Harmonic Video Timing (HVT)

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“Will / should IT and CE industry standards converge?”

Ian Miller, Samsung Electronics America

The answer is:

…they already have at your video signal generator company.

Wrenching change at Quantum Data over the last three years.

- Integration of digital video and CE timings.
- Integration of OpenLDI, DVI, and HDMI interfaces.
- Switching emphasis away from IT-only to integrated IT-CE test equipment.
- A majority of our customers are in the CE or ProAV markets.
- Many of our former IT customers now make CE equipment as well.

Has prompted areas of research…

- Naming conventions
- DVI interoperability & compliance testing methods
- Timing Format Integration (HVT)

What is HVT?

HVT is an alternative method for timing design that:

- **Integrates IT and CE timings.**
- **Reduces frame rate error to zero.**
- **Optionally, supports a scheme for reducing jitter in digital video systems, whereby all the pixel clock frequencies can be generated from a very quiet single fixed-frequency master clock source followed by a programmable divider.**
- **Maintains audio coherence, by insuring that a well-behaved rational (N / M) relationship exists between video and audio clocks at all times.**

CVT vs. HVT
An Example

Method	Name	H Res Pixels	V Res Lines	Frame Rate Hz	Aspect Ratio	H Total Pixels	V Total Lines	Pixel Rate MHz
CVT	0.98M9	1280	768	49.927	10:9 “9”	1648	793	65.250
HVT “HVT”	HVT1250E	1280 “12”	768	50.000 “50”	5:3 “E”	1650	800	66.000

CVT vs. HVT (continued)

Is the timing audio friendly when the frame rate is locked?

Method	Pixel Rate MHz	Frame Rate Correction Factor	32kHz Synth Factors	44.1kHz Synth Factors	48kHz Synth Factors
CVT	65.250	163358/ 163125	40/ 81679	60/ 81679	441/ 653432
HVT	66.000	1	2/ 4125	1/ 1375	147/ 220000

Other Considerations

- **What if VTOT is a prime number?**

Timing Standards

- **History**
  - **VESA Discrete Monitor Timings (DMT)**
  - **VESA Generalized Timing Format (GTF)**
- **Today**
  - **VESA Coordinated Video Timings (CVT)**
- **Possible Future**
  - **Harmonic Video Timing (HVT)**

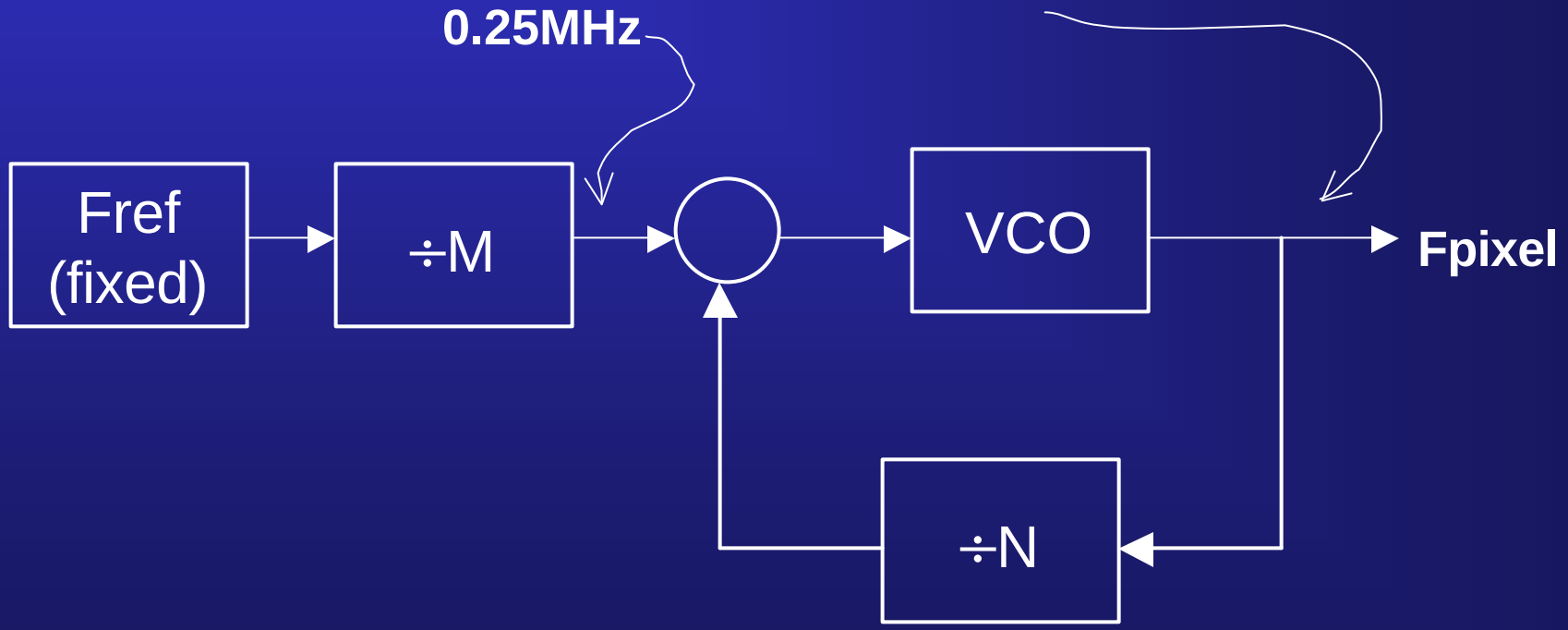
The Basis for Legacy Timings

- Narrow-scope computer industry needs
- Image fidelity
- Old display technologies
  - CRT retrace-based blanking requirements
  - Signal-based format detection (e.g polarity)
- Old host technologies
  - Character-resolution timing counters
  - Noisy wideband PLL clock synthesizers

