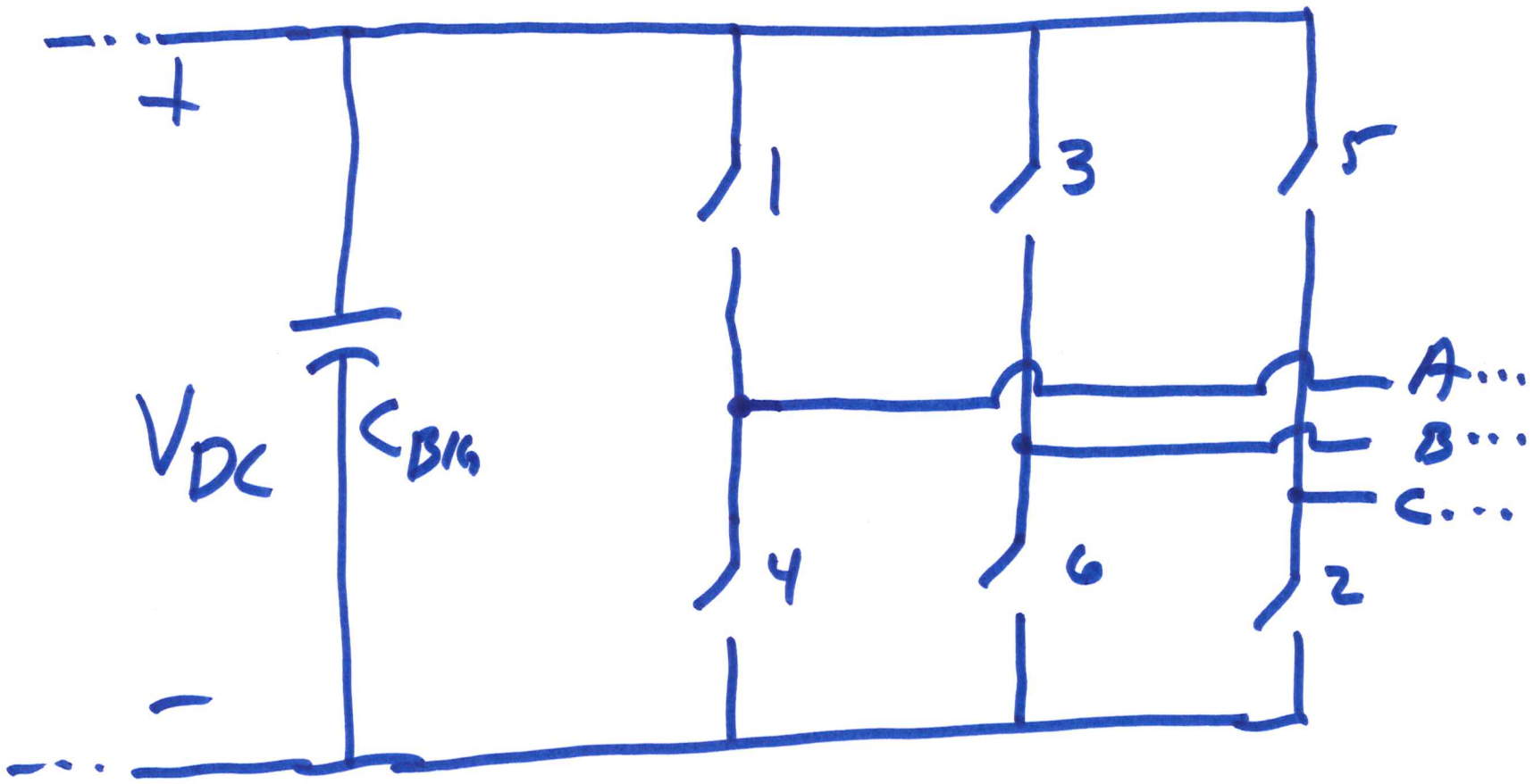
