LICENSING REQUIREMENTS FOR THE CSS DVD COPY PROTECTION METHOD

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The terms of the CSS license are undergoing ongoing review as of the writing of this document. Manufacturers should use this document only as a guide to issues.

MPEG is an international standard for video compression/decompression promoted by ISO. Implementations of MPEG CODECs, or MPEG enabled platforms may require licenses from various entities, including Intel Corporation.

ABSTRACT

A protection system called “CSS” is being adopted to prevent home piracy of movies on DVD. Movies are scrambled, and access to the descrambling algorithm and keys is legally conditioned on following certain design and resale restrictions. This paper presents a discussion of these restrictions and contact information for parties seeking such a license.

BACKGROUND

DVD, with its dramatically increased storage capacity, is expected to drive a revolution in multimedia software applications and movies. However, motion picture owners have been reluctant to embrace this exciting new medium until reasonable steps to deter casual home copying are in place. The studios have been concerned that the quality and reproducibility of the DVD may result in innumerable illegal copies being made by casual home users, leading to a loss of revenue.

The motion picture and consumer electronics industries, later joined by the computer industry, have developed and negotiated a plan for limiting home copying. It includes a scrambling algorithm known as the “Contents Scramble System” or “CSS.” It relies on a combination of content scrambling, key encryption, conditional access, and licensing terms to enforce a set of design rules. In order to receive the keys and algorithms needed to access the content, manufacturers must commit that systems which incorporate these keys and algorithms will meet these design rules.

A document called the “Procedural Specification” contains the design rules and generally requires that the video outputs of authorized devices have some sort of copy protection on them. The rules further require that the devices not be designed or readily modifiable to serve as copying or circumvention devices.

CSS OVERVIEW

A CSS encoded DVD disc contains movie data which is MPEG-2 compressed. This compressed data is then scrambled according to the secret CSS algorithm and a set of keys. To access the data on the disc, a device must know the CSS algorithm, including the method of key extraction, and be in possession of certain authenticating keys.

The Disc

- MPEG-2 Compressed
- Content Scrambled
  Use algorithm under CSS license only
  Apply secret keys
  Keys encrypted, hidden on disc
- Rate of scrambling limited to permit S/W descramble

A PC performs a handshake with an authenticating device on the disc drive. This handshake establishes an encrypted path for the transmission of keys, and by convention, authorizes the release of data from the drive as well as the reading of certain title-related keys which are located on a normally inaccessible part of the disc.[1] Figure 1, below, includes a schematic representation of CSS.

