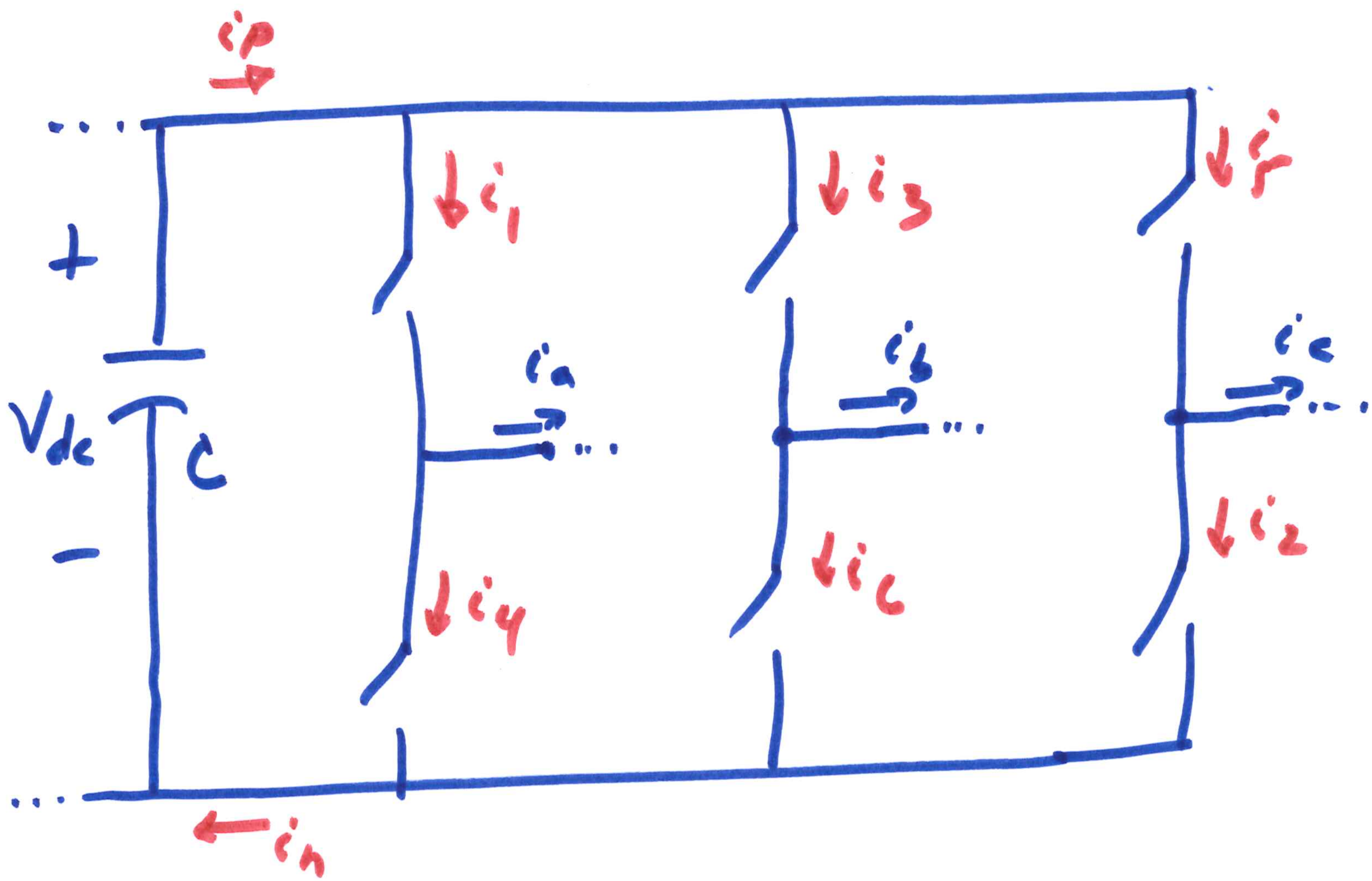
ECE 404-TD / 504-TD

ST: T&D APPLICATIONS OF VOLTAGE SOURCE CONVERTERS

SESSION no. 19

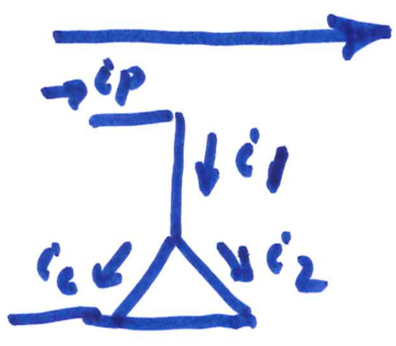


ip
+
Vdc
C
−
in
i1
i4
ia
i3
i6
ib
i5
i2
ic

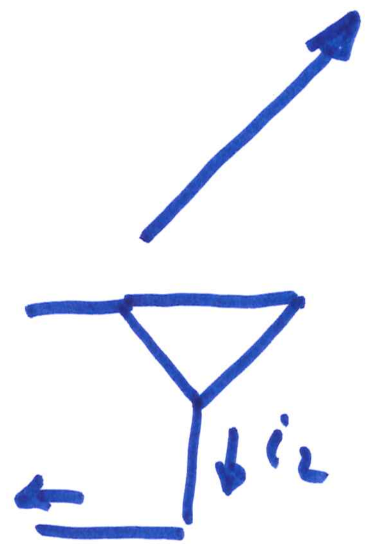
Space vector

