Development of an Environmentally Conscious LCD Projector

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Abstract

As the reduction of the environmental loads of IT equipment is recently becoming an important topic, NEC Display Solutions has developed the NP-M series of standard projectors that incorporate improved environmental performance for enterprises and educational institutions. This paper introduces the environmentally friendly technologies featuring reduced environmental loads that are employed in the NP-M Series of projectors.

Keywords

projector, standby power, environmental load reduction, ECO mode, lamp life
high-pressure mercury lamp, weight reduction, laser marker, recycling

1. Introduction

Worldwide attention to environmental issues has made a reduction in environmental loads one of the important themes of projector system developments.

At NEC Display Solutions, we have released the NP-M series of education- and business-oriented standard projectors as the flagship series of environmentally-friendly projectors for promoting reduced environmental loads. The standard-model projectors are the main products with the largest sale among our projector lines, so that environmental measures in this category will contribute greatly to the environmental load reduction of our entire projector production.

The NP-M Series has been developed to target environmental performance at the industry-top level by improving the standby mode performance, enhancing the functions of the lamp lighting modes, extending the lamp life, reducing the cabinet weight and improving the recyclability. This paper introduces the environmental technologies by taking NP-M300X as an example (**Photo** , **Table 1**).

Photo NP-M300X external view.

Table 1 Main product specifications of NP-M300X.

Item		Details
Display Technology		3-Primary color LCD shutter projection type
Panel	Size	0.63-inch with MLA
	Pixels	1,024 × 768 (786,432 pixels)
Light source		180 W AC lamp
Lamp Life (up to)		ECO mode OFF: 5,000 hours
		ECO mode: 6,000 hours
Light Output		3,000 lumens
Contrast Ratio		2,000:1
Screen size		25 to 300 inches
Power consumption	ECO mode OFF	248 W
	ECO mode	ECO1: 198 W / ECO2: 138 W
	Standby mode	Normal: 8 W / Power-save: 0.2 W
Dimensions (excl. projections)		339 (W) × 99 (H) × 257 (D) mm
Weight		2.9 kg

2. Improvement of the Standby Mode Performance

The reduction of power consumption during standby is one of the critical issues for a reduction of environmental loads. With the NP-M300X, we have reduced the standby power consumption by about 60% from that of previous models with low cost by adding only a few parts. **Fig. 1** shows the changes in the standby power consumption since the 2007 model.

The purpose behind a reduction in the standby power consumption is to improve the overall power efficiency of the model and to reduce the load power.

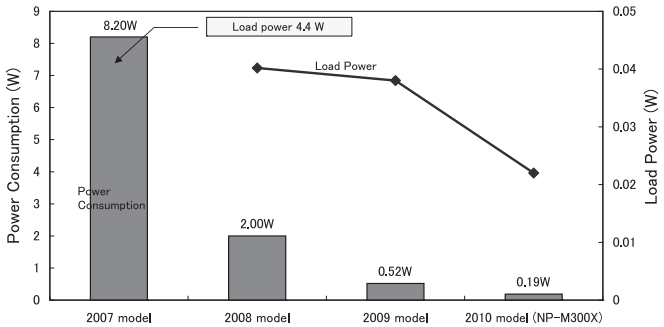

Fig. 1 Standby power consumption since the 2007 model.

2.1 Power Efficiency Improvement

The most usual approach for improving the power efficiency is to add a dedicated standby power converter. Although this is possible with existing technology, problems are posed in relation to the cost and power supply capacity. Therefore, with the NP-M300X, we set the design target to achieve power consumption at below 0.5 W with a single-converter system, using only the main converter and without adding a standby power converter. Such a 1-converter design is accompanied by issues, including output voltage instability, power efficiency and residual voltage. Since the power supply for the projector has four output voltage systems and the load power range is as wide as 0.015 W to 75 W, the output voltages tend to increase during standby under a light load. In addition, the main converter is designed to maximize the efficiency at 75 W output so its power efficiency is deteriorated during standby. In order to solve these issues, we optimized the output voltage of the NP-M300X so that the gain of the feedback circuitry is adjusted by receiving a signal from the main CPU during standby. This solution reduced the power consumption during standby by about 13%.

