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

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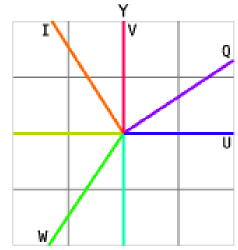
R, G, B, Range: 0–1

		HSV Hue
Y = 0.299×Red + 0.587×Green + 0.114×Blue		
U = 0.492111 × (B – Y) (0.4921110411)	U #2900FC	249.76°
V = 0.877283 × (R – Y) (0.8772832199) Phase inverted @ ½H	V #FF0056	339.76°
W = –0.509370 × (R – Y) – 0.194208 × (B – Y) ⇐ [G – Y] (–0.5093696834) (–0.1942078377)	W #1BFA00	113.52°
I = 0.595901×Red – 0.274557×Green – 0.321344×Blue (0.5959007249) (–0.2745567667) (–0.3213439582)	I #FC6600	24.29°
Q = 0.211537×Red – 0.522736×Green + 0.311200×Blue (0.2115366883) (–0.5227362571) (0.3111995688)	Q #8900FE	272.36°

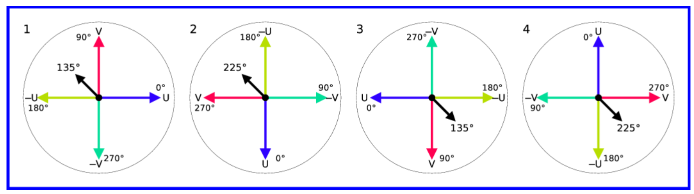
	IRE=1V/140	
Luma (Y) Level:	98	700mV
Sync:	–42	300mV
ColorBurst:	±21	±150mV
Max (Yl & Cy)	130⅔	1.23̅V
Min (Rd & Bl)	–32⅔	66⅔mV

For more information on signal levels, Luma/Chroma matrixing, composite & vector scope images and other info see NTSC Specifications .



Rec.709 sRGB Gamut	1931 CIE x	y	nm
Red	0.64	0.33	~607
Green	0.30	0.60	~556
Blue	0.15	0.06	~467
White Point	0.3127	0.329	6504°K
Contrast 2^{12}:1	Gamma 2.4		

PAL On Screen Vector Rotation/Shift & V Switch Phases



Colorburst & Carrier

The **PAL** line phase alternation signal for **V** uses the standard **135°**(+) / **225°**(–) phase toggling of the colorburst. Using synchronous detection with a reduced carrier level will increase coverage and signal quality. The sound is placed on the ¼MHz data **Q** channel of the main carrier with additional data possible while the composite video signal modulates the **I** channel.

Claims:

● Using a **3:1** interlace with the **4** phase states of **PAL** **Chroma** produces a **Luma**/**Chroma** fine mesh harmonic spacing of ½ the frame rate of **12**Hz and a **2** frame repeat rate like **NTSC**.

● A **3:1** interlace also creates Hanover lines instead of bars within a completed frame that are stationary and do not scroll unlike a **2:1** interlace; i.e. the hue palette phase rotation reverses on alternate lines of a field and a full frame whereas with a **2:1** interlace the rotation reversal is with alternate line pairs of a frame that alternate the hue palette phase rotation for every full frame. This makes any hue error effects twice as fine compared to a **2:1** interlace.

● On a per frame basis the diagonal **Chroma** dot pattern for **U** & **V** is similar to **NTSC** and for axes rotated **45°** away, nearer to **I** & **Q** the pattern is identical.

● A **3:1** interlace offers **24PsF**, **36PsF**, & **72fps** motion refresh. For the faster **36** & **72** refresh rate line interpolation for the missing lines can be used for good quality de-interlaced full frame motion.

3:1 Interlace

Vertical scan is from top to bottom and the field lines shift up ⅓ horizontal field line per field instead of ½ line in a **2:1** interlace. This will produce **2** hammer heads during the vertical blank, offset from the center to each side, or **3** hammer heads separated and centered within the vertical blanking. The vertical sync of the **1**ST field is advanced by **1** horizontal line in relation to the other **2** fields. This is necessary to arrange the on screen **Chroma** dots in a uniform diagonal pattern to facilitate the use of a standard PAL **3** line [diagonal] comb filter for **Luma**/**Chroma** separation for both field and frame. The **Chroma** dot pattern repeats at a **2** frame interval and complete **Luma**/**Chroma** separation for static/non-motion areas is realized using an NTSC field comb of **1** frame delay.

Standard Definition **WVGA**

PAL-TV | 24PsF | 432i72 | 15:9

NTSC +11⅔%, PAL-B/G −21½% in a **4**MHz Channel Space

22½"×13½" ⇒ **26¼"** Diag, **794**µm Line Pitch **2.34**MHz Chroma

$57\underline{15}$×$34\underline{3}$cm ⇒ **66⅔** Diag **PAL+** Std. Def. Compatible Resolution Format

General:

		Fair Contrast
Aspect Ratio	5:3 = 1⅔	151:108 ≈ 1.3970
Total Picture Pixels (**D**igital)	720×432 ; 311040 Pixels	604×432 ; 260928
Kell Factor (**A**nalog Resolution)	509×305 ; 155520 Pixels	427×305 ; 130464
Maximum @−9dB	**D:** 724×432 ; 312768 Pixels	**A:** 512×305 ; 156384
		Pixel Aspect 1.193:1

Vertical:

Frames Per Second	24Hz
Total Lines Per Frame	470
Fields Per Second	72Hz
Total Lines Per Field	156⅔
Field Picture Lines	144
Lines Per Blank	12⅔
Blank	1.123ms
Sync	177µs ; 2 Lines

Aspect Ratio × Super Pixel = Pixel Resolution

$$\begin{bmatrix}15\\9\end{bmatrix} \times \begin{bmatrix}48\\48\end{bmatrix} = \begin{bmatrix}720\\432\end{bmatrix}$$