612

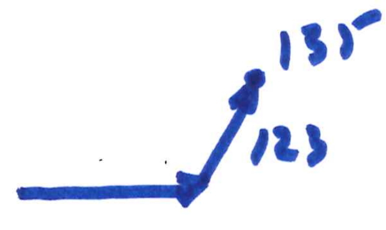
123



$i_p = i_1$



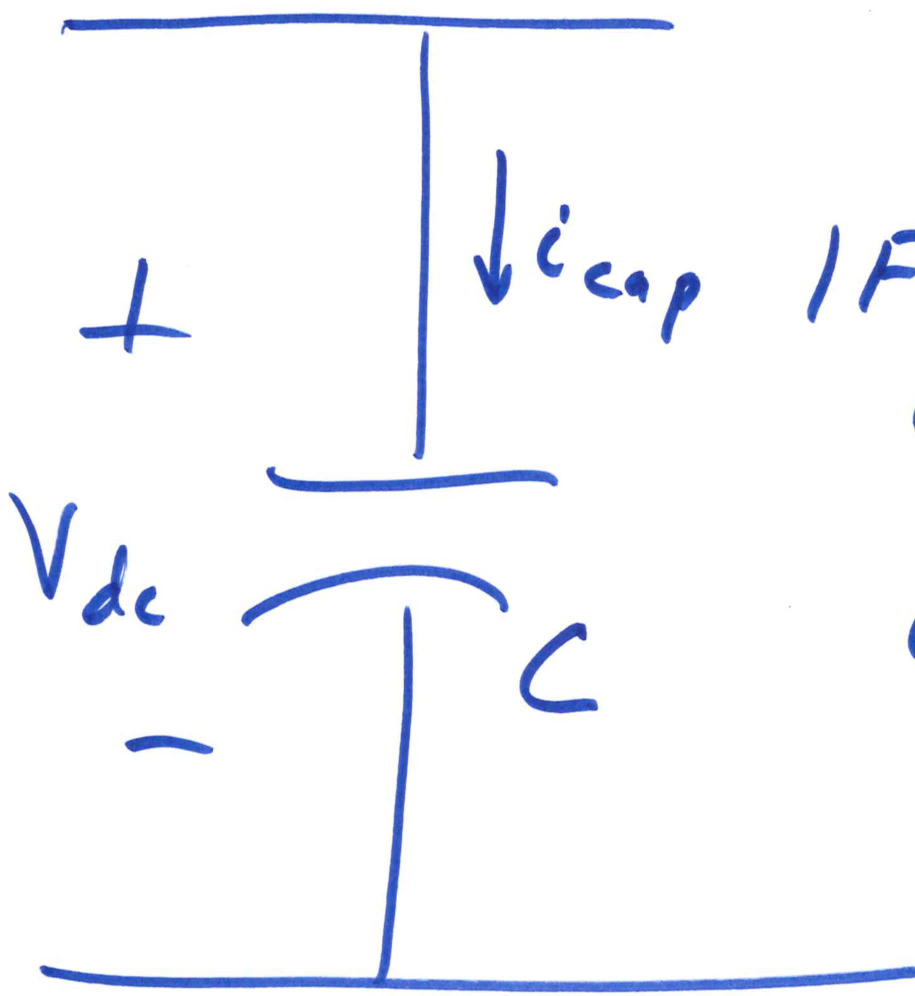
$i_n = i_2$



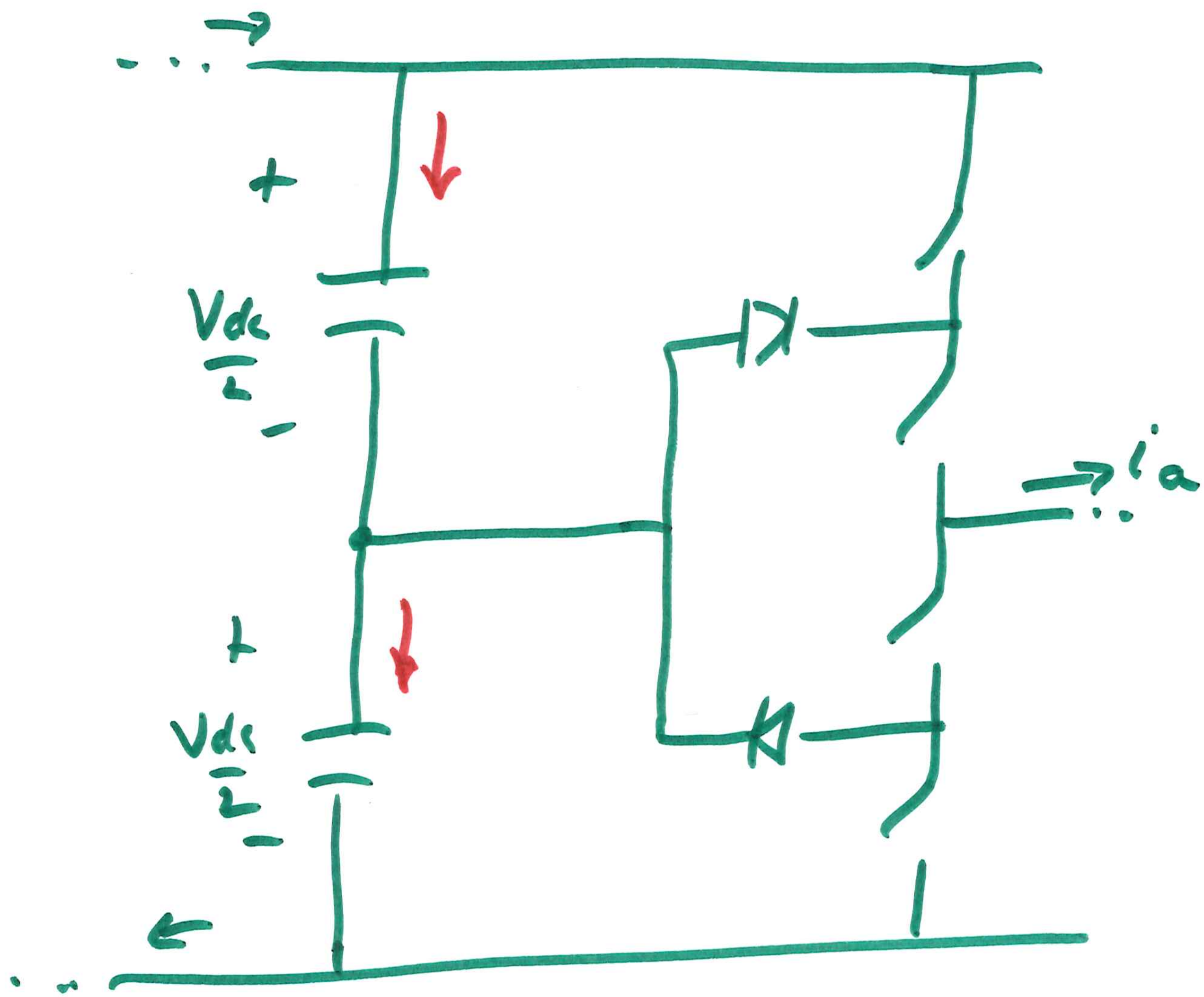
612

$\sum i_p \neq 0$

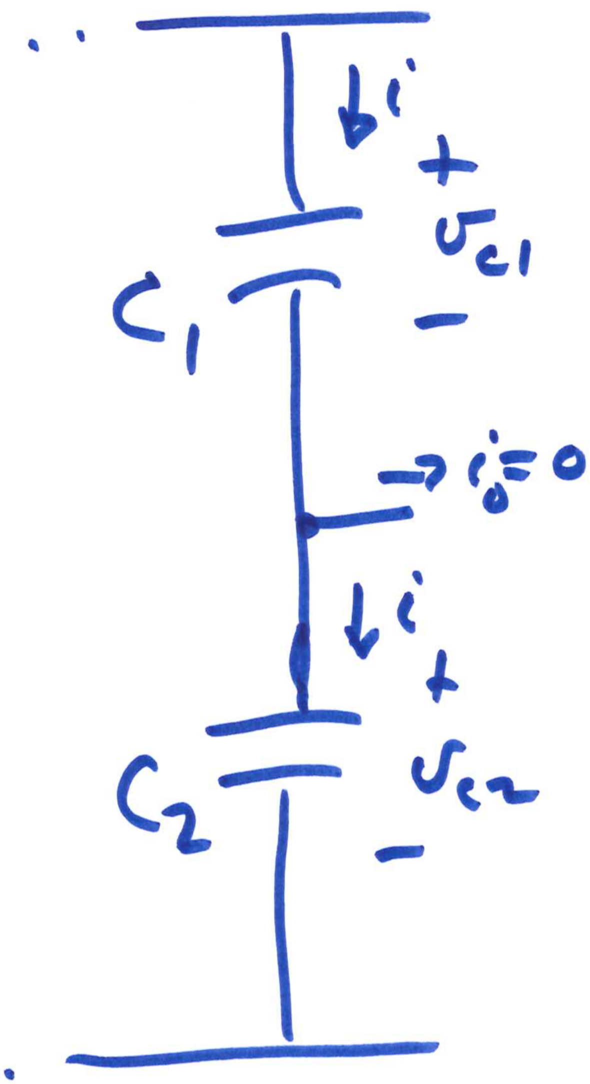
$\sum i_n \neq 0$



IF V_{dc} = constant; $i_{cap} = 0$



+
Vdc/2
-
+
Vdc/2
-
ia



$$v_{c1} + v_{c2} = V_{dc}$$

$$v_{c1} = \frac{1}{C_1} \int i \, dt$$

$$v_{c2} = \frac{1}{C_2} \int i \, dt$$

$$v_{c2} = V_{dc} - v_{c1}$$

$$2 v_{c2} = V_{dc} - v_{c1} + \frac{1}{C_2} \int i \, dt$$

$$v_{c2} = \frac{V_{dc}}{2} - \frac{1}{2}\left(\frac{1}{C_1} \int i \, dt\right) + \frac{1}{2} \frac{1}{C_2} \int i \, dt$$

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$$v_{C2} = \frac{V_{dc}}{2} + \frac{1}{2}\left(-\frac{1}{C_1} + \frac{1}{C_2}\right)\int i\,dt$$

