# Improvement in the Picture / Sound quality of DMP-BDT310/210/110

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## 1 Introduction

Panasonic has been improving picture/sound quality and invented many unique technologies for BD players. Those black-box technologies in our past products have given us the world's highest level of picture and sound quality.

For Year 2011 models, again we have developed new video and audio processing technology that gives the further improvements in sound and image quality. This paper explains those new technologies developed for Y2011 models: DMP-BDT310 /210/110.

## 2 Picture Quality Enhancements

### 2-1 Panasonic Chroma Technology

As we have reported before, "4:2:0" to "4:2:2" or "4:4:4" chroma up conversion is the key for high performance picture quality. We developed the high order and high bit precision chroma up-conversion technology called "PHL reference Chroma processor (Plus)" and "High precision 4:4:4".

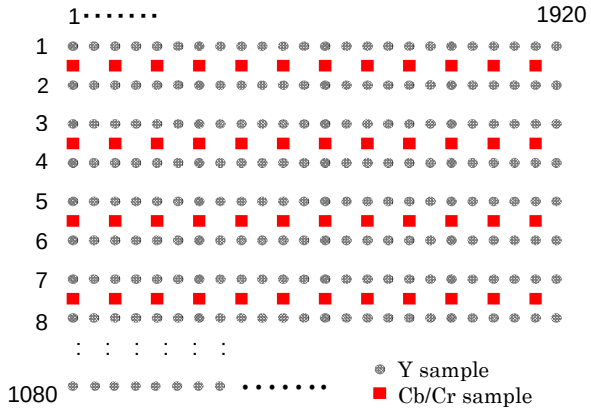


Fig. 1 4:2:0 Format

On Blu-ray discs, signals are recorded in "4:2:0" format (Fig. 1), in which the chroma (color) signals (Cb/Cr) are sub-sampled both vertically and horizontally, and the numbers of samples in the chroma channel are one quarter of those in the Y channel. But on the display, Y and chroma samples should be equally allocated, so the 4:2:0 must be up converted to "4:4:4" (Fig. 3). HDMI also requires signals to be in either "4:2:2" (Fig. 2) or "4:4:4". Therefore, chroma up-conversion in Blu-ray players is necessary.

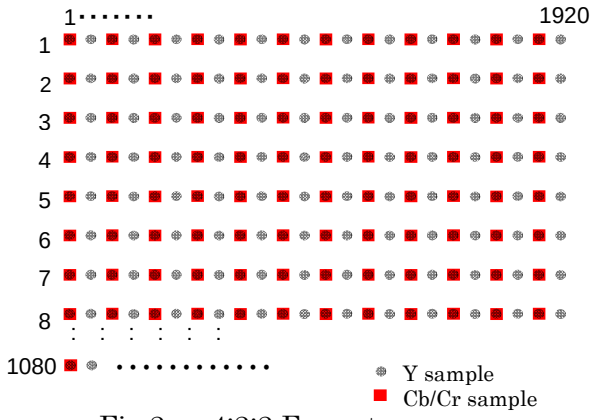


Fig.2 4:2:2 Format

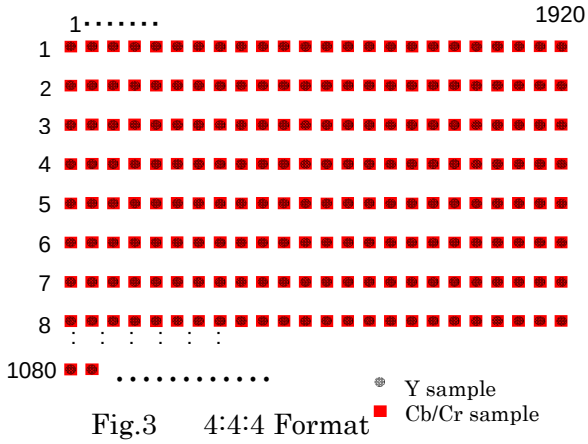


Fig.3 4:4:4 Format

Fig. 4 shows the history of the 4:2:0 to 4:2:2 up conversion from the era of DVD players.

