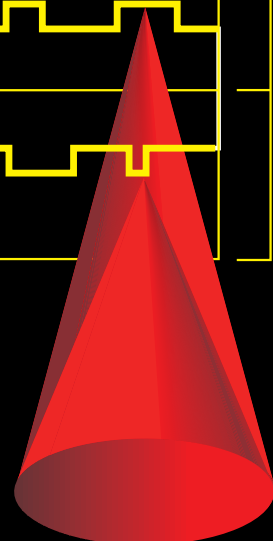
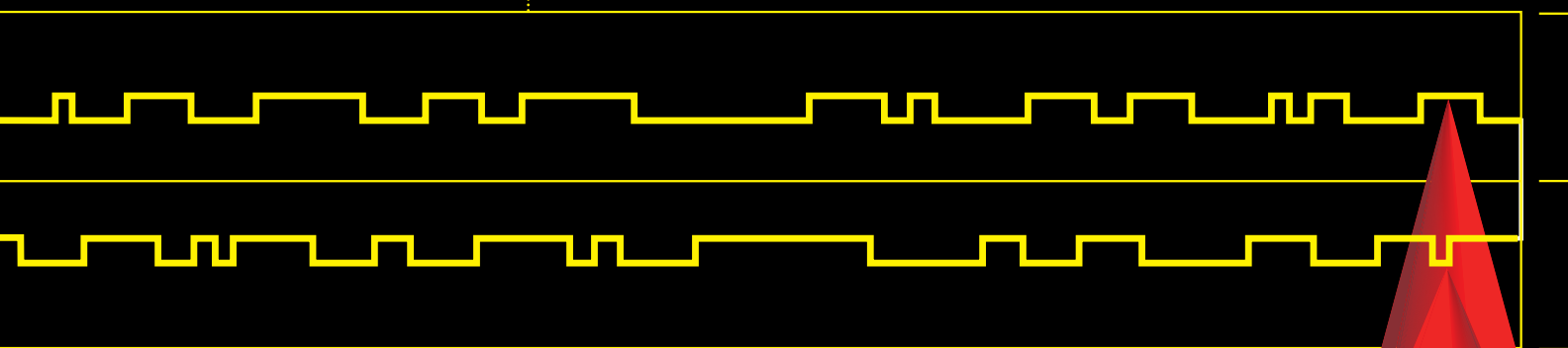
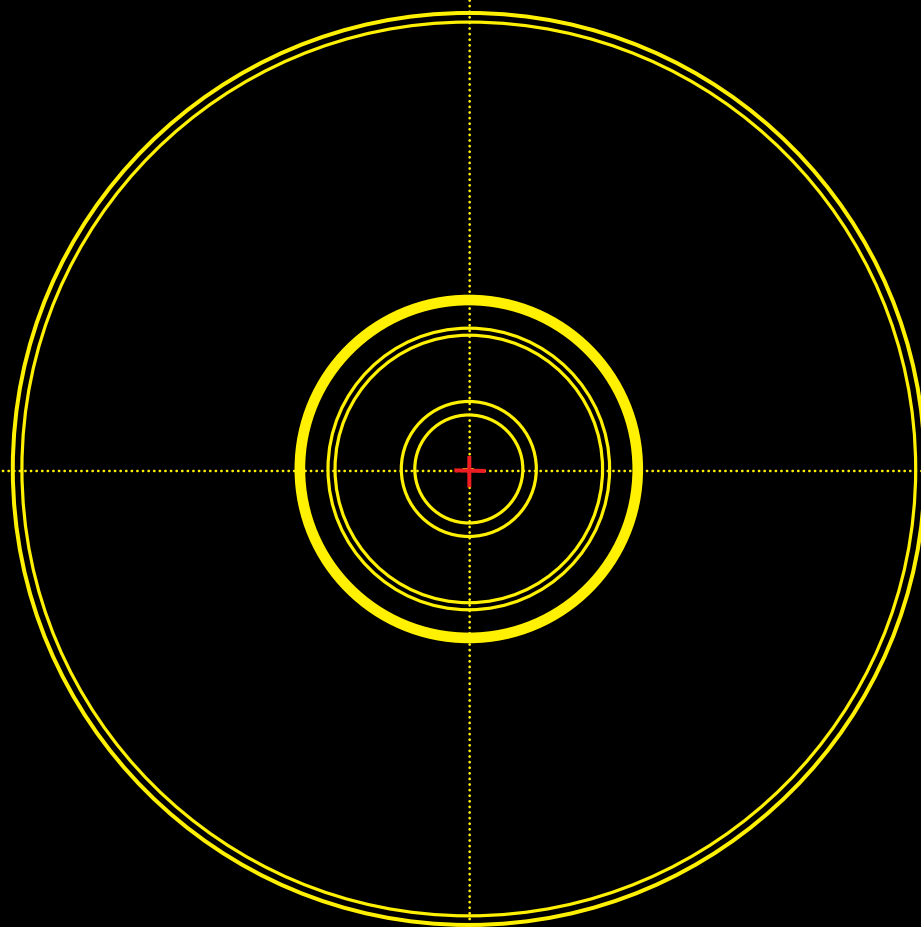


