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Hardware (w/ || w/o software): Tucson Arizona Packet Radio TAPR PDF ODT TXT

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Summary of Claims & Features

Trade Secret: Proprietary & Confidetial

TruColor™, Specification originally published in 2012 – A **Luma**/**Chroma** matrix with **RGB** weighting that produces an even stair step **Luma** signal when the 'WhYlCyGrMgRdBlBk' 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 ±45° away from the **U**&**V** channels. The hue of TruColor's **I** channel is <2⅕° away from NTSC's **I** channel hue of #**FC6600** and TruColor's **Q** channel's hue of #**E700FB** is <4⅛° 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° 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 1st field has been received a full color image at ⅓ resolution can 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 **1st** field is being received the lines for the other two fields will be temporarily interpolated from the **1st** 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 **2nd** field is being received interpolated lines in the **2nd** field will be replaced and the additional color information will be applied and re-calculated for all fields. As the **3rd** field is being received the update process will repeat and produce full resolution as the **3rd** 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 **½:½** or **¼:½:¼** 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 ±15° 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 ±15° & ±30° hue deviations.

Time Compressed Chroma – The **Chroma** signals will be time compressed requiring only ½ the samples required for the **Luma** per line. During image sampling for transmission the Chroma DotClock will run at ½ speed of the **Luma** DotClock. During transmission it will produce the same bandwidth as the **Luma** but its transmission period is only ½ the length of the **Luma**. During reception the **Chroma** sample rate will run at 2 × **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 verses 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. Tanθ is the correct transfer curve. There are analog circuits that can produce the benefits of a limited signal and output Tanθ in the process, shown later. The Tanθ 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 and 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 µ-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**°** 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[aTan(**Q**÷**I**)].

Master Clock & Pilot Tone Burst – At the receiver the master clock operates at 8× the Pilot Tone Burst which is transmitted on the **Q** channel during the Sync pulses on the **I** channel. Using a PLL a ÷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 **½** 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. The data header must be received before image decoding occurs so its integrity is paramount. QAM32 modulation may be sufficient but using QAM16/COFDM (think DRM) may offer a more robust solution. The default character set is ASCII with UTF-8 being optional.

To extract the test pattern on page 11 of this pdf highlight image and copy to clipboard then paste into image editor and save image as .png or .bmp in 24-bit.

Not So Slow Scan TV / Widerband 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 **US**) using QAM for **Chroma**.
PAL – Phase Alternation Line (Walter Bruch @ Telefunken **DE**) NTSC Variant
SÉCAM – Séquentiel Couleur Avec Mémoire (Henri de France **FR**)
MAC – Multiplexed Analog Components (**UK**)

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

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

$$\mathbf{0.\overline{285714}} + \mathbf{0.\overline{571428}} + \mathbf{0.\overline{142857}} = \mathbf{1}$$

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

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

Scaling applied for Armstrong PM:

$$\mathbf{M_\lambda} = 2\times\mathbf{Red} + 4\times\mathbf{Green} + \mathbf{Blue} - 3½ \;\; ; \;\; 0\text{–}1 \text{ ea.}$$

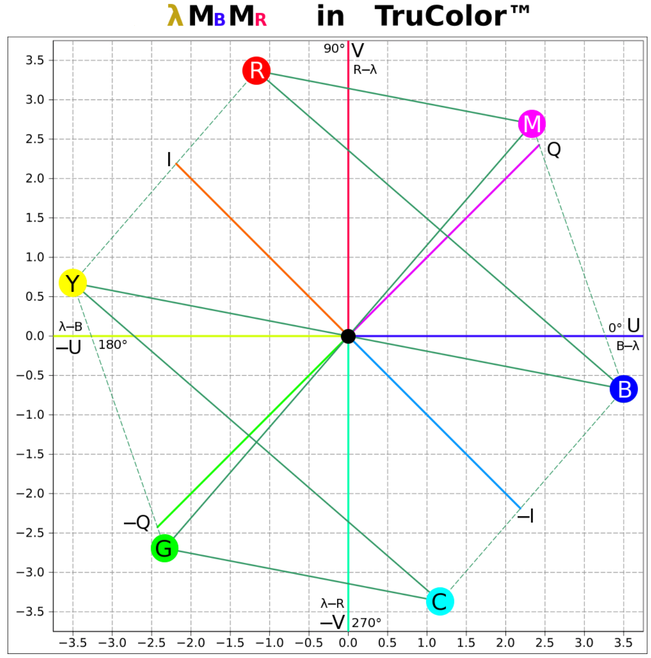
$$\mathbf{M_B} = \mathbf{K} \times \mathbf{-U}$$

