and mHz for SSTV ms and kHz will be used. The default image size chosen is **720x480** and this is 345600 digital pixels. Applying the Kell factor of  $1/\sqrt{2}$  the analog resolution is 172800 pixels or  $509\frac{1}{8} \times 339\frac{2}{5}$ . The needed lines of resolution for analog video modulation of good contrast is **509** and the default horizontal period to be used here is **36ms** so  $509 \div 36\text{ms} \div \phi \approx 8\frac{3}{4}\text{kHz}$ . This is the corner frequency roll off point with full cut at **10kHz**. The absolute maximum analog resolution is 630 with  $<35\%$  contrast and using the Kell factor would need 890 digital pixels to reproduce this.

In the 6 meter band the maximum bandwidth available for a single channel is **20kHz** or  $\pm 10\text{kHz}$ . In the 50.3mhz–50.6mHz range is the experimental band where all modes may be used so testing could be done here. For the default definition the master clock frequency will be **40kHz** and used for a **720x480** image. The signal timing structure for all components is linked to the master clock so scaling this up or down can increase or decrease bandwidth requirements and increase or decrease transmit speed.

Chroma	Luma	Chroma	Pilot	Start
Sample	Sample	Sample	Tone	Tone
Rate RX	Rate	Rate TX		
$40\text{kHz} \div 2 = 20\text{kHz}$	$\div 2 = 10\text{kHz}$	$\div 2 = 5\text{kHz}$	$\div 10 = 500\text{Hz}$	

$720 \times 50\mu\text{s} = 36\text{ms}$  ;  $360 \times 50\mu\text{s} = 18\text{ms}$   
**Luma** Period ; **Chroma** Period

20K0D9CNX(F+C+T)?	50.3–50.6mHz	
Channel Bandwidth	$\pm 10\text{kHz}$	
Video Bandwidth @-3dB	$8\frac{3}{4}\text{kHz}$	
<b>Luma</b> Pixel Period	$50\mu\text{s}$	
<b>Chroma</b> Pixel Period TX	$100\mu\text{s}$	Pilot
<b>Chroma</b> Pixel Period RX	$25\mu\text{s}$	Cycles
Horizontal Sync	$2\text{ms}$	(10)
Pad	$800\mu\text{s}$	(4)
<b>Luma</b> Period	$36\text{ms}$	(180)
<b>Chroma</b> Period	$18\text{ms}$	(90)
Front Porch	$3\frac{3}{5}\text{ms}$	(18)
<b>Chroma</b> Line I.D.	$2\frac{2}{5}\text{ms}$	(6+6)
Vertical Sync	$19\frac{1}{5}\text{ms}$	(96)



<b>Luma</b>	Sync	Pad	Period	Pad	FrntPrch	
	2ms	800µs	36ms	800µs	3 <sup>3</sup> / <sub>5</sub> ms	= 43 <sup>1</sup> / <sub>5</sub> ms
	10	4	180	4	18	= 216 Pilot Cycles
<b>Chroma</b>	Sync	Pad	Period	Pad		
	2ms	800µs	18ms	800µs		= 21 <sup>3</sup> / <sub>5</sub> ms
	10	4	90	4		= 108 Pilot Cycles

43<sup>1</sup>/<sub>5</sub>ms + 21<sup>3</sup>/<sub>5</sub>ms = 64<sup>4</sup>/<sub>5</sub>ms (1 Scan Line Period)  
 216 108 = 324 Pilot Cycles

64<sup>4</sup>/<sub>5</sub>ms × 160 + 19<sup>1</sup>/<sub>5</sub>ms = 10<sup>2</sup>/<sub>5</sub> Seconds per Field  
 324 Lines Vsync