SONY

DVD:
THE INSIDE STORY



A N I N S I D E L O O K A T T H E
N E X T G E N E R A T I O N I N O P T I C A L M E D I A

T H E R O A D F R O M C D T O D V D

It is now 14 years since Sony and Philips launched the Compact Disc digital audio format and gave the world its first taste of digital entertainment. CD has enjoyed unprecedented success and universal support among music companies and hardware manufacturers. To date, over 120 million CD Players and 3 billion CDs have been sold in the United States alone.

From its origins as a music format, Compact Disc has grown to encompass computer applications (CD-ROM), imaging applications (Photo CD), and video game applications with products like the Sony PlayStation® system.

Over the years since the introduction, we have seen significant advances in the enabling technologies that support the Compact Disc. Laser optics, reflective films, and disc replication have all made major strides. Digital coding and compression algorithms have become vastly more sophisticated. Moreover, integrated circuits and drive mechanisms have made impressive advances.

All of these advances came into play when Sony began work on the next generation of optical media. The goal: vastly increased capacity, with the ability to feature an entire movie in high-quality digital video on a single side of a disc.

This was the start of DVD.

A C O M P A C T D I S K
C H R O N O L O G Y

- 1980:** Sony and Philips define the shape of things to come by creating standards for the Compact Disc Digital Audio format.
- 1982:** Sony starts the Compact Disc rolling by introducing the world's first CD player, the CDP-101, and manufacturing the world's first CD, Billy Joel's 52nd Street.
- 1984:** Sony takes music on the road with the world's first Car CD/Receiver and the world's first portable CD Player.
- 1985:** Sony and Philips announce the standard for Compact Disc storage of computer data — the CD-ROM.
- Sony introduces the first portable CD music system.
- 1986:** Sony launches the world's first CD Changer for the car.
- Sony creates the world's first CD Player with outboard D/A Converter.
- 1987:** Sony changes the concept of changers with the world's first CD Carousel.
- 1989:** U.S. installed base of CD Players surpasses 25 million.
- Sony and Philips announce the standard for Compact Disc Interactive (CD-I).
- 1990:** Sony and Philips expand upon CD-ROM with CD-ROM XA and standards for CD-Recordable (CD-R).
- 1993:** Sony introduces the world's first home-use 100-CD Changer.
- 1994:** As multimedia booms, CD-ROM drives become a "standard" feature in home computers.
- U.S. installed base of CD Players surpasses 100 million.
- 1995:** New standards announced for CD-Erasable and CD Plus (Enhanced Music CD).
- The CD-based Sony PlayStation® system is introduced and becomes the fastest-selling new video game system ever.



A S I N G L E S T A N D A R D
F O R T H E W O R L D

In September 1995, Sony joined eight other companies to create a single, unified standard for the emerging DVD format. The format enjoys the enthusiastic support of the world's major electronics companies. As a movie playback format, it meets the specific and detailed requests of the motion picture industry's Studio Advisory Committee. As a computer ROM format, it meets the specifications of the computer industry's Technical Working Group. No other product has enjoyed such broad international support across so many industries prior to launch.