The simplest way of 4:2:0/4:2:2 up conversion is to duplicate the line, as shown in left column. Some of the first generation DVD player had used this technique. But this caused terrible jaggies called "Chroma Up-sampling Error (CUE)" on chroma edges.

Panasonic had never used this faulty filter option for chroma processing. Instead, we used a 2 tap interpolation technique from the beginning as shown in center column of Fig. 4. With this, the chroma edge was rendered very smoothly.

In 2007, through the study at PHL (Panasonic Hollywood Laboratory), we learned that even 2tap filter doesn't have enough performance for reproducing picture encoded in MPEG4-AVC stream, and developed a high order high precision filter system called "PHL reference Chroma Processer (Plus)" and deployed all Panasonic players thereafter.

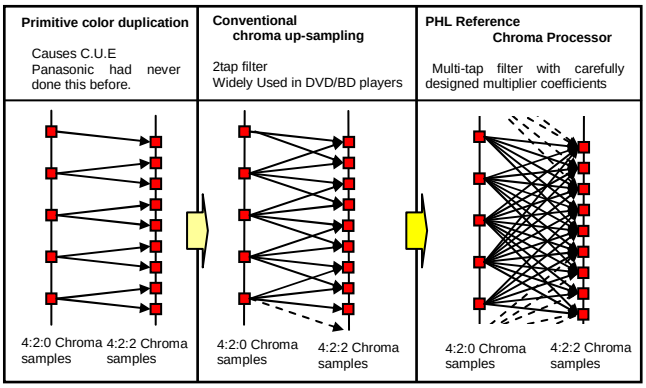


Fig. 4 History of 4:2:0/4:2:2 chroma up conversion

## 2-2 Y2011 model's improvement

Even the "PHL Reference Chroma Processer" gave us industry-leading level of picture quality, we wanted to try more. Because we have learned that the number of the filter taps is the key for it. And for Y2011 models, we had a chance to re-design the Uniphier hardware from the bottom layer of the chip. So we tried it.

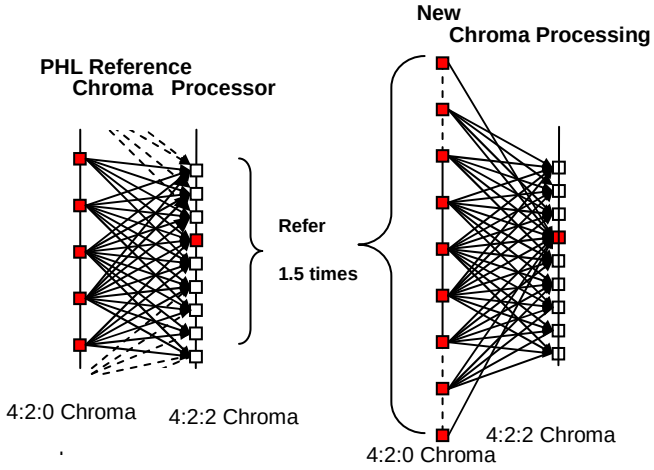


Fig 5. New Chroma Processing

For new version of Uniphier, we increased the number of chroma up sampling filter taps to one and half times of the previous version. (Fig. 5) And the result is more than we envisioned.

By increasing taps, we could acquire better phase characteristic in addition to the original wide bandwidth.

