



# **An Introduction to DVD Formats**

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# 1. Introduction

**DVD**, the Digital Versatile Disc, is a high capacity CD-size disc for video, multimedia, games and audio applications. Capacities for the read-only disc range from 4.7GB to 17.1GB. The high quality of video and audio has helped DVD-Video to grow rapidly as the foremost packaged media format for movies and statistics show that DVD has grown faster than any other consumer electronics format in the USA and Europe. PCs come with DVD capability, but multimedia and games applications of DVD have been slow to start. The advent of new games consoles using DVD is also helping to stimulate further sales.

## 1.1 DVD Applications

Despite the success of the compact disc there has been a clear need for a higher capacity format to meet additional application requirements.

- **DVD-Video**, which was launched in 1997 in the USA, has become the most successful of all the DVD formats. It can store a full-length movie in high quality video with surround sound audio on a disc the same size as a CD. DVD now accounts for the majority of video sales in the USA and Europe.
- **DVD-ROM** is beginning to replace the CD-ROM and provide a new high capacity disc format for the computer industry. New PCs are now provided with DVD drives and new games consoles (eg Sony's PS2 and Microsoft's X-Box) include DVD-ROM drives for more realistic games applications.
- **DVD-Audio**, which was launched in 2000, is slowly gathering momentum to become the format for very high quality, surround sound music, offering the music industry new revenue opportunities.
- **DVD-R, DVD-RAM, and DVD-RW** are recordable and re-writable formats that are now being extensively used in PCs for computer backup and short runs of DVDs and in standalone products such as video recorders and camcorders.
- **DVDPlus** (also known as 'DualDisc') is a double sided hybrid format combining a DVD side with a CD side and offering playability in CD players as well as DVD players.

DVD-Video and DVD-ROM hardware and software have been available since 1997. DVD-Audio was launched in 2000. DVD writers and DVD video recorders are now available at affordable prices.

## 1.2 DVD Features

DVD started as the Digital Video Disc but now means Digital Versatile Disc or just DVD. It is a multi-application family of optical disc formats for read-only, recordable and re-writable applications. The main features of the DVD formats are:

- Backwards compatibility with current CD media. All DVD hardware will play audio CDs and CD-ROMs and most will play CD-Rs and CD-RWs.
- Physical dimensions are identical to the compact disc but each disc comprises two 0.6 mm thick substrates, bonded together.
- Single-layer/dual-layer and single/double sided options are available.
- Up to 4.7 GB read-only capacity per layer, 8.5 GB per side maximum.
- Designed from the outset for video, audio and multimedia, not just audio.
- All formats use a common file system (UDF).

- Built-in digital and analogue copy protection for DVD-Video and DVD-Audio.
- Recordable and re-writable versions are part of the family.

### 1.3 DVD History

DVD started in 1994 as two competing formats, Super Disc (SD) and Multimedia CD (MMCD). DVD was the result of an agreement by both camps on a single standard to meet the requirements of all the various industries involved. The major milestones are listed in Table 1.

**Table 1 DVD Milestones**

1994	Hollywood ad hoc committee defined features for movies on 'CD'.
1995	Agreement on a single standard format called DVD.
1996	DVD-ROM and DVD-Video specifications version 1.0 published Digital copy protection scheme (CSS) agreed First DVD-Video players sold in Tokyo (November)
1997	Launch of DVD in USA (August) DVD Consortium becomes DVD Forum, expands membership and holds first General DVD Forum Meeting with 120 members
1998	DVD-Video version 1.1 and DVD-ROM version 1.01 specifications issued. DVD Forum adopts DVD-RW as another re-writable format 7 new members of DVD Forum Steering Committee making 17 in all DVD Forum publishes DVD-Audio specification version 0.9 Full launch of DVD in Europe. 1m DVD-Video players sold in USA 4.7 GB DVD-R and DVD-RAM version 1.9 specifications released
1999	DVD-Audio (1.0), DVD-Video Recording (0.9 & 1.0), DVD-RW (0.9) and DVD-RAM (2.0) specifications published.
2000	CPPM copy protection for DVD-Audio agreed DVD-Audio players launched in USA (July) First DVD-Audio discs in USA (November) DVD-RW Part 2 (1.0), DVD-R for Authoring (2.0), DVD-R for General (2.0) and DVD Stream Recording (0.9) specifications published.
2001	DVD-Audio players & discs available in Europe and elsewhere DVD Video Recorders launched in Europe etc Guidelines for IEEE 1394 transmission for DVD-Video/Audio issued. DVD Video Recorders launched in Europe etc DVD-Multi (1.0), DVD Stream Recording (1.0), DVD-Audio (1.2) and DVD-Video Recording (1.1) specifications published.
2002	WG-11 created to study future blue laser format DVD-Audio recording specification ver 0.9 issued Hybrid DVD-Audio format approved by DVD Forum
2003	DVD Forum rejects hybrid DVD-Audio format; selects 0.6mm HD DVD, shelves 0.1mm version and releases iDVD specifications.
2004	DVD Forum adds three new members to Steering Committee DVD Forum approves HD DVD-ROM specification and the addition of AAC to DVD-Audio discs and approves new logo for HD DVD-ROM disc. DVD Forum adds thin substrate for DVD side of DVDPlus disc;

## 2. DVD Specifications

The DVD technical specifications are contained in five books A to E created and maintained by the DVD Forum and listed in Table 2.

