An improved four-vector model for predictive current control used for PMSM drives

Shujun Fang,North China University of Technology, Beijing, China,a1321148440@126.com
Xiaoguang Zhang, North China University of Technology, Beijing, China, zxg@ncut.edu.cn

Introduction-Based on the improved four-vector model predictive current control strategy, the calculation method of minimum current ripple is introduced. First, the optimal first voltage vector U_1 is determined by the fast vector selection method, and the optimal second voltage vector U_2 and the optimal third vector U_3 are determined according to their sectors.Then, the action time of each voltage vector is derived by the method of calculating the minimum current ripple. In addition, the four voltage vectors are reordered without changing the switching frequency compared to the conventional three-vector. Finally, the purpose of further improving the control performance of the PMSM system is achieved.

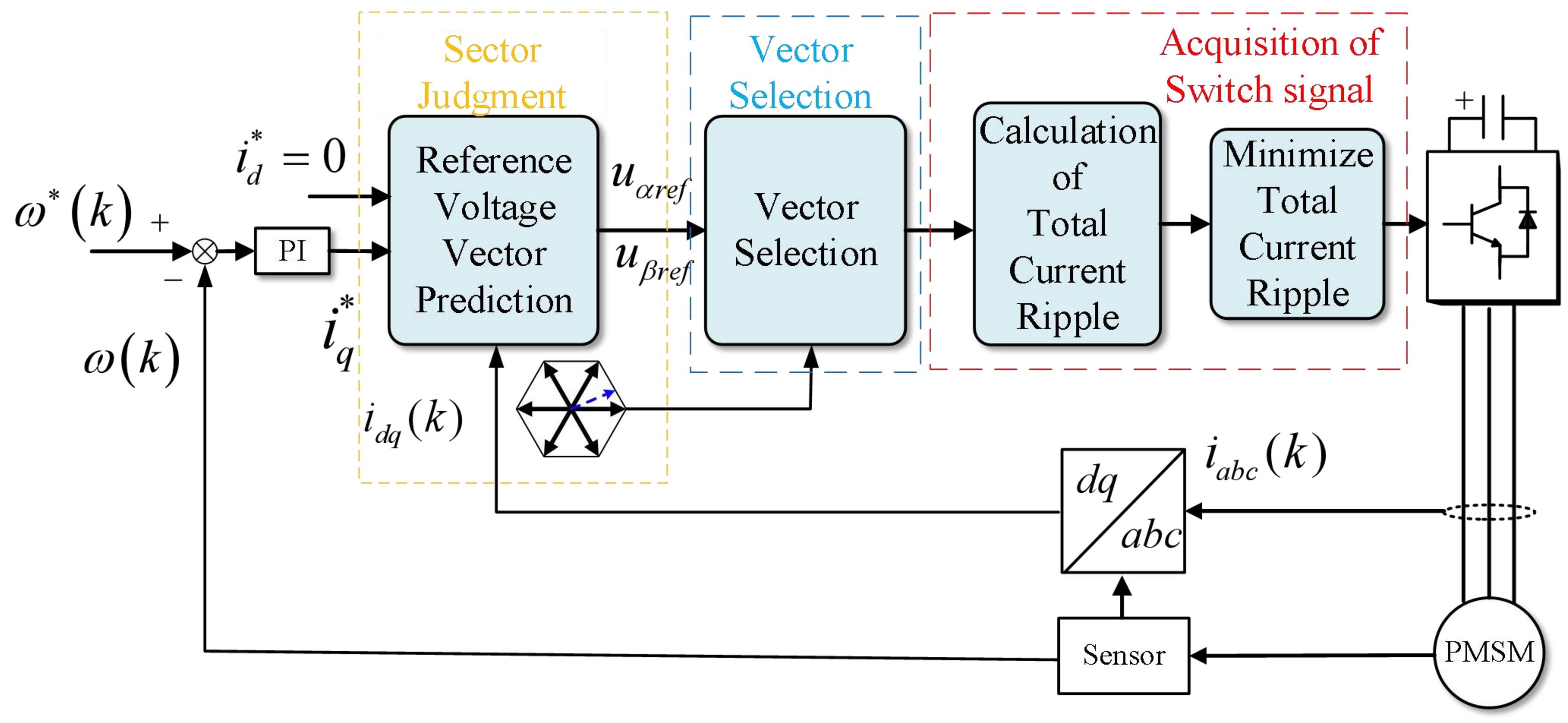

Fig.1 Control block diagram

Fast vector selection and sector judgment