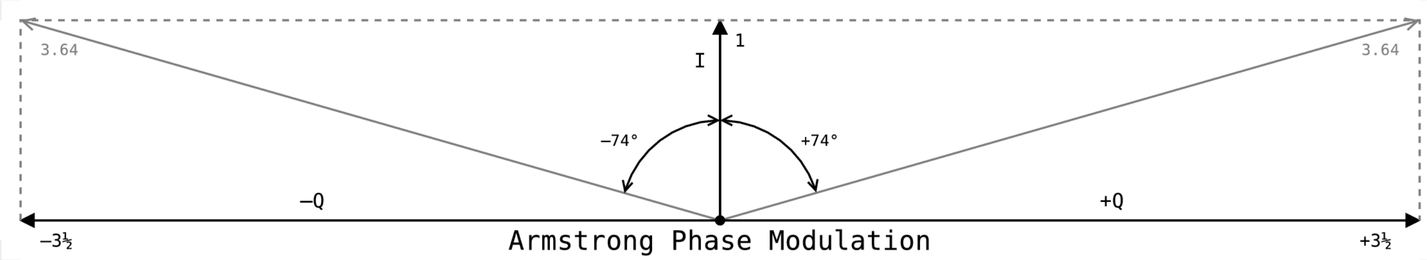
$$\mathbf{M_R} = \mathbf{K} \times \mathbf{V}$$

$$\mathbf{K} = 4.715 \quad (4.71502719838196)$$

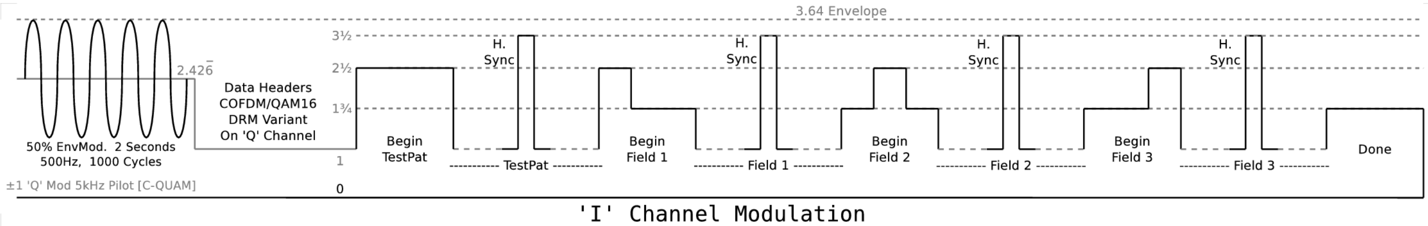
The graph to the right shows the **Chroma** signal as displayed on a VectorScope. It produces an equally level and spaced color circle, unlike NTSC or PAL, and better than $\mathbf{YC_BC_R}$. **I** & **Q** are are located equidistant from **U** & **V** at 135° & 45° respectively.

λ $\mathbf{M_B M_R}$ in TruColor™





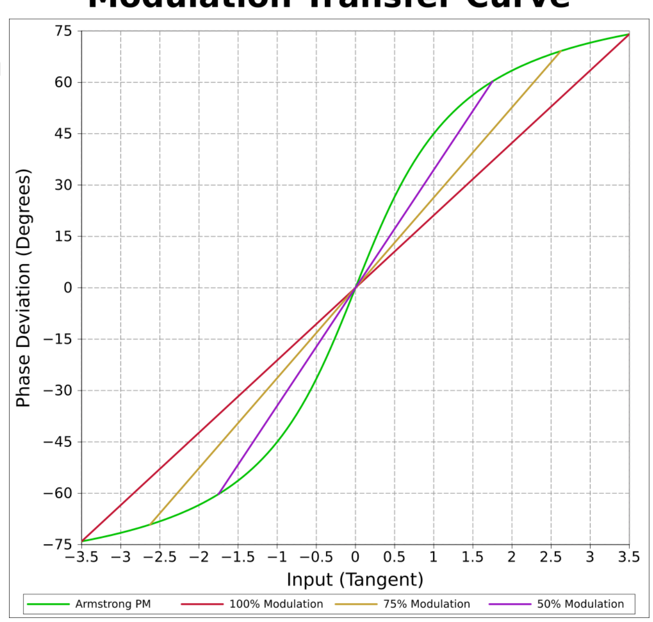
In the image above is the phase deviation graph during **Luma** & **Chroma** modulation. While the **I** channel remains static with a DC carrier level of 1 the **Q** channel when modulated by M_{λ}, M_{B} & M_{R} will peak at Tan(±74°)=±3½ producing a peak envelope modulation of 3.64 .



