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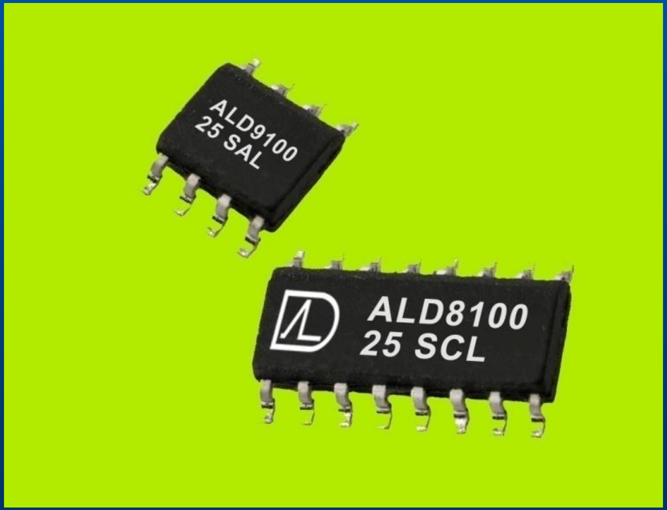
# How do Supercap Auto Balancing SAB™ MOSFETs work?



# Example

Series-connect a pair of supercapacitors

Capacitor value C1 equal to C2

Rated for 2.7V

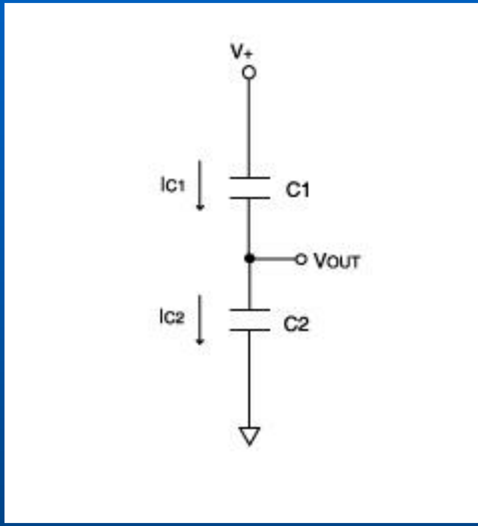
Power supply of 4.6V

# Two Supercapacitors in Series

$V_+ = +4.6V$

$I_{C1}$ is leakage of C1

$I_{C2}$ is leakage of C2




If $I_{C1} = I_{C2}$

$V_{OUT} = V_+ / 2 = 2.30V$

The two supercapacitors are exactly balanced only if $I_{C1}$ is exactly and perfectly equal to $I_{C2}$.

Total leakage current equals $I_{C1}$.

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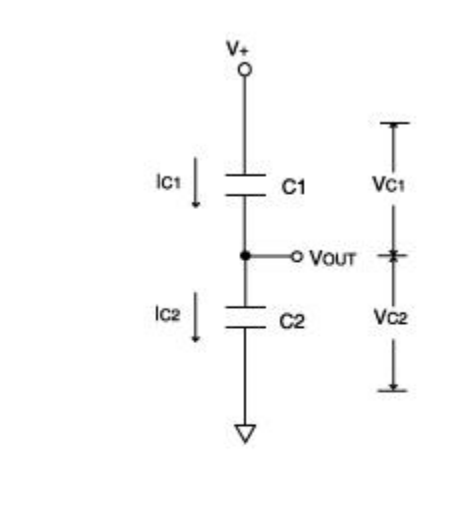
# Two Supercapacitors in Series

$V_+ = +4.6V$




If $I_{C1} > I_{C2}$

$V_{OUT}$ rises until $I_{C1} = I_{C2}$

If $V_{C2} = V_{OUT} > 2.7V$, C2 is damaged due to over – voltage

Total leakage current equals $I_{C1}$.

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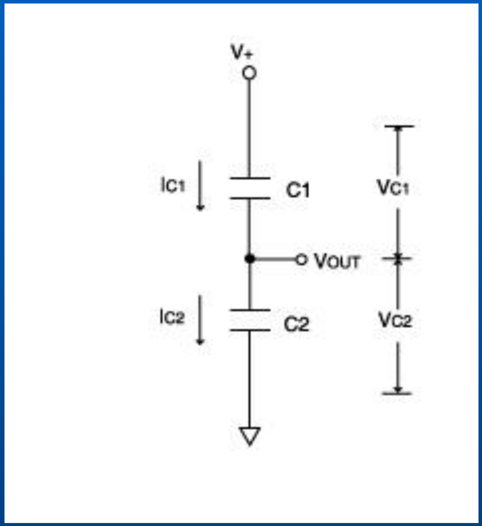
# Two Supercapacitors in Series

$V_+ = +4.6V$




If $I_{C2} > I_{C1}$

$V_{OUT}$ drops until $I_{C1} = I_{C2}$

If $V_{C1}$ $(V_+ - V_{OUT}) > 2.7V$, C1 is damaged due to over-voltage

Total leakage current equals $I_{C2}$.

