Model Predictive Control of Inverter and Linear Drive

Dr. Low Kay Soon
Director, Satellite Research Centre (SaRC)
Associate Professor, School of Electrical & Electronic Engineering
Nanyang Technological University

Model Predictive Control (MPC) is a digital control strategy that was developed initially for the process control industry in the mid-1970's. It was also previously termed as Generalized Predictive Control (GPC). It is a model-based approach employing the receding horizon scheme. Using the system model, the MPC predicts the output of the system over a time horizon based on the assumption about future output sequences of the controller. An appropriate control sequence is then calculated to reduce the tracking error by minimizing a quadratic cost function. However, only the first element of the control signals is applied to the system. This process is repeated every sampling interval to allow regular updating of new information. Consequently, the MPC gives good rejection against modelling errors and disturbances.

MPC has been used successfully in various process control industries such as arc welding and sheet/film processes; and has proven to be an effective and reliable control methodology. It has also been investigated in the area of motion control [1,3,8,9,11,12,14], single phase inverter [13,15], three phase inverter, multilevel inverter, uninterruptible power supplies [2,5] and surgical robot.

In this seminar, we present two applications based on MPC: 1. Parallel Connected Inverter for UPS Application, 2. Repetitive MPC for Precision Control of a Linear Motor Drive.

Uninterruptible power supplies (UPS) have been used in many installations for critical loads that cannot afford power failure or surge during operation. It is often difficult to upgrade the UPS system as the load grows over time. Due to lower cost and maintenance, as well as ease of increasing system capacity, the parallel operation of modularized small power UPS has attracted much attention in recent years. In this work, a new scheme for parallel operation of inverters is introduced. A multi-input multi-output (MIMO) state space model is developed to describe the parallel connected inverters system, and a MPC scheme suitable for paralleled inverters control is proposed. In this algorithm, the control objectives of voltage tracking and current sharing are formulated using a weighted cost function. The effectiveness and the hot swap capability of the proposed parallel connected inverters system have been verified with experimental results.

For applications that are repetitive in nature such as control of inverter [4,6,7,10], harddisk drive and automated process etc, the system can be designed with a repetitive controller to achieve better performance as the disturbance exists in the system is periodic. In this work, a MPC that possesses the repetitive control property is proposed to achieve high precision tracking in real time. The proposed repetitive MPC (RMPC) controller attempts to combine the merits of MPC and repetitive control. For the proposed predictive controller, the feedforward controller of the conventional MPC has been modified to provide zero phase learning property. This is achieved by augmenting the reference trajectory with a phase compensated term that is updated with the historical tracking error. Experimental results have demonstrated that the system reduces the tracking error from the periodic disturbance caused by the friction effectively. Its performance under varying reference conditions and different loadings shows that the system is robust.
References:

1. A Repetitive Model Predictive Control Approach for Precision Tracking of a Linear Motion system

2. Model Predictive Control of Parallel Connected Inverters for Uninterruptible Power Supplies

3. Repetitive Model Predictive Control of a Precision Linear Motor Drive
   R. Cao, and K. S. Low, IEEE Industrial Electronics, Control and Instrumentation Conference (IECON '07), 7 - 10 Nov 2007, Taipei, Taiwan, pp. 1132 - 1137.

4. Zero-Phase Odd-Harmonic Repetitive Controller for a Single-Phase PWM Inverter

5. Model Predictive Control of Parallel Connected Inverters for Uninterruptible Power Supplies
   K. S. Low, and RZ Cao, 37th IEEE Power Electronics Specialists Conference (PESC '06), 18 - 22 Jun 2006, Jeju, Korea, pp. 2158-2163.

6. Digital odd harmonic repetitive control of a single-phase PWM inverter
   K. S. Low, K. Zhou and D. W. Wang, IEEE Industrial Electronics, Control and Instrumentation Conference (IECON '04), 2 - 6 Nov 2004, Busan, Korea, pp. 6-11.

7. Odd harmonic repetitive controlled CVCF PWM inverter with phase lead compensation

8. Robust model predictive control of a motor drive with control input constraints

9. Advanced Precision Linear Stage for Industrial Automation Applications

10. Periodic errors elimination in CVCF PWM DC/AC converter systems: Repetitive control approach

11. Robust model predictive control and observer for direct drive applications

12. A high performance linear stage using predictive control and genetic algorithms
    K S Low and M T Keck, In ”Recent Advances in Mechatronics”, Eds. O. Kaynak etc., Springer-Verlag 1999, pp. 232-244.

13. A DSP-based single-phase AC power source

14. Evaluating generalized predictive control for a brushless DC drive

15. A digital control technique for a single phase PWM inverter