

4

D.C. MOTOR DRIVES

INTRODUCTION

The thyristor d.c. drive remains an important speed-controlled industrial drive, especially where the higher maintenance cost associated with the d.c. motor brushes (c.f. induction motor) is tolerable. The controlled (thyristor) rectifier provides a low-impedance adjustable 'd.c.' voltage for the motor armature, thereby providing speed control.

Until the 1960s, the only really satisfactory way of obtaining the variable-voltage d.c. supply needed for speed control of an industrial d.c. motor was to generate it with a d.c. generator. The generator was driven at fixed speed by an induction motor, and the field of the generator was varied in order to vary the generated voltage. The motor/generator (MG) set could be sited remote from the d.c. motor, and multi-drive sites (e.g. steelworks) would have large rooms full of MG sets, one for each variable-speed motor on the plant. Three machines (all of the same power rating) were required for each of these 'Ward Leonard' drives, which was good business for the motor manufacturer. For a brief period in the 1950s they were superseded by grid-controlled mercury arc rectifiers, but these were soon replaced by thyristor converters which offered cheaper first cost, higher efficiency (typically over 95%), smaller size, reduced maintenance, and faster response to changes in set speed. The disadvantages of rectified supplies are that the waveforms are not pure d.c., that the overload capacity of the converter is very limited, and that a single converter is not capable of regeneration.

Though no longer pre-eminent, study of the d.c. drive is valuable for several reasons:

- The structure and operation of the d.c. drive are reflected in almost all other drives, and lessons learned from the study of the d.c. drive

- The d.c. drive tends to remain the yardstick by which other drives are judged.
- Under constant-flux conditions the behaviour is governed by a relatively simple set of linear equations, so predicting both steady-state and transient behaviour is not difficult. When we turn to the successors of the d.c. drive, notably the induction motor drive, we will find that things are much more complex, and that in order to overcome the poor transient behaviour, the strategies adopted are based on emulating the d.c. drive.

The first and major part of this chapter is devoted to thyristor-fed drives, after which we will look briefly at chopper-fed drives that are used mainly in medium and small sizes, and finally turn attention to small servo-type drives.

THYRISTOR D.C. DRIVES – GENERAL

For motors up to a few kilowatts the armature converter can be supplied from either single-phase or three-phase mains, but for larger motors three-phase is always used. A separate thyristor or diode rectifier is used to supply the field of the motor: the power is much less than the armature power, so the supply is often single-phase, as shown in Figure 4.1.

The arrangement shown in Figure 4.1 is typical of the majority of d.c. drives and provides for closed-loop speed control. The function of the two control loops will be explored later, but readers who are not familiar

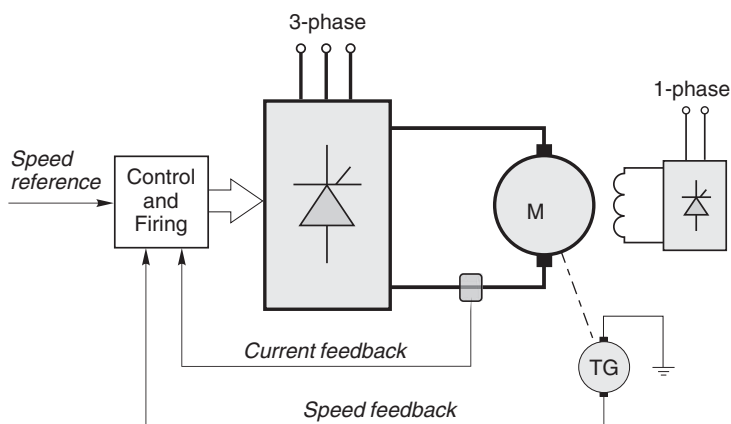


Figure 4.1 Schematic diagram of speed-controlled d.c. motor drive

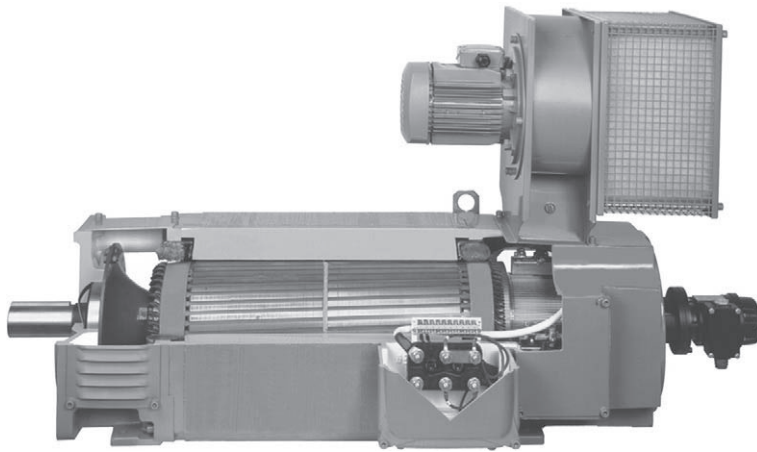


Plate 4.1 *High performance force-ventilated d.c. motor. The motor is of all-laminated construction and designed for use with a thyristor converter. The small blower motor is an induction machine that runs continuously, thereby allowing the main motor to maintain full torque at low speed without overheating. (Photo courtesy of Control Techniques)*

with the basics of feedback and closed-loop systems may find it helpful to read through the Appendix at this point.

The main power circuit consists of a six-thyristor bridge circuit (as discussed in Chapter 2), which rectifies the incoming a.c. supply to produce a d.c. supply to the motor armature. The assembly of thyristors, mounted on a heatsink, is usually referred to as the 'stack'. By altering the firing angle of the thyristors the mean value of the rectified voltage can be varied, thereby allowing the motor speed to be controlled.

We saw in Chapter 2 that the controlled rectifier produces a crude form of d.c. with a pronounced ripple in the output voltage. This ripple component gives rise to pulsating currents and fluxes in the motor, and in order to avoid excessive eddy-current losses and commutation problems, the poles and frame should be of laminated construction. It is accepted practice for motors supplied for use with thyristor drives to have laminated construction, but older motors often have solid poles and/or frames, and these will not always work satisfactorily with a rectifier supply. It is also the norm for drive motors to be supplied with an attached 'blower' motor as standard. This provides continuous through ventilation and allows the motor to operate continuously at full torque even down to the lowest speeds without overheating.

Low power control circuits are used to monitor the principal variables of interest (usually motor current and speed), and to generate appropriate firing pulses so that the motor maintains constant speed despite

Chapter extract

**To buy the full chapter, and for copyright
information, click here**

<http://www.download-it.org/learning-resources.php?promoCode=&partnerID=&content=story&storyID=1363>



The publisher detailed in the title page holds the copyright for this document

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recorded or otherwise, without the written permission of Spensford IT Ltd who are licensed to reproduce this document by the publisher

All requests should be sent in the first instance to

rights@download-it.org

Please ensure you have book-marked our website.

www.download-it.org