Compatibility of PC & CE Displays White Paper

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VESA Compatibility of PC & CE Displays White Paper
July 9, 2005

Purpose

This white paper makes recommendations for changes in standards and industry practices to improve compatibility between displays used in the "PC" (or "IT") market and those of the television or "CE" market. It is the intention of this document to focus the IT and CE industries toward true “Plug & Play” of compatible displays in both areas. It also intended to support ease of use concepts as they apply to the average end user.

Note

This white paper is intended to be generic in nature. There are no implied or stated references to any specific manufactured software, hardware or operating system product (past, present or future) contained in this document. However, there are references to specific products needed to support compatibility.

Preface

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Revision History

July 9, 2005 Initial release of the white paper

Acknowledgments

This standard would not have been possible without the efforts of the VESA Display Systems Standards Committee. In particular, the following individuals and their companies contributed significant time and knowledge to this edition.

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Syed Athar Hussain	ATI Technologies, Inc.
Chi Tai Hong	Chrontel, Inc.
Joe Goodart	Dell
Jim Webb	Genesis Microchip
Bob Myers	Hewlett-Packard Company
Susan Luerich	IBM Corporation
Eric Wogsberg	Jupiter Systems
Isaac Yang	NVIDIA Corporation
Jim Carrington	Portrait Displays, Inc.
George Wiley	Qualcomm, Inc.
Ian Miller	Samsung Information Systems
Alain d'Hautecourt	ViewSonic Corporation

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1. Reference Documents

Note: Versions identified here are current at the release date of this document, but readers of this document are advised to ensure they have the latest versions of referenced standards and documents.

- Digital Display Working Group (DDWG) - Digital Visual Interface (DVI) Specifications, Version 1.0, April 2, 1999 – (information available at www.ddwg.org)
- Digital Content Protection, LLC - High-bandwidth Digital Content Protection (HDCP) System, Revision 1.0, February 17, 2000 -
- EIA/CEA-861-B, "A DTV Profile for Uncompressed High Speed Digital Interfaces", May 2002
- CEA CEB-14, "EDID Recommended Practice for EIA/CEA-861", December 2002
- HDMI – High-Definition Multimedia Interface (HDMI) Specifications, Version 1.0 – (information available at www.hdmi.org)
- Microsoft Windows and the Plug and Play Framework Architecture, March 1994
- Microsoft Plug and Play for Windows 2000 and Windows XP, December 2001
- Microsoft Windows XP – Plug and Play Overview,
- Microsoft Plug and Play Technology, December 2001
- VESA and Industry Standards and Guidelines for Computer Display Monitor Timing (DMT™), Version 1.0, Revision 10, August 21, 2003
- VESA Display Information Extension Block (DI-EXT™) Standard, Release A, August 21, 2001
- VESA Enhanced Display Data Channel (E-DDC™) Standard, Version 1, September 2, 1999
- VESA Enhanced Extended Display Identification Data (E-EDID™) Standard, Rel. A, Rev. 1, Feb. 9, 2000
- VESA - Enhanced Extended Display Identification Data (E-EDID™) – Implementation Guide, Version 1.0, June 4, 2001
- VESA - Coordinated Video Timing (CVT™) Standard, Version 1.1, September 10, 2003
- VESA - Display Data Channel, Command Interface (DDC/CI™) Standard, Version 1, August 14, 1998

2. Purpose and Scope

This white paper defines guidelines that support the compatibility of display products as used in a “Plug & Play” (PnP) environment for both personal computer (PC) and consumer electronics/television (CE) applications. It is the intention of this document to focus the PC and CE industries toward true Plug & Play in all display products.

The following statement is the definition of Plug & Play, per the existing VESA Plug & Play Standard (PnP). Please refer to that document for a further definition of the terms used: *An optimal image (using a video timing/format that is defined in base EDID {or timing extension block} or end user selected image setting) is displayed on the screen after the end user has connected (via a video cable or a wireless interface) and has powered up (in either order) the monitor/display and the host system*. Plug & Play is an important consideration when designing and manufacturing video/graphics subsystems.

2.1 Interfaces Considered and Definitions

2.1.1 Video Interface Types Discussed

There are many types of video or display interfaces in common use today. These include but are not limited to the following:

1. RF connections (i.e., the above video types carried on an RF carrier, for input to a TV tuner or similar device).
2. Composite video (baseband NTSC-, PAL-, or SECAM-encoded color video, or simply monochrome video with composite syncs, as carried via (typically) an RCA plug, BNC, etc.,)
3. S-Video (separate Y/C analog signals supplied via a standard DIN connector)
4. Component Video (e.g., YPbPr; often connected via BNC or similar connectors)
5. SCART (a European connector standard providing a mix of stereo audio, composite video, separate Y/C, RGB, and some control signals)
6. The "D connectors" (JEITA CP-4120, and specifically the “D5” connector defined therein), carrying component video, commonly used in HDTV products (originally for the Japanese market).
7. Analog RGB plus separate HV/C syncs (VGA, 13W3)
8. DVI (Digital Visual Interface) - a connector specification providing digital and/or analog video on a unique connector.
9. HDMI (High-Definition Multimedia Interface) - a digital-only display interface, now coming into widespread use in many digital TV products.