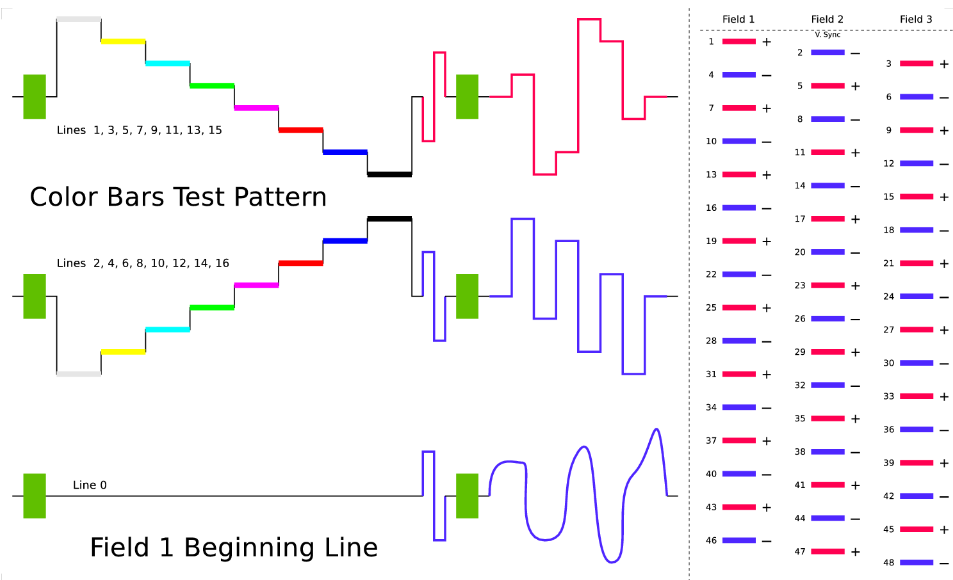
In the image above is the starting tone which modulates the envelope at 50% with a peak at 3.64 and with a frequency of Pilot÷10 for 1000 cycles while the Pilot tone is modulated at ±1 on the **Q** channel. C-QUAM is used for the start tone since the PLL has yet to acquire carrier lock and the envelope should carry a clean tone while also having the **Q** channel carry the Pilot tone. The same circuit that detects Tanθ 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 1¾ & 2½ providing the field ID depending on which position the peak is at. The **1st** all high pulse precedes several progressive lines of color bars test pattern before the **1st** field pulse arrives. A 'Pad' or two will precede all Field pulses. The **I** channel is at 3½ 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 ±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 ±100% **Red** linear line represents maximum modulation while the ±75% **Gold** line modulation is where the majority of **Luma** image modulation will occur and the ±50% **Purple** line is where the majority of **Chroma** modulation will be. Only a minimum amount of image information exceeds the ±75% modulation levels where it starts to compress a lot.