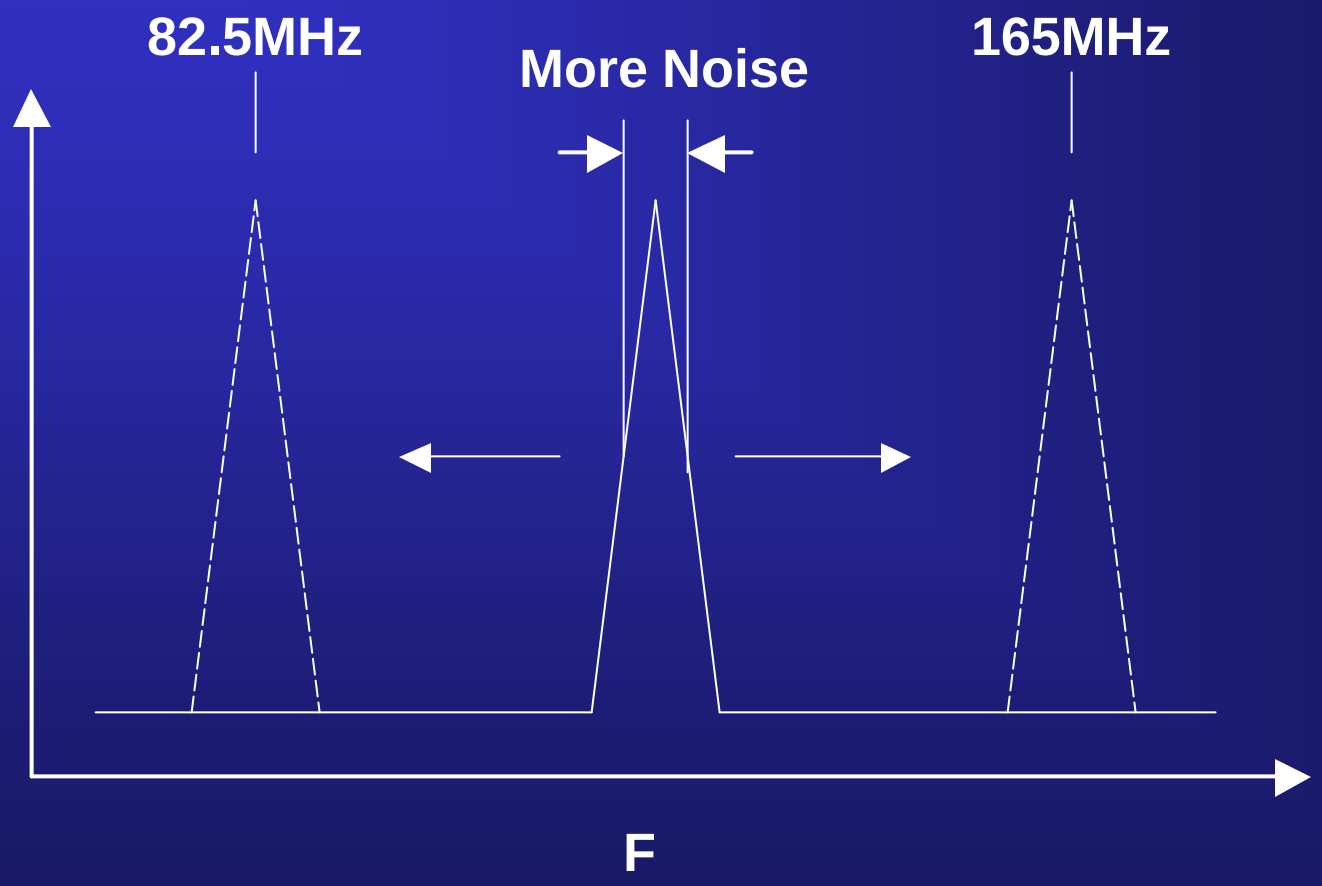
Legacy Pixel Clock Generator

Fpixel = N*(Fref/M) = 0.25MHz*N

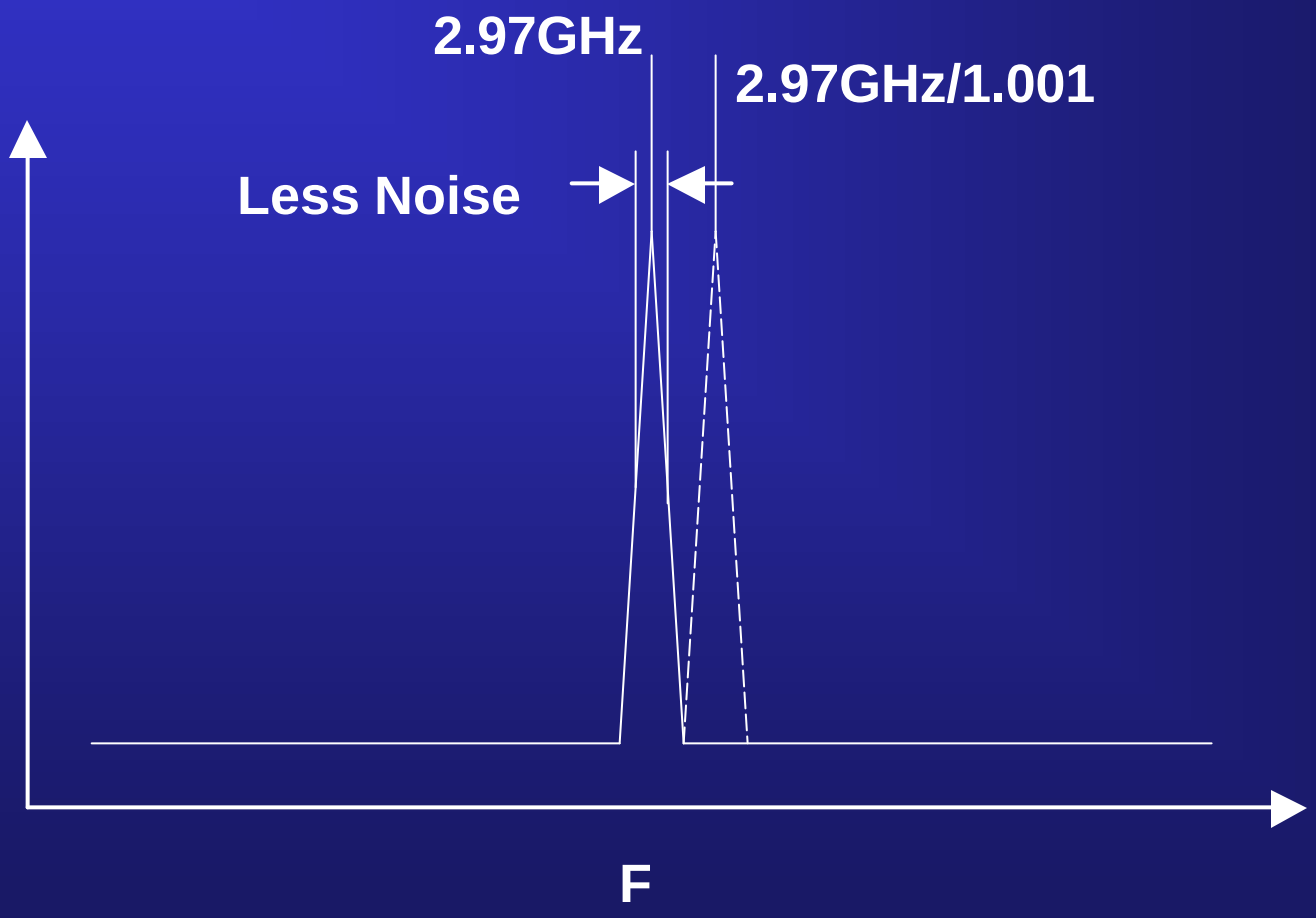
(i.e. hundreds of arbitrary pixel rates)