The first 5 listed here (composite video, RF, S-Video, component video and SCART) do not include support for the VESA DDC (Display Data Channel) communications protocol and therefore are not capable of reading EDID (Extended Display Identification Data). These video interfaces cannot support Plug & Play, and so will not be considered here. (For more information on Plug & Play, refer to section 1.2 - Reference Documents.)

Three of the video interfaces (VGA or 13W3, DVI, & HDMI) support the VESA DDC (Display Data Channel) communications protocol and are capable of reading EDID (Extended Display Identification Data). These interfaces already support Plug & Play. These, as well as any other interface specifications either current or in the future which support this mode of operation, are the subject of this white paper.

3. Introduction

As both the consumer entertainment electronics and personal computer industries move to digital display interface standards, incompatibilities between standards and common practices within these two markets are becoming a serious problem. A major contributing factor to this growing problem is the use of similar (and in some cases identical) digital interfaces used in both markets. Examples include the DVI and HDMI specifications, both of which are based on a common electrical interface definition and which are showing up more and more in both entertainment and PC systems. There is a growing likelihood of consumers having products of both types in their homes, and the apparent compatibility (as indicated by similar or identical physical interfaces) naturally leads the consumer to believe that such products will interoperate. However, due to the current incompatibilities between PC and CE industry standards (generally as defined by the Video Electronics Standards Association and the Consumer Electronics Association, respectively, and specifically the differences in the use of the EDID extensions as defined by these two bodies, as in CEA-861-B and the VESA DI-EXT standard) and typical industry practices, a consumer attempting to connect CE and PC products will very often find that they do not work well together as expected. The fact that manufacturers of these products, in many cases, clearly state that they are not *intended* to interoperate is irrelevant; the perception of a compatible interface leads to the expectation of interoperability, and ultimately to a dissatisfied customer.

The situation is today being further complicated by the increasing presence of so-called convergence products in the consumer market. Digital television and the home personal computer are evolving independently and may be on a collision course; this is not at all unexpected, as the home user today expects to be able to use his or her PC to manage "entertainment" material, including both commercially-produced and consumer-produced content. These include digital music, video, still images, etc. Coming from the other side, many consumers are also today using their televisions as the display device for web access services (e.g., WebTV), most often in conjunction with the normal use of these products for the display of television programming. The lines between the personal computer system and the audio/video entertainment system in the home are blurring, a trend that can only be expected to continue. Further, and especially as both markets move away from CRT-based displays (and their inherent brightness/resolution tradeoff) and toward fixed-format technologies such as the LCD and PDP, the distinction between TV and PC displays is blurring as well. It is very reasonable to expect that in the near future, the only significant difference between the display device primarily used for entertainment viewing in the home, and that display used primarily for PC applications, will be one of size and typical viewing distance. The two will very likely share a common interface, similar native pixel formats, colorimetry, and other characteristics and capabilities. Even the usage of these two displays will not be completely dissimilar - it will not be unreasonable that the larger entertainment display in the home will occasionally be used for computer applications, or that entertainment content will occasionally be shown via the smaller, desktop display. This will continue to blur the distinction between computer and television products, especially displays, in the mind of the consumer, and makes addressing today's compatibility problems even more urgent.

We should also note at this point that while the above discussion has focused on the current situation in the consumer market, and so on consumer entertainment (television) products and personal computers (PCs), much if not all of what will be said here applies not only to personal computers specifically, but in reality throughout the information technology, or IT, industry. Due to the dominance of personal computer products within the overall IT industry, we are today faced with the situation of PC standards almost always being adopted for all IT products - no matter how far removed from personal or consumer markets these may be. While there is less of a concern regarding, for example, a customer potentially trying to connect a high-end engineering workstation display to a consumer video recorder's output (due in part to the expected higher degree of sophistication in the case of the workstation user), the possibility does exist. However, there is also no reason to expect that the needs of these non-PC products, in the areas to be discussed here, will be significantly different from those of the standard PC, and so it should be possible to devise solutions to the PC vs. CE compatibility problems which will also be usable within the broader IT industry. We will, therefore, use the terms PC and IT somewhat interchangeably within this paper; PC is the more common term, and tends to be used whenever one is speaking of computer products, and so it will likely dominate. It should be understood, though, that the methods, practices, and standards to be discussed within this document will be created with an eye toward usage across the IT industry.

It is the purpose of this white paper, then, to describe the technical details which cause the current incompatibility situations, and to recommend practices (and in some cases, revisions to existing standards) to address these.

