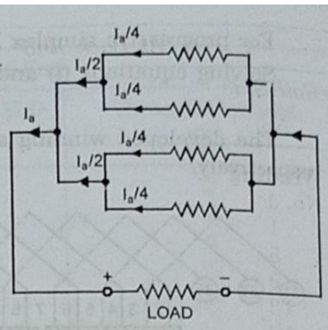
Characteristics of Simplex Lap Winding:

4. There are as many parallel paths in the armature as the number of poles.
5. The emf between + ve and – ve brushes is equal to the emf generated in any of the parallel paths. If Z is the total number of armature coil sides and P is the number of poles, then armature coil sides connected in series in each path = $\frac{Z}{P}$.



Current Distribution in Parallel paths
Fig. 4.26

Total generated emf, E = E M F generated per path

$$= \text{Average emf per coil side} \times \frac{Z}{P} = e_{av} \times \frac{Z}{P}$$

6. Round the complete armature winding, the resultant emf is zero, so that there will be no circulating current round the closed winding.
7. If I_a is the total armature current, then current per parallel path (or carried by each coil side) is given by

$$I_c = \frac{I_a}{P}$$

8. If l is the length of each armature conductor, a is its area of x-section and ρ is the resistivity of the material of conductor, then resistance of each conductor (or coil side) $= \rho\frac{l}{a}$

Number of conductors connected in series = $\frac{Z}{A}$ in each parallel path

$$\text{Resistance of each parallel path} = \rho\frac{l}{a}\cdot\frac{Z}{A}$$

Since the number of paths in parallel is A,

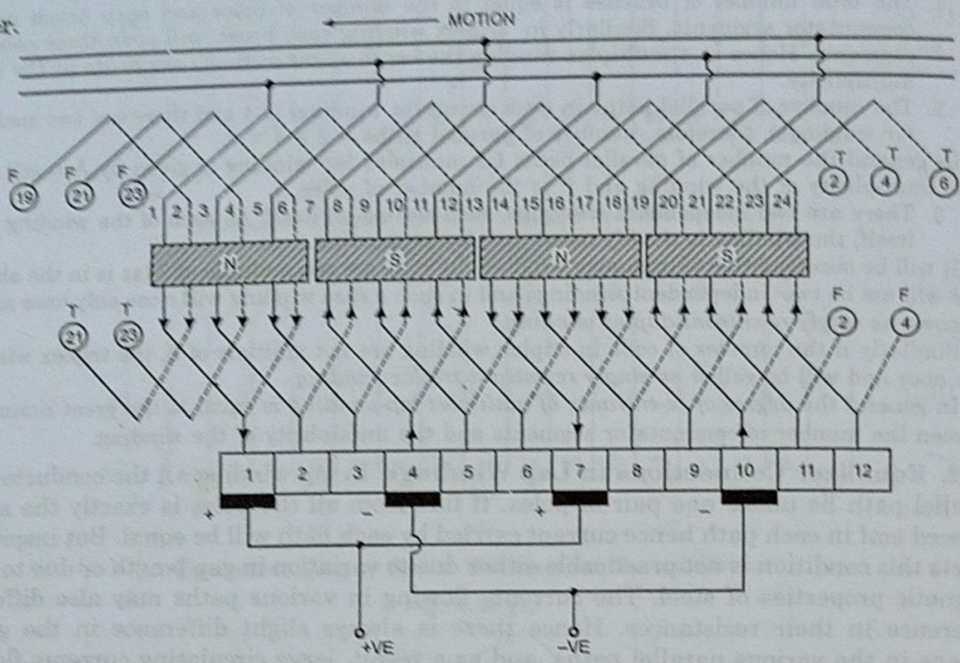
$$\text{Equivalent armature resistance, } R_a = \frac{\rho\frac{l}{a}\cdot\frac{Z}{A}}{A} = \rho\frac{l}{a}\cdot\frac{Z}{A^2}$$

between the number of commutator segments and the multiplicity of the winding.

4.7.2. Equalizer Connections in Lap Windings. In lap winding all the conductors in any parallel path lie under one pair of poles. If flux from all the poles is exactly the same, the induced emf in each path hence current carried by each path will be equal. But inspite of best efforts this condition is not practicable either due to variation in gap length or due to different magnetic properties of steel. The currents flowing in various paths may also differ due to difference in their resistances. Hence there is always slight difference in the generated voltage in the various parallel paths, and as a result, large circulating currents flow in the armature winding. These circulating currents not only tend to heat the armature above the temperature caused by the normal load current, but also cause an undue amount of sparking at the brushes since such currents must circulate from one path to another through the contacts between brushes and commutator. Sparking should, of course, be avoided, because it causes undue burning and wear of the commutator and brushes and, if carried too far, may result in *flash over* from + ve to – ve brushes, a condition representing a short-circuit across the supply lines.

To overcome the detrimental effects resulting from the circulating currents, it is customary to employ equalizer connections in all lap wound armatures. These are low resistance copper wires that connect together points in the armature winding which should, under ideal conditions, be at exactly the same potential at all time but which, because of mechanical and electrical differences, are not. Thus, the equalizer rings relieve the brushes to the circulating current load by causing the latter to be by-passed.

To make these equalizer connections, the number of coils should be multiples of the number of poles and the number of coils per pole should be divisible by a small number 2 or 3. As an example assume a 4-pole generator having 24 coil sides. The number of coil sides per pole will be 6. The winding with equalizer connections is shown in fig. 4.29. Note that every 3rd coil is connected to an equalizer. The coils that are connected to the same equalizer occupy the same position relative to the poles. This is necessary as such coils, at any instant, should be generating the same emf. Note in fig. 4.29 that (*i*) one equalizer ring is connected to coil side two pole pitch apart, (*ii*) number of connections to one equalizing ring is equal to the pair of poles and (*iii*) number of rings is equal to the number of coils under one pair of poles *i.e.* equal to $\dfrac{\text{Number of coils}}{\text{Number of pairs of poles}}$ in case every coil is connected to an equalizer.



Simplex Lap Winding With Equalizer Connections
Fig. 4.29

Theoretically, every coil should be connected to an equalizer but as this would require an undue number of equalizers, it is sufficient, practically, to connect every third or fourth coil. This is the reason why the number of coils per pole should be divisible by a small number as 2,3 or 4. In fig. 4.29 alternate coil has been connected to the equalizer ring and in such a case the winding is said to be 50% equalized. If all the coils were connected to the equalizer rings then the winding would have been 100% equalized.