Compact/Fastest A4 Monochrome LED Printers in class: B400 Series

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During the one-year period, beginning third quarter fiscal 2008 and ending second quarter fiscal 2009, the printer market saw a decline in shipments as it fell under the influence of economic downturn caused by the Lehman Shock. Among the largest drops were with low-cost machines, but there has been a trend toward recovery since third quarter fiscal 2009. Despite the situation, the Desktop (DT) and Small Work Group (SMB) segments, which OKI Data is focused, are relatively stable and market share has been maintained. This market is expected to remain stable in the future. However, between fourth quarter fiscal 2008 and first quarter fiscal 2009, competitors have introduced new products to this segment heating up the competition.

In the DT and SMB segments, our product specifications have been quick to respond to market demand, and we have strong distribution channels. To further meet the segments' customer requirements, we developed the small and high-speed monochrome LED printers B431dn/B411dn (**Photo1**).

Photo 1. B431dn A4 Monochrome Printer

Product Concept and Target Market

In order for us to maintain a strong position in the DT and SMB segments, which is expected to be stable and hold a constant share within the monochrome printer market, we must continue to provide competitive new products. Therefore, we followed up the commercialization of the previous B430dn/B410dn printers with the development of the B431dn/B411dn.

(1) Product concept

Since the printers are to be introduced into market segments with strong price requirements, development was focused on reducing cost. Additionally, attention was given to small size, high-speed, high print quality, long life and design. Environmental considerations were also part of the development.

(2) Product positioning

Most models from the competitors' lineups in the monochrome DT and SMB segments are centered on products that feed A4 sheets longitudinally and print at 33ppm. Our newly developed models B411dn and B431dn print at 33ppm and 38ppm, respectively, and they have both been priced below the competition (**Figure 1**).

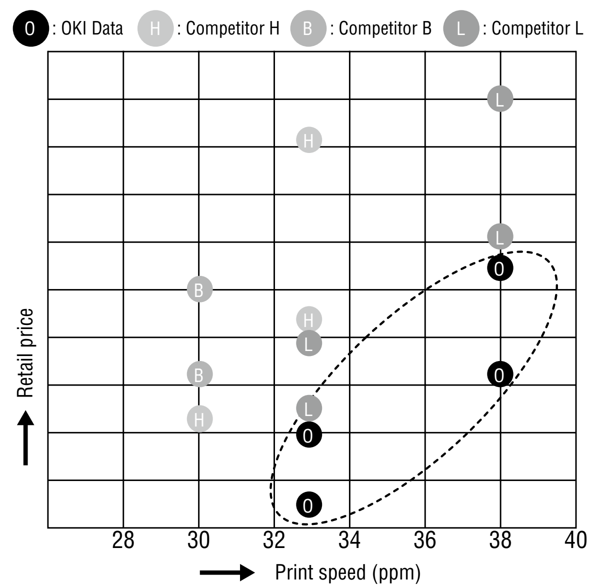

Figure 1. Product Positioning

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(3) Printer Specifications

Printer specifications are presented in **Table 1**.

Table 1. Printer Specifications

		B431dn	B411dn
Printing Method		Digital LED head, dry electrophotographic system	
Print Speed	Letter	40ppm	35ppm
	A4	38ppm	33ppm
LED Head Resolution		1,200dpi	600dpi
Print Width		A4/Letter	
Paper Capacity		280 sheets (64g/m²)	
Multi-Purpose Tray		110 Sheets (64g/m²)	1 sheet (manual feed)
Dimensions (W x D x H)		387 x 393 x 245mm	
Weight (including consumables)		11.6kg	
Local Host I/F		USB 2.0, IEEE std 1284-1994 compliant	
Network Functions		Standard	

ppm: page per minute dpi: dot per inch

Key Technologies for Realizing the Product Concept

Low cost, small size, high speed, high print quality and long life were achieved with the development of the following technologies.

(1) Low cost

To take advantage of the LED printer's simple construction, a thorough design review was performed starting at the development stage of the new models. In order to lower cost, exhaustive cost-cutting measures were exercised including standardization and miniaturization of components. However, print speed and print quality of the new models were not compromised, and in fact surpass performances of previous models. As a means of reducing cost, lower cost parts were procured from international sources. Repeated evaluation of the parts raised reliability and ensured quality while keeping cost down. In terms of total cost reduction, some key components were standardized with previous models or with color LED printers under development at the same time. Approximately 57% of components were standardized enabling management and tooling investment expenses to be held down. Standardization of components was determined by verifying whether the components can withstand the high speeds and satisfy requirements. Only components that maintained reliability were standardized. As a result, over 57% of the paper-drive related components including the printer's paper feeder, multi-purpose tray (MPT) unit, paper drive unit and paper discharge unit were standardized. **Table 2** shows the percentage of standardized printer components.

