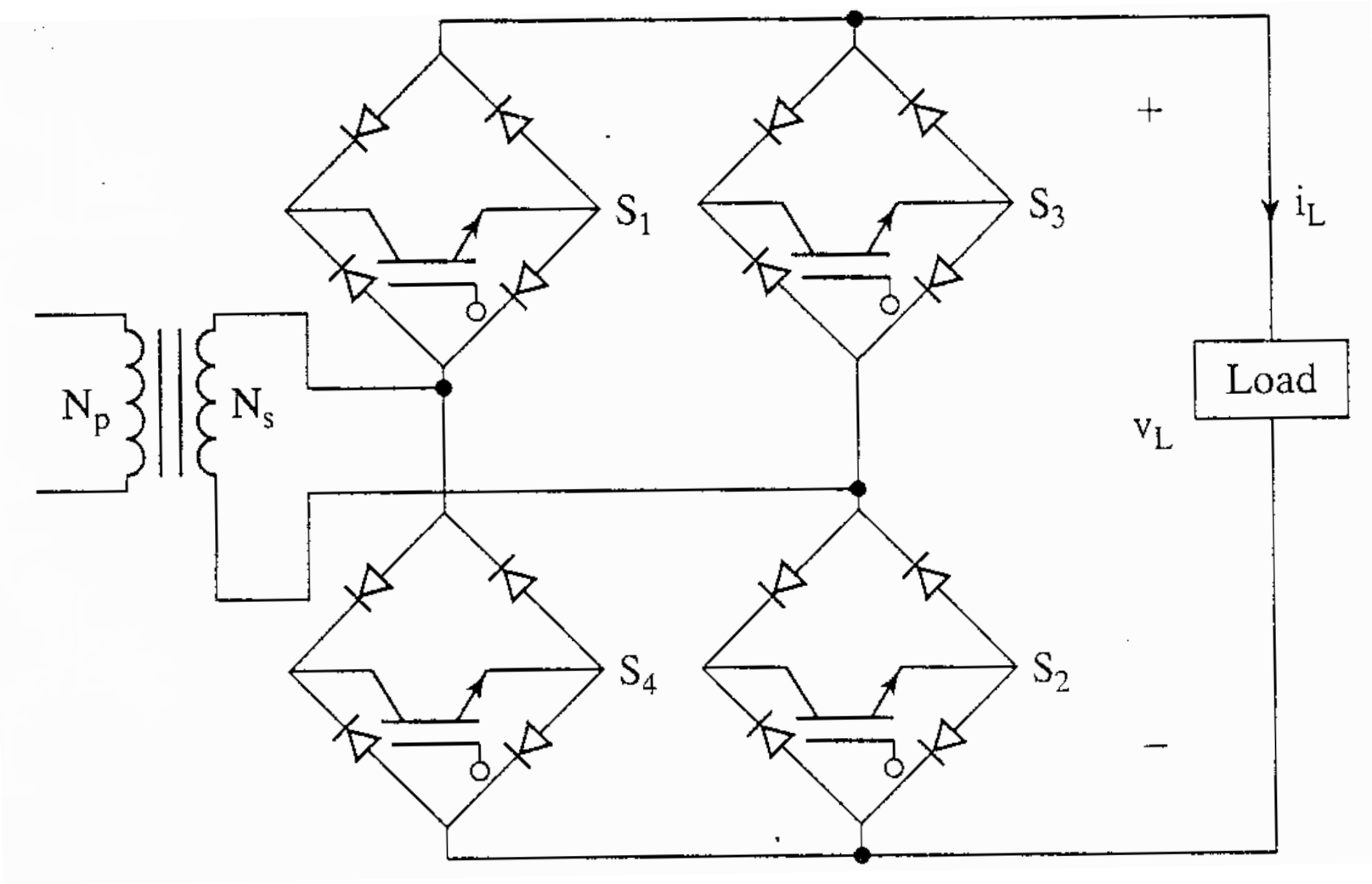
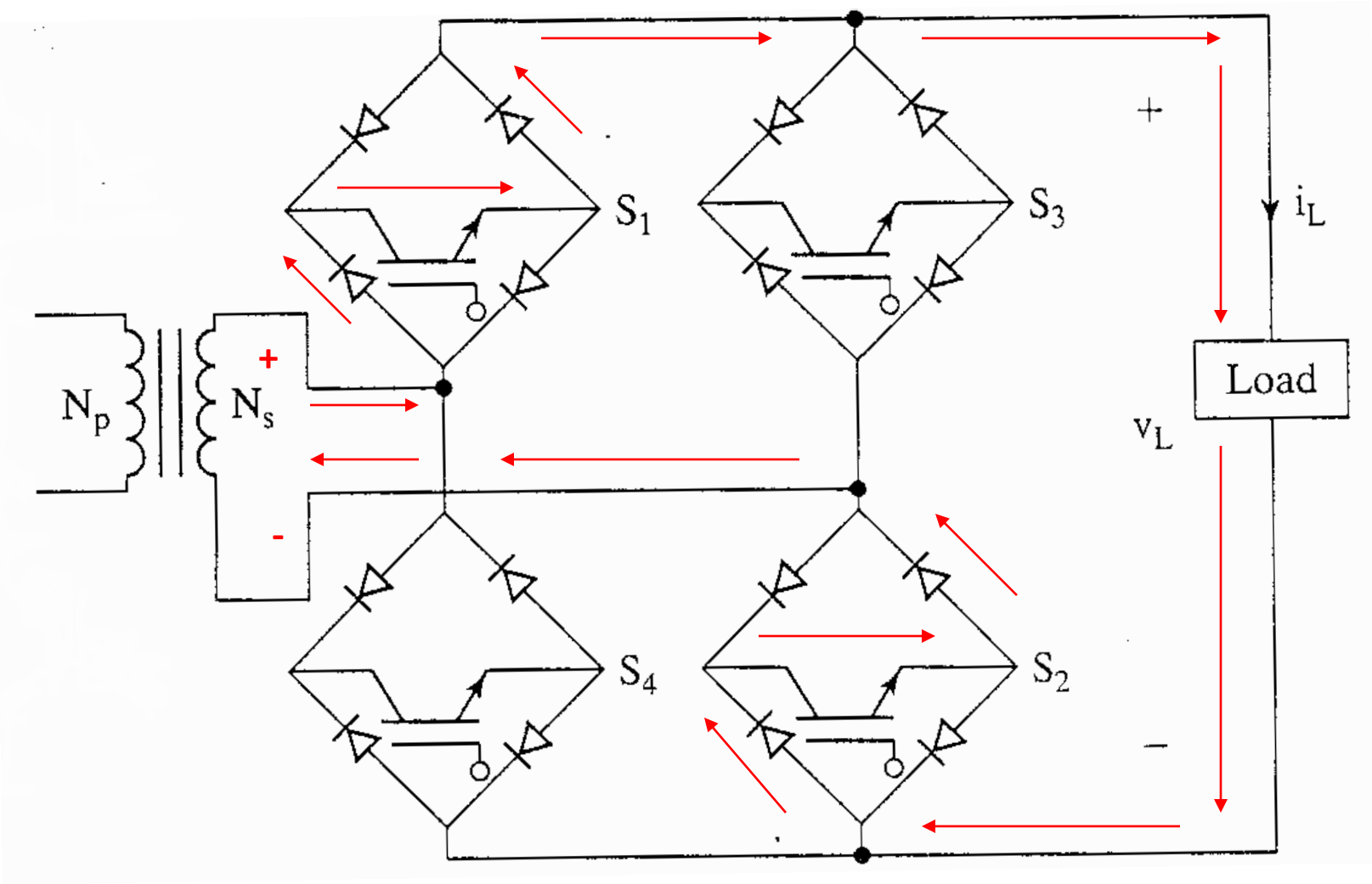
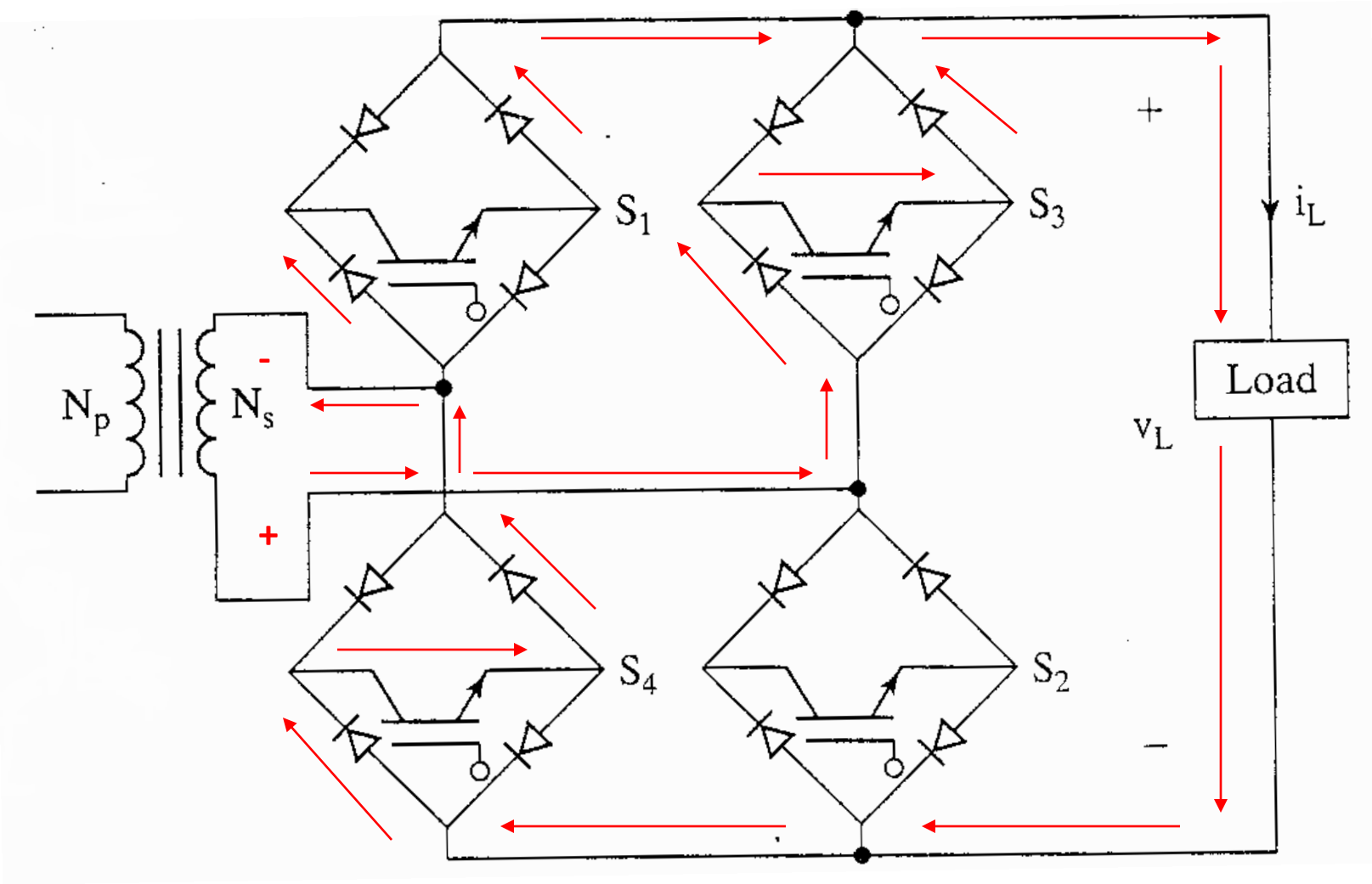
Cycloconverter