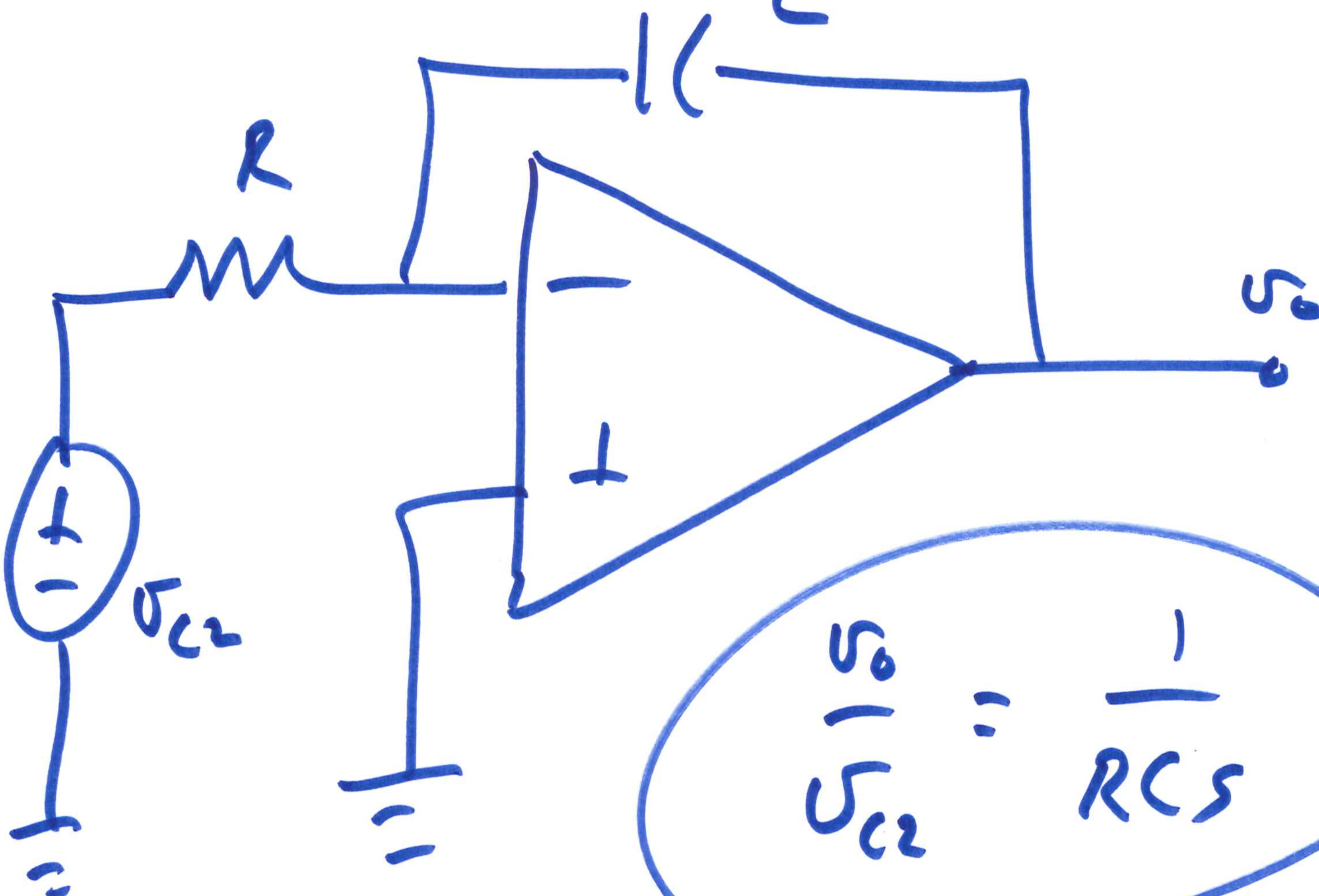
$$\dot{v}_{C2} = \frac{1}{2}\left(\frac{1}{C_2} - \frac{1}{C_1}\right) i$$

