THYRISTOR DUAL CONVERTERS

I. Introduction

This leaflet will discuss the basic characteristics of the dual converter-type, thyristor power amplifiers. Familiarity with single converter-type, thyristor power amplifiers is essential to the discussion which follows; and a description of their operation is contained in I.L. 16-800-44.

For brevity, TPA will be used as the abbreviation for thyristor power amplifier throughout the leaflet.

II. General (Converter-Type TPA)

The converter-type TPA can convert a-c to d-c as well as d-c to a-c. That is, the amplifier can operate as a rectifier (net power flow from the line to the load) or as an inverter (net power flow from the load to the line). The second mode of operation is, of course, only possible when the load is generative. As the load current cannot reverse, operation in two quadrants only of the V_O-I_O plot is possible (quadrants I and IV or II and III of Figure 5).

III. Dual Converter

Connecting two converter-type TPAs back to back allows one to build a controlled power source which can supply voltage and current of either polarity and is, therefore, a static analog of a rotating exciter. Such a supply is called a dual converter.

Figure 1 is a block diagram of the dual converter circuit. As can be seen, the two converter-type TPAs are back-to-back connected and supply a common load.

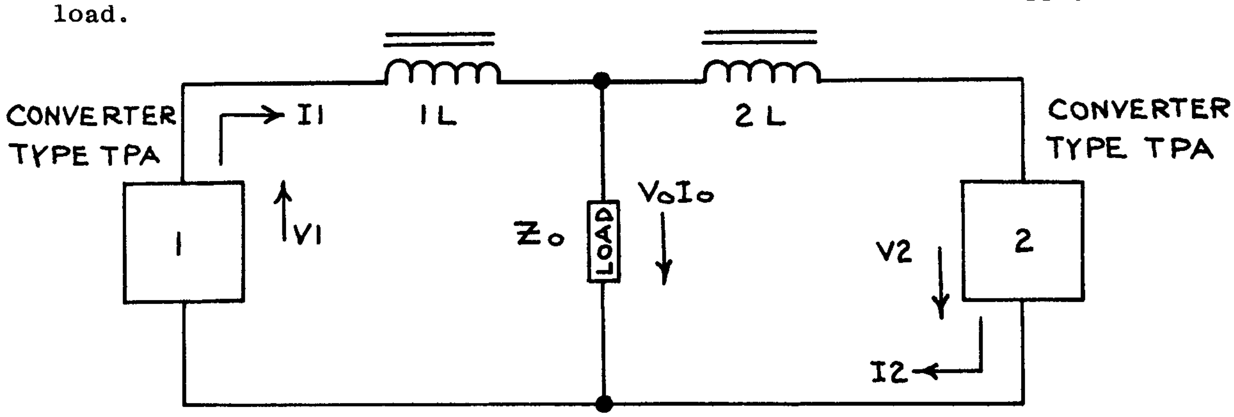

FIGURE 1 - DUAL CONVERTER BLOCK DIAGRAM

Figure 2 is the schematic representation of two, single-phase, thyristor power modulators connected as a dual converter.

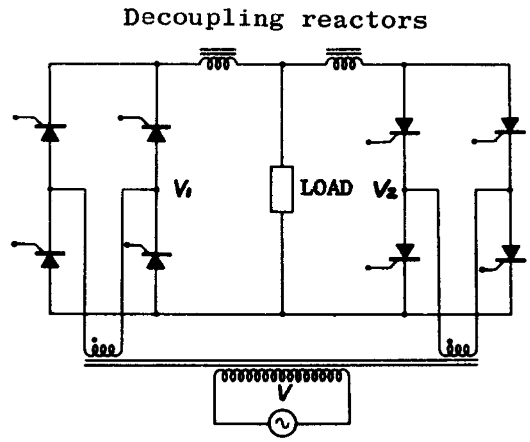

FIGURE 2 - DUAL CONVERTER SCHEMATIC DIAGRAM

Three-phase, converter-type, thyristor power modulators could have been shown in Figure 2. For simplicity, the discussion and wave shapes to follow are for a dual converter employing single-phase amplifiers; however, the fundamental theory of operation applies equally to both.

The two converters are controlled together in such a manner that the firing angle α_1 of converter 1 and the firing angle α_2 of converter 2 always add up to 180° ($\alpha_1 + \alpha_2 = 180°$). If this condition is met, the two average output voltages are equal in magnitude but have opposing signs. The smoothing reactors 1L and 2L are necessary to limit the current due to the instantaneous differences between V_1 and $-V_2$.