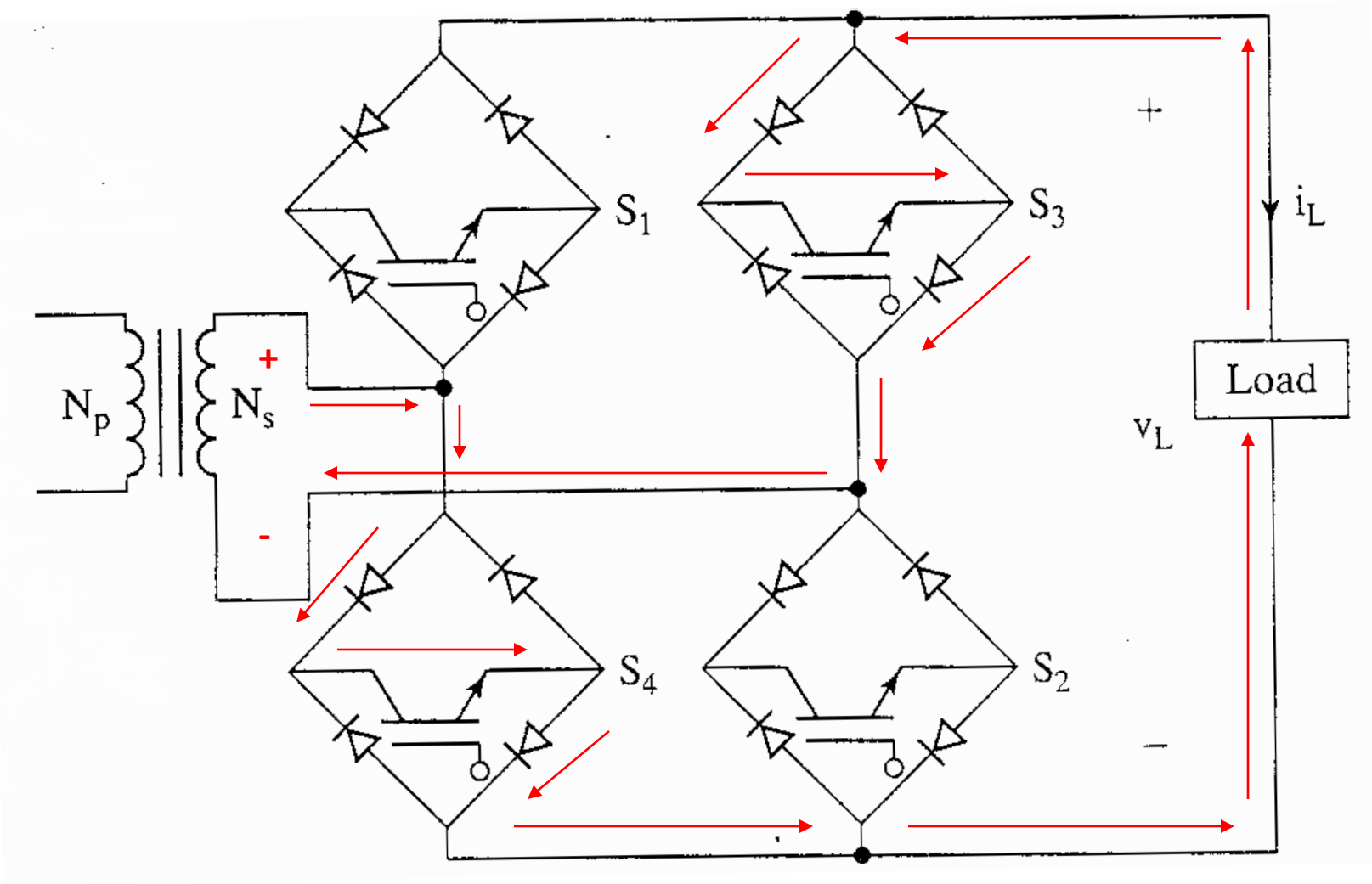
Transformer Polarity as shown, S_1 and S_2 ON