Modulation Transfer Curve

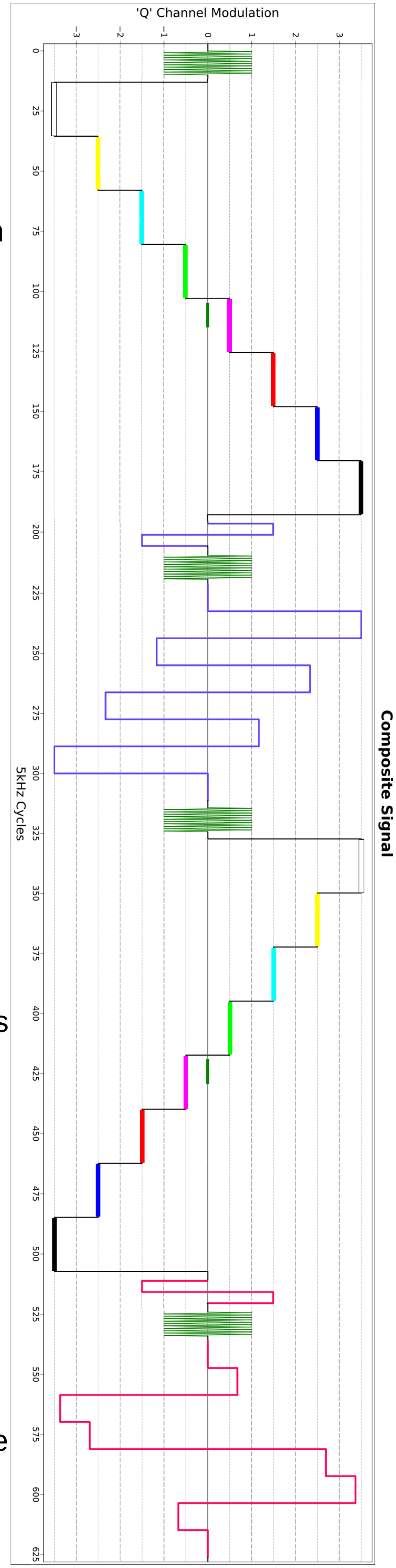


To the right, vertically displayed, is the detailed **Luma** and **Chroma** modulation for two lines. The **1st** half has both the **Luma** and **U** channel inverted (**λ** – **B**) and the **2nd** half has the non-inverted **Luma** and **V** channel (**R** – **λ**). At the beginning of each line are **10** cycles of the Pilot Tone Burst 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 1st two lines in the image above represent the **16** lines of color bars preceding the **1st** 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 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 ~335 lines and 4⅕mHz bandwidth the horizontal period of active picture is needed. The full period of a horizontal line is 1/15734Hz ≈ 63.56µs . The horizontal blank is 10.9µs leaving 52.66µs for video modulation. Subtracting 6⅗% of over scan leaves 49.18µs for active picture signal. How many cycles of 4⅕mHz are in 49.18µs? 1/4⅕mHz ≈ 0.238µs and 2 × 49.18µs ÷ 0.238µs ≈ 413 lines. The 2 × is needed since one cycle represents two lines. This is the absolute maximum resolution available with <37% of peak contrast at peak modulation. This is greater than 335 so the 335 spec is for an acceptable contrast although not completely 100%. Or ϕ × 49.18µs × 4⅕mHz ≈ 334 where 334 ÷ 413 ≈ 80.9% and 2 × 0.809 = 1.618 ≈ ϕ . While this calculation uses µs and mHz for SSTV ms and kHz will be used. The default image size chosen is **720**×**480** and this is 345600 digital pixels. Applying a Kell factor of 1/√2 the analog resolution is 172800 pixels or 509⅛×339⅖. The needed lines of resolution for analog video modulation of good contrast is **509⅛** and the default horizontal period to be used here is **36**ms so **509⅛** ÷ **36**ms ÷ ϕ ≈ **8¾**kHz. This is the corner frequency roll off point with full cut at **10**kHz. The absolute maximum analog resolution is 630 with <37% 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 **20**kHz or ±**10**kHz. In the 50.3mhz–50.6mHz range is the experimental band where all modes may be used so testing could be done there. For the default definition the master clock frequency will be **40**kHz and used for a **720**×**480** 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 transmit speed.

Chroma Sample Rate RX	Luma Sample Rate	Chroma Sample Rate TX	Pilot Tone	Start Tone

40kHz ÷ 2 = 20kHz ; ÷ 2 = 10kHz ; ÷ 2 = 5kHz ; ÷ 10 = 500Hz

720 × 50µs = 36ms ; 360 × 50µs = 18ms
Luma Period ; Chroma Period

20K0D9CNX		50.3—50.6mHz	
Channel Bandwidth		±10kHz	
Video Bandwidth @–3dB		8¾kHz	
Luma Pixel Period		50µs	
Chroma Pixel Period	TX	100µs	Pilot
Chroma Pixel Period	RX	25µs	Cycles
Horizontal Sync		2ms	(10)
Pad		800µs	(4)
Luma Period		36ms	(180)
Chroma Period		18ms	(90)
Front Porch		3⅗ms	(18)
Chroma Line I.D.		2⅖ms	(6+6)
Vertical Sync		19⅕ms	(96)

	HSync		Pad		LPeriod		Pad		FrntPrch			
Luma	2ms		800µs		36ms		800µs		3⅗ms	=	43⅕ms	
	10	+	4	+	180	+	4	+	18	=	216 Pilot Cycles	
	HSync		Pad		CPeriod		Pad					
Chroma	2ms		800µs		18ms		800µs			=	21⅗ms	
	10	+	4	+	90	+	4			=	108 Pilot Cycles	

