Today

Wednesday, April 22, 2020 10:54 AM

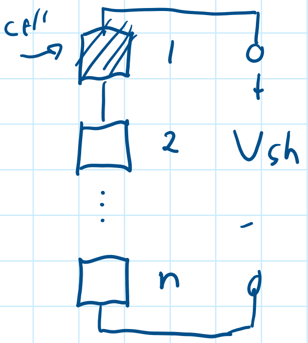
Homework 10 assigned today - Last HW!

Bypass + blocking diodes (5.9.2)

Maximum Power Point Trackers (MPPT) (5.9.2)

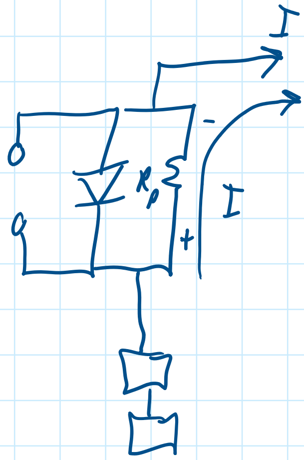
Review:

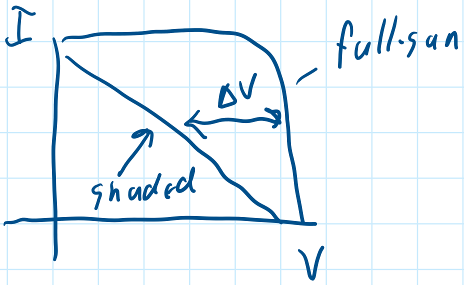
1 shaded cell



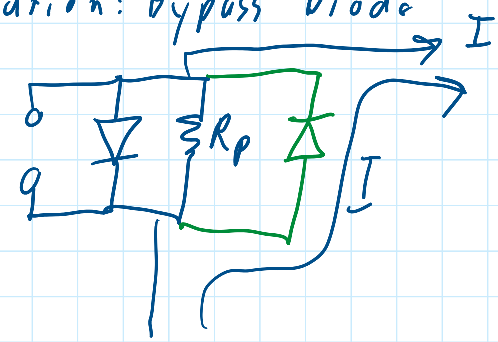
$$\Delta V = \frac{V}{n} + I R_p$$

↑ normal cell voltage ↑ drop due to current in R_p

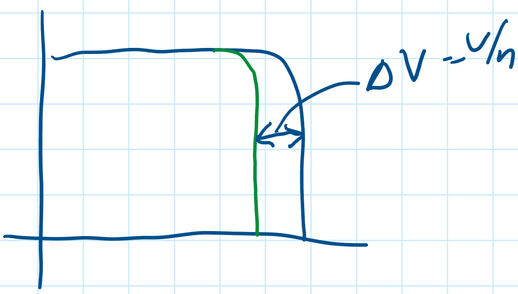




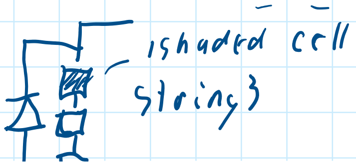
Solution: Bypass Diode



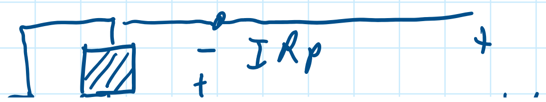
$$\Delta V = \frac{V}{n} \Rightarrow \text{no drop from } I R_p$$

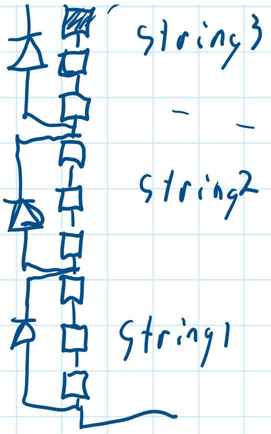


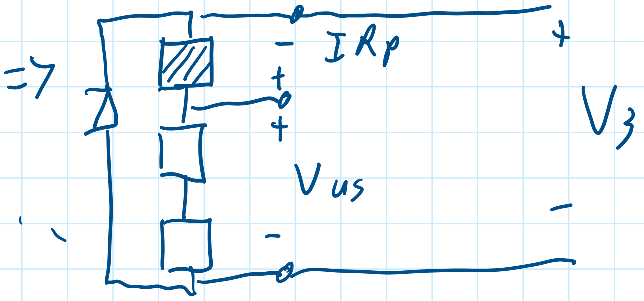
However, it would be exensive to include a bypass diode for every cell ⇒ use one diode for multiple cells



