EDID: Problems, Pitfalls and Complications

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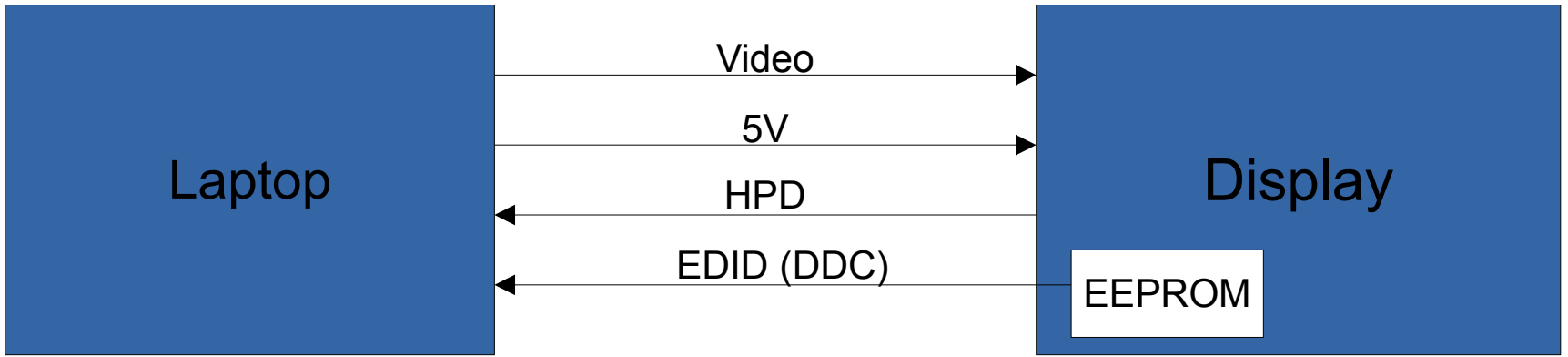
EDID: Extended Display Identification Data

- Display capability information that is typically stored in an EEPROM in the display and that is read via I^2C by the source.
- The core standard is maintained by VESA. EDID 1.0 appeared in August 1994. Originally for VGA displays, later extended to DVI, HDMI and DisplayPort.
- How EDIDs are read is defined in the VESA E-DDC standard (Enhanced Display Data Channel). Note that to store EDIDs specialized EEPROMs are needed that support the E-DDC standard.
- The current versions are EDID 1.3 (required by HDMI interfaces, but why?) and EDID 1.4 (used by DisplayPort interfaces).
- An EDID typically consists of 1 to 4 blocks of 128 bytes each. The first block (the EDID Base Block) is defined by the VESA EDID standard, and there may be up to 255 additional blocks (called Extension Blocks). Standards can define their own Extension Block variants.
- In practice the only Extension Blocks that you will see are CTA-861 (defined by the CTA organization) and DisplayID (defined by VESA).

HDMI: Signaling Between Laptop and Display



Complication: Hotplug Detect

- The Sink supplies a Hotplug Detect pin (HPD). If the HPD is high, then the Source can assume there is a valid EDID and that it can read. The HDMI specification requires these voltages for the HPD at the Source side: 0-0.8V = Low, 2-5.3V = High. Note how the range from 0.8-2V is left unspecified.
- The HPD voltage can drop by a lot when using long (> 5 meters) HDMI cables, even below 2V, so the voltage threshold for Sources has to be lower than that if you want to accommodate such cables.
- If the HPD goes low for 100 ms or more, then the Source has to re-read the EDID when it goes high again since that indicates that the EDID might have changed. Often this does not happen.
- Displays often toggle HPD when switching inputs or transitioning from On to Standby or vice versa. Pin bounce when (un)plugging can also cause problems.

Base EDID for a 5120x1440 Monitor

```
Block 0, Base EDID:
EDID Structure Version & Revision: 1.3
Vendor & Product Identification:
   Manufacturer: XXX
   Model: 1234
   Serial Number: 123456789
   Made in: week 1 of 2020
 Basic Display Parameters & Features:
   Digital display
   Maximum image size: 119 cm x 34 cm
   Gamma: 2.20
   DPMS levels: Off
   RGB color display
   First detailed timing is the
                  preferred timing
 Color Characteristics:
   Red  : 0.6777, 0.3105
   Green: 0.2734, 0.6542
   Blue : 0.1425, 0.0566
   White: 0.3125, 0.3291
```

Complication: Image size is often wrong, esp. between displays of the same series, but with different sizes. Also limited to 255 cm.