**Table 2 DVD Book Specifications**

Book	Name	Part 1 Physical	Part 2 File System	Part 3 Application	Version
A	DVD-ROM	Read-only	ISO9660/UDF	undefined	1.01
B	DVD-Video	Read-only	UDF	MPEG-2 video	1.1
C	DVD-Audio	Read-only	UDF	MLP & PCM audio	1.2
D	DVD-R	Write once	UDF	not defined	2.0
E	DVD-RAM/RW	Rewritable	UDF	not defined	2.0

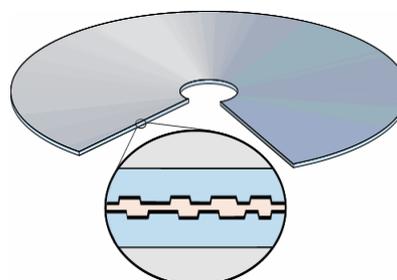
Note that SACD, DVD+R and DVD+RW, although based on the DVD physical format, are not approved by the DVD Forum.

Like CDs, all DVD discs are 12 cm in diameter and nominally 1.2 mm thick. The maximum disc thickness is 1.5 mm to include the on-body printed label. This maximum thickness is used for DVDPlus discs which are nearly 1.5 mm thick but do not include a disc label (see 2.1).

### 2.1 Pre-recorded Disc Formats & Parameters

Although identical in appearance, DVDs and CDs differ in a number of key physical parameters.

To meet the capacity requirements of 4.7 GB the designers of the DVD format needed a shorter wavelength laser than CD and a higher numerical aperture. Also it was found necessary to reduce the thickness to 0.6 mm to allow discs to be manufactured without unacceptably small tolerances for tilt (disc warping). As a result each DVD comprises two such substrates bonded together to produce a single disc 1.2 mm thick (see Figure 1).



**Figure 1 DVD Construction**

The use of a sandwich of two substrates also allows a range of formats, with capacities from 4.7 to as much as 17.1 GB. These are listed in Table 3 and illustrated below.

**Table 3 DVD Physical Disc Formats**

	DVD-5	DVD-9	DVD-10	DVD-18	DVD-R	DVD-RW	DVD-RAM
Capacity (GB <sup>1</sup> )	4.7	8.54	9.4	17.08	4.7	4.7	4.7 or 9.4
Layers/side	1	2	1	2	1	1	1
Sides	1	1	2	2	1	1	1 or 2

<sup>1</sup> Note that for capacity purposes one GB (gigabyte) is actually a billion bytes or  $10^9$  bytes. This contrasts with normal computer storage capacities whereby a GB is  $1024 \times 1024 \times 1024$  bytes. Therefore the capacity of a DVD-5 disc is 4.337 GB using the latter definition.

**DVD-5** discs comprise a sandwich of two 0.6mm substrates (see Figure 2), one metallised and with data, the other blank, bonded together. The data is read from one side only so that labels can be printed on the top surface of the disc as for CDs.

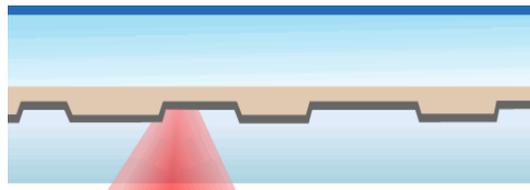


Figure 2 DVD-5 Disc

**DVD-9** discs (see Figure 3) comprise one semi-reflective substrate (layer 0) and one fully metallised substrate (layer 1) above it giving a reduced capacity of 4.25 GB per layer, to ease the manufacturing tolerances for such discs. Labels can be printed as for DVD-5 discs and CDs.

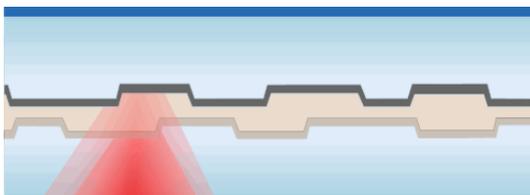


Figure 3 DVD-9 Disc

**DVD-10** discs (Figure 4) comprise two metallised substrates bonded together and read from both sides. The disc label is restricted to a small annular area within the disc hub, on both sides of the disc. These discs have been superseded by DVD-9 discs, which are read from one side.