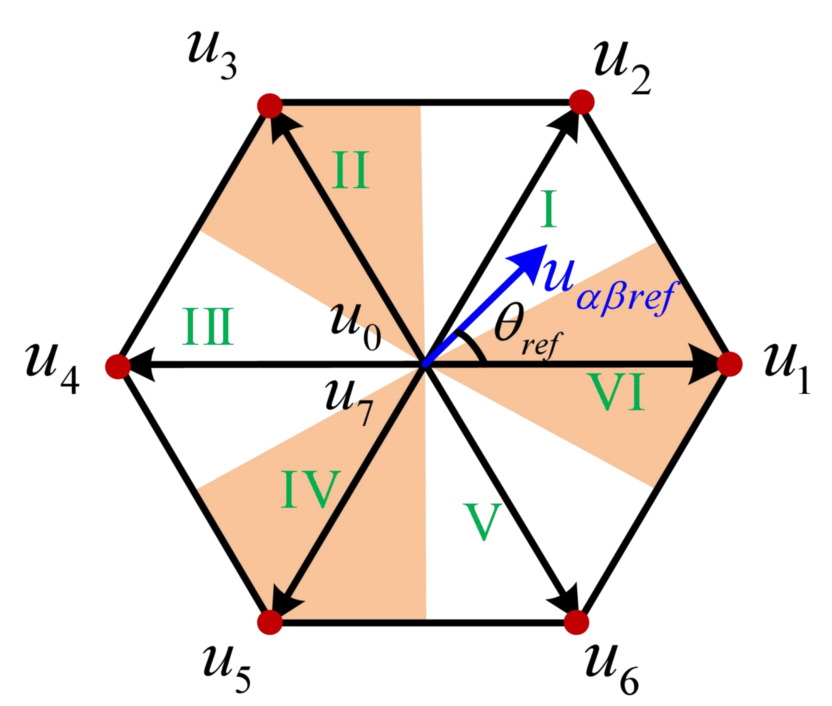

Fig.2 sector judgment

TABLE I
Selection of four candidate vectors

Sector number	Position angle of the reference VV	U_1	U_0	$U_2$and U_3
I	$\theta\epsilon[\pi/6,\pi/2]$	u_2	u_0	u_1,u_3
II	$\theta\epsilon[\pi/2,5\pi/6]$	u_3	u_0	u_2,u_4
III	$\theta\epsilon[5\pi/6,7\pi/6]$	u_4	u_0	u_3,u_5
IV	$\theta\epsilon[7\pi/6,3\pi/2]$	u_5	u_0	u_4,u_6
V	$\theta\epsilon[3\pi/2,11\pi/6]$	u_6	u_0	u_5,u_1
VI	$\theta\epsilon[0,\pi/6]U[11\pi/6,2\pi]$	u_1	u_0	u_2,u_6

Determination of the second optimal voltage vector

TABLE II
U_2 and U_3 act at each sector for times t_1 and t_2

Sector number	t_1	t_2
I	B	A
II	A	C
III	C	-B
IV	-B	-A
V	-A	-C
VI	-C	B

$$\begin{cases} A=\dfrac{\sqrt{3}T_s}{V_{dc}}\cdot u_{\beta ref} \\ B=\dfrac{\sqrt{3}T_s}{2V_{dc}}\cdot(\sqrt{3}u_{\alpha ref}+u_{\beta ref}) \\ C=\dfrac{\sqrt{3}T_s}{2V_{dc}}\cdot(-\sqrt{3}u_{\alpha ref}+u_{\beta ref}) \end{cases} .$$

Vector duration calculation

Since the action times of U_2 and U_3 have been obtained, it is then possible to get to the action time of U_1 by simple vector synthesis.