Wide Range == Noisy Clock



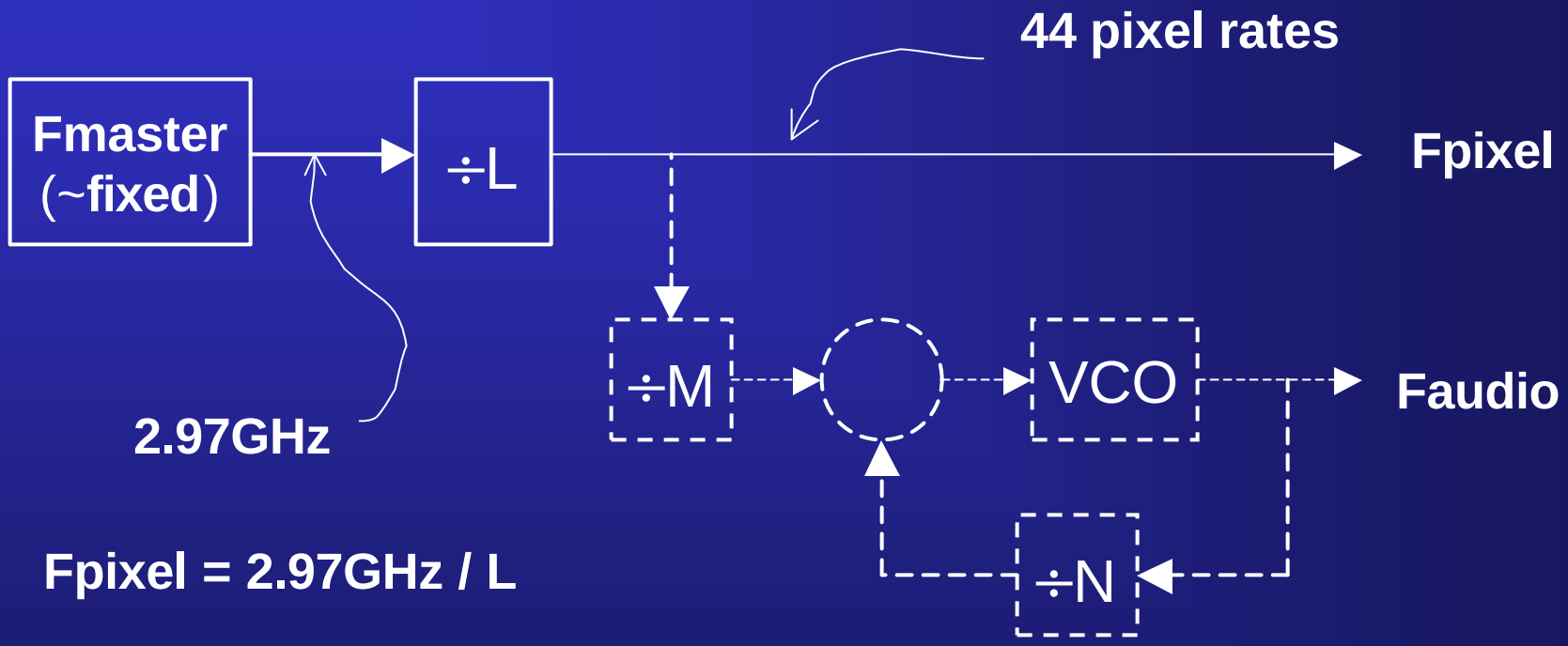
Narrow-range == Quiet Clock



A New Basis for Future Timings

- Wide-scope (IT, CE, ProAV, et al) requirements
- Video/Audio/Data Integration & Integrity
- New Display Technologies
  - Audio/Data based blanking requirements
  - Data channel based system/format discovery
- New Host Technologies
  - Pixel & sub-pixel resolution timing counters
  - Quiet telecom-like fixed rate master clocks

New Pixel Clock Generator



Fpixel = 2.97GHz / L

Faudio = Fpixel * (N / M)