4. Similarities and Differences Between Current CE and PC products

Traditionally, and especially in the past when both television and computer displays were almost always CRT-based, the primary difference between the two (ignoring distinctions which are not related to the display proper) has been that the PC display was typically capable of operating with input video of any timing within its acceptable range - which was often from approximately a 30 kHz horizontal rate up to 64 kHz, 85 kHz, or even higher - and in general, exclusively progressive-scan. In contrast, television products (within a given market region, such as North America) were built to operate only at a single timing, appropriate to the broadcast standards of that region, and further commonly employed an interlaced scanning format. Secondary differences between the two products include the common use in TV products of "overscan" (i.e., the active area of the raster extending beyond the visible limits of the CRT screen), and lower resolution (larger spot sizes) but much higher typical luminance levels in the case of the television display as compared with the PC monitor.

These differences led to distinctly different approaches in interface standards within the two industries. As television products all used a single, common timing, and in general shared other common operating characteristics, there was little need for the video source to be able to distinguish the display's capabilities or preferred operating mode. (In fact, in the traditional television product, the display and its video source were contained within a single physical product and electrical design - only rarely in consumer television was the separate "source" and "monitor" model encountered. Instead, the display device – the CRT and its driving circuits – were contained within the same product as the “video source” – the tuner – and the characteristics of the former were already accommodated in the design and set-up of the latter.) In contrast, the personal computer developed along the model of the display device (the monitor) being physically separate, and very often purchased separately and from a different manufacturer, from the video source which drove it (the PC itself). This, along with the wide range of possible monitor capabilities available, led the PC industry to develop methods through which the host PC could determine the capabilities of the monitor attached to it (e.g., through accessing the EDID information via the VESA Display Data Channel), and to automatically configure itself appropriately.

Recently, the advent of digital television has led to a more "PC-like" operating model for the television market. Several different image formats and video timings may be used under today's digital television broadcast standards, and television displays have been produced which use various of these as their preferred operating mode. For instance, standard-definition products, using the traditional 525-line, 60 Hz interlaced video timing, now co-exist with high-definition products built for the 1280 x 720 or 1920 x 1080 broadcast formats, or the widescreen 848 x 480 pixel format seen in some TV displays, within the North American market. Europe and other regions face similar situations. This has led to a need within the television market for a means whereby the video source can determine the preferred operating mode of its current display device, just as is done in the standard PC practice. Fortunately, the CE industry has adopted the same basic system as was developed for PC use - the VESA Enhanced Display Identification Data (EDID) format for display descriptors, conveyed over the VESA Display Data Channel data communications interface (basically, an I^2C connection between the display and its host system). In addition, the same basic goal applies in both the PC and CE cases - that the host system, or video source, receives enough information regarding the capabilities of the display to enable automatic self-configuration, and so to operate the display in the best possible mode within the limits of both devices. And equally fortunately, both CEA and VESA have standardized on a common default mode (i.e., one which can be assumed to be usable even if no display information is available) of 640 x 480 pixels at 60 Hz refresh, progressive scan. This mode may be safely used, and should result in a visible image, on essentially all standards-compliant PC and digital TV products.

However, the two industries have at this point evolved slightly different definitions for the display description carried in the EDID information. The behavior of the video source device in terms of how and when this information is read, and how it is interpreted (and especially the default actions taken when certain information is present or missing) also differs slightly. This paper will make recommendations for dealing with these differences in the short term, and also for modifying the definitions of the EDID information and the standard system behavior to improve compatibility between products for these markets. Before presenting these recommendations, though, it is important to understand the various standards currently in use.

5. Basic Operating Model - DDC and EDID

The original VESA EDID standard defined a 128-byte data array, typically programmed into non-volatile memory (such as a PROM) contained within the display device, and which provided basic information such as the display's colorimetry, gamma, and supported video timings. The definition of the base EDID has been revised several times since its original release, with the current version of this structure now referred to as EDID 1.3. The EDID standard also includes the concept of additional 128-byte blocks of data, or "extensions," which could be appended to the base 128-byte EDID and used to provide additional information if this was determined to be necessary by the display manufacturer. Several EDID extensions have been defined to date, by both VESA and the CEA. Standard extensions include those which can provide information on additional timings supported by the display (beyond those identified in the base EDID), plus a recent VESA standard, the Display Information Extension (DI-EXT).

An additional standard, the VESA Display Data Channel, or DDC, was published at the same time as EDID, and defined the electrical interface used to transmit the EDID information from the display to its video source. Originally, two different DDC interfaces were defined; the first, DDC1, is now obsolete and is not used by any significant number of products currently in the installed base. The second, DDC2, is based on the I^2C electrical interface, and is today the standard means of display/host data communication in both markets.

The simplest form of DDC2 (also known as DDC2B) provides for read-only access to a 256-byte space (limited by address allocations within I^2C), permitting access to the basic EDID data plus a single, optional, 128-byte extension. The VESA E-DDC (Enhanced DDC) mode introduces a “segment pointer” register which extends the read-only access to a 32K-byte space. This allows access to the base EDID data plus multiple 128-byte extension blocks.

In all versions of DDC, though, the interpretation of the base EDID information is essentially the same. As detailed below, the base EDID provides information identifying the unique display product attached (by manufacturer, model number, and serial number), some basic knowledge of the display's features and colorimetry, and supported timings. A large part of the base EDID - over half of the space, in fact - is devoted to identifying supported timings, including four 18-byte sections at the end of the base EDID space which may be used to convey timings in detail. The first of these Detailed Timing blocks is, in both CE and PC usage, assumed to define the preferred timing mode of the display (i.e., the timing which should be used if the host video source is capable).

