Video Electronics Standards Association

PnP Standard

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VESA "Plug & Play" (PnP) Standard for the Display/Graphics Subsystem

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Purpose

This standard defines a procedure for "Plug & Play" (PnP) in the Display/Graphics Subsystem. It is the intention of this document to focus the display/graphics industry toward true "Plug & Play". It also intended to support "Ease of Use" concepts as they apply to the average end user.

Summary

This document contains a definition of "Plug & Play" in the Display/Graphics Subsystem. This document also includes a list of required elements and processes for true "Plug & Play" in the Display/Graphics Subsystem. In addition, some special cases are considered.

Note

This document 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.

1. Preface

1.1 Background

For more than 20 years, the computer industry has experienced explosive growth. Every year new computer hardware, software applications and operating systems have hit the marketplace. With each new generation of computer hardware and software, the capabilities of the personal computer (PC) have increased by several orders of magnitude. Today's PCs contain more computing power than most of mainframe computers and mini-computers of a few short years ago. The Video Electronics Standards Association (VESA) has published standards, guidelines and other documents in support of the Display/Graphics Industry. VESA's effort has been focused toward "Ease of Use" and improving the end user's experience. For the past several years, some of the new computer hardware and software products related to the Display/Graphics Subsystem have not focused on "Ease of Use". The Display/Graphics Subsystem includes the monitor, the video interface (cable, if required) and the source of the computer generated images. The source of the computer generated images can be a graphics card in a computer, a graphics chip/system on a computer's motherboard, external monitor video ports from a notebook computer, a workstation computer, a tablet PC or a PDA. Image sources can also include other computer-based products (for example: game consoles, set-top boxes, etc.).

1.2 Scope

This standard defines a process for "Plug & Play" (PnP) in the Display/Graphics Subsystem. It is the intention of this document to focus the Display/Graphics Industry toward true PnP.

PnP, as used in this standard, is intended to cover operations that occur in the Display/Graphics Subsystem. When necessary, there may be references to operations that occur in the operating system (OS) and device drivers. The PnP Standard does not include information related to other PnP initiatives: including but not limited to "Universal Plug and Play (UPnP)", IEEE1394, USB, etc. It is assumed that the graphics subsystem (in the computer) has already been installed, enumerated and configured by the computer system. It is also recommended that the capabilities (video pixel formats, color depth, vertical refresh rates, etc.) of the video generating hardware match or exceed the capabilities of the monitor. For example, it is not recommended that you connect a 1600x1200x24 bit LCD monitor to a low end graphics card with only 4 Mb of memory. The results may be less than satisfactory.

This standard contains a definition of PnP in the Display/Graphics Subsystem. This document also includes a list of required elements and processes for true PnP in the Display/Graphics Subsystem. In addition, some special cases are considered. Also, there are discussions related to what should be done in the event of a preferred PnP process failure.

1.3 Conformance Glossary - Definition of Terms

The following is a list of definitions for certain keywords used throughout this document:

1.3.1 **shall**: A keyword that indicates a mandatory requirement for compliance with this standard.
1.3.2 **should:** A keyword that indicates a choice with a strongly preferred preference. Equivalent to "is strongly recommended".
1.3.3 **may:** A keyword that indicates a choice with no expressed or implied preference.

1.4 Intellectual Property

1.5 Trademarks

All trademarks used within this document are the property of their respective owners. VESA is a trademark of the Video Electronics Standard Association.

1.6 Patents

The user's attention is called to the possibility that compliance with this VESA standard may require the use of an invention or other items covered by a patent or other intellectual property rights. In publishing this standard, no position is taken by VESA with respect to the validity of this claim or of any intellectual property rights in connection therewith. The holder of the intellectual property in question, however, may have filed (with the VESA office) a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license. Details may be obtained from VESA.

1.7 Support for this Standard

Clarifications and application notes to support this standard may be written. To obtain the latest VESA Standards and any support documentation, contact VESA.

If you have a product that supports PnP, you should ask the company that manufactured your product for assistance. If you are a manufacturer, VESA can assist you with any clarification you may require. All comments or reported errors should be submitted in writing to VESA using one of the following methods.

- Fax: 408-957-9277, *direct this note to Technical Support at VESA*
- Email: support@vesa.org
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2. OVERVIEW

2.1 Summary

The VESA PnP Standard contains the following subjects:

1. A definition of PnP in the Display/Graphics Subsystem.
2. Elements required for support of PnP in the Display/Graphics Subsystem.
3. The Preferred Process for PnP in the Display/Graphics Subsystem.
4. Operating Systems – Additional Requirements
5. Default Actions in the Event of a PnP Process Failure
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    - 10.4 Handling Updates to EDID Data Structures.
11. Appendix C - Glossary

Details on the above subjects are discussed in Sections 3, 4 & 5 of this document.

The "Primary Video Interface Connector", as used in this document, is the connector which is currently connected (active) between the monitor and the host. It is the connector that contains the Display Data Channel (DDC), which transmits the EDID and extension block data structures from the monitor to the host.

2.2 Standard Objectives

The PnP Standard was developed by VESA to meet, exceed and/or complement certain criteria. These criteria are set forth as standard objectives as follows:

- Support Microsoft® Plug and Play definition for displays.
- Support the Digital Visual Interface Specification (Version 1.0) and other recognized digital interface standards (VESA P&D & DFP).
- Refocus the Display/Graphics Industry toward true “Plug & Play”.

2.3 Reference Documents

Note: Versions identified here are current (at release date of this document), but readers of this standard 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 or newer
- 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
- The Unicode Standard, Version 3.2.0 (information available at www.unicode.org)
- VESA and Industry Standards and Guidelines for Computer Display Monitor Timing (DMT), Version 1.0, Revision 0.9, August 21, 2003
- VESA Digital Flat Panel (DFP) Standard, Version 1, Feb.14, 1999
- VESA Display Color Management (DCM) Data Standard, Version 1, Jan. 6, 2003
- VESA Display Data Channel, Command Interface (DDC/CI) Standard, Version 1, August 14, 1998
- VESA Display Information Extension Block (DI-EXT™) Standard, Release A, August 21, 2001
- VESA Display Power Management (DPM), Release A, March 3, 2003
- VESA Display Power Management Signaling (DPMS™) Standard, Ver.1.0, Rev. 1.0, August 20, 1993
- 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

3. VESA PnP Process

3.1 A Definition of PnP in the Display/Graphics Subsystem

What is PnP as it relates to the Display/Graphics Subsystem?

In very general terms PnP means, "plug it in, turn it on and it works", with minimal intervention by the end-user. For example, refrigerators, microwave ovens, television sets, etc. could be considered to be PnP devices. You plug them in, turn them on and they work with minimal intervention by the end-user.

In more specific terms, the following statement is a definition of PnP in the display/graphics subsystem. An optimal image (as defined in EDID 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 and the host system. The preferred process (see section 3.3) to do this can be quite complicated for the Display/Graphics Subsystem. What happens during this process is highly dependent upon the operating system and the graphics subsystem driver.

3.2 Elements Required to Support PnP in the Display/Graphics Subsystem

The basic elements required for the support of PnP in the display/graphics subsystem include a PnP compatible monitor, a data communications channel, a PnP compatible graphics subsystem and a PnP compatible operating system (OS). These subjects are discussed in the following sections.

1. A PnP Compatible Monitor: A PnP compatible monitor shall contain a valid base EDID (Extended Display Identification Data) table. The base EDID table (also known as "EDID Block 0") is the only mandatory data block that must be stored in the PnP-compatible monitor. In addition, optional EDID extension blocks (one or several – 128 bytes each in length) may be stored in the monitor. For example, the monitor's memory may contain a DI-EXT (Display Information Extension) block. The base EDID Table contains 128 bytes of encoded data. The EDID data contains information related to the identification of the monitor and the video formats/features supported by the monitor. The host system uses this information to configure the graphics subsystem. Application software programs may also make use of some of the information contained in the base EDID table and extension blocks. The host system shall be able to read the EDID content when the monitor is turned on or turned off.

It is the monitor manufacturer's responsibility to make certain that the contents of the base EDID and all extension blocks are valid. The 8 byte EDID header shall be correct, all stored information shall be supported by the monitor and the checksum/s shall be correct. For more information on EDID tables and DI-EXT extension block, please refer to the reference documents in section 2.3. In the future, VESA may publish additional standards that define new function specific EDID extension blocks.

2. A Data Communications Channel: A functioning data communications channel shall be connected between the monitor and the host computer's graphics subsystem. Today, in the display/graphics subsystem, the data communications channel of choice is VESA's DDC-2B (Display Data Channel). The primary purpose of the DDC is to transport the contents of the EDID table (including optional extension blocks) from the monitor to the host computer's graphics subsystem. DDC-CI (Display Data Channel Command Interface) can be used for host control of the monitor. For more information on DDC and DDC-CI, please refer to the reference documents in section 2.3.

3. A PnP Compatible Graphics Subsystem: A PnP compatible graphics subsystem shall be installed in the host computer system. The graphics subsystem includes a Video BIOS stored in firmware and a graphics subsystem driver. The Video BIOS (under certain circumstances) is capable of requesting EDID information from the monitor. The BIOS and some graphics subsystem drivers are able to read and parse (decode) some or all of the EDID table contents. The graphics subsystem driver is capable of configuring certain higher functions on the graphics card. The graphics subsystem driver also provides for communications between the operating system and the graphics board hardware. The preferred process includes a BIOS EDID read during system startup and a read/store of the base EDID and extension block/s content by the operating system. A graphics subsystem driver read of the base EDID and extension blocks are not part of the preferred PnP process.

4. A PnP Compatible Operating System: The PnP compatible operating system shall be capable of receiving EDID information, decoding and storing monitor information and graphics board information. The "Display Graphics Subsystem Identification" (DGSSID) Object is a place to store this information. A DGSSID Object can be located in non-volatile memory or located in a storage media (e.g. hard disk drive). The operating system also provides an interface to the end user. This interface allows the end user to control or select certain higher functions (e.g. image pixel formats, image refresh rate, color depth, color management tools, port activation/shutdown, etc.) that are available in the graphics subsystem.

3.3 The PnP Process in the Display/Graphics Subsystem

Section 3.3 describes the preferred process for PnP in the display/graphics subsystem. It is called the "Preferred PnP Process". There are four process flowcharts (contained in three figures) in this section. There are additional sections that deal with specific issues that are related to PnP. This section is broken down into the following subsections:

- 3.3.1 The PnP Process Flowcharts:
  1. Figure 1 shows the PnP Process Flowchart – Overview
  2. Figure 2 shows the PnP Process Flowchart – Part 1 (The Plug & Play Process)
  3. Figure 3a shows the PnP Process Flowchart – Part 2 (EDID Timing Priority)
  4. Figure 3b shows the PnP Process Flowchart – Part 3 (Extension Block Process)
- 3.3.2 The PnP Process Description – references Part 1 in figure 2
- 3.3.3 The EDID Timing Priority Description – references Part 2 in figure 3a
- 3.3.4 The Extension Block Process Description – references Part 3 in figure 3b
- 3.3.5 Operating System – Additional Responsibilities
- 3.3.6 Default Actions in the Event of a PnP Process Failure

It is recommended that the reader prints the PnP Process Flowcharts in figures 2 & 3a/3b. Lay the flowcharts out in front of you as you read sections 3.3.2, 3.3.3 and 3.3.4.

In the real world, the "Preferred PnP Process" may fail. These failures can be caused by a variety of reasons: hardware failures, software failures, etc. When failures do occur, then an alternate set of processes shall be followed. These alternate processes are referred to as the "Non-Preferred (Recovery) Process". The purpose of the "Non-Preferred (Recovery) Process" is to have a readable image displayed on the monitor's screen, such that the end user can start to run application programs. The "Preferred PnP Process" has priority over the "Non-Preferred (Recovery) PnP Process".

In the event of a conflict between the contents of the PnP process flowcharts and the process descriptions (defined in section 3.3), the process descriptions take priority.

In section 3.3, both the "Preferred PnP Process" and the "Non-Preferred (Recovery) Process" are discussed. In Figures 1 through 3, the "Preferred PnP Process" steps (blocks) are outlined by a box with dashed lines and a yellow (or gray) background. The "Non-Preferred (Recovery) Process" steps (blocks) are outlined by a box with dotted lines and a white background. The use of normal text indicates a "Preferred PnP Process" step description. The use of italicized text indicates a "Non-Preferred (Recovery) Process" step description. Solid line connectors between blocks indicate the "Preferred PnP Process" path. Dashed line connectors between blocks indicate the "Non-Preferred (Recovery) PnP Process" path.