Horizontal: Resolution Fair: 426¾ Max@−9dB:512

Lines Per Second	11.280kHz
Period (H**P**)	88.652µs (415½)
Picture	79.371µs (372)
Total Picture Pixels	441 ≈ 1⅔×**Y**BW×(H**P**−H**B**) ; (426¾+14¼)≈3¼%/2$\underline{56}$µs OverScan
Viewable Picture Pixels/Line	426¾ ; 76.811µs (360×2 Dot Clock)
Blank (H**B**)	9.281µs (43½)
Front Porch	1.067µs (5)
Sync	3.520µs (16½)
Back Porch	4.694µs (22)

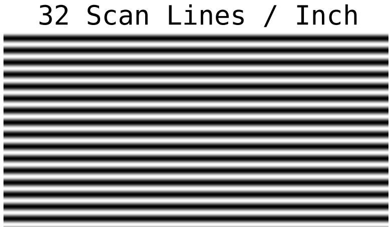
Luma & Chroma on **I** Ch. Main Carrier:

		Chroma Rotary Phase™ with TruColor™
Luma (**Y**) Bandwidth @−3dB	**(512)** 3⅓MHz Corner, 3½MHz FullCut Vestigial −½MHz, Corner −⅓MHz	
Chroma:	Sub-Sampling 4:2:2	2.35188MHz
Sub-Carrier	2.34342MHz ; 8× ⇒ 18.74736MHz	8× ⇒ 18.81504MHz
¼H Odd Harmonic	415½:**207¾**:138½	417:**208½**:139
V Bandwidth	**(254)** 1⅔MHz (USB +1MHz & LSB −1⅔MHz)	
U Bandwidth	**(254)** 1⅔MHz (USB +1MHz & LSB −1⅔MHz)	
Color Burst Duration	2.987µs ; 7 cycles 2×(1+7+3)=22 **426/533ns 1.28/1.17µs**	
Baseband Guard	½MHz	

Sound Sub-Carriers on **Q** Ch. of Main Carrier: **Armstrong PM²** ±120°

Sub-Carrier Frequencies:	**L+R:** 129.72kHz, **L−R:** 208.68kHz, **SAP:** 50.76kHz 4½×H 11½×H 18½×H
Frequency Response:	50Hz−15kHz @ −3dB (Harmonic Peak PSNs 2×1ms)
Equalization:	50µs Pre-Emphasis, Pole at 13kHz (12¼µs) 2⅔ms Pre-Emphasis, Pole at 180Hz (884µs)
Alternative Digital COFDM:	5.1 Surround & SAP (Opus) with analog only **L+R** 50Hz-12½kHz (2½×H 28.2kHz)
Processing:	Harmonic Peak PSNs 2×1ms 2:1 Linear Compression, Attack: 1ms, Decay: 60ms

32 Scan Lines / Inch



All the advanced processing for both encoding and decoding that has been developed for **PAL** and **NTSC** some of it described in **NTSC Specifications** should be used along with any additional techniques available to improve signal quality, TX/RX robustness e.g. GCR, and image resolution maximization.

↓↓ **Chroma** LoR/Freq: 94⅝ / ⅝MHz, 189¼ / 1¼MHz

720×432
Expanded to
1440
2×HorizSample

270.72kHz
(41⅓)

383.52kHz
(60¼)

541.44kHz
(84⅓)

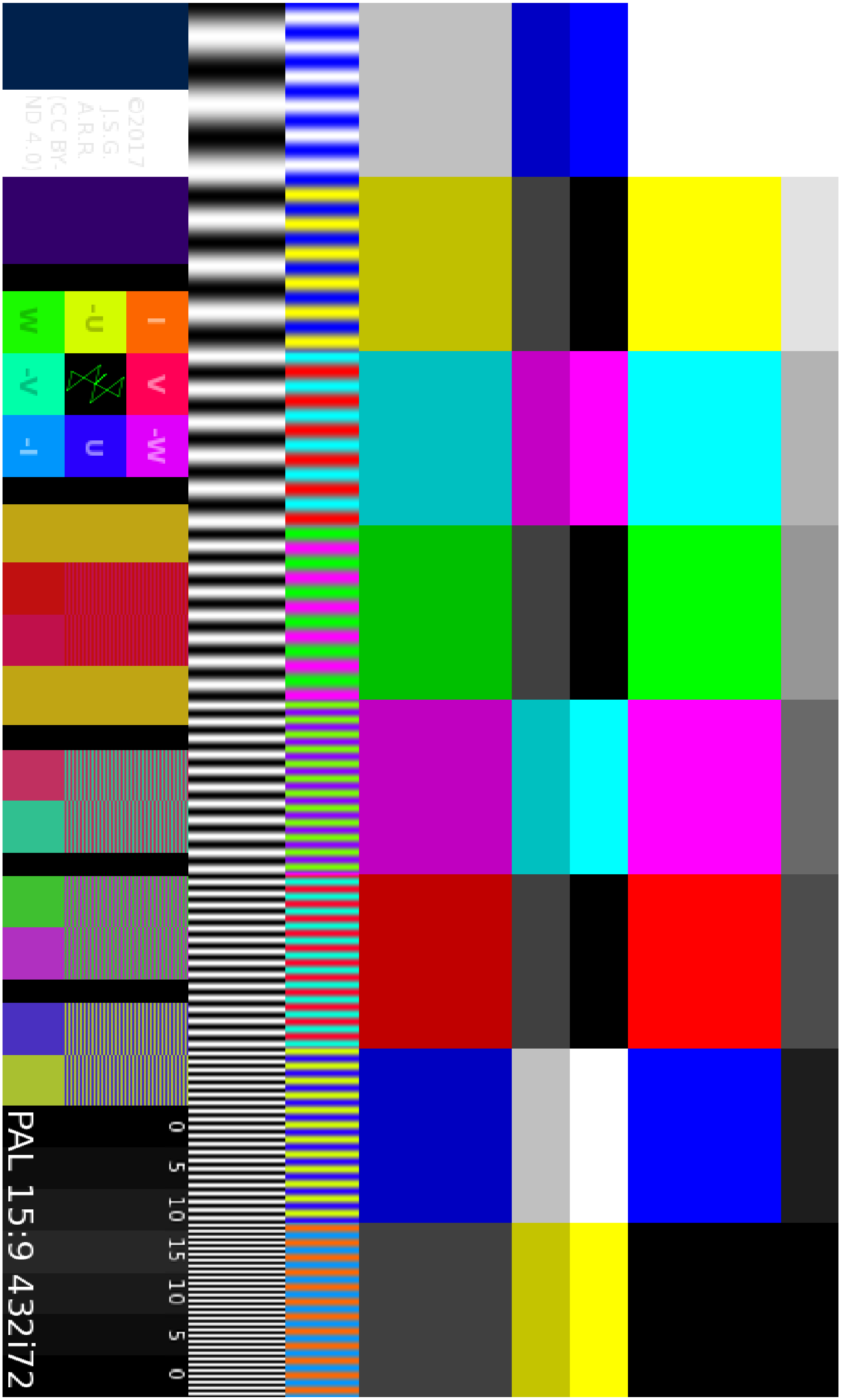
789.600kHz
(120⅘)