For the problem of residual voltage, this is caused because the lamp lighting power supply and the main converter connect to the PFC (Power Factor Control) circuit of the projector power supply. As a power of 260 W is supplied to the lamp power supply, the electrolytic capacitor for the PFC circuit output is provided with capacitance of some hundreds of μF. As a result, if the power cord is unplugged in the light-load status during standby, the high capacitance causes the voltage to be output for a long period, causing the POWER Indicator of the system to be illuminated during this period. We solved this problem by monitoring the drop in the input voltage and forcibly stopping the main converter oscillation accordingly. This solution reduced the POWER Indicator lighting period from 60 seconds before treatment to 3 seconds afterwards.

2.2 Load Power Reduction

In order to reduce the power consumption during standby, it is also important to minimize the activated circuits. However, when remote control of the projector is required, for example when it is mounted on a ceiling, it is necessary to continue activating the outside communication circuitry, even during standby. The communication circuitry is usually processed by the main CPU, but the NP-M300X is designed to activate the main CPU from the standby CPU through external communication control. This design enables external communication control even if the main CPU stops completely during standby.

3. Improvement of the Lamp Lighting Mode Function

Most of the power consumed by a running projector consists of the power for lighting the lamp, thus making it extremely important to control the lamp power supply in order to effectively reduce the overall power consumption.

The NP-M300X incorporates various lighting modes for reducing the lamp power consumption (**Table 2**). The three new lighting modes in addition to the traditional ECO1 mode (25% lamp power reduction) allow users to reduce unnecessary power according to the various usage scenarios.

3.1 AUTO ECO Mode

The AUTO ECO mode renewed the concept of conventional ECO modes that reduces the power consumption by dimming the image. Instead, the AUTO ECO mode is capable of reducing power consumption without altering the image brightness. It can reduce the lamp power by up to 25% by controlling the lamp power and video amplitude simultaneously according to the video signal level.

Table 2 Lamp lighting modes of NP-M300X.

Function		Lamp Power	Remark
ECO mode	OFF	100%	
	AUTO ECO	100-75%	New function
	ECO1	75%	
	ECO2	50%	New function
AV MUTE		25%	New function

3.2 ECO2 Mode

A large amount of light output is not required for projection on a small screen or in a dark room. In such usage situations, the ECO2 mode makes it possible to reduce the lamp power by up to 50%.

The high-pressure mercury lamp used in the projector increases the lamp life and reduces flickering by optimally controlling the halogen cycle, in which electrode material is evaporated from the lamp electrodes due to discharge between them. This is re-deposited on the electrode because of the action of the halogen gas sealed inside the lamp's light-emitting bulb. This process requires the lighting power, lighting frequency and temperature to be controlled. In addition, a suitable power control arrangement is required to enable complex variation of the lamp power in order to provide stable lamp light under low power conditions. This requirement is also accompanied by the need to optimize cooling control according to the lamp power and video amplitude controls that can cancel any variation in brightness resulting from the lamp power control.

The ECO2 mode of the NP-M300X is enabled by the lamp lighting power supply with a low-power lighting capability, a lamp power control using software in the main CPU, a video amplitude control and a cooling control.

3.3 Standby Lighting Mode (AV MUTE)

The AV MUTE function is convenient for temporarily turning off the projected image. The AV MUTE function of the NP-M300X puts the lamp in the standby lighting mode and saves about 75% of the lamp power consumption. Previous AV MUTE functions simply displayed a black image and the consumed lamp power was the same, which made it necessary to switch the projector completely off if the power consumption or projection of black image light was problematic. However, this lowered the usability because re-lighting of the lamp took time once the power supply was switched off completely.

On the other hand, the change from the standby lighting mode to the normal lighting mode was very quick. Consequently, the standby lighting mode not only reduces the power consumption but also significantly improves the usability.

4. Extension of the Lamp Life

Since the projector lamp has its lifetime and periodical replacement is necessary to maintain the light output, an extension of the lifetime leads to a reduction in the environmental load for the entire product life.

The temperature of the high-pressure mercury lamp used with the projector is usually higher at the top of the bulb. This makes it important to cool the top of the bulb, but the light emission becomes unstable if the temperature of the whole bulb drops too much. The projector is also designed for ceiling mount, so it is difficult to prioritize cooling of the top of the lamp in any position. Nevertheless, this issue should be resolved by equalizing the temperature of the whole bulb in order to extend the lamp life and in particular for this model, which includes various lamp lighting modes that feature variable lamp heat generation for the purpose of environmental load reduction, it is important to solve this issue in all of the lamp lighting modes from the viewpoint of compatibility of high brightness with long life.

