The Lowest Power Consumption Sleep Mode in the Category/Fast A4 Color LED Printers: C600/C700 Series

Naoki Sunaga Hideki Shinyama
Tatsumi Yamaguchi Masato Sakai

The "C610/C711" models (**Figure 1**), launched in January 2010, are OKI Data's high-end A4 color printers. With their low power consumptions and high speeds, they are ideal printers for office use. This article introduces the power-saving and high-speed technologies that went into the development of these printers.

Figure 1. C610/C711 Printers

Target Market Trends

Color printers are classified according to the type of users and distribution channels. Entry level and desktop level A4 printers are compact low-cost machines targeted at personal and SOHO users. The small to mid-sized small workgroup A4 printers are aimed at SOHO and small to medium businesses. Large A4 printers in the middle workgroup target small to medium businesses and large corporations. The high-end class mainly includes machines capable of printing A3 copies.

Although competition is fierce and there is a prominent move toward lower retail costs, shipments for low-end entry to desktop level printers are growing, and this trend is expected to continue.

In contrast, printer shipments for the mid/upper class small and middle workgroups remain essentially flat with very little chance of market growth. However, price drops in these segments have not been as significant as the low-end segments and can be considered as markets that will retain high profitability.

C610/C711 Product Concept

C610 and C711 Series incorporate the following concepts and were developed to target the small and middle workgroups replacing the previous C6000/C710 models.

1) Lower power consumption

Consumes less power during power save mode

Faster warm-ups

2) Faster printing

Prints color at 34ppm, monochrome at 36ppm

3) Support various print media

Supports from 64gsm lightweight paper up to 250gsm cardstock paper

Expandable to support ultra-long sheets

Reduced Power Consumption

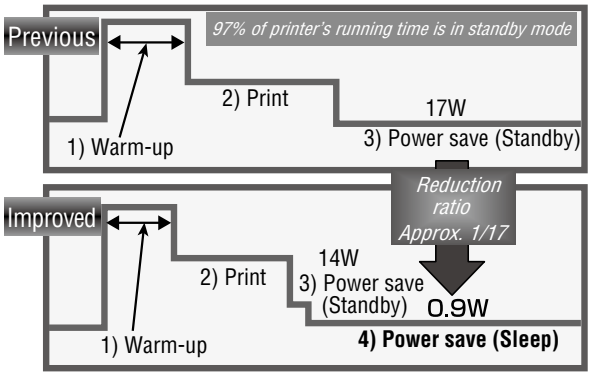

Figure 2. Printers' Power Consumptions

In previous office A4 color printers, there were three power consumption modes as shown in **Figure 2**. They were the warm-up mode 1) when fuser temperature is raised to the toner melting point, the print mode 2) when power is used to fuse the toner to the print medium, and the power save (standby) mode 3), which the printer enters when printing is completed and fuser heating is stopped after a set period.

With C610/C711, the newly developed fuser unit reduced warm-up and print times speeding up the overall speed of the printer. The new ASIC and power unit made it possible to add a sleep mode 4) to the low power consumption mode 3) enabling these printers to achieve the industry's best-in-class low power mode.

New Fuser Unit

Our fuser unit utilizes under belt fusing, which results in excellent fusion on various print media contributing to faster printing and shorter warm-up. Wall thickness of the upper roller has been thinned and belt drive optimized to cut warm-up time from 45 seconds to 35 seconds. Color printing was improved from 30ppm to 34ppm without compromising fusion or paper feed. **Figure 3** shows the comparison of the new and previous fuser units.

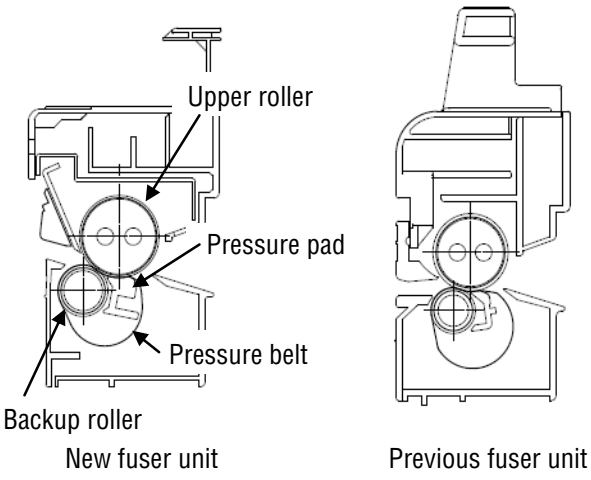

Figure 3. Fuser Unit Cross Sections

Main components of the fuser unit are upper roller in the top section and pressure belt, which houses the backup roller and pressure pad, in the bottom section. The pressure belt pressing against the upper roller forms a certain amount of contact width referred to as fuser nip width. Fuser nip width is a factor that determines fusion, and as printing speed is increased, the width must be widened.