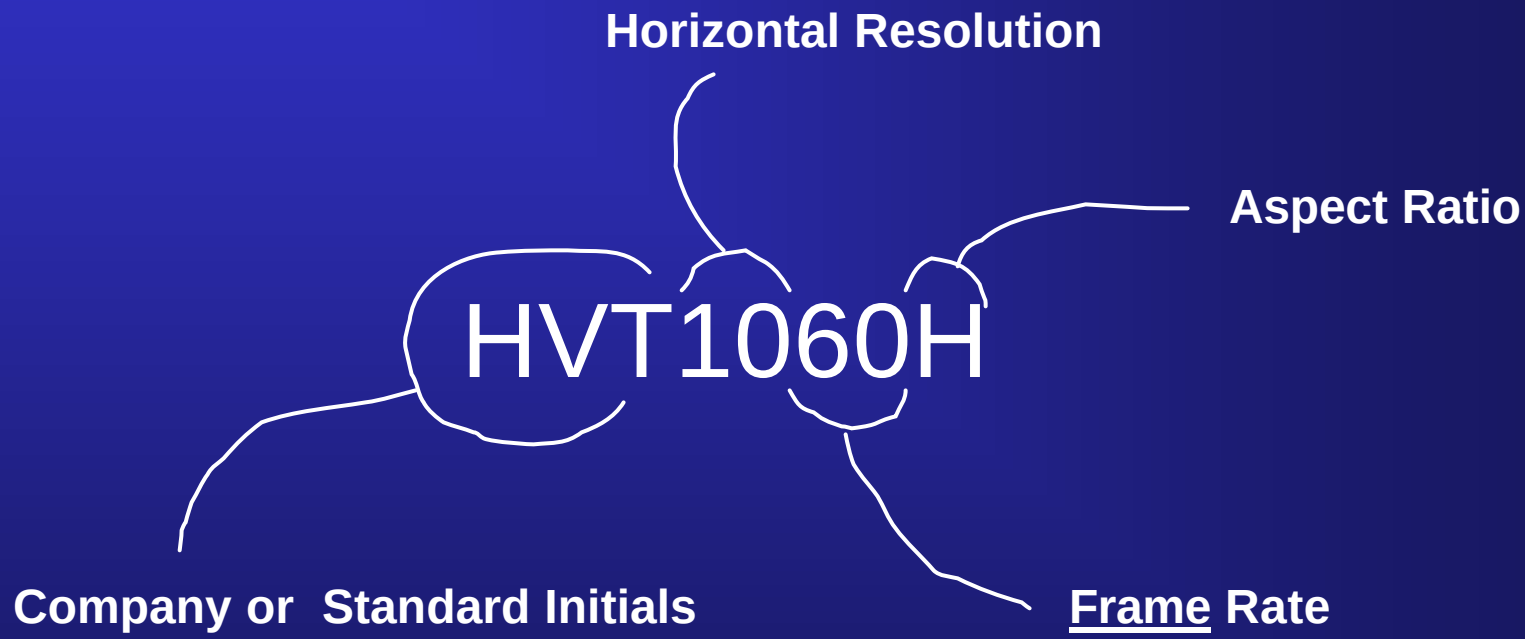
HVT modifications to CVT

Issue	CVT	HVT
Frame Rates (Hz)	**50, 60, 75, & 85 ±0.65 max**	**Exactly 24, 25, 30 48, 50, 60, 75, or 90**
Pixel Rate	**Noisy wideband PLL w/0.25MHz steps**	**Quiet fixed-rate PLL w/divide-by-N**
Htotal / Vtotal Framework	**On-the-fly calculation**	**Pre-calculated look-up table-based**
CRT blanking	**GTF defaults**	**uses GTF defaults only as target**
Reduced blanking	**Fixed 160 pixels**	**Minimal, but variable Audio/Data friendly**