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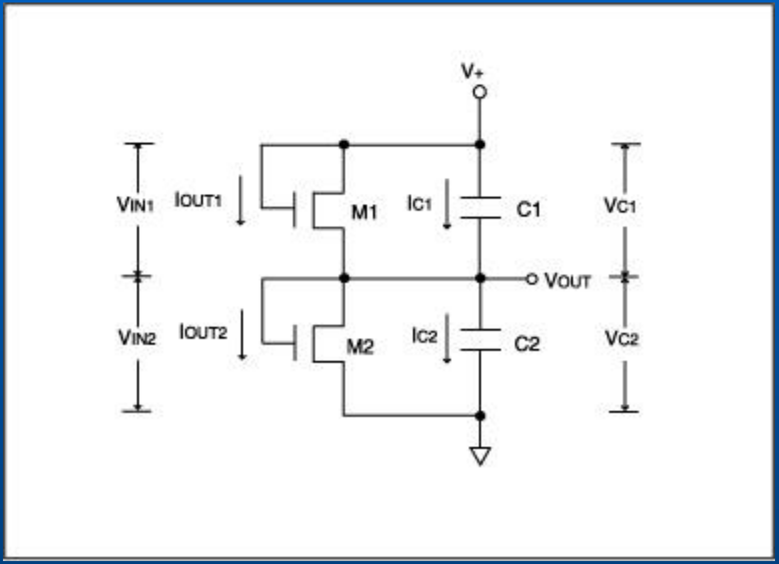
# Two Supercapacitors in Series with a SAB MOSFET across each Supercapacitor

$V_+ = +4.6V$




M1 connects across C1, $V_{IN1} = V_{C1}$

M2 connects across C2, $V_{IN2} = V_{C2}$

$V_+ = V_{IN1} + V_{IN2} = V_{C1} + V_{C2}$

$I_{C1} + I_{OUT1} = I_{C2} + I_{OUT2}$

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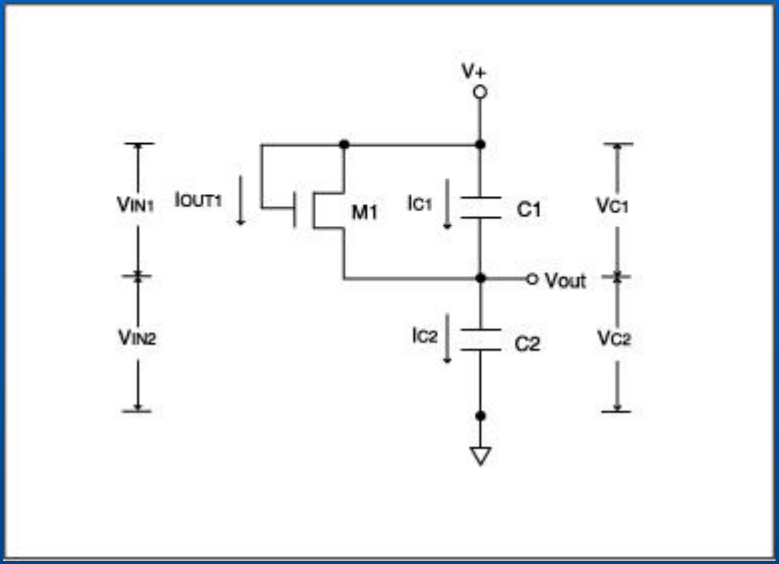
# Two Supercapacitors in Series with a SAB MOSFET across each Supercapacitor

$V_+ = +4.6V$




If $I_{C2} > I_{C1}$

$V_{OUT}$ drops until M1 is turned on

M2 is turned off, $I_{OUT2}$ is zero

$I_{OUT1} + I_{C1} = I_{C2}$

$V_{OUT}$ ~= 2.25V for $I_{C2}$ ~= 10 x $I_{C1}$

Total leakage current equals $I_{C2}$ at 2.25V.