L O O K S F A M I L I A R

- The DVD standard defines a disc that maintains the overall dimensions, look and feel of the current Compact Disc. Some of these similarities will be unmistakable to consumers experiencing DVD for the first time. Others are less apparent, but equally important to the rapid and successful introduction of DVD:*
- ▶ Like CD, DVD is 120 mm (4-3/4 inches) in diameter.
 - ▶ Like CD, DVD is 1.2 mm thick.
 - ▶ The new DVD Players will be able to play the billions of existing music CDs.
 - ▶ DVD software can be replicated using existing CD production facilities.
 - ▶ Using the existing form factor reduces the re-tooling required to manufacture DVD Players and DVD-ROM drives.
 - ▶ Non-contact laser optics mean playback without wear and tear.
 - ▶ A disc-based format means the kind of split-second random access that no tape format can match.
 - ▶ As with Compact Disc, DVD will be durable, and tolerant of dust, dirt and fingerprints.

W H A T ' S N E W A N D
D I F F E R E N T ?

- Under the surface, of course, DVD reveals some substantial differences:*
- ▶ DVD holds *seven times* the data of CD: 4.7 gigabytes per layer, as compared to 680 megabytes for CD.
 - ▶ DVD offers a dual-layer, single-side option, for even higher capacity: 8.5 gigabytes on a single side.
 - ▶ Every DVD is a bonded disc, composed of two 0.6 mm substrates joined together.

THE CAPACITY IS WAY UP.
THE SIZE ISN'T.

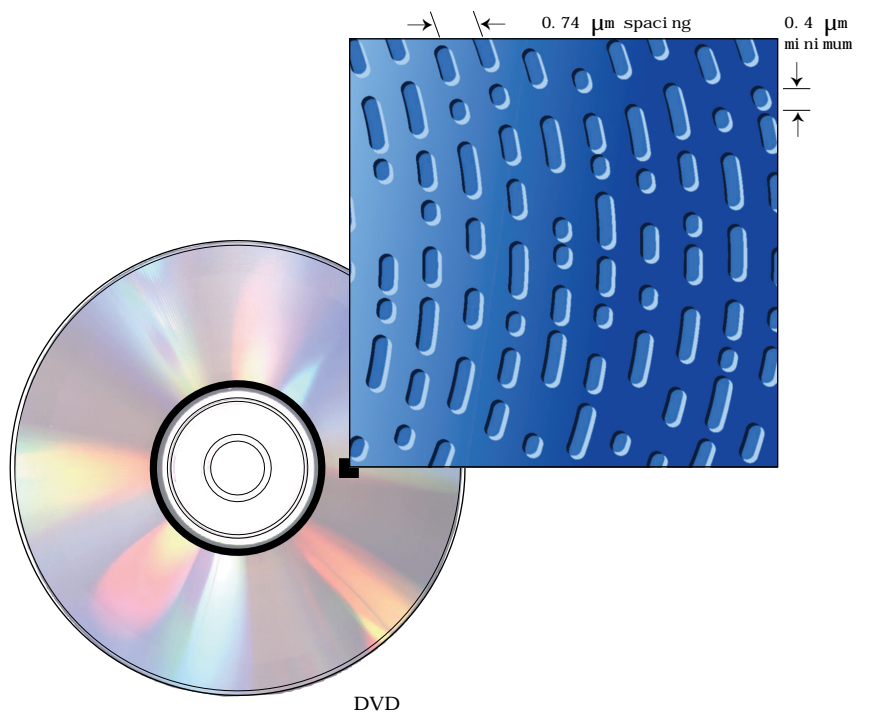
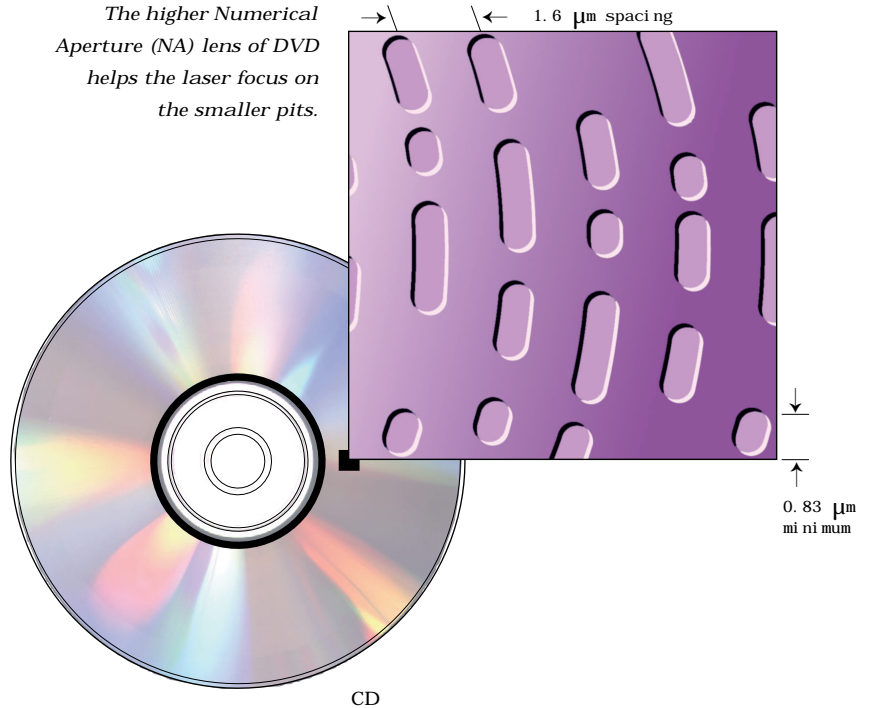
Almost every aspect of DVD was developed, refined or reinvented to achieve the seven-fold increase in data capacity and data density. Refinements include smaller pit dimensions, a more closely-spaced track (finer "track pitch"), and a shorter-wavelength laser.