1.11672MHz
(170⅓)

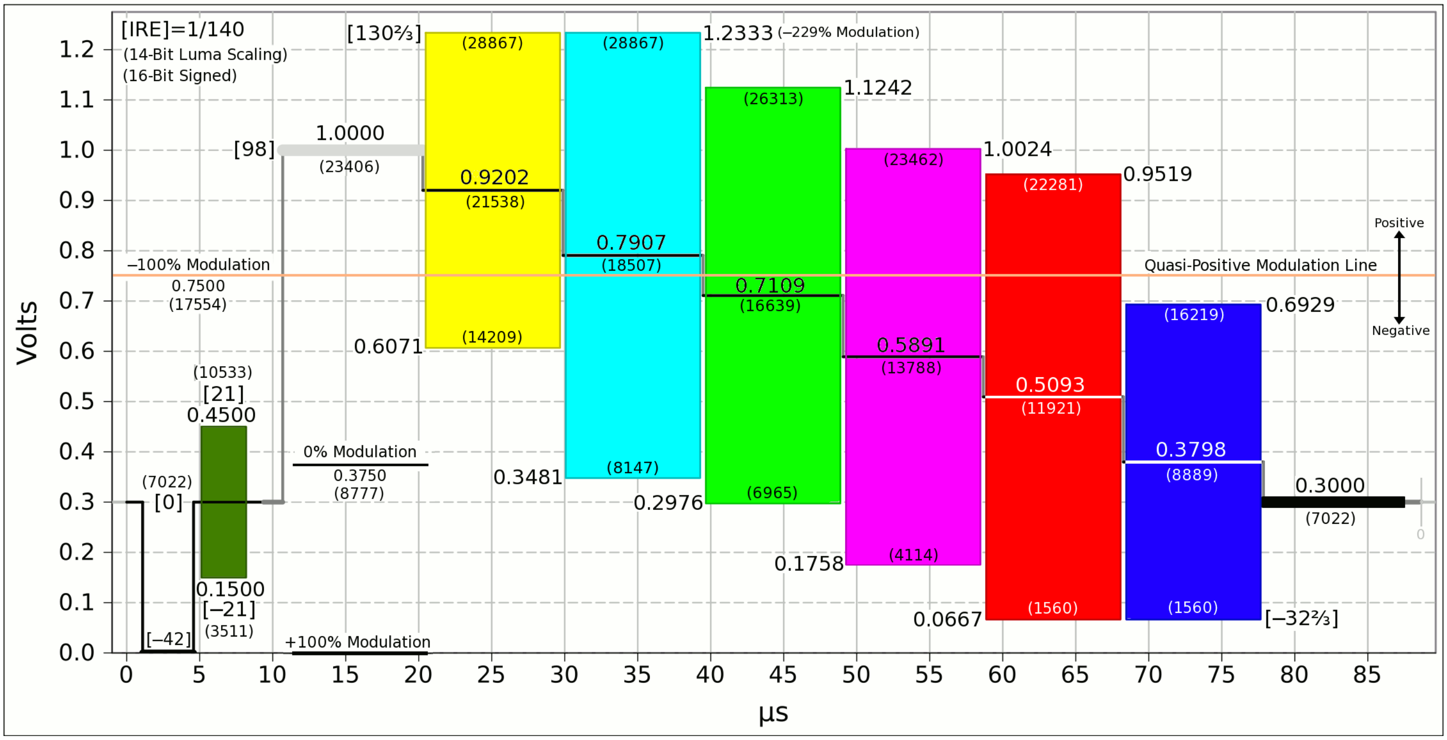
1.57920MHz
(240⅞)

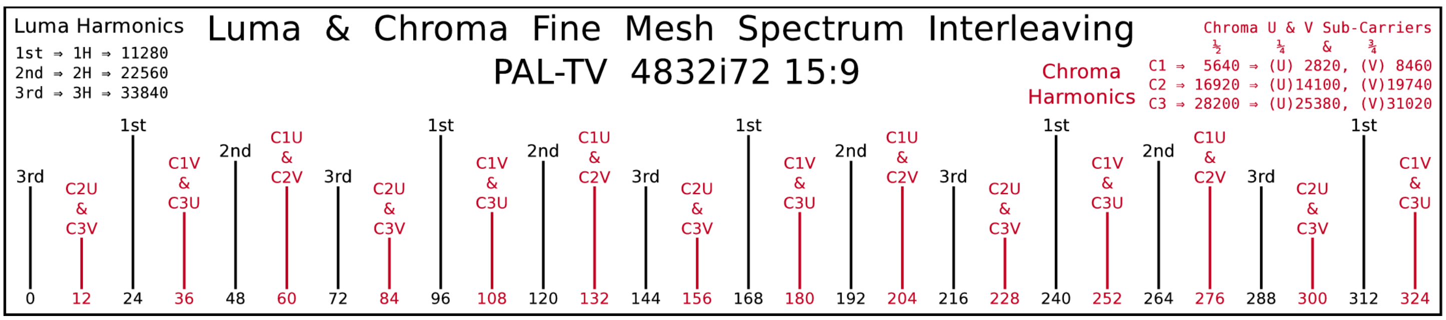
2.22216MHz
(338⅞)

3.14712MHz
(480)



