

# A Three-Phase Inverter with Reactive Power Control

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**Abstract**—A new type of self-commutated inverter for fixed or moderately variable frequency has been developed. The inverter is characterized by an extremely uncomplicated main circuit. In its basic form the inverter contains two converter circuits: a principal converter circuit and an auxiliary converter circuit. The principal converter circuit transfers power from the input dc side to the output ac side, and the auxiliary converter circuit generates an inductive current to balance the reactive current of a three-phase capacitor on the ac side. This capacitor has the combined function of a phase compensator, a filter capacitor, and is also the source of the commutating voltage. Both converter circuits are of the line-commutated type, meaning that at power frequencies normal converter thyristors can be employed. This makes it possible to build high-power inverters without series or parallel connected thyristors. All filter reactors are smoothing reactors placed on the dc side of the converter circuits. Thus the inverter has a very good efficiency even at the higher frequencies. The ability of a converter circuit to generate a negative sequence current when unsymmetrically controlled makes the inverter insensitive to unbalanced loads. The transient behavior of the inverter is similar to that obtained from a conventional self-commutated inverter with an output filter.

## I. INTRODUCTION

A CONVENTIONAL self-commutated inverter has a rather complicated main circuit when compared with an externally commutated converter. It may contain a number of auxiliary components intended to assist in the process of commutation which are not found in the externally commutated converters, i.e., commutating capacitors, inductances, regenerating transformers, etc. Furthermore, the thyristors must be of the "inverter" type to comply with the special requirements of the circuit, i.e., the turn-off time must be short, the  $di/dt$  and/or the  $dv/dt$  capabilities high, etc. These auxiliary components and thyristor requirements make self-commutated inverters expensive when compared with the inverter being introduced in this paper.

This paper deals with a new type of inverter which is a further development of the well-known single-phase load commutated inverter which has been primarily used as a power source for induction heating and melting equipments. Only three-phase inverters are described as these, just as three-phase rectifiers, are superior to the single phase ones in many respects, especially in the high-power field.

The inverter described here basically consists of two converter circuits of the line-commutated type with smoothing reactors, a three-phase capacitor, and an output transformer.

The type and nature of the load determines if the output transformer is required.

No auxiliary components of the aforementioned types are included, and for power frequencies, the thyristors used may be of the ordinary "converter" type. This technique offers an economical way of building simple and robust high-power inverters using sections of standard line-commutated converters.

The aforementioned types of converters are shown in Figs. 1-3. Fig. 1 shows a load commutated inverter; Fig. 2 shows an example of a conventional three-phase inverter with a filtered, uncontrolled output voltage; and Fig. 3 shows an inverter of the new type.

## II. LOAD COMMUTATED INVERTER

The new type of three-phase inverter which is described here is a further development of the single-phase load commutated inverter as shown in Fig. 1.

The load  $Z$ , e.g., an induction furnace with its phase compensating capacitor, is represented by a parallel connection of a capacitor  $C$ , an inductance  $L$ , and a resistance  $R$ .  $L$  and  $C$  oscillate at a frequency near resonance, and the alternating voltage is approximately sinusoidal. The active load current (through  $R$ ) is supplied by the converter circuit 3 which works as an inverter. The current from the direct supply voltage 1 is smoothed by a reactor 2. The converter circuit contains four elements in a bridge, and elements belonging to the same diagonal are fired simultaneously. It works as a line commutated inverter, only here the "line" is a resonant circuit, and the commutating voltage is supplied by the capacitor. The alternating voltage can be controlled by varying the firing angle of the inverter. If the load, especially one of its reactive components, varies, the frequency will also vary. For induction heating and melting purposes a considerable frequency variation may be tolerated, but for a general purpose fixed frequency inverter a variation of 1 percent or less might be desirable, and the inverter could be required to operate anywhere from no load to full load at varying power factors.

This could be achieved with an inverter as shown in Fig. 4. The capacitor and the inductance of the load in Fig. 1 are here regarded as a part of the inverter, and the inductance has been made variable. A new load represented by a resistance and a reactor has been added. In this inverter the active power is supplied from the dc source via the principal converter circuit and the reactive power from the capacitor. The balance between the capacitor current and the reactive components of the load current, the principal converter circuit and the inductance is achieved by varying the latter. This can be illustrated by means of the phasor diagram of Fig. 5, which is valid for the fundamental components of voltage and current.

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