White Paper

“Turbo 240” to decrease motion blur

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EIZO CORPORATION

Preface

A typical LCD monitor exhibits motion blur. Motion blur is caused by a slow LCD response time, lack of frames, and hold-type rendering. Recent LCD monitors have a good response time of one or two milliseconds, but motion blur still remains.

To decrease motion blur, we developed a new function called "Turbo 240".

Response Time

Response time is the amount of time a pixel in an LCD monitor takes to go from one value to another. If response time is slow, the user sees the changing state as motion blur.

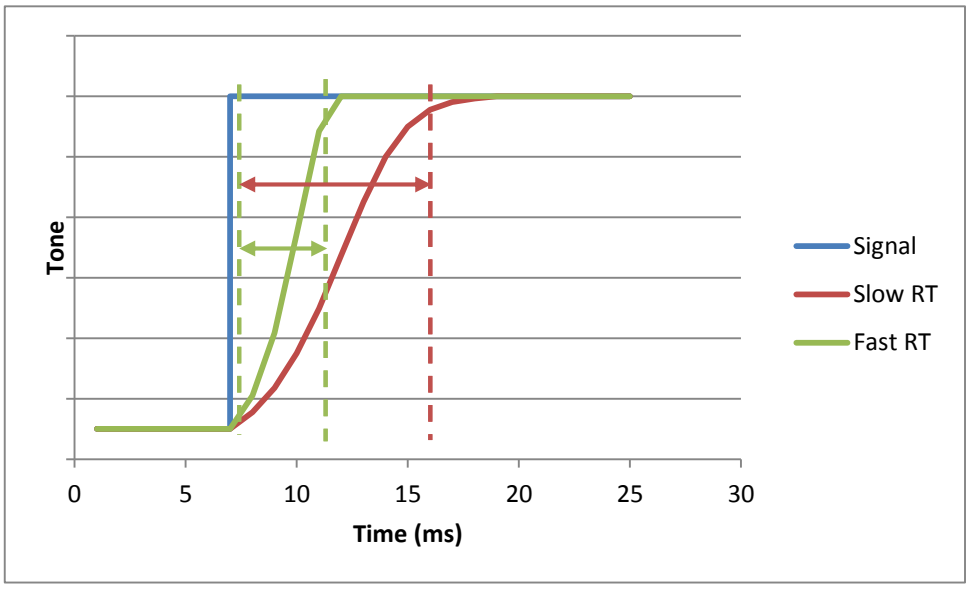

Fig.1 Response Time

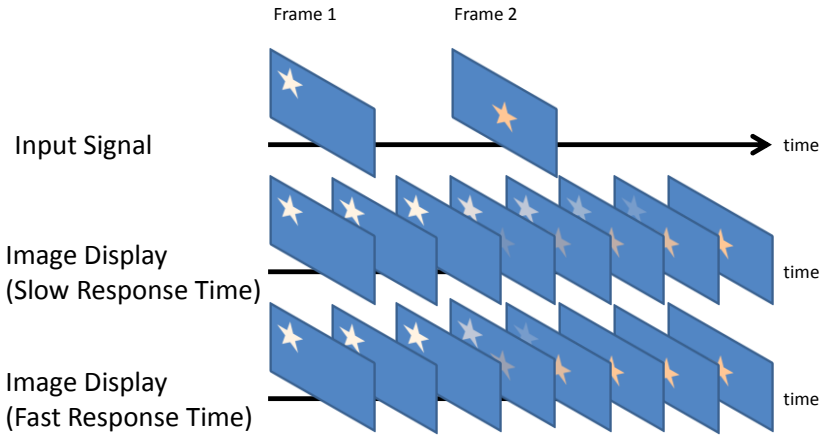

Fig.2 Image Display

If a pixel takes no time to go from one value to another, the user cannot see the changing state. However, the user perceives that the displayed image still has blur. This is because the displaying image is not contiguous so the human eye perceives it as unnatural.

Hold-Type Display and Impulse-Type Display

An LCD is a hold-type display device that sustains the same image until the next frame. Ideally, moving images should be displayed as non-step (continuous), but on an LCD they appear unnatural. As a result, the user perceives motion blur.