Pitfall: The Gamma + Color Characteristics are not those of the sRGB colorspace as used by PCs.

Transmitting RGB over HDMI is supposed to use this information (stated in a footnote of a large table in CTA-861), so the PC has to convert from sRGB to this colorspace.

In practice only Apple does this, everyone else ignores it and transmits sRGB. Calibrating a display from a MacBook and from a Windows/linux laptop will produce different results! It is also completely unclear what displays do with this.

CTA-861.6 adds explicit sRGB or defaultRGB signaling support, hopefully eliminating this issue in the future.

Base EDID for a 5120x1440 Monitor

```
Established Timings I & II:
  IBM     :   720x400    70.081663 Hz   9:5     31.467 kHz     28.320000 MHz
  DMT 0x04:   640x480    59.940476 Hz   4:3     31.469 kHz     25.175000 MHz
  Apple   :   640x480    66.666667 Hz   4:3     35.000 kHz     30.240000 MHz
  DMT 0x05:   640x480    72.808802 Hz   4:3     37.861 kHz     31.500000 MHz
  DMT 0x06:   640x480    75.000000 Hz   4:3     37.500 kHz     31.500000 MHz
  DMT 0x08:   800x600    56.250000 Hz   4:3     35.156 kHz     36.000000 MHz
  DMT 0x09:   800x600    60.316541 Hz   4:3     37.879 kHz     40.000000 MHz
  DMT 0x0a:   800x600    72.187572 Hz   4:3     48.077 kHz     50.000000 MHz
  DMT 0x0b:   800x600    75.000000 Hz   4:3     46.875 kHz     49.500000 MHz
  Apple   :   832x624    74.551266 Hz   4:3     49.726 kHz     57.284000 MHz
  DMT 0x10:  1024x768    60.003840 Hz   4:3     48.363 kHz     65.000000 MHz
  DMT 0x11:  1024x768    70.069359 Hz   4:3     56.476 kHz     75.000000 MHz
  DMT 0x12:  1024x768    75.028582 Hz   4:3     60.023 kHz     78.750000 MHz
  DMT 0x24:  1280x1024   75.024675 Hz   5:4     79.976 kHz    135.000000 MHz
  Apple   :  1152x870    75.061550 Hz 192:145   68.681 kHz    100.000000 MHz
```

Base EDID for a 5120x1440 Monitor

```
  Standard Timings:
    DMT 0x15:  1152x864    75.000000 Hz   4:3     67.500 kHz    108.000000 MHz
    DMT 0x1c:  1280x800    59.810326 Hz  16:10    49.702 kHz     83.500000 MHz
    DMT 0x55:  1280x720    60.000000 Hz  16:9     45.000 kHz     74.250000 MHz
    DMT 0x23:  1280x1024   60.019740 Hz   5:4     63.981 kHz    108.000000 MHz
    DMT 0x53:  1600x900    60.000000 Hz  16:9     60.000 kHz    108.000000 MHz (RB)
    DMT 0x3a:  1680x1050   59.954250 Hz  16:10    65.290 kHz    146.250000 MHz
    DMT 0x2f:  1440x900    59.887445 Hz  16:10    55.935 kHz    106.500000 MHz
    DMT 0x52:  1920x1080   60.000000 Hz  16:9     67.500 kHz    148.500000 MHz
  Detailed Timing Descriptors:
     DTD 1:  3840x1080   59.968497 Hz  32:9     66.625 kHz    266.500000 MHz (1193 mm x 336 mm)
                 Hfront   48 Hsync  32 Hback   80 Hpol P
                 Vfront    3 Vsync  10 Vback   18 Vpol N
     Display Range Limits:
       Monitor ranges (GTF): 24-120 Hz V, 30-160 kHz H, max dotclock 600 MHz
     Display Product Name: 'ABCDEF'
     Display Product Serial Number: '123456789'
   Extension blocks: 3
Checksum: 0x89
```