Horizontal Granularity	**8-pixels**	**single pixel**

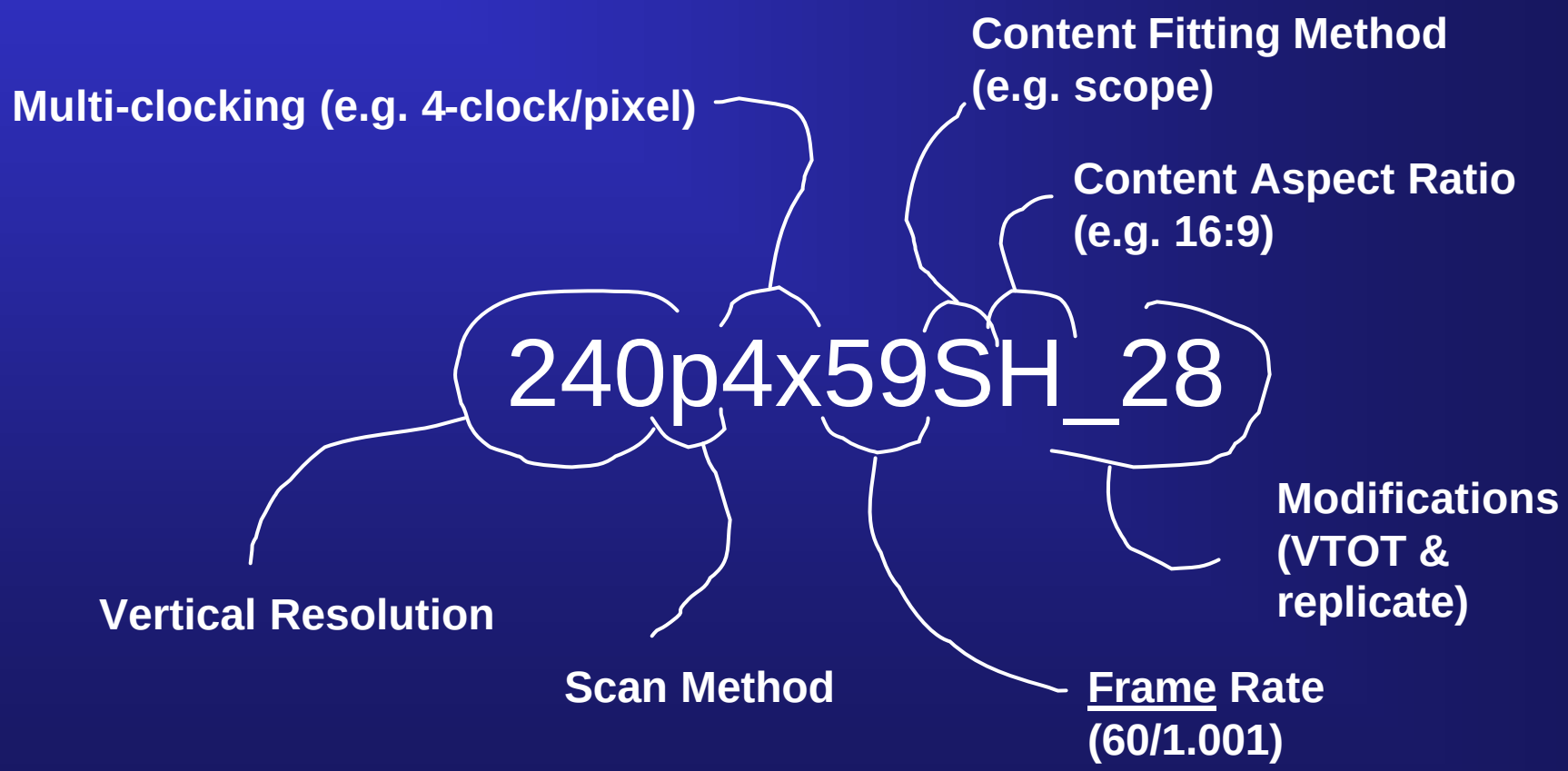
Issue	CVT	HVT
Apertures	**4:3, 16:9, & 16:10 (discourage 5:3 & 5:4)**	**12 landscape/portrait pairs**
Content Mapping	**Not Addressed**	**Letterbox, Scope, & Safe-Title**
Genlock	**Machine timing remains fixed**	**Machine timing remains fixed**
Analog Video Clock Recovery	**Depends on CVT calculated timing**	**Depends on HVT best-fit timing**
Minimum digital clock rate	**25MHz**	**24.75MHz**
Sync Polarity	**HS-/VS+ CRT HS+/VS- reduced**	**Don't care**