On the other hand, an impulse-type display device such as a CRT displays an image for an instant and then displays nothing until the next frame. The user sees the skipped image on the screen, but perceives it as a continuous image and smooth motion. This is because the user fills the image gap in his/her head.

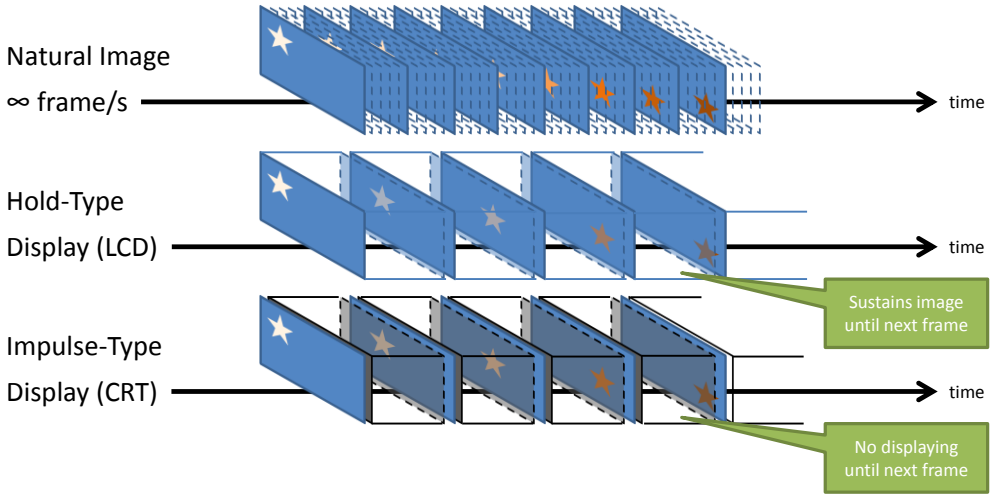

Fig.3 Hold-Type display vs. impulse-Type display (1)

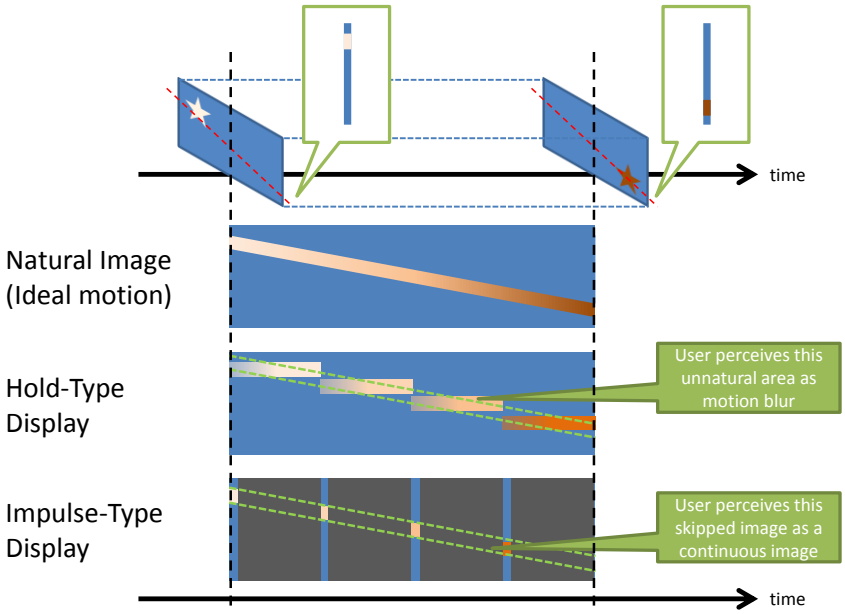

Fig.4 Hold-Type display vs. impulse-Type display (2)

120 Hz Signal Input

A signal with a 60 Hz refresh rate is commonly used in PCs. 60 Hz means the monitor displays the screen image 60 times per second. If the input signal has a 120 Hz of refresh rate, the monitor displays the screen image 120 times per second and the displayed image is smoother than that of a 60 Hz signal.