Extension Block 1 for a 5120x1440 Monitor

```
Block 1, Block Map Extension Block:
  Block   2: CTA-861 Extension Block
  Block   3: DisplayID Extension Block
Checksum: 0x9e
```

- Originally EDIDs were one block (128 bytes) long. Later versions allowed up to 2 blocks. Starting with EDID 1.3 up to 256 blocks could be addressed (Enhanced EDID, or E-EDID). In practice the vast majority of EDIDs is just 2 blocks, but increasingly 3 and 4 block EDIDs are seen.
- Problem: EDID 1.3 requires that for EDIDs of more than 2 blocks the second block is a Block Map Extension Block (defined by VESA), which is basically an index of the following blocks. This just wastes EEPROM space and EDID 1.4 did away with that. But HDMI is stuck on 1.3, so still needs this.
- Complication: older transmitter hardware might support only 2 blocks. Newer hardware will usually support at least 4 blocks.
- Pitfall: to work around this HDMI 2.1 (Amendment A1), added an HDMI Forum EDID Extension Override Data Block for use with the CTA-861 Extension Block to override the number of Extension Blocks as reported in the first EDID block. So if the base block reports 1 Extension Block, and that CTA-861 Extension Block contains this HDMI Data Block, then the real number of Extension Blocks is equal to what is reported here. Thus bypassing the need for the Block Map.

Extension Block 2 for a 5120x1440 Monitor

```
Block 2, CTA-861 Extension Block:
  Revision: 3
  Underscans IT Video Formats by default
  Basic audio support
  Supports YCbCr 4:4:4
  Supports YCbCr 4:2:2
  Native detailed modes: 1
  Video Data Block:
    VIC  16:  1920x1080   60.000000 Hz  16:9     67.500 kHz    148.500000 MHz (native)
    VIC  97:  3840x2160   60.000000 Hz  16:9    135.000 kHz    594.000000 MHz
    VIC  96:  3840x2160   50.000000 Hz  16:9    112.500 kHz    594.000000 MHz
    VIC  31:  1920x1080   50.000000 Hz  16:9     56.250 kHz    148.500000 MHz
    VIC   4:  1280x720    60.000000 Hz  16:9     45.000 kHz     74.250000 MHz
    VIC  19:  1280x720    50.000000 Hz  16:9     37.500 kHz     74.250000 MHz
    VIC  18:   720x576    50.000000 Hz  16:9     31.250 kHz     27.000000 MHz
    VIC   3:   720x480    59.940060 Hz  16:9     31.469 kHz     27.000000 MHz
    VIC  90:  2560x1080   60.000000 Hz  64:27    66.000 kHz    198.000000 MHz
    VIC  93:  3840x2160   24.000000 Hz  16:9     54.000 kHz    297.000000 MHz
    VIC  94:  3840x2160   25.000000 Hz  16:9     56.250 kHz    297.000000 MHz
    VIC  95:  3840x2160   30.000000 Hz  16:9     67.500 kHz    297.000000 MHz
```

Extension Block 2 for a 5120x1440 Monitor

```
Audio Data Block:
  Linear PCM:
    Max channels: 2
    Supported sample rates (kHz): 48 44.1 32
    Supported sample sizes (bits): 24 20 16
Speaker Allocation Data Block:
  FL/FR - Front Left/Right
Colorimetry Data Block:
  BT2020YCC
  BT2020RGB
Video Capability Data Block:
  YCbCr quantization: No Data
  RGB quantization: Selectable (via AVI Q)
  PT scan behavior: No Data
  IT scan behavior: Supports both over- and underscan
  CE scan behavior: Supports both over- and underscan
```

Problem: RGB Quantization Range

- Full Range: red, green and blue are encoded with values 0-255: 0=off, 255=full brightness.
- Limited Range: values are 16-235: 16=off, 235=full brightness.
- Consumer Electronics equipment traditionally defaults to Limited Range for RGB, and IT equipment to Full Range. That was fine, until the two worlds collided...
- According to CTA-861 by default the CE video timings (720p, 1080p, 4k) should use Limited Range, and IT video timings (1920x1200, 4096x2160) should use Full Range.
- The chances of both Source and Sink doing the Right Thing are 50/50 at best. And that goes down even more when you add DP-to-HDMI (or vice versa) adapters into the mix. PC monitors behave differently from TVs, and different graphics drivers make different choices, and that can even depend on the OS.
- Since CTA-861-H Sinks are required to set Selectable RGB Quantization Range to 1, allowing Sources to explicitly signal what they are using.
- If you design a Sink, then please set this bit to 1. If you are a Source, please check for this and explicitly signal the RGB Quantization Range; or even better: always signal the RGB Quantization Range regardless.