Conventional CD Players and CD-ROM drives use a laser that emits invisible, infrared light at the wavelength of 780 nanometers. The new DVD Players and DVD-ROM drives use a laser that emits red light at 650 and 635 nm. The shorter wavelengths are better suited to reading the smaller, more densely packed pits. The laser assembly has also been refined with a higher Numerical Aperture (NA) lens, resulting in a narrower, more tightly focused laser beam.

Even more significantly, DVD's digital modulation and error correction schemes have been specifically designed to support this increase in capacity. The 8 to 16 (EFM PLUS) modulation scheme is highly efficient and ensures backward compatibility with current discs as well as with future rewritable media. And the RS-PC (Reed Solomon Product Code) error correction system is approximately 10 times more robust than the current CD system. Both of these developments are direct outgrowths of Sony technology.

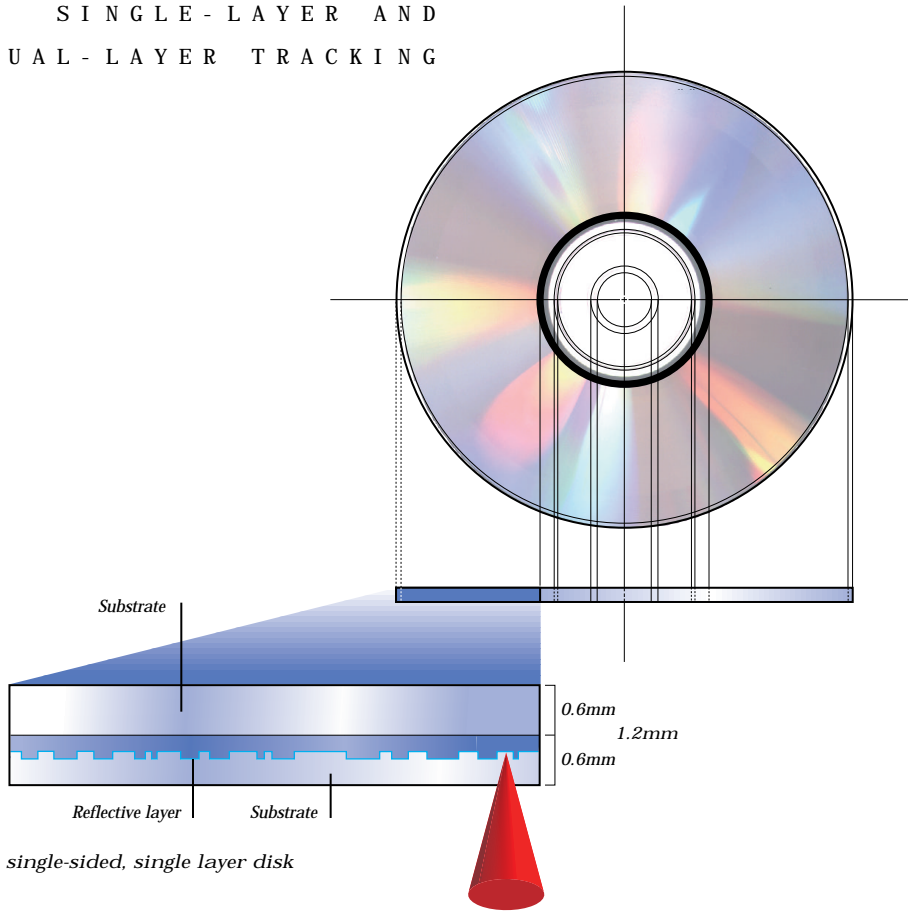
CD VERSUS DVD PIT
SIZE COMPARISON.

