How do Supercap Auto Balancing SAB™ MOSFETs work?
Series-connect a pair of supercapacitors
Capacitor value C1 equal to C2
Rated for 2.7V
Power supply of 4.6V
\[ V_+ = +4.6V \]

\( I_{C1} \) is leakage of \( C1 \)

\( I_{C2} \) is leakage of \( C2 \)

If \( I_{C1} = I_{C2} \)

\[ V_{OUT} = \frac{V_+}{2} = 2.30V \]

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

Total leakage current equals \( I_{C1} \).
$V_+ = + 4.6V$

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 $I_{C1}$. 
V+ = + 4.6V

If IC2 > IC1
VOUT drops until IC1 = IC2
If VC1 (V+ - VOUT) > 2.7V, C1 is damaged due to over-voltage
Total leakage current equals IC2.
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, \( V_{IN2} = V_{C2} \)
\[ V_+ = V_{IN1} + V_{IN2} = V_{C1} + V_{C2} \]
\[ I_{C1} + I_{OUT1} = I_{C2} + I_{OUT2} \]
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} \approx 2.25V \text{ for } I_{C2} \approx 10 \times I_{C1}
Total leakage current equals I_{C2} at 2.25V.
If $I_{C1} > I_{C2}$

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

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

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

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

Total leakage current equals $I_{C1}$ at 2.25V.
When \( I_{C1} = I_{C2} \) \( V_{OUT} \approx 2.30 \text{V} \)
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 \( \sim I_{C1} \)
* SAB MOSFETs balances supercapacitors
* Less leakage currents
* Simple and yet elegant solution
* Scalable and stackable
* Totally automatic
* Adjusts for changing conditions
THANK YOU for watching