Extension Block 2 for a 5120x1440 Monitor

```
Vendor-Specific Data Block (HDMI), OUI 00-0C-03:
  Source physical address: 1.0.0.0
  Supports_AI
  DC_36bit
  DC_30bit
  DC_Y444
  Maximum TMDS clock: 300 MHz
  Extended HDMI video details:
    HDMI VICs:
      HDMI VIC 1:  3840x2160   30.000000 Hz  16:9     67.500 kHz    297.000000 MHz
      HDMI VIC 2:  3840x2160   25.000000 Hz  16:9     56.250 kHz    297.000000 MHz
      HDMI VIC 3:  3840x2160   24.000000 Hz  16:9     54.000 kHz    297.000000 MHz
Vendor-Specific Data Block (HDMI Forum), OUI C4-5D-D8:
  Version: 1
  Maximum TMDS Character Rate: 600 MHz
  SCDC Present
  Supports 12-bits/component Deep Color 4:2:0 Pixel Encoding
  Supports 10-bits/component Deep Color 4:2:0 Pixel Encoding
```

Problem: HDMI VICs

- When HDMI 1.4 introduced 4k support, there were no CTA-861 VIC codes for that, so they rolled their own: HDMI VICs.
- The HDMI Specification never specified the default RGB Quantization Range for these HDMI VICs, so implementers did not know what to do: limited or full range?
- Later CTA-861 added ‘proper’ VICs for these timings.
- And later still the HDMI Spec clarified that the HDMI VICs can be considered equivalent to the CTA-861 VICs and that both can be used. Thus the answer to the default RGB Quantization Range question is: Limited Range.

Pitfall: HDMI VSDBs

- The presence of HDMI Vendor-Specific Data Blocks in the CTA-861 Extension Block indicates an HDMI interface, as opposed to an e.g. DisplayPort interface.
- Except if there is a DP/USB-C to HDMI adapter in between: the adapter may or may not remove these Data Blocks. And an HDMI to DP/USB-C adapter may or may not add these Data Blocks to the EDID it exposes.
- What interface adapters are supposed to do with EDIDs is poorly defined, if at all.

Extension Block 2 for a 5120x1440 Monitor

```
  YCbCr 4:2:0 Capability Map Data Block:
    VIC  97:  3840x2160   60.000000 Hz  16:9    135.000 kHz    594.000000 MHz
    VIC  96:  3840x2160   50.000000 Hz  16:9    112.500 kHz    594.000000 MHz
  HDR Static Metadata Data Block:
    Electro optical transfer functions:
      Traditional gamma - SDR luminance range
      SMPTE ST2084
    Supported static metadata descriptors:
      Static metadata type 1
  Detailed Timing Descriptors:
    DTD 2:  2560x1440   59.950550 Hz  16:9     88.787 kHz    241.500000 MHz (1193 mm x 336 mm)
                Hfront   48 Hsync  32 Hback   80 Hpol P
                Vfront    3 Vsync   5 Vback   33 Vpol N
    DTD 3:  2560x1080   60.000000 Hz  64:27    66.000 kHz    198.000000 MHz (1193 mm x 336 mm)
                Hfront  248 Hsync  44 Hback  148 Hpol P
                Vfront    4 Vsync   5 Vback   11 Vpol P
Checksum: 0x7f
```

Extension Block 3 for a 5120x1440 Monitor

```
Block 3, DisplayID Extension Block:
  Version: 1.2
  Extension Count: 0
  Display Product Type: Extension Section
  Video Timing Modes Type 1 - Detailed Timings Data Block:
    DTD:  5120x1440   59.976879 Hz   0:0     88.826 kHz    469.000000 MHz (aspect undefined, no
3D stereo, preferred)
               Hfront   48 Hsync  32 Hback   80 Hpol P
               Vfront    3 Vsync  10 Vback   28 Vpol N
    DTD:  5120x1440   29.977651 Hz   0:0     43.797 kHz    231.250000 MHz (aspect undefined, no
3D stereo)
               Hfront   48 Hsync  32 Hback   80 Hpol P
               Vfront    3 Vsync  10 Vback    8 Vpol N
  Checksum: 0x89
Checksum: 0x90
```