6. The E-EDID Definition and VESA- and CEA-Defined EDID Extensions

As noted earlier, the current definition of the base EDID information is given in the Enhanced Extended Display Identification Data (E-EDID) Specification, and is referred to as EDID 1.3 (data structure version 1, rev. 3). A basic outline of the contents of EDID 1.3 is given in the following table:

Starting Address	# Bytes	Description
00h	8	Header: 00,FF,FF,FF,FF,FF,FF,00h
08h	10	Mfr. name, product code, serial no., datecode (wk/yr)
12h	2	EDID version and revision numbers
14h	5	Basic info: video input, max H & V size, gamma, features
19h	10	Colorimetry: R, G, B, and W color coordinates (CIE xy)
23h	3	"Established Timings" - 24 one-bit flags
26h	16	"Standard Timings" - 8 two-byte standard timing ID codes
36h	18	Detailed Timing #1 (preferred mode)*
48h	18	Detailed Timing or Monitor Descriptor**
5Ah	18	Detailed Timing or Monitor Descriptor
6Ch	18	Detailed Timing or Monitor Descriptor
7Eh	1	Extension Flag (number of extension blocks to follow)
7Fh	1	Checksum (1 byte sum of entire 128-byte EDID to be 00h)

Table 1 - Base EDID information (EDID 1.3)

* Earlier versions of the EDID standard permitted Monitor Descriptors to be stored here.

** Monitor Descriptor blocks currently defined include those for monitor serial number storage; ASCII text strings, including a special block for the monitor name in ASCII; additional Standard Timing codes; additional color point information; and a "monitor range limits" descriptor which provides information on the timing range supported by the monitor.

As previously noted, several additional extension blocks, which may follow the base EDID, have also been defined by VESA and the CEA. Of these, the DI-EXT is currently expected to become very important within PC usage of the DDC/EDID system, and digital television products expected to be compliant with the CEA-861-B standard are required to use a special CEA extension. An overview of the contents of the DI-EXT extension is as follows:

Starting Address	# Bytes	Description
00h	1	Header: 40h identifies DI-EXT extension
01h	1	DI-EXT version number
02h	12	Digital Interface Support: type, version, data format used, min/max clock rates supported, crossover frequency
0Eh	6	Display Device physical characteristics: subpixel layout/shape, pixel pitch, major display characteristics
14h	35	Display Capabilities & Feature Support: stereo support, scaler capabilities, frame rate conv. support, centering, scan orientation, color/luminance decoding, color depth, etc.
37h	17	Unused bytes (currently reserved at 00h)
48h	9	Audio support bytes (currently reserved at 00h)
51h	46	Display Transfer Characteristic ("gamma")
7Fh	1	Checksum (1-byte sum over entire DI-EXT to equal 00h)

Table 2 - VESA DI-EXT Extension

Finally, the CEA's EDID extension, as defined in CEA-861 (the latest revision is CEA-861-B, which includes Version 3 of this extension), is:

Starting Address	# Bytes	Description
00h	1	Header: 02h identifies CEA extension
01h	1	Version number
02h	1	Offset of start of Detailed Timing information (d)
04h	X	CEA Data Block collection
(d)	N * 18	Detailed Timings (N blocks of 18 bytes each)
(d + 18N)		Padding (bytes between end of Detailed Timings and checksum byte are all set to 00h)
7Fh	1	Checksum (1-byte sum over entire DI-EXT to equal 00h)

Table 3 - CEA EDID Extension, Version 3 (from CEA-861-B)

It should be noted that the CEA extension uses the same 18-byte Detailed Timing definition as the various VESA standards, with the addition that conventions better defining the meaning of such timings when used with interlaced scanning have been defined within the CEA-861 standard.

The CEA Data Block area within the CEA extension serves a similar purpose as many of the fields within the VESA DI-EXT extension; it permits the storage of additional information not covered in the base EDID. As of CEA-861-B, four (of a possible eight) different Data Block types have been defined. These are:

Data Block Type	# Bytes	Description
Video	Max. 32 bytes for each block; more than one of a given type may be included; Speaker Allocation blocks have a fixed length of 3 bytes	Contains CEA "Short Video Descriptors," which are effectively one-byte ID codes identifying standard video formats and timings. Up to 127 different codes are possible; one bit is reserved to indicate whether or not the format is "native" for the display.
Audio		Contains CEA "Short Audio Descriptors," which are three-byte codes describing digital audio formats recognized by the device. The Short Audio Descriptor provides information on the number of channels, sampling rate, and bit depth (for uncompressed audio) or bit rate (for compressed audio).
Speaker Allocation		Describes the speaker allocation for the device; 2 bytes of this block are currently reserved at 0.
Vendor Specific		Vendor-specific information; includes three bytes which provide the IEEE Registration Identifier

Table 4 - CEA Data Block descriptions

7. Addressing the CE/PC Incompatibility Issues

There are two basic compatibility problems to be addressed: the first is the short-term problem of current products, built under the existing CEA and VESA standards, failing to interoperate when connected in what appears to the consumer to be a permissible manner. The second, longer-term problem has to do with the fundamental differences between these standards, when considered in the light of what is expected to happen within these markets.

