

**PHILIPS**

Philips 9000 series Blu-ray Disc player  
with Qdeo™ video processing technology

Technical backgrounder

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## 1 Introduction

### 1.1 What is Qdeo™?

Qdeo™ video processing technology produces quiet and natural video free from noise and artefacts.

Qdeo processing includes three main stages:

- *Noise Reduction*: Per-pixel noise and compression artifact reduction removing noise inherent in digital video.
- *Format Conversion*: Per-pixel motion-adaptive 3D de-interlacing and advanced nonlinear scaling transforming the image to the desired resolution while suppressing artefacts like feathering and jaggies.
- *Enhancement*: 2D Edge Enhancement increasing detail and sensation of depth, Adaptive Contrast Enhancement (ACE) providing larger dynamic range and Intelligent Color Remapping (ICR) rendering rich and vivid images.

Qdeo processing can be applied to wide range of content and applications from QVGA resolution video all the way up to 4K x 2K resolutions.

### 1.2 Who owns and develops Qdeo?

Qdeo is developed by Marvell® Semiconductor, Inc, a leading fabless semiconductor company based in Santa Clara California, USA.



Qdeo is an award-winning technology, having received numerous industry awards such as the “IMS Research TV Innovation Award of 2009”, “Secrets of Home Theater Best Video” and numerous awards of products applying Qdeo. More information can be found on [www.ClearlyQdeo.com](http://www.ClearlyQdeo.com).



Qdeo processing is designated by the Qdeo logo on the product. Qdeo™ is a trademark of Marvell and/or its affiliates.

## 2 Marvell products that fall under the Qdeo™ technology

### 2.1 88DE2710 (“Kyoto”) Digital Video Format Converter

The first generation 88DE2710 (“Kyoto”) processor was launched at the CES 2007 and has the following features:



- Compression Artifact Reduction (CAR)
- 3D Video Noise Reduction (VNR)
- 3D De-interlacing
- Nonlinear scaling
- 2D Edge Enhancement
- Adaptive Contrast Enhancement (ACE)
- Intelligent Color Remapping (ICR)

This first generation processor has been used in several high-end products and was widely recognized for its performance, although the Qdeo branding was not always present.

### 2.2 88DE2750 (“Kyoto-G2”) Digital Video Format Converter

The second generation 88DE2750 (“Kyoto-G2”) processor was launched at CES 2009 with improved performance of most of the original features and two new additional features:



- 3D Video Noise Reduction (VNR)
- 3D De-interlacing
- Nonlinear scaling
- 2D Edge Enhancement
- Adaptive Contrast Enhancement (ACE)
- Intelligent Color Remapping (ICR)
- Compression Artifact Reduction (CAR)
- **Qdeo True Color**
- **Natural Depth Expansion (NDE)**

### 2.3 Embedded versions of Qdeo

The first embedded version of Qdeo is featured in the 88DE3010 (HD Media processor System-On-a-Chip or SOC). This SOC integrates some of the technologies found in the dedicated video post processors.

The 88DE3010 has the following Qdeo features:



- 3D Video Noise Reduction (VNR)
- 3D De-interlacing
- Nonlinear scaling
- Adaptive Contrast Enhancement (ACE)
- Intelligent Color Remapping (ICR)
- Natural Depth Expansion (NDE)

### 3 Qdeo™ technology in-depth

There are three main stages: Noise reduction, Format conversion, and Enhancement. They are explained in more detail below.

#### 3.1 Qdeo Noise reduction

The 3D motion adaptive noise reduction function works by applying a combination of spatial and temporal filtering. The combination is dependent on the motion of each pixel, which means the algorithm is truly operating on a per-pixel basis, in detecting and calculating motion. For each noise level, programmable proportions of filtering are possible, allowing the performance to be fine-tuned extensively.

The edge adaptive spatial filtering reduces the amount of smoothening or loss of detail and increases the accuracy for temporal filtering. This all contributes in reducing noise without softening the image.

The amount of noise reduction applied is automatically determined based on the amount of noise in the input. This avoids applying noise reduction on content which simply doesn't need it, like animated or high-quality content and preserves the original sharpness.



In applying noise reduction, specific exceptions can be made for skin tones on a per-pixel basis, so the noise reduction does not produce 'waxy' or 'plastic' skin toned regions and preserves detail in e.g. faces.