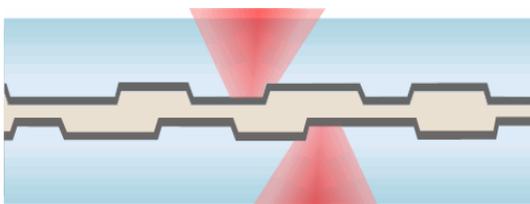


Figure 4 DVD-10 Disc

**DVD-18** discs, which have limited availability, comprise two dual-layer substrates bonded together and read from both sides. The disc label is restricted as for DVD-10 to small annular areas on both sides. These are not yet widely used due to manufacturing difficulties and the perceived extra value of two DVD-9 discs instead of one DVD-18.

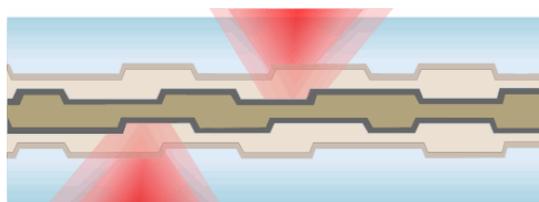


Figure 5 DVD-18 Disc

## Pre-recorded DVD Disc Parameters

Table 4 provides a comparison between the main physical parameters of DVD and CD discs. Note the smaller geometries and two layers/sides.

Table 4 DVD Disc Parameters

Parameter	CD	DVD	Comments
Sides	1	1 or 2	See 2.1
Layers	1	1 or 2	
Capacity (GB)	0.68	4.7 - 17	1 GB = 10 <sup>9</sup> bytes (not 1024 <sup>3</sup> )
Track pitch (μ)	1.6	0.74	Radial distance between pits
Minimum pit length (μ)	0.83	0.4	For I3 pit
Wavelength (nm)	780	650	of laser diode pickup
Numerical aperture (NA)	0.45	0.6	defines angle of beam
Linear velocity (m/s)	1.3	3.49	at nominal 1x speed

Parameter	CD	DVD	Comments
Modulation	EFM	8 to 16	EFM is 8 to $(14 + 3) = 17$
Error protection	ECC	RSPC	RSPC is block protection
3rd layer ECC	Yes	No	not needed for DVD after RSPC
Subcode	Yes	No	no subcode needed
Tracks	Yes	No	DVD uses files not tracks

## Hybrid and combination disc formats

A number of formats that combine different formats on different layers have been developed.

**Combination disc formats**, for example combining DVD-ROM on one side with DVD-RAM on the other, have been approved by the DVD Forum.

**Hybrid SACD** was developed by Philips and Sony and combines an SACD (ie physically a DVD layer) with a CD layer (see Figure 6). Both layers are read from the same side, which means that the SACD layer must be reflective for the red laser but will transmit the infra red CD laser. Such discs can then be played on both a CD player (which will read the CD layer) and a SACD player.

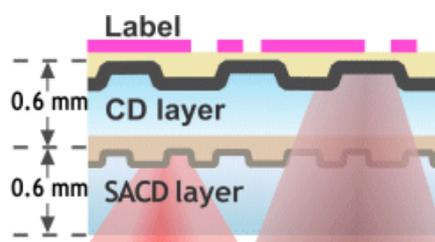


Figure 6 Hybrid SACD

**Hybrid DVDs**, comprising a CD layer and a DVD layer, were studied by the DVD Forum, but it was found that over half of DVD players would not read the DVD layer of such discs. This format would have been suitable for a DVD-Audio/CD audio combination which is almost identical to the hybrid SACD format.

**DVDPlus** is an alternative format comprising a CD bonded to a DVD substrate. The resulting disc allows both DVD and CD data to be read from one disc, like a hybrid DVD, but the disc is read from both sides. Early versions of this format were 1.8 mm thick, but this has been reduced to 1.5 mm. These discs are also called **DualDisc**.

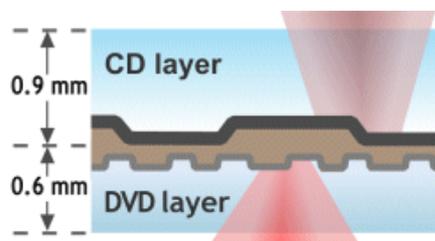


Figure 7 DVD Plus

The DVD Forum has approved the use of a slightly thinner single layer DVD substrate (at 0.565 mm) for such discs to allow the overall thickness to meet the maximum of 1.5 mm for both CDs and DVDs. Current DVDPlus discs are a little less than 1.5 mm thick. The alternatively named DualDisc, which has been launched by the major music companies, is essentially identical to DVDPlus.

## 2.2 Recordable/Re-writable DVD Formats

The recordable and re-writable formats include two DVD-R types plus DVD-RW and DVD-RAM. In addition DVD+R and DVD+RW are alternative formats that are not supported by the DVD Forum.

### DVD-R and DVD+R

DVD-R discs make use of a similar technology to CD-Rs but with a different dye and smaller geometries. The first version of this format had a capacity of 3.95

GB but current versions offer 4.7 GB, with a dual layer version (DVD-R DL) offering 8.5 GB per disc. There are two types of DVD-R disc.

- **General purpose** discs are intended for use by consumers but do not allow any data to be written to the lead-in area. This means that, for example, CSS copy protection cannot be used, but provision is made for adding CPRM copy protection.
- **Authoring use** discs which are intended to be used by authoring studios to test titles and also as media for glass mastering.