43⅕ms + 21⅗ms = 64⅘ms (1 Scan Line Period)
216 + 108 = 324 Pilot Cycles

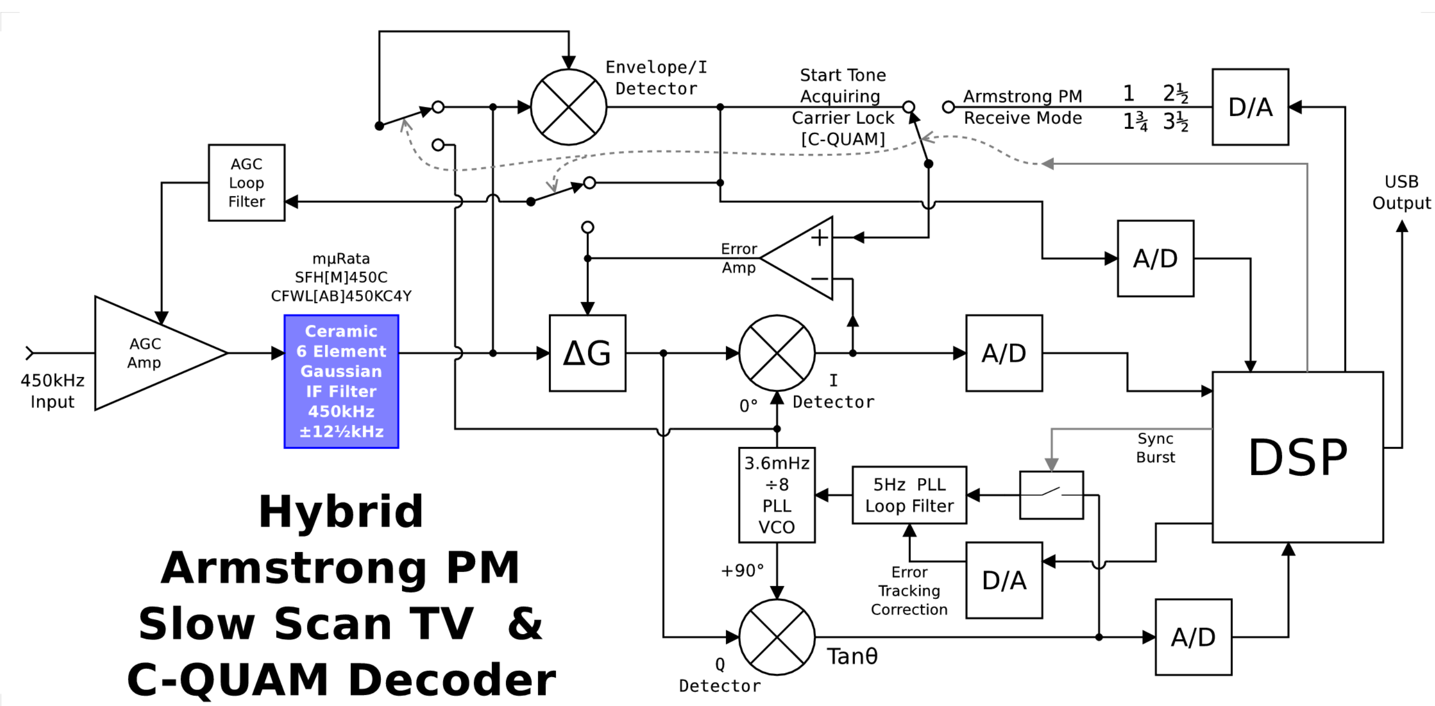
64⅘ms × 160 + 19⅕ms = 10⅖ Seconds per Field
324 Lines Vsync

10⅖s × 3 = 31⅕ 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	20⅖	9 ⇒ 10⅕	31⅕		525	AM / MW
40	**20**	**8¾ ⇒ 10**	**31⅕**		**509**	
38	25	9⅚ ⇒ 12½	32⅘		603	FMSt-SC
38	19	8¼ ⇒ 9½	32⅚		506	852×480
32	16	7 ⇒ 8	39		509	16:9
30	15	6½ ⇒ 7½	41⅗		505	22½/45kHz
25	12½	5½ ⇒ 6¼	50		512	ReSample
20	10	4⅓ ⇒ 5	62⅜	1'02"	505	
15	7½	3¼ ⇒ 3¾	83⅙	1'23"	505	
13½	6¾	3 ⇒ 3⅜	92⅖	1'32"	518	
12	6	2⅝ ⇒ 3	104	1'44"	509	
		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 Emission LumaDotClock ChromaDotClock ResampleClock Pilot VSync HSync Pad LumaPeriod ChromaPeriod FrntPrch ChromaID

Mode	— [B+W|SEQ|PAL|CRP] (B&W, Sequential, PAL, Chroma Rotary Phase™).	**SEQ**
Orientation	— [Landscape|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|ISB|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 ID identification duration on HSync front porch.	**6+6**

Order of components in a Luma/Chroma scan line: (ASCII)
HSync Pad LumaPeriod Pad FrntPrch HSync Pad ChromaPeriod Pad

Information: (UTF-8)
Emission CallSign Name xMitTime xMitDate xMitLocation ImageTime ImageDate ImageLocation ImageID History Owner Title Description