The first problem is actually relatively easy to fix. As the basic goal is simply to ensure that the user is never left with a blank screen when connecting any given video source to any given display device, via what appears to be a compatible interface, all that is required is that products be strongly encouraged to adhere to the existing standards in full. Both the CEA (in CEA-861-B) and VESA (in the recent Plug & Play standard) recognize the 640 x 480 pixel, 60 Hz progressive-scan timing as a "baseline" or default mode (the VESA standard refers to this as Base Video Mode) which should provide a usable image when used with any compliant display. Therefore, the first recommendation to be made here is simply that all video sources and display devices support this model. For the video source, this means that if no other usable timing or format can be identified for the display, then the source must use this default format - at the very least, to communicate to the user that a proper auto-configuration with a higher-level or more "preferred" timing could not be achieved, and so to permit manual intervention to complete the set-up process.

The second, longer-term problem is more complicated, and will require more of an effort to properly address. There are several contributors to this situation. Clearly, the different EDID extensions in use (especially the CEA extension and the VESA DI-EXT) are incompatible, and yet are becoming more and more likely to be required in their respective target markets. The CEA extension is already virtually mandatory for CEA-861-B compliant products, while DI-EXT (or at least much of the information currently defined within that extension) will likely soon become a de-facto requirement within the PC industry, with the introduction of new operating systems such as Microsoft's upcoming Longhorn version of Windows. However, as noted above, many systems are incapable of accessing more than a single extension to the base EDID - and even when this *is* possible, overlapping and incompatible definitions within these extensions have the potential for future problems. Just to name the most basic concern - if multiple extensions are permitted which should come first and be given priority over the other? This problem becomes even more acute in the case of the so-called convergence products - display devices or other products which are intended to operate in both the CE or home entertainment context, and within the PC environment. If only the base EDID and a single extension are permitted, which extension should be used by such products? How could the needs of both applications be addressed without giving strong preference to either one?

To respond to these needs adequately, it should be clear that something in these standards will have to change. Ideally, we would come up with a solution which permitted the information needs of both markets to be addressed within the base EDID and a single extension, such that those systems which cannot access additional extensions would still be served. Fortunately, there appears to be a relatively simple means of achieving exactly this.

First, we must recognize that in the EDID extension defined in CEA-861-B, the CEA has developed a very powerful means for permitting manufacturers to configure a single extension to meet the needs of various products, while still remaining within a common standard. The CEA Version 3 EDID extension permits any number of various "data blocks," each with a unique identifying tag, to be place within the 128-byte extension space, in addition to more 18-byte Detailed Timings per the VESA definition. Thus, while the contents of the CEA extensions of any two given products may be very different, both remain interpretable by the host system under the CEA specifications. This is a far more flexible system than the fixed structures used in the VESA DI-EXT definition.

Second, we must also acknowledge that the VESA DI-EXT definition, being the more recent, has to date not been widely adopted, and that this definition contains a considerable amount of unused space, or space devoted to information that is not likely to be used in the majority of systems. Examples of this include the 17 unused bytes at address 37h, the Audio Support bytes at 48h which are not yet defined (and whose purpose could likely be filled by definitions already given in the CEA extension), and the 46-byte Display Transfer Characteristic block (which is unlikely to be used in full). These account for over half of the 128-byte DI-EXT block.

With the above in mind, we are making the following recommendations to address this longer-term incompatibility situation:

1. VESA should identify the DI-EXT extension specification as deprecated, and recommend that it not be used for future designs. Instead, the CEA extension specification, Version 3, with new data blocks defined by VESA and CEA, would become the recommended extension. DI-EXT would remain a valid standard until its existing uses migrate to the common CEA definition.

2. VESA and the CEA should reserve two additional tag codes (from the four currently unused in the CEA specification) for assignment to two new data blocks which then could be used under CEA-861-B. These would be assigned to:

    1. A 32-byte Display Device Information block, which would contain much of the information presently provided in the Digital Interface, Display Device, and Display Capabilities and Feature Support Set blocks of the VESA DI-EXT definition, and

    2. A 32-byte Display Transfer Characteristic block which would replace the current 46-byte definition of DI-EXT.

3. We also recommend that the VESA E-EDID Task Group, in the next revision of that standard, add explicit identification of which EDID extension blocks may and may not appear more than once in a given implementation. (i.e., multiple CEA-type extensions should be explicitly identified as permissible, but similarly extensions such as DI-EXT should be explicitly restricted to one extension of that type for any given implementation.) This would bring VESA standards more in line with the existing CEA-861 specification (which explicitly states that multiple extensions of the type it defines are permitted) while avoiding potential problems which could exist from permitting multiple copies of other extension types (which is implicitly permitted under the existing EDID extension scheme as defined by VESA standards).

