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SELF-COMMUTATED THYRISTOR INVERTERS

11.1. INVERTER CLASSIFICATION

The classification philosophy used in this text divides all inverters into two classes—self-commutated inverters and externally commutated inverters. A self-commutated inverter is one in which the means of commutation is included within the inverter itself. This is the case for circuits including electronic power switches with turn-off capability. Thus, a bipolar transistor, GTO thyristor, or power FET inverter is self-commutated. In addition, SCR inverters which include capacitors, inductors and possibly auxiliary thyristors to provide commutation are also examples of self-commutated inverters.

Externally commutated inverters are those in which the commutation means is external to the inverter circuit. The phase-controlled rectifier operating as a line-commutated inverter is the best known externally commutated circuit. Circuits in which the nature of the load provides the means of commutation are also examples, i.e., an SCR inverter supplying a synchronous motor where commutation is accomplished by the motor CEMF, or an inverter in which a particular load filter or a resonant circuit is used to cause commutation. Another example of an externally commutated inverter is one in which the dc bus is interrupted to produce commutation. Although such an approach may be considered self-commutated if the electronic switch hardware for causing the bus interruption is in the same package as the inverter switches, this scheme is functionally an externally commutated approach.

Self-commutated circuits are further subdivided into voltage-source inverters and current-source inverters. As the names imply, the VSI is fed from a voltage source, and the CSI is fed from a current source. The input for the simplest VSI is a battery. However, the dc source voltage also may be adjusted to control the inverter output voltage. In any case, the VSI is such that the dc input voltage remains relatively constant in spite of large transient or steady-state variations in the input current. For the CSI, the input current remains relatively constant over a wide range of dc input voltage variations. The most common input for the CSI is a phase-controlled rectifier supplying the inverter in series with a relatively large inductor. This forces a given input current to flow at least throughout a cycle of operation, in spite of the switching which occurs within the inverter circuit.

In this chapter, one VSI and one CSI are discussed in some detail to illustrate the behavior of these inverters.
11.2. McMURRAY INVERTER

When the SCR first became available, there was considerable effort to develop inverter circuit techniques which would utilize the unique features of this electronic power switch. The most successful and widely used SCR inverter is the circuit devised by McMurray [1], [2]. One of the simplest circuit configurations is shown in Fig. 11-1. This arrangement is also the basic building block for the single-phase and three-phase bridge versions of the McMurray inverter.

11.2.1. Half-Bridge—No Load

The operation of the circuit in Fig. 11-1 is as follows. Assuming the correct initial capacitor voltage, a main SCR is commutated by gating the appropriate auxiliary. When SCR1A or SCR2A is triggered, this causes a resonant pulse of current to flow in opposition to that being carried by the conducting main SCR. When the main SCR current has been reduced to zero, the commutating-current pulse will continue to flow in the appropriate feedback or bypass diode, thus providing a small reverse voltage across the main SCR for the time interval necessary for it to regain its blocking capability.

One of the most advantageous features of this inverter is that after a given main SCR is commutated, the capacitor voltage is left at a value required to commutate the next main SCR. This feature combined with the pulse nature of the commutating action provides a highly efficient inverter for operation at normal power frequencies. In fact, an efficiency of over 90 percent can be obtained, with SCR turn-off times in the 20-μs range, for circuit operating frequencies up to several kilohertz.

Another very advantageous feature of this inverter approach is that with the proper SCR triggering sequence, sufficient commutating capacitor voltage is assured for a wide range of load conditions.