The two different types require two different recorders and media. One recorder can only write one type of media. The parameters for DVD-R discs are listed in Table 5

**Table 5 DVD-R Disc Parameters**

Parameter	Ver 1.0	Authoring use	General use
<b>Capacity (GB)</b>	3.95	4.7	4.7
<b>Recording method</b>	Organic dye layer		
<b>Laser wavelength</b>	635/650nm	635nm	650nm
<b>Min pit length (microns)</b>	0.44	0.40	0.40
<b>Track pitch (microns)</b>	0.80	0.74	0.74
<b>Pre-pit addressing</b>	increment	increment	decrement
<b>Serialisation for CPRM</b>		No	Yes
<b>Track format</b>	Wobble pre-groove		

DVD-R is compatible with DVD-ROM, DVD-Video and DVD-Audio so that recorded DVD-R discs can be read on any suitable DVD hardware, depending on the format of the data contained on the DVD-R. However discs cannot use CSS copy protection. Also DVD-9 discs cannot be written to DVD-R. Media and drives are capable of up to 8x writing speed, with speeds up to becoming available in the future.

DVD-R discs allow incremental writing including drag and drop file transfer and using UDF. Each section of data written to the disc is a Bordered Area and is followed by Border Out and Border In which precede the next Bordered Area (if any). Each Bordered Area begins with the UDF file system and ends with the Virtual Allocation Table (VAT).

**DVD+R** discs are not recognised by the DVD Forum, but are very similar to DVD-R General media. The format was developed by Philips and Sony as an extension of the DVD+RW format supported by the DVD+RW Alliance comprising HP, Philips, Ricoh, Sony, Yamaha, Verbatim/Mitsubishi Chemical, Dell and Thomson. Speeds up to 8x are available with faster media and drives expected in the future.

## **DVD-RAM, DVD-RW and DVD+RW**

DVD-RAM and DVD-RW are the two official re-writable DVD formats. Both formats use phase change recording where the active layer is made to change between amorphous and crystalline state by means of a laser at different power. The differences between the two formats are shown in Table 6 below.

Table 6 Parameters for DVD-RAM and DVD-RW

Parameter	DVD-RAM Ver 1.0	DVD-RAM Ver 2.1	DVD-RW Ver 1.0
Sides	1 or 2	1 or 2	1
Capacity (GB)	2.6 per side	4.7 per side	4.7 per side
Recording method	Phase change marks		
Track format	Wobble land & groove		Wobble groove
Track pitch (microns)	0.74	0.615	0.74
Min pit length (microns)	0.41	0.28	0.40
Number of zones	24	35	
User data rate (Mb/s)	11.08	22.16	

**DVD-RAM** discs use land/groove recording and Zoned CLV (ZCLV) method instead of CLV, where the angular velocity continuously changes. Within each zone the data is written/read using the CAV method, the angular velocity changing from zone to zone to maintain a constant average linear velocity. The data is written on both land and groove, the address information being moulded into the disc as pits.

The current specification (version 2.1) is for 4.7GB or 9.4GB (double sided) capacity media (12 cm) which offer over 100,000 recording cycles and a 30-year life or more.

**DVD-RW** discs use groove recording offering a 4.7GB capacity per side. The format offers advantages over tape in life (videotape life is only 15 to 20 years) and the ability to edit home movies. DVD-RW discs are designed to be compatible with existing players and drives. Discs are recordable over 1,000 times and they have the same optical properties as a DVD-9 disc.

DVD-RW discs can be used for videotape replacement, video authoring and desktop PC backup. Consumer applications include video recording and home authoring. DVD-RW discs also offer CPRM copy protection and can include BCA serialisation.

**DVD+RW** is a re-writable format introduced in October 2001 by the DVD+RW Alliance (HP, Philips, Ricoh, Sony, Yamaha, Verbatim/Mitsubishi Chemical, Dell and Thomson). It is not supported by the DVD Forum. DVD+RW discs have a capacity of 4.7 GB and do not need a cartridge. They offer 1,000 re-writes.

DVD+RW incorporates lossless linking technology, allowing the drive or video recorder to accurately stop and start the writing process, or to replace individual 32kB data blocks. Lossless linking improves compatibility, performance and ease of use.

For PC applications, CAV (constant angular velocity) recording allows fast, random access reading of the disc. Multi-session writing, as for CD-R, allows users to add data at a later date. DVD+RW's defect management ensures that data is accurately written to and read from the disc.

## 2.3 DVD Disc Layouts

The dimensions and other details for DVD discs are shown in Figure 8. Close to the centre hole is the clamping area bounded by the stacking ring, which is needed to ensure that when discs are placed on spindles after replication they

do not stick together. The annular space between the stacking ring and the outside of the disc is the Information Area, the contents of which depend on whether the disc is single or dual layer.