## 2-3 Picture quality comparison

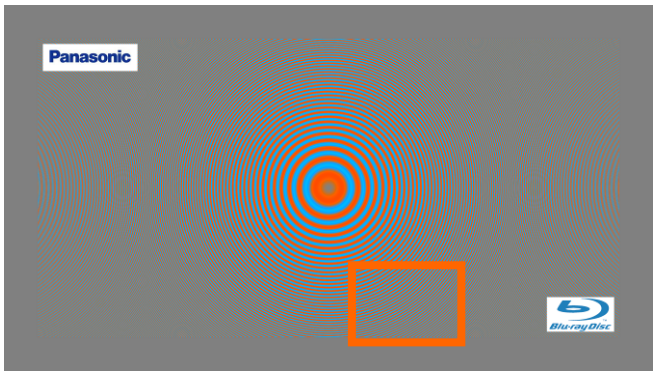


Fig. 6 Chroma CZP

Below are the magnified view of the red rectangle part of the "Chroma CZP" shown on Fig. 6, captured from both the conventional (Fig.7) and new chroma process (Fig. 8) systems.

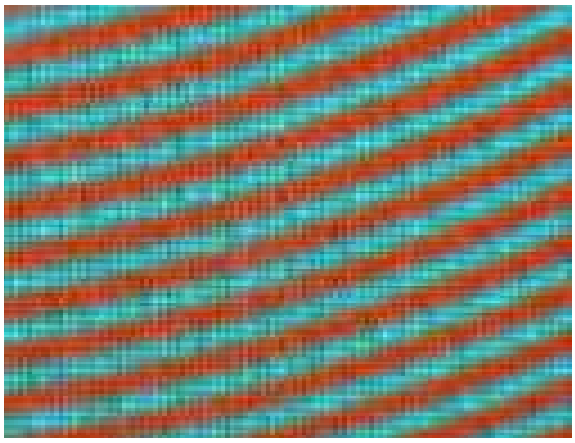

Fig. 7 Y2010 Model

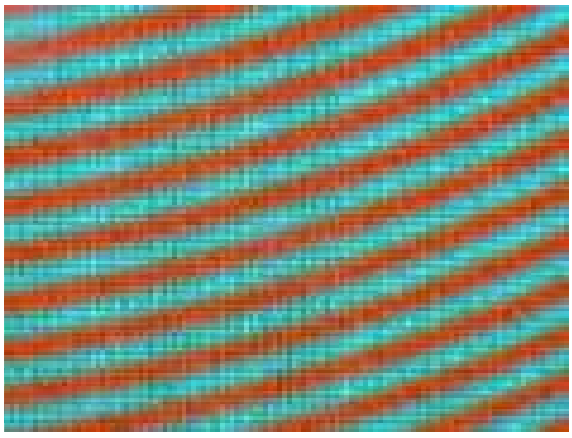

Fig. 8 Y2011 Model

On Y2010 model (Fig. 7), a slight moiré (discontinuity of arc) that is because of the phase

error in high frequencies can be observed. And Y2011 model (Fig. 8), those moiré can not be seen. That means the phase characteristic is improved. Even the Y2010 models had enough chroma bandwidth but it contains slight phase error, which is fixed in Y2011 models. Therefore it is clear that the Y2011 model is much faithful to original than previous models.

## 2-4 Adaptive Chroma Processing

Our Y2011 models also take over the full advantage of "High Precision 4:4:4" from Y2010 models.

In Y2010, we invented a new signal processing system named "Motion Adaptive Chroma Up-sample". In this system, all "4:2:0" to "4:2:2" conversion is done in the "progressive domain" even the source is interlaced. And in this system, there is no rounding down process through the whole signal path. The precision of data only increases as it passes through, as shown in Fig.9. This gives big improvement on the picture quality.