⇒

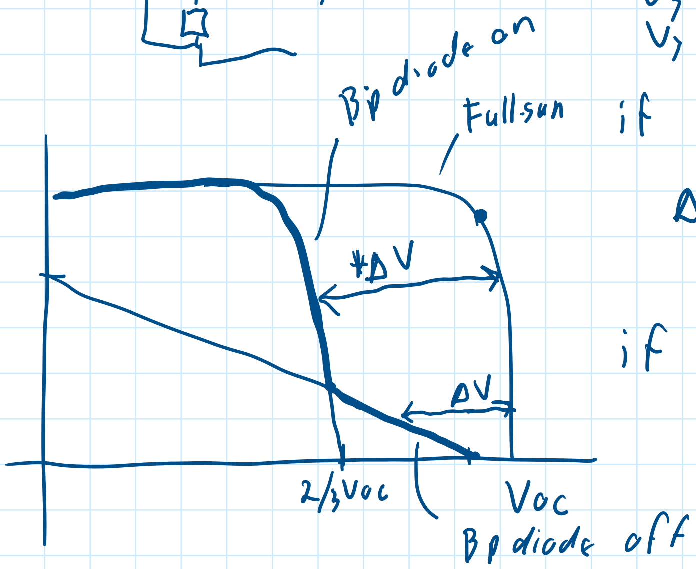






$V_3 = V_{us} - IR_p$ (diode off) ≥ 0

$V_3 = 0$ (diode on) ≤ 0



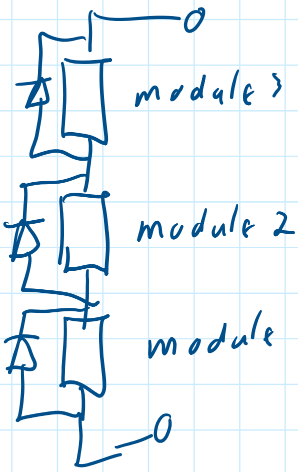
if $V_{us} > IR_p$ (diode off)

$$\Delta V_3 = \frac{V}{n} + IR_p$$

if $V_{us} < IR_p$ (diode on)

$$*\Delta V = \frac{3V}{n}$$ (all 3 cells bypassed)

what about multiple modules in series?

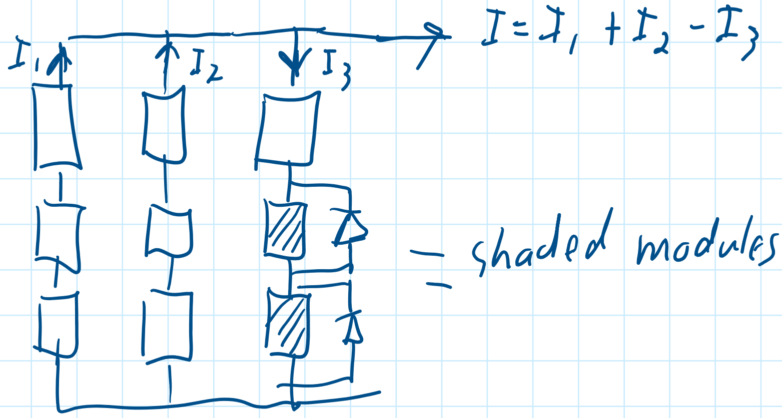


=> Same idea

one bypass diode per module

If a cell is shaded in a module, lose the contribution of the module, but rest are still contributing fully

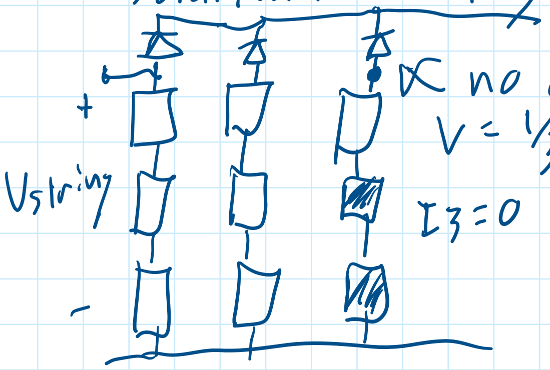
what about Parallel Modules?



- Voltage of shaded string is 1/3 of full sun strings

=> Current Flows into shaded string

Solution: Blocking diodes



$I = I_1 + I_2$

✗ no current flows

$V = \frac{1}{3} V_{string}$.