##### 3.1.1 Compression artifact reduction (CAR)

The compression artifact reduction can automatically detect and reduce the two most common artifacts commonly found in digitally compressed video content, namely mosquito noise and block noise. Especially in lower bit-rate video content, these kinds of artifacts are commonly present.



To address mosquito noise adequately, pixels that exhibit mosquito noise and are lying near to strong edges in the input picture are identified. The pixels are then filtered, dependent on the actual noise level. The filtering used is edge adaptive, to prevent softening true image edges.

To reduce block noise, a detection mechanism is employed which automatically detects 8x8 blocks in the input video that are typical for more highly compressed digital video content. Once blocks in the input video have been detected, filtering can happen in grid mode and global mode. In grid mode, the filter focuses on pixels that neighbour the block grid, while global mode addresses all pixels. Both modes can be used simultaneously; selection of the modes is dependent on the actual noise level. Again, the filtering is edge adaptive to prevent unnecessary softening of true image edges.

As before, when no noise is detected, no processing is done to avoid affecting sharpness of good quality material. Aside from detection 8x8 blocks, the block detection mechanism can also handle non-standard size blocks larger than 8x8. This sometimes occurs as the result of video scaling or the usage of non-standard compression schemes.

### 3.2 Qdeo Format conversion

Qdeo Format conversion refers to e.g. converting an interlaced standard definition image in RGB format with a 24fps frame rate to a progressive-scan high definition image in YCbCr format with a 60fps frame rate. It does not imply video codec format conversions.

At the heart of the format conversion lies a sophisticated 3D per-pixel motion adaptive de-interlacing engine with high quality automatic film mode detection.

The de-interlacing engine features:

- Per-pixel robust motion detection with ability to detect motion holes
- Vector Interpolation reduces “jaggies” on moving objects
- Motion adaptive low pass filtering to further reduce any leftover “jaggies”
- Film de-interlacing
- Automatic detection of all common cadences like 3:2, 2:2, 2:3:3:2, etc

- 3:2 and 2:2 film detection automatically adjusts to the noise present (to prevent seeing film as video)
- Two programmable cadences can also be detected
- Fast entry and exit from film mode to video mode
- Optimal mixed-mode handling of scrolling text and sub-titles at bottom of the screen

### 3.3 Qdeo Enhancement

#### 3.3.1 Local Adaptive Contrast Enhancement (ACE)



The local adaptive contrast function allows improving shadow regions in the image without blowing out the highlights. This is especially useful on less well exposed material with under-detailed shadow regions.

#### 3.3.2 Intelligent Color Remapping (ICR)

Intelligent Color Remapping enables for instance vivid colors in outdoor scenes without causing hue shifts or loss of detail or changes in skin tones. It provides the ability to enhance certain colors in the spectrum while leaving other colors untouched.

### 3.3.3 Qdeo Natural Depth Expansion (NDE)

Natural depth expansion consists of two technologies: Detail Enhancement and Large Transient Improvement (edge enhancement), with the aim of sharpening the picture and introducing an improved depth perception.

The Detail Enhancement focuses on finer details of the picture, but has a protection against noise amplification and offers two frequency enhancement modes. It is invariant to scaling and will therefore yield equal enhancement to scaled or non-scaled material.



