Sector Identification Method of Space Vector Modulation Using Boundary Line in Dual Inverter Motor Drive

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I. INTRODUCTION

The sector identification in the space vector modulation (SVM) is required by a dual inverter motor drive to control motor terminal voltages and a capacitor voltage regarding the charging and discharging modes. There have been many methods to identify the sector such as comparing the time duration ratio of each voltage vector surrounding the reference voltage vector [1]. This paper focuses on the detection of the reference voltage vector position in the dual inverter motor drive by determining boundary line equations surrounding each sector.

II. PROPOSED METHOD

The open-end winding motor fed by a dual inverter is depicted in Fig. 1. The left side is INV1 and the other side is INV2 where the DC bus is replaced with a capacitor having a half DC-bus voltage of INV1. The sector identification is proposed by using the space voltage vector as shown in Fig. 2. The hexagon is divided into 6 regions with 60-deg phase zone in which each region is also divided into 4 shaped sectors of equilateral triangle. The region from 0 to 60 deg is called region 1 and the sectors located in region 1 are sector 11, 12, 13, and 14. Boundary lines, which are lines a, b, c, d, e, f limiting the sector, are employed to identify the location of the reference voltage vector.

The equation of each boundary line can be calculated by considering the maximum voltage vector amplitude and the reference voltage vector decomposed into αβ axis. The maximum voltage vector amplitude can be obtained as follows:

$$\left|V_0\right| = \left|V_{60}\right| = \left|V_{120}\right| = \ldots = \left|V_{360}\right| = \sqrt{\frac{2}{3}}Vdc, \tag{1}$$

$$\left|V_{30}\right| = \left|V_{90}\right| = \left|V_{150}\right| = \ldots = \left|V_{330}\right| = \frac{1}{2}\sqrt{2}Vdc, \text{and} \tag{2}$$

$$\left|V_{0in}\right| = \left|V_{60in}\right| = \left|V_{120in}\right| = \ldots = \left|V_{360in}\right| = \frac{1}{2}\sqrt{\frac{2}{3}}Vdc, \tag{3}$$

where $V_0 \ldots V_{360}$ are large vectors, $V_{30} \ldots V_{330}$ are medium vectors, and $V_{0in} \ldots V_{360in}$ are small vectors having a half magnitude of the large vector. Moreover, the voltage vector can be calculated as follows:

$$Vref = \frac{V_\alpha}{\cos\theta} = \frac{V_\beta}{\sin\theta} \tag{4}$$

where $Vref$ is a voltage vector, V_α and V_β are voltage vectors decomposed into αβ axis, and θ is a space vector angle. The overall line equations are presented in Fig. 2.

For instance, if the reference voltage vector is located in the sector 11, boundary line equations a, b, and d are required. The sector can be selected using inequality equations of the boundary lines as shown in Fig. 2.

III. SIMULATION RESULT

Some simulations are conducted in both lower and higher modulation index conditions. In the lower modulation index which is $m \leq 0.5$, during 1 period, reference voltage vector is located in sector 14, 24, … , 64 as depicted in Fig. 3a. Sector 11, 12, 13, 21, 22, 23, … , 61, 62, 63 is passed sequentially by reference voltage vector during 1 period as depicted in Fig. 3b. This condition indicates higher modulation index ($m > 0.5$).

IV. CONCLUSION

The simulation of the sector identification has been presented. It can be confirmed that the proposed method can be achieved both in the lower and higher modulation index. The future plan is to verify this method using an experimental setup.

REFERENCES

[1] Y. Ohto, T. Noguchi, and T. Sasaya, "Space Vector Modulation of Dual Inverter with Battery and Capacitor across DC Buses," *IEEE Int. Conf. on Pow. Elec. and Drive Sys.*, 2017, 1172-1177.

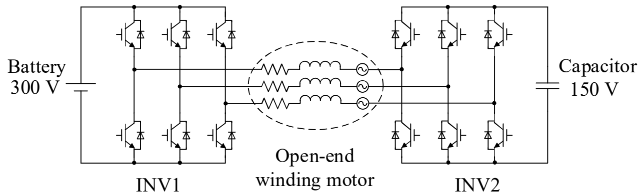


Fig. 1. Dual inverter motor drive.

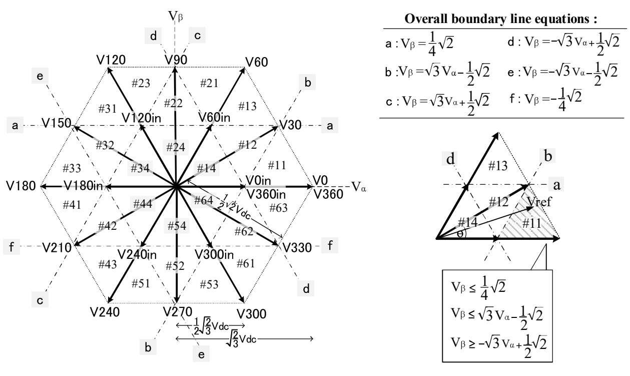
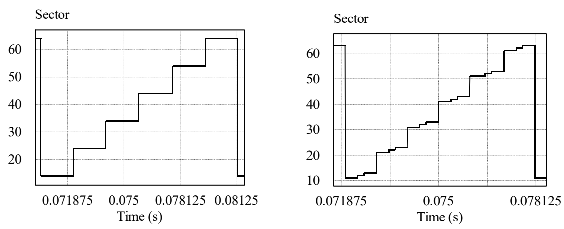


Fig. 2. Space voltage vectors and proposed sector identification.



(a) Lower modulation index. (b) Higher modulation index.

Fig. 3. Sector identification results.