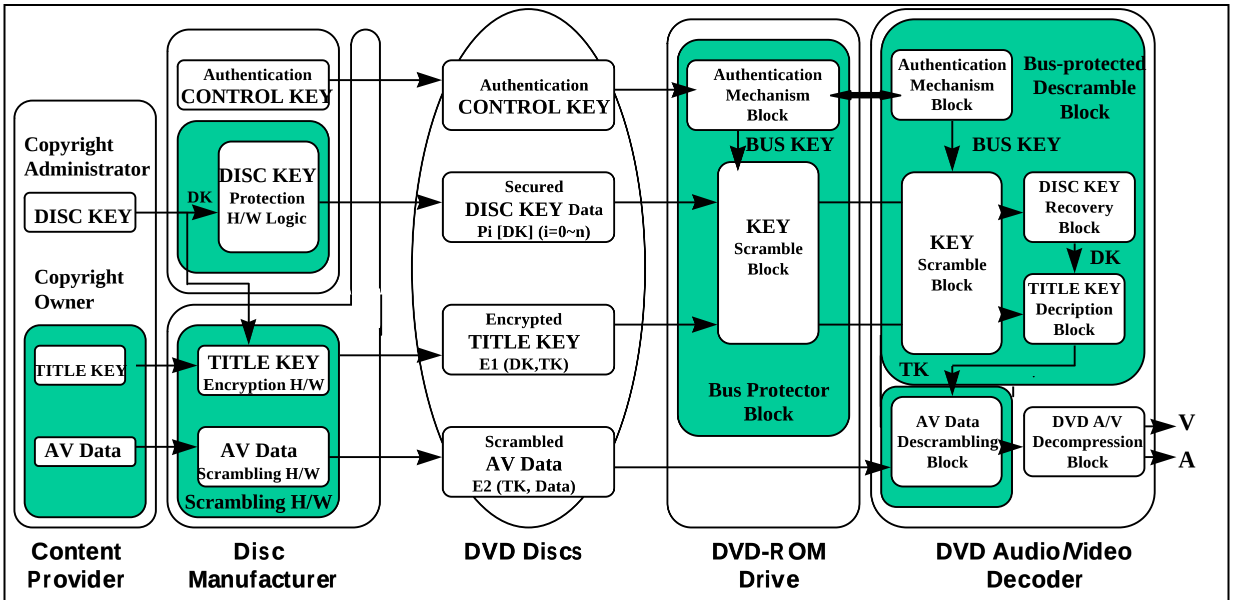
Copyright Administrator
DISC KEY
Copyright Owner
TITLE KEY
AV Data
Authentication CONTROL KEY
DK
DISC KEY Protection H/W Logic
TITLE KEY Encryption H/W
AV Data Scrambling H/W
Scrambling H/W
Authentication CONTROL KEY
Secured DISC KEY Data Pi [DK] (i=0~n)
Encrypted TITLE KEY E1 (DK,TK)
Scrambled AV Data E2 (TK, Data)
Authentication Mechanism Block
BUS KEY
KEY Scramble Block
Bus Protector Block
Authentication Mechanism Block
Bus-protected Descramble Block
BUS KEY
KEY Scramble Block
DISC KEY Recovery Block
DK
TITLE KEY Decription Block
TK
AV Data Descrambling Block
DVD A/V Decompression Block
V
A
Content Provider
Disc Manufacturer
DVD Discs
DVD-ROM Drive
DVD Audio/Video Decoder

Figure 1: MEI and Toshiba's CSS "Content Scramble System," Key and Algorithm breakdown

[1] Consumer electronics devices which are fully integrated do not make use of this authentication handshake. Since they are integrated into a single unit, the designers of this system do not believe that an encrypted pathway is necessary within a single component.

When the title keys have been received by the playback portion of the PC, they are applied via the CSS algorithm to the data stream coming from the DVD disc in order to provide descrambled audio and video. These data streams are still compressed, and must be decompressed for listening and display.

The Player / PC

- Negotiates authentication with DVD ROM Drive
- Drive delivers content and encrypted key
- PC decrypts key and uses it to descramble content
- Content then decompressed / viewed

As a condition for receiving access to the keys and the secret CSS algorithms, the manufacturer of devices which use them must agree to follow certain design rules. These design rules are contained in a set of specifications available from Matsushita.[2]

DESIGN RULES FOR CSS-COMPLIANT DEVICES

The CSS license and the lengthy CSS Procedural Specification contain the design rules. Article 6 of the Specification sets out the obligations which a manufacturer must follow as a condition of its license. These obligations include mandatory application of copy protection to certain outputs, prohibition of providing formerly-scrambled CSS video and CSS audio over most outputs which lack an agreed form of copy protection, and various architectural rules which are intended to safeguard the internal integrity of the CSS data in a PC or consumer device.[3]

The drafting and amendment processes on these design rules are ongoing. Certain technical matters are intended to be upgraded or added within the next few months, such as the identification of a system or systems which may be used to safeguard digital transmissions of CSS data. A mechanism is also provided by which inadvertent oversights in the specification may be addressed, and loopholes closed, in order to continue to provide a reasonable degree of security for copyrighted materials.

[2] Matsushita is acting as the interim license entity. It is expected that a permanent, independent licensing entity will be formed before the end of the year.

[3] The terms CSS video, CSS audio and CSS data refer to content which has been previously scrambled using the CSS algorithm but which has now been descrambled. The CSS license provides that even after descrambling, these materials must be safeguarded.