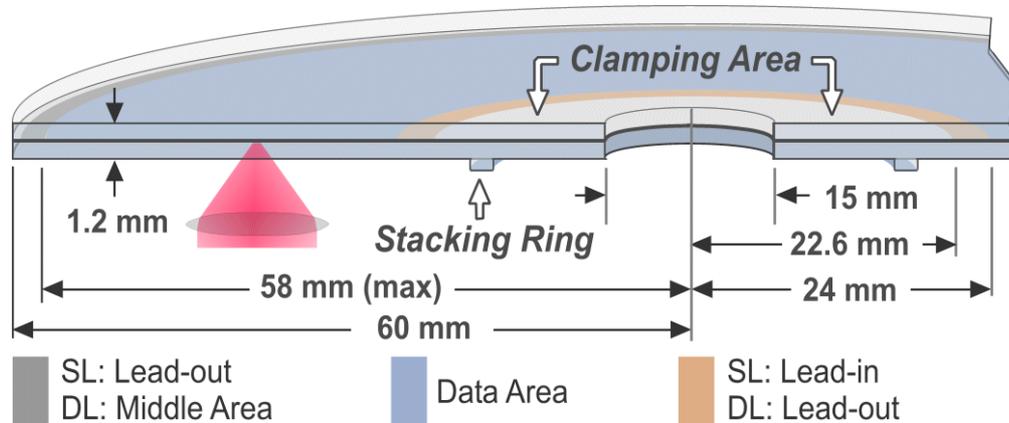


Figure 8 DVD Disc Layout and Dimensions

### Single and dual layer information area

For a single layer (SL) disc the Information Area is divided into three areas, similar to a CD.

- **Lead-in**, which starts at radius 22.6 mm, contains the control data which identifies the type of disc, the layer and other information.
- **Data area**, which starts at radius 24 mm, containing the data content.
- **Lead-out**, which follows the Data area and ends at or before 58 mm.

For dual layer discs (DVD-9) there are two options for the data layout depending on the application (see Figure 9).

Single layer disc



Dual layer disc – parallel track path



Dual layer disc – opposite track path



Figure 9 Single and Dual layer DVD disc layouts

- **Parallel track path**, where the two layers are independent and both start at the inside diameter (ID) and end at the OD with the Lead Out. Dual layer DVD-ROM discs use this layout for access to files on either layer.
- **Opposite track path**, where layer 0 starts at the ID and layer 1 starts where layer 0 ends at the Middle Area. For such discs there is one Lead In (on layer 0), one Lead Out (on layer 1) and two Middle Areas. DVD-Video discs will use opposite track path so that a movie can be placed across both layers and played almost seamlessly from layer 0 to layer 1.

Note that the file system data (see 2.5) will be contained in layer 0.

## Burst Cutting Area

The Burst Cutting Area (BCA) is an annular area within the disc hub where a bar code can be written for additional information such as serial numbers (see Figure 10). The data stored in the BCA can be from 12 bytes to 188 bytes in steps of 16 bytes.

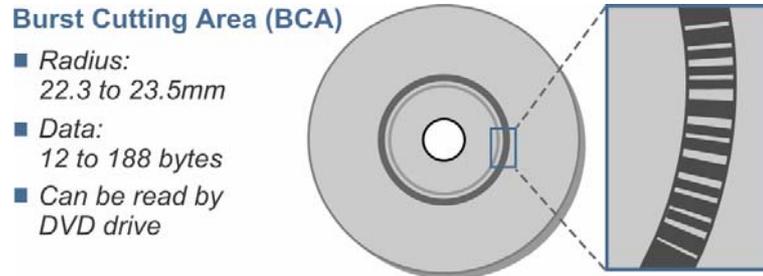


Figure 10 Burst Cutting Area

The BCA can be written during mastering and will be common for all discs from that master or, more usually, will be written using a YAG laser to 'cut' the barcode into the aluminium reflective layer of the finished disc.

The ill-fated Divx format used BCA to uniquely identify every disc. New uses of this or similar technologies are being developed to use the BCA as a unique, tamper-proof means of identifying individual discs or for copy control.

## 2.4 DVD Sectors and Error Correction

The data structure of a DVD disc is simpler than a CD, as there are no subcode channels and only one type of sector. The data on a DVD disc are organised as sectors of 2048 bytes plus 12 bytes of header data and 4 bytes of error detection code (EDC) making a total of 2064 bytes per sector.

