Cartridge Out-Of-Ink Event Detection

**Abstract:** The out-of-ink (OOI) condition of a print cartridge is detected with a remaining amount of ink that is less than 0.5%.
This disclosure relates to the field of printers.

A technique is disclosed that detects an out-of-ink (OOI) condition of a print cartridge.

One type of printer system employs intermediate tanks in which the ink is extracted from the cartridge by means of servo-controlled volumetric pumps. It is desirable to detect the exact moment, in real time, when the cartridge becomes completely empty. However, “drop-counting” techniques that estimate when the cartridge is empty are only accurate to within about 20%, which is not sufficient. Physical sensor techniques, such as PIP sensor detection, are expensive and used in conjunction with more pumps that are more powerful than the servo-controlled volumetric pumps in this printer system.

According to the present disclosure, and as understood with reference to the Figure, the OOI state of the cartridge is detected by analyzing both the signal of a differential pressure sensor and the voltage applied to the pump by the closed-loop control.

The OOI detection is performed while the pump is working to provide ink. Eventually, the cartridge gets physically OOI, and the pressure in the system drops due to the lack of ink. At the same time, this pressure drop causes the closed-loop control to reduce the voltage it is applying to the pump, since it requires less power to keep the required pump speed. The combination of these two characteristic events is used to determine that the cartridge is OOI.

The pump voltage and the pressure sensor are sampled concurrently to detect the OOI condition. In one example, the pulse-width modulation (PWM) of the pump is sampled at 10. This may include obtaining a sufficient number of samples and updating a maximum value. The ink pressure sensor is sampled at 40. This may also include obtaining a sufficient number of samples, and updating both a maximum value and a minimum value.

For the pump, at 20 it is determined whether a signal drop has been found. This may be determined, for example, by a value that is below 97.5% of the maximum value. If not, sampling continues at 10. If so, at 30, OOI based on the pump has been detected.

For the pressure sensor, at 50 it is determined whether a signal drop has been found. This may be determined, for example, by a value that is below 97.5% of the maximum value. If not, sampling continues at 40. If so, at 60, sampling is resumed. At 70, it is determined whether a signal increase has been found. This may be determined, for example, by a value that is above 12% of the minimum value. If not, sampling continues at 60. If so, at 80, OOI based on the pressure sensor has been detected.

An OOI condition for the cartridge is determined, at 90, by both the pump OOI and the pressure sensor OOI conditions having been determined at 30 and 80 respectively.
The disclosed technique advantageously provides accurate OOI detection of the cartridge at less than 0.5% of the ink remaining, regardless of the drop count precision or the type of cartridge. It is based on a relative detection that enables adjusting the OOI detections to the physical differences of the ink fluidic system or aging or wear of the fluidic components.

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Start

Sample Pump PWM

Signal Drop Found?  No

Yes

Samples Pump OOI Detected

Start

Sample Ink Pressure Sensor

Signal Drop Found?  No

Yes

Sample Ink Pressure Sensor

Signal Increase Found?  No

Yes

= Pump OOI Detected

= Sensor OOI Detected

Cartridge is OOI when both Pump OOI & Sensor OOI detected