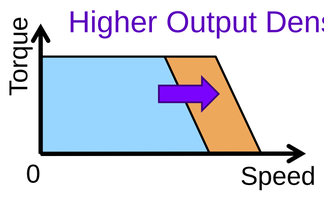
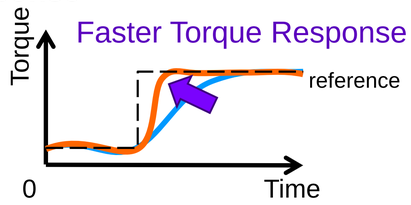
The Characteristic Evaluation of the Method to Improve the Voltage Phase Resolution of Model Predictive Control for Current Control System of PMSM

Introduction

Motor drive system for vehicle required
higher output density and **faster torque response**





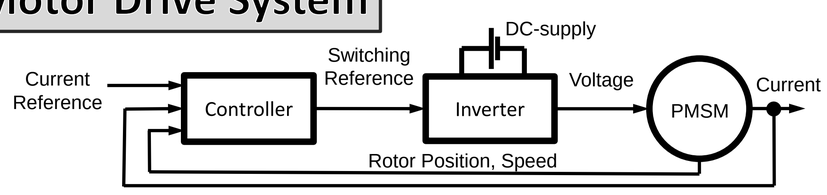
- For these requirements, **Model Predictive Control (MPC)** is taken notice
- Conventional MPC's weak point : steady control performance
  ⇒This cause is **large voltage phase resolution**

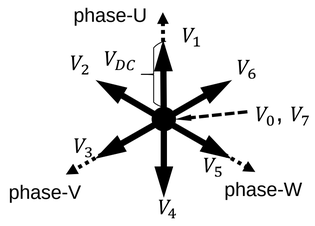
We have proposed **New MPC** for Motor drive system
for improving steady current control performance

Purpose

Evaluation of New MPC

Motor Drive System





Voltage vector

Controller decides input voltage for PMSM

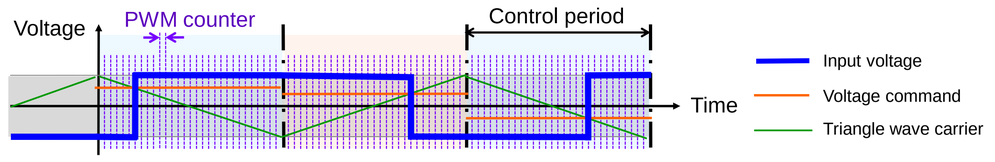
- One phase of inverter has 2 switches
  ⇒The outputs of inverter are 8 voltage vector

The fineness of input voltage (voltage phase resolution)
decides steady current control performance

Conventional Vector Control (PI with PWM)

PI with PWM

- calculates voltage command from the error between current reference and current
- decide input voltage by comparing voltage command and triangle wave carrier of PWM



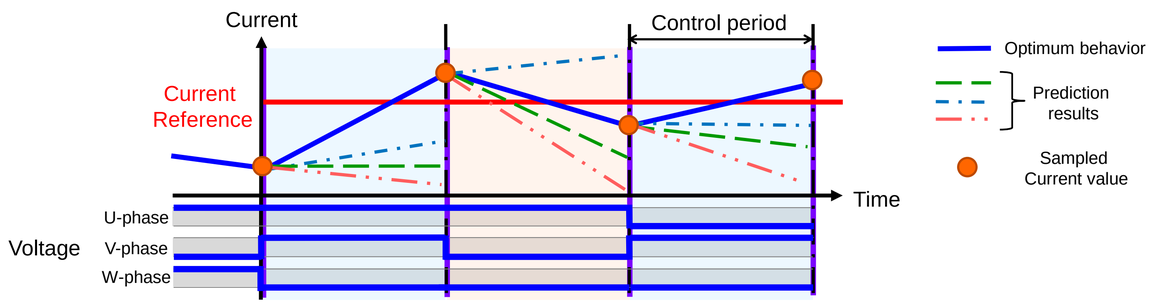
Voltage phase resolution is **PWM counter**

➢ Counter increment period is very narrow (hundreds nanoseconds)

Conventional MPC (FCS-MPCVC)