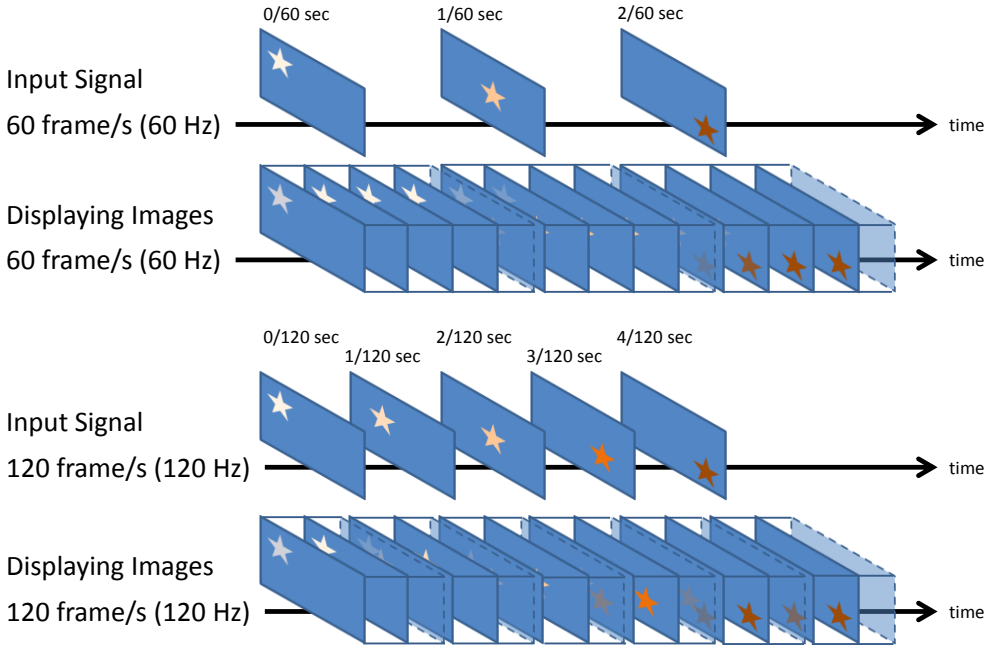

Fig.5 60 Hz vs. 120 Hz (1)

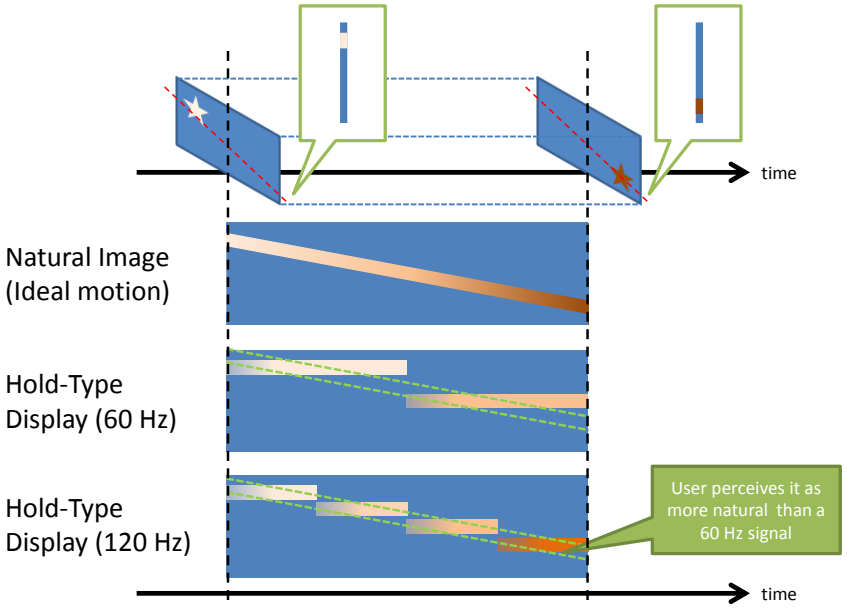

Fig.6 60 Hz vs. 120 Hz (2)

A 120 Hz signal is generally preferred for FPS (first-person shooter) games because it decreases the operation delay and the player perceives rapid motion more smoothly.

The higher the refresh rate, the more natural the displayed image appears to the human eye. However, a higher refresh rate increases the load on the PC, graphics board, and software. Moreover, existing signal cables does not have enough bandwidth to transmit a higher refresh rate signal.