PAL-TV 432i72 Composite Luma/Chroma 720×432 Test Pattern

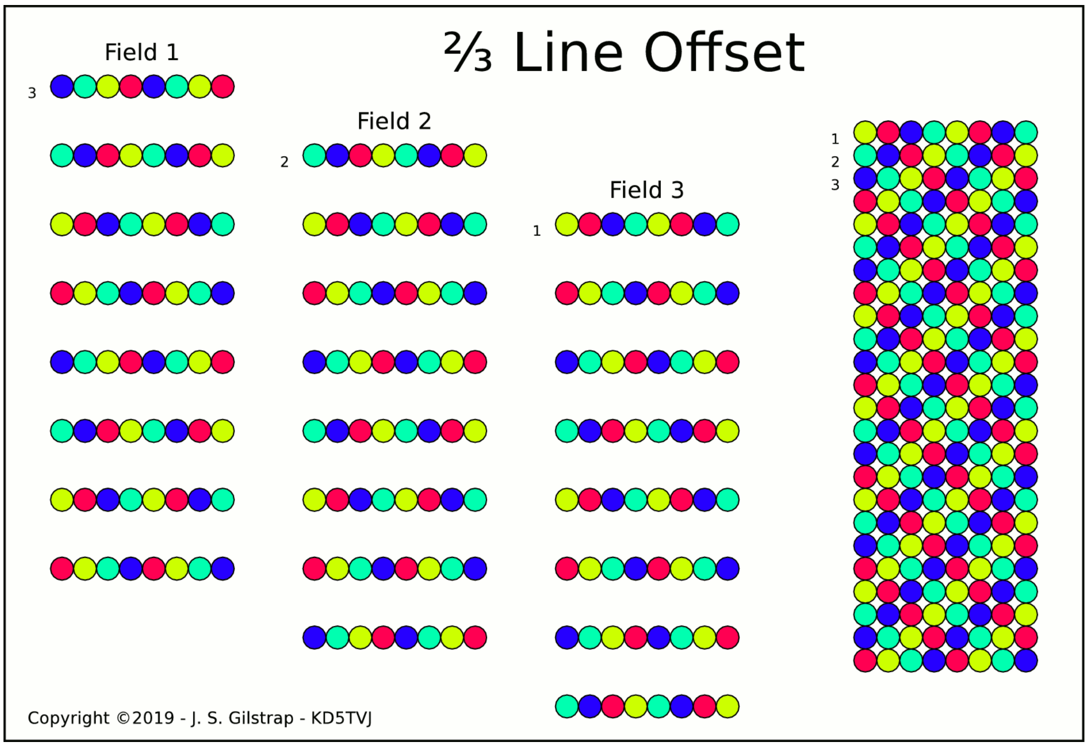




In the image above using a 3:1 interlace the normalized spectrum distribution of Luma with PAL Chroma is shown at the fine mesh level. The 3:1 interlace with a 72Hz field rate ending with ⅓ line causes the Luma and Chroma harmonics to be placed at 24Hz intervals which is also the frame rate. When a 3:1 interlace is used with PAL Chroma the sub-carrier is placed at 3×H×[Integer+½]÷2 (H = Horizontal Sweep) so at the coarse mesh level the U & V Chroma clusters will lie on the ¼ & ¾ offsets respectively, in between the Luma Clusters. Having both the Luma and Chroma fine mesh harmonics spaced at 24Hz intervals for cluster triads, the Chroma SC being placed on the ¼ mark, and that H/2 is evenly divisible by 24 means that all Chroma harmonics are shifted by ±12Hz off center thus moving them away from interference with the Luma and placing them exactly centered in between them. The ¼U & ¾V offsets also creates overlapping Chroma harmonics from the U & V channels in a triad configuration of: C1V & C3U, C1U & C2V, and C3V & C2U. This is a repeating 3 cluster pattern even when shifting over 1 cluster at a time. A Fourier spectral analysis has not been done but for the overlapping harmonics it can be assumed that some may be constructive and increase in strength and others may be completely destructive and create Fukinuki holes. The most desirable outcome would be for Chroma harmonics which are from adjacent Chroma clusters and are centered within a Chroma cluster are constructive and those that are centered within the Luma clusters are destructive and are the ones creating the Fukinuki holes. For the Luma the reverse is not true as it is not sub-modulated. For both Luma and Chroma the harmonics for each cluster are spaced 72Hz apart and for a cluster triad there is a 24Hz offset between the 3 so a combined triad of harmonics creates the 24Hz interval. As with a 2:1 interlace the energy in between the Luma clusters is minimal and is where and why the Chroma clusters were placed there originally. The void of strong harmonics in between the Luma clusters for a 3:1 interlace is probably very similar to a 2:1 interlace. Even if the voids are not as defined as a 2:1 interlace the Luma/Chroma fine mesh harmonic separation at the 12Hz interval is as evenly spaced as NTSC's 15Hz interval which is FrameRate/2 for both.