To widen the fuser nip width, shape of the pressure pad was changed to increase the belt's contact surface, and the outer diameter of the upper roller was enlarged. Increasing the contact surface produced an unwanted side effect of intensifying the fuser unit's drive torque. However, re-examination of the pressure pad's coating composition and optimization of the pressure pad's shape solved the problem. There were other problems as well. The enlarged outer diameter of the upper roller led to longer warm-up time due to greater heat capacity. Moreover, paper can easily become wrapped around the upper roller potentially causing poor paper separation.

Since warm-up time is heavily dependant on the performance of the heat source and heat capacity, time reduction was achieved through thinning the upper roller wall down to a minimum in which durability can be retained and refining the halogen gas to improve heat source efficiency. To address the paper separation issue, sharp edge stamped metal plate was fixed into contact position with spacers placed on both ends of the upper roller surface just outside the boundary of the paper path. This enabled an adequately narrow gap to be formed inside the paper path boundary without the upper roller contacting the separation plate allowing stable paper separation when the upper roller's outer diameter is enlarged.

Newly Created Sleep Mode

As a means of lowering power consumption, new sleep mode was created. When printing has completed and a set period has elapsed, the printer enters the power save mode and stops heating the fuser. After another set period, the printer enters the sleep mode, a state in which only portions of the power unit and ASIC remains operating. In previous models, the ASIC was divided into the engine control unit (PU) that controlled the print engine, and the image control unit (CU) that controlled image data processing. However, in the new models, the PU and CU are integrated together into a single ASIC. When this new ASIC enters sleep mode, only a portion of it remains running while all other functions are suspended. The power unit has a sub-unit capable of operating in sync with the ASIC during sleep mode. By keeping only portions of the ASIC and power unit running in sleep mode, power consumption was cut approximately 1/17 from the previous models' 17W down to 0.9W. Since high-speed network printers are often left powered on, power consumption during standby mode can be a considerable factor in the office's power savings.

New ASIC

Figure 4 is a block diagram of the newly developed Green ASIC. Advances in semiconductor technology have made micro processing that enables large-scale circuit implementation at low cost possible. Functions that were previously divided into several chips have been integrated into one reducing the number of devices.

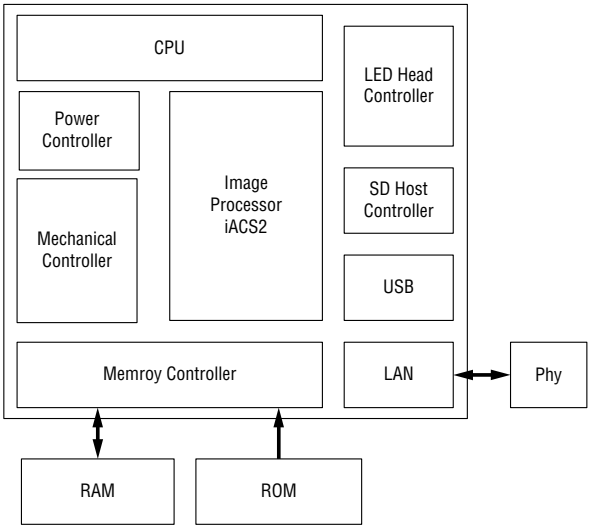

Figure 4. Block Diagram of Green ASIC

To achieve the single chip configuration, the number of pins on the ASIC needed to be reduced. For this, DDR2-SDRAM was adopted, and through increased access frequency, number of pins connected with the RAM was reduced while securing required performance. Additionally, standardization of the ROM and RAM further eliminated pins and reduced device count leading to lower power consumption.

In the newly created sleep mode, power to most of the ASIC's internal circuitry is suspended. By supplying power to only certain circuits, low power consumption was achieved even while the printer is connected to a network.

New Control Board Utilizing Green ASIC

The new printers are configured with a new control board that utilizes Green ASIC. This control board has the following two features.

1) The CPU core functions of the CU and PU sections are both built into Green ASIC. Previously, two CPU cores were required, necessitating the configuration of separate boards for the CU and PU sections. With the adoption of Green ASIC, these separate circuits have been integrated on to a single board.

2) Green ASIC and the control board consist of circuits powered by the main power unit and those that are powered by the sub-power unit. During sleep mode, power is supplied to only some of the circuits, and rest of the circuits powered by the main unit are suspended achieving a significant reduction in power consumption.

Furthermore, small and highly efficient chips were selected for the DCDC converters on the control board to improve power efficiency in sleep mode. The use of two power circuits prevented expansion of the board surface area from the increase in required number of DCDC converters.

Figure 5 is a photo comparing the new control board with the previous control boards.

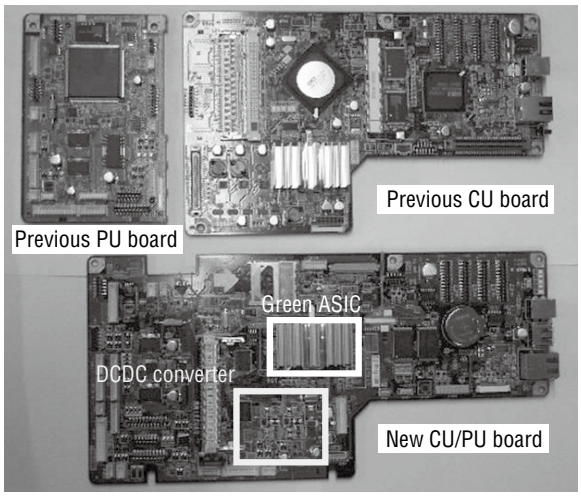

Figure 5. Comparison of Control Boards

Low Voltage Power for Sub-Transformer Configuration

In addition to reducing power consumption of the Green ASIC equipped control board mentioned above, a power unit with efficiency greater than 70% was required to lower power consumption during sleep mode to less than 1W.