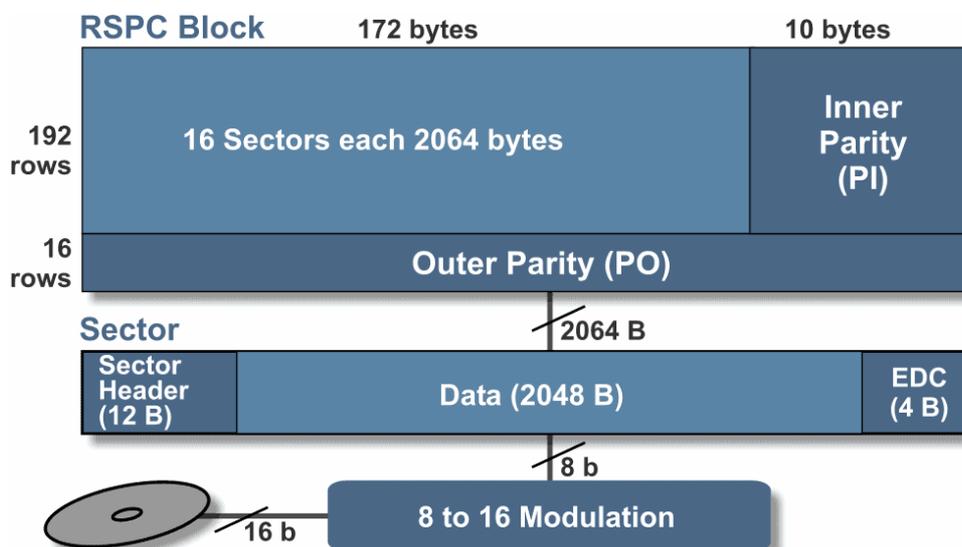


Figure 11 DVD Sector Structure

16 sectors are combined in a block (see Figure 11) which is error protected using RSPC (Reed Solomon Product Code), which is more suitable for re-writable discs (with packet writing) than CIRC, which does not use a block format. The PI and PO data are parity bytes calculated horizontally and vertically over the data bytes.

## Modulation

Finally an 8 to 16 modulation scheme (called EFMplus) is used to convert each byte to pits and lands on the discs. This results in pit/land lengths of 3 to 14 (minimum to maximum length) compared with CD's 3 to 11 with EFM modulation. This is only a small difference but does make the jitter specification slightly tighter.

The EFMplus modulation is also designed to ensure that the Digital Sum Value (DSV) is close to zero. The DSV is the result of subtracting the number of zero values from the number of one values at the output of the modulator.

## 2.5 DVD File System

All DVD discs contain data in files, which are accessed using a file system common to all DVD discs. For compatibility with recordable and re-writable versions the UDF Bridge Format has been chosen. This comprises a combination of UDF (Universal Disk Format) plus ISO 9660 for compatibility with CD-ROM. UDF offers the following features:

- Robust file exchange
- System & vendor independent
- Writable & read-only media
- Based on ISO 13346 (ECMA 167)

UDF has been extended to provide the necessary features for both write-once and re-writable discs. The file system specifications for different writable formats are different in some respects. A combination of UDF and ISO 9660 (known as UDF Bridge) is used on some DVD discs to provide compatibility with existing operating systems, including Windows9x and later. Applications can access the data files using either ISO 9660 or UDF file structures, but use of UDF is recommended.

## Directories and files

All pre-recorded discs are DVD-ROM discs, but contain any or all of the application data shown in Figure 12. Only DVD-Video and DVD-Audio data must be contained within specific directories VIDEO\_TS and AUDIO\_TS.

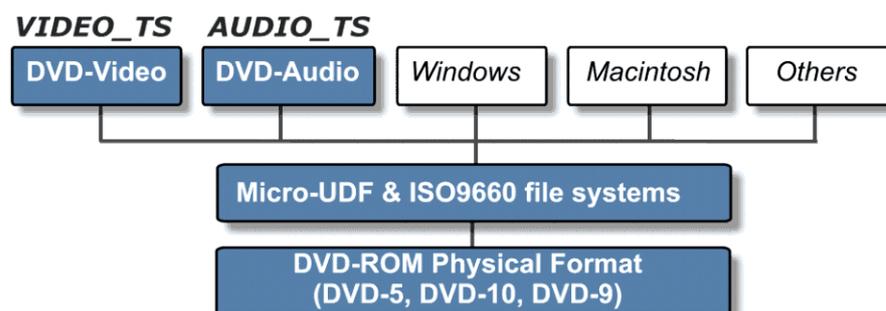


Figure 12 DVD Disc Directory and File Structure

DVD-Video discs use only UDF (not ISO 9660) with all required data specified by UDF and ISO 13346 to allow playing in computer systems. The DVD-Video files must be no larger than 1 GB in size and be recorded as a single extent (ie in one continuous sequence). The first directory on the disc must be the VIDEO\_TS directory containing all the files. All filenames are in the 8.3 format. All other files not included in the DVD-Video specification are ignored by DVD-

Video players. DVD-Audio discs also only use UDF and files are contained in the AUDIO\_TS directory.

## 2.6 The DVD Forum and DVD FLLC

The DVD specifications were originally written by the DVD Consortium, which comprised the original 10 companies (see Table 7). In late 1997 the name was changed to the DVD Forum and membership opened up to other companies in the DVD industry. The original 10 members became the Forum's Steering Committee and increased its numbers to 17. In early 2004 three more companies were added to the Steering Committee making a total of 20.