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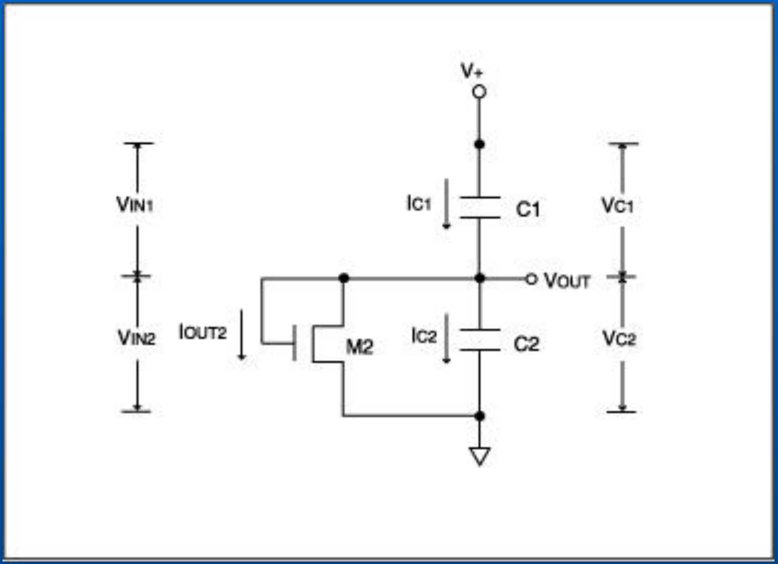
# Two Supercapacitors in Series with a SAB MOSFET across each Supercapacitor

$V_+ = +4.6V$




If $I_{C1} > I_{C2}$

$V_{OUT}$ rises until M2 is turned on

M1 is turned off, $I_{OUT1}$ is zero

$I_{OUT2} + I_{C2} = I_{C1}$

$V_{OUT} \sim= 2.35V$ for $I_{C1} \sim= 10 \times I_{C2}$

Total leakage current equals $I_{C1}$ at 2.25V.

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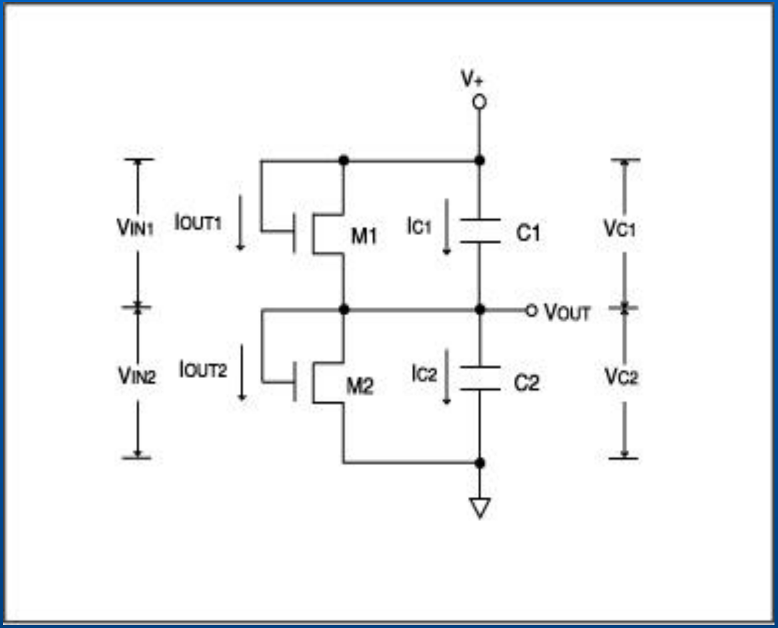
# Two Supercapacitors in Series with a SAB MOSFET across each Supercapacitor

$V_+ = +4.6V$




When $I_{C1} = I_{C2}$ $V_{OUT} \approx 2.30V$

M2 is slightly turned on

M1 is slightly turned on

$I_{OUT1} + I_{C1} = I_{OUT2} + I_{C2}$

Pick minimum $I_{OUT1}$ value so that $I_{OUT1} \ll I_{C1}$

Total leakage current equals $\sim I_{C1}$

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# Summary

* SAB MOSFETs balances supercapacitors

* Less leakage currents

* Simple and yet elegant solution

* Scalable and stackable

* Totally automatic

* Adjusts for changing conditions

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# THANK YOU for watching