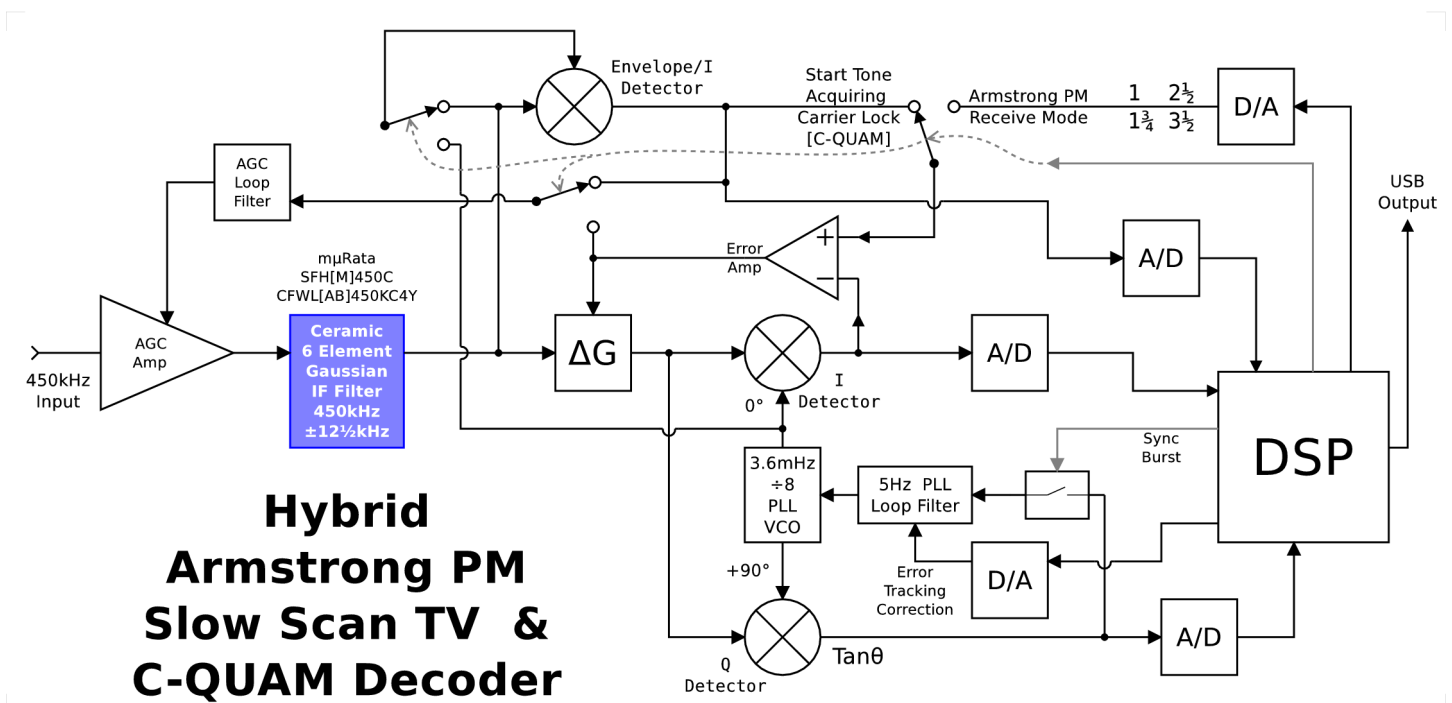
10<sup>2</sup>/<sub>5</sub>s × 3 = 31<sup>1</sup>/<sub>5</sub> Seconds per Frame

This is just for the full frame but does not include the start tone, data header and color bars which will add more time. 36 seconds would probably be a reasonable time with a modest data header for full transmission.

### Scaled to other bandwidths

Master Clock kHz	Channel BW kHz	Video BW kHz	Seconds	Analog Lines of Resolution	
40	20 <sup>2</sup> / <sub>5</sub>	9 ⇒ 10 <sup>1</sup> / <sub>5</sub>	31 <sup>1</sup> / <sub>5</sub>	525	
40	20	8 <sup>3</sup> / <sub>4</sub> ⇒ 10	31 <sup>1</sup> / <sub>5</sub>	509	Stretch
38	30	12 <sup>1</sup> / <sub>2</sub> ⇒ 15	32 <sup>5</sup> / <sub>6</sub>	766	16:9
38	19	8 <sup>3</sup> / <sub>4</sub> ⇒ 9 <sup>1</sup> / <sub>2</sub>	32 <sup>5</sup> / <sub>6</sub>	506	Y/C Resample
32	16	7 ⇒ 8	39	509	23%/47%kHz
30	15	6 <sup>1</sup> / <sub>2</sub> ⇒ 7 <sup>1</sup> / <sub>2</sub>	41 <sup>3</sup> / <sub>5</sub>	505	850×480
25	12 <sup>1</sup> / <sub>2</sub>	5 <sup>1</sup> / <sub>2</sub> ⇒ 6 <sup>1</sup> / <sub>4</sub>	50	512	
20	10	4 <sup>1</sup> / <sub>3</sub> ⇒ 5	62 <sup>3</sup> / <sub>8</sub>	505	1'02"
15	7 <sup>1</sup> / <sub>2</sub>	3 <sup>3</sup> / <sub>4</sub> ⇒ 3 <sup>3</sup> / <sub>8</sub>	83 <sup>1</sup> / <sub>6</sub>	505	1'23"
13 <sup>1</sup> / <sub>2</sub>	6 <sup>3</sup> / <sub>4</sub>	3 ⇒ 3 <sup>3</sup> / <sub>8</sub>	92 <sup>2</sup> / <sub>5</sub>	518	1'32"
12	6	2 <sup>5</sup> / <sub>8</sub> ⇒ 3	104	509	1'44"