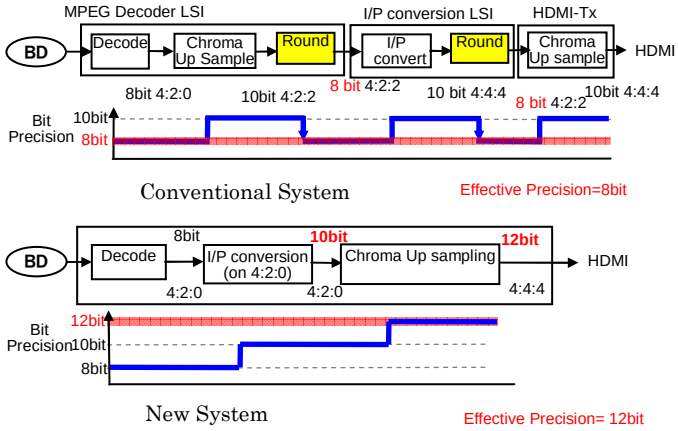


Fig.9

New models also inherit "Edge adaptive High precision 4:4:4", in which chroma up sampling filters for "4:4:2" to "4:4:4" is adaptively changed according to the image data, and results sharp and smooth chroma edges.

By these technologies, Panasonic have achieved world top level of picture quality again, and we named the entire these technologies "Adaptive Chroma Processing".

## 2-4 3D Picture Quality

One of the uniqueness of Uniphier is that all these chroma processes are applied both L and views respectively when it plays back 3D titles. See Fig.10.

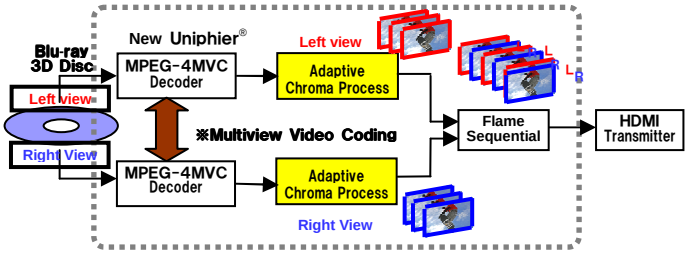


Fig. 10

The "Adaptive Chroma Processing" gives the higher frequency response with minimum phase error, those results "rich details" or "sharp images" on 2D pictures.

On 3D pictures, difference between L/R signals tells the depth information of the objects. Texture of the objects caused by the difference of the light reflection gives high frequency and minimal signal difference between L and R views. Panasonic "Adaptive Chroma Processing" has enough bandwidth and phase precision to render such subtle nuances. Therefore, on 3D pictures, the advantage of Panasonic's chroma processing results in faithful depth, which improves "texture" in addition to "rich details" and "sharper images".

## 2-5 Net Picture Quality Improvement

Another improvement in Y2011 models is for Net Picture Quality. Recently net contents had become key function for BD players. Customers began to enjoy net streaming like "You-tube", "Netflix", etc with BD-players. But in some cases the picture quality of streaming is poorer than BD or DVD.

Therefore we applied our key technologies to streaming videos to improve picture quality and to make them more enjoyable.

### 2-5-1 4:2:2:2 to 4:3:4:3 transform

One of the problems of net delivered video is "cadence". For efficient compression, 24p movie is sometimes encoded in 30p for net streaming. In such case, 24p is encoded in 2:1:1:1 cadence (see 2nd row of Fig.11).

Conventional players decode this 30p stream and simply duplicate fields or flames that result in a 4:2:2:2 cadence shown in 3rd row of Fig. 11, which has a bad judder. To improve the visibility, we applied our I-P conversion technology in this field, Uniphier can detect 4:2:2:2 cadence and transform it to 3:2:3:2, as shown in the bottom row of Fig. 11.

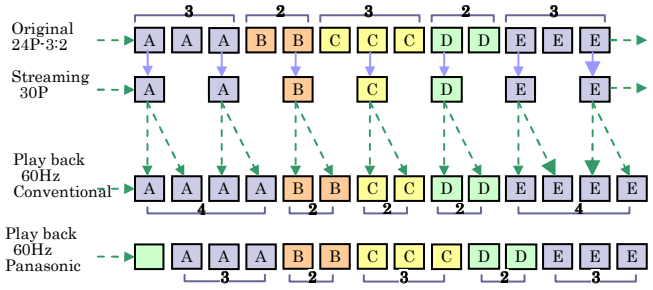


Fig. 11

With this technology, movie is displayed with common 2:3 cadences, and judder is reduced.