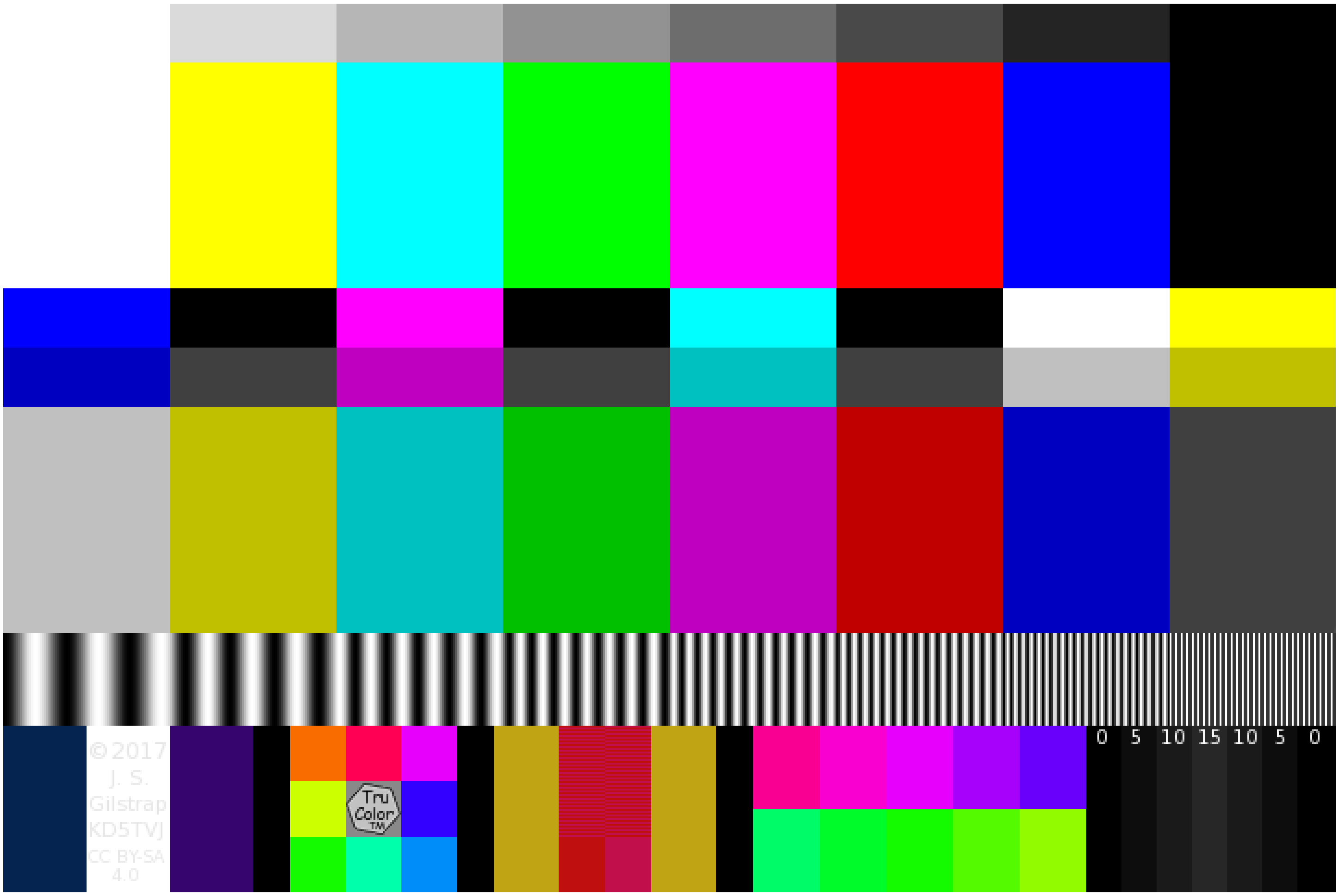
Emission	— Emission Designation.	**20K0D9CNX**
CallSign	— Ham/Station call sign or identification.	
Name	— Person, Group, or Company Name.	
Owner	— Owner/copyright holder, and license.	
xMitTime	— Transmit time. \ UTC from NIST.	
xMitDate	— Transmit date. > To be filled in at time of transmission.	
xMitLocation	— Transmit location. /	
ImageTime	— Image creation time.	
ImageDate	— Image creation date.	
ImageLocation	— Image creation location. (Possibly GPS info.)	
ImageID	— Image identification code or file name.	
History	— Records of transmit, receive, Ajdustments: Brightness, Contrast, Color, Hue ...	
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>DataOrder,LineOrder,Data<GS>Mode,Orientation,Width,Height,LpF,Interlace,ModBW,LumaDotClock,
ChromaDotClock,ResampleClock,Pilot,Vsync,Hsync,Pad,LumaPeriod,ChromaPeriod,FrntPrch,ChromaID,
Emission,CallSign,Name,Owner,xMitTime,xMitDate,xMitLocation,ImageTime,ImageDate,ImageLocation,
ImageID,History,Title,Description,Attachment<GS>Hsync,Pad,LumaPeriod,Pad,FrntPrch,Hsync,Pad,
ChromaPeriod,Pad<GS>Mode<RS>Orientation<RS>Width<RS>Height<RS>LpF<RS>Interlace<RS>ModBW<RS>
LumaDotClock<RS>ChromaDotClock<RS>ResampleClock<RS>Pilot<RS>Vsync<RS>HSync<RS>Pad<RS>LumaPeriod
<RS>ChromaPeriod<RS>FrntPrch<RS>ChromaID<RS>Emission<RS>CallSign<RS>Name<RS>Owner<RS>xMitTime<RS>
xMitDate<RS>xMitLocation<RS>ImageTime<RS>ImageDate<RS>ImageLocation<RS>ImageID<RS>History<RS>Title
<RS>Description<RS>Attachment<GS>

