低電壓製程之電荷幫浦電路設計

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摘要

USB-OTG (On-The-Go)使得 USB 廣泛應用於現在的產業中，而 USB-OTG 電路需要高電壓與高電流驅動能力，在 USB 兩用 OTG 設備收發器(USB On-The-Go dual-role transceiver)中，電荷幫浦電路(charge pump circuit)將被用來提供 USB 兩用 OTG 設備收發器作為 A 設備(A-Device)時，VBUS 所需之功率以及 VBUS 訊號。在本篇論文中，提出了兩種低電壓製程之電荷幫浦電路設計，除了提供高電壓與高電流驅動力，亦可解決閘極氧化層可靠度的問題。

藉由使用新的時序方波以及電荷傳遞開關(charge transfer switches)來實現論文中所提出的兩種新電路，除了能加強電荷幫浦電路每級的幫浦增益，解決閘極氧化層可靠度的問題，亦可解決舊有電路中，在方波上升或下降時間的回漏現象。

此外，當 VBUS 的輸出負載電流變動時，其輸出電壓值亦受影響而隨之改變，而在電荷幫浦電路中，時序方波頻率的快慢，將影響輸出電壓的高低。於是我們藉由回授電路來控制電壓控制震盪器(voltage-controlled oscillator)的頻率，進而控制電荷幫浦電路的輸出電壓維持在我們想要的準位。

Design of Charge Pump Circuit in Low-Voltage CMOS Process With Consideration on Gate-Oxide Reliability

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Abstract

Recent applications like USB OTG (On-The-Go) require not only the high voltage level but also high current drivability. The internal charge pump circuit of the USB On-The-Go dual-role transceiver supplies VBUS power and signaling that is required by the transceiver. In this thesis, two kinds of design of charge pump circuit in low-voltage CMOS process with consideration on gate-oxide reliability are presented. The two designs of charge pump circuit can also provide high voltage level and high current drivability.

In order to enhance the pumping gain of each stage, it is necessary that charge transfer switches must be used in the two proposed charge pump circuits. We use new clock control signals to implement the two kinds of charge pump circuits in thesis. This method may not only dealing the gate-oxide reliability but also solving the back leakage effect in the rise or fall time of the clock signals in the old charge pump

design.

In order to deal the variation of the output voltage value causing by the change of the output current loading, we will add the feedback loop to the charge pump circuit. By controlling the frequency of the voltage-controlled oscillator (VCO) in the feedback loop, we will tune the output voltage of the charge pump circuit to the voltage level we want.

During the initial pumping state, the voltage value of output is very small, so we let the frequency of the voltage-controlled oscillator circuit to be fast. This method can speed up the pumping progress and let the output voltage achieve the level we want quickly. After the pumping progress, the voltage value of output might be higher than we want, so we let the frequency of the voltage-controlled oscillator circuit to be slow. This method can lower the pumping efficiency let the output voltage maintain the level we want. If the voltage value of output is lower than what we want, we will let the frequency of the voltage-controlled oscillator circuit to be fast. And we can know that this circulation will last constantly when there exist the variation of the output voltage.

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