CornerFreq ⇒ FullCut



## Hybrid Armstrong PM Slow Scan TV & C-QUAM Decoder

# Data Headers

Transmitted Mode Code using conventional method: VIS

Parameters: (ASCII)

Mode Orientation Width Height LpF Interlace ModBW LumaDotClock ChromaDotClock  
ResampleClock Pilot VSync HSync Pad LumaPeriod ChromaPeriod FrntPrch ChromaID

Mode – B+W or Color.  
Orientation – Landscape or Portrait. Image is sent in landscape mode.  
Width – Width of image in pixels. ÷4 (Pilot dependent) **720**  
Height – Height of image in pixels. ÷3 (Interlace dependent) & ÷2 = ÷6 **480**  
LpF – Lines per Field. **160**  
Interlace – Number of fields per frame. **3**  
ModBW – Modulation method [DSB|VSB|SSB] and bandwidth in Hz. **DSB20000**  
LumaDotClock – Sample rate for Luma signal in Hz. **20000**  
ChromaDotClock – Sample rate for Chroma signal in Hz. **40000**  
ResampleClock – Luma re-sample rate for non-standard bandwidth of master clock in Hz. **?**  
Pilot – Synchronization tone sent during Start, VSync & HSync to control 8× master clock. **5000**  
VSync – Number of pilot cycles for VSync duration. ÷3 **96**  
HSync – Number of pilot cycles for HSync duration. **10**  
Pad – Number of pilot cycles to pad between components. **4**  
LumaPeriod – Number of pilot cycles during Luma signal. **180**  
ChromaPeriod – Number of pilot cycles during Chroma signal. **90**  
FrntPrch – Number of pilot cycles for Front Porch preceding HSync of Chroma signal. **18**  
ChromaID – Number of pilot cycles for U or V Chroma line identification duration on HSync front porch. **6+6**

Order of components in a Luma/Chroma scan line: (ASCII)

Pad HSync Pad LumaPeriod Pad ColorID Pad HSync Pad ChromaPeriod

Information: (ASCII or UTF-8)

CharSet CallSign Name xMitTime xMitDate xMitLocation ImageTime  
ImageDate ImageLocation ImageID History Owner Title Description

CharSet – Character Set (ASCII, UTF-8...)  
CallSign – Ham call sign or station identification.  
Name – Person, Group, or Company Name.  
xMitTime – Transmit time. \ UCT from NIST.  
xMitDate – Transmit date. > To be filled in at time of transmission.  
xMitLocation – Transmit location. /  
ImageTime – Image creation time.  
ImageDate – Image creation date.  
ImageLocation – Image creation location. (Possibly GPS info.)  
ImageID – Image identification code.  
History – Records of transmit, receive, Adjustments: Brightness, Contrast, Color, Hue ...  
Owner – Owner/copyright holder, and license.  
Title – Image title.  
Description – Detailed description of image.

ASCII Database Separators

	Oct	Dec	Hex	Char
<GS> Group	035	29	1D	GS
<RS> Record	036	30	1E	RS
<US> Unit	037	31	1F	US

Transmitted Data String using QAM, COFDM optional:

<GS>Mode<US>Orientation<US>Width<US>Height<US>LpF<US>Interlace<US>ModBW<US>LumaDotClock  
<US>ChromaDotClock<US>ResampleClock<US>Pilot<US>VSync<US>HSync<US>Pad<US>LumaPeriod  
<US>ChromaPeriod<US>FrntPrch<US>ChromaID<RS>Pad<US>HSync<US>Pad<US>ChromaPeriod<US>Pad<US>ChromaID  
<US>Pad<US>HSync<US>Pad<US>ChromaPeriod<RS>CharSet<US>CallSign<US>Name<US>xMitTime<US>xMitDate  
<US>xMitLocation<US>ImageTime<US>ImageDate<US>ImageLocation<US>ImageID<US>History<RS>Owner  
<US>Title<US>Description<GS>