Compared to CD, DVD uses smaller pits and a more closely spaced track. The result is a significant increase in data density. The higher Numerical Aperture (NA) lens of DVD helps the laser focus on the smaller pits.



THE SINGLE - S I D E D
D U A L L A Y E R D I S K

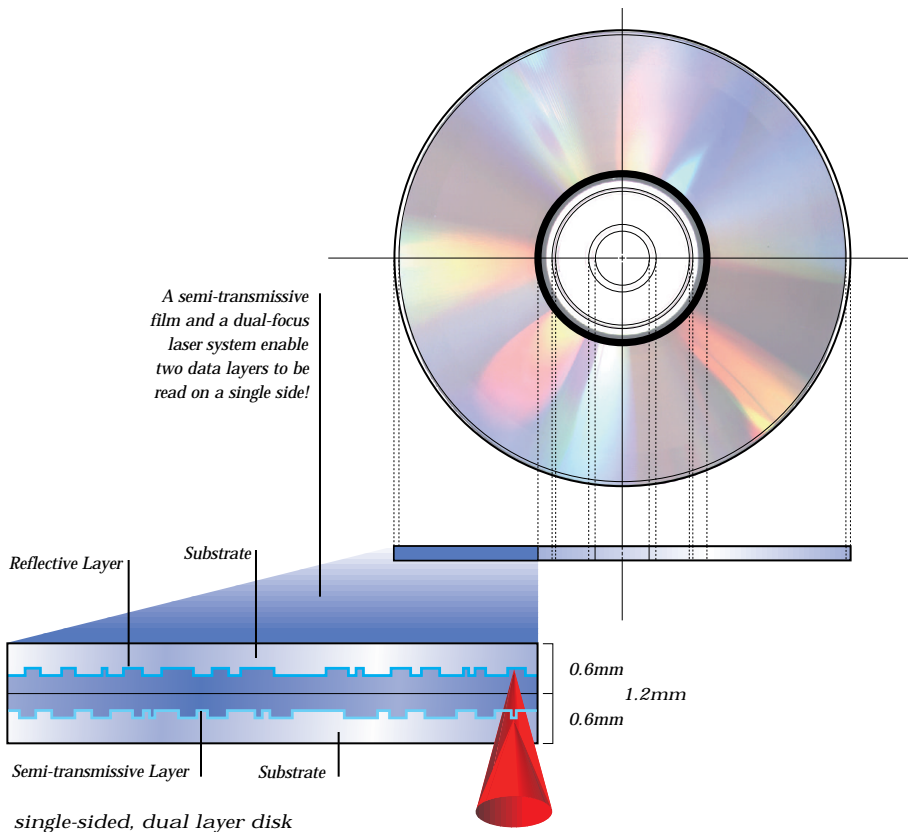
S I N G L E - L A Y E R A N D
D U A L - L A Y E R T R A C K I N G



single-sided, single layer disk

For future applications that may demand even higher on-line capacity, the DVD specifications call for a single-sided, dual-layer disc option, which nearly doubles the standard disc's capacity to 8.5 gigabytes. That's *more than 12 times* the data of a standard Compact Disc!

This single-sided, dual-layer disc incorporates a new, semi-transmissive film which coats the layer of pits that is closest to the laser pickup. Therefore, when the laser "plays" the deeper data layer, it is actually reading through this semi-transmissive material. At the end of the first (deeper) layer, the laser pickup instantly changes its focus and begins reading the second (semi-transmissive) layer. An electronic buffer ensures that there is seamless playback between layers.