The "Preferred PnP Process" assumes that the end user is connecting a monitor to a graphics subsystem with similar (or better) capabilities (pixel formats, refresh rates, color depth, pixel clock range, etc.). The "Preferred PnP Process" cannot compensate for the connection of a high-end monitor (for example, preferred timing mode is 1600x1200 at 32 bit color depth) to a low-end graphics card (maximum pixel format of 1280x1024 at 8 bit color depth). Compatible hardware is required for PnP to work.

Completion of the preferred PnP process shall result in an optimal image being displayed on the monitor's screen. The optimal image is defined by the preferred timing mode listed in the base EDID. The preferred timing mode is defined by the monitor manufacturer as the video timing mode that will result in the best displayed image on the monitor's screen. If the graphics/display subsystem does not support the preferred timing mode, then another video timing mode may be used (refer to section 3.3.3). This other video timing mode may not result in an optimal image being displayed on the monitor's screen. The displayed image may not be full screened and/or may not be centered. However, the displayed image shall be readable.

If a failure occurs in the preferred PnP process, then a readable image (which may not be the preferred image) shall be displayed on the monitor's screen.

3.3.1 PnP Process Flowcharts

Refer to Figure 1. The preferred PnP process is broken down into three separate but connected flowcharts.

Part 1 (Figure 2) is the main PnP process. The process includes the following items: initial system setup and power up; the Video BIOS operations of reading and storing base EDID tables; System POST; GSS Driver EDID Read; OS functions; OS EDID Read; Hot Plug Detection (HPD); OS determination of the base EDID type; the loading of display drivers; the running of application software and the system shutdown process.

Part 2 (Figure 3a) deals with the BIOS-GSS-OS decoding of video timing data (priority order), stored in the base EDID.

Part 2 (Figure 3b) deals with OS reading and storing of extension block data.

Figures 2, 3a and 3b are shown on the next two pages.

Fig 1: PnP Process Flowchart - Overview

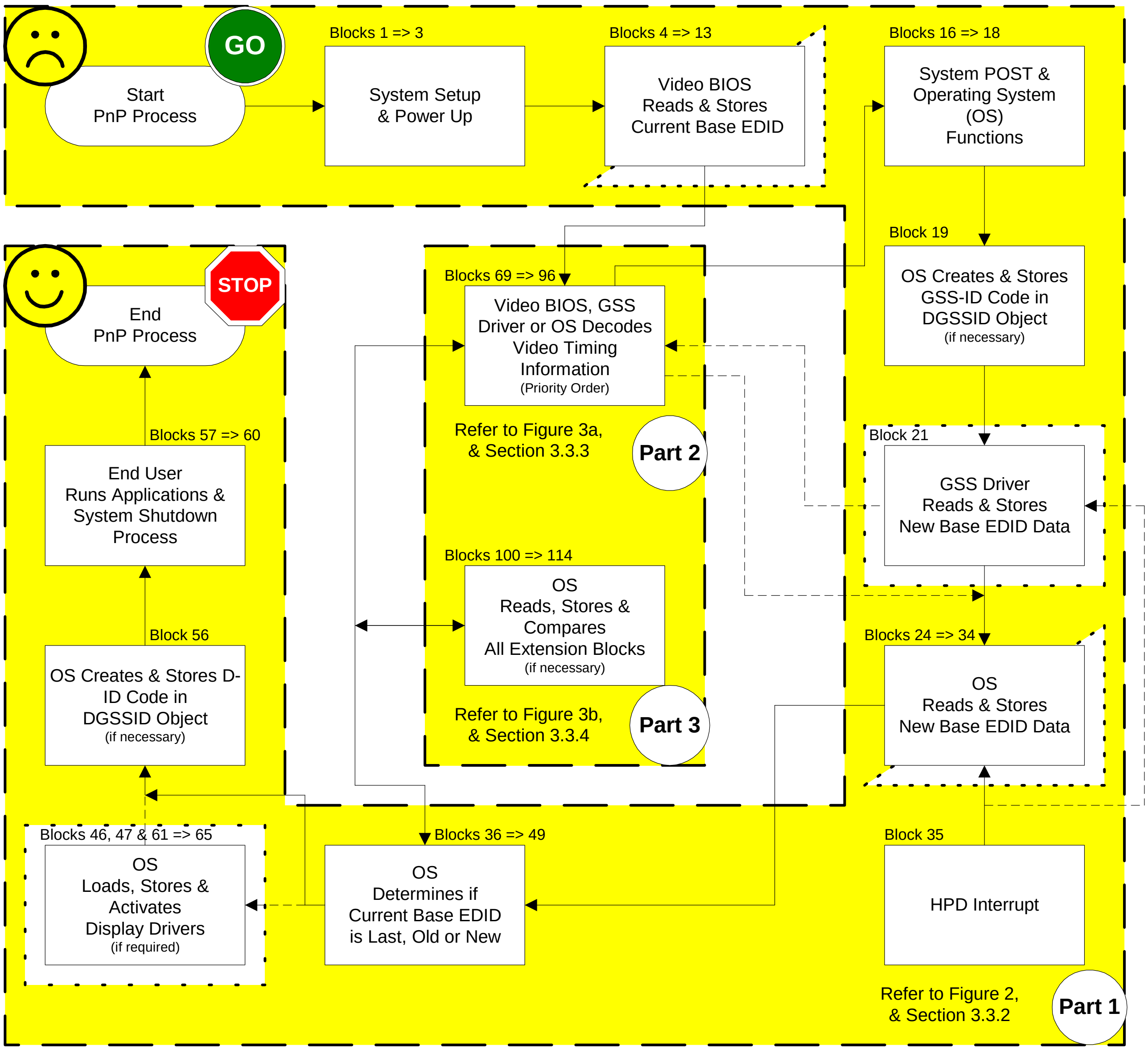
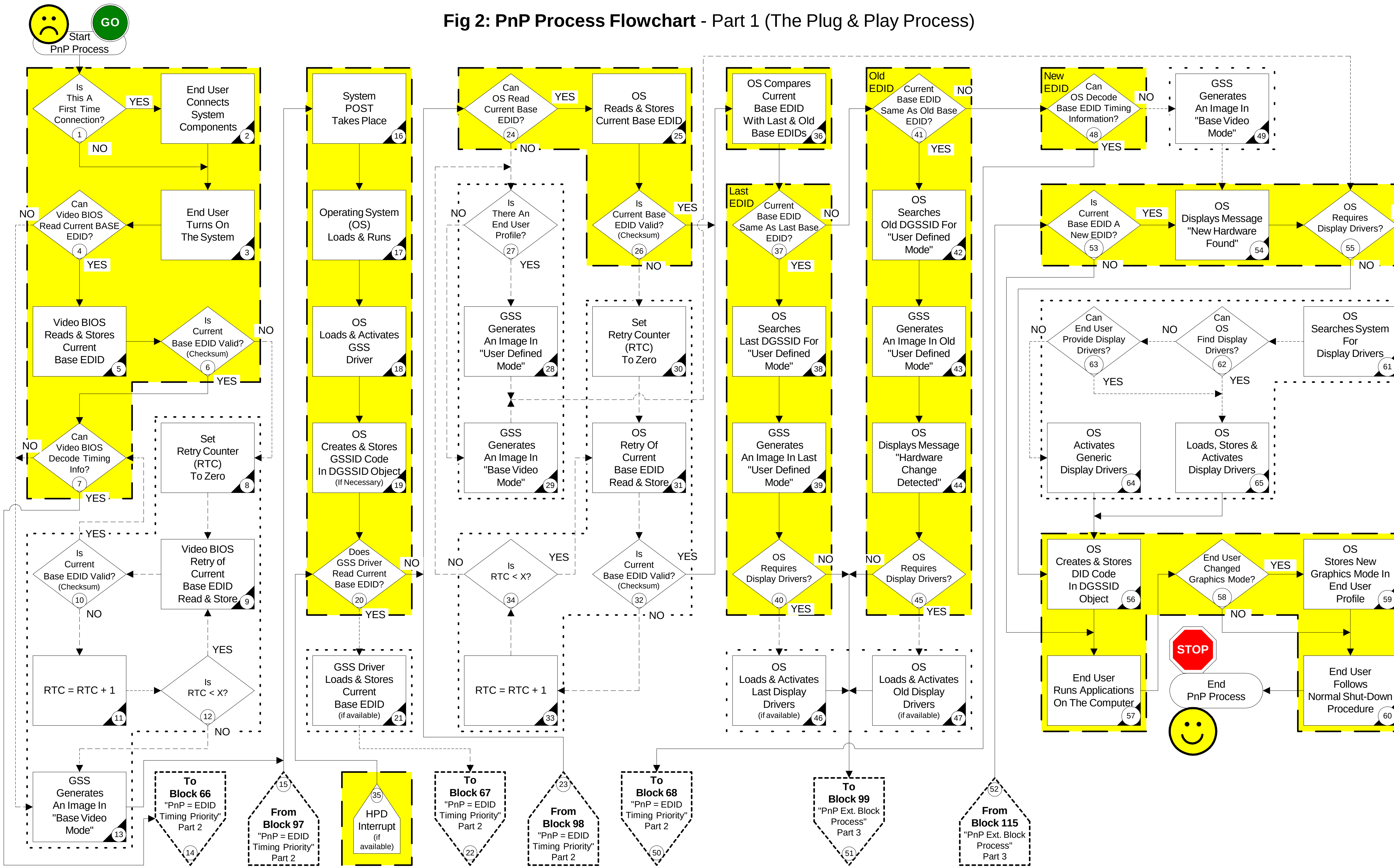


Fig 2: PnP Process Flowchart - Part 1 (The Plug & Play Process)



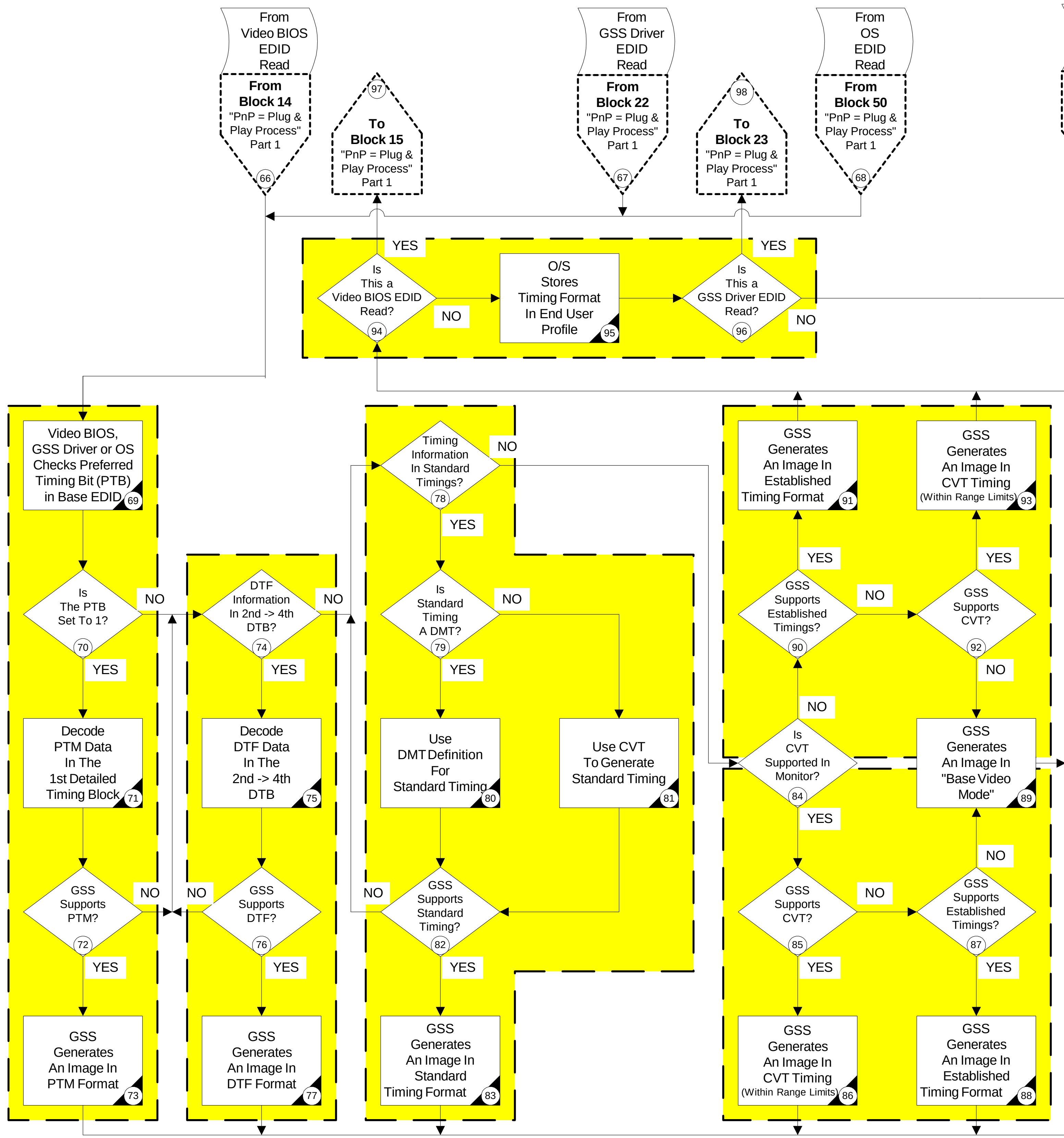


Fig 3a: PnP Process Flowchart - Part 2 (EDID Timing Priority)

