Charge pumps

[TI_CP]

Charge pumps

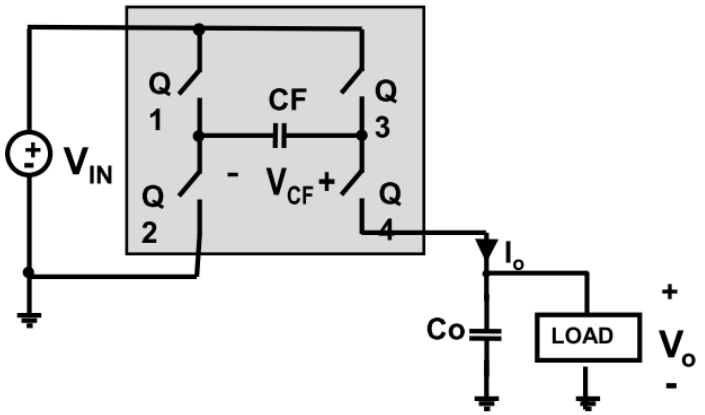
- The charge pump regulator is a kind of switching regulator that delivers power by only alternatively charging and discharging capacitors
- Good for low load current and moderate input to output voltage difference

Advantages

- No inductor is needed, smaller size
- Moderate Efficiency, higher than linear regulators
- V_{out} can be higher or lower than V_{in}
- Fewer components needed make the charge pump easier to design and lower cost

Disadvantages

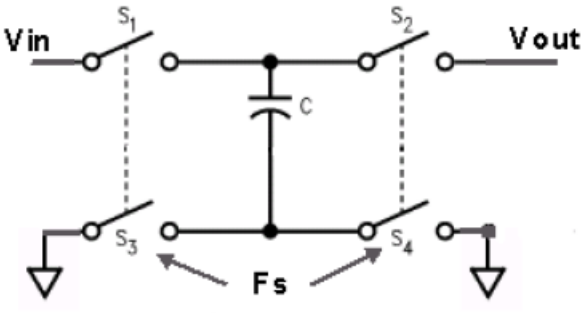
- Switching produces higher output ripple & noise
- The output current capacity is limited by the capacitors



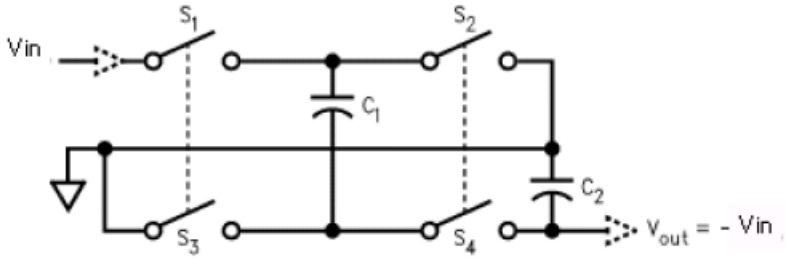
Charge pumps

- The capacitors connection is altered by the switches so that the charge and discharge is controlled
- Switches S1, S3 and S2, S4 are switching in complementary:
  - S1, S3 on, S2, S4 off, charging
  - S1, S3 off, S2, S4 on, discharging