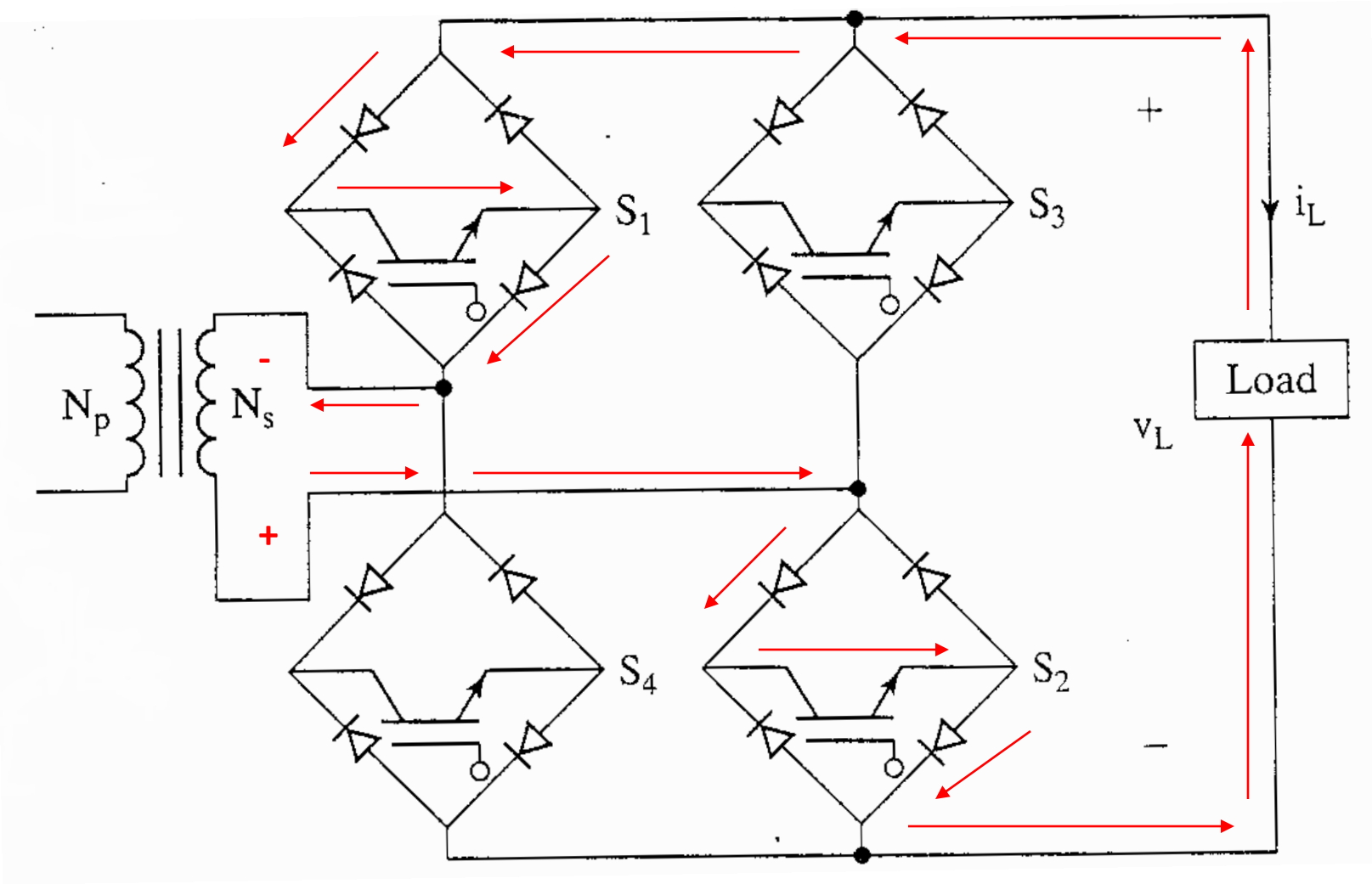
Transformer Polarity as shown, S_3 and S_4 ON



