The Novel Power Supply System in the Yamanashi Maglev Test Line

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Abstract

The aims of the second test period in Yamanashi Maglev Test Line are verification of system duravility and reduction of construction cost to realize the Chuo Shinkansen from Tokyo to Osaka. In this paper, the improvement in power supply and drive control system lead to cost down are introduced.

1 Introduction

In the first test period of Yamanashi Maglev test line from FY1997 to FY1999, technical readiness for practical use of Superconducting Maglev system has been proven by its remarkable test results, such as world speed record of 552kmph and relative speed of 1,003kmph. From FY2000, running test to confirm the durability has proceed to the second test period of 5 years and the test vehicle MLX01 had clocked over 350,000km by the end of FY2003. Other aims of the second test period are improvement of the aerodynamic and reduction of construction cost to realize the Chuo Shinkansen from Tokyo to Osaka. In this paper, we introduce the improvement in power supply and drive control system lead to cost down.

2 System Overview

Superconducting Maglev system as a high power and high performance linear motor drives, requires a high power supply and accurate position sensing system on the ground. Those particular facilities rise construction and maintenance cost compared with conventional railway. So the utilization of those facilities and economic characteristics should be improved.

3 Improvement in power converter

Two types of power up technique have been introduced to the test line. One is the conventional neutral point bias control and the other is novel asymmetrical PWM control.

3.1 Neutral point bias control

It is well known that by superimposing third order harmonic of 1/6 of the fundamental components, peak phase voltage is reduced to $\sqrt{3}/2$ and thus output voltage of the inverter is increased by 15% as shown in Fig.1. Effectiveness of this control was proven in full power operation of 552kmph run with 5 car train set in 1997 and new world speed record of 581kmph on December 2, 2003.

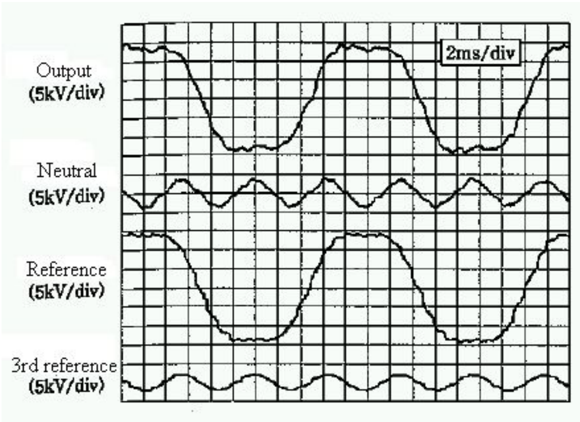

Fig.1 Neutral point voltage control

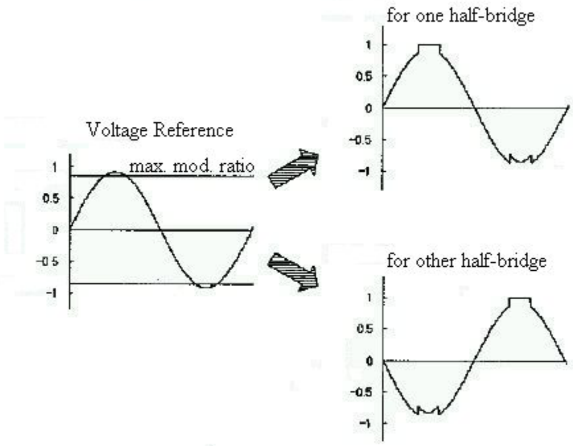

Fig.2 Novel asymmetrical PWM control

3.2 Asymmetrical PWM control

Usually, the output voltage of the inverter is restricted with maximum value of modulation ratio Mmax. To increase Mmax, novel PWM control method using full-bridge inverter with asymmetrical switching was developed. If the modulation ratio M exceeds Mmax, modulation ratio for one half-bridge is fixed to 1 and for other half-bridge modulation ratio is reduced to 2M-1(=M-(1-M)) as shown in Fig.2. Thus maximum value of modulation ratio is increased to Mmax'=(1+Mmax)/2. For example, Mmax of 0.86 is increased to Mmax' of 0.93 and output voltage is increased by +8%. With this power up, efficient run of 2,876km in one day was achieved on November 7, 2003.

3.3 IEGT inverter

In FY2002, new inverter using IEGT(Injection Enhanced Gate Transistor) was developed and installed in the substation as shown in Fig.3. Its volume is 1/2 and losses are 1/3 compared with the former GTO inverter.

Fig.3 New IEGT inverter(left) and former GTO inverter(right)

The 4.5kV-3kA IEGT is a novel power device consists of 30 small IEGT chips and 12 anti-paralleled diode chips as shown in Fig.4. Also, the IEGT is a voltage controlled device and volume and required power of the driver unit is remarkably reduced compared with the GTO as shown in Fig.5.

Fig.4 External form, inner structure and chip of 4.5kV-3kA IEGT

Fig.5 Gate driver unit for IEGT(left 110x165x50mm, Pin=0.13W) and GTO(right 140x219x450mm, Pin=200 to 300W at 500Hz)

4 Position sensorless (indirect) control

For stable and efficient operation of the LSM drive, precise pole position is needed. In the Yamanashi Maglev Test Line, the pole position is detected by the Inductive Radio system. However, for the long distance application, more simple method is desired and novel sensor-less control using EMF observer and tachometer of the wheel was developed. With this control, Inductive Radio Wire will be removed. The sensorless control operated stable in the speed range of 0kmph(even in start and stop) to 500kmph.

5 Conclusions

Latest Improvement in the Yamanashi Maglev Test Line which lead to cost down are reported. We will also make efforts to decrease total construction costs.

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