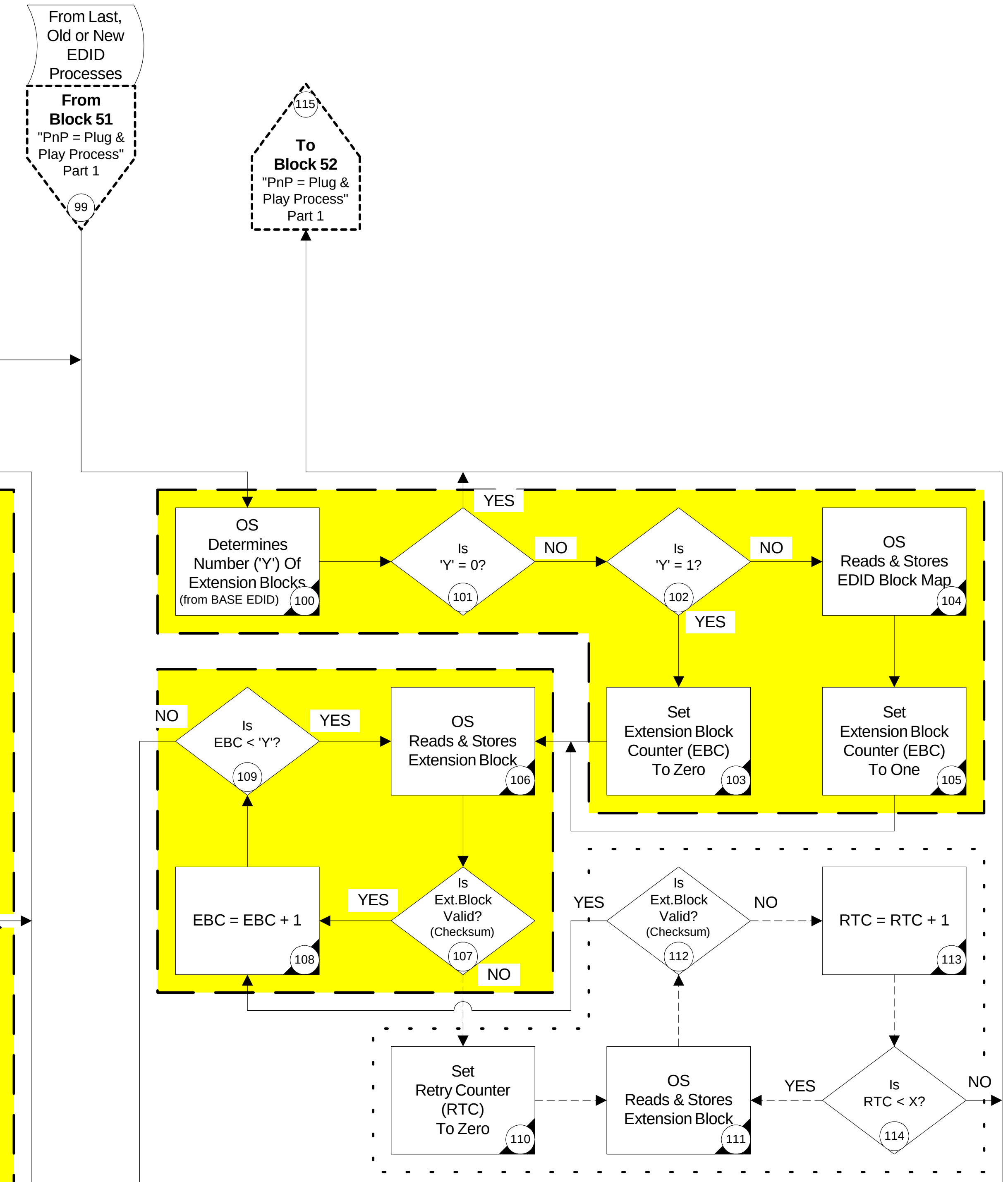


Fig 3b: PnP Process Flowchart - Part 3 (Extension Block Process)

3.3.2 The PnP Process Description

Part 1 of the PnP process flowchart is shown in figure 2 (section 3.3.1). Section 3.3.2 provides a description of the individual steps (blocks) in the PnP process.

Monitor display drivers (as used in this document) do not refer to the graphics drivers that are supplied with graphics generating sub-systems. Monitor display drivers can include information (INF) files, color management profiles (ICM), catalog (CAT) files, etc. Display drivers may also include certain types of application programs such as video orientation (portrait/landscape) switching software, font size control software, color management software and other special purpose application programs. These special purpose display drivers may require manual installation by the end user. The manual installation of display drivers is not part of the preferred PnP process.

3.3.2.1 <u>System Setup, Turn On & Video BIOS Read</u> ---

--- Blocks 1 ⇒ 7 in Figure 2 – Preferred Process

The start of the preferred PnP process begins with a question – "Is This a First Time Connection?" (Block 1). "A First Time Connection" is defined as a new monitor that is connected to a new computer (desktop, workstation, notebook, etc.). It may be an old monitor that is connected to a new computer. Or it may be a new monitor that is connected to an old computer or an old monitor that is connected to an old computer with a new graphics board. If this is "A First Time Connection", then of course the end user has to connect the system components (Block 2) together prior to turning on the system (Block 3), otherwise the end user simply turns on the system. "End User turns on the System" (Block 3) means that the end user can turn on the monitor first, the computer first or both at the same time. In either case, the PnP process shall work. In other words, the computer (or other video signal source) shall be able to read the EDID content of a connected monitor even if the monitor is powered off.

Once the system has been powered up, the next step in the preferred PnP process is the reading of the current base EDID by the Video BIOS (Block 5). For the PnP process to work, the Video BIOS shall be able to read, store, error check (Block 5) and decode (some of the content) the current base EDID. The Video BIOS can perform error checking (Block 6) by adding (using modulo 256) all 128 hexadecimal bytes. If the result of the addition is '00h', then the contents of the base EDID are probably valid. The preferred PnP process requires the Video BIOS to do one read of a valid base EDID. *In the case of a failed EDID read, the "Non-Preferred (Recovery) Process" allows for re-tries (see section 3.3.2.2).*

At this point, the Video BIOS shall decode some of the information contained in the current base EDID. The most important information is the video timing data that is stored in the base EDID. The Video BIOS shall follow the EDID Timing Priority (refer to Section 3.3.3) as defined in VESA's E-EDID Standard. For more information on EDID Timing Priority, please refer to the reference documents in Section 2.3.

Also, the Video BIOS may need some of the other information that is stored in the current base EDID. For example, a connected analog video input port on the monitor shall transmit an analog EDID to the host system. The Video BIOS should then turn on the analog video output port on the graphics subsystem. Also, a connected digital video input port on the monitor shall transmit a digital EDID to the host system. The Video BIOS should then turn on the digital video output port on the graphics subsystem. The preferred PnP process continues with Block 14. Refer to section 3.3.3 "Part 2 – BIOS-GSS-OS Decodes Video Timing Information" (Blocks 69 ⇒ 96) for the EDID Timing Priority process.

3.3.2.2 <u>Video BIOS Fails to Read Current Base EDID</u> ---

--- Blocks 8 ⇒ 13 in Figure 2 – Non-Preferred (Recovery) Process

This section defines a non-preferred process that is required to recover from a failure that may have occurred in the preferred PnP process.

There may be cases where the Video BIOS cannot read the base EDID (Block 4). A defective video cable, defective DDC hardware in the monitor or in the graphics subsystem (GSS) can cause a failure to read the base EDID. Or, maybe the Video BIOS was not designed to read the base EDID. If the Video BIOS cannot read the base EDID (Block 4) then the GSS shall generate an image in the "Base Video Mode" (Block 13). Then the PnP process continues with Block 16, "System POST Takes Place".

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.

In some cases, the Video BIOS may misread a valid base EDID (stored in the monitor). This can be caused by noise on the DDC data line. In this case, retries should be allowed. The Video BIOS manufacturer determines the number of retries (X). However, the more retries, the slower the startup process can be. So, a trade-off is required between the number of retries and the speed of the Video BIOS EDID read. If the Video BIOS cannot read a valid base EDID (after {X} retries) (Blocks 8 ⇒ 12) then the GSS shall generate an image in the "Base Video Mode" (Block 13). Then the PnP process continues with Block 16, "System POST Takes Place".

If the Video BIOS is able to read the base EDID but cannot decode the Video Timing Data (Block 7) then the GSS shall generate an image in the "Base Video Mode" (Block 13). Then the PnP process continues with Block 16, "System POST Takes Place".

3.3.2.3 <u>System POST, OS Loads, GSS Driver etc</u>. ---

--- Blocks 16 ⇒ 20 in Figure 2 – Preferred Process

After the Video BIOS has completed the EDID Timing Priority process (Part 3 in section 3.3.3), the preferred PnP process continues with Block 16 (in Part #1). At this point, the System BIOS (not to be confused with the Video BIOS) takes over control. The System BIOS runs a "Power on Self Test" (POST) (Block 16). The POST performs several functions related to the computer hardware components. After completion of the POST, the System BIOS loads and runs the operating system (OS) (Block 17).

At this point, the OS takes over control of the computer system. The OS shall determine if this is a "First Time Connection" for the GSS hardware and/or driver software. The OS determines a "First Time Connection" by looking at the contents of the PCI Configure Space for the GSS. The PCI Configure Space contains information (vendor ID, device ID, capabilities, etc.) about the GSS. During each computer system startup cycle, the OS shall compare the current PCI Configure Space with the last PCI Configure Space that was previously stored in the last Graphics SubSystem Identification (GSSID) code. The GSSID code contains information (or the location of the information) related to the graphics subsystem. The OS then loads and activates the appropriate (the last or requests a new) graphics subsystem (GSS) driver (Block 18). If this is a "First Time Connection", the OS shall create and store a GSSID code (Block 19). The OS then stores a GSSID code in the Display/Graphics Subsystem Identification (DGSSID) Object. The DGSSID Object contains information (or the location of the information) related to the display/graphics subsystem. If this is not a "First Time Connection", then the OS does not make any changes to the GSSID Code in the DGSSID Object. The preferred process continues with Block 20, "Does GSS Driver Read Current Base EDID?"

3.3.2.4 <u>GSS Driver Reads Current Base EDID</u> ---
--- Blocks 20 & 21 in Figure 2 – Non-Preferred (Recovery) Process

This section defines a non-preferred process that is required to recover from a failure that may have occurred in the preferred PnP process.

In some computer systems, the GSS driver (Blocks 20 & 21) may be capable of reading, storing and decoding the base EDID data. If this is the case then the GSS driver shall follow the EDID Timing Priority (refer to section 3.3.3) as defined in VESA's E-EDID Standard. For more information on EDID Timing Priority, please refer to the reference documents in section 2.3. The GSS driver's ability to read and decode base EDID is not considered to be a part of the preferred PnP process. The EDID Timing Priority rules for the GSS driver are the same as the rules for the Video BIOS and the OS. If the GSS driver can read a base EDID (Block 20) then the GSS driver shall decode the video timing information. The preferred PnP process continues with Block 22. Refer to section 3.3.3 "Part #3 – BIOS-GSS-OS Decodes Video Timing Information" (Blocks 69 ⇒ 96) for the EDID Timing Priority process. After decoding the video timing information, the preferred process continues with Block 24.

3.3.2.5 <u>OS Reads/Stores Current Base EDID & HPD</u> ---
--- Blocks 24 ⇒ 26 & 35 in Figure 2 – Preferred Process

After completion of the EDID Timing Priority process by the GSS Driver (if GSS Driver reads base EDID), the preferred process proceeds to the OS read of the base EDID (Block 25). For the preferred PnP process to work, the OS shall be able to read, store, (Block 25) error check (Block 26) and decode the contents of the base EDID. The OS performs the error checking (Block 26) by adding (using modulo 256) all 128 hexadecimal bytes. If the result of the addition is '00h', then the contents of the base EDID are probably valid. The preferred PnP process requires the OS to do one read of a valid base EDID. This read of the base EDID is known as the "Current Base EDID".