It is important to again note that, under the CEA specification, and presumably the future adoption of this extension specification by VESA, the inclusion of either or both of these new blocks would be at the manufacturer's discretion, as is the case with *any* of the data blocks currently defined by the CEA. The loss of the Audio Support definition in the existing DI-EXT extension should not be expected to be a problem, as this information should be adequately covered by the existing CEA Short Audio Descriptions and/or Speaker Allocation data block, or through future extensions to these developed through a cooperative effort between the CEA and VESA. This means, for one thing, that current and much future usage of the CEA definition within the CE market will remain unchanged; there is no need for CE devices to use the new VESA blocks until and unless their manufacturers see some benefit in doing so.

The above plan will permit both industries to move forward under a single common set of specifications, including the base EDID specification and an enhanced CEA extension. This will permit manufacturers to meet the needs of either or both markets in any given product, while all display products remain completely usable by all standards-compliant sources.

8. Details of the Proposed New Data Blocks

As noted above, it is our recommendation that two new data blocks, compliant with the existing CEA definition for such items, be created to permit the storage of the information currently provided in the DI-EXT extension in a fully CEA-compatible extension. In keeping with the existing CEA practice, these blocks would be a maximum of 32 bytes each, and their use would be completely optional. This permits, under the CEA definition, extensions to be created which are aimed solely at the CE market, solely at the PC market (i.e., being functionally a replacement for DI-EXT,), or for any intermediate "convergence" product. In fact, owing to the great flexibility of the CEA extension format, there is no need to identify *any* particular example of such an extension as a CE type, PC type, or by any such label. All extensions remain configured as their manufacturers see fit, as is the current CEA practice. (Following the presentation of the proposed definition of these new blocks, several example extensions will be described to demonstrate the flexibility of this approach.)

The first block which must be defined is one we are calling the Display Device Information block, which contains that information from DI-EXT necessary to describe the configuration of the display itself (i.e., subpixel layouts, pixel pitch, etc.) and the details of the digital interface used by the display product. One possible definition (please note that this is not a formal proposal at this time) of this block which might meet this goal is as follows:

Display Device Information Block - fixed 32-byte length. CEA block tag 05h

Rel. address (hex)	No. of bytes	Description
00	1	3 bit block tag (5h); 5 bits version number
01	1	4 bits Interface Type; 4 bits no. links/channels (if needed)
02	1	Interface Std. version/release number (4 bits each)
03	1	Content Protection Support flags
04	1	Dig. Interface format description: 2 bits DE support (per DI-EXT definition) 2 bits shift clock usage; 1 bit double clocking support 3 bits reserved
05	2	Min/Max Clock Frequency per link (new definition)
07	1	Crossover frequency
08	4	Sub-pixel layout/configuration/shape (new definition)
0C	2	Horizontal and vertical dot/pixel pitch
0F	1	Major Device Characteristics (per DI-EXT 3.3.3)
10	1	Misc. Display Capabilities (per DI-EXT 3.4.1)
11	3	Frame Rate/Mode Conversion (new definition)
14	1	Display/Scan Orientation (per DI-EXT 3.4.3)
15	1	Default Color/Luminance Encoding (per DI-EXT 3.4.4)
16	1	Preferred Color/Luminance Encoding (per DI-EXT 3.4.4)
17	2	Color/Luminance Decoding Capabilities (per DI-EXT 3.4.4)
19	4	Color Bit Depth (new definition)
1D	1	Aspect Ratio Conversion Modes (per DI-EXT 3.4.6)
1E	1	Overscan/Underscan info (new definition; to include % over/under)
1F	1	Unused (reserved at 00h)

Note that several of the items conveyed by this new block require definitions different from those originally used in DI-EXT; this is primarily due to the need to save space in their representations. However, a look at the current DI-EXT definitions suggests several ways in which this data could be presented more efficiently.

The second new block required, the Display Transfer Characteristic block, performs the same function as the 46-byte section of DI-EXT currently used for the "gamma" tables, as described in section 3.7 of the DI-EXT standard. Here, one simplifying assumption will permit a representation which is both more compact and at the same time more accurate than the DI-EXT definition. For any practical display device, we should be able to assume that no matter the shape of the transfer characteristic curve, it is always monotonically increasing - in other words, there should be no case in which an increase in the input signal level results in a *decrease* in the output luminance, especially over the intervals as will be seen in tables of 16 or 32 samples spread evenly over the input range. With this assumption, it becomes a simple task to define a block which provides 10-bit accuracy in the normalized luminance values provided, far better than the 8-bit values provided by the DI-EXT definition. To achieve this, we first require that the peak luminance value be normalized to 3FFh; this is assumed to be the output luminance of the display when the input in question is set to its maximum normal value. With this assumption made, only 31 values need to actually be stored (since the 32^{nd}, the peak value, is assumed), and after the first value is given (that for the minimum, or "zero," input level), all the remaining values may be given as increments from the previous value. Storing 8 bits for each of these permits the initial normalized luminance value to be anything from zero up to one-quarter of the peak (which should be more than sufficient), while each increment on successive sample points can vary from the one prior to it by (again) one-quarter of the peak value. This method results in the following definition for this block. Please note that the length of this block is not fixed; it may be either 16 or 32 bytes long. Multiple Display Transfer Characteristic blocks may also be included in the same extension in order to provide even more detailed transfer curve information (for example, three or four 16-sample curves). (Again, please note that the following is given as an example only, and does not constitute a proposed formal specification of this block.)