Unity gain

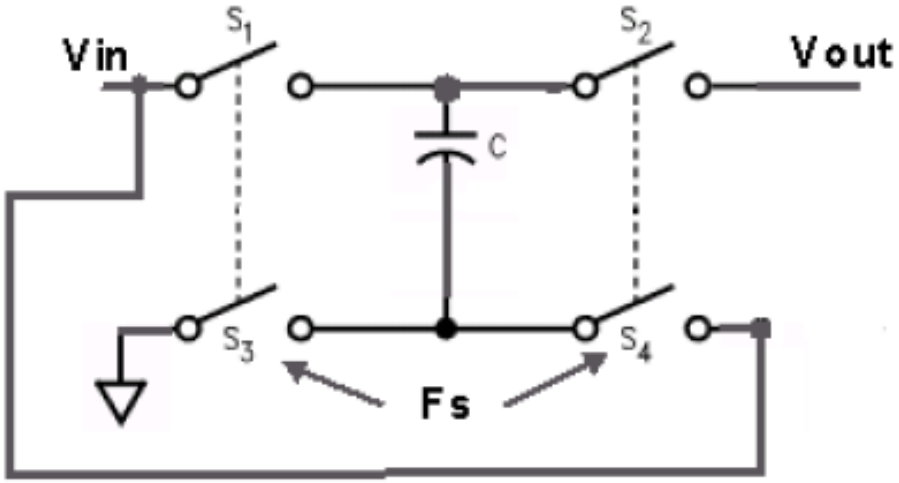


Inverting gain



Charge pumps

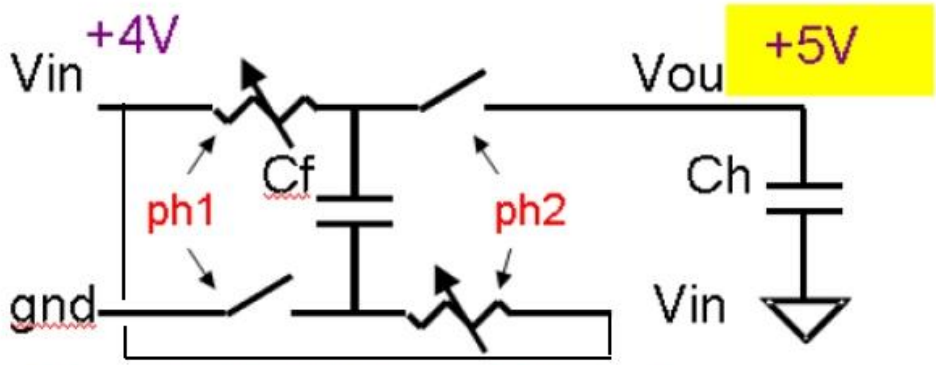
- The voltage doubler circuit shown below still has a single capacitor in the topology, only the connections are different
- The switching of the four switches are still the same
  - S1, S3 on, S2, S4 off, gain phase
  - S1, S3 off, S2, S4 on, common phase



Charge pumps

- By including a post regulator stage, the charge pump can achieve fine regulation of the output voltage
- Also, the switch impedance can be controlled to act effectively as a post regulator

R_{out}: effective output impedance including the switch impedance R_{sw}, and the switched cap. impedance ($1/F_{SW}*C_F$)
Fine adjustment can be accomplished by controlling F_{SW} or R_{SW}



Regulate Gate Drive on 2 Switches to Control Vout

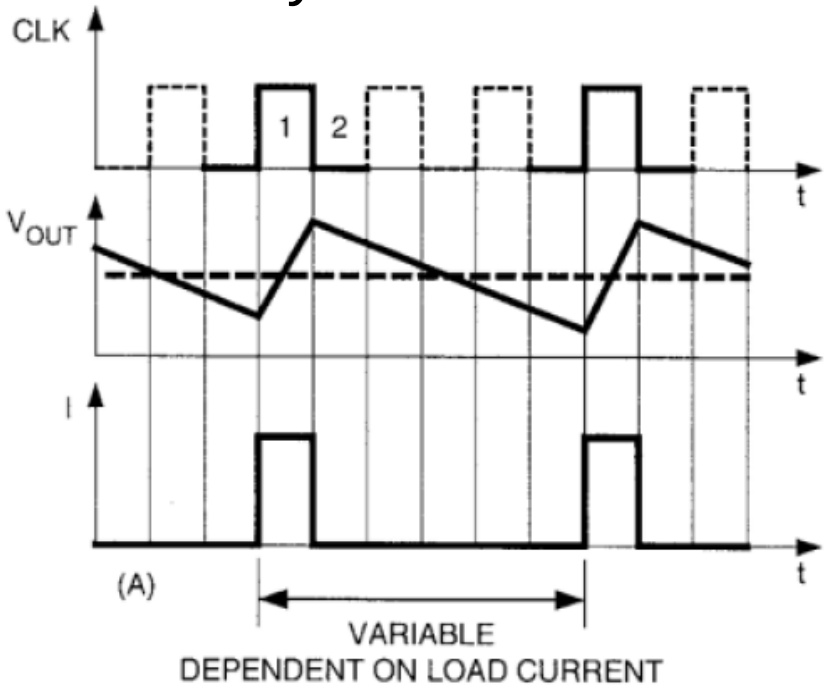
Vout= 2 x Vin– (Iout x Rout)

Fine adjust: Modulate Output Resistance (R_{OUT})

$$R_{OUT} = (G \times R_{SW}) + [1 / (F_{SW} \times C_F)]$$

Charge pumps

- Pulse Frequency Modulation (PFM): the output voltage is held constant by skipping unneeded pulses
- Advantages: very low quiescent current, higher efficiency



- Constant Frequency Regulation: regulate the output by changing the resistance of the internal switches
- Advantages: low voltage ripple, fixed frequency