**Table 7 DVD Forum Steering Committee Members**

Year	Steering Committee Members Added
1995	Hitachi, Matsushita, Mitsubishi, Philips, Pioneer, Sony, Thomson, Time Warner, Toshiba and JVC.
1997	IBM, Industry Technology Research Institute (ITRI) of Taiwan, Intel, LG Electronics, NEC, Samsung and Sharp.
2004	Microsoft, Sanyo and Walt Disney.

### Working Groups

The DVD Forum has a total membership of over 220 and continues to produce and maintain the DVD specifications by means of nine working groups:

- **WG1** DVD-Video, video recording and stream recording specifications, plus, more recently, the DVD-Video specification version 2.0, for HD video on DVD and HD DVD.
- **WG2** DVD physical specification. Recent additions include 3x speed to allow HD video to be stored on DVD discs.
- **WG3** File systems for pre-recorded and recordable DVD formats.
- **WG4** DVD-Audio and audio recording specifications.
- **WG5** DVD-RAM specifications.
- **WG6** DVD-R and DVD-RW specifications.
- **WG9** Copy protection review.
- **WG10** Industrial/professional applications of DVD.
- **WG11** New blue laser disc formats for HD video. WG-11 is concentrating on HD DVD-ROM, -R and -RW formats using a DVD compatible 0.6 mm cover layer approach.

In addition, the DVD Forum has established committees for verification of DVD discs, players etc and promotion of the DVD Format.

### DVD Format/Logo Licensing

In April 2000 the DVD Format/Logo Licensing Corp (DVD FLLC) was established to handle issuing of the DVD specifications, granting licenses to manufacturers and policing the use of the DVD logos.

All manufacturers of hardware, discs and related DVD products must be licensed and first products verified to ensure that all players will play all discs. The correct logos must be used for licensed DVD products in the appropriate way as shown. Deluxe is licensed make discs and use the relevant logos for DVD-ROM, DVD-Video and DVD-Audio discs. Therefore any such discs made

by Deluxe and the associated packaging can include the appropriate logo (see Figure 13).



Figure 13 DVD-ROM, DVD-Video and DVD-Audio Logos

The DVD FLLC is taking firm action against companies that are manufacturing or selling non-licensed products or are using the incorrect logos.

## 3. DVD Application Formats

Two DVD application formats have been developed: DVD-Video, and DVD-Audio. DVD-ROM is the basis of the other two and can be used for a wide variety of other applications.

### 3.1 DVD-Video

DVD-Video discs are intended for full-length movies and offer a range of features including the following:

- **Playing time:** a nominal 133 minutes playing time for DVD-5 or each side of a DVD-10 and 240 minutes for DVD-9 using opposite track path format. In practice playing times are often reduced in favour of improved quality.
- **Video encoding:** MPEG-2 (for better than Laserdisc quality) or MPEG-1.
- **Audio Quality and Languages:** Dolby Digital, DTS, MPEG-2 or Linear PCM audio for up to 5.1 channel surround sound.
- **Subtitling:** Subpictures allow subtitling for up to 32 languages.
- **Range of Video Formats:** Pan & scan, letterbox and widescreen formats.
- **Interactivity:** a range of interactive features is available including seamless transitions, menus, camera angles and different routes or endings.

Longer movies can make use of dual layer DVDs (DVD-9) for continuous play and the two sides of a DVD-10 disc can be used for two different versions of a movie. Some video titles contain data that can be played only on a PC. Access to websites can be achieved in this way.

### DVD players and titles

All DVD-Video players should be capable of playing all types of DVD-Video discs (within the region specified), CD audio discs and Video CDs, but most will play additional formats as well. DVD-Video players will output video to both wide-screen and conventional TVs. The user can choose between wide-screen, letterbox and pan & scan outputs where available. Players in the USA will generally only play NTSC video, whilst those in Europe usually play NTSC as well as PAL, but only if the monitor/TV is capable of both systems.

DVD-Video titles can also be played on PCs with DVD-ROM drives and MPEG-2 hardware or software decoders.

### Region coding

Many DVD-Video discs are region coded to restrict playing to specific regions as shown below.

- Region 1:** USA, Canada
- Region 2:** Europe, Middle East, South Africa, Japan
- Region 3:** Southeast Asia, Taiwan
- Region 4:** Central & S America, Mexico, Australia, New Zealand
- Region 5:** Russian Federation, Africa (part), India, Pakistan
- Region 6:** China
- Region 8:** For discs used in aircraft and similar applications

DVD titles do not have to be region coded, but players generally are coded for only one region. Non-region coded discs will play on any player, as long as the player will play the PAL or NTSC video on the disc.

### **3.2 DVD-ROM**

DVD-ROM is essentially the pre-recorded DVD physical and logical format used for DVD-Video, DVD-Audio and a range of other applications, particularly general computer and multimedia applications, for which it can provide at least 7 times the capacity of a CD-ROM. Applications can include MPEG-2 video, as used on DVD-Video discs, to give added realism to games and richer content for multimedia applications.