A semi-transmissive film and a dual-focus laser system enable two data layers to be read on a single side!

single-sided, dual layer disk

The DVD format offers both single-sided, single-layer discs (above) and single-sided, dual-layer discs (below). On a single-sided, dual-layer disc, the laser first shines through the nearer, semi-transmissive layer to track the deeper layer of pits. The laser then switches focus to read the semi-transmissive layer.

Just as the original CD created a revolution in audio, DVD will raise the standard for home video picture quality. In fact, picture quality approaches “D-1,” the CCIR-601 TV studio production standard.

DVD delivers far and away the best color, sharpness and clarity in home video, far surpassing the Laserdisc standard. DVD also offers high resolution, with exceptional rendering of fine picture detail. Video distortion is extremely low, which reduces unwanted color “noise.”

Because the recording format is component video, as opposed to NTSC composite video, the pictures are free of the well-known drawbacks of NTSC — artifacts including dot crawl and cross color distortion. And because DVD is an optical format, the picture quality doesn’t degrade over time and repeated use.

M P E G 2 V I D E O C O M P R E S S I O N

The CCIR-601 digital video standard specifies a video data rate of 167 megabits per second. At this bit rate, the 4.7 gigabyte capacity of a standard DVD could only store roughly 4 minutes of digital video! Thus, some form of data compression is required.

DVD takes advantage of a sophisticated compression technology called MPEG2. It’s a set of flexible compression standards, the second to emerge from the Moving Picture Experts Group (MPEG). Sony is an active participant in the MPEG proceedings, a primary developer of the MPEG system and a manufacturer of encoders. This expertise even extends to developing our own MPEG decoding devices.

MPEG2 works by analyzing the video picture for repetition, called redundancy. In fact, over 95% of the digital data that represent a video signal is redundant, and can be compressed without visibly harming the picture quality. By eliminating redundancy, MPEG2 achieves superb pictures at far lower bit rates.

T H E B I T R A T E F L U C T U A T E S

As implemented for DVD, MPEG2 encoding is a two-stage process, where the signal is first evaluated for complexity. Then, higher bit rates are assigned to complex pictures and lower bit rates to simple pictures, using an “adaptive,” variable bit-rate process. The DVD format uses 4:2:0 component digital video compressed to bit rates with a range of up to 10 megabits per second. Although the “average” bit rate for digital video is often quoted as 3.5 megabits per second, the actual figure will vary according to movie length, picture complexity and the number of audio channels required.

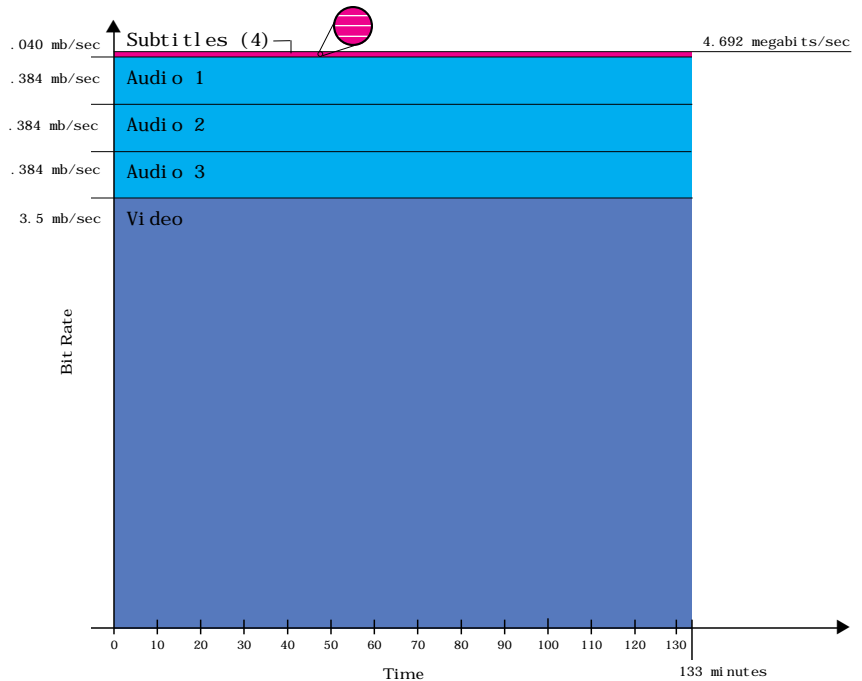
T W O H O U R S O F M O V I E
O N O N E S I D E

Thanks to MPEG2 compression, a single-layer, single-sided DVD has enough capacity to hold two hours and 13 minutes of spectacular video on a 4-3/4-inch disc! At the nominal average data rate of 3.5 megabits per second, this still leaves enough capacity for discrete 5.1-channel digital sound in three languages, plus subtitles in four additional languages! Including video, audio and subtitles, the total average data rate is 4.962 megabits per second. And because it's single-sided, DVD can store all this with no need to flip the disc over.