Rel. address (hex)	No. bytes	Description
00h	1	3-bit Tag (for this block, 6h); 4 bits usage, as follows: 00 - White 01 - Red 10 - Green 11 - Blue (i.e., if these four bits are 0011, then the block contains a white curve followed by a blue curve; if both bytes are the same value, then the block contains information for only that color, of whatever length is given in the final bit) 1 bit total sample count - 16 samples if "0", 32 if "1"
01h	1	Initial luminance value (normalized); absolute luminance when input signal level is at minimum normal level.
02-1Fh	14 or 30	Incremental luminance values, for 30* input values spread evenly over the input signal range, excluding the maximum value (which is assumed to have the peak output of 3FFh). 8 bits each, permitting increments of 000h to 0FFh.

* - See text below for details.

The two "usage" bits, plus the "sample count" bit in the first byte permit this block to be used in several ways. Most often, a single block would be provided, and so the system would have transfer characteristic information given as 16 or 32 points of white luminance. However, it is also possible for a more detailed description to be given, if the manufacturer is willing to use additional space for one or two additional Display Transfer Characteristic blocks. If two are provided, then 16-step tables can be described for white, red, green, and blue; with three, full 32-step tables are given for the red, green, and blue outputs. (This method also permits the possibility of a 16-byte version of this block, which would be a simplified white-only characteristic, or for three separate 16-byte versions covering red, green, and blue - a close match to the 46 bytes originally used by DI-EXT.)

9. APPENDIX A – Glossary

The following table contains a glossary of some terms and acronyms used in this white paper.

Item #	Term/Acronyms	Definition
1	Base Video Mode	The Base Video Modes are defined as low resolution (and low color depth) video timing formats. Most (if not all) monitors are capable of supporting the Base Video Modes. Today, the most commonly used Base Video Modes are "VGA' based (e.g., the common 640 x 480 @ 60 Hz display timing).
2	CE	Refers to Consumer Electronics – TV products
3	CRT	Cathode Ray Tube – a display device
4	CVT	Coordinated Video Timing – indicates a reference to VESA’s CVT Standard
5	DDC-2B	Display Data Channel-2B: A communications protocol based on I^2C and used on a bi-directional data channel between the display and the host. DDC is a requirement for Plug and Play under the VESA Plug & Play standard.
6	DI-EXT	Shorthand reference to VESA’s Display Information Extension Block Standard
7	DLP	Digital Light Processing – a display device used in projectors.
8	DMT	Display Monitor Timing
9	DTF	Detailed Timing Format – Defined in VESA’s E-EDID Standard
10	DTV	Digital Television
11	DVI	Digital Visual Interface – short hand reference to the Digital Display Working Group’s DVI 1.0 Specification
12	DVD	Digital Video Disc
13	EDID	Extended Display Identification Data – short hand reference to the base (block 0) 128 bytes of encoded data stored in the monitor.
14	E-DDC	Shorthand reference to VESA’s Enhanced Display Data Channel Standard
15	E-EDID	Enhanced Extended Display Identification Data – short hand reference to VESA’s E-EDID Standard
16	IT	Refers to Information Technology – computers, etc.
17	GTF	Generalized Timing Formula – indicates a reference to VESA’s GTF Standard
18	HDMI	High Definition Multimedia Interface
19	HPD	Hot Plug Detect – ability of a host (source) to detect the presence of an attached display.
20	LCD	Liquid Crystal Display – a display device
21	LCoS	Liquid Crystal on Silicon – a display device
22	PnP	Refers to the “Plug & Play” process.
23	PTM	Preferred Timing Mode – Defined in VESA’s E-EDID Standard
24	SCART	Syndicat des Constructeurs d’Appareils Radiorécepteurs et Téléviseurs – publishers of a video interface standard commonly used in Europe which is generally referred to by this name.
25	TVC	Short hand reference to VESA Television Compatibility Task Group
26	VCR	Video Cassette Recorder
27	VESA	Video Electronics Standards Association
28	VGA	Video Graphics Array
29	VTB-EXT	Video Timing Block Extension – reference to VESA VTB-EXT Standard
30	V-PnP	Refers to VESA’s Plug & Play Process Flowcharts and Standard.

10. Appendix A - Space Analysis for Base EDID with CEA and DI-EXT extensions.

Some concern has been expressed over the amount of space within the EDID structure (the base EDID plus extensions) required to convey the minimum information necessary for compliance with various standards. This appendix is intended to provide information in this area, describing what is required by the various standards and also what might be expected to be needed in a typical configuration for various applications.