The design requirements for PCs and for consumer electronics devices are not identical. Among other things, the requirement of modular design for PCs, as opposed to the integral design of most consumer electronics devices, has mandated the addition of certain measures for avoiding unnecessary exposure to illegal copying, such as the use of the authentication chips for software. Practical realities of design cycles in the computer industry and the lack of any known means of introducing copy protection to computer monitor outputs, have necessitated other compromises among the groups negotiating the design rules.

A chart attached at the end of this paper summarizes the design rules for computers and consumer electronics devices. Designers should be cautioned that both this paper and the chart are only a summary as of the writing of this document, and designers should make careful reference to the specific language of the CSS license and specifications when they receive them.

DESIGN RULE DETAILS

The design rules set out in the CSS license may be divided conveniently into three categories: output requirements, playback control, and architectural requirements. There is some overlap between these, but they are all designed with the intention that CSS-protected materials are not unreasonably exposed to illegal copying.

Output Requirements

CSS data may only be present on the output of a device where (1) that output is authorized, and (2) any required copy-protection technologies are applied to the signal on that output. As the design rules chart shows, most analog outputs (NTSC, YUV, PAL, SECAM) are required to have an authorized analog protection system applied to them. Currently, the only authorized analog protection system is licensed by Macrovision Corporation.

On the computer side, there is no known method for applying copy protection to computer monitor outputs such as SVGA. Computers may continue to make use of these outputs without the obligation of applying a protective system to them. However, it is expected that one will be defined and mandated in the future.[4]

Putting descrambled CSS video on digital outputs, such as IEEE1394, Universal Serial Bus, and RS232 is forbidden for video and somewhat limited for audio, at least until a method defined and authorized for providing secure delivery across these media. The industry members working on this problem have, at the time of this writing, narrowed the field to a handful of proposed methods for providing this method of secure transmission, and it is hoped that the digital ports may be opened reasonably rapidly.

Under the CSS license, digital audio must be transmitted in a form which is descrambled, transmitted in a compressed audio format or using Linear PCM format at no more than 48 kHz and no more than 16 bits, and SCMS may not actively be stripped out (in PC's). CE devices are required to assure the presence of the SCMS in proper form. Until a "secure" digital transmission means is added to the license, Linear PCM transmissions may be at no more than 48 kHz and 16 bits regardless of the recorded sampling rate or bit length on the DVD Disc. After the digital transmission means is added, a device may not transmit or support transmission of audio content originally recorded at a sample rate greater than 48 kHz except as provided in the amendment with respect to such "secure" technology.

The output limitations described here apply regardless of the medium of transmission. That is, they apply not only to direct connections but to RF transmissions from a device or other conceivable means such as fiber optic.

Playback Control

There are three basic playback control rules: (1) a DVD-ROM drive may not release CSS data unless authentication has been performed. (2) A DVD drive may not play back CSS data from a recordable disc. (3) A DVD player (or computer) may not play a movie from a region other than the region for which the player has been set.

[4] Technological changes required by the updating of the CSS specification will ordinarily have an adoption period or grace period on the order of 18 months. In some cases, a shorter or longer period may be required.

The requirement that a DVD-ROM drive not release CSS data without authentication is enforced by the drive mechanism itself. Drive manufacturers who wish to include authentication capabilities in their products must enforce this rule, as well as the rule that they not release or play back CSS data from a recordable disc. Each of these rules is intended as a backup provision, the first to reduce the impact of a pure software hack, and the second to reduce the value of home pirated copies which might be passed around from person to person.

The third playback control requirement, and perhaps the most controversial, is referred to as “regionalization.” Many motion picture owners serially release titles in different geographies (summer movies come out in July in the United States and in December in Australia), and ownership of the copyrights in many products may vary from country to country or region to region. Therefore, the motion picture studios requested the ability to target certain products at certain geographic regions. This capability also replicates the natural markets created by the various video standards in use around the world.

As shown in Figure 2, the world is divided for CSS purposes, into six regions. A CSS-encoded disc may be encoded for one or more of the regions, but the player must be identified as one region only. A player may only play discs which are encoded for that player’s region.