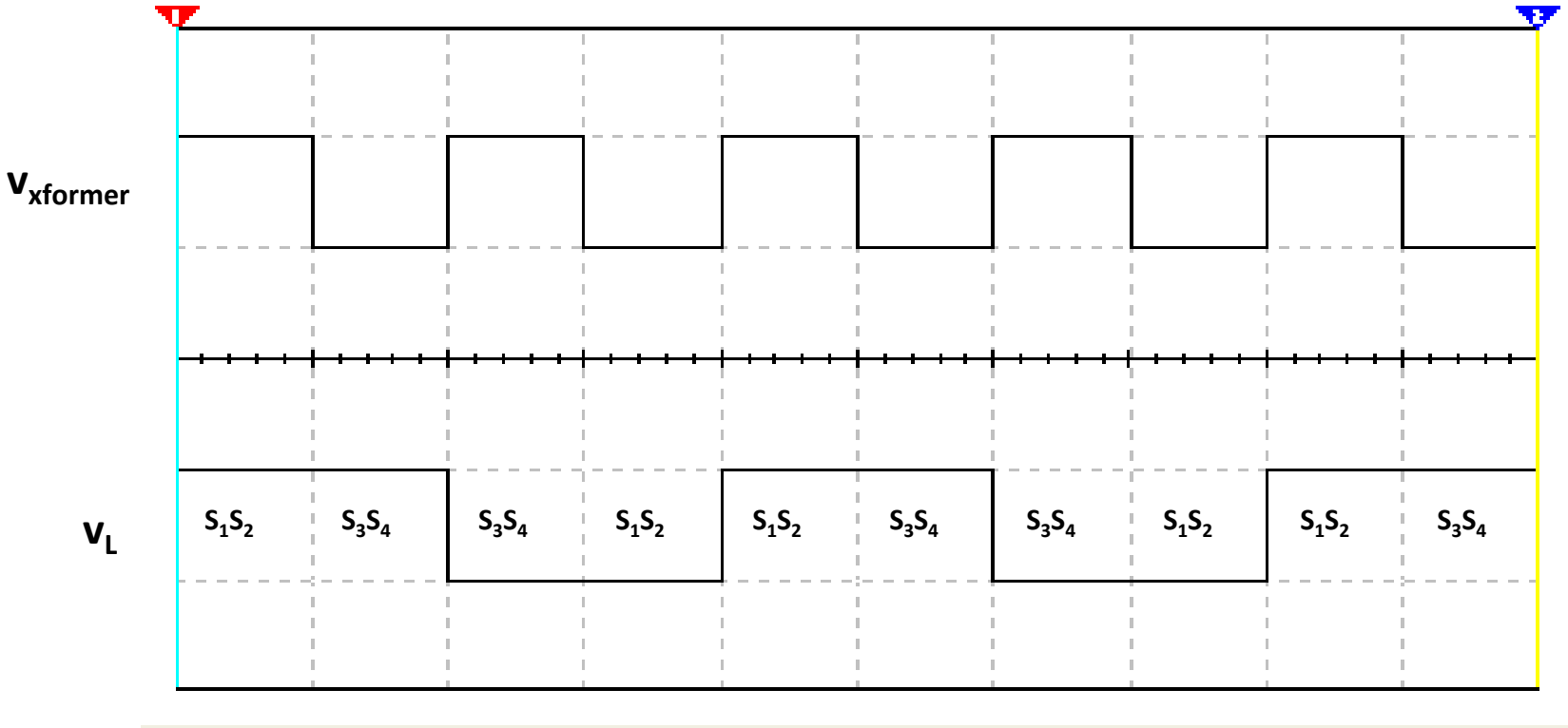
Transformer Polarity as shown, S_3 and S_4 ON