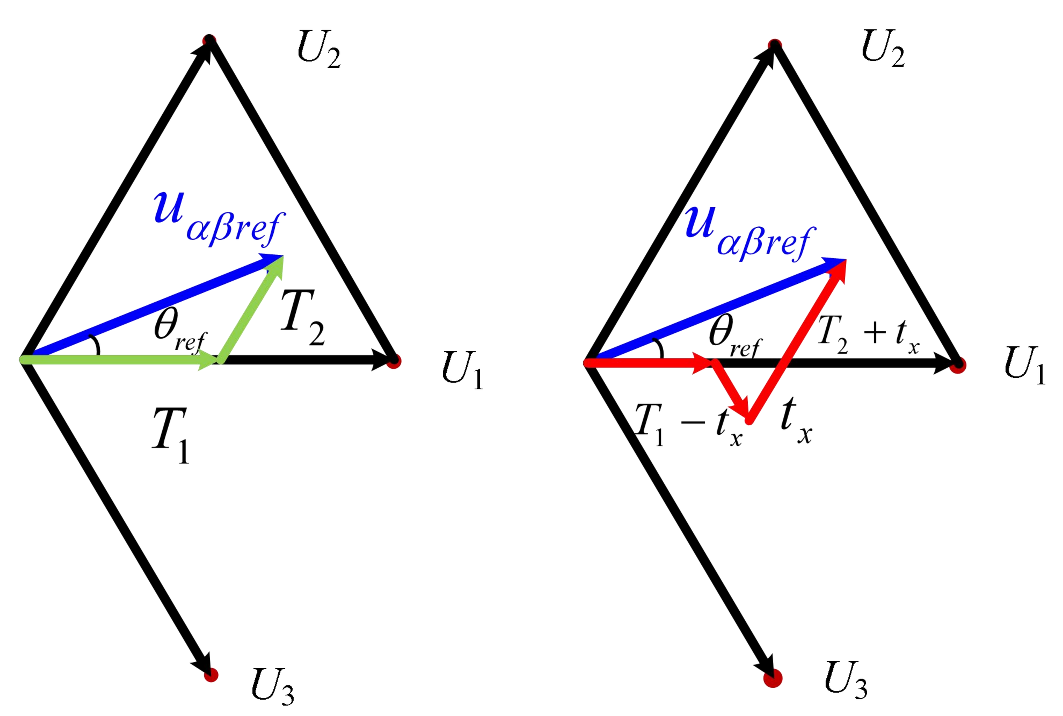

Fig.3 Voltage Vector Synthesis

An improved four-vector model for predictive current control used for PMSM drives

Next, the dq-axis current ripple generated by a single voltage vector can be expressed as:

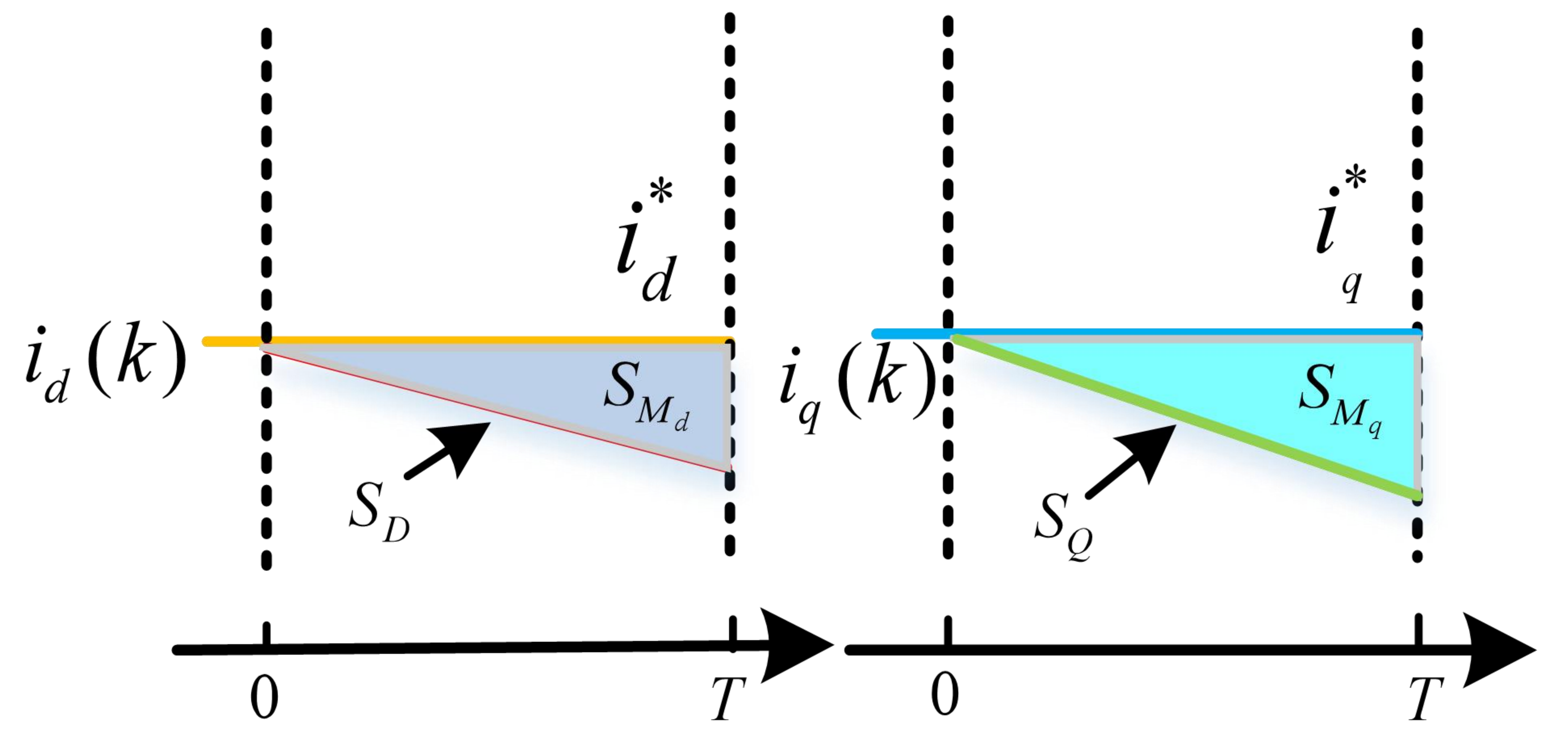

Fig.4 The dq-axis current ripple generated by a single voltage vector

$$S_{M_d} = \frac{1}{T_s}\int_0^T (S_D t)^2\,dt = \frac{S_D^{\,2}\cdot T^3}{3T_s}$$

$$S_{M_q} = \frac{1}{T_s}\int_0^T (S_Q t)^2\,dt = \frac{S_Q^{\,2}\cdot T^3}{3T_s}$$

$$S_0 = \frac{S_{d0}^{\,2}+S_{q0}^{\,2}}{3T_s} \qquad S_1 = \frac{S_{d1}^{\,2}+S_{q1}^{\,2}}{3T_s}$$

$$S_2 = \frac{S_{d2}^{\,2}+S_{q2}^{\,2}}{3T_s} \qquad S_3 = \frac{S_{d3}^{\,2}+S_{q3}^{\,2}}{3T_s}$$

$$S = S_0(t_0^*)^3 + S_1(t_a^*)^3 + S_2(t_b^*)^3 + S_3(t_c^*)^3$$

Then, we obtain t_x according to the principle of minimum current ripple.

Simulation Results and Verification

Simulation results and validation Simulation and validation are carried out in MATLAB software to compare the performance of the FV-MPCC method and traditional three-vector methods.