Table 2. Percentage of Components Standardized with Previous Models

	% Reused from previous models
Sheet metal components	28%
Molded components	61%
Springs	79%
Cords	17%
Circuit boards, sensors, others	56%
Total	57%

Additionally, development time was cut by 25%, sharing of spare components improved maintenance, and component inventory was reduced.

(2) Small size

From the initial stage of development, the aim was to develop a lightweight and compact printer that was easy to use on the desktop. Making printer size a priority, work began on studying the layouts of functional units and circuit boards, and miniaturizing component parts. The resulting printers were 16% smaller in volume compared to our previous models. At 24.5cm tall, the printers were low in profile, but capable of supporting duplex printing (**Figure 2**). Specific measures that enabled the achievement of the smaller size were:

1. Compact paper feeder unit.
2. Simplified mechanisms and reduced components due to implementation of duplex unit inside the printer.
3. Improved implementation efficiency due to review of circuit board layout.
4. Compact high-capacity toner cartridge due to integration of high-capacity waste toner box with image drum.

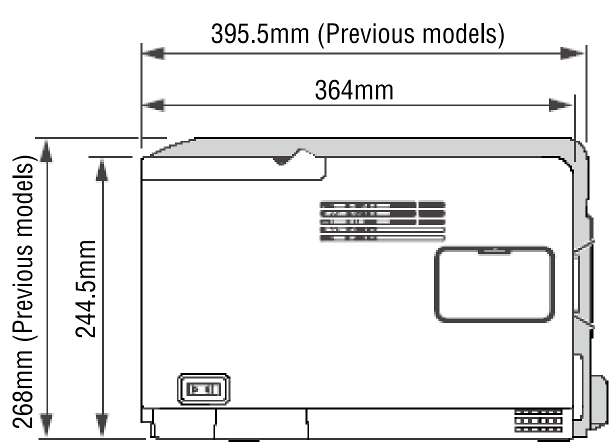

Figure 2. Printer Size Comparison

(3) High speed

Utilizing our expertise in LED printers, speed of the upper B431dn model was increased 36% while reducing size and cost, and we produced our first A4 longitudinal feed printer capable of printing at 38ppm, fastest in its class. This class leading achievement was reached through developments described below.

a) Quick response OPC drum

Due to higher speed, time from exposure received from the LED head to reach the developing unit is shortened thus, surface electrical potential of the drum must be attenuated to a prescribed level in an extremely short period of time. Therefore, a new photosensitive layer material capable of faster charge transfers was developed, and together with the optimization of the photosensitive layer's electrical and material properties, we were able to achieve a quick response OPC drum.

b) New monochrome toner with low melting point

To ensure proper fusing during high-speed printing, it was necessary to lower the toner's melting point. For this, the toner's main ingredient, resin, was changed from conventional styrene-acrylic to polyester, which is more suitable for use at the lower melting point and fuses to paper better. On that basis, molecular weight distribution was adjusted and amounts of external additives were optimized to lower the toner's melting point. Although toner development requires considerable time, a highly reliable toner was developed in a short period by using the color printer's proven toner as a base. Since monochrome toners used in the past have been low-gloss, glossiness of the color printer's black toner utilized as the base was toned down suppressing light reflection.

c) Thermal design

Heat generated by the fuser during high-speed printing raises the internal temperature of the printer degrading the toner inside the image drum. Furthermore, due to the compact design requirement, image drum and fuser are placed closer together allowing heat to easily transfer from fuser to image drum. This can lead to poor print quality. To prevent temperature rise of the image drum, a ventilation duct to pass air was placed between the fuser and image drum. Despite its compact size, fuser heat was prevented from directly transferring to the image drum, and thereby holding down temperature rise (**Figure 3**).

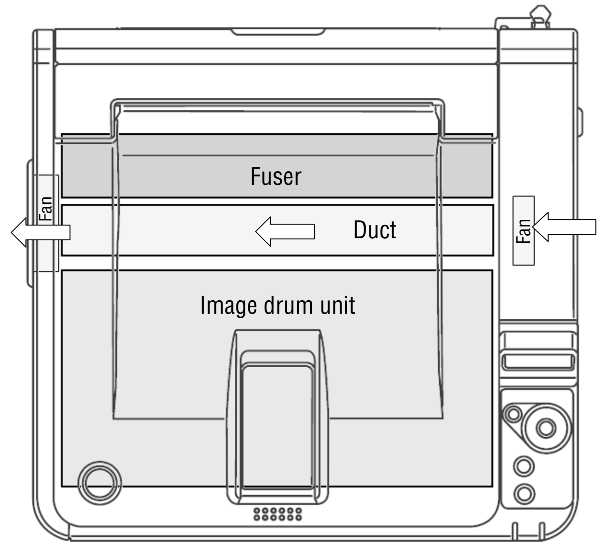

Figure 3. Air Flow

d) Control unit

ASIC adopted for the new models is identical to the one used in the color LED printers that were developed at the same time. This newly developed ASIC incorporates a PPC405 330MHz CPU and DDR2 165MHz RAM, and performance was improved through high-speed memory access.