$$s V_{C2} = \frac{1}{2}\left(\frac{1}{C_2} - \frac{1}{C_1}\right) I$$

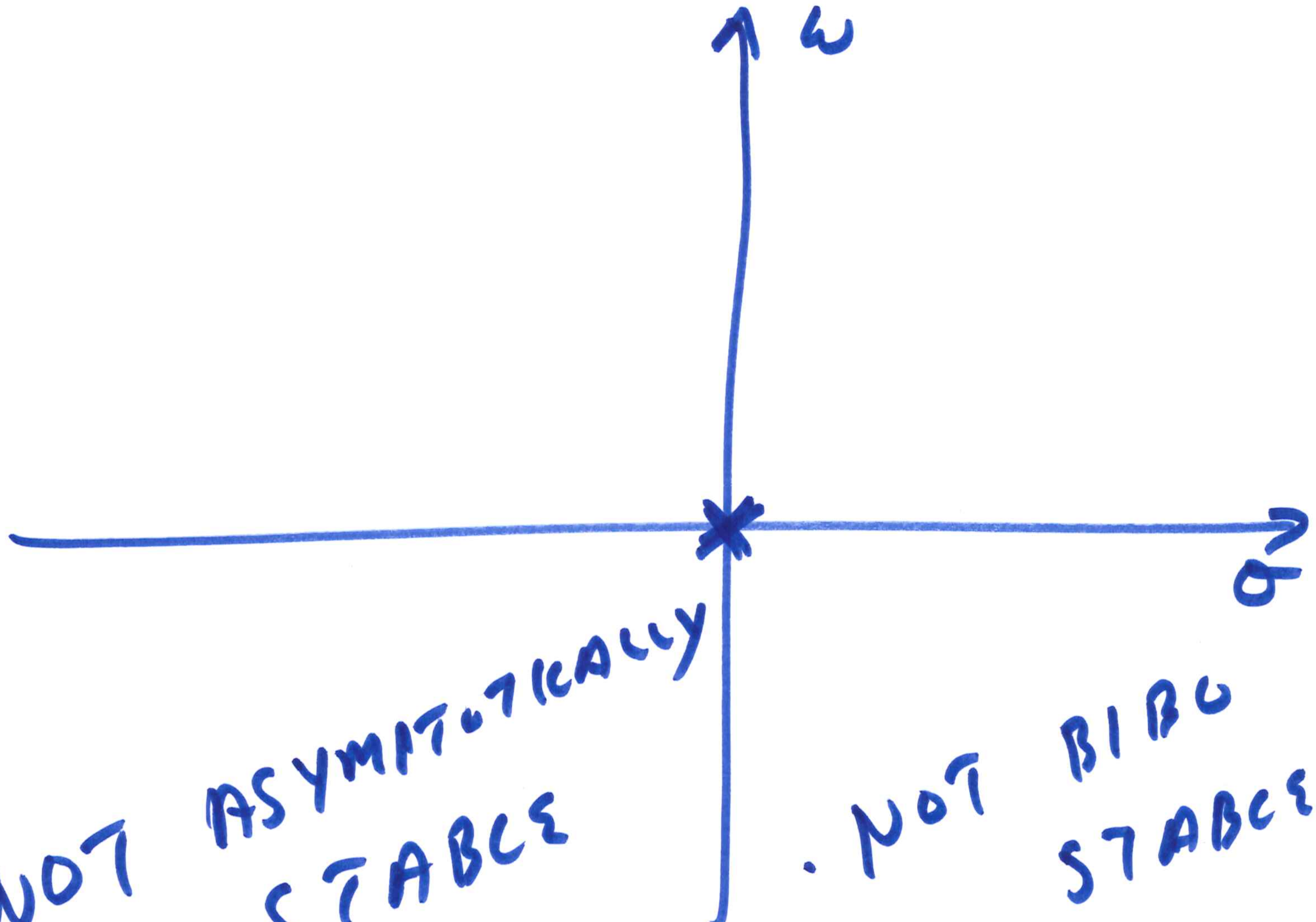
$$\frac{V_{C2}}{I} = \frac{\frac{1}{2}\left(\frac{1}{C_2} - \frac{1}{C_1}\right)}{s}$$

INTEGRATOR

IF $C_1 = C_2$!!! YES !!!



$$\frac{v_o}{v_{c2}} = \frac{1}{RCs}$$



- NOT ASYMPTOTICALLY STABLE
- NOT BIBO STABLE

$$i_a + i_b + i_c = 0$$

i_a

i_b

i_c

$$v_a + v_b + v_c = 0$$

$$v_{ab} + v_{bc} + v_{ca} = 0$$

$$\begin{bmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ -1 & 0 & 1 \end{bmatrix} \begin{pmatrix} v_a \\ v_b \\ v_c \end{pmatrix} = \begin{pmatrix} v_{ab} \\ v_{bc} \\ v_{ca} \end{pmatrix}$$