Some video interfaces support Hot Plug Detection (HPD). An HPD event occurs when a video cable from a monitor is connected to a host system while the host is powered on. If a HPD event occurs then the HPD Interrupt (Block 35) shall address the GSS driver in Blocks 20 & 21. *If the GSS driver can read base EDID and an HPD event has occurred, then a re-read by the GSS driver is required*. If not, the GSS driver shall pass the HPD request to the OS and the OS shall initiate a re-read of the base EDID (Block 25). Refer to section 3.6 for more information on HPD.

The preferred PnP process continues with Block 36 in Part 1 (Figure 2). Refer to section 3.3.2.7.

3.3.2.6 <u>OS Fails to Read Current Base EDID</u> ---
--- Blocks 27 ⇒ 29 & 30 ⇒ 34 in Figure 2 – Non-Preferred (Recovery) Process

This section defines a non-preferred process that is required to recover from a failure that may occur in the preferred PnP process.

For the preferred PnP process to work, the OS shall be able to read (in one try) the base EDID (Block 25). However, there may be cases where the OS cannot read the base EDID. A defective video cable, defective DDC hardware in the monitor or in the graphics subsystem (GSS) can cause a failure to read the base EDID. Or, maybe the OS was not designed to read the base EDID. If the OS cannot read the base EDID (Block 24) then the OS shall search for an "End User Profile" (Block 27). The "End User Profile" is located in the DGSSID Object. A "User Defined Mode" is listed in the "End User Profile". The "User Defined Mode" is the video timing format that the GSS output prior to the last system shutdown. If the OS finds an "End User Profile", then the

GSS shall generate an image in the "User Defined Mode" (Block 28). Otherwise, the GSS shall generate an image in the "Base Video Mode" (Block 29). Then the PnP process continues with Block 55 in Part 1 of the "PnP Process Flowchart" (see section 3.3.2.9).

The preferred PnP process requires the OS to do one read of a valid base EDID (Block 25). However, in some cases, the computer may misread a valid base EDID (stored in the monitor). This can be caused by noise on the DDC data line. In this case, retries (Blocks 30 ⇒ 34) should be allowed. The OS manufacturer determines the number of retries (X). However, the more retries, the slower the EDID read process can be. So, a trade-off is required between the number of retries and the speed of the OS EDID read. If the OS cannot read a valid base EDID (after X retries) then the GSS shall generate an image in the "User Defined Mode" (Block 28) or in the "Base Video Mode" (Block 29). Then the PnP process continues with Block 55 in Part 1 of the "PnP Process Flowchart" (see section 3.3.2.9).

3.3.2.7 <u>OS Determines Base EDID Type</u> ---
--- Blocks 36 ⇒ 48 in Figure 2 – Preferred Process

Once a valid EDID has been read, the OS shall determine (Block 36) the base EDID type. There are three types (last, old and new) of base EDIDs. The current base EDID (most recently read) can be the last base EDID (from the last monitor connected to the GSS prior to the last system shutdown), one of the old base EDIDs (from a previously connected monitor) or a new base EDID ("First Time Connection"). The OS can do this by comparing Manufacturer's IDs, Product IDs, Serial Numbers and/or Checksums. The preferred PnP Process continues in Block 37.

If the current base EDID is the same as the last base EDID (Block 37), then the OS shall search for the last "User Defined Mode" in the last DGSSID Object (Block 38). The GSS then generates an image in the last "User Defined Mode" (Block 39). If the OS requires the use of Display Drivers (Block 40), then refer to section 3.3.2.8. Then the preferred PnP process continues with the extension block process. See Block 99 in Part 3, figure 3b (section 3.3.4). If the OS determines that the current base EDID is not the same as the last base EDID (Block 37), then the preferred PnP process proceeds to Block 41, "Current Base EDID Same as Old Base EDID?"

If the current base EDID is the same as one of the old base EDIDs (Block 41) then the OS shall search for the old "User Defined Mode" in one of the old DGSSID objects (Block 42). The GSS then generates an image in the old "User Defined Mode" (Block 43). The OS shall display a "Hardware Change Detected" message (Block 44), indicating to the end user that the system has detected an old monitor. The OS should include the manufacturer's name and model name of the old monitor in the displayed message. This information is available in one of the old DGSSID objects. If the OS requires the use of Display Drivers (Block 45), then refer to section 3.3.2.8. Then the preferred PnP process continues with Block 99 (extension block process) in Part 3, figure 3b (section 3.3.4).

If the OS determines that the current base EDID is not the same as one of the old base EDIDs (Block 41), then the current base EDID must be a new base EDID (Block 48). A new base EDID indicates that this system startup includes a "First Time Connection". Since this is a "First Time Connection", the preferred PnP process requires that the OS is able to decode EDID timing information (Block 48). At this point, the OS shall decode some of the information contained in the new base EDID. The most important information is the video timing data that is stored in the base EDID. When decoding the video timing information, the OS shall follow the EDID Timing Priority Rules (refer to section 3.3.3) as defined in VESA's E-EDID Standard. For more information on EDID Timing Priority, please refer to the reference documents in section 2.3.

Also, the OS may need some of the other information (Manufacturer's ID, Product ID, Serial Number, Monitor Range Limits, Color Data, etc.) that is stored in the new base EDID.

The preferred PnP process continues with Block 50. Refer to section 3.3.3 "Part 2 – BIOS-GSS-OS Decodes Video Timing Information" (Blocks 69 ⇒ 96) for the EDID Timing Priority process. After the OS completes the EDID Timing Priority process the preferred PnP process continues with Block 99 (extension block process). The OS shall look for extension blocks (Blocks 100 ⇒ 114) to the new base EDID. Refer to section 3.3.4 "Part 3 – OS Extension Block Read Process" (Blocks 100 ⇒ 114) for the Extension Block process.

3.3.2.8 OS Requires Display Drivers & OS Cannot Decode EDID ---

--- Blocks 46, 47, 48 & 49 in Figure 2 – Non-Preferred (Recovery) Process

This section defines a non-preferred process that is required to recover from a failure that may have occurred in the preferred PnP process.

Some operating systems require the loading of display drivers (not to be confused with graphics board drivers). Display drivers can include but are not limited to information files, color management profiles and catalog files. The preferred PnP process does not include the loading of display drivers.

However, for those operating systems which do require display drivers, the OS shall load and activate the required display drivers. If the current base EDID is a last base EDID (Block 37) then the OS shall activate the last display drivers (Block 46), if available. The last Display Drivers (or their locations) can be found in the last DGSSID object. If the current base EDID is an old base EDID (Block 41) then the OS shall activate the old display drivers (Block 47), if available. The old display drivers (or their locations) can be found in the old DGSSID object. Then the PnP process continues with Block 99 (extension block process) in Part #3 (section 3.3.4). For more information on display drivers refer to section 5.2. For new display drivers related to a new base EDID, refer to section 3.3.2.10.

If the OS cannot decode the new base EDID (Block 48) then the GSS shall generate an image in the "Base Video Mode" (Block 49). Then the preferred PnP process continues in Block 54 (New Hardware Found Message). The "New Hardware Found" message shall indicate to the end user that the OS has detected a monitor but does not know what the monitor is or its capabilities. If the OS can decode the new base EDID (Block 48), then the PnP process continues with Block 69 in Part 2 (refer to section 3.3.3).

3.3.2.9 Final Steps in the PnP Process ---

--- Blocks 53 ⇒ 60 in Figure 2 – Preferred Process

If the OS has just completed a new base EDID read (Block 53), then the OS shall display a message "New Hardware Found" (Block 54). The OS shall also indicate to the end user the manufacturer's name and the model number of the new monitor. This information is available in the base EDID data table.

If the OS has just completed a last base EDID read (Block 53), then refer back to Blocks 37 ⇒ 40 & 46 (section 3.3.2.7) in Part 1 of the V-PnP Process Flowchart. If the OS has just completed an old base EDID read (Block 53), then refer back to Blocks 41 ⇒ 45 & 47 (section 3.3.2.7) in Part 1 of the V-PnP process flowchart.

If the OS requires display drivers (Block 55), then proceed to section 3.3.2.10. If display drivers are not required (Block 55), then proceed to Block 56.

At this point, the OS shall store all available display/graphics subsystem information (new base EDID table & new extension blocks) in a new DGSSID object (Block 56). The available information may include: new base EDID table; all extension blocks; monitor supported video timing modes; display drivers (if required); end user profile; and graphics subsystem information (type, drivers, active video output port being used, graphics subsystem capabilities, timing modes supported by the graphics subsystem, etc.).

The end user may now run application software programs (Block 57) on the computer. During normal operation, the end user may have manually selected a graphics video timing mode (Block 58) different from the mode selected by the preferred PnP process. If this occurs, then the OS shall store the new graphics video timing mode (Block 59) in the end user profile (which is stored in the DGSSID Object).

When the end user is finished using the computer, s/he follows the normal shut-down procedure (Block 60) as defined by the OS/computer manufacturer. This concludes the preferred PnP process for the display/graphics subsystem.

3.3.2.10 __Display Drivers for a New Base EDID__ ---
--- Blocks 61 ⇒ 65 in Figure 2 – Non-Preferred (Recovery) Process

This section defines a non-preferred process that is required to recover from a failure that may have occurred in the preferred PnP process.

Some operating systems require the use of monitor display drivers (not to be confused with graphics board drivers). The end user has to go through a manual step to install the required new display drivers. This is not PnP. A true PnP compatible OS does not require the use of display drivers. All required information is contained in the base EDID and/or extension data blocks. Monitor display drivers are typically stored on CD-ROMs or floppy disks and are shipped with the monitor product. It is possible that some of these monitor display drivers can be downloaded from internet websites.

If the OS has just completed a new base EDID read (Block 53), and display drivers are required (Block 55), then the OS shall search the appropriate locations on the system hard disk drive for the necessary monitor display drivers (Block 61). If the monitor display drivers have been located on the hard disk drive (Block 62) then the OS shall load and activate the drivers (Block 65). The preferred PnP process then continues with Block 56.

If the monitor display drivers cannot be found in the computer system (Block 62) then the OS shall ask the end user for access to the monitor display drivers. If the end user can locate the display drivers (Block 63), then s/he inserts the CD-ROM or the floppy disk into the appropriate drive and clicks 'OK' or 'Continue'. The OS shall search all directories on the CD-ROM/floppy disc, then download the monitor display drivers and save them to an appropriate location on the hard disk drive (Block 65). In addition, the OS will activate the necessary monitor display drivers without intervention by the end user. At no time should the end user be forced to manually update and activate the monitor display drivers. The preferred PnP process then continues with Block 56.

During the loading/activation of display drivers, it is important the OS checks the version number/date code (if available) of the new drivers. It is not appropriate for the OS to replace current drivers with older versions. If the OS determines that a newer version is being replaced by an older version, then the OS shall warn the end user and ask for permission to proceed.

If the OS has just completed a last base EDID read (Block 37), then refer back to Blocks 37 ⇒ 40 & 46 (section 3.3.2.7) in Part 1 of the PnP Process Flowchart for last display driver installation (Block 46). If the OS has just completed an old base EDID read (Block 41), then refer back to Blocks 41 ⇒ 45 & 47 (section 3.3.2.7) in Part 1 of the PnP Process Flowchart for old display driver installation (Block 47).

If the end user cannot locate the monitor display drivers (Block 63) then the OS shall activate a generic display driver (Block 64). Generic display drivers are supplied with the OS. However, some caution is required here. The OS supplied generic display driver shall not allow the end user to select a video timing mode that is outside of the normal operating range of the monitor. It may be necessary for the OS to ask the end user to select (from a list) the maximum pixel format supported by the monitor. A correct selection by the end user will prevent "Out of Range" errors from occurring when the end user selects a new (non-valid) video timing format. An incorrect choice by the end user can result in a blank screen. Therefore, it is important that the OS always seek confirmation from the end user that an acceptable image is displayed on the monitor's screen after a video timing mode change has occurred. The end user shall click on 'Yes' (in a specific period of time – for example 15 sec). Otherwise, the OS instructs the graphics subsystem driver to return to the previous video timing format. After an OS supplied generic display driver has been activated, the preferred PnP process continues with Block 56.

During this process of updating the monitor display drivers, an alternate method would include a search on the internet for the necessary files. If the OS cannot find the monitor display drivers on the computer's hard disk drive (Block 62), then the OS should search the internet (if access is available). The Manufacturer's ID Code (stored in the base EDID table) can tell the OS to search the monitor manufacturer's website. The Product ID Code (also stored in the base EDID table) can tell the OS the name/s of the file/s that has/have to be downloaded and activated. Another option is to have an alternate website (known to the OS) available for a monitor display driver search. The monitor display drivers from all PnP monitor manufacturers can be stored at this alternate website. The OS should give the end user the option to search the internet, or the local drives. The use of an internet search can make the loading and activation of the monitor display drivers a very simple process for the average end user.