DVD-ROM drives will also play CD-ROM and CD audio discs and have replaced CD-ROM drives in all new PCs. Early drives were 2x speed, but 16x drives are now commonplace.

### **3.3 DVD-Audio**

The DVD-Audio specification was released in 1999, copy protection methods agreed in 2000 and players and discs became available in 2000. DVD-Audio discs use scalable multi-channel linear PCM coding with optional lossless compression. Additional content can comprise video, text and still pictures. DVD-Video like navigation is also included in the specification.

DVD-Audio discs will require DVD-Audio players or universal DVD-Video/DVD-Audio players. DVD-Audio discs can optionally include DVD-Video content for compatibility with DVD-Video players. Most discs released so far include DVD-Video content so that they will play on DVD-Video players, although the audio quality is not as good as DVD-Audio can provide.

Philips and Sony have developed Super Audio CD (SA-CD), an alternative to DVD-Audio, which uses DSD (direct stream digital) encoding and offers a hybrid disc version containing CD and DVD audio on different layers so that the one disc will play on both SA-CD and CD audio players (although with a difference in quality).

Some DVD-Audio discs may also offer a hybrid option by using the DVDPlus (also called DualDisc) double sided format.

### **3.4 Copy Protection**

Copy protection for DVD is only for video and audio content and comprises both digital and analogue methods for preventing users from making perfect copies of the source material.

**Digital** copy protection involves scrambling the raw data using certain keys, which are stored on the disc in encrypted form. In the decoder, the original keys are obtained by inverting the encryption process and the data is then de-scrambled using the decrypted keys.

- DVD-Video titles can use **CSS** (Content Scrambling System).
- DVD-Audio titles can use **CPPM** (Content Protection for Pre-recorded Media).
- Recordable discs can use **CPRM** (Content Protection for Recordable Media).
- For DVD-ROM, existing CD-ROM copy protection, such as Macrovision's SafeDisc, has been extended to DVD.

**Analogue** copy protection (ACP) for DVD-Video makes use of a technique developed by Macrovision, which distorts the analogue output waveform so that the picture quality is unaffected but it cannot be successfully played back from VHS tape.

**Watermarking** systems have been developed for both audio and video content and are undergoing tests. These systems allow the source and ownership of the audio or video to be verified.

## 4. DVD Production

DVD discs are produced by first premastering and then manufacturing.

### 4.1 DVD Premastering

Premastering of DVD applications is relatively straightforward for DVD-ROM but can be very complex for DVD-Video and DVD-Audio.

#### DVD-Video premastering

DVD-Video premastering comprises the following processes.

- **Video encoding to MPEG-2** using variable or constant bit rate encoding.
- **Audio encoding** to Dolby Digital, MPEG, PCM or DTS.
- **Subtitles** created as subpictures.
- **Authoring** to add interactivity and create menus and navigation data.
- **Emulation/title testing.**

#### DVD-Audio premastering

DVD-Audio premastering is similar to DVD-Video and can include:

- **Audio encoding** and lossless packing
- **Still image encoding** for slideshows (optional)
- **Text preparation** for audio related text
- **Authoring** for optional interactivity, menus and navigation data.
- **Emulation/title testing**

#### DVD-ROM premastering

DVD-ROMs can be premastered in a similar way to CD-ROM. Premastering tools must format the data according to the DVD specifications including the UDF file system. A single disc can comprise any or all of DVD-Video, DVD-Audio and DVD-ROM content each complying with the appropriate specifications. Combination discs are likely to play differently on a DVD-Video player, DVD-Audio player and DVD PC.

## 4.2 Manufacturing DVD Discs

Manufacturing CD and DVD discs both require similar processes. The data are stored as minute pits (which are much smaller for DVD) in the surface of the plastic disc. A stamper is created by a glass mastering process and used to mould the DVD pits in the surface of the polycarbonate disc substrate. An additional stage, bonding, is required only for DVD discs to bond two thin substrates together to produce the finished disc.

### Glass mastering

For both CD and DVD discs, glass mastering is needed to create stampers used to mould pits in the surface of the disc. The differences between DVD and CD means that much of the mastering process for DVD needs new equipment including improved glass master preparation, laser beam recording and developing.

### Replication

Replication comprises injection moulding, using the stamper created during mastering, of two disc substrates, metallisation of one or both substrates and bonding.

### Disc Finishing

**Printing** of single sided DVD discs can be the same as CDs, eg using screen-printing of up to six colours. Double-sided discs can only be printed within the hub area but on both sides.

**New Packaging** has been developed for DVD to differentiate it from CDs and, in most cases, to allow the disc to be removed from the packaging while protecting them from any force that might delaminate the substrates.

### Quality Assurance

DVD discs must meet certain stringent quality parameters, the most important of which are disc flatness, low jitter and signals within specifications. Mastering and replication equipment must be set up to ensure these specifications are met and measurement equipment is needed to check the actual parameters.

In addition, mastering and replication is the only way to ensure that a DVD title has been pre-mastered correctly. Therefore it is important to verify the replicated discs using DVD players to ensure correct functionality.