### 2-5-2 Super Resolution for Net Contents

Panasonic had developed "Super Resolution" technology for DVD up-conversion in Y2010 models. And in new models we applied this technology also for net contents.

Panasonic's Super Resolution is an intra-frame process. The processor analyzes and divides every pixel of the frame into three categories: texture, edge and plane. The processer applies appropriate up conversion process according to the "Category". To avoid overshoots on edges that spoil the picture quality, the processed picture is compared to the up-converted bilinear filtered picture for performing overcompensation correction. See Fig.12.

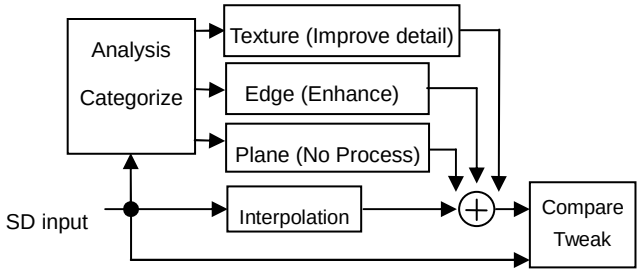


Fig. 12

This super resolution results very sharp and smooth image of 1080p from SD or 720P pictures of streaming videos.

By applying these two technologies, we succeeded in making net streaming pictures more natural and sharper.

## 2-5 3D effect controller and 2D-3D transform

It is well known that the 3D perception varies among different individuals. Some might feel eye fatigue when seeing popped out pictures, while others enjoying comfortably. Hollywood studios design 3D contents very carefully to avoid eye fatigue, therefore we think that everybody can enjoy 3D contents. But there might be few cases popped out picture being uncomfortable to such sensitive people.

### 2-5-1 3D Effect Controller

For such cases, we prepare the "3D effect controller" to adjust the depth of objects. For that purpose, offset is added left and right view independently and shift the picture back and forth as shown in Fig.13.

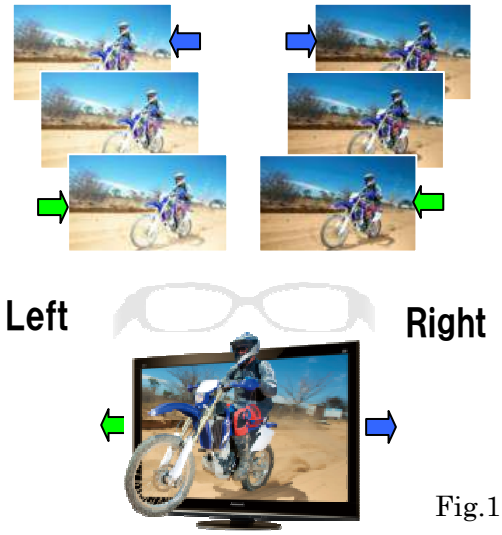


Fig.13

### 2-5-2 Additional functions

Another discomfort of 3D pictures is on the border of the screen. Especially, in case the objects on the screen border have popped out much, difference between 3Dpicture and TV bezel could be an annoyance.

For more comfortable viewing, two additional functions are prepared.

The one is the "Rounded Screen Mode", shown in Fig. 14. In this mode, the depth on both side of the screen and that of the center is controlled independently. By reducing the pop out on both side of the screen, 3D screen is smoothly contact to the bezel of the TV.

Fig. 14

The other function is "Flame Mode", shown in Fig. 15. In this mode, the feathering is applied on

screen borders. Because the feathering gets denser towards the edge of the screen, it also makes conformable to see the screen and bezel border.

Fig 15

### 2-5-3 2D to 3D conversion

Panasonic had also developed unique 2D-3D conversion technology for Y2011 models. Both L and R view originate same 2D picture but applied different process respectively to give deeper and wider 3D image. The new way for enjoy 2D BD title with 3D-TV is proposed. And in combination with Super Resolution Technology, DVD is also converted to Full-HD 3D.