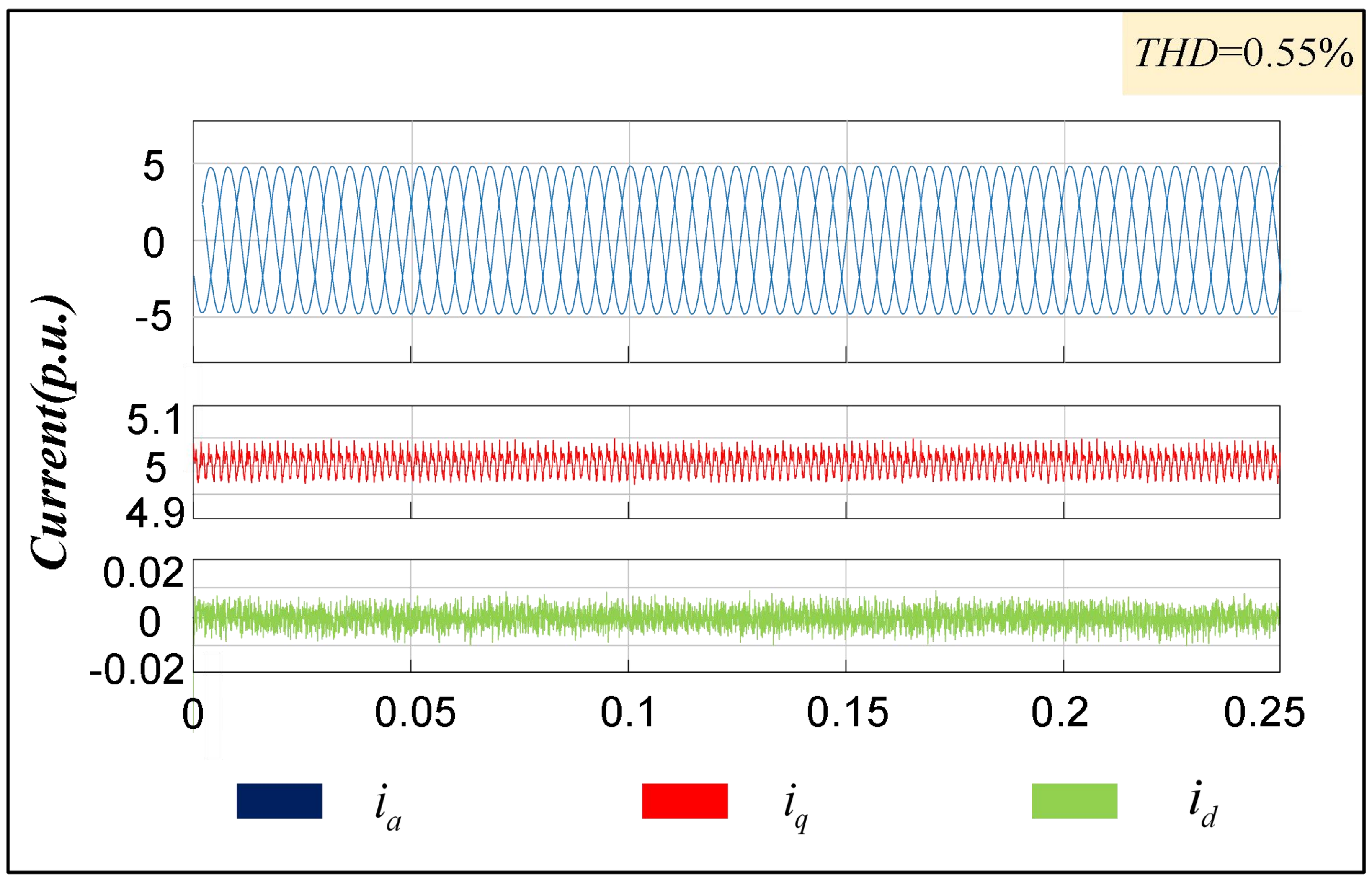

Fig.5 The steady-state performance of the proposed method at 2000rmp