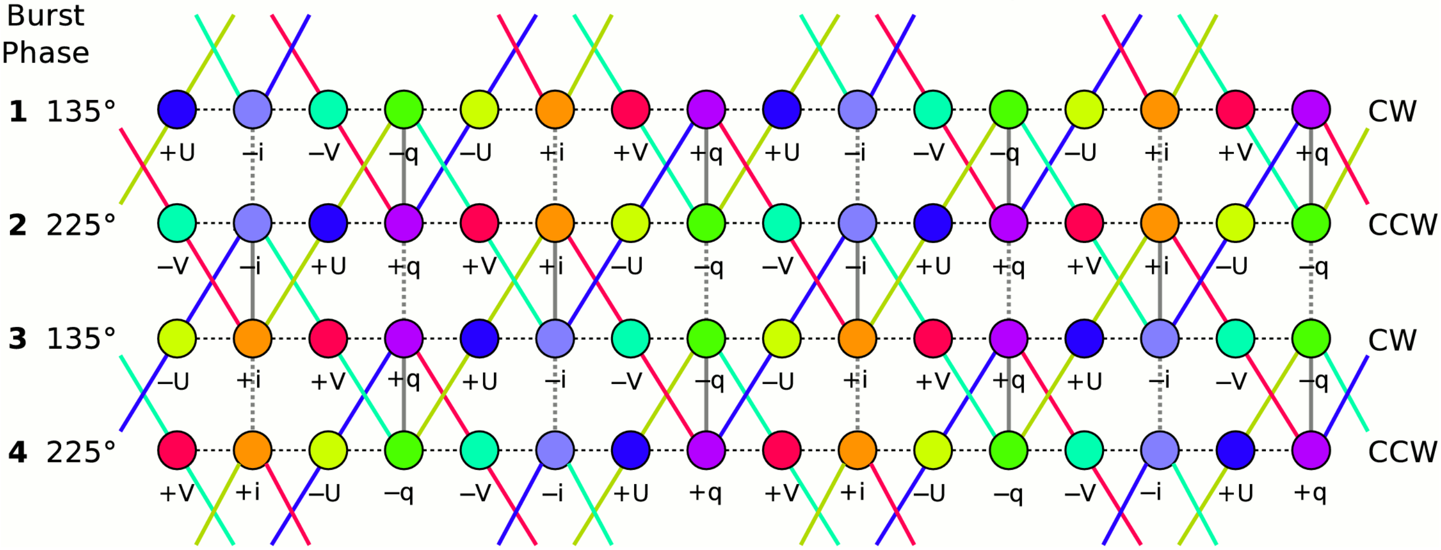
To the right is the chroma dot sequence for a **470** line format using a ⅔ line offset. It shows the **2** frame repeat rate where the chroma dots are inverted on the even frames and the odd frames are non-inverted, or vice-versa, for an on screen per spot basis. The staggered vertical sync pulses cause the chroma dots to align diagonally on screen to create a uniform pattern. The dots are colored for the **U** & **V** axes where they each rotate **90°** per line in opposite directions. This also causes the axes close to **i** & **q** to invert **180°** every **2** lines in a flip-switch manner. The directions that **U** & **V** rotate (shift) on screen will depend on whether the **H/2** multiplier ends with ¼ or ¾ , **625** PAL ends with ¾ while **525** PAL-M & **625** PAL-N ends with ¼ causing chroma dot patterns to be a mirror image of each other. Depending on whether ¼ or ¾ is used, in the image to the right the diagonal representation of the dots for **U** or **V** may or may not be mirror reversed along the vertical.

To view the full **470** lines of chroma rotation for **2** frames zoom in on the diagram to the right. You can also highlight the image within the pdf and copy it to the clipboard and then paste it onto an image editor like The GIMP or Photoshop.



In the diagram above are the **3** fields of chroma dots separated out and also combined revealing the uniform diagonal pattern. In the left half the separated fields are vertically staggered to each other so the **4** line chroma repeat pattern is aligned between the fields. Field **1** starts with line **1** of a frame, field **2** with line **2**, and field **3** with line **3**. When assembled and properly staggered vertically the pattern on the right is realized.

Per Field Luma Separation 3 Line Processing
For Non-Static Full Motion Image Areas



For **Luma** samples that fall on **U** or **V** **Chroma** Sample points there are 2 **Luma** samples from **i** & **q** sample points from adjacent lines on the diagonal that when added together will form the complimentary color to cancel out the **Chroma** on each **Luma** sample. The mapping is shown via the cpmplimentary color lines connected to an **U** or **V** sample and the associated **i** & **q** samples. The ratio is (√2:2:√2)/(1+√2)/2 .

For **Luma** samples that fall on **i** or **q** sample points **i** or **q** points directly above or below on adjacent lines are added or subtracted to cancel out **Chroma** on each **Luma** sample point. The mapping is shown via gray lines. Solid lines are additive and dotted lines are subtractive. The ratio is ±¼:½:±¼ .

Since **Luma** sample recovery on **U** or **V** sample points is all additive it provides noise reduction but **Luma** sample recovery on **I** or **q** sample points have some S/N loss since adjacent lines are subtracted nullifing **Luma** but additive for the complimentary color that cancels out **Chroma** on the current line leaving only the **Luma** from the curent line but also the noise from the adjacent lines.

To average out this noise variation between the **i** & **q** and **U** & **V** sample points the recovered **Luma** on a line can be a running average of 3 points in a ¼:½:¼ ratio or 5 points in a ⅘×(⅛:¼:½:¼:⅛) ratio. This averaging has minimal effect on sharpness since the sample rate is ~3¾ times the image resolution.

To eliminate **Luma** and obtain **Chroma** it can be as simple as subtracting adjacent lines from the current line as in NTSC with the ¼:½:¼ ratio. Unlike NTSC the adjacent lines do not contribute any to **Chroma** levels but just nullify the **Luma**. The **Chroma** on the adjacent lines are inverted to each other so when they are added together the **Chroma** is nullified. Inverting these 2 summed lines will produce inverted **Luma** which will nullify the **Luma** on the current line Leaving only the quadrature **Chroma** signal to be used for **Chroma** decoding. However this method does not correct for hue phase errors and some lines of **Chroma** resolution are lost nor does it produce the best S/N ratio.

Subtracting one line, above or below from the current line will eliminate the Luma and either the **i** or **q** **Chroma** channel. This method will correct for hue phase errors and produce much better S/N ratio but the **Chroma** lines of resolution will be cut in half. Which **Chroma** channel that will be eliminated and which one will remain will depend on which chroma phase rotation the current line is using. **1**: 1-4 ⇒ +**i**, 1-2 ⇒ +**q** ; **2**: 2-1 ⇒ −**q**, 2-3 ⇒ −**i** ; **3**: 3-2 ⇒ +**i**, 3-4 ⇒ +**q** ; **4**: 4-3 ⇒ −**q**, 4-1 ⇒ −**i**. For positive values: 1-4 & 3-2 ⇒ +**i** ; 1-2 & 3-4 ⇒ +**q** and for negative 4-3 & 2-3 ⇒ −**i** ; 2-1 & 4-3 ⇒ −**q**

Since the **Chroma** sub-carrier is inverted 180° from frame to frame to average out **Luma** brightness two frames can be added or subtracted to obtain the **Luma** or **Chroma** respectively so motion free static image areas will produce full **Luma**/**Chroma** separation without any artifacts. This will produce the highest resolution and best S/N ratio but unless adjacent line **Chroma** information is incorporated with the current line any hue phase errors that exist will not be canceled out but will produce Hanover lines that may be visible and viewer must rely on visual blending for the correct hue.