$I_3 = 0$

Maximum Power Point Tracking

Wednesday, April 22, 2020 10:54 AM

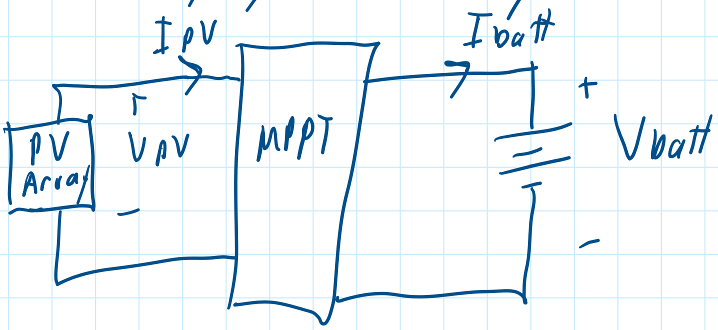
↳ want to operate PV Array at maximum power point, otherwise we're wasting available power

↳ Not easy => Maximum Power Point moves around as I-V curves shift with insolation, temperature...

↳ We need a circuit and controller that allows us to track and operate at the MPP.

↳ Call this unit a Maximum Power Point Tracker (MPPT)

Ex/ charging a battery



- V_{batt} is fixed
- want $V_{pv} = V_{mpp}$, $I_{pV} = I_{mpp}$
- $P_{in} = P_{mpp} = P_{out} = V_{batt} \cdot I_{batt}$

If $V_{batt} \neq V_{mpp}$, we need to convert the voltage level

=> Assume that the MPPT acts like an ideal DC transformer with a conversion ratio "a" => $a = \frac{V_{out}}{V_{in}}$

note in different classes $a = M$ (↑ gain)

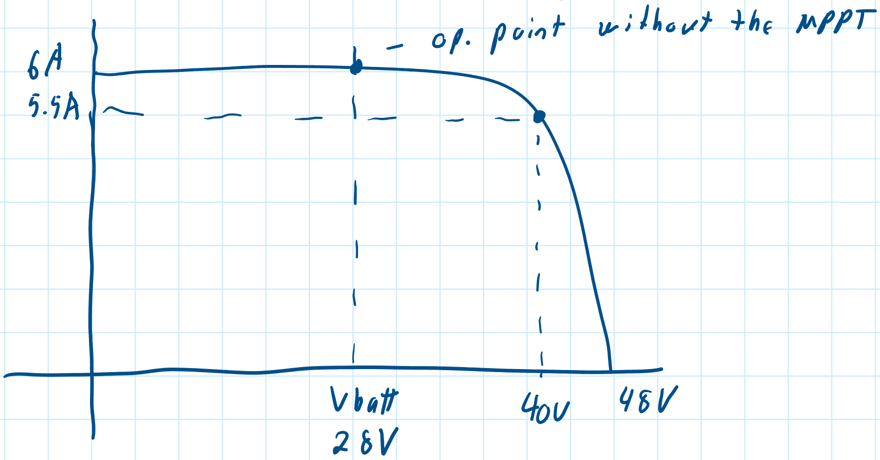
how does this work? => Power Electronics!!! ECE 464/469
→ FA 2020
→ Familiar Prof!!!

For MPPT:

$V_{out} = aV_{in}$, $I_{in} = aI_{out}$] $P_{in} = P_{out}$, $V_{in} \cdot I_{in} = V_{out} \cdot I_{out}$

Suppose:

$V_{batt} = 28V$
$V_{mpp} = 40V$
$I_{mpp} = 5.5A$
$P_{mpp} = 220W$



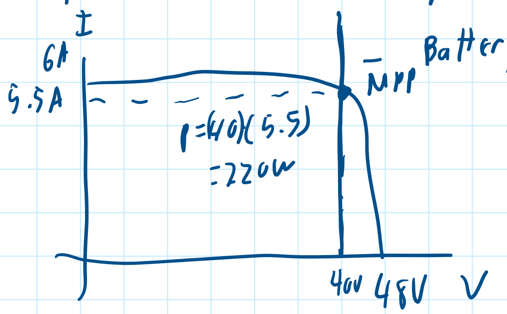
Vbatt 28V | 40V | 48V

we use the MPPT to alter the battery V-I curve as the PV panel sees it so that it intersects the P-V I-V curve at the MPP

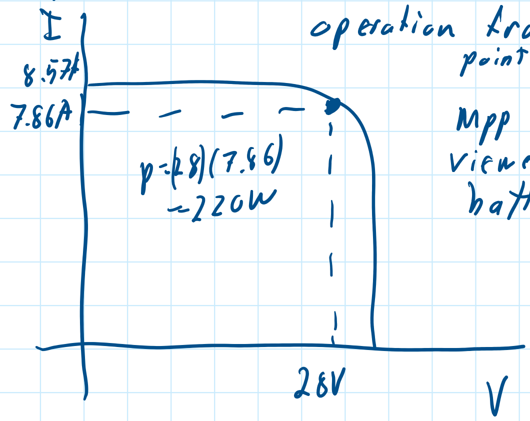
$$a = \frac{V_{out}}{V_{in}} = \frac{V_{batt}}{V_{mpp}} = \frac{28V}{40V} = 0.7$$

