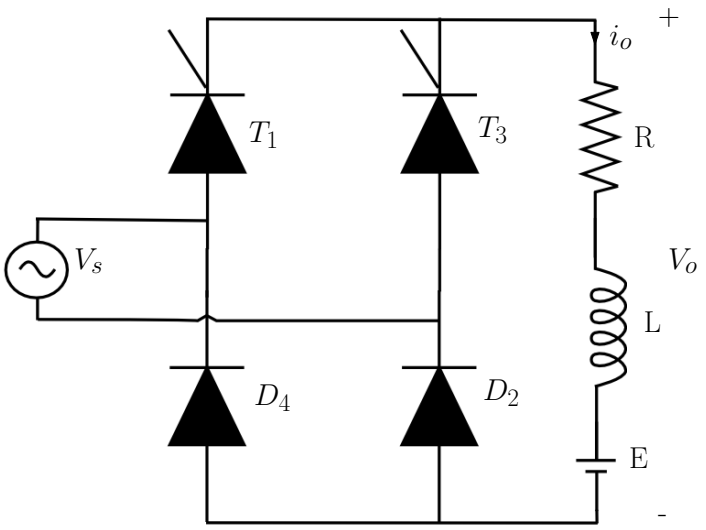
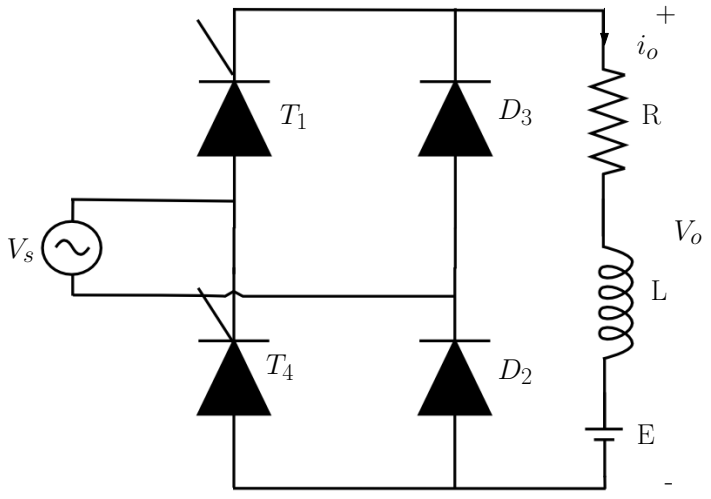
Single phase half controlled bridge converter

Single phase fully controlled bridge converters are two quadrant converters having unidirectional current with both positive and negative voltage polarity. Thus they can be operated either as a controlled rectifier or an inverter. But for some applications that do not utilize the inverter mode operation, a fully controlled converter with four thyristors and their associated control and gate drive circuit makes the system unnecessarily complicated. In such situations, two of the thyristors of a single phase fully controlled converter has to be replaced by diodes as shown in figure 1. The resulting converters are called single phase half controlled converters. Half controlled convertors are single quadrant converters having one polarity of voltage and current at the DC terminals. Input and output behavior of both circuits (fig.1(a) and 1(b)) are identical although the device designs differs. In Fig. 1 (b) the diodes carry current for a considerably longer duration than the thyristors. However, in Fig. 1 (a) both the thyristors and the diodes carry current for half the input cycle. Operation of circuit in fig. 1(b) will be explained here as it is used in our laboratory.