Sound: Unlimited Armstrong PM²

$X = 1$

$Y \leq |\pm\sqrt{3}|$

$1 \leq R \leq 2$

$\theta \leq |\pm 60°|$

$\theta = aTan(Y)$

$R = \sqrt{1+Y^2}$

$I = R^2 \times Cos2\theta$

$Q = R^2 \times Sin2\theta$

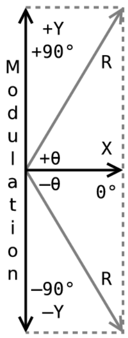
$I = 1 - Y^2$

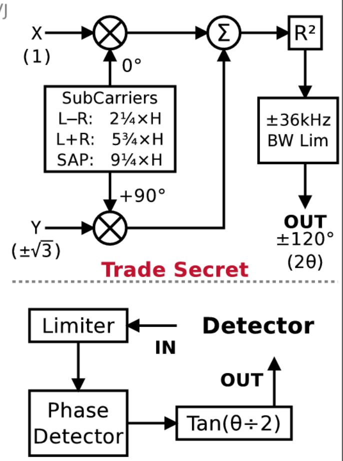
$Q = 2Y$

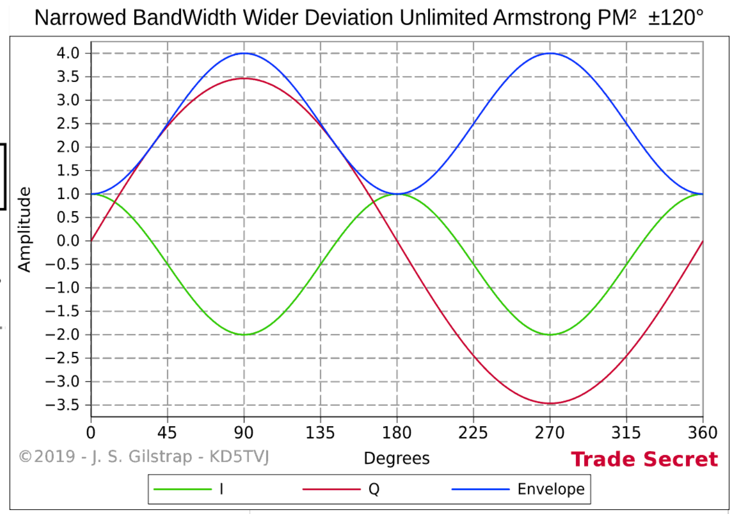
$Env = R^2 = 1 + Y^2$

$2 = Env + I$

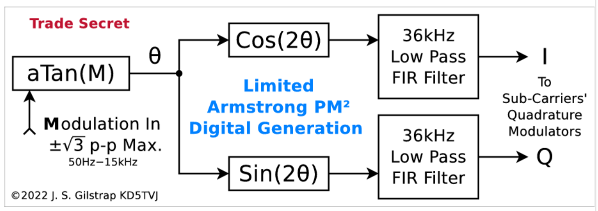
$2\theta = aTan[2Y \div (1 - Y^2)]$

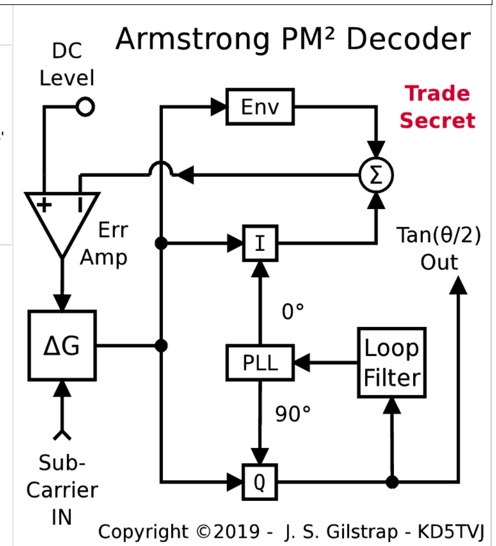




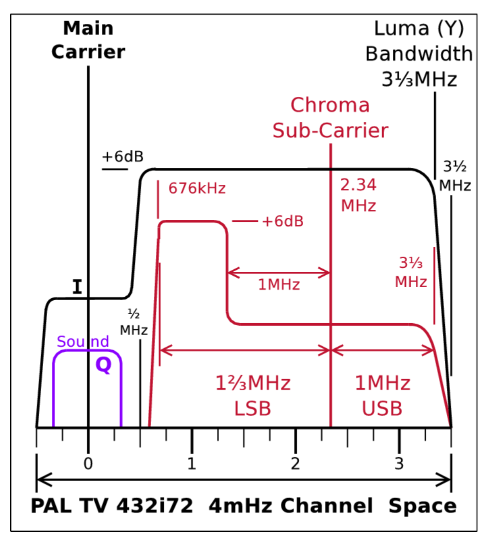


Narrow Band Sound





The sub-carriers which can contain up to 12dB of amplitude modulation can be compressed down to 6dB, possibly following the peak amplitude prior to the squaring of the signal. A full 12dB of compression could be employed but signal quality might be noticeability affected or a 9dB reduction could be a good choice. The over easy compression should have an attack of ~1ms and a decay of ~60ms with the proper amount of compression already achieved prior to the signal modulation, i.e. the compression action should happen ~1ms sooner than the signal modulation. The actual compression modulation should not widen the signal bandwidth any since the attack and decay filtering will only contain low frequency modulation information. This compression will not affect the phase deviation but only lower the S/N ratio by a maximum of 6dB. This will allow twice the headroom and stronger un-modulated carrier levels for all three sound signals on the main **Q** channel. For detection an alternative to hard limiting and Tan(θ/2) wave shaping a similar process used in a C-QUAM® decoder can be employed. The Env and I signals are identical but phase inverted to each other. If the signal doesn't contain any amplitude noise the sum of the two will contain no information, only a DC level. The decoding process will un-modulate any amplitude noise by using the ΔG modulator controlled by the sum of the Env and I signals being compared to a DC reference through a feedback path. This effectively functions as a limiter while also outputting Tan(θ/2) eliminating the need for wave shaping and will also remove any amplitude compression applied.