3.3.3 Part 2 – BIOS-GSS-OS Decodes Video Timing Information

--- Blocks 69 ⇒ 96 in Figure 3a – Preferred Process for EDID Timing Priority

Figure 3a in section 3.3.1 shows the flowchart (Part 2) for the preferred process when dealing with BIOS-GSS-OS decoding of EDID Video Timing Data (timing priority order). Section 3.3.3 provides a written description of the individual steps (blocks) in the EDID timing priority process.

Part 2 should be followed only after the Video BIOS has read a base EDID (Block 66) or after the GSS driver (if available) has read a base EDID (Block 67) or after the OS has read a new base EDID ("First Time Connection") (Block 68). Part 2 is not used when dealing with a last base EDID or an old base EDID (an OS EDID read).

If the Video BIOS, the GSS Driver or the OS can decode the base EDID video timing data, then the timing information priority order shall comply with Section 5 of the E-EDID Standard (Release A, Revision 1, or newer). The timing information priority order process (Blocks 69 => 96) is repeated here. For more information on EDID timing information priority, please refer to the reference documents in section 2.3.

3.3.3.1 <u>Preferred Timing Mode</u> ---

--- Blocks 69 ⇒ 73 in Figure 3a – Preferred Process

When decoding the new base EDID video timing information, the BIOS-GSS-OS shall start by looking at the "Preferred Timing Bit (PTB)" (bit 1 of the "Feature Support" byte at address **18h** in the base EDID) (Block 69). If the PTB is set to '1' (Block 70), then the BIOS-GSS-OS shall decode the "Preferred Timing Mode (PTM)" data (Block 71) which is located in the first "Detailed Timing Block (DTB)" (18 bytes starting at address **36h**) of the base EDID. The monitor manufacturer defines the "Preferred Timing Mode (PTM)" as the video timing mode that will produce the best quality image on the monitor's display screen. Please note that the use of the "Preferred Timing Mode" is required by EDID data structure version 1, revision 3 and newer. If the GSS supports the PTM

stored in the first DTB (Block 72), then the GSS shall generate an image in the "Preferred Timing Mode (PTM)" (Block 73). The preferred PnP process continues with Blocks 94 ⇒ 96. Refer to section 3.3.3.5 – "Exiting the EDID Timing Priority".

3.3.3.2 <u>Second, Third & Fourth Detailed Timing Blocks</u> ---

--- Blocks 74 ⇒ 77 in Figure 3a – Preferred Process

If the PTB is not set to '1' (Block 70) or if the PTM is not valid data (Block 71) or if the GSS does not support the PTM (stored in the first DTB) (Block 72), then the preferred PnP process continues at Block 74. The BIOS-GSS-OS shall look for a "Detailed Timing Format (DTF)" (Block 75) in the second DTB (18 bytes starting at address **48h** in the base EDID). If the DTF is valid data (Block 75) and the GSS supports (Block 76) the DTF (stored in the second DTB), then the GSS shall generate an image in the "Detailed Timing Format (DTF)" (Block 77). The preferred PnP process continues with Blocks 94 ⇒ 96. Refer to section 3.3.3.5 – "Exiting the EDID Timing Priority". If the DTF is not valid data (Block 75) or if the GSS does not support (Block 76) the DTF (stored in the second DTB), then the process is repeated for the third DTB (18 bytes starting at address **5Ah** in the base EDID) and the fourth DTB (18 bytes starting at address **6Ch** in the base EDID). If a valid DTF is not found (or DTF is not supported by the GSS) in DTB 2, DTB 3 or DTB 4, then the preferred PnP process continues on to Block 78 (Standard Timings).

3.3.3.3 <u>Standard Timings</u> ---

--- Blocks 78 ⇒ 81 in Figure 3a – Preferred Process

If the second, third or fourth DTB does not contain a valid DTF (Blocks 74 & 75) or if the GSS does not support the DTF (Block 76) then the BIOS-GSS-OS shall look at the "Standard Timings".

"Standard Timings" are 2 byte codes starting at address **26h** in the base EDID. Up to 8 "Standard Timings" may be stored (starting at address **26h**). Additional "Standard Timings" (up to 6) may be stored in DTBs using the "Standard Timings" monitor descriptor (data type tag 'FAh'). There may be additional "Standard Timings" defined in a VESA Timing Block Extension (VTB-EXT). The 2 byte codes define the number of horizontal active pixels (range is 256 → 2288 in increments of 8 pixels), the image aspect ratio (4:3, 5:4, 16:9 or 16:10) and the vertical refresh rate (range is 60Hz → 123Hz). Standard timings do not support interlaced formats. If the 2 byte code defines a VESA DMT Mode (Block 79), then the BIOS-GSS-OS shall using the video timing format defined in VESA DMT (version 1.0, revision 0.9 or newer). Otherwise, the BIOS-GSS-OS shall use a video timing format based on VESA's CVT formula (Block 81). The priority of "Standard Timings" is in the order listed. The first listed has the highest priority. The last listed has the lowest priority. For more information on Standard Timings, DMTs and CVTs, please refer to the reference documents in Section 2.3.

The BIOS-GSS-OS shall look at the first "Standard Timing" (Blocks 78, 79, 80 & 81). If the GSS does not support the first "Standard Timing" (Block 82) then the BIOS-GSS-OS shall look at the second "Standard Timing" (Blocks 78, 79, 80 & 81). If the GSS does not support the second "Standard Timing" (Block 82) then the BIOS-GSS-OS shall look at the third "Standard Timing" (Blocks 78, 79, 80 & 81), and so forth. The processes in Blocks 78, 79, 80 & 81 may be repeated several (up to 8 times for a base EDID read) times until a valid "Standard Timing" that is supported by the GSS is found. The GSS shall generate an image in the selected "Standard Timing Format (STF)" (Block 83). The preferred PnP process continues with Blocks 94 ⇒ 96. Refer to section 3.3.3.5 – "Exiting the EDID Timing Priority".

3.3.3.4 <u>CVT, Established & Base Video Modes</u> ---

--- Blocks 84 ⇒ 93 in Figure 3a – Preferred Process

If the BIOS-GSS-OS cannot find a valid/supported Standard Timing Format (STF) (Blocks 78 ⇒ 83) then the BIOS-GSS-OS shall determine (from the base EDID) if the monitor supports CVT (Block 84). For more information on EDID tables and CVT, please refer to the reference documents in section 2.3.

If the monitor is CVT compliant (Block 84) and the GSS supports CVT (Block 85) then the GSS shall generate an image in the CVT mode (Block 86). The CVT mode selected by the GSS shall be within the range limits (stored in base EDID) of the monitor. See CVT note below on page 23. The preferred PnP process continues with Blocks 94 ⇒ 96. Refer to section 3.3.3.5 – "Exiting the EDID Timing Priority".

If the monitor is CVT compliant (Block 84) and the GSS does not support CVT (Block 85) then the BIOS-GSS-OS shall look at the "Established Timings" and the "Manufacturer's Reserved Timings" (3 bytes starting at address **23h** in the base EDID). If the GSS supports "Established Timings" (Block 87) then the GSS shall generate an image in the "Established Timing" format (ETF) (Block 88). The choice of which "Established Timings" to use is optional. The preferred PnP process continues with Blocks 94 ⇒ 96. Refer to section 3.3.3.5 – "Exiting the EDID Timing Priority".

If the monitor is CVT compliant (Block 84) and the GSS does not support CVT (Block 85) and if the GSS does not support "Established Timings" (Block 87) then the GSS shall generate an image in the "Base Video Mode" (Block 89). The preferred PnP process continues with Blocks 94 ⇒ 96. Refer to section 3.3.3.5 – "Exiting the EDID Timing Priority".

If the monitor is not CVT compliant (Block 84) and if the GSS supports "Established Timings" (Block 90) then the GSS shall generate an image in the "Established Timing" format (ETF) (Block 91). The choice of which "Established Timings" to use is optional. The preferred PnP process continues with Blocks 94 ⇒ 96. Refer to section 3.3.3.5 – "Exiting the EDID Timing Priority".

If the monitor is not CVT compliant (Block 84) and if the GSS does not support "Established Timings" (Block 90) and if the GSS supports CVT (Block 92) then the GSS shall generate an image in the CVT mode (Block 93). The CVT mode selected by the GSS shall be within the range limits (stored in base EDID) of the monitor. See CVT note below on page 25. The preferred PnP process continues with Blocks 94 ⇒ 96. Refer to section 3.3.3.5 – "Exiting the EDID Timing Priority".

If the monitor is not CVT compliant (Block 84), and if the GSS does not support "Established Timings" (Block 90, and if the GSS does not support CVT (Block 92,) then the GSS shall generate an image in the "Base Video Mode" (Block 89). The preferred PnP process continues with Blocks 94 ⇒ 96. Refer to section 3.3.3.5 – "Exiting the EDID Timing Priority".

<u>Special Note on CVT</u>: If the GSS is requested to generate a CVT timing (by the Video BIOS, the GSS driver or the OS), the pixel format of the chosen CVT timing format is optional. However, the selected CVT pixel format is recommended to have the same image aspect ratio as defined in the base EDID. The monitor's image aspect ratio can be determined by looking at the preferred timing mode in the first detailed timing block (18 bytes starting at address **36h** in the base EDID). The recommended (standard) image aspect ratios include 4x3, 5x4, 16x9 and 16x10. However, other non-standard image aspect ratios are allowed.

It is also important that the horizontal and vertical frequencies (of the chosen CVT timing) be evaluated and verified to be within the range limits (horizontal and vertical frequencies) defined in the base EDID (Data type tag 'FDh' in one of the detailed timing blocks). EDID data structure (version 1.3) requires the inclusion of the monitor range limits in the base EDID. CVT shall not be allowed to generate a video timing format that is outside of the monitor range limits. An exception to this rule is discussed in section 3.3.5.2.

Special Note on Timing Extension Blocks: There may be video timing information stored in EDID extension blocks. If additional timing information is contained in EDID extension blocks, then the timing priority order should be according to the rules established by the VESA Standard which defines the timing extension block. For more information on EDID extension blocks, refer to section 3.3.4.

At this point in the process (Video BIOS EDID read, GSS EDID read or OS EDID read), an optimal image shall be displayed on the monitor's screen. An optimal image is one that is readable. The optimal image may not be properly sized and/or centered. The displayed image can be in one of the following video timing formats (listed in order of priority): the "Preferred Timing Mode (PTM)" format, a "Detailed Timing Format (DTF)", one of the "Standard Timing Formats (STF) --- DMT or CVT generated", a "Coordinated Video Timing (CVT)" format, one of the "Established Timing Formats (ETF)" or the "Base Video Mode (BVM)".

3.3.3.5 Exiting the EDID Timing Priority ---

--- Blocks 94 ⇒ 96 in Figure 2 – Preferred Process

If this is a Video BIOS EDID read (Block 94) then the preferred PnP process returns to Block 15 in Part #1 (refer to section 3.3.2.1) of the PnP Process Flowchart. If this is a GSS driver or OS EDID read then the PTM, the DTF, the STF, the GTF, the ETF or the BVM shall be stored in the "End User Profile" (Block 95) located in the DGSSID Object. In the case where both the GSS driver and OS are capable of reading, storing and decoding EDID data, then the OS read of the EDID data has priority over the GSS driver read of the EDID data. If this is a GSS driver EDID read (Block 96), then the preferred PnP process returns to Block 23 in Part 1 (refer to section 3.3.2.4) of the V-PnP Process Flowchart. If this is not a Video BIOS or a GSS driver EDID read then this must be an OS EDID read and the preferred PnP process proceeds to Part 3 – "Extension Block Process". Refer to Blocks 100 ⇒ 114 (section 3.3.4.1).

3.3.4 Part 3 – OS Extension Block Read Process

Figure 3b shows the flowchart for the preferred PnP process (Part 3) when dealing with the OS reading and storing of extension block data. Section 3.3.4 provides a description of the individual steps (blocks) in the OS extension block read process. In the preferred PnP process, only the OS is allowed to read, store and decode extension blocks. The Video BIOS and GSS Driver read of extension blocks is optional but not recommended.

