Modification of the Cockcroft-Walton charge pump by using switched capacitors technique for improved performance under capacitive loads

DAVOR VINKO, TOMISLAV SVEDEK, TOMISLAV MATIC
Department of Communications
Faculty of Electrical Engineering
J.J.Storssmayer University of Osijek
Kneza Trpimira 2b, 31000 Osijek
CROATIA
davor.vinko@etfos.hr

Abstract: - This paper presents a modified Cockcroft-Walton charge pump designed for driving capacitive or low current resistive loads. The proposed modification by using switched capacitors technique shows great improvement in output voltage levels that it achieves, and in number of capacitors needed for reaching a certain voltage level. Also, it requires no additional clocking scheme besides the present single phase AC signal. The proposed Switched Cockcroft-Walton (SCW) charge pump was simulated and compared with the CW charge pump.

Key-Words: - Charge pump, Driving capacitive loads, Heap pump, High-voltage generation, Switched capacitors, Voltage multiplier

1 [1]Introduction

Charge pumps are on-chip circuits used for generating voltage levels higher than voltage available from power supply [1]. One of the areas where they are commonly used, are the RFID circuits. More specific, the passive RFID circuits, which do not have power supply of their own, but they use the RF signal generated from the reader as power source [2]. The power transmitted to the RFID tag in that manner, depending on the certain conditions such as reader-tag distance, sometimes is not sufficient to be used for powering of the circuit. This is the main reason for usage of *indirectly* powered circuits. The idea is that the tag „waits“, while the charge pump is charging [3], [4]. When the voltage stored in pumps capacitors reaches predefined value, the control circuit discharges the capacitors allowing the tag to perform its function, usually sending the serial number. When used in *indirectly* powered circuits the charge pump sees only capacitive load which consists of output capacitor and capacitors in each stage of the charge pump. This opens a necessity to design charge pumps which are suitable to operate under capacitive load.

Another important aspect of the passive circuits and on-chip integrated circuits in general, is that they are to occupy the smallest area possible. Since the capacitors, with respect to the transistors, occupy the majority of the chip surface, their number is significant factor in scaling down the circuit size.

Fig.1 shows the circuit schematics of the 4-stage Cockcroft-Walton (CW) charge pump. The circuit consists of diode connected MOSFETs and pumping capacitors. The body of each MOSFET is connected to the ground (not shown in Fig.1). This is very simple design since it doesn't requires any additional clock signals or DC voltage levels. Drawback of this charge pump is the gain loss due to threshold voltage drop and by the body effects of the stage MOSFETs, as in (1).

$$V_{out} = \sum_{i=1}^{k} \left(V_{AC} - V_{Tni}\right) + \left(V_{AC} - V_{Tnout}\right) \qquad ,(1)$$

where V_{Tni} is a threshold voltage of i^{th} and V_{Tnout} of the output MOSFET and k is the number of identical pre-output stages.

A more recent approach to charge pump development is usage of the switched capacitors circuits and heap charge pumps [5]-[7]. Both approaches are

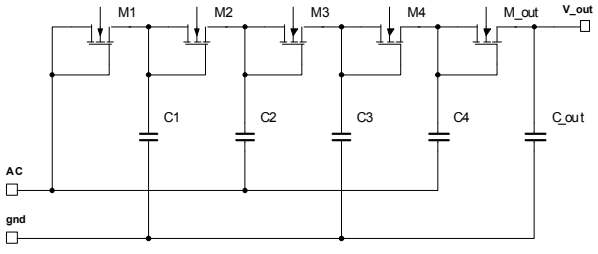

Fig.1 A 4-stage Cockcroft-Walton (CW) charge pump

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