Chapter 9
Commutation

ABSTRACT

This chapter highlights about commutation and causes of mal commutation. Then the authors discuss how commutation can be improved. They then continue their discussion in this chapter on commutation by providing details about brushless commutation and types of brushless commutation.

9.1 INTRODUCTION

The goal of this chapter is to discuss commutation, causes of mal commutation, brushless commutation and its types. It is a well-known fact that the current in the armatures of D.C. machines is alternating while in the circuits connected externally to the armature through the bushes is D.C. for normal steady state conditions. The direction of current in each armature coil is reversed in which the coil terminates pass under the brush. The interval during which this occurs is called commutation period. Commutation is said to be linear if current reverses at uniform rate, as shown in Figure 1 (a) which is an ideal condition. Four stages of linear commutation are shown in Figure 1 (b) in which several armature coils are shown in simplified form along which their respective commutator segments and one brush. The current per brush is I amperes, and as the associated leading commutator segment approaches the brush, the current in the coils in I/2 amperes.

When the trailing commutator segments leaves the brush, the current in the coil is – I/2. Commutation is a complicated process and the linear time variation of the current in the short in the short circuited coil is not realized in practice.

Unless a voltage is introduced in the short circuiting coil either by shifting the brushes in the required direction or by the use of interpoles, to overcome the emf of self-induction produced by the reversal of the leakage fluxes in the short circuited coils, the current reversal is delayed and under commutation takes place. As a result, the current must change at an excessive rate towards the end of the commutating period. The delayed current reversal also produces excessive current density at the trailing brush tip and may cause the brush to overheat.

In addition, if the reversal of the current of current is not complete when commutator bar leaves the brush, sparking will result at the trailing brush tip.

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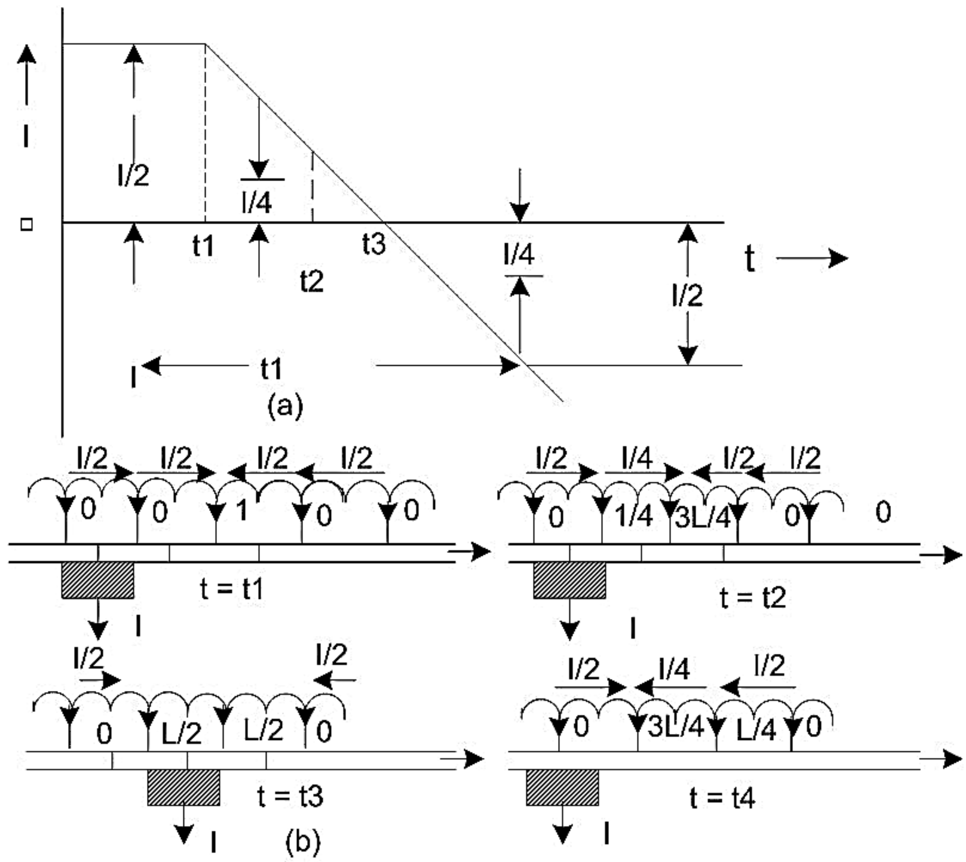
Figure 1.



Excessive sparking burns the brushes and commutator surface. If the brushes are shifted too far in the proper direction as if the commutating field is too strong, an excessive voltage is introduced in the coil undergoing commutation, causing the current to reverse prematurely, and over-commutation results. The reversed current may be excessive and in this case the current density may also be excessive at the leading brush tip or at both brush tips. Figure 2 shows the characterstics of short-circuit current for linear commutation as well as for under commutation and over-commutation, applying to motors as well as generators.

Brushes are usually of carbon, graphite, and organic materials. In case of low voltage machines such as auto mobiles starting motors, the resistance between brushes and commutator must be quite low, and graphite brushes with carbon impregnation are used.

An interface film of copper oxide with a thin deposition of graphite exists between the brush and commutator surface. This film has an important effect on the life of brushes; wear of commutator, and on commutation itself. The graphite acts as lubricant, although other ingredients in the brush maintain a polish on the surface of the commutator. The resistance of film is high enough to limit the short circuit current, thus making for what is known as resistance commutation.

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