EIZO Turbo 240

The EIZO "Turbo 240" function decreases motion blur by doubling the frames of the input signal and blinking the backlight. With backlight blinking, the monitor displays the screen like an impulse-type display.

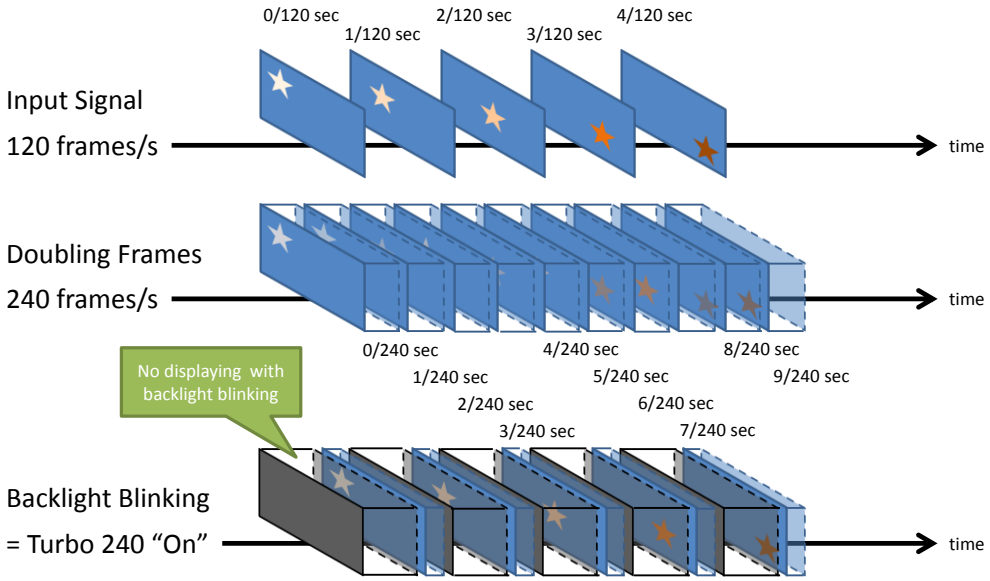

Fig.7 Working principle of Turbo 240

At first, the monitor doubles the input signal from 120 frames/second to 240 frames/second. It is not creating new frames but doubling the frames. At this point, the displayed image is the same as a common 120 Hz gaming monitor. Next, the monitor blinks the backlight in synchronization with the screen to insert a black screen. With the backlight blinking at a rate of 240 times/second, the monitor displays the screen like an impulse-type display.

Fig.8 shows that the monitor responds to the input signal. With Turbo 240, the user hardly sees the changing state of the LCD.

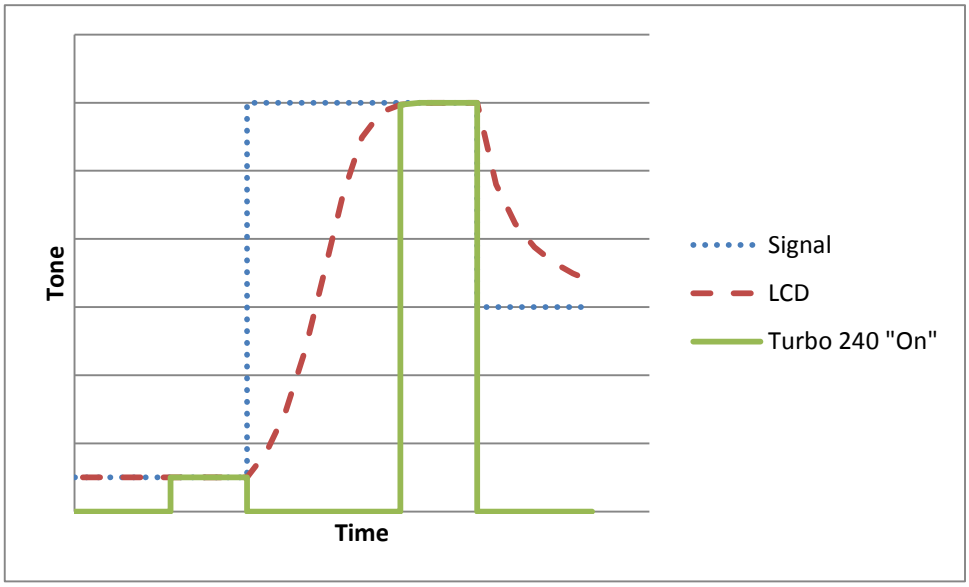

Fig.8 Response of the monitor with Turbo 240

Fig.9 illustrates a comparison between a common gaming monitor and an EIZO FORIS monitor with Turbo 240. A common gaming monitor is a hold-type display and the user perceives motion blur. On the other hand, an EIZO FORIS monitor with Turbo 240 displays the screen like an impulse-type display and it is difficult to perceive motion blur.