↓ ↓

Cable Band Plan — 4MHz Channel Spacing

Including Broadcast & Amateur Radio Overlapping Spectrum

Cable must carry Broadcast & Ham Channels.

Lower MHz	Carrier MHz	Chroma MHz	Upper MHz	Cable	Broad Cast	Ham
Composite Line Input				00		
112	112½	114.84342	116	01		
116	116½	118.84342	120	02		
120	120½	122.84342	124	03		
124	124½	126.84342	128	04		
128	128½	130.84342	132	05		
132	132½	134.84342	136	06		
136	136½	138.84342	140	07		
140	140½	142.84342	144	08		
144	144½	146.84342	148	09	2M	0
148	148½	150.84342	152	0A		
152	152½	154.84342	156	0B		
156	156½	158.84342	160	0C		
160	160½	162.84342	164	0D		
164	164½	166.84342	168	0E		
168	168½	170.84342	172	0F		
172	172½	174.84342	176	10		
176	176½	178.84342	**180**	11	1	
180	180½	182.84342	184	12	2	
184	184½	186.84342	188	13	3	
188	188½	190.84342	**192**	14	4	
192	192½	194.84342	196	15	5	
196	196½	198.84342	200	16	6	VHF2
200	200½	202.84342	**204**	17	7	
204	204½	206.84342	208	18	8	
208	208½	210.84342	212	19	9	
212	212½	214.84342	**216**	1A	10	
216	216½	218.84342	220	1B		
220	220½	222.84342	224	1C		
224	224½	226.84342	228	1D		
228	228½	230.84342	232	1E		
232	232½	234.84342	236	1F		
236	236½	238.84342	240	20		
240	240½	242.84342	244	21		
244	244½	246.84342	248	22		
248	248½	250.84342	252	23		
252	252½	254.84342	256	24		
256	256½	258.84342	260	25		
260	260½	262.84342	264	26		
264	264½	266.84342	268	27		
268	268½	270.84342	272	28		
272	272½	274.84342	276	29		
276	276½	278.84342	280	2A		
280	280½	282.84342	284	2B		
284	284½	286.84342	288	2C		
288	288½	290.84342	292	2D		
292	292½	294.84342	296	2E		
296	296½	298.84342	300	2F		
300	300½	302.84342	304	30		
304	304½	306.84342	308	31		
308	308½	310.84342	312	32		
312	312½	314.84342	316	33		
316	316½	318.84342	320	34		
320	320½	322.84342	324	35		
324	324½	326.84342	328	36		
328	328½	330.84342	332	37		
332	332½	334.84342	336	38		
336	336½	338.84342	340	39		
340	340½	342.84342	344	3A		
344	344½	346.84342	348	3B		
348	348½	350.84342	352	3C		

Lower MHz	Carrier MHz	Chroma MHz	Upper MHz	Cable	Broad Cast	Ham
620	620½	622.84342	624	80	48	
624	624½	626.84342	628	81	49	
628	628½	630.84342	632	82	50	
632	632½	634.84342	636	83	51	
636	636½	638.84342	640	84	52	
640	640½	642.84342	644	85	53	
644	644½	646.84342	648	86	54	
648	648½	650.84342	652	87	55	
652	652½	654.84342	656	88	56	
656	656½	658.84342	660	89	57	
660	660½	662.84342	664	8A	58	
664	664½	666.84342	668	8B	59	
668	668½	670.84342	672	8C	60	
672	672½	674.84342	676	8D	61	
676	676½	678.84342	680	8E	62	
680	680½	682.84342	684	8F	63	
684	684½	686.84342	688	90	64	
688	688½	690.84342	692	91	65	
692	692½	694.84342	696	92	66	
696	696½	698.84342	700	93	67	
700	700½	702.84342	704	94	68	
704	704½	706.84342	708	95	69	
708	708½	710.84342	712	96	70	
712	712½	714.84342	716	97	71	
716	716½	718.84342	720	98	72	
720	720½	722.84342	724	99	73	
724	724½	726.84342	728	9A	74	
728	728½	730.84342	732	9B	75	
732	732½	734.84342	736	9C	76	UHF
736	736½	738.84342	740	9D	77	Lost
740	740½	742.84342	744	9E	78	to
744	744½	746.84342	748	9F	79	Chan.
748	748½	750.84342	752	A0	80	Repak
752	752½	754.84342	756	A1	81	
756	756½	758.84342	760	A2	82	
760	760½	762.84342	764	A3	83	
764	764½	766.84342	768	A4	84	
768	768½	770.84342	772	A5	85	
772	772½	774.84342	776	A6	86	
776	776½	778.84342	780	A7	87	
780	780½	782.84342	784	A8	88	
784	784½	786.84342	788	A9	89	
788	788½	790.84342	792	AA	90	
792	792½	794.84342	796	AB	91	
796	796½	798.84342	800	AC	92	
800	800½	802.84342	804	AD	93	
804	804½	806.84342	808	AE	94	
808	808½	810.84342	812	AF	95	
812	812½	814.84342	816	B0	96	
816	816½	818.84342	820	B1	97	
820	820½	822.84342	824	B2	98	
824	824½	826.84342	828	B3	99	
828	828½	830.84342	832	B4	100	
832	832½	834.84342	836	B5	101	
836	836½	838.84342	840	B6	102	
840	840½	842.84342	844	B7	103	
844	844½	846.84342	848	B8	104	
848	848½	850.84342	852	B9	105	
852	852½	854.84342	856	BA	106	
856	856½	858.84342	860	BB	107	
860	860½	862.84342	864	BC	108	

Lower MHz | Carrier MHz | Chroma MHz | Upper MHz | Cable | Broad Cast | Ham — Channels
Lower MHz | Carrier MHz | Chroma MHz | Upper MHz | Cable | Broad Cast | Ham — Channels