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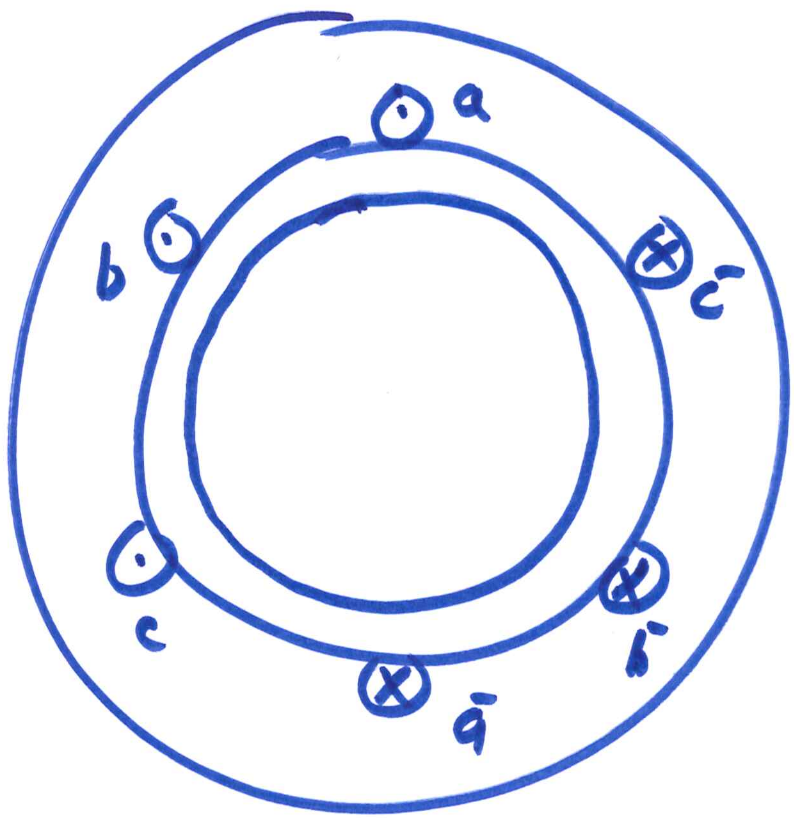

- PITCH
- BREADTH

ECE 404 / 504

T & D Applications of Voltage Sourced Converters

Lesson 19

Multilevel converters

Issues with the currents in the converter, such as voltage drift, etc.

That means we have capacitances to think about.

The current drawn comes from the capacitor or the input or both. It is not necessarily zero for a single vector creation. The current in the capacitor should average out over a complete cycle? No, it needs some current from the rectifier.

The switching may make ripple voltage on the capacitor, depending on what we get from the rectifier.

The point here is that current can cause the capacitor to change voltage and we can see how that might happen.

Now to a three-level converter...

An issue that we encounter is imbalance between the two capacitors.

Therefore, we can get control from our input at the neutral point, due to our switching algorithm .

For the MMC, the issue is more complicated. We have, not two capacitors, but we have 6N capacitors for N modules in our converter. The solution is similar: we use the switching to adjust the voltage balance. The problem is beyond the scope of this course.

The full bridge gives us a lot more flexibility to do this than the half bridge: we have three possibilities (+,0,-)

Another interesting issue involving currents is bearing current. Similar issues are at hand.

A power converter has three output currents: i_a, i_b, and i_c. They sum to zero over time, but each does have a third harmonic, if switched six step, and other nonzero components that integrate to zero if switched PWM.

We set up commands for i_a, i_b, and i_c and then PWM each independently to get current regulation. There are small errors in doing this...quantization, noise, lag, etc., that find their way into the currents fed to the machine. The sum of these currents is not always zero. And the charge builds up on the machine.

How are the windings in most motors grounded? Capacitively. Enough charge and we get little arcs. In the bearings. Bearings get pitted. Solution: recognize that only two of the three currents are independent: Paulo Tenti, discovered this. i_a, i_b, and i_c

Independent?

Next: Doubly Fed Induction Generator…

Describe the stator…

Three phase, nice, sinusoidal MMF (& magnetic field) distribution in the air gap.

Rotor? Shorted bars…squirrel cage.

Wound rotor…think stator inside out. Uses a resistance on the terminals.

How about putting an input on both windings? Come back next time and find out… ☺