Transformer Polarity as shown, S_1 and S_2 ON

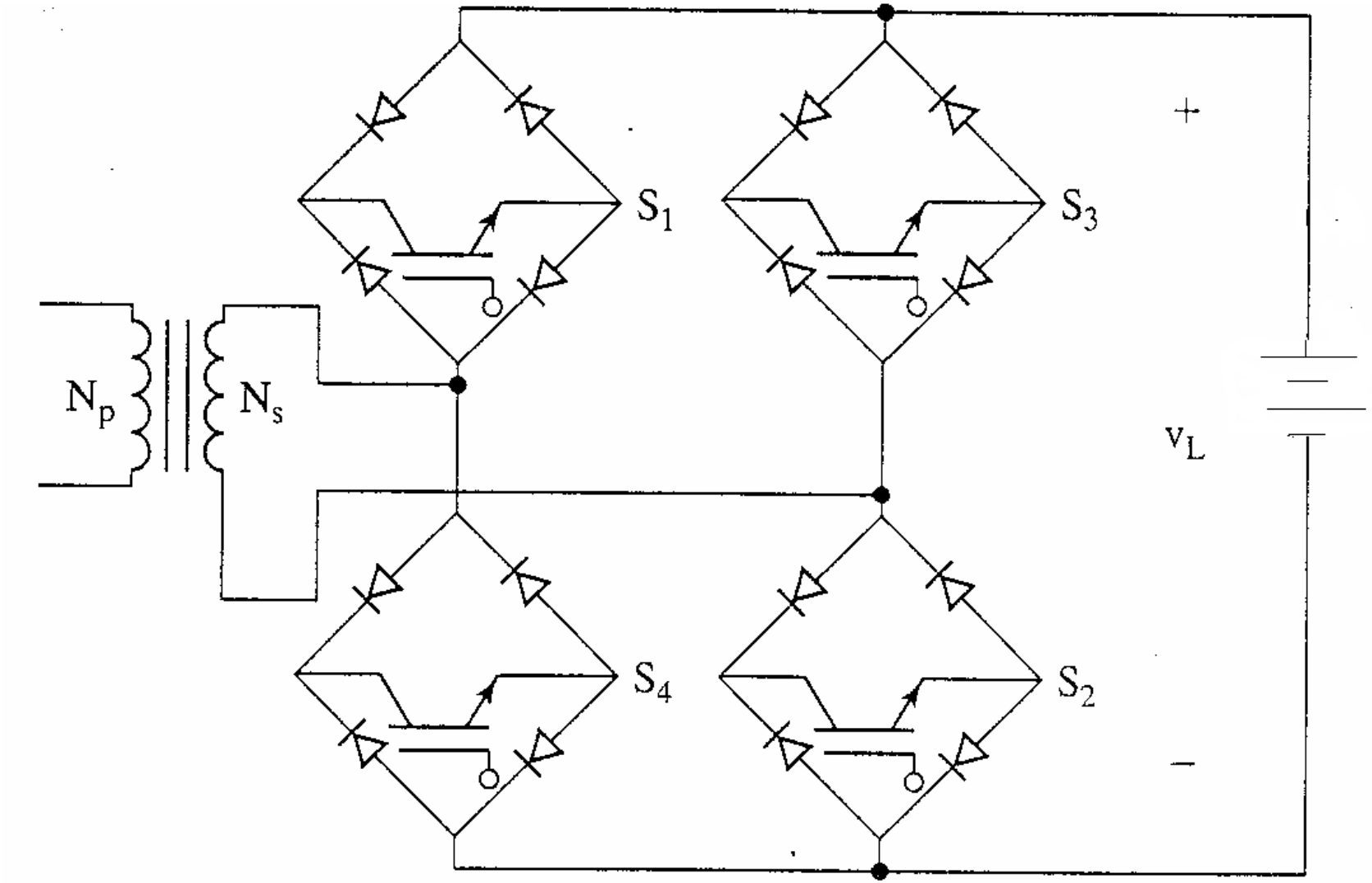


Look At The Voltages

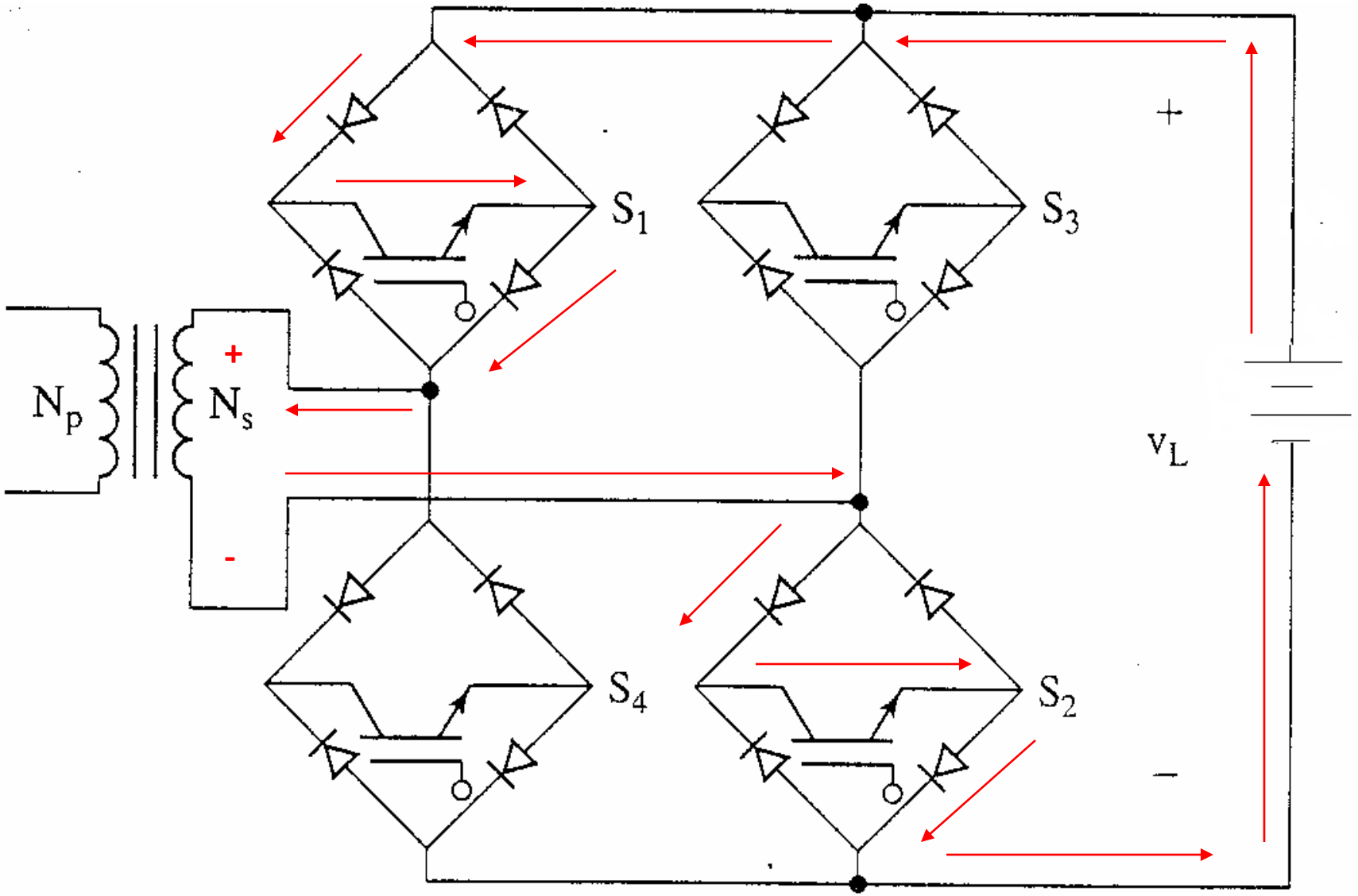


v_L has a lower frequency than $v_{xformer}$

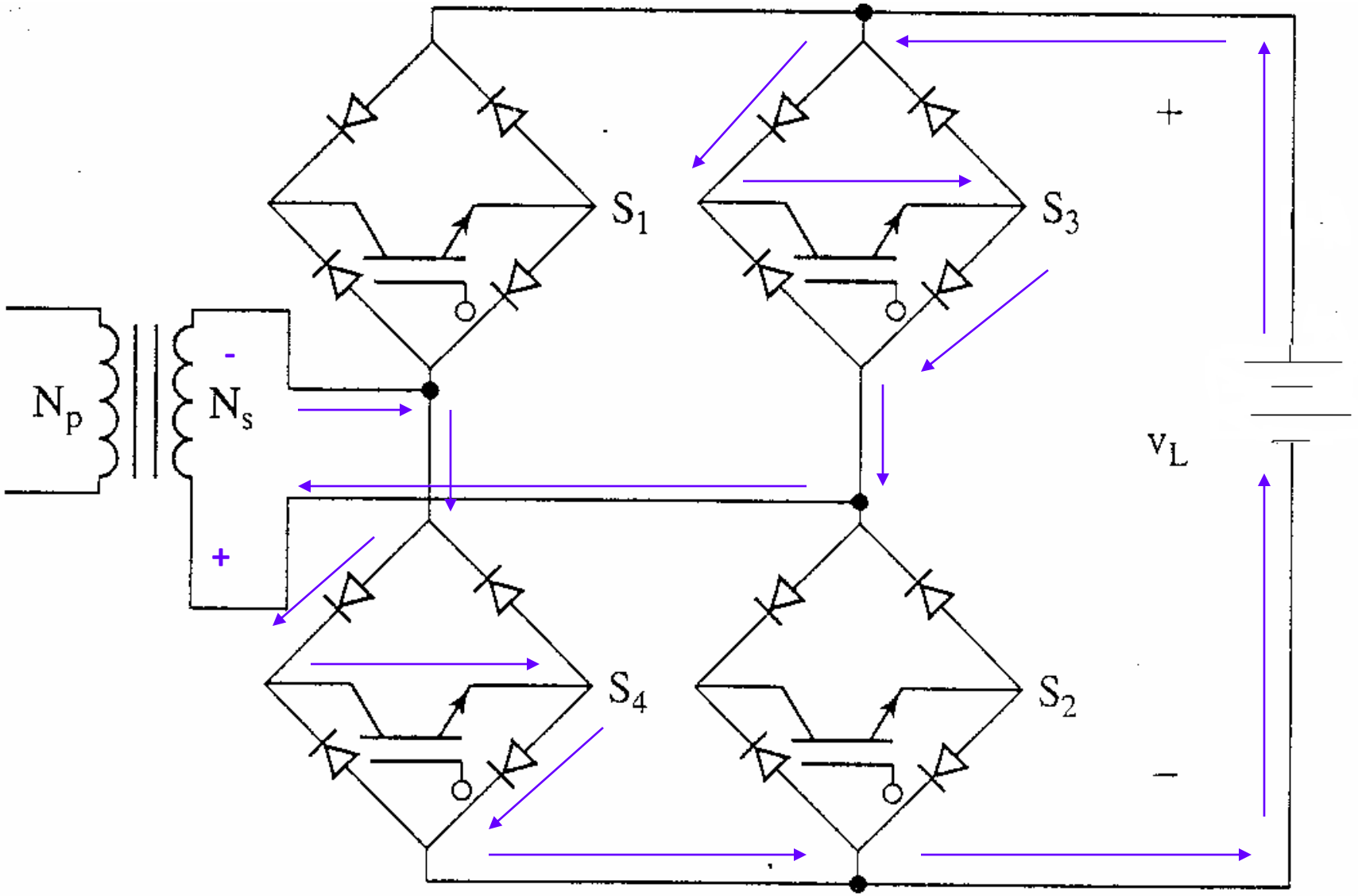
Replace The Load With A Battery



Turn S_1 and S_2 ON



Turn $S_3$and S_4 ON



LECTURE 29

DC DRIVES

- DC DRIVES: Electric drives that use DC motors as the prime movers
- DC motor: industry workhorse for decades
- Dominates variable speed applications before PE converters were introduced
- Will AC drive replaces DC drive ?
  - Predicted 30 years ago
  - DC strong presence – easy control – huge numbers
  - AC will eventually replace DC – at a slow rate

DC Motors

- Advantage: simple torque and speed control without sophisticated electronics

- Limitations:
  - Regular Maintenance
  - Heavy motor
  - Expensive motor
  - Sparking

General Torque Equation

Translational (linear) motion:

$$F = M\frac{dv}{dt}$$

F : Force (Nm)
M : Mass (Kg)
v : velocity (m/s)

Rotational motion:

$$T = J\frac{d\omega}{dt}$$

T : Torque (Nm)
J : Moment of Inertia (Kgm^2)
ω : angular velocity (rad/s)

Torque Equation: Motor drives

$$T_e = T_L + J\frac{d\omega}{dt} \quad or \quad T_e - T_L = J\frac{d\omega}{dt}$$

Te : motor torque (Nm) T_L : Load torque (Nm)