Lower MHz	Carrier MHz	Chroma MHz	Upper MHz	Cable Channels	Broad Cast Channels	Ham Channels
352	352½	354.84342	356	3D		
356	356½	358.84342	360	3E		
360	360½	362.84342	364	3F		
364	364½	366.84342	368	40		
368	368½	370.84342	372	41		
372	372½	374.84342	376	42		
376	376½	378.84342	380	43		
380	380½	382.84342	384	44		
384	384½	386.84342	388	45		
388	388½	390.84342	392	46		
392	392½	394.84342	396	47		
396	396½	398.84342	400	48		
400	400½	402.84342	404	49		
404	404½	406.84342	408	4A		
408	408½	410.84342	412	4B		
412	412½	414.84342	416	4C		
416	416½	418.84342	420	4D		
420	420½	422.84342	424	4E		1
424	424½	426.84342	428	4F		2
428	428½	430.84342	432	50		3
432	432½	434.84342	436	51		70CM 4
436	436½	438.84342	440	52		5
440	440½	442.84342	444	53		6
444	444½	446.84342	448	54		7
448	448½	450.84342	452	55		
452	452½	454.84342	456	56		
456	456½	458.84342	460	57		
460	460½	462.84342	464	58		
464	464½	466.84342	468	59		
468	468½	470.84342	472	5A		
472	472½	474.84342	**476**	5B	11	
476	476½	478.84342	480	5C	12	
480	480½	482.84342	484	5D	13	
484	484½	486.84342	**488**	5E	14	
488	488½	490.84342	492	5F	15	
492	492½	494.84342	496	60	16	
496	496½	498.84342	**500**	61	17	
500	500½	502.84342	504	62	18	
504	504½	506.84342	508	63	19	
508	508½	510.84342	**512**	64	20	
512	512½	514.84342	516	65	21	
516	516½	518.84342	520	66	22	
520	520½	522.84342	**524**	67	23	
524	524½	526.84342	528	68	24	
528	528½	530.84342	532	69	25	
532	532½	534.84342	**536**	6A	26	UHF
536	536½	538.84342	540	6B	27	
540	540½	542.84342	544	6C	28	
544	544½	546.84342	**548**	6D	29	
548	548½	550.84342	552	6E	30	
552	552½	554.84342	556	6F	31	
556	556½	558.84342	**560**	70	32	
560	560½	562.84342	564	71	33	
564	564½	566.84342	568	72	34	
568	568½	570.84342	**572**	73	35	
572	572½	574.84342	576	74	36	
576	576½	578.84342	580	75	37	
580	580½	582.84342	**584**	76	38	
584	584½	586.84342	588	77	39	
588	588½	590.84342	592	78	40	
592	592½	594.84342	**596**	79	41	
596	596½	598.84342	600	7A	42	
600	600½	602.84342	604	7B	43	
604	604½	606.84342	**608**	7C	44	
608	608½	610.84342	**612**	7D	45	
612	612½	614.84342	616	7E	46	
616	616½	618.84342	620	7F	47	
864	864½	866.84342	868	BD	109	
868	868½	870.84342	872	BE	110	
872	872½	874.84342	876	BF	111	
876	876½	878.84342	880	C0	112	
880	880½	882.84342	884	C1	113	
884	884½	886.84342	888	C2	114	
888	888½	890.84342	892	C3		
892	892½	894.84342	896	C4		
896	896½	898.84342	900	C5		
900	900½	902.84342	904	C6		
904	904½	906.84342	908	C7		8
908	908½	910.84342	912	C8		9
912	912½	914.84342	916	C9		10
916	916½	918.84342	920	CA		33CM 11
920	920½	922.84342	924	CB		12
924	924½	926.84342	928	CC		13
928	928½	930.84342	932	CD		
932	932½	934.84342	936	CE		
936	936½	938.84342	940	CF		
940	940½	942.84342	944	D0		
944	944½	946.84342	948	D1		
948	948½	950.84342	952	D2		
952	952½	954.84342	956	D3		
956	956½	958.84342	960	D4		
960	960½	962.84342	964	D5		
964	964½	966.84342	968	D6		
968	968½	970.84342	972	D7		
972	972½	974.84342	976	D8		
976	976½	978.84342	980	D9		
980	980½	982.84342	984	DA		
984	984½	986.84342	988	DB		
988	988½	990.84342	992	DC		
992	992½	994.84342	996	DD		
996	996½	998.84342	1000	DE		
1000	1000½	1002.84342	1004	DF		
1004	1004½	1006.84342	1008	E0		
1008	1008½	1010.84342	1012	E1		
1012	1012½	1014.84342	1016	E2		
1016	1016½	1018.84342	1020	E3		
1020	1020½	1022.84342	1024	E4		
1024	1024½	1026.84342	1028	E5		
1028	1028½	1030.84342	1032	E6		
1032	1032½	1034.84342	1036	E7		
1036	1036½	1038.84342	1040	E8		
1040	1040½	1042.84342	1044	E9		
1044	1044½	1046.84342	1048	EA		
1048	1048½	1050.84342	1052	EB		
1052	1052½	1054.84342	1056	EC		
1056	1056½	1058.84342	1060	ED		
1060	1060½	1062.84342	1064	EE		
1064	1064½	1066.84342	1068	EF		
1068	1068½	1070.84342	1072	F0		
1072	1072½	1074.84342	1076	F1		
1076	1076½	1078.84342	1080	F2		
1080	1080½	1082.84342	1084	F3		
1084	1084½	1086.84342	1088	F4		
1088	1088½	1090.84342	1092	F5		
1092	1092½	1094.84342	1096	F6		
1096	1096½	1098.84342	1100	F7		
1100	1100½	1102.84342	1104	F8		
1104	1104½	1106.84342	1108	F9		
1108	1108½	1110.84342	1112	FA		
1112	1112½	1114.84342	1116	FB		
1116	1116½	1118.84342	1120	FC		
1120	1120½	1122.84342	1124	FD		
1124	1124½	1126.84342	1128	FE		
1128	1128½	1130.84342	1132	FF		

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