Previous monochrome models were configured with a main ASIC and sub-ASIC (mainly for high-voltage power control). However, adoption of a single-chip ASIC that integrates sub-ASIC functionality has helped reduce the number of components on the control board (B411dn).

For the B431dn, LED head control ASIC capable of high data transfer was developed to cope with the adopted 1,200 DPI LED head and increased 40/38ppm print speeds. Use of the above-mentioned new ASIC and LED head control ASIC allows the B431dn to print fine 1,200dpi images at high speed.

Additionally, the use of the new ASIC was an opportunity to modify the firmware configuration to that based on the color models under simultaneous development. This shortened development time and improved maintenance.

(4) High print quality

Despite the low cost, high print quality was achieved by developing a new toner based on color toners that have been proven to produce high quality images demanded from color printers, and by making adjustments in printing conditions with the technical development described below.

a) LED print head utilizing EFB technology[1)]

We adopted a new LED print head employing a multi-functional LED element produced with Epi Film Bonding (EFB) technology. This LED print head cut the chip width by 22% leading to resource savings, but retains its characteristic of producing high-definition dots. Although the LED print head equipped with the new LED array board is available in 600dpi and 1,200dpi resolutions, components other than LED array board have been completely standardized. As a result, development time was shortened and production/maintenance has been improved. The 1,200dpi head is used in our upper B431dn model. Not only does the LED print head utilizing EFB technology produce high quality images, but it also contributes to downsizing the printers. While capable of 1,200dpi, this print head is smaller than previous LED print head making it easier to design a compact layout.

b) Process control

In order to ensure quality and stability in the customer's usage environment, three types of high voltage applied to the internal elements of the image drum, roller, and other components during printing are automatically and independently variable, and optimized to produce high quality images under various usage environment and conditions.

(5) Long life

A high print-resistant OPC drum was developed to prolong the life of the consumable image drum unit from the previous model's 20,000 pages (A4, 3 pages/job) to 30,000 pages.

Life of the image drum unit is largely dependent on the life of the OPC drum. As the OPC drum's surface layer wears away, the vital charging and light-attenuation performances degrade causing defects in the printed images. This time around, using new measurement technology, we were able to find the physical parameters related to the amount of wear. Based on the physical parameters, a new material was developed to balance the characteristics. As a result, resin with half the wear amount of previously used material was adopted as an ingredient in the photosensitive layer that forms the surface layer making it possible to extend the number of copies. By increasing the abrasion resistance, long life was achieved, and that allows a lower running cost.

(6) Design

Considering that the printer will most often be placed on the desktop of the printer's administrator, every part of the printer down to the control panel was to be simple, easy to use and smart while being reliable. We adopted the product design concept "S3 (S cubed)" based on the three "S" keywords of SIMPLE, SMART, and SOLID.

(7) Environment

As measures to reduce environmental impact, power consumption and fan noises were reduced.

a) Reduced power consumption

In the fuser component, combination of thin heat roller and toner with low melting point enabled the thermal capacity of the heating element to be reduced while maintaining the required nip (amount of contact between fuser roller and pressure roller). This allowed the new models to achieve the same warm-up time as previous models despite the higher speed. Furthermore, for printing small number of copies, setting the fuser temperature lower and decreasing print speed reduces warm-up time contributing to reduction in power consumption.

b) Reduced fan noise

One way to improve operating noise was to reduce the noise produced by the cooling fan drawing air into the printer. Lower fan noise is vital to reducing noise both during operation mode and standby mode, but on the other hand, cooling of the power supply and internal components must be strengthened to handle the engine speedup. In order to reduce fan noise, especially after printing when fan noise can be most annoying, the new models use a more efficient fan control, and status of the internal temperature is estimated to stop the fan within one minute after printing. This also led to lower power consumption in standby mode.

Conclusion

In recent years, environmental support has become a requirement for monochrome printers used in general offices. Thus during development, emphasis is placed on reducing power consumption/noise and improving usability while increasing print speed and improving print quality.

OKI Data will continue to develop new products to meet customer needs. ◆◆

References

1) M. Ogihara, "Dissimilar Material Fusing Using Epi Film Bonding", OKI Technical Review No. 211, Vol.74 No.3, pp.98-103, October 2007

TIPS 【Glossary】

S3 (S cubed)

Product design based on the three "S" keywords of SIMPLE (elegant, clean, pure), SMART (intuitive, intelligent, dependable), and SOLID (solidly made, reliable, proven).

Epi Film Bonding

OKI' s proprietary nano-technology in which epitaxial layers required for light emission is released from the compound semiconductor and bonded onto the driver IC (driving circuit) of different silicon material using intermolecular forces.

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