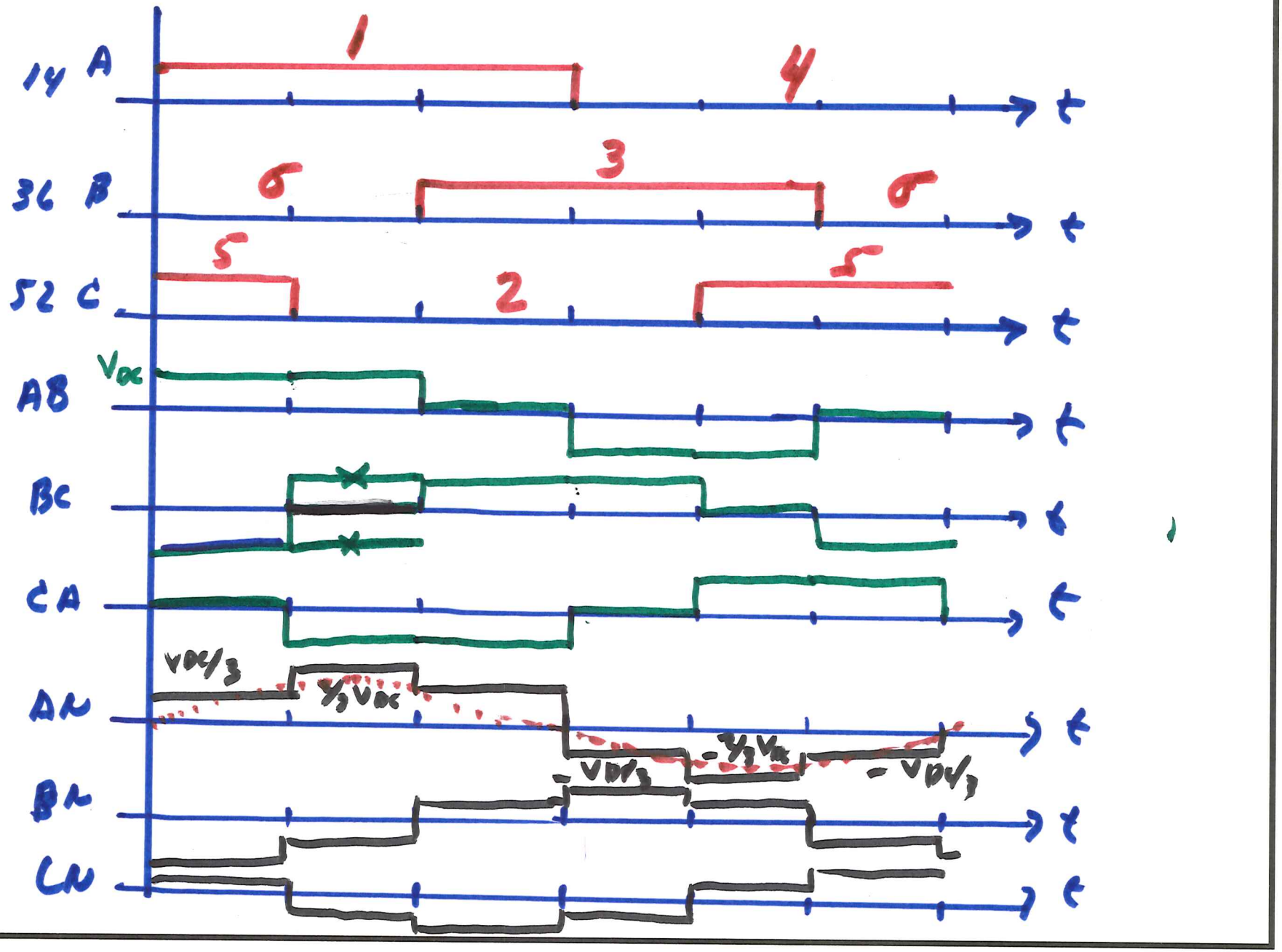