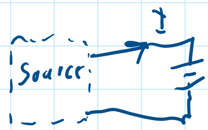
$$\Rightarrow I_{out} = \frac{I_{in}}{a} = \frac{I_{mpp}}{0.7} = \frac{5.5}{0.7} = 7.86A$$

Operation from PV point of view



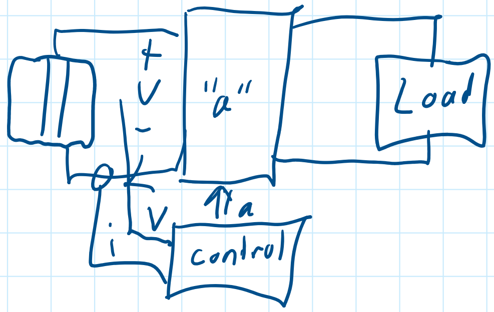
operation from battery point of view





MPPT Controllers

- MPPT circuit needs a way to control "a" to find the MPPT
  - ↳ there are tons of ways to do this
  - ↳ we'll look at one

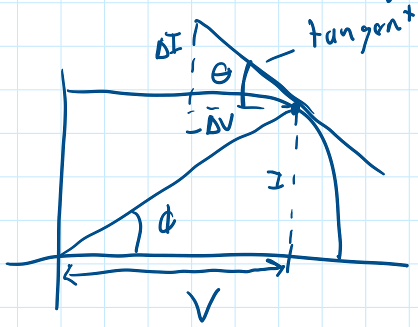


"Hill climbing" or "Perturb and Observe"
↳ converging methods

at the MPP $\frac{dP}{dV} = 0 \Rightarrow$ slope of the tangent to P-V curve

$$P = V \cdot I \Rightarrow \frac{dP}{dV} = \frac{d}{dV}(VI) = V \cdot \frac{dI}{dV} + \frac{dV}{dV} I = V\frac{dI}{dV} + I = 0$$

⇒ at MPP : $\frac{+I}{V} = -\frac{dI}{dV} \approx \boxed{\frac{\Delta I}{\Delta V} \approx \frac{I}{V}}$ MPP condition



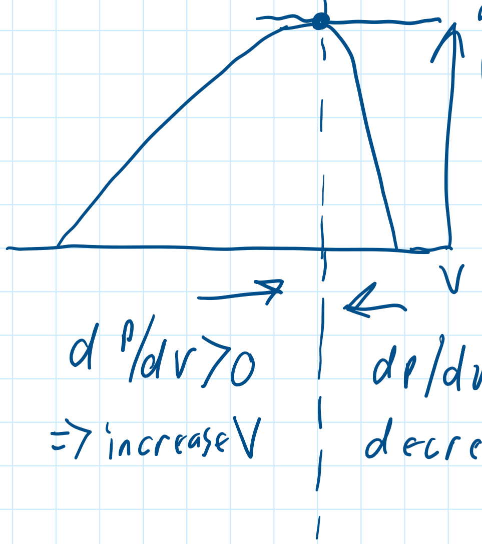
Book Fig 5.56

$\frac{I}{V} = -\frac{\Delta I}{\Delta V}$

$\phi = \theta$

if $\phi < \theta$ decrease V
if $\phi > \theta$ increase V

Why does this work?



d P/dV > 0
⇒ increase V

dP/dV < 0
decrease V

$\frac{dP}{dV} > 0$ ⇒ Increase V

$V\frac{dI}{dV} + I > 0$

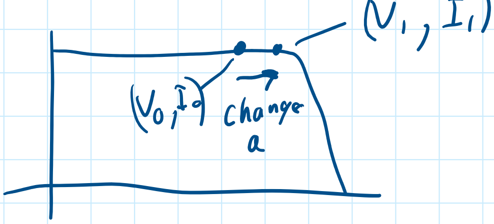
$\frac{I}{V} > -\frac{dI}{dV} \approx -\frac{\Delta I}{\Delta V}$

$\frac{I}{V} > \frac{-\Delta I}{\Delta V}$

$\phi > \theta$ ✓ ⇒ increase V

How do we find ΔI and ΔV?

⇒ take measements



$dI = I_1 - I_0$
$dV = V_1 - V_0$
} "Perturb and observe"

Once we find MPP, we want to stay there
↳ check conditions often to see if state has changed