Lines of Resolution

Luma Frequency for

↓↓40kHz DotClock      ↓↓**720×480**↓↓

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1<sup>1/9</sup>kHz

1<sup>1/4</sup>kHz

1<sup>3/7</sup>kHz

1<sup>2/3</sup>kHz

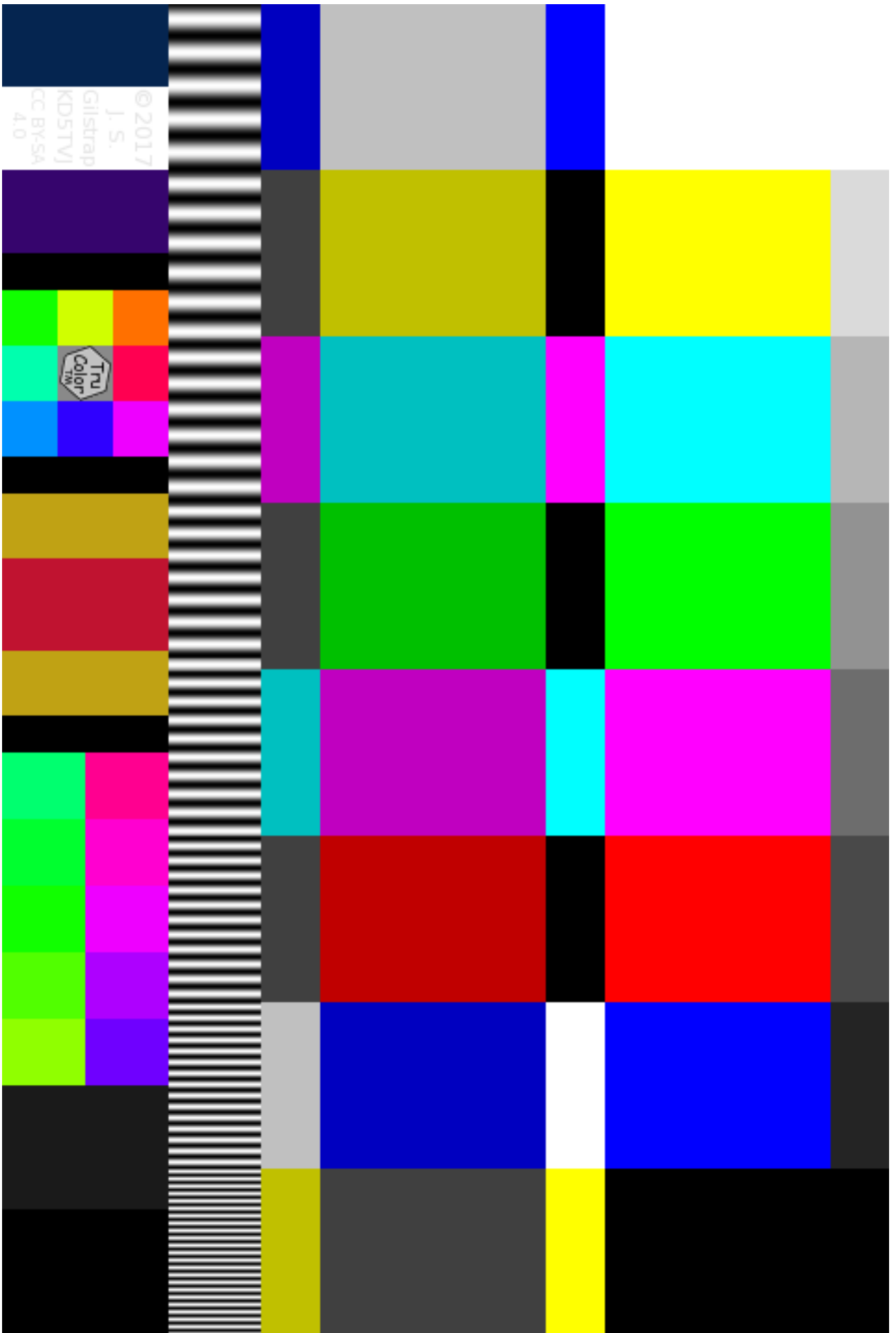
2 kHz

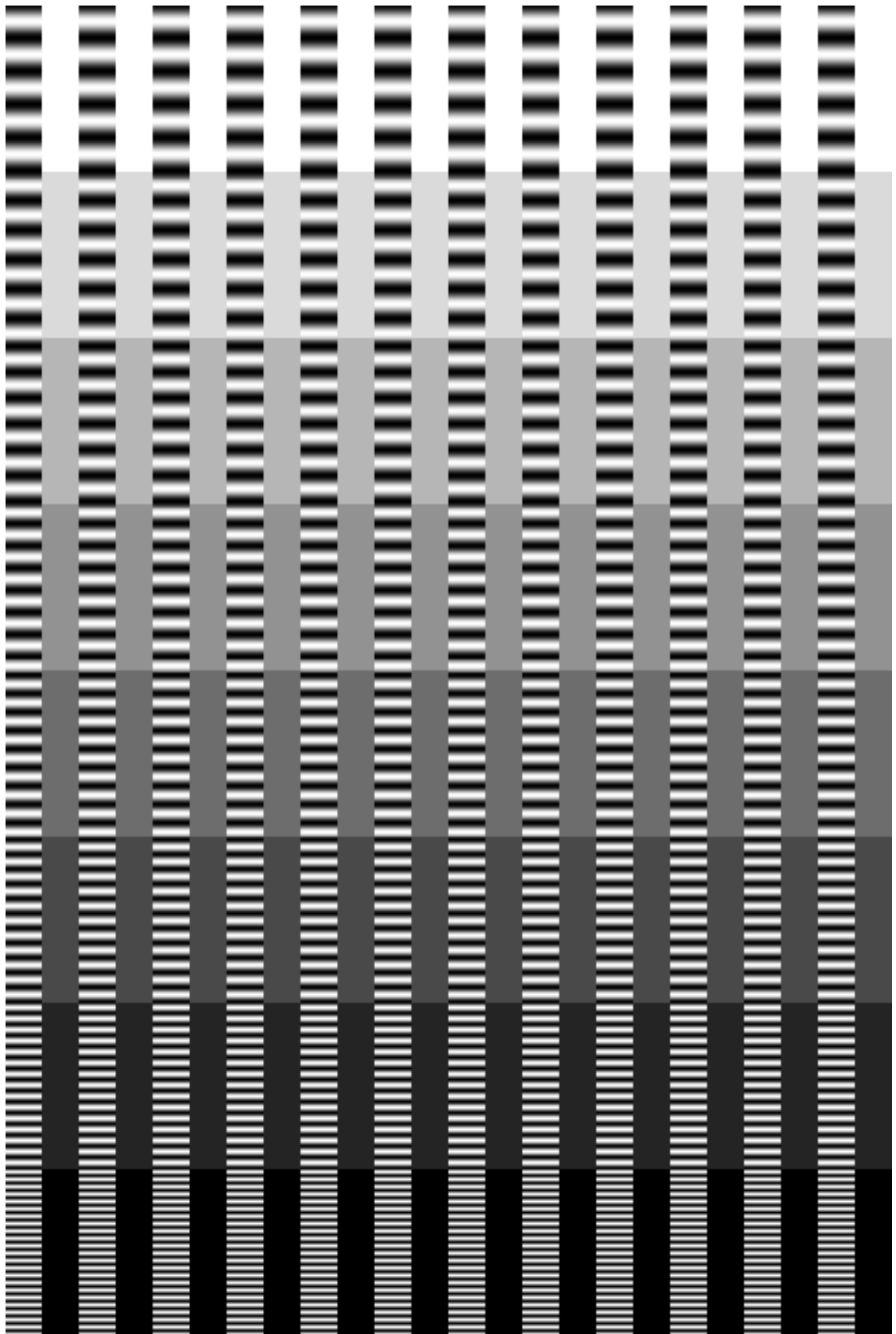
2<sup>1/2</sup>kHz

3<sup>1/3</sup>kHz

10%

5 kHz





Notes:

The receive device/application should have DC bias error control to manually correct for any reception/detection tracking errors. While the DC carrier tracking is checked/corrected each time during the sync pulses and during the summation of 2 or 3 consecutive **Luma** lines but not the **Chroma** lines tracking errors can still occur. Using a low enough corner frequency and proper gain on the PLL for fast lock onto the IF carrier without overshoot is the optimal tuning but also not to be affected by the signal itself. Co-channel interference can produce a beat note causing PLL mis-tracking creating platform motion and a correction signal from the DSP can be synthesized to neutralize this. Platform motion can cause incorrect  $\text{Sec}\theta$  modulation to occur through the  $\Delta G$  block to the signal that is easier to prevent than to correct within the DSP. The C-QUAM decoder chip MC13028 has a maximum tracking accuracy of  $\sim\frac{2}{5}^\circ$  resulting in  $\sim 43\text{dB}$  of separation. This represents a  $\pm 25\text{mV}$  offset for a maximum 'Q' output peak of  $\pm 7\text{V}$  of the video signal. This is of no consequence and under ideal reception conditions this would be unnoticeable to the eye.

If used on the AM/MW band then employing 9/10kHz whistle filters are desirable.

Reducing recommended bandwidth for a given master clock frequency will reduce sharpness, but will still produce a softer viewable image, e.g. NTSC/PAL-M with its  $1\frac{3}{8}:1$  pixel aspect ratio.

The standard controls of brightness, contrast, color, hue and possibly gamma should be included within the application. Advanced controls could also include individual **RGB** gain and bias controls.

A detailed meta data history should follow image upon each re-transmission. Original origin and time, date & location stamps about each re-transmission. Original image meta data along with any adjustments made to image, described above.

As part of the meta data history it should have a dropout record and if patched, where, using the surrounding information. A comprehensive method of detecting dropouts, caused by interference, should be employed.

An optimized image file format is desirable that uses TruColor™ **YUV** matrixing and that contains all meta data. A file extension of '.ffx' for Fast Fax might be good.

The IF oscillator should be a crystal reference of 450kHz ( $3.6\text{mHz}\div 8$ ) while the local oscillator will be a PLL so the incoming carrier signal frequency will be locked to the 450kHz oscillator. This will maintain the center frequency for the ceramic IF filter. Any Doppler shift occurring will 1<sup>st</sup> be corrected for center tracking of IF and then the master clock will track the changes so accurate sample timing will be maintained.

# The $\Sigma\text{HS}\lambda$ to $\lambda\text{UV}$ TruColor™ Matrix

(Yet Another Chroma Matrix ;-). What NTSC should have been?

A method for converting  $\Sigma\text{HS}\lambda$  Color with a modified Luma ( $\lambda$ ) to analog Color TV  $\lambda\text{UV}$  to balance for better Chroma (UV) matrixing.

Where:  $\Sigma$  = Chroma level is a vector matrix sum/difference and not a saturation percentage factor.

H = Hue of the Chroma signal in  $\theta^\circ$  derived from the quadrature matrix.

S = Saturation level (R) of the Chroma signal as quadrature summation of the U & V vectors.

$\lambda$  = Brightness, or intensity factor of the Luma signal.

32-Bit – 12-Bit Luminance, 2x10-Bit Chrominance, U & V each.

## Matrixing

Let:

R = Red \   
 G = Green \ Each range from 0 to 1.   
 B = Blue /

$\lambda$  = Matrixed B & W Luma channel.   
 U = Matrixed B -  $\lambda$  Chroma channel.   
 V = Matrixed R -  $\lambda$  Chroma channel.   
 W = Matrixed G -  $\lambda$  Chroma channel.

Enhanced channels:

I = Matrixed Skin Chroma channel.   
 Q = Matrixed Purple Chroma channel.

We have:

$$\begin{aligned} \lambda &= +1/7 \times B + 2/7 \times R + 4/7 \times G \\ B - \lambda &= +6/7 \times B - 2/7 \times R - 4/7 \times G \\ R - \lambda &= -1/7 \times B + 5/7 \times R - 4/7 \times G \\ G - \lambda &= -1/7 \times B - 2/7 \times R + 3/7 \times G \\ G - \lambda &= -1/4 \times (B - \lambda) - 1/2 \times (R - \lambda) \end{aligned}$$

Encode:

$$\begin{aligned} \text{If: } U(x) &= \sqrt{3}/2 \times (B - \lambda) \times \theta^\circ \\ V(y) &= (R - \lambda) \times 90^\circ \end{aligned} \left. \begin{array}{l} \text{Quadrature} \\ \text{Sub-Carrier} \end{array} \right\} \begin{array}{l} - \\ | \\ - \end{array}$$