$T_e - T_L > 0$ Acceleration

$T_e - T_L < 0$ Deceleration

$T_e - T_L = 0$ Constant speed

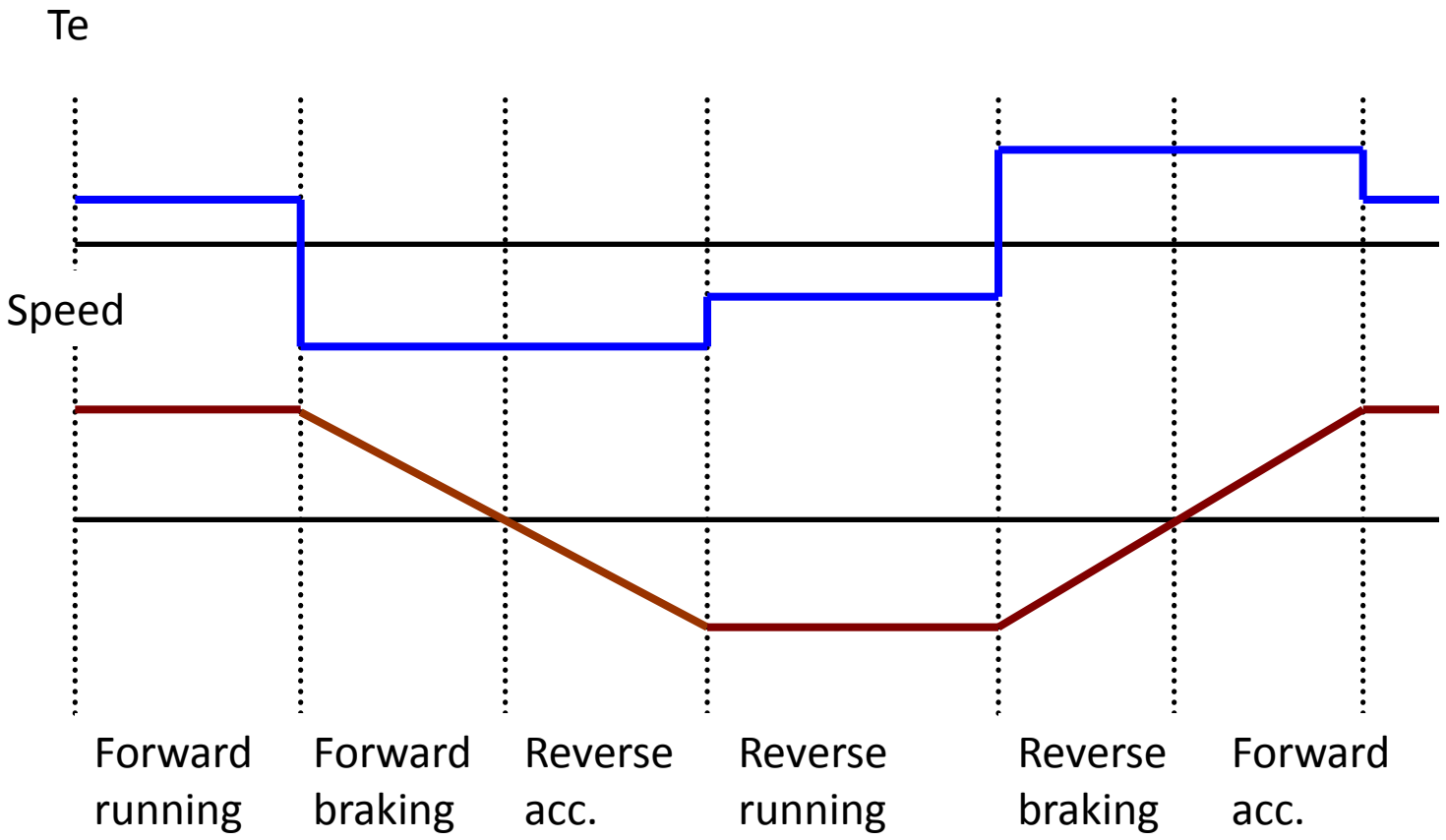
…continue

Drive accelerates or decelerates depending on whether Te is greater or less than T_L

During acceleration, motor must supply not only the load torque but also dynamic torque, ($Jd\omega/dt$).

During deceleration, the dynamic torque, ($Jd\omega/dt$), has a negative sign. Therefore, it assists the motor torque, Te.

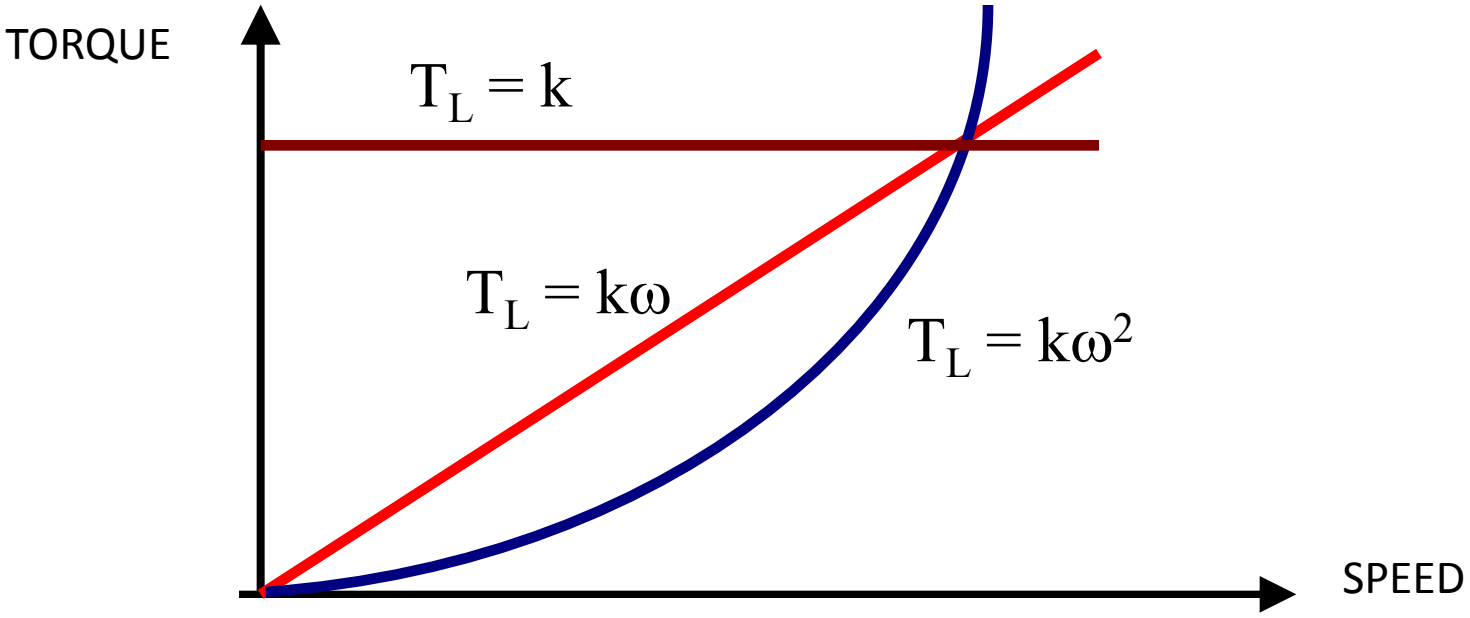
Torque Equation: Graphical



Load Torque

Load torque, T_L, is complex, depending on applications.