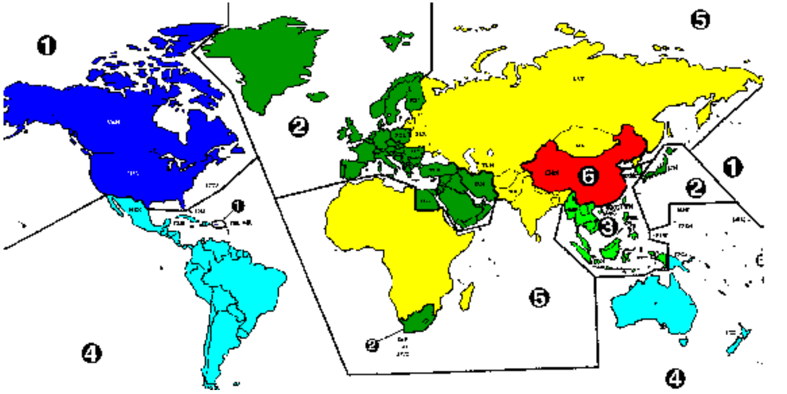

Figure 2: The CSS Regions

After an initial grace period, these rules will be enforced in hardware in the drive itself. Through 1998, however, the rules may be enforced in the driver or authentication software which is difficult to replace and therefore difficult to circumvent. The CSS license requires that extra care be taken to assure that the regionalization of a player or drive may not be changed readily by the user.

Because of the relative difficulty of change once a disc drive has been regionalized, it is permissible to have one of a number of methods to allow the end-user several tries at initial regionalization of the drive. These include entering a special code, letting the drive decide based on the majority of regions represented by the discs inserted in the drive, and use of a disc which contains regionalizing instructions. However, once the drive has been regionalized for more than a specified number of times, it must be returned to a service center, and ultimately the factory, for reinitialization. Disc regions will be identified by a globe with one or more numbers on the DVD packaging.

Architectural Requirements

In addition to requirements relating to outputs and data access, the CSS license and specifications require certain design rules intended to limit the misuse of licensed products. These rules were negotiated among the industry groups, and represent a dramatic scaling back from the legislation originally proposed in 1996.

The architectural rules relate principally to resistance of a product to alteration or tampering, or to circumvention of copy control methods by easily designed devices. The principal architectural requirements are:

- Non-support of “drag and drop” file copying.
- Analog copy protection technology on internal video signals.
- Robust (“tamper resistant”) software implementations.
- Robust hardware implementations.
- Restrictions on data present on various buses.

Drag and Drop File Copying. The prohibition on file copying applies to descrambled data, and refers to an obligation that the CSS data, after having been descrambled, not be made available to the system for recording. This requirement does not prohibit ordinary caching incident to playback, whether in RAM or, in some appropriate cases, spooled to the hard drive. However, the limitation clearly prohibits such activities as facilitating the copying of an entire movie from a DVD to a big hard drive and then watching the movie later.[5]

[5] While the participants in the licensing discussions contemplate the existence of a digital time-shifting technology, as well as the ability to record materials which are designated as recordable, in general, CSS-encoded materials may not be copied for any purpose.

Analog Copy Protection on Internal Video Signals. Just as an external output which might be connected to a VCR must have anti-copy technology apply to it, an internal connection to a VCR must also have anti-copy technology applied to it. This requirement is intended to prevent manufacturers from circumventing the copyright protection aspects of the CSS plan by making an integrated device.

Software Tamper Resistance. Throughout its participation in content protection efforts, Intel has been committed to the idea that DVD movie playback, including any copy protection routines, should not add materially to the cost of a family's multimedia computer. This commitment required that software, where appropriate in a machine's design, should be permitted.

While the studios agreed in principle that software should be permitted, the conditions imposed for software implementations are somewhat burdensome. Software must be designed so that no one but a professional, using high-end lab equipment and specialized training would be expected to be able to defeat the software by exposing the CSS algorithms or keys, or redirecting the data being handled by a software implementation.[6]

Software implementations, like other implementations of CSS, are not subject to pre-inspection or pre-certification. However, once a product has been introduced on the market, it may be inspected by the licensor (MEI or the CSS entity to be formed) or motion picture owners in order to ascertain that the product in question is reasonably resistant to misuse. An improperly designed product may not be distributed.