Issue	CVT	HVT
V Sync Width	**Communicates aspect ratio**	**Don't care**
H Sync Width	**8% of H-total**	**Don't care**
V Sync Position	**Vertical centering**	**Analog centering Digital field ID**
Naming	**Borrowed from digital photography**	**Three name spaces: 1. IT 2. CE composite 3. CE / ProAV component**

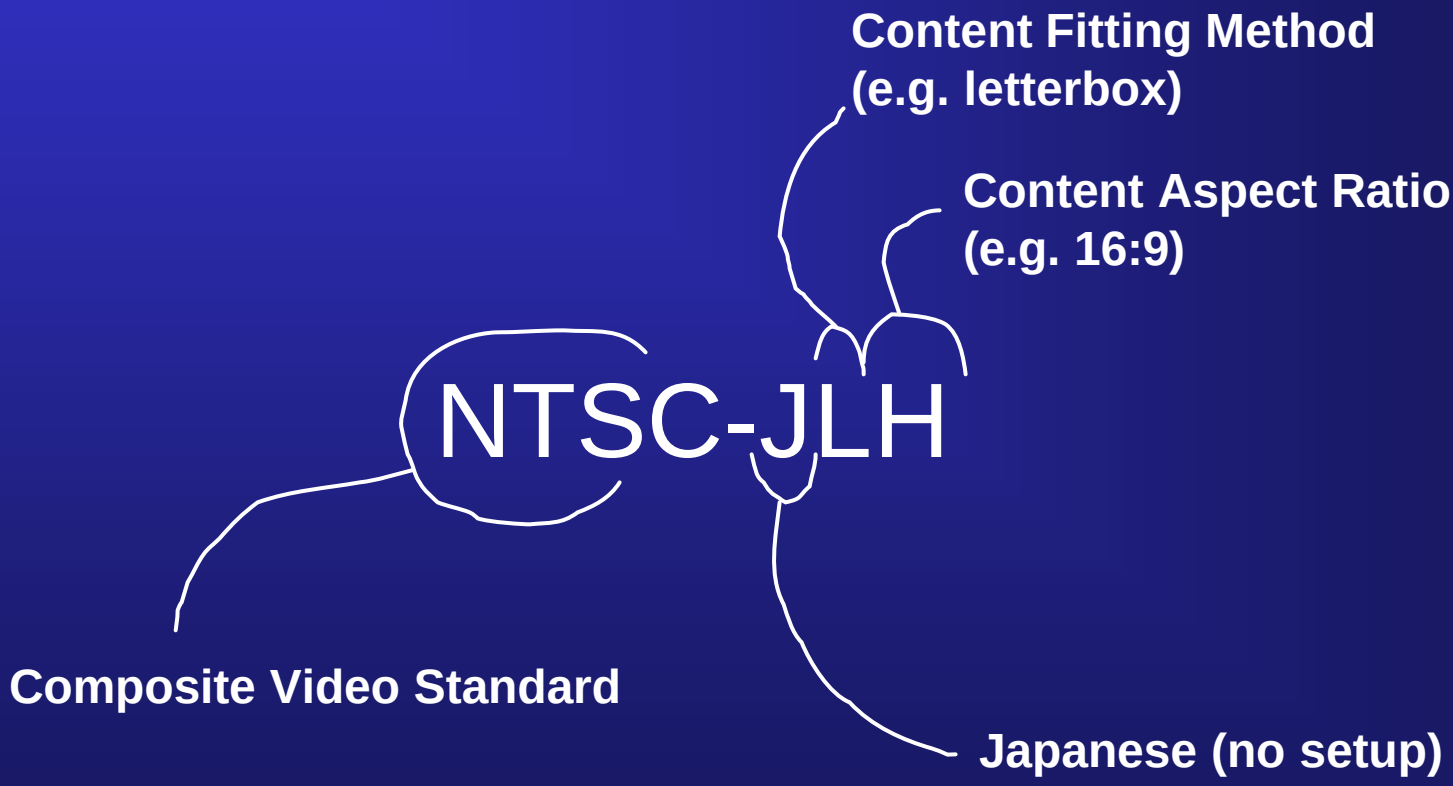
IT Timing Name Example



CE / ProAV Component Video Timing Name Example



Composite Video Timing Name Example



10-steps to HVT

1. Choose prime-based master clock frequency.
2. Create sorted (descending) list of all prime-divided rates.
3. Extract pixel rates from top of list.
4. Select frame rates from bottom of list (excluding many).
5. For each pixel rate and frame rate combination, find all HTOT*VTOT frameworks that fit and sort by frame rate.
6. Establish list of supported aspect ratios, orientations, and content mappings.
7. Establish list of supported horizontal resolutions.
8. Establish criteria for placing active into total (e.g. GTF).
9. For each aspect ratio, horizontal resolution, and frame rate combination, try placing content into every framework (one-at-a-time) and select the best fit based on optimum placement criteria of step 8.
10. Sort, encode, store results in a look-up-table, and apply.