Problems: CTA-861 + DisplayID Blocks

- Traditionally HDMI interfaces use the EDID 1.3 Block + a CTA-861 Extension Block. And DisplayPort interfaces use the EDID 1.4 Block + VESA DisplayID Extension Block.
- Some EDIDs have both. One reason (common for 5120x1440 displays) is that CTA-861 couldn't represent such resolutions until support for that was added in CTA-861-H (December 2020). And reporting such a resolution as a native resolution only became available in CTA-861.6 (February 2022). DisplayID could always do this, so both Extension Blocks are sometimes reported.
- Even for DisplayPort interfaces CTA-861 is often used in addition to DisplayID to 1) share most of the EDID with another HDMI port, and/or 2) since CTA-861 makes it easy to report commonly used resolutions (1080p, 4k, etc.).
- There are no rules which of the two Extension Blocks would have priority in case of conflicting information, there is no coordination between the two standards bodies in this respect.
- You end up with awful heuristics in your code, trying to support this mess.

EDID Parser/Checker: edid-decode

- Creating EDIDs is a painful process: the standards can be hard to read, there is a lot of information and it is hard to know that all corner cases were caught.
- The edid-decode utility (dating back to 2006!) helps with this: it parses an EDID into human readable text.
- Originally maintained by Adam Jackson, it had become outdated by 2017. Since 2018 I have been maintaining it and added support for the latest features and also worked on improving the conformity checks.
- I also provide access to this via a webpage: https://hverkuil.home.xs4all.nl/edid-decode/edid-decode.html

EDID Parser/Checker: edid-decode

- Useful options:

```
-c, --check Check if the EDID conforms to the standards, failures and warnings are reported at the end.
-n, --native-resolution Report the native resolution.
-p, --preferred-timings Report the preferred timings.
```

- Timing options:

```
--std <byte1>,<byte2> Show the standard timing represented by these two bytes.
--dmt <dmt>           Show the timings for the DMT with the given DMT ID.
--vic <vic>           Show the timings for this VIC.
--hdmi-vic <hdmivic>  Show the timings for this HDMI VIC.
--cvt w=<width>,h=<height>,fps=<fps>[,rb=<rb>][,interlaced][,overscan][,alt]
      [,hblank=<hblank>][,vblank=<vblank>][,early-vsync]
                      Calculate the CVT timings for the given format.
--gtf w=<width>,h=<height>[,fps=<fps>][,horfreq=<horfreq>][,pixclk=<pixclk>][,interlaced]
      [,overscan][,secondary][,C=<c>][,M=<m>][,K=<k>][,J=<j>]
                      Calculate the GTF timings for the given format.
--ovt (rid=<rid>|w=<width>,h=<height>),fps=<fps>
                      Calculate the OVT timings for the given format.
--list-established-timings List all known Established Timings.
--list-dmts           List all known DMTs.
--list-vics           List all known VICs.
--list-hdmi-vics      List all known HDMI VICs.
--list-rids           List all known RIDs.
--list-rid-timings <rid> List all timings for RID <rid> or all known RIDs if <rid> is 0.
```

Preferred timings for a 5120x1440 Monitor

```
Preferred Video Timing if only Block 0 is parsed:
  DTD   1:  3840x1080   59.968497 Hz  32:9     66.625 kHz    266.500000 MHz (1193 mm x 336 mm)
                Hfront   48 Hsync  32 Hback   80 Hpol P
                Vfront    3 Vsync  10 Vback   18 Vpol N

Preferred Video Timings if Block 0 and CTA-861 Blocks are parsed:
  DTD   1:  3840x1080   59.968497 Hz  32:9     66.625 kHz    266.500000 MHz (1193 mm x 336 mm)
                Hfront   48 Hsync  32 Hback   80 Hpol P
                Vfront    3 Vsync  10 Vback   18 Vpol N
  VIC  16:  1920x1080   60.000000 Hz  16:9     67.500 kHz    148.500000 MHz (native)
                Hfront   88 Hsync  44 Hback  148 Hpol P
                Vfront    4 Vsync   5 Vback   36 Vpol P

Preferred Video Timing if Block 0 and DisplayID Blocks are parsed:
  DTD:  5120x1440   59.976879 Hz   0:0     88.826 kHz    469.000000 MHz (preferred)
              Hfront   48 Hsync  32 Hback   80 Hpol P
              Vfront    3 Vsync  10 Vback   28 Vpol N
```