Even where a software implementation was proper when originally marketed, if generally available technology advances to the point that the product becomes readily circumventable, the designer of the product has a certain period of time to develop a new version and substitute it for the old one in the line of commerce.[7] Software developers interested in developing software

[6] This tamper-resistance requirement does not, of course, refer to a general cryptographic attack on a CSS device as a "black box." Software and hardware are equally susceptible to such attacks, and even extremely robust and time-tested algorithms are known to be actually or theoretically breakable.

[7] The CSS license further requires that those who seek to develop implementations commit to exert positive efforts toward adoption of certain other architectural features such as watermarking, and they have agreed to certain limitations of placing data on the bus of a computer which are more stringent than other licensees. Because most

implementations of CSS components such as the authenticator or descrambler should base their designs on a strong cryptographic background and a close reading of the language of the licenses, as well as consultation with suppliers or customers who may have had experience in this area.

Hardware Robustness. Consumer electronics devices which implement CSS, and certain of their computer counterparts, will also, by the end of the year,[8] be subject to design requirements intended to reduce the likelihood of misuse of their products. Such requirements are already in place with respect to the regionalization functions of players and drives, and will include requirements, for example, that critical functions of the copy protection scheme not be defeatable by simply flipping a switch or clipping a wire.

Restrictions on Data Present on Various Buses. To complete the task of putting easily copyable data out of the way of temptation, the CSS license includes restrictions on what data may be carried in what form on what buses. In general, the easier it is to copy usable data, the less accessible that data must be. The rules are partitioned according to whether the data is CSS scrambled, clear text, or rescrambled using some proprietary method, and whether the data is in compressed or uncompressed (high bandwidth) form.

CSS scrambled, compressed data is the same bitstream which is found on the disc. A DVD drive may not release this data except in response to an authentication handshake. However, the purpose of encrypting the data was that a system need take no special pains and undertake no obligations with respect to that data until it has been descrambled. Therefore, there are no obligations relating to treatment of data in this form within the system.[9]

Descrambled, compressed data is the most highly protected. This data, which is essentially the output of the CSS descrambler module, may not be transmitted over a "user accessible bus."[10] The only appropriate way to transmit descrambled compressed CSS data over

implementations of CSS in PCs appear likely to be either pure software or a hybrid of software and hardware, these design requirements are reflected as PC requirements in this paper.

[8] Predicted. These rules will come into place sooner if a need for them becomes urgent.

[9] Manufacturers should note, however, that an application which seeks somehow to exploit this point to make a product which unlawfully copies copyrighted motion picture content may well find themselves the subject of a suit for contributory copyright infringement.

[10] The CSS license defines user accessible bus as a bus such as PCI or a card bus which is designed for end-user upgrades of components, but not an internal bus such as a CPU bus or memory bus.

the PCI or other user accessible bus is to rescramble or re-encrypt it. In general, manufacturers are either making their CSS functions integral with MPEG decompression functions, either in software or hardware, or they are providing encryption between separate modules, whether hardware, or software, or both, which perform these functions.

Descrambled, decompressed CSS data is the high bandwidth bitstream which has undergone all or most of the MPEG decoding process. Over the next several years, it is expected that it will be quite difficult both to intercept this data stream and to record it in any commercially meaningful way, unless the device or module emitting the data stream is directing it toward a capture and compression software or hardware module also located on the bus. This data stream may be present on any internal computer bus so long as it is being directed towards the graphics subsystems. This may mean either that fully decompressed video data is being sent to a graphics card for rendering, or, in other implementations, similarly high bandwidth free-motion compensation data is being directed to a device which will perform the motion compensation function.

Where a device or software product is designed in such a way that its high bandwidth output is directed solely toward the graphical rendering function, it will qualify under the license definitions as a “Schedule 3 Product.” This means that, barring some other disqualifying condition, it may be sold without restriction to manufacturers and end-users. On the other hand, if a product does not direct its decompressed high bandwidth output, such as a chip which simply places the data on its output pins, the product will be a “Schedule 2 Product” which may only be sold to other licensees or associate licensees. Further discussion of the licensing definitions may be found in the section of this paper relating to the legalities of the license.