Extension blocks (to a base EDID) are 128 bytes (each) of data that can be stored in the monitor. Every PnP compatible monitor shall have a base EDID table (version 1.3 or newer). However, the inclusion of extension blocks is optional. Extension blocks contain information that is not available in the base EDID. The stored information may include special video timing formats, color management support information, monitor capabilities, etc. Extension block information may be used by the OS, device drivers and/or application software programs. Extension blocks are defined in separate VESA standards. The exception is the CEA 861-B Timing Extension Block which is defined in the EIA/CEA 861-B Specification. For more information on EDID tables and extension blocks, please refer to the reference documents in section 2.3.

As of the writing of this document, there are five defined extension blocks, plus a manufacturer's specific extension block:

1) CEA 861-B Timing" Extension Block – (Tag #02h) - Defined in EIA/CEA-861B "A DTV Profile for Uncompressed High Speed Digital Interfaces".
2) Video Timing Block Extension (VTB-EXT)" – Release A – (Tag '10h') – VESA Standard.
3) Display Information Extension (DI-EXT) Block – Release A – (Tag '40h') – VESA Standard.
4) Localized String Extension (LS-EXT) – Release A – (Tag '50h') – VESA Standard.
5) Digital Packet Video Link Extension (DPVL-EXT) –Version 1 – (Tag '60h') –VESA Standard
6) Block Map – (Tag 'F0h') – Contains a list of all extension block tag labels contained in the monitor.
7) Manufacturer's Specific Extension Block – (Tag 'FFh') –Contents defined by the monitor manufacturer.

The "Tag Numbers" 'xxh' define the type of extension block and are located in the first byte of the extension block data. VESA may define new extension blocks in the future. Refer to reference documents in section 2.3.

Base EDID/Extension Block Data can be stored in the monitor in one of three possible configurations.
Configuration 1: One base EDID table and one extension block table (256 bytes total). This configuration allows the use of the DDC definitions to read the 256 bytes (2 blocks) of data. Configuration 1 uses DDC address (**A0h**/**A1h**) method to read up to 256 bytes of data.

Configuration 2: One base EDID table, one EDID block map and one extension block table (more than 256 bytes total). This configuration requires use of E-DDC definitions to read the data. Configuration 2 shall use E-DDC Segment Pointer address (**60h**/**A0h**/**A1h**) method to read the 384 bytes (3 blocks) of data. Note that configuration 2 is redundant to configuration 1, in terms of useful data. It is not recommended that you use configuration 2.

Configuration 3: One base EDID table, one EDID block map and two or more extension block tables (more than 256 bytes total). This configuration requires use of E-DDC definitions to read the data. Configuration 3 shall use E-DDC Segment Pointer address (**60h**/**A0h**/**A1h**) method to read up to 32 Kbytes (256 blocks) of data.

For more information on DDC and E-DDC addressing methods, please refer to the reference documents in section 2.3.

Refer to Part 3 in figure 3b. The preferred PnP process requires the OS to read and store all extension blocks associated with a new base EDID (a "First Time Connection") read. The OS shall also check all extension blocks associated with a last base EDID read or an old base EDID read to determine if there have been any changes. The OS can determine extension block changes by looking at the extension block tag number labels (byte 1) and checksums (byte 128). Similar tag numbers and checksums will usually indicate that changes have not occurred. However, changes in two or more data bytes (in the extension block) may result in the same checksum value. So, this method cannot guarantee that changes have not occurred. If changes have occurred, then the OS shall read and store the new/changed extension block. If no changes have occurred, then the OS does not have to read the extension blocks. An alternate method is to simply read and store all extension blocks each time the system is turned on. This works fine for a small number of extension blocks. However, if there are a large number of extension blocks, then reading and storing all extension blocks would slow down the startup process. Therefore, it is not recommended to use the read all/store all method when there are a larger number of extension blocks.

There may be information (e.g. video timing data, etc.) that is needed by the Video BIOS or the GSS driver. Therefore, a Video BIOS or GSS driver read of extension blocks is optional. However, if the Video BIOS and/or the GSS driver are capable of reading extension blocks then the Video BIOS and/or the GSS driver shall follow the rules listed in this section. Video BIOS extension block reads and GSS driver extension block reads have not been included in the preferred PnP process flowcharts (figures 2, 3a & 3b). If the Video BIOS is capable of

reading extension blocks then the read shall occur after EDID timing priority completion (Block 15) and before the system POST time (Block 16). If the GSS driver is capable of reading extension blocks then the read shall occur after EDID timing priority completion (Block 23) and before the OS EDID read (Blocks 24 & 25).

The preferred PnP process requires the OS to read and store all extension blocks each time the system has been turned on and a change in the extension blocks has been detected. However, to do this may slow down the system startup process. Therefore, if there is only one extension block, then the OS shall read, error check and store the extension block. For systems that include two or more extension blocks, the OS should read only the information (for example, video timing formats, color management information, etc.) needed to support the system startup process. The OS can determine the location of the important startup information by searching the EDID Block Map/s (Block 1 & Block 128). The OS can read and store additional support information (used by application programs, etc.) at some point after the system startup process has been completed. This procedure will help to speed up the startup process. The OS also has the option to read and store all extension blocks during the startup cycle and then decode the information as needed.

3.3.4.1 <u>Extension Block Read Process</u> ---
--- Blocks 100 ⇒ 114 in Figure 3b – Preferred Process

In the preferred PnP process, the OS shall first determine the number 'Y' of extension blocks (Block 100) that are stored in the monitor. The OS can do this by looking at the number of extension blocks ("Extension Flag" at address **7Eh**) defined in the base EDID.

If 'Y' = 0 (Block 101), then there are no extension blocks and the preferred PnP process returns to Block 52 in Part #1 (refer to section 3.3.2.9).

If 'Y' = 1 (Block 102), then there is only one extension block and the OS shall set the Extension Block Counter (EBC) to zero (Block 103). Also, there are 256 bytes of data (one base EDID & one extension block) stored in the monitor. So the OS needs to read/store only one extension block (Block 106) at addresses **80h** to **FFh**. The process will exit the EBC loop (Blocks 106 ⇒ 109). The preferred PnP process continues at Block 52 in Part 1 (refer to section 3.3.2.9).

If 'Y' ≠ 1 (Block 102), then there are two or more extension blocks and the OS shall set the Extension Block Counter (EBC) to one (Block 105). Also, there are more than 256 bytes of data (one base EDID & two or more extension blocks) stored in the monitor. So the OS needs to read/store the EDID Block Map/s (Block 104) which is the first extension block located after the base EDID block. If there are more than 128 blocks of data stored in the monitor then the OS shall read/store a second EDID Block Map (stored in EDID/Extension Block 128). The preferred PnP process continues at Block 106.

The preferred PnP process requires the OS to read/store (Block 106) and error check (Block 107) each of 'Y' extension data blocks stored in the monitor. The OS is not required to decode all of the data stored in each extension block. Decoding of the stored data should only occur when there is a need for information. This need may come from an application software program, a device driver or the OS.

For each read of an extension block, the OS shall perform error checking to determine if the contents of the extension block are valid. Error checking (Block 107) occurs when the OS adds (using modulo 256) all 128 bytes. If the result of the addition is '00h', then the contents of the extension block are probably valid. The preferred PnP process requires the OS to do one read of a valid extension block. If the OS fails to obtain a valid extension block after one read, then go to section 3.3.4.2. If the OS has read/error checked/stored all necessary and valid extension blocks then the preferred PnP process returns to Block 52 in Part 1 (refer to section 3.3.2.9). This completes the preferred process for the reading and storing of extension blocks.

3.3.4.2 __Invalid Extension Block__ ---

Blocks 110 ⇒ 114 in Figure 3b – Non-Preferred (Recovery) Process

This section defines a non-preferred process that is required to recover from a failure that may occur in the preferred PnP process.

The preferred PnP process requires the OS to do one read of a valid extension block. However, in some cases, the OS may misread a valid extension block (stored in the monitor). This can be caused by noise on the DDC Data Line. In this case, retries should be allowed. The OS manufacturer determines the number of retries (X). However, the more retries, the slower the extension block read process can be. So, a trade-off is required between the number of retries and the speed of the OS extension block read. If the OS cannot read a valid extension block (after 'X' retries) then the OS shall ignore the presence of the extension block. The preferred PnP process then returns to Block 52 in Part 1 (refer to section 3.3.2.9).

3.3.5 Operating System – Additional Requirements

Section 3.3 (above) explains the preferred PnP process for the display/graphics subsystem. Also, the non-preferred (recovery) PnP process explains what shall be done in the event that the preferred PnP process fails. Requirements of the OS have been discussed in parts of section 3.3. However, not all OS requirements have been covered in section 3.3. Here are some additional responsibilities for the OS.

3.3.5.1 __The "Mode - Not Supported" Syndrome__

In some of today's computer systems, the end user is given access to video timing modes (via a Display Properties Control Panel) that are not supported in the monitor and/or the graphics subsystem. When the end user selects one of these non-supported video timing modes, the monitor may not display an image (blank screen). Or, if the monitor does display an image, the resulting quality of the displayed image is substandard. Some monitors will display an "Out of Range" error message.

To prevent this situation from happening, the OS shall decode all video timing modes supported in the monitor. The supported video timing modes are available in the base EDID and optional video timing extension blocks. The OS shall maintain a list of video timing modes supported in the monitor. The OS shall also maintain a list of video timing modes supported by the graphics subsystem. The OS shall give the end user access to only the video timing modes that are supported by both the monitor and the graphics subsystem. The end user shall never be given access to any non-supported video timing modes.

3.3.5.2 __The "CVT Exception"__

It should be noted here that VESA has decided to replace the "Generalized Timing Formula" (GTF) Standard with the "Coordinated Video Timing" (CVT) Standard. The GTF Standard will be (or is) retired. For the purpose of GTF legacy support, all references to CVT in this section can be replaced with GTF. This assumes that the system (graphics subsystem and monitor) are GTF compliant and use EDID data structure version 1.3 (or older). In the case of GTF compliant products, the CVT rules listed here still apply.

VESA's CVT is an exception to the "Mode – Not Supported" Syndrome (section 3.3.5.1). In theory, CVT can generate almost any desired video timing format within a given range of horizontal and vertical scanning frequencies. If the monitor and the graphics subsystem are CVT compliant, then the Display Properties Control Panel shall allow the end user to select one of these desired CVT video timing formats. The OS shall not allow the end user to select a CVT video timing mode that is outside of the minimum and maximum horizontal and vertical scanning frequency ranges (listed in the base EDID - Data type tag 'FDh').

The pixel format of the chosen CVT timing is optional. However, the selected CVT pixel format shall have the same image aspect ratio as defined in the base EDID. The monitor's image aspect ratio can be determined by looking at the preferred timing mode in the first detailed timing block (18 bytes starting at address **36h** in the base EDID). The recommended (standard) image aspect ratios include 4x3, 5x4, 16x9 and 16x10. However, other non-standard image aspect ratios are allowed.

When the end user has selected a desired CVT video timing mode and the graphics subsystem generates video using the new mode, the OS shall request a response from the end user. For example, if the end user sees an acceptable image on the monitor's screen, then the end user clicks an 'OK' (or "Continue", "Yes", "Proceed", etc.) button. If the OS does not receive a response (within a specified period of time. e.g. 15 seconds) from the end user, then the OS shall force the graphics system to switch from the new video timing mode back to the original video timing format.

For more information on CVT, please refer to the reference documents in Section 2.3.

3.3.5.3 The "But, I Want To Do It Myself" Syndrome

Some of today's graphics boards are designed to allow for manual programming of the graphics chips. This can be done by programming data into various hardware registers in the graphics chip. Some graphics board drivers provide an easy to use graphical user interface (GUI) to assist in programming the graphics chips. In some cases, a custom made computer program is required to create these special timings. Using these tools, a technically competent individual can program almost any desired video timing mode. Some of these video modes may be outside of the monitor's horizontal and vertical frequency range limits defined in the base EDID.

Manual programming of a graphics chip is not part of the preferred PnP process. The OS and/or the graphics subsystem driver shall not give the average end user easy access to the programming controls. However, a technically competent individual should be given access to these functions. When an end user attempts to access the manual programming control screens, the OS or the GSS driver shall display a warning message. The average end user shall be warned to not proceed into the manual programming control screens.

3.3.5.4 The "Reduced Capability" Syndrome

In section 1.2, it was mentioned that the capabilities (video pixel formats, color depth, refresh rates, etc.) of the video generating hardware shall match or exceed the capabilities of the monitor. This is a requirement for PnP to work. This situation does not always exist in the real world. The average consumer may not understand the relationships between graphics generating capabilities and monitor supported video timing modes.