HVT Master Clock

Borrow a concept from the television industry - use a master clock frequency that is the product of powers of a handful of small prime numbers, for example:

$$F_{master} = 2^7 * 3^3 * 5^7 * 11^1 = 2.97GHz$$

HVT Divider

Obtain candidate frequencies by dividing the master clock frequency by a variable integer divisor that is the product of powers of the master clock primes, as follows:

$$Fpixel = 2.97MHz / (2^a * 3^b * 5^c * 11^d)$$

HVT Divide Cases

- For example, by varying a, b, c, and d powers, a list of 512 candidate frequencies are obtained at 2.97GHz (i.e. 8 * 4 * 8 * 2 = 512 frequencies):

  FOR a=0 to 7
  FOR b=0 to 3
  FOR c=0 to 7
  FOR d=0 to 1
  Fcandidate = 2.97MHz / ($2^a * 3^b * 5^c * 11^d$)
- Sort candidates by frequency - descending.
- Extract pixel rates from the top of the list and desired frame rates from the bottom.

HVT Pixel Rate Set @ 2.97 GHz

24,750,000	27,000,000	27,500,000	29,700,000
30,000,000	30,937,500	33,000,000	33,750,000
37,125,000	39,600,000	41,250,000	45,000,000
46,406,250	49,500,000	54,000,000	55,000,000
59,400,000	61,875,000	66,000,000	67,500,000
74,250,000	82,500,000	90,000,000	92,812,500
99,000,000	110,000,000	118,800,000	123,750,000
135,000,000	148,500,000	165,000,000	185,625,000
198,000,000	247,500,000	270,000,000	29,7000,000
330,000,000	371,250,000	495,000,000	594,000,000
742,500,000	990,000,000	1,485,000,000	2,970,000,000

HVT Frame Rate Set

90 Hz Progressive Computer

75 Hz Progressive Computer

60 Hz Progressive TV (American, Japan, Korea, et al) & Computer

50 Hz Progressive or 100 Hz Interlaced-fields (European, et al.)

48 Hz Progressive Digital Cinema (Film Projection 2x)

30 Hz Progressive or 60 Hz Interlaced-fields TV (American, et al.)

25 Hz Progressive or 50 Hz Interlaced-fields TV

24 Hz Progressive or 48 Hz Segmented-fields Digital Cinema (Film)

HVT Aspect Ratio Set

Q = 1.00:1 Quadrate - MIL, Radiology (square, 512x512, 1024x1024)

G = 1.25:1 Graphics workstation (5x4, 1280x1024, 1600x1280)

A = 1.33:1 Academy (4x3, 640x480, 800x600, 1024x768, 1280x960, 1600x1200)

B = 1.44:1 Big (13x9, IMAX™)

T = 1.50:1 Three halves (3x2, 1152x768 Apple Computer)

V = 1.56:1 PALplus WWS case #2 (14x9, see ITU-R BT.1119)

D = 1.60:1 VESA CVT proposed (16x10, 1728x1080, 1280x800)

E = 1.67:1 European film (15x9 or 5x3, 1200x720, 1280x768, 1800x1080, a.k.a. “1.66”)

H = 1.78:1 High-definition image (16x9, 1280x720,1920x1080)

F = 1.85:1 US film (320x173, 1280x692, 1920x1038)

U = 2.00:1 Univisum™ (2x1, 1280x640, 1920x960)

C = 2.39:1 CinemaScope™ (160x67, 1280x536, 1920x804, a.k.a. “2.35”, was 2.35 before 1971)

HVT Horizontal Resolution Set

256	320	352	384	512	528	544
640	704	720	768	800	848	960
1024	1064	1152	1200	1224	1280	1360
1365	1400	1440	1536	1600	1680	1704
1728	1792	1800	1864	1920	2048	2128
2304	2456	2560	2728	3072	3200	3408
3840	4264	4608	5120			

HVT Framework Set
(of all possible total frameworks)

FrameRate	HTOT	VTOT	PixelRate
60	7920	3125	1485000000
60	8250	3000	1485000000
60	9000	2750	1485000000
75	400	825	24750000
75	440	750	24750000
75	440	900	29700000
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HVT Framework Set Construction

```
FOR each FrameRate
  FOR each PixelRate
    FOR each possible HTOT (e.g. 256 to 10000)
      FOR each possible VTOT (e.g. 256 to 10000)
        IF
          PixelRate == HTOT*VTOT*FrameRate
        THEN
          ADD Framework to Set
```

HVT Timing Set

(the best of all possible timings)

FrameRate	Aspect	HRES	HTOT	VTOT	PixelRate
60	A	800	1056	625	39600000
60	A	1024	1375	800	66000000
60	A	1280	1650	1000	99000000
75	A	640	800	550	33000000
75	A	800	1000	660	49500000
75	A	1024	1500	880	99000000
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HVT Timing Set Construction

Establish a best framework for every possible combination of FrameRate-AspectRatioOrientation-HorizontalResolution.

```
FOR each FrameRate
   FOR each AspectRatioOrientation
      FOR each HorizontalResolution
        FOR each Framework at FrameRate
          try to fit the implied active into the Framework
          grade relative to previous best
          maybe store a new best
```