CSS LICENSE MECHANICS AND FUNDAMENTALS

Potential manufacturers select from three types of license with up to twelve classes of of product, according to the products they wish to make, use, or sell. The three types of license are Participating, Basic, and Associate.

Participating licensees receive confidential information and licenses necessary to manufacture products in any or all of the twelve product classes. There is a significant fee for each class (currently ¥1,000,000; about $10,000 per category). A Participating licensee will have the ability to participate in technical discussions relating to future upgrades and modifications to the specifications.

Basic licensees receive the same materials as Participating licensees, but pay a lower fee and may not necessarily participate in technical discussions relating to future upgrades and modifications to the specifications.

Basic and Participating licensees identifying which categories of products they plan to manufacture and/or distribute under the license. A company seeking to make only the lowest-level components for the CSS system might, for example, only sign up as an *Authentication Chip Manufacturer*. A company seeking to make add-in cards for PCs would, on the other hand, need to sign up in three categories: *Authentication Chip Manufacturer*, *Decoder Chip Manufacturer*, and *Decoder Card Manufacturer*.

CSS License Categories

1. Content Providers
2. Authoring Studios
3. DVD Disc replicators
4. DVD Disc Formatter manufacturers
5. DVD Player manufacturers
6. DVD-ROM Drive manufacturers
7. Descramble Module manufacturers (hardware and/or software)
8. Authentication Chip manufacturers for DVD-ROM Drives
9. Authenticator manufacturers for DVD Decoder (hardware and/or software)
10. DVD Decoder Card manufacturers
11. DVD Decoder Software developers
12. Integrated Product manufacturers

A computer company seeking only to manufacture products from licensed components supplied by others may find it sufficient to sign up as an *Integrator*. The other categories are generally self explanatory, or are explained in materials which accompany the license application.

Associate licenses are available to companies manufacturing end-user products from a certain nearly fully integrated components referred to as “Schedule 2 Products.” This license is considerably shorter and less complex. No confidential information is furnished, and there is only one class.

Resale Restrictions - Schedules 1,2, and 3

The CSS license governs who may purchase products made under its authority. The scope of permitted purchasers depends on the nature of the product made.

Schedule 1 Products are the most high-risk products, and may only be sold to other Participating or Basic licensees who are signed up in the appropriate category. Examples of Schedule 1 products include authentication devices and descrambling devices, as well as other products which do not fall clearly into Schedules 2 or 3.

Schedule 2 Products are a small class of products which has as an output, descrambled, decompressed video which is not otherwise copy-protected. These may be sold to Participating or Basic licensees, or to Associate licensees for incorporation into Schedule 3 Products.

Schedule 3 Products. If a Licensee's product is fully CSS compliant, *i.e.,* all outputs have proper treatment and other design rules followed, then the product is a Schedule 3 Product under the license, and it may be sold without restriction.

Other License Terms

In addition to requiring compliance with the design rules described in this paper, the CSS licenses require the following:

- License-back of patents which are "absolutely necessary" to implement the various CSS specifications, and agreement to provide nondiscriminatory, reasonable license to patents which are economically necessary to implement the specification.
- Liquidated damages provision of one million dollars for material breaches of the agreement.
- Ability of the content providers to sue for injunctive relief in case of misuse of the technology. Other licensees may sue the content providers if they, in turn, misuse the technology.
- Strict obligations of confidentiality including use of locked rooms, etc.
- Prohibition on the sale or distribution of products which incorporate CSS technology unless they are fully compliant with the design rules or are being sold to other CSS licensees.

HOW TO GET A CSS LICENSE AND OTHER INFORMATION

It is expected that an independent, multi-industry entity will coordinate licensing of CSS in the future. In the meantime, Matsushita (who, with Toshiba originated the CSS algorithm) has agreed to license the technology as a surrogate “Interim Licensing Entity.” MEI’s procedures are meticulous and may take quite a few weeks to complete. Prospective developers are advised to allow plenty of time for this process and to be detail-oriented in addressing it.