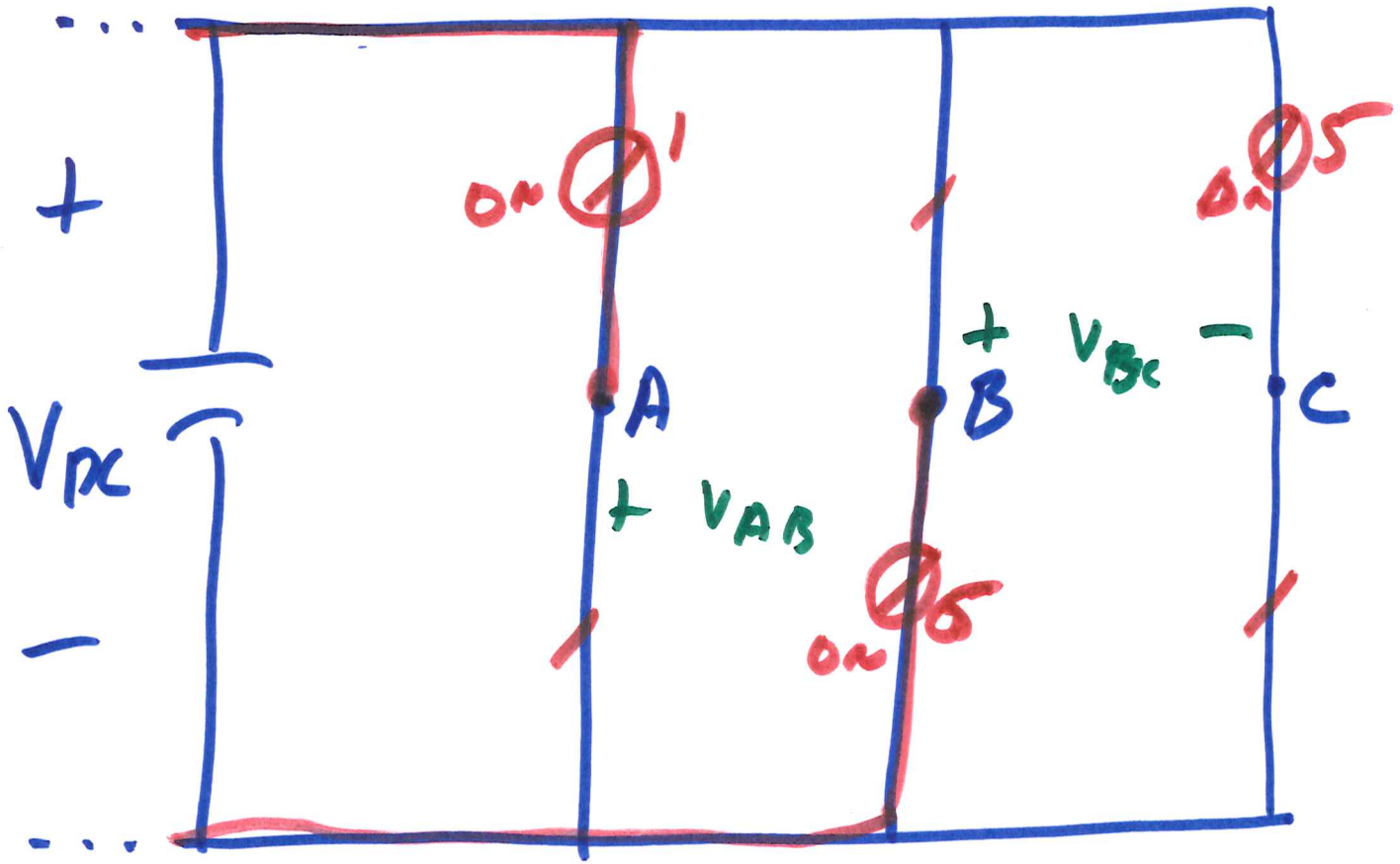
ECE 404-TD / 504-TD