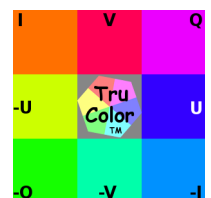
Then: W =  $\sqrt{3}$  x (G -  $\lambda$ ) @ 240°

Chroma Vector R =  $\sqrt{U^2 + V^2}$    
 Chroma Hue  $\theta = [ \text{aTan2}(V, U) ; \text{If } \theta < 0 \text{ Then } \theta + 2\pi ]$

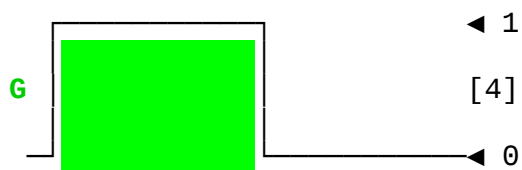
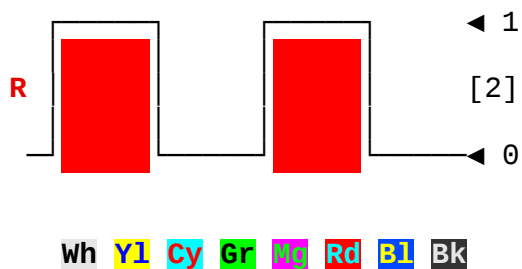
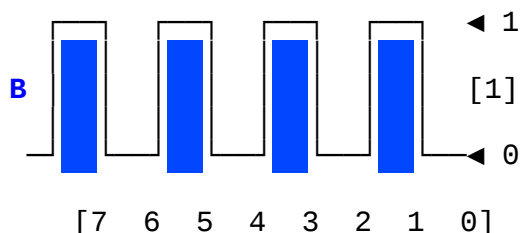
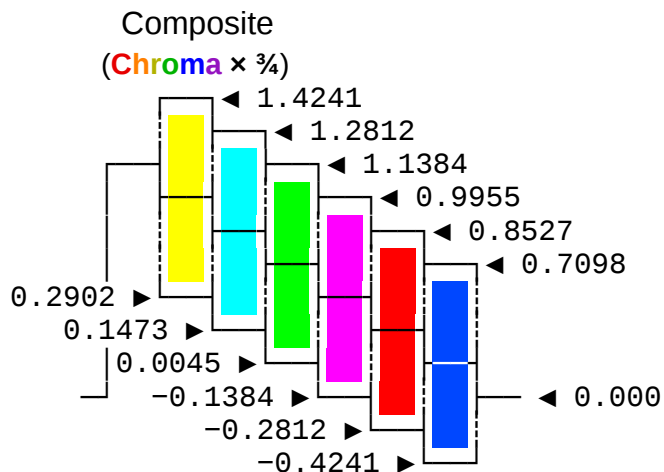
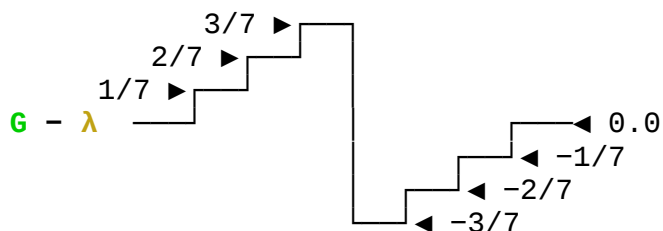
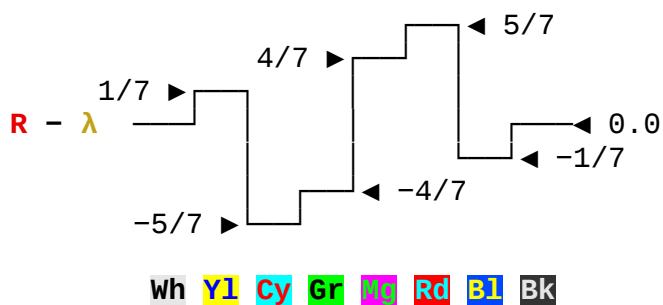
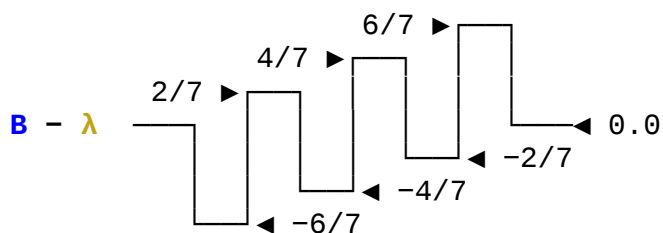
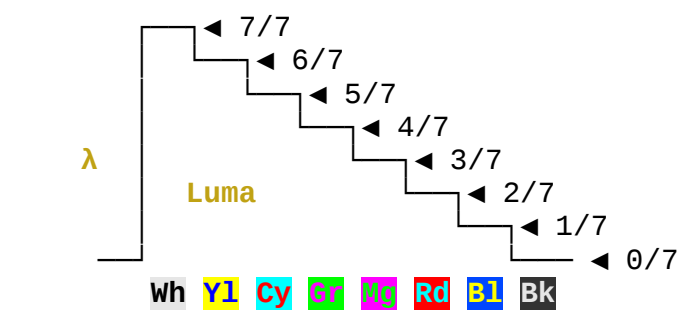
Decode:

$$\begin{aligned} U: B - \lambda &= \text{---} @ \theta^\circ \div \sqrt{3}/2 \\ V: R - \lambda &= \text{---} @ 90^\circ \\ W: G - \lambda &= \text{---} @ 240^\circ \div \sqrt{3} \end{aligned}$$

SyncDet



# 100% Color Bars



Color Bar	Luma	Rectangular		Polar	
	Level	Chroma $U \times \sqrt{3}/2$	Levels $V$	Chroma Hue $\theta$	Chroma Peak Level
White	100.00%	N/A	N/A	N/A	N/A
Yellow	85.71%	$-3 \times \sqrt{3}/7$	+1/7	169.11°	$2/\sqrt{7}$
Cyan	71.43%	$+1 \times \sqrt{3}/7$	-5/7	289.11°	$2/\sqrt{7}$
Green	57.14%	$-2 \times \sqrt{3}/7$	-4/7	229.11°	$2/\sqrt{7}$
Magenta	42.86%	$+2 \times \sqrt{3}/7$	+4/7	49.11°	$2/\sqrt{7}$
Red	28.57%	$-1 \times \sqrt{3}/7$	+5/7	109.11°	$2/\sqrt{7}$
Blue	14.28%	$+3 \times \sqrt{3}/7$	-1/7	349.11°	$2/\sqrt{7}$
Black	0.00%	N/A	N/A	N/A	N/A

The composite **Chroma**  $\times \frac{3}{4}$  scaling for all colors with full saturation produces a level of **0.5669pk** or **1.134p-p** when modulated. When combined with **Luma** the **Luma + Chroma** peak for **Yellow** is at **142 $\frac{2}{5}$ %**, and **Blue** is at **-42 $\frac{2}{5}$ %**.

# Decode, Display & Storage

Detected (32-Bit Float each)

$$\lambda = (M_\lambda + 3\frac{1}{2}) \div 7$$

$$U = M_B \div K$$

$$V = M_R \div K$$

$$K = 4.715 \text{ (4.71502719838196)}$$

Color Difference (32-Bit Float each)

$$B - \lambda = 2 \times U \div \sqrt{3}$$

$$R - \lambda = V$$

$$G - \lambda = -\frac{1}{4} \times (B - \lambda) - \frac{1}{2} \times (R - \lambda)$$

Display (24-Bit Integer)

$$R_D = 255 \times [ \lambda + (R - \lambda) ] \text{ (Unsigned ; 0-1)}$$

$$G_D = 255 \times [ \lambda + (G - \lambda) ] \text{ (Unsigned ; 0-1)}$$

$$B_D = 255 \times [ \lambda + (B - \lambda) ] \text{ (Unsigned ; 0-1)}$$

Storage (32-Bit Integer)

$$\lambda_S = 2^{12} \times \lambda \text{ (Unsigned ; 0-1)}$$

$$B_{\lambda_S} = 2^{10} \times 7 \times (B - \lambda) \div 12 \text{ (Signed ; } \pm\frac{1}{2}\text{)}$$

$$R_{\lambda_S} = 2^{10} \times 7 \times (R - \lambda) \div 10 \text{ (Signed ; } \pm\frac{1}{2}\text{)}$$

$2^{32}$