The contact at Matsushita is:

Mr. S. Yamaguchi
Matsushita Electric Industrial Co., LTD.
CSS Interim Entity
1006 Kadoma, Kadoma-Shi, Osaka 571 Japan
Fax: 81-6-901-9299

Additional information may be available from customers or suppliers who will be working with you to create a compliant product offering. Further information about the status of DVD and related products can be found on the websites of many of the manufacturers. Many news articles are conveniently collected at http://www.unik.no/~robert/hifi/dvd/.

CONCLUSION

DVD presents a tremendous opportunity for software developers, manufacturers, and consumers. Although the legal description of the CSS method may appear somewhat challenging, it is implementable and designed to be used by a robust, innovative, and competitive computer industry.

The establishment of a content protection system to reduce the concerns of the motion picture industry has helped move this technology forward. Intel has worked to limit the impact of this solution on manufacturing processes and on bottom-line costs for manufacturers and their customers by assuring that software solutions may be used on their multimedia systems.

Chart of Design Rules as of 9/97

(Consult Your own CSS License for Current Requirements)

Type of Connection	**Player Rules**	**ROM/Computer Rules**
NTSC Out	MVN + CGMS	MVN after April 1
PAL, SECAM, YUV	MVN + CGMS	MVN after April 1
SCART Connectors	AGC-SCART	Same
Computer Monitor RGB	Forbidden till amendment	Permitted till amendment
Consumer RGB and other Analog Video Outputs	Forbidden till amendment	Forbidden till amendment
Digital Video Outputs		
• **Scrambled Compressed**	Only provide direct to descrambler	Release from drive only with authentication
• **On Bus**	N/A (No Bus)	No rule.
• **DEscrambled compressed**	Forbidden till amendment	same
• **On Bus**	N/A (No Bus)	Forbidden unless rescrambled
• **Descrambled DEcompressed**	Forbidden till amendment	Forbidden till amendment
• **On Bus**	N/A (No Bus)	permitted; future rule may require scrambling on the bus
Analog Audio	OK	OK
Digital Audio		
• **Compressed**	OK	OK
• **LPCM <48Khz x 16bits**	SCMS. Also downsampling may be restricted after transmission security spec is adopted	OK, but downsampling may be restricted after transmission security spec is adopted
Design Features	**Player Rules**	**ROM/Computer Rules**
Regional Playback Control	Must observe.	Drive must observe after EOY; before then, rules may be enforced in associated software.
Recordable Media Playback Control	Reject on encounter	
Software Robustness	Must be designed so that keys and algorithm can’t be detected by disassembly; data stream can’t be intercepted or copied.	
Hardware Robustness	Rules under development	
File Copying	No copying of content	No support for file copying

Key:

AGC-SCART = Automatic Gain Control specifications for the composite signal (NTSC, YUV, etc) carried by that connector, provided that the connector must be configured so that the component signal carried by the connector is accompanied by a composite signal that provides the synchronization for the component signal.

CGMS = CGMS-A specifications contained in IEC 1880 (for inclusion on Line 20) and [in EIA-IS-702] (for inclusion on Line 21 for NTSC and CGMS-A specifications contained in [pr ETS 300294] for PAL, YUV, and SECAM

Forbidden till amendment = Licensor is working with relevant industry players to develop a security means to permit such output in a reasonably copy-resistant manner. It is expected that this output will be permitted with such protection when identified.

MVN = Macrovision Antitaping Process for DVD Products, Revision 1.0, July 5, 1997

OK= Ok to transmit this content in this manner

Permitted till amendment. = Licensor is working with relevant industry players to develop a security means to permit such output in a reasonably copy-resistant manner. It is expected that this output will require such means when identified.

SCMS = such transmission carries Serial Copy Management System information in the manner specified for the relevant transmission format, including either SCMS information converted from the copy protection information contained on the DVD Disc containing the CSS Data or SCMS information sufficient to prevent copying by a digital audio recording device subject to the Audio Home Recording Act.

User Accessible Bus = A data bus which is designed for end user upgrades or access such as PCI, PCMCIA, or Cardbus, but not memory buses, CPU buses, and similar portions of a device's internal architecture