ST: T&D APPLICATIONS OF VOLTAGE SOURCE CONVERTERS

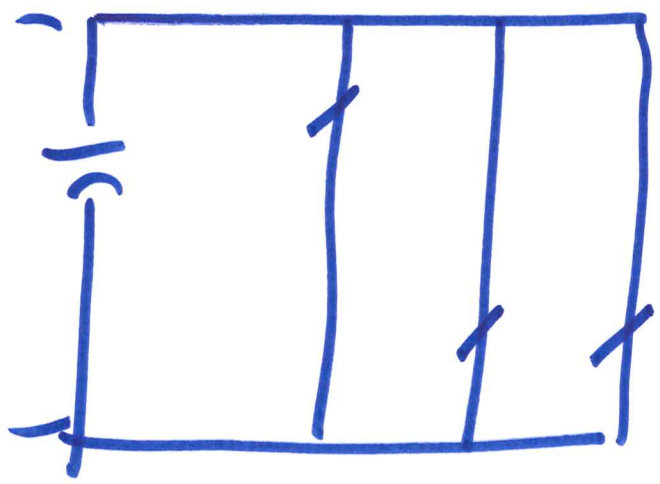
SESSION no. 11


+
1
3
5
V_{DC}
C_{Big}
A...
B...
C...
4
6
2
−


1
4
A
t
3
6
B
6
6
t
5
2
C
5
2
t
AB
Vdc
t
BC
t
CA
t
Vdc/3
AN
2/3Vdc
-2/3Vdc
-Vdc/3
-Vdc/3
t
BN
t
CN
t



$$V_{AB} = V_{DC}$$



6 12

$$V_{AB} = V_{AN} - V_{BN}$$

$$V_{BC} = V_{BN} - V_{CN}$$

$$0 = V_{AN} + V_{BN} + V_{CN}$$

$$\begin{bmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ 1 & 1 & 1 \end{bmatrix} \begin{pmatrix} V_{AN} \\ V_{BN} \\ V_{CN} \end{pmatrix} = \begin{pmatrix} V_{AB} \\ V_{BC} \\ 0 \end{pmatrix}$$

$$\begin{pmatrix} V_{AN} \\ V_{BN} \\ V_{CN} \end{pmatrix} = \begin{bmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ 1 & 1 & 1 \end{bmatrix}^{-1} \begin{pmatrix} V_{AB} \\ V_{BC} \\ 0 \end{pmatrix}$$

$$\begin{pmatrix} V_{AN} \\ V_{BN} \\ V_{CN} \end{pmatrix} = \frac{1}{3} \begin{bmatrix} 2 & 1 & 1 \\ -1 & 1 & 1 \\ -1 & -2 & 1 \end{bmatrix} \begin{pmatrix} V_{AB} \\ V_{BC} \\ 0 \end{pmatrix}$$

$$v_{AN_1} = \frac{2}{\pi} V_{DC} \sin(\omega t) \text{ V}$$

$$v_{BN_1} = \frac{2}{\pi} V_{DC} \sin\left(\omega t - \frac{2\pi}{3}\right) \text{ V}$$

$$v_{CN_1} = \frac{2}{\pi} V_{DC} \sin\left(\omega t + \frac{2\pi}{3}\right) \text{ V}$$

$6N \pm 1$

$$\delta = \sqrt{\frac{2}{\omega \mu \sigma}}$$

ECE 404 / 504

T & D Applications of Voltage Sourced Converters

Lesson 11

Three phase: Three power poles switching our DC input into AC output

Three power poles: six switches with one ON and one OFF in each power pole.

Three switches ON and three switches OFF at any time. Switching is BREAK before MAKE.

In this way, we get a waveform set that has a certain three phase character to it.

What we have are the LINE-TO-LINE voltages at the output of the switching inverter.

Line-to-neutral voltages?

What does this ancient technology tell us?

By selecting our switching instants carefully, we can set/control the frequency, phase. We will eventually

figure out how to control the amplitude also.

What is the conservation of sorrows on these ancient waveforms?

☹ Harmonics!

We have set up waveforms with only ODD harmonics. At least we got rid of the even harmonics by using ODD symmetry.

For the three phase waveform, we have also rid ourselves of the triplen harmonics. 3, 6, 9, 12, 15,…

What is so bad about having harmonics in the voltage (and current) waveforms that we send to our load?

Harmonics contribute mostly to losses. Useful power will

not appear in a synchronous machine from the harmonics. (Voltage and current at the same frequency is the only way to get real power.) Harmonics contribute to vibrating torques and surface heating of the rotor.

Skin depth

Pulse width modulation