Normally in areas where DC power consumption is less than 1W, power efficiency drops to below 50%. Therefore, a double transformer system (power circuit separated into main and sub-power circuits) was adopted supplying power in sleep mode with a circuit different from the main. Efficiency of sub-power circuits in areas with less than 1W of consumption was raised to above 70% enabling power saving in sleep mode.

However, model size and basic mechanical configuration is unchanged from previous models, thus the same limitation as the previous models was imposed on implementation area of the power unit. The double transformer system needed to be implemented without increasing the size of the power unit. Using space that was previously unavailable due to height restriction and expanding the power unit board 15mm to the open space on the AC inlet side solved the problem.

Figure 6 is a photo comparing the new power unit with the previous power unit.

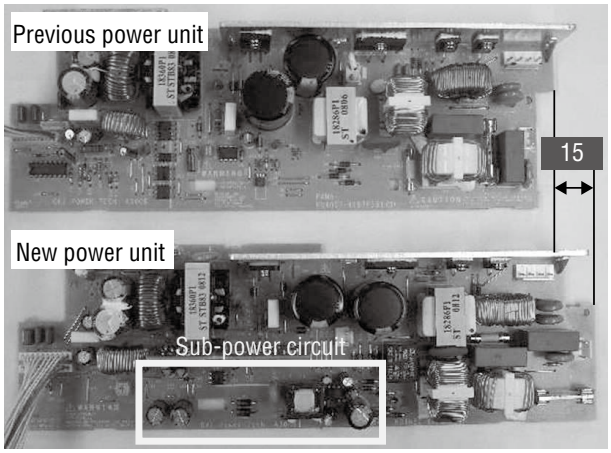

Figure 6. Comparison of Power Units

Various Paper Media Support

Other features include enhancement to the media feed capability. Printers are capable of feeding paper media of various weights from thin paper (64gsm) up to cardstock paper (250gsm). Duplex printing is possible with media up to 220gsm. Paper paths are shown in **Figure 7**. The C610/C711 printers come standard with two paper feeders (1st tray and MP tray) and two paper ejectors (face-up stacker and face-down stacker).

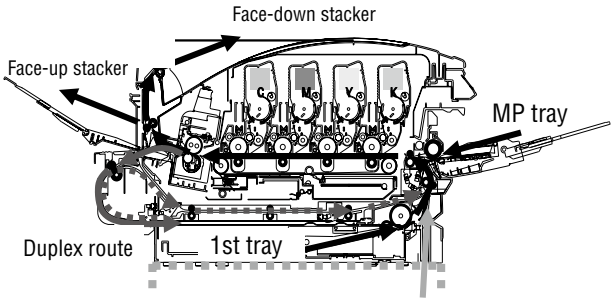

Figure 7. Paper Paths

Use of the MP tray and face up stacker forms a straight path from paper feeder to the ejector. This enables support for special paper that cannot be passed through the inverting path and allows the use of various media.

Furthermore, the printers are designed so that with the use of dedicated paper feeder for the MP tray section and ejector for the face-up stacker section, together with dedicated fuser unit and engine controller, they can be configured to handle continuous paper more than 100m long, rolled label sheets and perforated media.

Noise Reduction

Sources of noise include the operating drive gear, papers rustling against each other during paper feeding and paper making contact with the paper path. With speed increase of 20% over the previous models, noise level would normally go up proportionally. The paper feed drive system was re-evaluated, and extensive use of helical gears along with slower feeding speed reduced the noise level during the paper feeding process. Although the new printers are 20% faster, at a noise level of 54dB (A), they are quieter than the older models. They also cleared the noise level requirement for Eco Mark certification.

Conclusion

The sections above described the development of a new fuser unit and new ASIC that enabled the C610/C711 printers to achieve best-in-class sleep mode power consumption while providing high-speed printing. As demand for lower power consumptions and higher speeds increase in the future, the paper media capabilities, noise suppression, ease of use and reliability will be enhanced in additional to the pursuit of higher functionality and performance. OKI Data will continue its development of printers that are well suited for the office environment. ◆◆

Authors

Naoki Sunaga, Engineering Department 1, Product Engineering Center, Development Division, OKI Data Corporation
Hideki Shinyama, Engineering Department 2, Product Engineering Center, Development Division, OKI Data Corporation
Tatsumi Yamaguchi, Engineering Department 4, Technical Development Center 1, Development Division, OKI Data Corporation
Masato Sakai, Engineering Department 2, Technical Development Center 2, Development Division, OKI Data Corporation