↓↓720×480↓↓



589Hz (42⅖) | ⅚kHz (60) | 1.179kHz (84⅚) | 1⅔kHz (120) | 2.357kHz (169¾) | 3⅓kHz (240) | 4.714kHz (339⅖) | 6⅔kHz (480)

Luma Frequency (Lines of Resolution) for 40kHz DotClock

5% Step Grayscale

Detect, Display & Storage

Detected (16-Bit Integer [A/D], each channel)

$\lambda = M_\lambda \div 7 \times 49152$ [75%] (Signed) [(M_λ + 3½) ÷ 7 Unsigned]

$U = M_B \div K \times 49152$ [75%] (Signed) [$2/\sqrt{3} \Rightarrow 56756$]

$V = M_R \div K \times 49152$ [75%] (Signed)

$K = 4.715$

Color Difference (16-Bit Integer, each channel)

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

$R - \lambda = V$ (Signed)

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

Display (16-Bit Integer ea. to 3×8-Bit Integer)

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

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

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

Storage (16-Bit Integer ea. to 32-Bit[12+10+10] Integer)

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

$B_{\lambda S} = 2^{10} \times 7 \times (B - \lambda) \div 12$ (Signed ; ±½)

$R_{\lambda S} = 2^{10} \times 7 \times (R - \lambda) \div 10$ (Signed ; ±½)

2^{32}

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 Secθ modulation to occur through the ΔG 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 ~⅖° resulting in ~43dB of separation but the MC13020 and possibly the MC13022 are the only chips hackable capable of proper decoding. This represents a ±25mV offset for a maximum **Q** output peak of ±3½V 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–M/PAL–[M|N] with its 1⅜:1 pixel aspect ratio.

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

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.

Unless another image file format supports this an optimized 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 (3.6mHz÷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 **1st** be corrected for center tracking of IF and then the master clock will track the changes so accurate sample timing will be maintained.

Using the Weaver method a SSB signal can be generated for the HF band with a 3kHz BW using the DSB 6kHz BW spec. on page **9**. To detect a Weaver oscillator is used to unfold the SSB signal into a conventional DSB signal for normal detection. This method may also be known as SSB-FM although it actually uses PM. This could transmit a high resolution 720×480 image in <2 min. within a 3khz BW.

The ΣHSλ to λUV TruColor™ Matrix

(**Y**et **A**nother **C**hroma **M**atrix ;-). What **NTSC** should have been?

A method for converting **ΣHSλ** Color with a modified **Luma** (**λ**) to analog Color TV **λUV** to balance for better **Chroma** (**UV**) matrixing.

Where: **Σ** = **Chroma** level is a vector matrix sum/difference
and not a saturation percentage factor.
H = Hue of the **Chroma** signal in θ°
derived from the quadrature matrix.
S = Saturation level (R) of the **Chroma** signal as
quadrature summation of the **U** & **V** vectors.
λ = Brightness, or intensity factor of the **Luma** signal.

32-Bit – 12-Bit Luminance, 2×10-Bit Chrominance, **U** & **V** each.

Matrixing

Let:

```
R = Red      \
G = Green     Each range from 0 to 1.
B = Blue     /
                                                      HSV                   HSV
λ = Matrixed B & W    Luma channel.                  Hue                   Hue
U = Matrixed B − λ  Chroma channel.  U #3300FF 252.00°  −U #CCFF00  72.00°
V = Matrixed R − λ  Chroma channel.  V #FF0055 340.00°  −V #00FFAA 160.00°
W = Matrixed G − λ  Chroma channel.  W #00FF33 132.00°  −W #FF00CC 312.00°
```

Enhanced channels:

```
I = Matrixed  Skin  Chroma channel.  I #F96D00  26.27°  −I #008CF9 206.27°
Q = Matrixed Purple Chroma channel.  Q #E700FB 295.22°  −Q #14FB00 115.22°
```

We have:

```
    λ = +1/7 × B  +2/7 × R  +4/7 × G
B − λ = +6/7 × B  −2/7 × R  −4/7 × G
R − λ = −1/7 × B  +5/7 × R  −4/7 × G
G − λ = −1/7 × B  −2/7 × R  +3/7 × G
G − λ = −¼  × (B − λ) −½ × (R − λ)    [W, B−λ Scaled with √3/2]
```

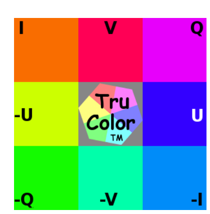
Encode:

```
If:   U(x) = √3/2 × (B − λ) ×   0° ⌉ Quadrature  _|_
      V(y) =        (R − λ) ×  90° ⌋ Sub-Carrier  |
Then: W    = √3   × (G − λ) @ 240°

Chroma Vector    R = √ U² + V²
Chroma Hue       θ = [ aTan2(V,U) ; If θ < 0 Then θ + 2π ]
```