## 3 Sound Quality Improvements

### 3-1 Jitter Purifier Improvement

Panasonic have been focused on sound quality over HDMI because it is the only way for output high-resolution audio (DTS-HD True-HD) in digital form, and developed "Jitter Purifier". By stabilizing a controlling parameter (CTS) for Audio Clock Regeneration, (Fig. 16) clock jitter caused by CTS variation is shifted to non-audible frequency (Fig. 17). Thus we had improved sound quality over HDMI.

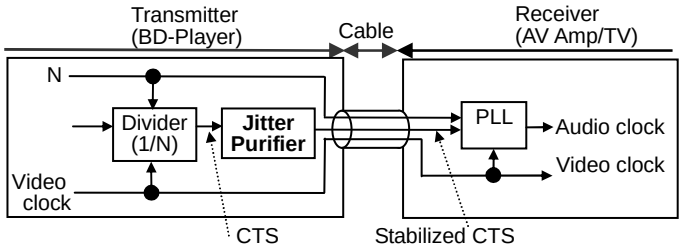


Fig. 16

For Y2011 models, we have improved the CTS holding duration as shown in Fig. 17, and succeeded in reducing the clock jitter in audible band than Y2010 models. By this technique we could improves sound quality on our new players

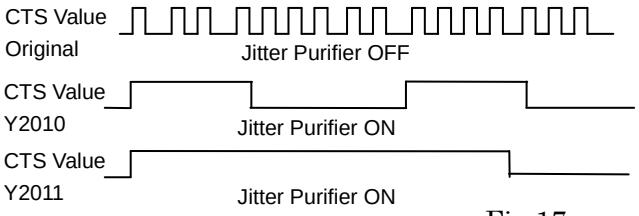


Fig.17

### 3-2 Tube Sound Improvement

"Tube Sound" was another challenge for sound quality enhancement for Y2010 models.

We have tried to simulate the "Tube" amplifier shown in Fig. 18. by Uniphier.

$$ip=K(\mu \times vgk+vpk)^{3/2}$$

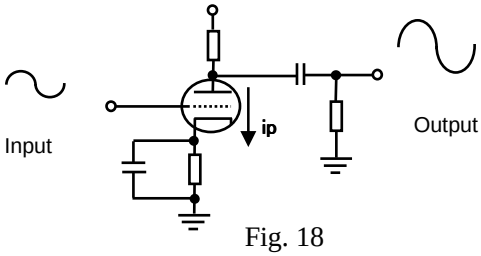


Fig. 18

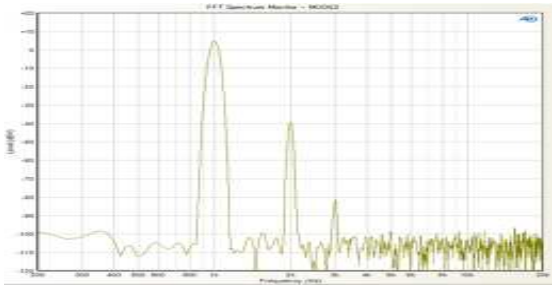

Fig.19 result of Uniphier simulation

And we succeeded in duplicate the uniqueness of the 2nd and 3rd harmonic distortion caused by tubes, as shown in Fig. 19. And we also got the warm enjoyable sound.

For Y2011 models, we improved the precision of Uniphier signal processing, to enhance the sound quality in "Tube sound" mode. And beside that, we add three more different mode in addition to original three types of tube: 12AX7A (ECC83) / 12AX7 (ECC83) / 12AU7A (ECC82) modes in Y2010 models.

## 4 Conclusions

Relied on the powerful processor Uniphier, Panasonic could improve picture and sound quality again in Y2011 models. We are very pleased to have these improvements. And we expect all our customers to enjoy these benefits.