F O R M U L A F O R
C A L C U L A T I N G S P A C E
R E Q U I R E D F O R F I L M

The following is the formula for calculating the total capacity needed on a disk if you wish to encode a specific film.

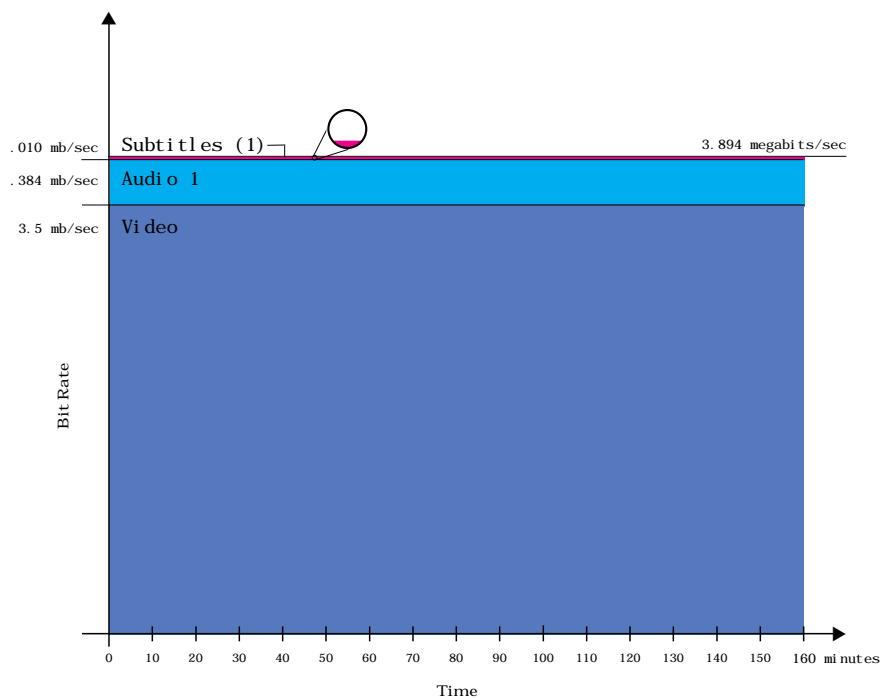
$$\begin{aligned}
 & \text{PICTURE COMPLEXITY (AVE. 3.5 MB/SEC)} \\
 + & \text{ NO. OF LANGUAGES X .384 MB/SEC} \\
 + & \text{ NO. OF SUBTITLED LANGUAGES X 0.01 MB/SEC} \\
 \hline
 = & \text{ REQUIRED BITS FOR ONE SECOND} \\
 \times & \text{ 60 SECONDS} \\
 \hline
 = & \text{ REQUIRED NUMBER OF BITS PER MINUTE} \\
 \times & \text{ MOVIE RUN TIME IN MINUTES} \\
 \hline
 = & \text{ TOTAL NUMBER OF BITS REQUIRED FOR MOVIE} \\
 \div & \text{ 8 TO CONVERT BITS TO BYTES}
 \end{aligned}$$



$$4.692 \text{ megabits/sec} \times 133 \text{ minutes} = 4.680 \text{ gigabites}$$

Average Bit Rates: Though bit rates may vary due to complexity of image and other variables, the following are averages you may consider in generic calculations.
 Video-3.5 Mb/sec,
 Audio(5.1)-0.384 Mb/sec,
 Subtitles-0.01 Mb/sec

By changing the space allocation for audio and subtitles, we can fit more than 133 minutes of video onto a single-sided, single-layer disc.



$$3.894 \text{ megabits/sec} \times 160 \text{ minutes} = 4.673 \text{ gigabites}$$

T H E N E X T S T E P I N
D I G I T A L S U R R O U N D S O U N D

Movie DVDs released in the United States will be capable of carrying Dolby® AC-3™ digital audio sound tracks with either 2 or 5.1 channels. Unlike Dolby Pro Logic® coding, Dolby AC-3 multi-channel sound provides five completely separate (discrete) channels: Left, Center, Right, Left-Rear and Right-Rear, plus a common Subwoofer channel.