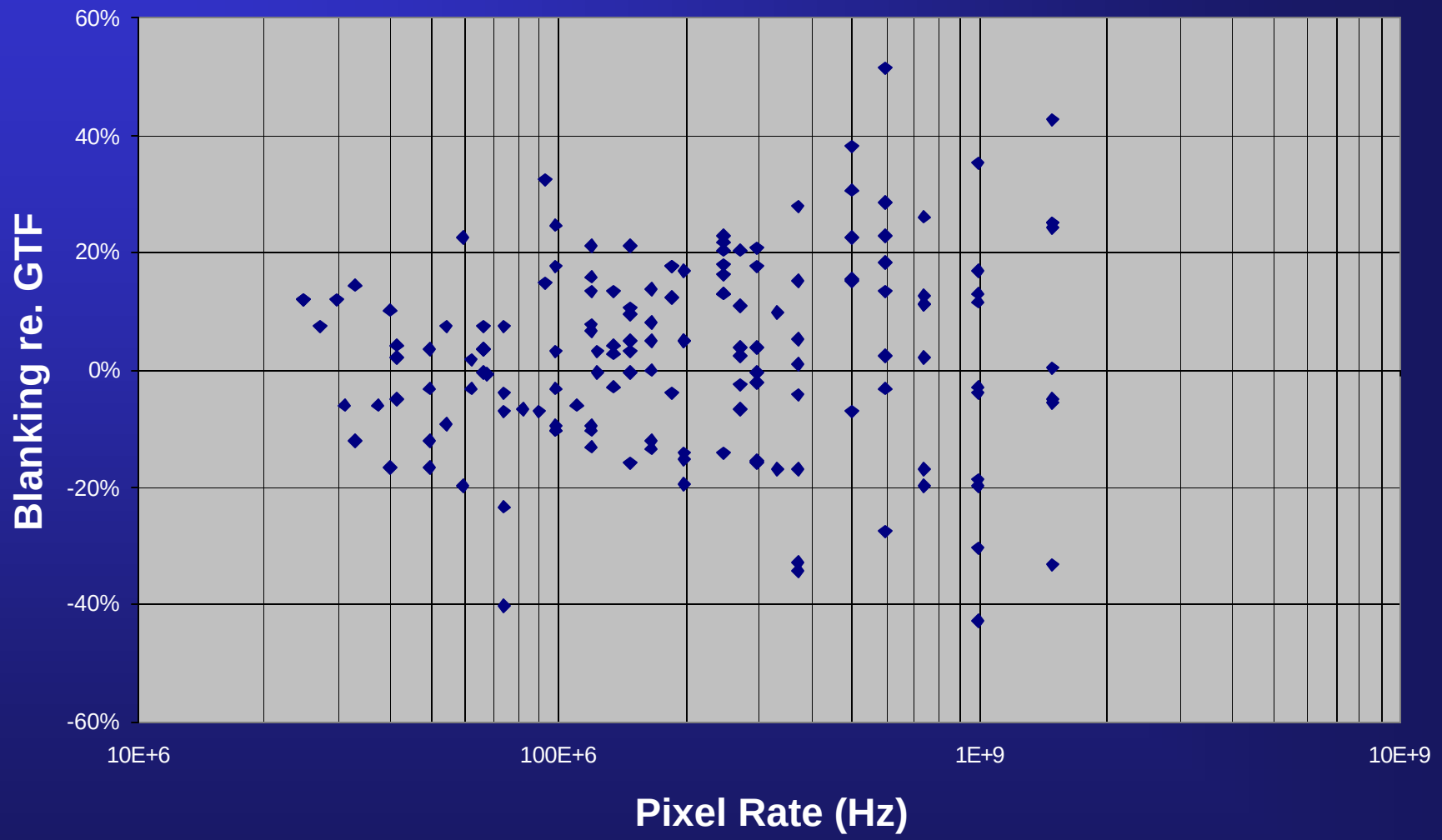
Applying the HVT Timing Set

- In the CE space, most of the timings in EIA/CEA-861-B are already harmonically related to 2.97GHz. VGA is an exception.
- In the IT space, CVT standard timings include 2 blanking schemes, 39 resolutions, and 4 frame rates for a total of 312. Most of these timings are not harmonically related to 2.97GHz, but can be replaced by nearby HVT timings.

Results from applying HVT to 156 CVT standard CRT modes:

- Most CVT timings have a nearby HVT equivalent, with blanking within 20% of GTF.
- Four exceptions are 640x480x50, 1450x1050x90, 4608x2880x90, 5120x2880x90, which have no viable HVT timing equivalents inside a +61%, -51% window relative to GTF.

HVT equivalents for CVT-CRT Timings



Summary

- Research continues into the possibility of integrating IT and CE standards.
- One possible solution is HVT.
- HVT can provide improved frame and audio lock between IT, CE, and ProAV systems.
- HVT can allow narrow-band oscillators to be used, which reduce clock noise.

Materials

Please visit www.quantumdata.com for a copy of this presentation and spreadsheets summarizing results from our investigation. These materials will be posted on our website Tuesday of next week.