

2.5 Four Quadrant Operation of a Converters:

First Quadrant–Forward motoring mode

For first quadrant operation, thyristor S4 is kept on, thyristor S3 is kept off and thyristor switch S1 is operated. With S1, S4 ON, armature voltage $V_a = V_s$ and armature current I_a begins flow. Here both V_a and I_a are positive giving first quadrant operation, when S1 is turned off, positive current freewheels through S4, D2. In this manner, V_a , I_a can be controlled in this first quadrant, and operation gives forward motoring mode.

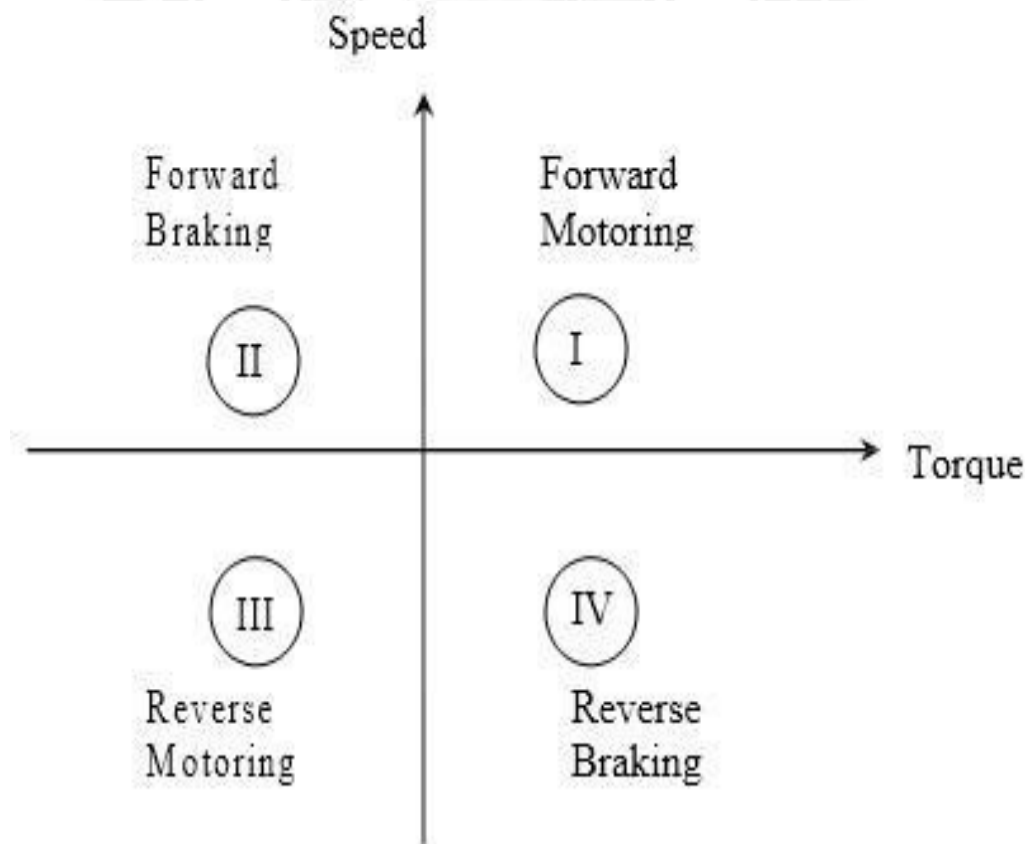


Figure 2.5.1 Four quadrant operation of drives

(Source: "Fundamentals of Electrical Drives" by G.K.Dubey, page-12)

Second Quadrant–Forward braking mode

Here thyristor S_2 is operated and S_1 , S_3 and S_4 are kept off. With S_2 on, reverse or negative current flows through L_a , S_2 , D_4 and E_b . During the operation time of S_2 , the armature inductance ' L_a ' stores energy during the time S_2 is on. When S_2 is turned off, current is fed back to source through diodes D_1 , D_4 . Note that here $(E + L(di/dt))$ is more than the source voltage V_s . As the V_s is positive and I_a is negative, it is a second quadrant operation gives forward braking mode. In that power is fed back from armature to source.

Third Quadrant–Reverse motoring mode

For third quadrant operation, thyristor S_1 is kept off, S_2 is kept on and S_3 is operated, polarity of armature back emf E_b must be reversed for this quadrant operation. With thyristor S_3 is on, armature gets connected to source V . so that both V_a , I_a are negative, leading to third quadrant operation. When S_3 is turned off, negative current free wheels through S_2 , D_4 . In this manner only V_a and I_a can be controlled in the third quadrant.

Fourth Quadrant–Reverse Braking mode

Here thyristor S_4 is operated and other devices kept off, back emf E_b must have its polarity reversed as in third quadrant operation. With S_4 on, positive current flows through S_4 , D_2 , L_a and E_b (armature). Armature inductance L_a stores energy during the time S_4 is on. When S_4 is turned off, current is fed back to source through diodes D_2 , D_3 . Here armature voltage V_a is negative, but I_a is positive, leading to the chopper drive operation in the fourth quadrant. Also power is fed back from armature to source.