In general:



DC MOTOR DRIVES

Principle of operation

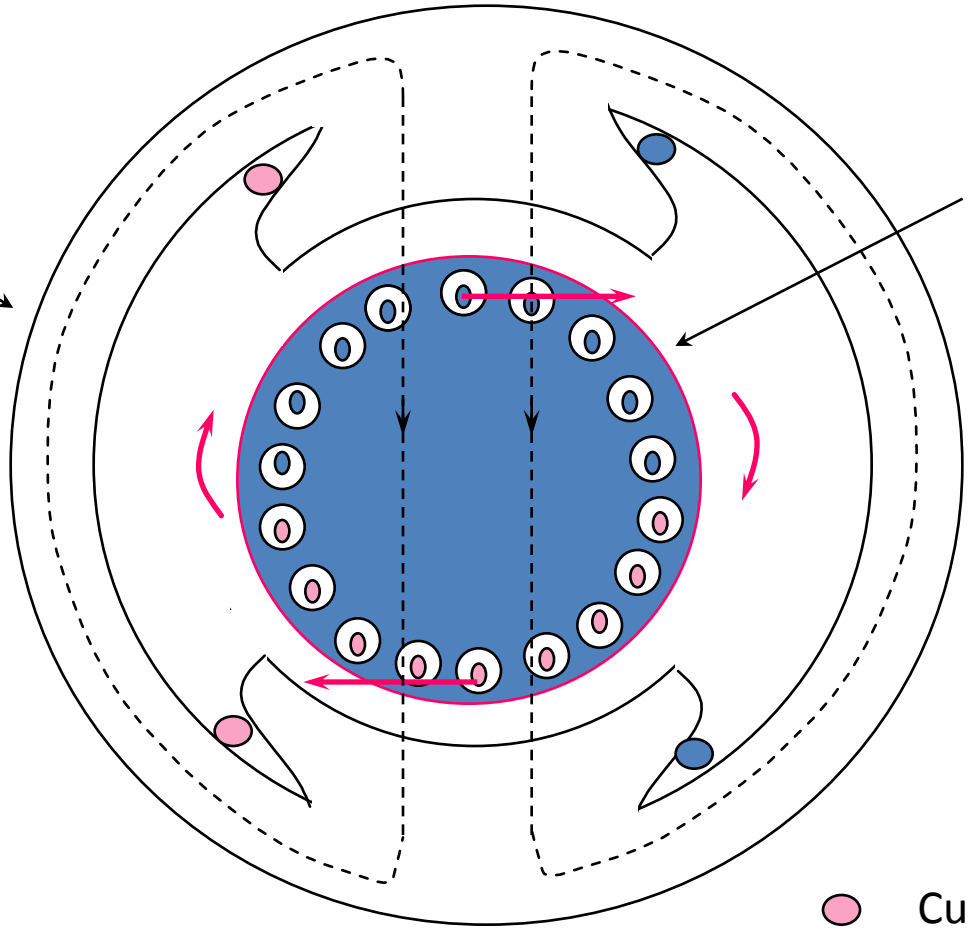
Torque-speed characteristic

Methods of speed control

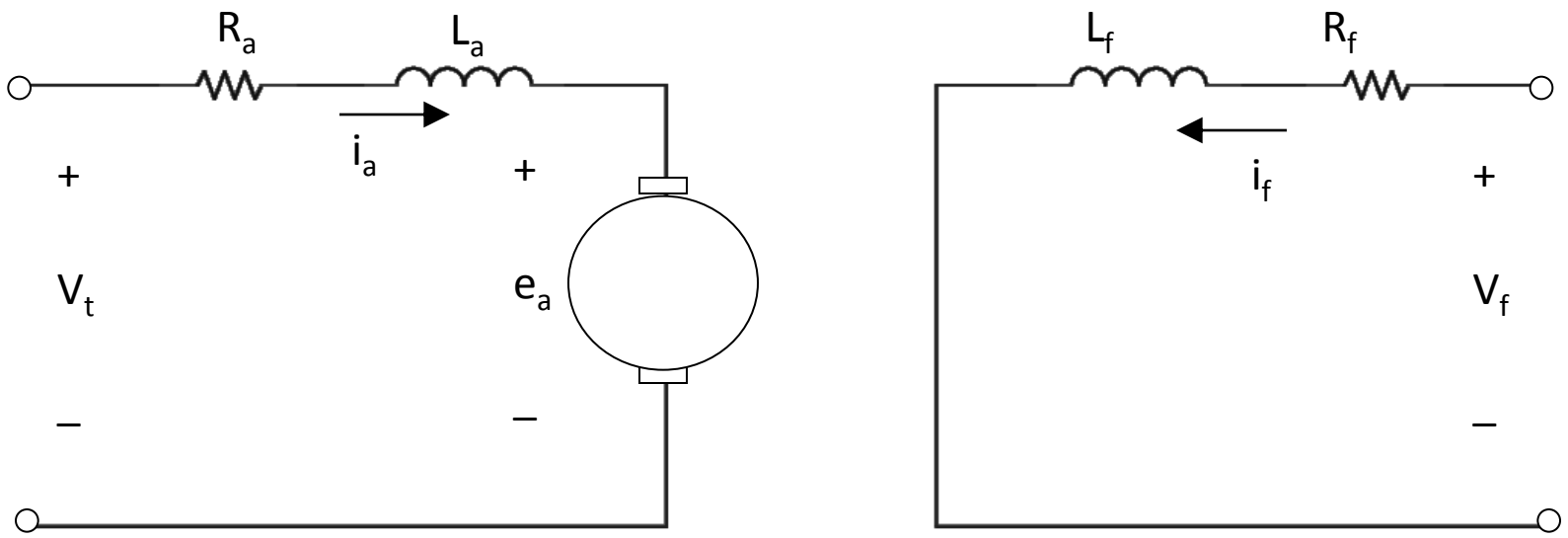
- Armature voltage control
  - Variable voltage source
    - Phase-controlled Rectifier
    - Switch-mode converter (Chopper)
      - 1Q-Converter
      - 2Q-Converter
      - 4Q-Converter

Principle of Operation

DC Motors



Equivalent circuit of DC motor



$$v_t = R_a i_a + L\frac{di_a}{dt} + e_a$$

$$v_f = R_f i_f + L\frac{di_f}{dt}$$

$$Te = k_t \phi i_a$$ Electromagnetic torque

$$e_a = k_E \phi \omega$$ Armature back e.m.f.

NPTEL LINK

- **https://www.youtube.com/watch?v=1Auay7ja2oY&list=PL3A9EE4428285E166**