First, while the base EDID and any extensions are fixed in length at 128 bytes each, not all of the available space is required to be used in any given application. The greatest flexibility is within the four 18-byte segments located near the end of the base EDID; these were originally used for Detailed Timing descriptions only, but later revisions to the EDID (and now E-EDID) standard have opened these up to other uses. The first is used to describe the "preferred" timing mode for the display in question. Of the remaining three, the current E-EDID standard requires that one be used to carry a Monitor Range Limits descriptor block; it also currently requires the inclusion of a Monitor Name block, although the usefulness of this is questionable. Thus, the base EDID as currently used will provide 1-2 open 18-byte spaces which may be used to carry additional Detailed Timings or other blocks per the E-EDID standard.

Use of the DI-EXT block does not provide additional space which may be used for additional timing descriptors or other optional data at the discretion of the manufacturer; all 128 bytes of this block are defined by the DI-EXT standard, although it should be noted that 42 bytes are currently defined as "reserved." However, since it is the recommendation of this paper that the DI-EXT standard be deprecated, the space allocation within that standard is not relevant to this analysis.

As noted earlier, the EDID extension defined by CEA-861-B is flexible and its 128-byte space may be allocated in various ways at the manufacturer's discretion. Within the current definition (Version 3), 5 bytes are dedicated to mandatory information (the tag, revision number, detailed timing data offset, number of preferred formats, and checksum bytes. The remaining 123 bytes may be allocated as the manufacturer desires, and will typically contain a mix of 18-byte Detailed Timing descriptors and CEA-defined "data blocks" (described earlier). The data blocks are for the most part variable-length, but none will be longer than 32 bytes. Per CEA-861-B, sections 7.2.2 and 7.5, the 861/861A required video formats are to be listed as full 18-byte structures, with such listing of the 480i and 576i formats optional but recommended. Other video formats (including the 861 and 861A formats) supported are listed using the new (as of 861-B) "short video descriptors" (in a video data block).

The required 861/861A formats, per the CEA-861-B standard, include the 640 x 480 and 720 x 480 60 Hz progressive formats, plus either the 1280 x 720 progressive or 1920 x 1080 interlaced format, for 60 Hz countries, or an equivalent set of 480- and 576-line formats plus either 1280 x 720 progressive or 1920 x 1080 interlaced at 50 Hz, for 50 Hz countries. Thus, the CEA-861-B standard mandates the inclusion of at least three (and possibly four, if the 480i or 576i timing is included) Detailed Timings within the base EDID and the extension. Assuming that one of these is, in fact, the preferred mode for the display in question, and one other Detailed Timing may be included in the base EDID, this leaves 1-2 Detailed Timings which must be included in the extension. We will assume that 2 are required for the purposes of this analysis. If the preferred timing is not among this set, then one additional timing description would be required under the current VESA standard (the CEA standard permits "native" formats to be flagged in the short video descriptors).

With 5 bytes of mandatory information plus 36 bytes of Detailed Timings from the original 128-byte extension, we are left with 87 bytes. There are 34 video identification codes currently defined by the CEA-861-B standard; however, it is unlikely (and in fact currently impossible) that a given display would indicate support for all of these. A 17-byte Video Data block, though, would suffice to indicate support for either all of the 59.94/60 Hz timings, or their 50 Hz equivalents. This would leave 70 bytes open for other uses. The Speaker Allocation Data Block is a fixed 4-byte structure; inclusion of one such leaves 66 bytes. The remaining Data Block definition provided by CEA-861-B is the Audio Data Block, which contains up to 10 3-byte "short audio descriptors" (plus the one-byte header which contains the tag and length values).

If the display in question wished to carry the 32-byte Display Device Information block proposed in this paper, this would leave 34 bytes for the Audio Data Block - sufficient for the maximum 10 short audio descriptors. Should the minimum (16-byte) Display Transfer Characteristics block also be desired (unlikely in a "purely CE" sort of product), 5 short audio descriptors could be carried. (Note that there is no minimum number of short audio descriptors required by CEA-861-B; if the product in question supports only "basic audio," then no Audio Data Block would be provided at all.

It should also be noted that further cooperative efforts between VESA and CEA could help in making the data storage of the CEA extension more efficient. For example, many of the video formats assigned unique codes in the current CEA-861-B standard differ only by frame or field rate; i.e., a 50 Hz version vs. a 59.94/60 Hz version. A more efficient means of coding these would be to assign a single code to both, and assume that the intended rate was that identified by the preferred timing mode in the base EDID, unless a flag was set indicating support for the "other" rate in any given case. Including this flag in the short video descriptor would reduce the number of available codes to 64 (half the current number), but this still would leave 30 codes open for future use (possibly 46, if the now-unused codes currently assigned to either the 50 or 60 Hz versions were opened for reassignment). Further, redefinition of certain sections of the base EDID by VESA (especially in the current Standard and Established timings spaces) could free up additional space within the total 256-byte structure.

This analysis shows that it is possible, under existing standards, to create usable EDID structures using only the base EDID and a CEA-compatible extension, which would be usable in CE, PC, and combined applications. However, use of more advanced addressing methods, which would permit the use of more than a single extension, should still be strongly encouraged.

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