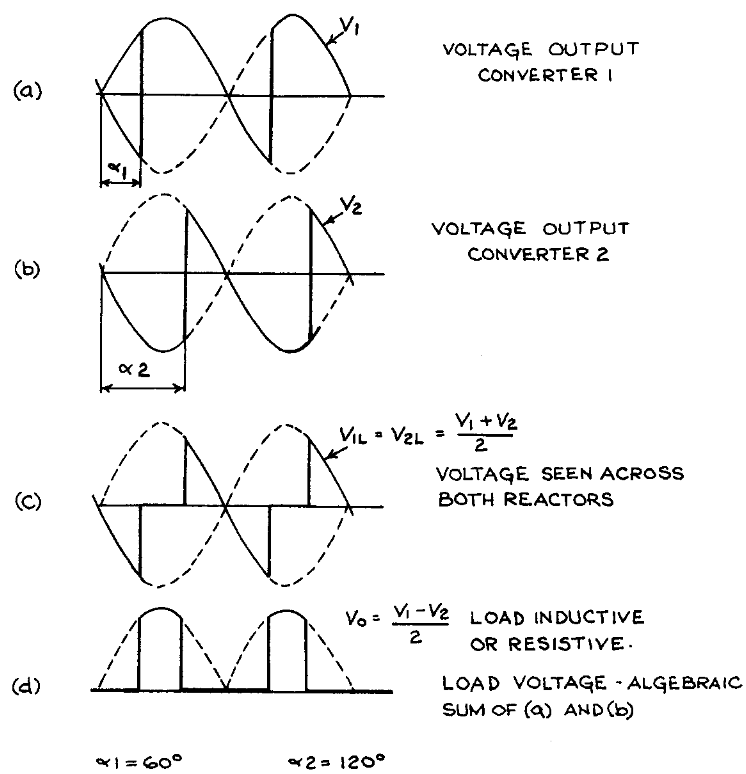

FIGURE 3 - WAVE FORMS OF SINGLE-PHASE DUAL CONVERTERS

Figure 3 shows some of the theoretical wave shapes for $\alpha_1 = 60^o$ and $\alpha_2 = 120^o$. Converter 1 is rectifying and converter 2 inverting. Depending on the load, the rectifier or the inverter has to carry the load current. If the load voltage is less than V_1, converter 1 (rectifying) will supply the power to the load. However, if the load voltage exceeds V_1 (generating), converter 2 (inverting) feeds power back to the line.

So far, it was assumed that the average voltages and the transfer functions of the two converters match perfectly. If this is not the case, a heavy, steady circulating current could flow limited only by the internal impedance of the converters and the resistance of the reactors. This is true if the rectifying converter supplies more voltage than the inverting one can absorb ($\alpha_1 + \alpha_2 < 180^o$). A static transfer curve of a dual converter is shown in Figure 4; i.e., it assumes the rectifying converter always supplying load current.