FCS-MPCVC (Finite Control Set – Model Predictive Current Vector Control)

- decides **optimum voltage vector** during the control period directly
  by **predicting future current behavior** for each voltage vector



Voltage phase resolution is **control period** in a principle

➢ It's very large compared with PWM

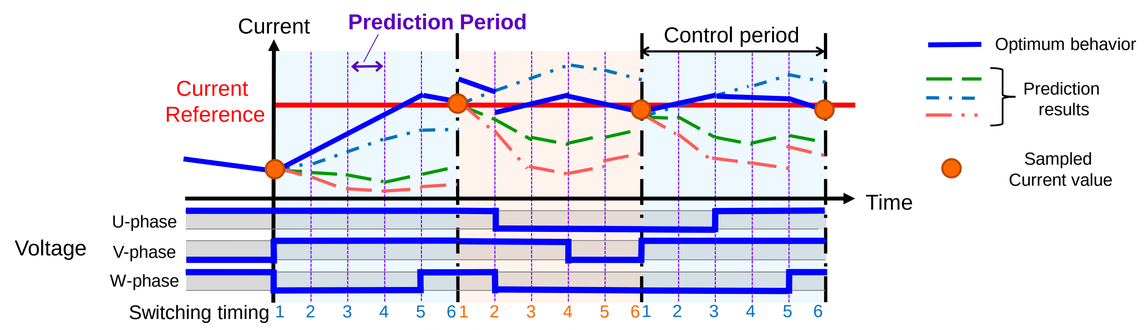
➢ Shortening of Control Period is needed for Improving of voltage phase resolution

Unlimited shortening of Control Period is impossible
due to constraints of equipment such as switching frequency

Propose MPC (MPM-CVC)

MPM-CVC (Model Predictive Modulated – Current Vector Control)

- decides **optimum switching timing** by predicting for every **prediction period**
  under the limitation which switching time is maximum one time in control period



Voltage phase resolution is **prediction period**

➢ Prediction period can be designed independently of control period

➢ Switching frequency don't change by the limitation

MPM-CVC can improve voltage phase resolution without increasing
the switching frequency while keeping MPC's output density and torque response

Control Performance of each method

	PI with PWM	FCS-MPCVC	MPM-CVC
Switching frequency	Control period	Control period	Control period
Voltage phase resolution	PWM counter	Control period	Prediction period
Control performance	**Satisfactory**	**Difficult to improve**	**Possible to improve**

MPM-CVC can improve control performance what couldn't be realized in FCS-MPCVC

Evaluation in Square – Wave drive

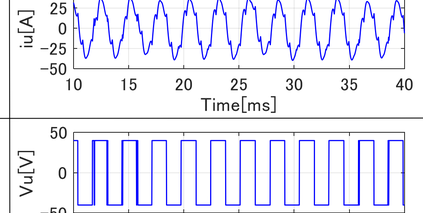
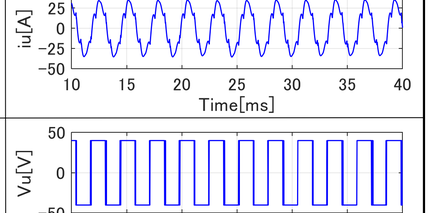
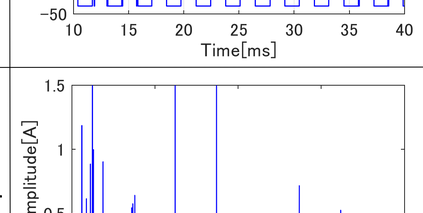
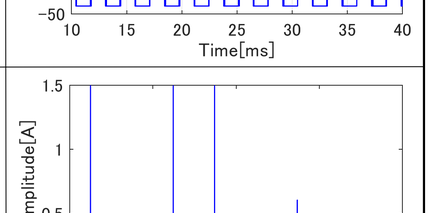
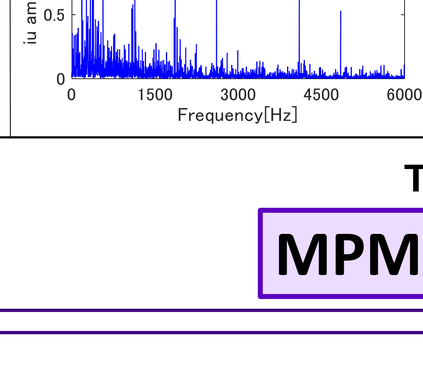
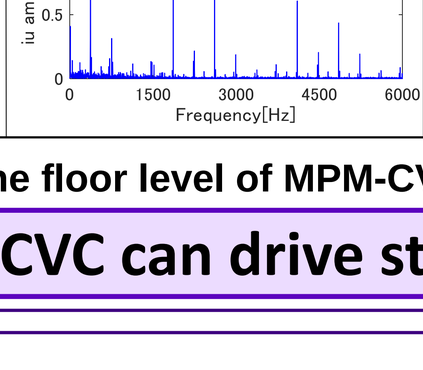
We evaluated the steady control performance of MPM-CVC in Square – Wave drive