(a)



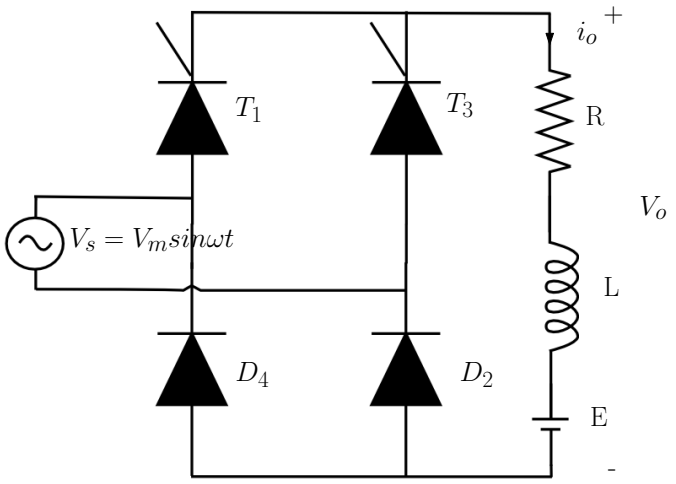
(b)

Figure 1: Half controlled converter

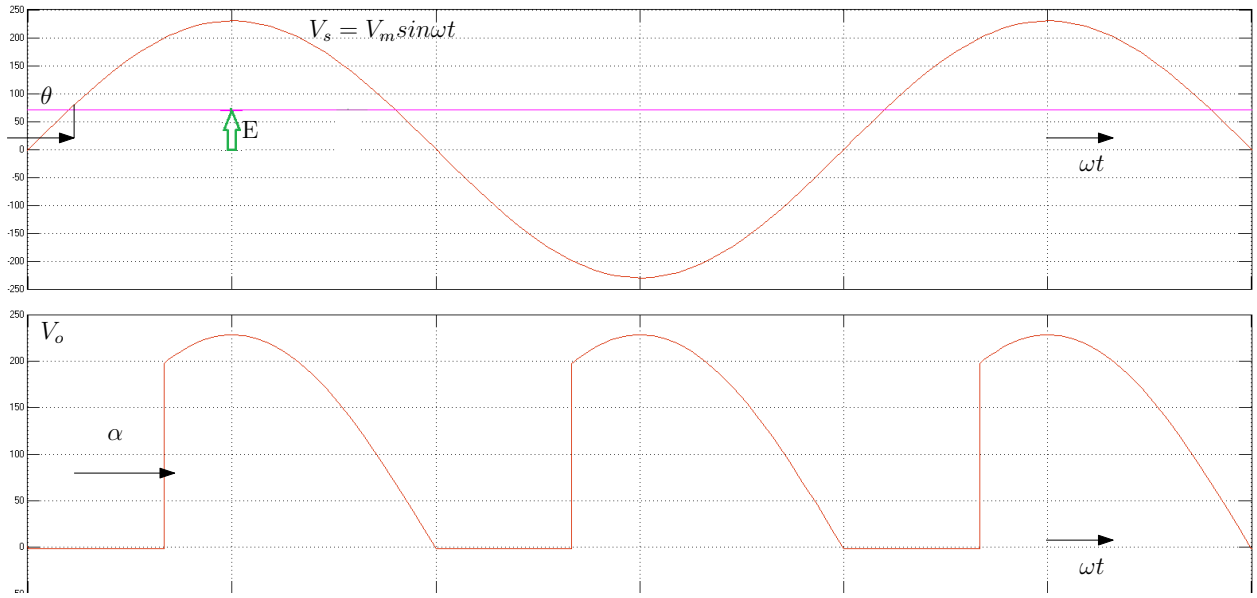
Converter operation

Since diodes can block only negative voltage, it can be concluded that diodes D_2 and D_3 conducts for positive and negative half cycle of the input voltage respectively. For the positive half cycle, when thyristor T_1 is fired at its firing angle α, load current flows through T_1 and D_2. When diode D_3 starts conduction in the negative half cycle, T_1 is reverse biased and is turned off. Then load current is transferred to diodes D_2 and D_3 as observed in the waveforms. Thyristor T_4 will come in once it is fired , which turns off diode D_2. Thus load current is continuous through out and this mode of operation is known as continuous mode of operation. If load current becomes zero for some time, then it is known as discontinuous mode of operation.