The NP-M300X incorporates a variable flap (moveable partition) inside the cooling duct as shown in **Fig. 2** . The variable flap moves according to gravitational force, varying the cooling path automatically, so that the top of the bulb is always cooled as a priority. This design makes it possible to reduce the temperature difference between the top and bottom of the bulb to less than a half that of the previous design. As a result, the lamp life is extended compatibly with various lighting modes without spoiling the light-emitting characteristics, thereby contributing to a reduction of environmental stress throughout the product life.

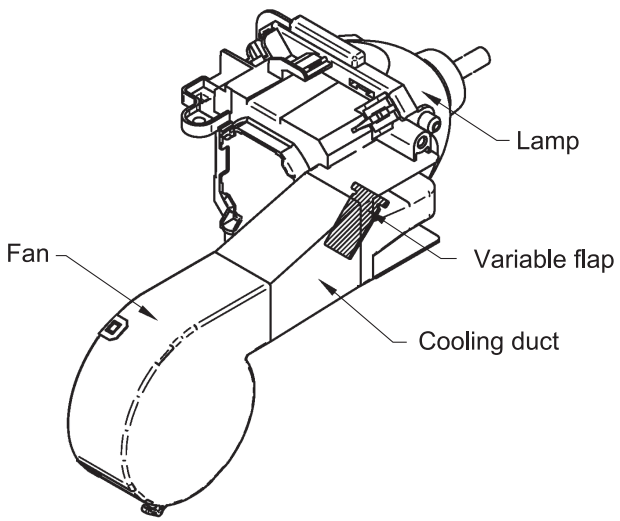

Fig. 2 Modification of the lamp cooling path using a variable flap.

5. Reduction of the Environmental Load of the Cabinet

The weight and recyclability of the projector cabinet also affects the environmental load. The cabinet of the NP-M300X features reduced weight and employs laser marking as advantageous environmental measures.

5.1 Weight reduction

The cabinet thickness of previous standard models has usually been 2 mm. The NP-M300X has reduced the thickness down to 1.8 mm and reduced the amount of material used by about 10%.

The reduction of the cabinet thickness tends to pose a problem of strength reduction. In order to achieve an equivalent strength to that of previous models, the structure and shape of the NP-M300X cabinet are optimized by means of strength simulations and actual cabinet evaluations.

Another problem posed by the thickness reduction is the ease of transmission of the light from inside to the outside of the cabinet. This problem was particularly noticeable with the original NP-M300X because its cabinet was white.

To deal with this, we requested the manufacturer of the cabinet material to develop a new material that reduces the light transmission while achieving equivalent characteristics to the original material. This solution reduced the light transmission.

5.2 Environmental load reduction of the cabinet

If a cabinet is finished by painting or silkscreen printing, the volatile organic compounds produced by the paint and ink can cause an environmental load issue. With the NP-M300X, we eliminated painting of the cabinet and applied laser marking of the character and symbol imprints in place of silkscreen printing. This solution eliminated the production of volatile organic compounds. In addition, this solution also improved the recyclability and reduced environmental loads.

6. Conclusion

In the above, we introduce the environmentally friendly technologies incorporated in the NP-M300X. These technologies improve not only the environmental friendliness of the product but also of the convenience of users. The NP-M300X has obtained worldwide environmental certifications including those of the Swedish TCO Certification and Japanese Eco Mark Program as well as the Chinese energy conservation accreditation and the Taiwanese Green Mark Program. It is also the first product as a projector to acquire the NEC ECO Symbol Star. In the future, we intend to pursue further improvements in environmental performance and to apply them to our other projector products. In this way we aim to reduce the environmental load throughout the whole range of projector products of the NEC brand.

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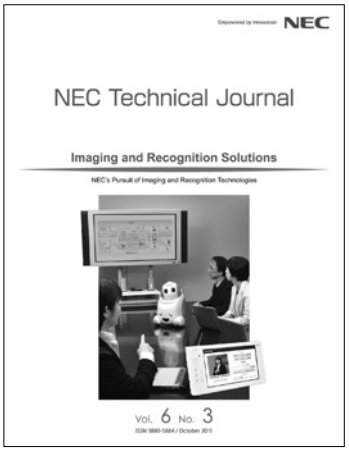

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