In some computer systems, selecting a video timing mode with a higher pixel format may result in a reduction in certain video timing parameters. These reductions may be caused by limitations in the design of the graphics generating subsystem hardware/software. For example, when switching between a 1024 x 768 video timing mode and a 1600 x 1200 video timing mode, the 1600 x 1200 video timing mode may have reduced color depth (24 bit color depth may be switched to 16 bit color or 8 bit color). Or the new video timing mode may be generated with a reduced vertical refresh rate (75 Hz may be reduced to 60 Hz).

If this situation occurs, the OS or the GSS driver shall display a warning message informing the end user that activation of the new video timing mode will result in reduced color depth and/or a lower vertical refresh rate.

3.3.5.5 Changes In The Computer System That May Affect GSS Bandwidth

Some computer systems are capable of making state changes to some of their subsystems. Some of these changes may have an effect on the bandwidth of the GSS. If the GSS bandwidth changes, then the GSS supported video timing modes may also change. If this condition occurs then the OS shall respond.

For example, some computer systems support more than one CPU clock frequency. This is a common feature in battery powered portable devices. The computer may reduce the clock frequency in order to conserve power. If there is a change in the clock frequency, then the OS shall query the GSS driver to see if there have been any changes in the list of GSS supported video timing modes. If there has been a change in the list of supported video timing modes, then the OS shall modify the available video timing modes in the display properties control panel. In addition, if the current video timing mode (prior to the clock frequency reduction) is changed to a different video timing format, the OS shall issue a warning message to the end user. In other words, any changes that occur in a computer system which may result in a GSS bandwidth reduction/change requires the OS to re-enumerate the GSS to determine if there has been a change in the list of GSS supported video timing modes.

3.3.5.6 Icon & Font Size Control --- The DPI Issue

Some of today's desktop monitors (TV/PC monitors, rear projection displays, etc.) have very large DPIs (Dots per Inch). The DPI is the number of pixels that can be displayed in one inch of the display screen. A monitor with a large DPI will generally result in a higher quality (better looking graphics and text) displayed image.

During a "First Time Connection", the OS must determine the DPI of the monitor and select an appropriate icon size and font size before an image is displayed. The end user must not be required to read extremely small text or click on a very small icon.

The OS can calculate the DPI for the attached monitor by looking at the pixel format defined in the Preferred Timing Mode (PTM). The PTM is located in the First Detailed Timing Block (18 bytes starting at address **36h**) of the base EDID (block 0). In most cases, the PTM will define the pixel format of the native mode of the display device (panel, CRT, etc). There are exceptions to this statement. When an exception occurs, the OS may not be able to accurately calculate the correct DPI. If the pixel format information is not available, then it is recommended that the OS use 96 DPI as the default.

The OS must also look at the horizontal and vertical image sizes (stored in addresses **15h** and **16h**). Horizontal DPI is calculated by dividing the horizontal pixel format (count) by the horizontal image size. Vertical DPI is calculated by dividing the vertical pixel format (count) by the vertical image size. Note that horizontal DPI may not be the same as vertical DPI. Once the OS has determined the correct icon and font sizes, the OS must store this information in the user profile contained in the DGSSID object. Stand alone projectors with adjustable image sizes (zoom function) are exceptions. Zero is the image size for stand alone projectors. In this case, the OS cannot determine the DPI. If the image size information is not available, then it is recommended that the OS use 96 DPI as the default.

Once an image has been displayed, the end user may wish to change the icon and font sizes. The OS must allow the end user to easily change the icon and font sizes by the use of an appropriate control panel. If the end user does change the icon and font sizes, then the OS must record the change in the user profile.

3.3.5.7 Operating Systems That Support Multiple Users

Some of today's operating systems allow for multiple users. Each user has an individual login name and password. In this case, the OS must maintain separate user profiles stored in separate DGSSID objects.

3.3.6 Default Actions In The Event Of A "Plug & Play" Process Failure

In section 3.3, there is an extensive discussion of the preferred PnP process in the display/graphics subsystem. A large part of this discussion focused on what happens in the event of a preferred PnP process failure. When a failure does occur, the non-preferred (recovery) process shall be followed. Section 3.3 includes a large number of possible failure modes. However, all possible failure modes cannot be foreseen and many of these possible failure modes were not included in the discussion.

The basic rule is simple. In the event of a known or an unknown failure mode occurrence, the system shall display an acceptable image. An acceptable image is an image that is readable. The acceptable image may or may not be properly sized and centered. This image may contain reduced color depth. The acceptable image shall be in one of the following video timing formats:

1. "Preferred Timing Mode (PTM)" --- (highest priority)
2. "Detailed Timing Format (DTF)" --- (defined in the 2nd, 3rd or 4th detailed timing block)
3. "Standard Timing Formats (STF)" --- (first listed has the highest priority, last listed has the lowest priority) --- may be a DMT, or generated from a CVT calculation.
4. "Coordinated Video Timing" (CVT) --- (pixel format is optional, shall maintain monitor's image aspect ratio & format shall be within the range limits)
5. "Established Timing Formats (ETF)" --- (choice of ETF is optional)
6. "Base Video Mode (BVM)" --- (lowest priority)

In today's computer systems, catastrophic failures can occur. Some of these failures may be caused by the OS, a device driver, an application software program or a computer virus. Sometimes, these failures can be caused by installed hardware. Typically, the result can be as simple as a loss of data or in the worst case a system lockup. These types of catastrophic system failures are beyond the scope of this document. However, from a "Plug & Play" perspective, when these types of failures occur, the OS shall make every attempt to save uncorrupted data to the hard drive and allow the end user the option to shutdown or restart the computer system. The computer system shall not be allowed to lock-up (frozen keyboard) and the end user shall not be allowed (or required) to do a hard power down. In other words, the end user shall be required to follow the normal shutdown procedure (see Block 60 in Figure 2).

3.4 Recovery from Power Savings States (including IAPC)

Most of today's computer systems and monitors have been designed to support power savings states. The purpose of power savings is the reduction of electricity usage and the associated impact on our environment. VESA has been and continues to be a supporter of power savings initiatives. For example, in 2003, VESA published the "Display Power Management (DPM) Standard". In 1993, VESA published the "Display Power Management Signaling (DPMS) Standard". For more information on DPMS and DPM, please refer to the reference documents in section 2.3.

Entering or leaving a power savings state can have an impact on the display/graphics subsystem. The step by step process for entering into or leaving from a power savings state can be relatively complicated and is beyond the scope of this document. The following discussion is based on a "Plug & Play" perspective and is relatively simplified.

Typically, entering or leaving a power savings state starts with the computer and the OS. After a certain period of inactivity (controlled by a user definable clock), the OS will transfer most of the information in main memory to the hard drive. This information may include but is not limited to the desktop content (icons, etc.), active device drivers, active (running) application software programs and data for the application software programs. The OS then shuts down (or reduces power to) various subsystems within the computer. When the OS shuts down the graphics subsystem (GSS), video (and/or sync) is no longer transmitted to the monitor. The monitor then responds by entering into one of its power savings states.

Computer systems and monitors may have one or more power savings states. The lower the state, the more power is saved. When there are more than one power savings states, there maybe some transition time between leaving a higher power savings state and entering a lower power savings state. Commonly used terminology is "sleep" mode and "deep sleep" mode. Typically, leaving a power savings state requires a keystroke, a mouse event or contact with a touch screen. The computer system shall wakeup first. The OS shall restore the information (that was saved on the hard drive) to the main memory. The OS will then re-activate various subsystems including the graphics subsystem. The graphics subsystem shall output a video signal (in the same video timing format and image content) that was in use prior to entering the power savings state. Once the monitor detects a valid video signal at the video input, the monitor chassis shall wakeup and transition from a power savings state to full on. An image is then displayed on the screen. The displayed image shall be identical to the image that was displayed prior to entering the power savings state. If there has been a change in the computer's state (compared with prior to entering the power savings state), for example, a change in clock frequency, then the OS shall re-enumerate the GSS to determine if there have been any changes in the GSS supported video timing modes (refer to section 3.3.5.5).

There are some computer based products which can be classified as Instantly Available Personal Computers (IAPC). Some pocket and tablet PCs are examples of such devices. For many of these types of products, the OS is embedded in firmware and the device drivers, application software programs, etc. are kept in non-volatile memory. Some of these devices have video output ports that can be connected to an external desktop monitor. Power management for these types of devices is important since most of these devices are battery powered. For IAPC type devices, the same rules apply when entering or leaving a power savings state.

3.5 Swapping Monitors Using a Cold Restart

A cold restart is defined as a normal power up of a computer and a monitor at some point in time after the computer and monitor have been properly shutdown. A proper computer shutdown means that the OS has closed all running application programs and stored (on a hard drive) all data files associated with these application programs. The shutdown process may require the OS to perform additional tasks. Then the computer and the monitor have been powered down.

During the time between a computer shutdown and a cold restart, it is possible that the external monitor could be changed. This situation is especially true for notebook computers, tablet PCs, PDAs and other portable computing devices. These devices can be plugged into base stations that are connected to an external monitor. For example, a notebook computer that is used in the office and in the home may be connected to two different monitors. In the past, some operating systems failed to detect that a lower resolution (eg.1024x768) LCD monitor has replaced a higher resolution (eg.1600x1200) LCD monitor. The result is a blank screen (or "Out of Range" Error) at power up causing some end users to make unnecessary phone calls to someone's customer support line.

To prevent blank screens, the OS (and possibly the graphics subsystem driver) shall read and decode the base EDID table each time the computer and monitor are powered up. The OS (and possibly the graphics subsystem driver) shall compare the Manufacturer's ID and the Product ID of the current monitor at startup with the

Manufacturer's ID and the Product ID of the previous monitor that was connected at shutdown. If the compared IDs are the same, then the operating system does not have to make any changes. If, however, the compared IDs are different, then the operating system has to go through the process defined in section 3.3 above.

3.6 Swapping Monitors Using Hot Plug Detection (HPD)

Hot Plug Detection (HPD) is the ability of a computer system to detect the disconnection and/or reconnection of an external monitor to the video output port on the computer. HPD can only occur when the computer is on. Not all video interface specifications/standards support HPD. The VGA analog video interface (industry standard) does not support HPD. Some of the digital video interface specifications/standards (P&D, DFP, DVI, etc.) support HPD. A +5 VDC source on the computer's video output connector is routed to the external monitor via the video interface cable. The +5 VDC is rerouted (as a loop-thru in the monitor) via the HPD pin on the monitor's video input connector to the HPD pin on the computer's video output connector. If the computer sees 0 VDC on the HPD pin, then an external monitor is not connected to the video output port. If the computer sees +5 VDC on the HPD pin, then an external monitor is connected to the video output port.

Some desktop computers and portable computing devices (such as notebooks, tablet PCs, PDAs, etc.) support HPD. This means that an external monitor can be disconnected from or connected to a computing device while the system is powered on.

The design of the graphics subsystem shall include hardware that monitors the +5 VDC HPD pin on the video output connector. The graphics driver shall monitor the HPD pin hardware. As long as +5 VDC is on the HPD pin, then an external monitor is connected to the computing device and the graphics driver shall activate the video output port. If however, the HPD pin drops to 0 VDC, then an external monitor has been disconnected and the graphics driver shall shut down the associated video output port. The graphics driver shall also notify the OS. If the HPD pin rises to +5 VDC, then an external monitor (possibly a different monitor) has been reconnected to the computer system. In this case, the graphics driver shall reactivate the video output port and then notify the OS. Then the OS (and/or GSS driver - optional) shall re-read and decode the base EDID table. Then the OS shall compare the Manufacturer's ID and the Product ID of the current monitor with the Manufacturer's ID and the Product ID of the previous monitor that was connected to the video output connector. If the compared IDs are the same, then the operating system does not have to make any changes. If, however, the compared IDs are different, then the operating system has to go through the process defined in section 3.3 above. More information on HPD is located in section 3.3.2.5.

4. Appendix A – Some Special Cases

4.1 Discussion on Signed and Unsigned Display Drivers

Some operating systems (OS) require the use of signed drivers. Signed drivers have digital watermarks embedded in them or the digital signature is part of a catalog file. The presence of the digital watermark (catalog file) indicates to the computer system that the manufacturer who created the driver did so in accordance with driver specifications created by the OS manufacturer. In some cases, the signed drivers have been tested and certified to comply with the driver creation specifications.

The required usage of display drivers is not part of the preferred PnP process (as defined in section 3.3). However, the use of signed display drivers can improve the non-preferred PnP process in the graphics/display subsystem by reducing software errors and possible driver conflicts in the computer system. Signed display drivers may include but are not limited to information files (INF), color management profiles (ICM) and catalog files (CAT). For more information on the subject of display drivers, refer to section 5.2.