Dolby AC-3, which uses a digital bit rate of 384 kilobits per second, is already well accepted among videophiles and home theater enthusiasts. As a true digital system, it offers high quality sound, with outstanding dynamic range, vanishingly low distortion, wide frequency response and wow & flutter beneath the threshold of measurement.

As an option to Dolby AC-3 sound, DVD also enables producers to choose 16-bit linear, CD quality stereo sound with Dolby Pro Logic encoding. And to facilitate international distribution of movie discs, DVD makes possible up to eight languages and 32 sets of subtitles.

D V D - R O M :
U L T I M A T E M U L T I M E D I A

The design of DVD reflects the widespread success of CD-ROM as a data carrier for computer programs, databases, multimedia software and video games. As computer processing power continues to increase, the need for higher capacity media is becoming increasingly apparent. And expanding markets for high-resolution graphics and full-motion video continue to push the limits of existing storage media.

In this environment, DVD-ROM will help satisfy the constant demand for increased storage.

- ▶ Greater capacity. With 4.7 gigabytes of storage capacity on a single layer and 8.5 gigabytes on a dual-layer disc, DVD-ROM offers more than 12 times the capacity of CD-ROM.
- ▶ Backward compatibility. New DVD-ROM drives will play the tens of millions of existing CD-ROMs.
- ▶ On-line availability. DVD-ROM delivers its increased capacity on a single side. So consumers won't need to turn the disc over — and computer manufacturers won't need to re-design their products to fit new drives.
- ▶ Faster data transfer. Even a standard DVD-ROM drive blasts along at higher data transfer speeds than even the fastest current CD-ROM drive.
- ▶ Future recordability. DVD-ROM will be compatible with future high density recordable (DVD-Write Once) and rewritable (DVD-Rewritable) media.
- ▶ Affordable cost. DVD-ROM will ultimately be priced comparably to current CD-ROM products.

U N L I M I T E D
P O S S I B I L I T I E S

With all these advantages, DVD-ROM is poised to become the undisputed leader in next-generation optical media for computers, multimedia and video games. DVD is poised to spark new opportunities and creative applications that we can only imagine today.

T H E S O N Y D I G I T A L
H E R I T A G E

Although DVD specifications are the work of many companies, Sony takes particular pride in the development of the new format. After all, Sony co-invented the Compact Disc. And the final DVD standards reflect Sony's expertise in MPEG2 compression, modulation and error correction technology.

In fact, Sony is involved in every link of the DVD chain: from manufacturing MPEG2 encoders, laser pickups, disc drives and decoding devices, all the way to replicating discs and developing content.

When it comes to DVD, Sony does it all.

S P E C I F I C A T I O N S

	CD	DVD
Disc diameter	120 mm	120 mm
Disc thickness	1.2 mm	1.2 mm
Disc structure	Single substrate	Two bonded 0.6 mm substrates
Laser wavelength	780 nm (infrared)	650 and 635 nm (red)
Numerical aperture	0.45	0.60
Track pitch	1.6 μm	0.74 μm
Shortest pit/land length	0.83 μm	0.4 μm
Reference speed	1.2 m/sec. CLV	4.0 m/sec. CLV
Data layers	1	1 or 2
Data capacity	Approx. 680 megabytes	Single layer: 4.7 gigabytes Dual layer: 8.5 gigabytes
Reference user data rate	Mode 1: 153.6 kilobytes/sec Mode 2: 176.4 kilobytes/sec	1,108 kilobytes/sec, nominal

V I D E O F O R M A T

	Video CD	DVD-Video
Video data rate	1.44 megabits/sec (video, audio)	1 to 10 megabits/sec variable (video, audio, subtitles)
Video compression	MPEG1	MPEG2
Sound tracks	2 Channel - MPEG	Mandatory (NTSC): 2-channel linear PCM; 2-channel/5.1-channel AC- 3. Optional: up to 8 streams of data available
Subtitles	Open caption only	Up to 32 languages

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