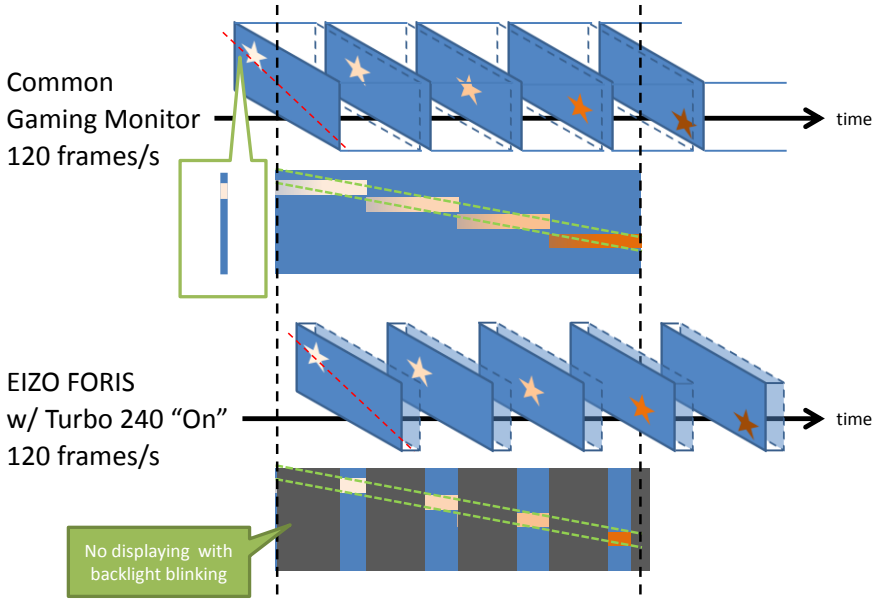

Fig.9 Typical gaming monitor vs. FORIS with Turbo 240

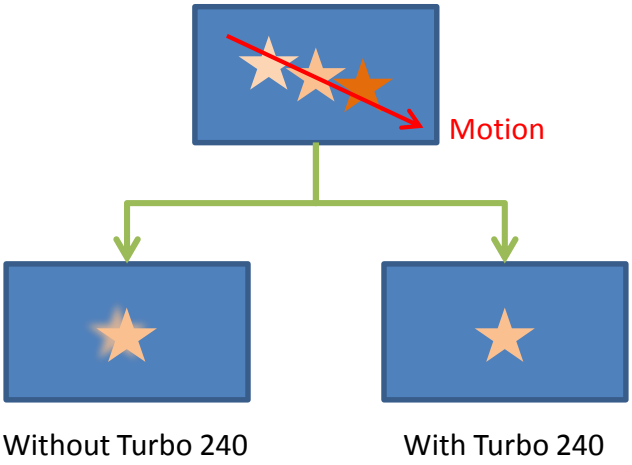

Fig.10 Effect of Turbo 240

Backlight Dimming and Flicker

With Turbo 240, a user will not see flicker when displaying a moving image, but may see flicker when displaying a still image. This is because the monitor blinks the backlight to reduce motion blur.

If the user perceives flicker, the user can get a flicker-free screen at all brightness levels by disabling Turbo 240. With this setting, the monitor dims the backlight with the combination of DC control and high-rate PWM (Pulse Width Modulation) control.

With a traditional PWM control, the monitor switches the backlight on and off at about every $^{1}/_{200}^{th}$ of a second. When the brightness level is low, the time that the backlight is "On" shortens and the user perceives flicker easily (Fig.11). If the monitor switches the backlight on and off at a fast rate, the user will hardly perceive flicker.