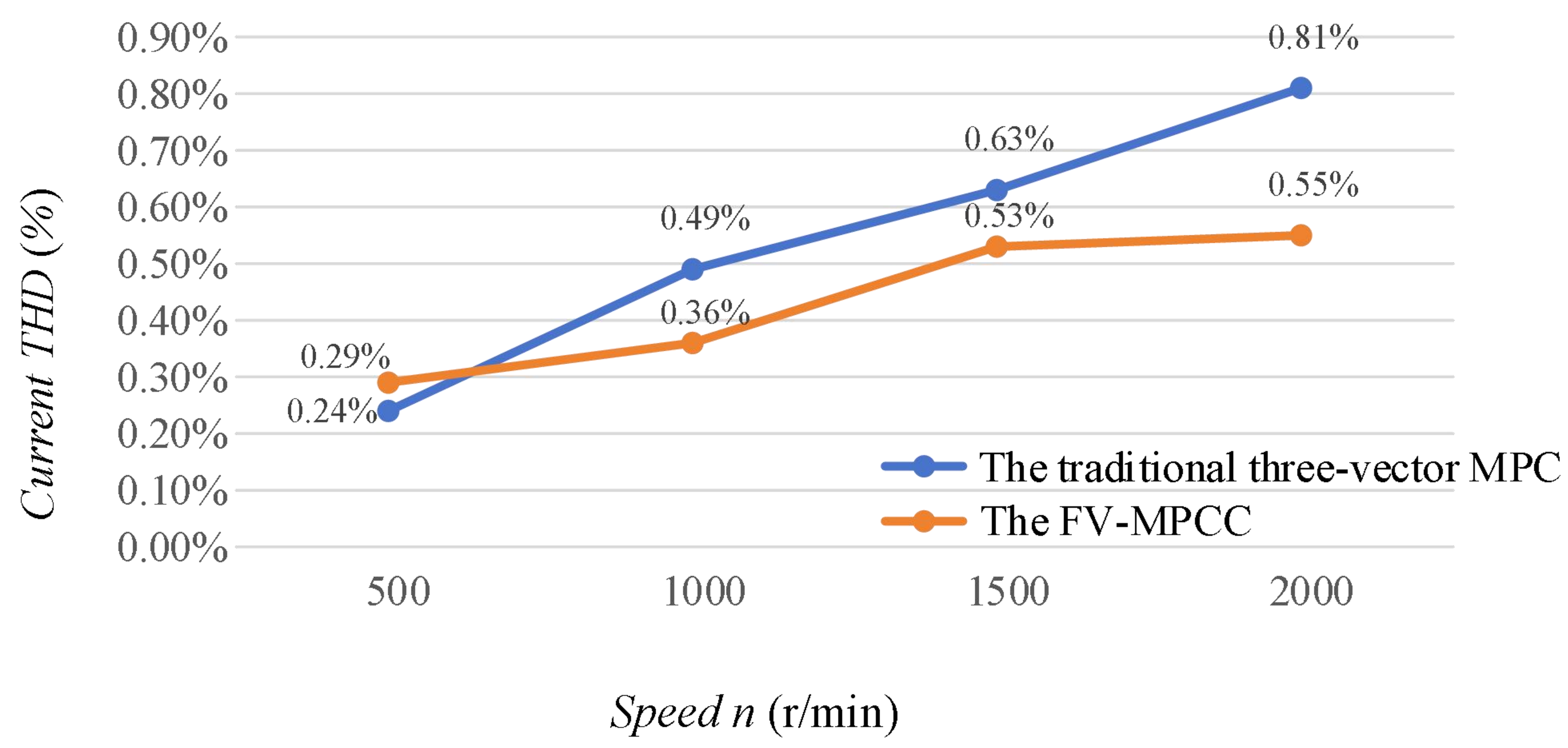

Fig.6 THD comparison of the two methods

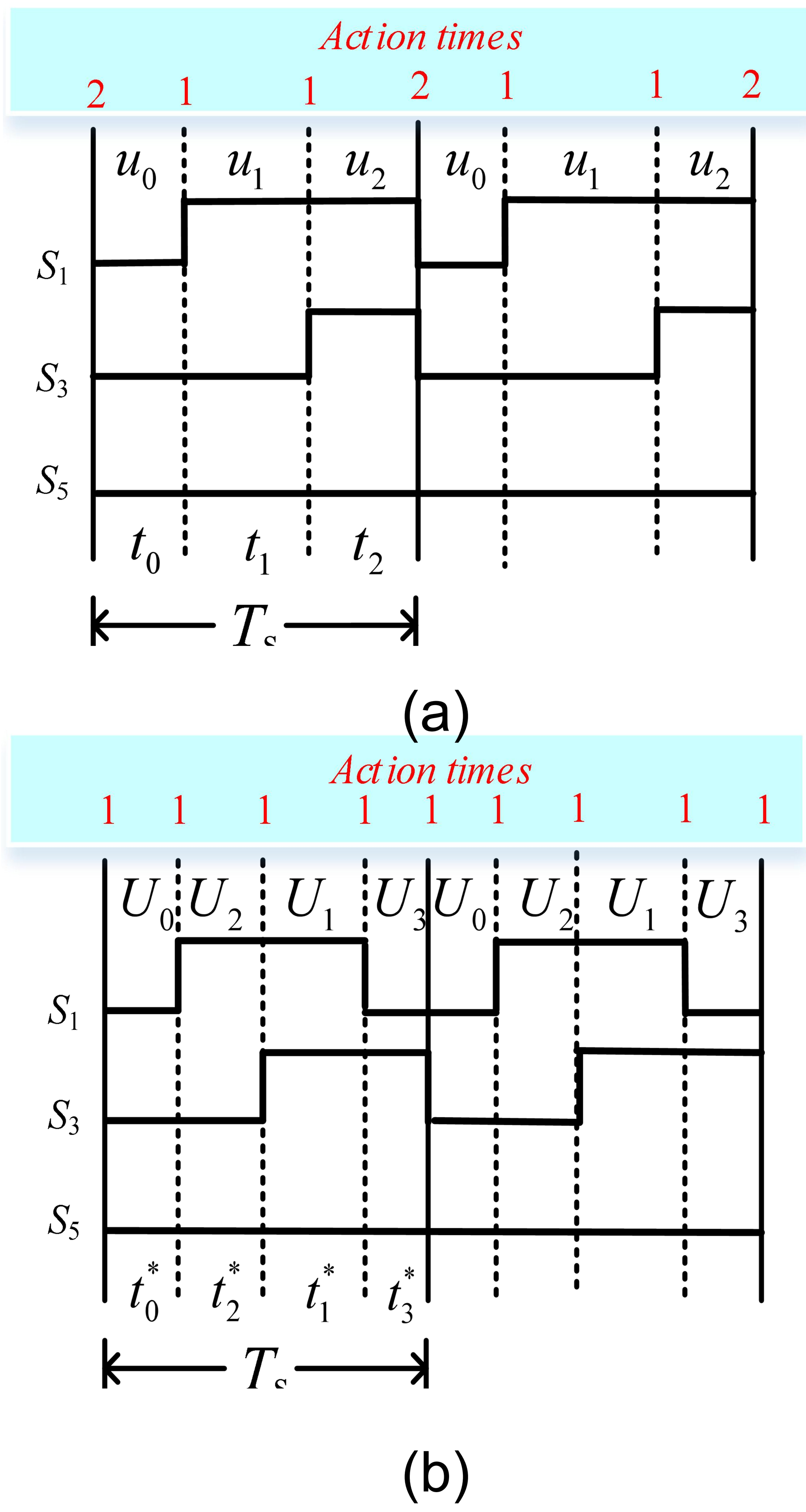

Fig.7 The diagrams of switching pulse (a) the traditional three-vector MPC, (b) the proposed FV-MPCC