When an OS requires signed drivers, the monitor manufacturer should provide signed display drivers for their products. Some monitors may be shipped with unsigned display drivers. The use of unsigned display drivers shall never be blocked by the OS. It is appropriate for the OS to issue a warning message to the end user that they are about to load unsigned display drivers. But the OS shall not prevent the loading and activation of unsigned display drivers. From a PnP perspective, signed display drivers should be more reliable than unsigned display drivers.

The installation of signed or unsigned display drivers may cause software conflicts and/or system failures. The OS shall be designed to provide the end user with an easy access to an uninstall function. In the event that a defective display driver has been installed, the uninstall function can be used to remove the defective display driver. The uninstall function shall also return the computer system to a state which existed prior to the installation of the defective display driver.

4.2 Multiple Head Graphics Cards or Several Graphics Cards in a Single Computer

This section discusses the special cases of multiple head graphics cards, several graphics cards in a single computer and the mixing of analog and digital video signals on the same connector.
Today, multiple head (2, 3, 4 or more video outputs from a single connector) graphics cards are available in the marketplace. Some of these special graphics cards include both analog and digital video outputs. Most of these multiple head graphics cards include one DDC communications channel per pair of video output channels. These video outputs can be a pair of digital outputs, a pair of analog outputs or one analog output and one digital output. These multiple head graphics cards can be connected to a single monitor with multiple video inputs (using separate connectors or a single connector) or to several monitors with single video inputs. The preferred PnP process requires that for each DDC communications channel only one video output channel can be active at any one time. Both video output channels (in the associated pair) cannot be active at the same time. Therefore, the video cabling shall be designed such that only one video output channel is connected to the monitor's video input connector. A monitor with two or more video input channels (using single or multiple input connectors) can have only one video input active at any one time (see exception below). Also, it is the responsibility of the Video BIOS, GSS driver and/or the OS to determine (using information in the base EDID data table) what type (analog or digital) of monitor video signal input is connected to the host system. If the Video BIOS-GSS-OS detects an analog EDID, then the Video BIOS-GSS-OS shall turn on the analog video output port on the multiple head graphics card's connector. If the Video BIOS-GSS-OS detects a digital EDID, then the Video BIOS-GSS-OS shall turn on the digital video output port on the multiple head graphics card's connector.

There may be applications (for example, an end user may want to double the size of the desktop) where both video channels are required to drive a single monitor (with 2 video input channels) or two separate monitors. Here the preferred PnP process cannot work. In this case, the graphics board driver and the OS has to provide the end user with a simple display properties control interface. The end user can then manually turn on both video channels at the same time.

Another special case is several graphics cards in the same computer. Several graphics cards in the same computer can be used to drive several monitors (individual or tiled). This type of application can be used to increase the size of the computer's desktop area. In this case, the preferred PnP process requires the graphics subsystem driver and the OS to detect (and store information in the DGSSID Objects) which monitor (with what capabilities) is connected to which video graphics card (or video output port). The graphics subsystem driver and the OS shall also provide the end user with a simple display properties control interface. The end user can then manipulate the display/graphics subsystem to display the desired image on the desired monitor.

4.3 Comments on the Use of Distribution Amplifiers

Some computer system setups will use a distribution amplifier to drive several monitors from a single video output port. Distribution amplifiers typically have a single video input port and several (2, 4, 8, 16, or more) video output ports. This is a special case because a single DDC host (e.g. personal computer, etc.) cannot communicate with several DDC devices (e.g. monitors, etc.). In these types of setups, PnP (the DDC communications link) shall be associated with video output port 1 on the distribution amplifier. The host computer shall read the EDID data from the monitor connected to video output port 1. Video output ports 2, 3, etc. shall not be used to read EDID data. In the case where monitors with different preferred timing modes are connected to a distribution amplifier, the end user shall connect the monitor with the lowest resolution preferred timing mode to video output port 1. This will prevent "Out of Range" errors on one or more of the monitors connected to the other video output ports on the distribution amplifier.

5. APPENDIX B – Some Miscellaneous Items

5.1 Scalers in the "Plug & Play" Environment

In some computer system setups, it is possible that both the graphics subsystem and the monitor may have scalers on board. Scalers are sophisticated devices which can convert one video timing format to another video timing format. The conversion process may include a change in pixel format, a change in horizontal and/or vertical scanning frequencies, a change in color depth, a change in pixel clock frequencies, etc. Scaling can include up conversion and down conversion. In most cases, the conversion process results in the addition of video anomalies to the converted image. To reduce or minimize the effects of video anomalies, high end scalers include sophisticated filtering algorithms.

Most CRT monitors do not have scalers on board. Most flat panel monitors (LCD, plasma, etc.) do have some form of scaling on board. Fixed format displays (e.g. flat panel monitors) have a native mode. The native mode is the optimal video timing mode for the display device (the flat panel). Native modes of the flat panel device are determined by the number of horizontal and vertical pixels that can be displayed on the screen. Also, most flat panel technologies are designed to operate at an optimum vertical refresh rate. Scalers typically convert the input video timing format to the native mode of the display device. In most cases, the native mode of a flat panel is the same as the preferred timing mode. However, there are some flat panel monitors where the native mode of the panel display device exceeds the capabilities of the video interface. In this case, the native mode of the flat panel is not the same as the preferred timing mode.

In the preferred PnP process (see section 3.3), the host computer should output a video signal in the preferred timing mode (stored in base EDID). When most flat panel monitors see a preferred timing mode (at the video input), scaler conversion is not required and the video is simply passed thru to the display device. There are cases where a host computer cannot output a preferred timing mode. The graphics subsystem may not support the preferred timing mode or a software application program (e.g. some games) cannot be output to the monitor in the preferred timing mode. In this case, the system has to rely on the monitor's scaler to convert the video signal.

There are flat panel monitors which are designed to operate at one and only one video timing format. There is no scaler on board the monitor. There is only one video timing format supported by these types of monitors and the EDID table shall indicate only one timing format. In this case, the graphics subsystem (in the host computer) shall do the scaling. All images shall be converted to the preferred timing mode (native mode). There may be some images that cannot be converted (startup screens). The GSS shall display these images (lower pixel formats) somewhere in the preferred timing field.

In some monitors, the scaling function may be superior to the scaling function in the host computer and visa versa. For the case where scaling can be done in both the monitor and the graphics subsystem, the end user should be given the option to select one scaler over the other scaler. There are 2 ways to do this. First, the end user can simply change the video timing format from the preferred timing format to a lower pixel format video timing mode. Then the monitor will scale the image up to the display device's native mode. The OS shall provide the end user with an easy to use control interface to select the desired video timing mode. Another method is to include the display information extension (DI-EXT) block in the monitor. DI-EXT contains one bit which indicates the presence of a scaler in the monitor. When the host detects the presence of a scaler in the monitor, the OS should give the end user a choice to select the monitor or the host to provide the primary scaling function. For more information on DI-EXT, please refer to the reference documents in section 2.3.

5.2 A Case for the Elimination of Display Driver Files

Some operating systems (OS) require the use of display drivers. Display drivers may include but are not limited to information files (INF), color management profiles (ICM) and catalog files (CAT). Other support files may also be included. The preferred PnP process (see section 3.3) does not include support for the use of display drivers. Today, monitor manufacturers are required to ship display drivers with their products. During a first time connection (a new base EDID read), the OS may request that the display drivers be installed. Many end users become confused by this request. They are required to search the monitor's shipping carton for a CD-ROM or a floppy disc and then install the display drivers. Sometimes the display drivers are not available because the CD-ROM or floppy disc was lost. This manual step is not compatible with a true "Plug & Play" environment.

It should be possible to design an OS that does not require the installation of display drivers. Information contained in display drivers should be available in the base EDID and associated extension blocks. The OS should be able to create display drivers using the information stored in the base EDID (and extensions).

Display drivers may be necessary in the event that there is a failure in the preferred PnP process to read and/or decode the EDID content (see section 3.3). In this case, the OS should activate a generic display driver which was shipped as part of the operating system. However, caution is required. The OS shall never allow the end user to manually select a video timing format that is outside the range supported by the monitor. So the OS shall ask the end user to select one driver from a list of available generic display drivers. The end user's selection should be based on the highest resolution video timing format supported by the monitor.

To improve the end user experience (Ease of Use), the industry should move toward the elimination of display drivers for monitors.

5.3 Localized EDID Tables (Native Languages)

Most of today's computer monitors contain a base EDID table. The base EDID (128 bytes of encoded data) contains information that describes the capabilities of the monitor --- video timing formats supported, color management/chromaticity information, etc. The computer can store this information in the DGSSID Object. The DGSSID Object can be used to support true "Plug & Play". Additional information such as manufacturer's ID, model name, serial number, etc. can also be stored in the base EDID using strings based on ASCII codes (or compressed ASCII). The problem with ASCII codes is that these strings are not user friendly when dealing with certain languages (e.g. Chinese, Japanese, Korean, Arabic, etc.).

The solution to this problem is to develop Multi-Lingual String Table Extension Blocks. These extension blocks could provide strings in regional languages or in languages that match the localization of the operating system. Unicode (http://www.unicode.org) is the best choice for encoding international characters. These Unicode based multi-lingual strings could replace the ASCII based strings that are in the base EDID. Most of today's major operating systems support Unicode in some form or another.

VESA has published the "Enhanced EDID Localized String Extension Standard" (LS-EXT) Release A, July 10, 2003. LS-EXT supports Multi-Lingual String Table Extension Blocks (based on Unicode). The LS-EXT mechanism allows for the display of user-friendly information in the language of the user. LS-EXT accomplishes this by using Unicode for all strings, which contains all the characters of the world, and thus displays correctly on any Unicode-compliant computer. For more information, refer to VESA's LS-EXT Standard.

5.4 Handling Updates To EDID Data Structures

On occasion, VESA will publish updates (revisions) to the E-EDID Standard. Some of these updated E-EDID Standards may contain new EDID data structure definitions. When VESA publishes a new EDID data structure with a new revision number (and the version number stays the same), the new EDID data structure is backward compatible. For legacy support, an older host system (that recognizes EDID version 1, revision 3, for example) connected to a monitor with a newer EDID data structure (for example --- version 1, revision 4), the host must decode the EDID data using the version 1, revision 3 definitions. When doing this, the Video BIOS/GSS Driver/Operating System EDID read/decode may result in some errors. These errors may appear to be corrupted data. If possible, the Video BIOS/GSS Driver/Operating System must ignore the corrupted data. The "Plug & Play" process must still work.

An older host system must never shut down a video output port when it detects a new monitor with a new EDID data structure.

6. APPENDIX C – Glossary

The following table contains a glossary of some terms and acronyms used in the PnP Standard.

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.
2	CVT	Coordinated Video Timing – indicates a reference to VESA's CVT Standard
3	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.
4	DFP	Digital Flat Panel –reference to VESA's DFP Standard
5	DGSSID	Display Graphics Subsystem Identification Object: A file or location where Plug and Play support information is stored.
6	DI-EXT	Reference to VESA's Display Information Extension Block Standard
7	Display Drivers	Software (supplied with a monitor) which can include information files, color profiles, catalog files, etc. Not to be confused with the graphics subsystem driver.
8	Display/Graphics Subsystem (DGS)	Those subsystems associated with a computer setup which generate and display a computer image. DGS includes the graphics generating hardware/software (driver), a video transport (interface) mechanism and a monitor.
9	DPM	Display Power Management –reference to VESA's DPM Standard
10	DPMS	Display Power Management Signaling –reference to VESA's DPMS Standard
11	DTF	Detailed Timing Format – Defined in VESA's E-EDID Standard
12	DVI	Digital Visual Interface –Reference to the Digital Display Working Group's DVI 1.0 Specification
13	EDID	Extended Display Identification Data – Reference to the base (block 0) 128 bytes of encoded data stored in the monitor.
14	E-DDC	Reference to VESA's Enhanced Display Data Channel Standard
15	E-EDID	Enhanced Extended Display Identification Data – Reference to VESA's E-EDID Standard
16	ETF	Established Timing Format
17	GSS	Shorthand reference to the Graphics Subsystem, includes any graphics generating hardware and support software located in a computer.
18	GTF	Generalized Timing Formula –Reference to VESA's GTF Standard
19	P&D	Plug & Display – Reference to VESA's P&D Standard
20	PDA	Personal Digital Assistant
21	PnP	Refers to the "Plug & Play" process.
22	POST	Short for "Power On Self Test", a series of diagnostic tests that run automatically when you turn your computer on.
23	PTM	Preferred Timing Mode – Defined in VESA's E-EDID Standard
24	STF	Standard Timing Format – Defined in VESA's E-EDID Standard
25	Video BIOS	Basic Input Output Services: Firmware associated with the graphics generating subsystem.
26	PnP	Refers to VESA's "Plug & Play" Process Flowcharts and Standard.