Soft edges leading to loss of detail

Sharpened edges improving detail

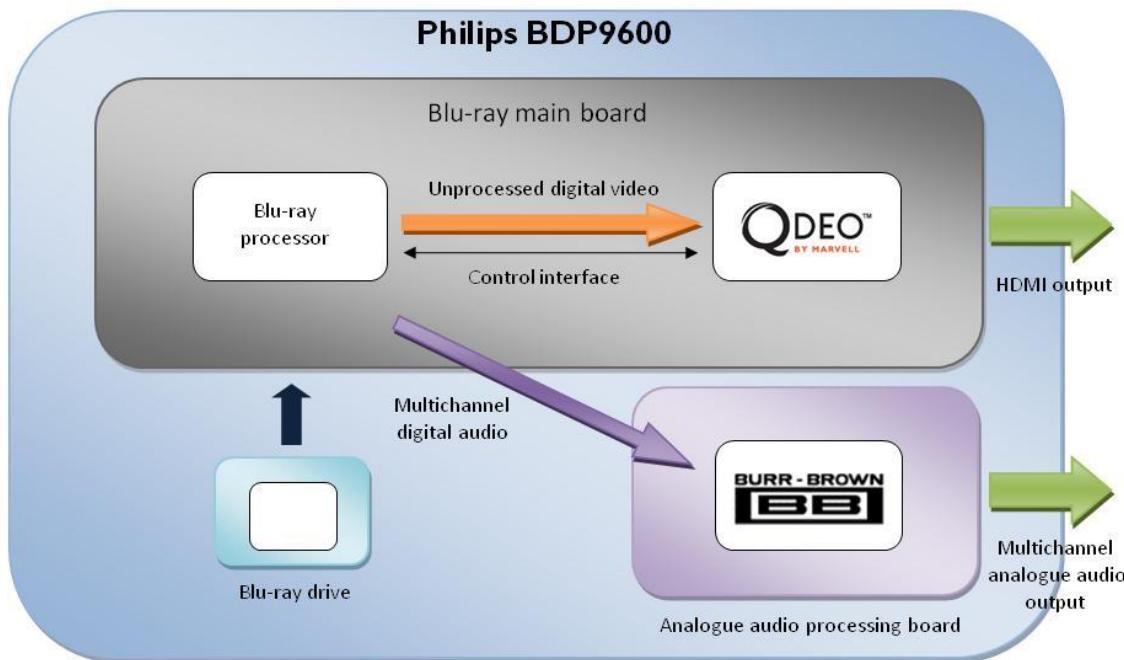
The Large Transient Improvement (edge enhancement) focuses on sharpening edges in the picture, but does so without creating over/undershoots and ringing artefacts. It can sharpen both luminance and chrominance transitions.

### 3.3.4 Qdeo True Color Processing (QTC)

Powered by Bit Resolution Expansion, it dynamically expands 8-bit video to use the full dynamic range offered by 10 and 12 bit displays, eliminating contours while preserving detail. This process, which we refer to as Qdeo True Color Processing (QTC), produces a perceived higher dynamic range.

## 4 Qdeo™ technology in the Philips new 9000 series Blu-ray Disc player

### 4.1 Architecture



The new Philips 9000 series Blu-ray Disc Player is using an architecture where the audio and video processing has been separated. In the main board of the player, the video is sent in its native digital format without any processing to the Qdeo™ video processor. All processing, including de-interlacing, is handled by the Qdeo™ video processor.

### 4.2 Pre-programmed profiles

Same as the previous 9000 series, a selection of carefully tuned profiles is available for selection to the user. On top of these tuned profiles, new Philips 9000 series allows the user to adjust key image parameters directly. The default profile (Optimal) is the most recommended. It will yield good result in most of the content by using the Philips 'Content adaptive video enhancement'. The other profiles are tuned to specific content with more pronounced processing. All video processing, even when only de-interlacing and scaling, is always handled by the Qdeo™ video processor.

Available profiles:

- **Optimal (default profile)**
  - Content adaptive video enhancement
  - The quality of the video stream is continuously analysed. The gathered information is used to guarantee the best possible picture quality for all input video streams.
- **Documentary**
  - De-interlacer and scaler

- Automatic controlled noise reduction, based on noise content of source video material with optimisation for natural appearance for facial features
- Scaler set to sharpen content
- Moderate Natural Depth Expansion (including noise threshold)
- Colour enhancement (focused on natural occurring colours)
- Adaptive Contrast Enhancement (low)
- **Animation**
  - De-interlacer and scaler
  - Automatic controlled noise reduction, based on noise content of source video material with optimisation for natural appearance for skin tones/facial features
  - Scaler set to sharpen content
  - Medium Natural Depth Expansion (including noise threshold)
  - Minimal Block Noise Reduction / Mosquito Noise Reduction
  - Adaptive Contrast Enhancement (low)
  - Colour enhancement (all colours with optimisation for natural appearance for facial features)
- **Internet Video**
  - De-interlacer and scaler
  - Strong noise reduction on the entire image
  - Scaler set to smoothen content
  - Strong Block Noise Reduction / Mosquito Noise Reduction
  - Medium colour saturation improvement on the entire image
  - Adaptive Contrast Enhancement (low)
- **No Optimisation**
  - Only the de-interlacer and scaler are enabled, no further processing is done.
- **Personalized**
  - There are 8 key parameters available for user adjustment
  - Adjust brightness, contrast and saturation individually on the entire image
  - Select different noise reduction level to reduce both analog and digital noise, like Gaussian noise, Block noise and mosquito noise.
  - Adjust ‘Adaptive Contrast Enhancement’ level to enhance the detail of shadow area without crushing mid-tones or highlights
  - Brings out fine details without causing side effects like halos and ringing
  - Five color settings can be used for different mood or image.