In Square-Wave drive, **switching timing** is important
⇒**Switching timing's deviation** caused by large voltage phase resolution becomes **disturbance**

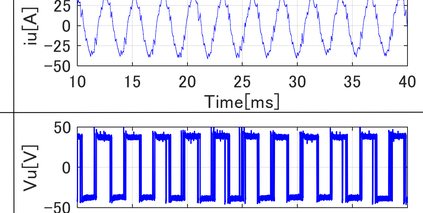
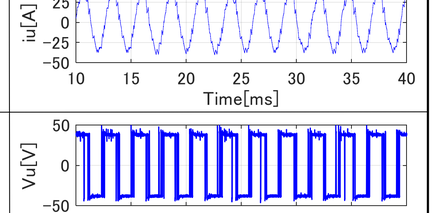
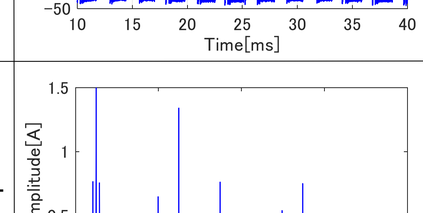
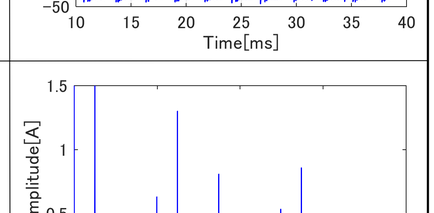
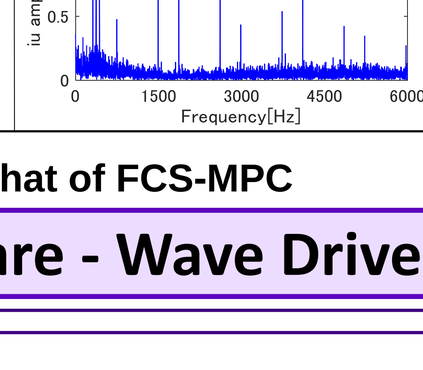
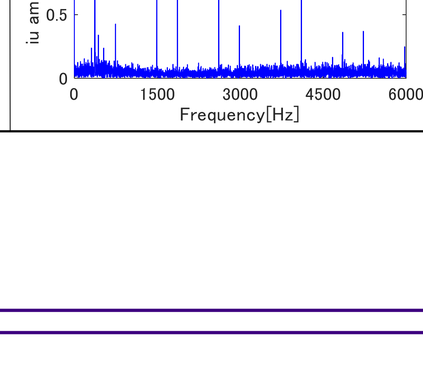
Setting of Controller

Control Period	40μs
Prediction Period(MPM-CVC)	4μs

Simulation results

	FCS-MPCVC	MPM-CVC
U-phase Current		
U-phase Voltage		
U-phase Current FFT		

Experimental results

	FCS-MPCVC	MPM-CVC
U-phase Current		
U-phase Voltage		
U-phase Current FFT		

The floor level of MPM-CVC is lower than that of FCS-MPC

MPM-CVC can drive stably in Square - Wave Drive

Conclusion

Our propose method, **MPM-CVC**, **can improve the voltage phase resolution** without shorting control period by introducing **prediction period**.
MPM-CVC can realize **stable drive** in Square-Wave drive compared with FCS-MPCVC.