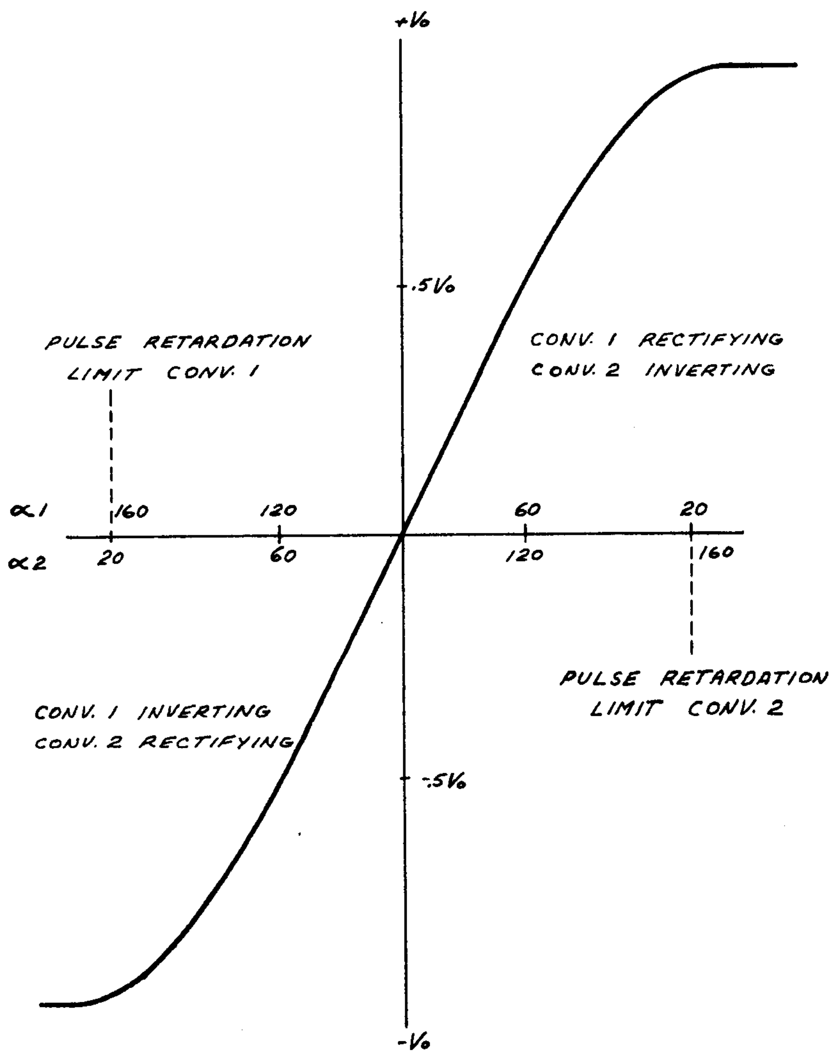

FIGURE 4 - DUAL CONVERTER STATIC TRANSFER CURVE

A family of load regulation curves for the dual converter showing the possible four quadrant V_o-I_o operation is given in Figure 5.

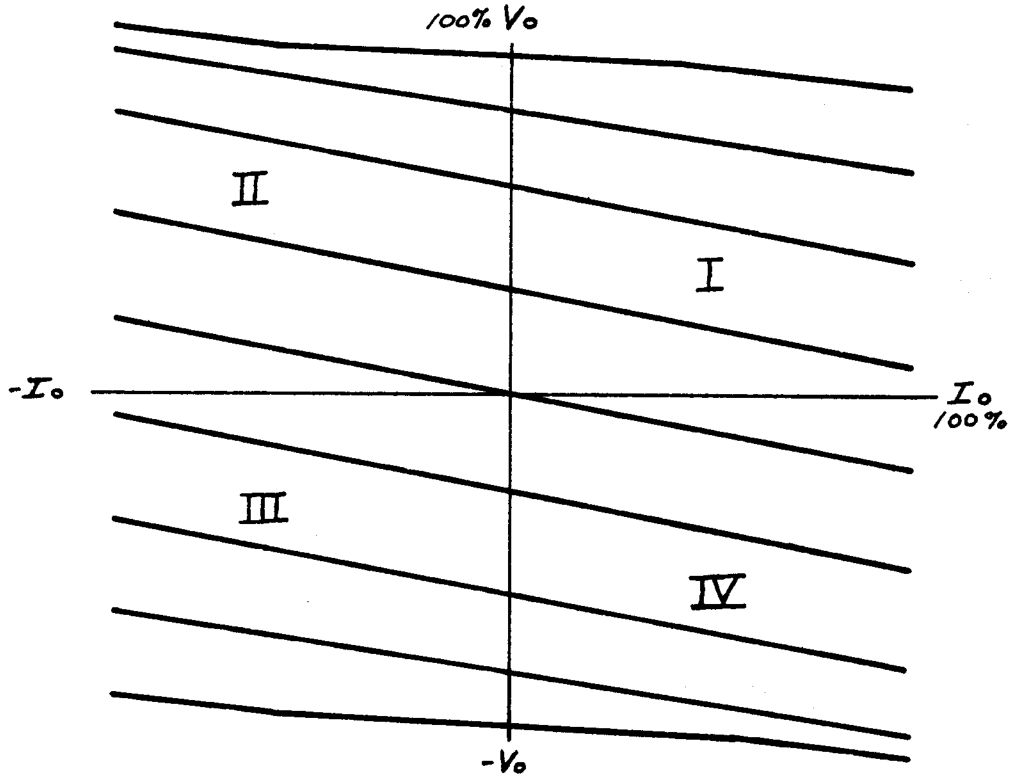

FIGURE 5 - DUAL CONVERTER LOAD REGULATION CURVE

IV. Miscellaneous

A. Alignment

In general, the firing angles α_1 and α_2 are not adjusted to 90° for $I_o = 0$ but rather to a firing angle slightly delayed ($\approx 92°$). This assures a minimum, steady circulating current and is, therefore, desirable as long as the transfer from one converter to the other occurs without deadband (crossover from quadrant 1 to quadrant 3 of Figure 5).

B. Line Transformers

All thyristor power amplifiers are equipped with line transformers to provide the following features:

1. isolation from the power system
2. change of voltage levels
3. commutating reactance.

Whereas 1 or 2 are not required in all cases, 3 is important in all applications. Commutating reactance alone could be supplied by air reactors, but the applications with no need for isolation and voltage transformation are too limited to justify consideration.

Particular information in regard to ratings, alignment procedures, and trouble shooting procedures are contained in separate instruction leaflets and may be found elsewhere in your instruction book.