The circuit diagram and the waveforms of a single phase half controlled converter supplying an R-L-E load is shown in figure 2. The device currents are shown in figure 3. Since the output voltage is



(a)



(b)

Figure 2: Half controlled converter in continuous mode of operation a) Circuit diagram b) Waveforms

periodic over half the input cycle, $V_{oav} = \frac{1}{\pi}\int_0^{\pi} v_o d\omega t = \frac{V_m}{\pi}(1 + cos\alpha)$. Thus by varying the firing angle α, average output voltage from the converter can be controlled and that is applied in most of the dc drives as a variable voltage dc source for the motor speed control. Both armature voltage control and field control requires a variable voltage dc source. If a fixed dc source is available, by using rheostats , variable voltage can be applied to the armature and field terminals. But this results in poor efficiency due to high copper loss. So nowadays power electronic controllers (half controlled converters) are used in dc drives to obtain efficient, smooth and flexible speed control.

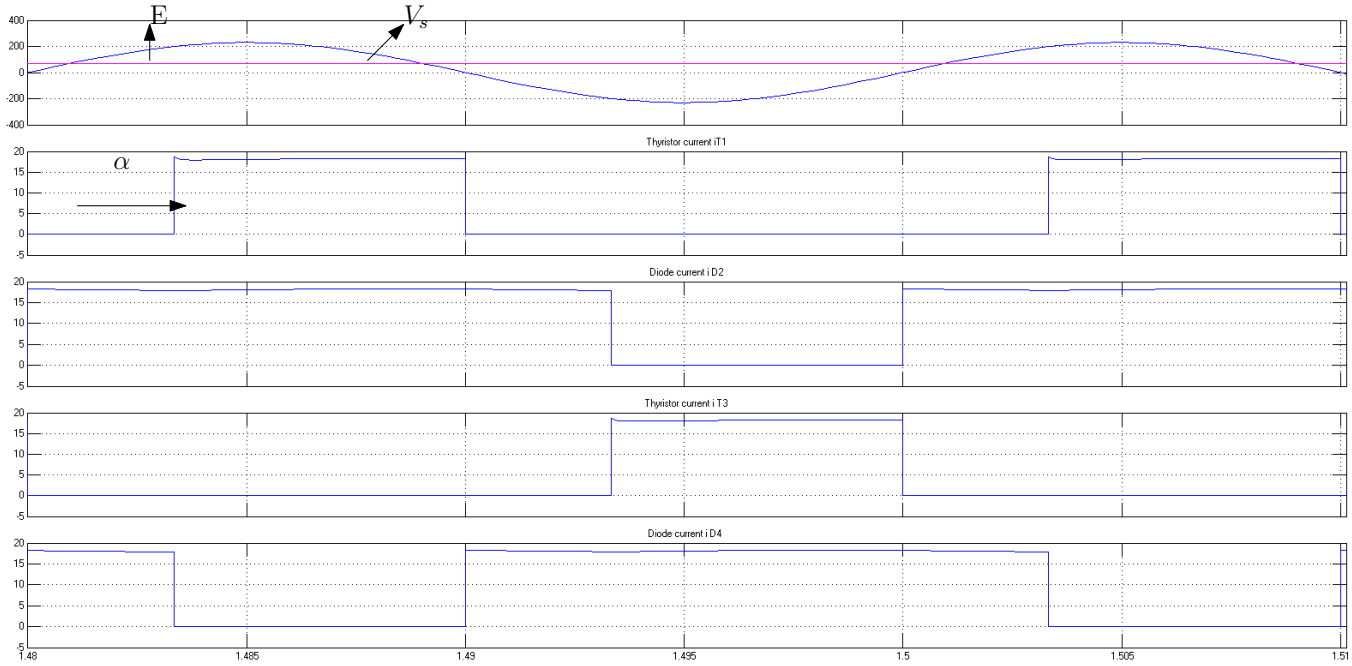


Figure 3: Device currents of a half controlled converter in continuous mode

References

[1] G. K. Dubey. *Fundamentals of Electrical Drives,* Alpha Science International Ltd., 2001.