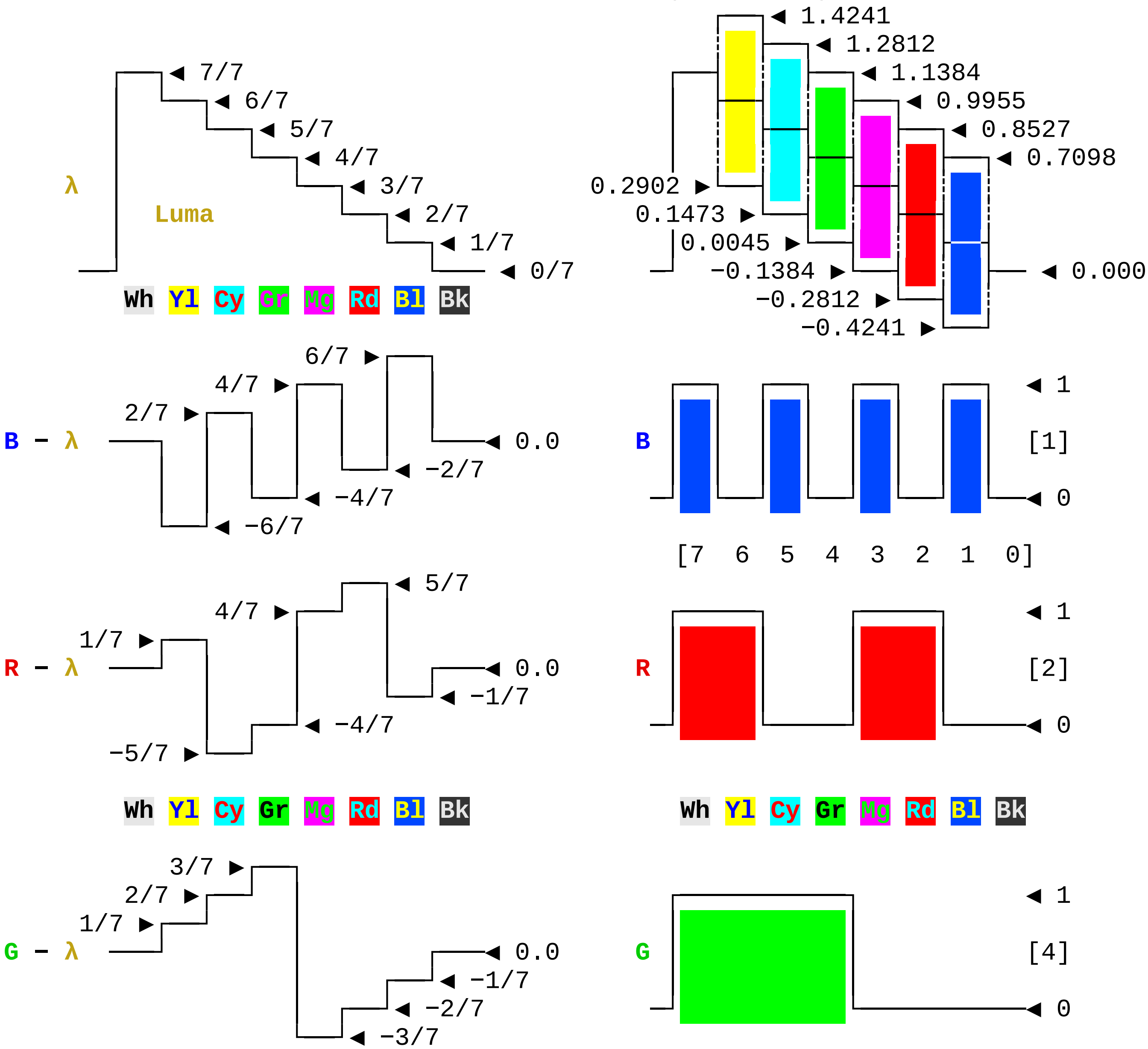
Decode: SyncDet

```
U: B − λ = ─┼─ @    0° ÷ √3/2
V: R − λ = ─┼─ @   90°
W: G − λ = ─┼─ @  240° ÷ √3
```



100% Color Bars

Composite
(Chroma × ¾)



Color Bar	Luma Level	Rectangular Chroma $U\times\sqrt{3}/2$	Rectangular Levels V	Polar Chroma Hue θ	Polar 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 × ¾ scaling for all colors with full saturation produces a level of **0.5669**pk or **1.134**p-p when modulated. When combined with Luma the Luma + Chroma peak for Yellow is at **+142⅖%**, and Blue is at **−42⅖%**.