Native resolutions for a 5120x1440 Monitor

```
Native Video Resolution if only Block 0 is parsed:
  3840x1080

Native Video Resolutions if Block 0 and CTA-861 Blocks are parsed:
  1920x1080
  3840x1080
```

VFPDB & NVRDB from test/cta-timings.test

```
DisplayID Type VII Video Timing Data Block:
  VTDB 1:  5120x2160   60.000000 Hz   1:1    133.320 kHz    693.264000 MHz (aspect 1:1)
DisplayID Type VIII Video Timing Data Block:
  DMT 0x48:  1920x1200  119.908612 Hz  16:10   152.404 kHz    317.000000 MHz (RB)
DisplayID Type X Video Timing Data Block:
  VTDB 2:  5120x1440   50.001305 Hz  32:9     73.702 kHz   383.250000 MHz (RBv3, aspect 32:9)
Video Format Data Block:
  RID 7@30p:  3840x1080   30.000000 Hz  32:9     33.000 kHz    134.112000 MHz
  RID 7@60p:  3840x1080   60.000000 Hz  32:9     67.200 kHz    268.800000 MHz
Video Format Preference Data Block:
  VTDB   1
  VIC  97:  3840x2160   60.000000 Hz  16:9    135.000 kHz    594.000000 MHz
  VIC 114:  3840x2160   48.000000 Hz  16:9    108.000 kHz    594.000000 MHz
  DTD   1
  DTD   3
  DMT 0x48
  VTDB   2
  RID 7@60p
Native Video Resolution Data Block:
  VTDB   1
```

test/cta-timings.test: edid-decode -p -n

```
Preferred Video Timing if only Block 0 is parsed:
  DTD   1:  3840x2160   60.000000 Hz  16:9    135.000 kHz    594.000000 MHz
Preferred Video Timings if Block 0 and CTA-861 Blocks are parsed:
  DTD   1:  3840x2160   60.000000 Hz  16:9    135.000 kHz    594.000000 MHz
  VIC  97:  3840x2160   60.000000 Hz  16:9    135.000 kHz    594.000000 MHz
Preferred Video Timings if Block 0 and CTA-861 Blocks are parsed with VFPDB support:
  VTDB   1:  5120x2160   60.000000 Hz   1:1    133.320 kHz    693.264000 MHz (>=CTA-861-H)
  VIC  97:  3840x2160   60.000000 Hz  16:9    135.000 kHz    594.000000 MHz
  VIC 114:  3840x2160   48.000000 Hz  16:9    108.000 kHz    594.000000 MHz
  DTD   1:  3840x2160   60.000000 Hz  16:9    135.000 kHz    594.000000 MHz
  DTD   3:  1280x720    59.855126 Hz  16:9     44.772 kHz     74.500000 MHz
  DMT 0x48:  1920x1200  119.908612 Hz  16:10   152.404 kHz    317.000000 MHz (RB, >=CTA-861-H)
  VTDB   2:  5120x1440   50.001305 Hz  32:9     73.702 kHz   383.250000 MHz (RBv3, >=CTA-861-H)
  RID 7@60p:  3840x1080   60.000000 Hz  32:9     67.200 kHz    268.800000 MHz (>=CTA-861.6)

Native Video Resolution if only Block 0 is parsed:
  3840x2160
Native Video Resolution if Block 0 and CTA-861 Blocks are parsed:
  3840x2160
Native Video Resolution if Block 0 and CTA-861 Blocks are parsed with NVRDB support:
  5120x2160
```

Resources

- edid-decode git repository: https://git.linuxtv.org/edid-decode.git
- EDID, E-DDC and DisplayID standards are freely available from https://vesa.org/vesa-standards
- CTA-861 standards are freely available from https://www.cta.tech/Resources/Standards
- email: hverkuil@xs4all.nl

Questions?