By contrast, DC control dims the brightness not by switching the backlight on and off but by changing the current value of the luminous element directly. Therefore, it has no flicker in principle.

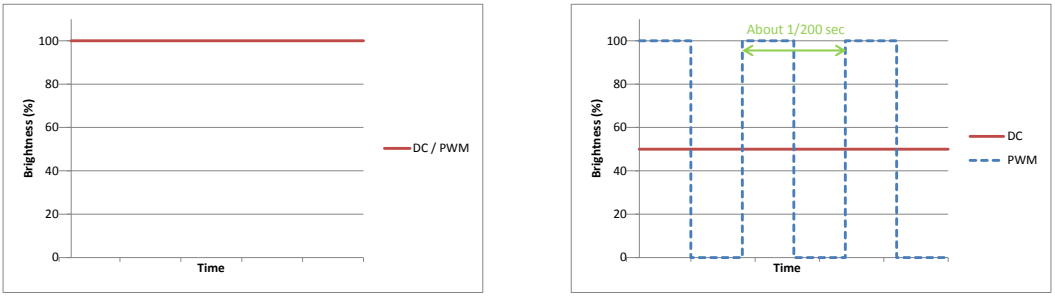

Fig.11 DC control vs. PWM control (Brightness 100%, 50%)

DC control can dim the brightness without flicker but cannot set the brightness lower than PWM control. To overcome this weakness, we combined DC control and high rate PWM (Hi-PWM) control. DC control covers high and middle brightness levels, and Hi-PWM control covers low brightness levels.

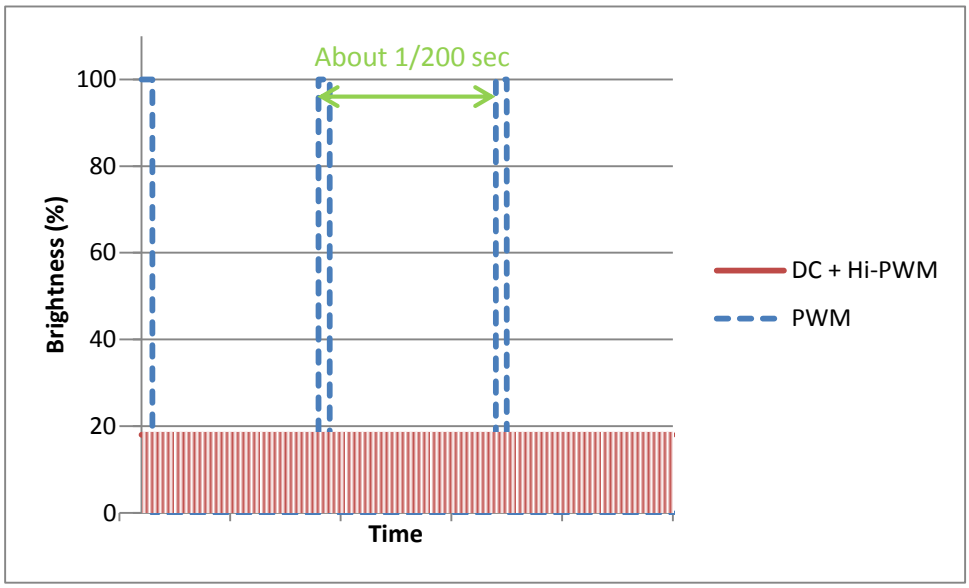

Fig.12 Turbo 240 "Off" (DC+Hi-PWM) vs. PWM control (Brightness 10%)

Fig.12 shows the behavior of the combination of DC and Hi-PWM control. The monitor dims the brightness as low as possible with DC control, and additionally dims the brightness with Hi-PWM control. With Hi-PWM control, the monitor switches the backlight on and off about 100 times faster than a traditional PWM control. Therefore, the user hardly perceives flicker if the brightness level is very low.

Summary

EIZO "Turbo 240" is an effective function to decreases motion blur. With Turbo 240, gamers can see the screen more clearly and understand exactly where things are.

Turbo 240 results in minimal delay – a little more than 10 milliseconds which is about 1.5 frames per 120 frames. This makes it ideal for first-person shooter, racing, fighting, and other fast-action games that require rapid, real-time response.

Note: All figures are based not on measurement results but simplified images.