ELEVATOR CONTROL USING DEDICATED PROCESSOR FOR POWER ELECTRONICS (PP7)

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ABSTRACT

Currently, elevator drive units, from medium-low-speed elevators to high-speed elevators, generally adopt inverter control.Teachnological advances have promoted steady progress year by year with these units.

We have developed a highly functional processor dedicated to power electronics(PP7) in which a 32-bit-CPU and a multi-function digital circuit are integrated on to a single chip.

This report outlines this dedicated processor and describes its application to a high-speed elevator drive system.

I. INTRODUCTION

Inverter control is now widely used in elevator drive units. The control hardware has changed from an analog and digital composite control to an all digital control method using a microcomputer and an ASIC (Application Specific IC). This has led to the development of a highly functional system,which integrates all functions such as CPU motor control operations and PWM control,as well as a DSP(Digital Signal Processor), and a GA (Gate Array). This processor can also be applied to devices other than elevators.

Applying this processor to a high-speed elevator simplifies the control system and enables development of a system offering higher speed and larger capacity.

In addition,high-speed operations processing enables control stabilization, including vibration suppression, and improves system reliability.

2. HIGHLY FUNCTIONAL PROCESSOR FOR POWER ELECTRONICS(PP7)

2.1 PP7 OUTLINE

PP7 is the pet name for a high-performance processor developed for power electronics (Power electronics Processor for Various Inverter control Integration : PPVII - PP7). It is a single chip controller in which

(1) a 32 Bit-CPU + peripheral functions and

(2) dedicated multi-function digital circuit for power electronics

are integrated.

This processor was developed for high-performance control in high-speed operations, miniaturization, and high reliability with an integrated digital circuit.
Fig. 1 shows the internal configuration of the PP7 chip and the basic system configuration of the motor control using this chip.

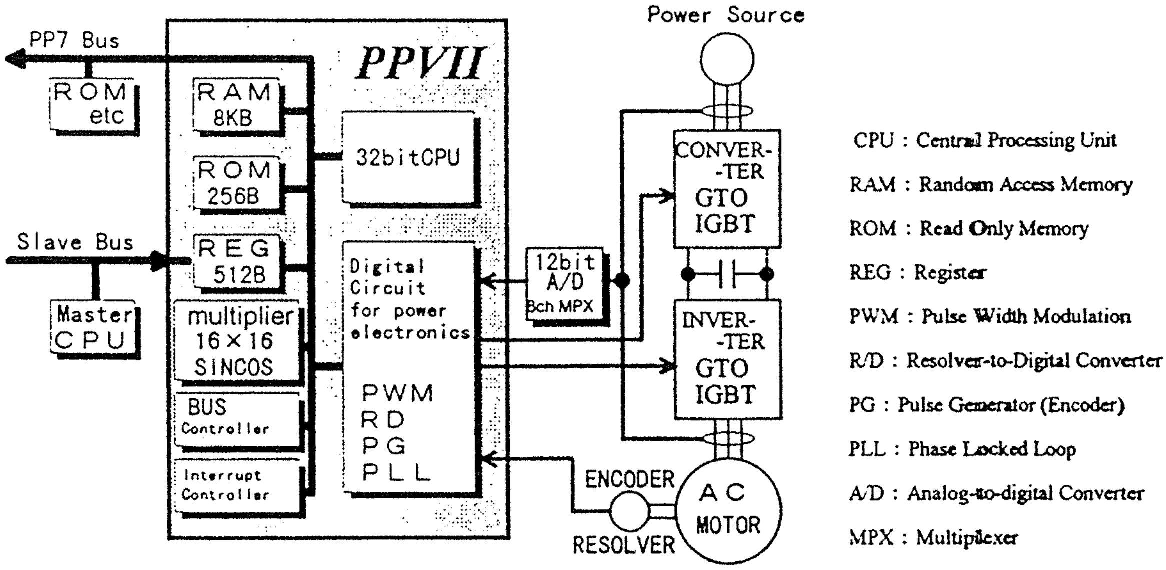


Fig. 1 Configuration of Converter-Inverter control system

2.2 Features of PP7

2.1.1 CPU function

The CPU is composed of the following :
(1) An arithmetic and logic unit
(basic arithmetic operations, product and sum operation, limit process, logic process)
(2) Various controllers
(bus controller, interrupt controller, expansion capabilities)
(3) Register with large operating capacity
(dual port function)
(4) Memory for both program and data
(high-speed access memory)
Fig. 2 is a block diagram of the CPU.

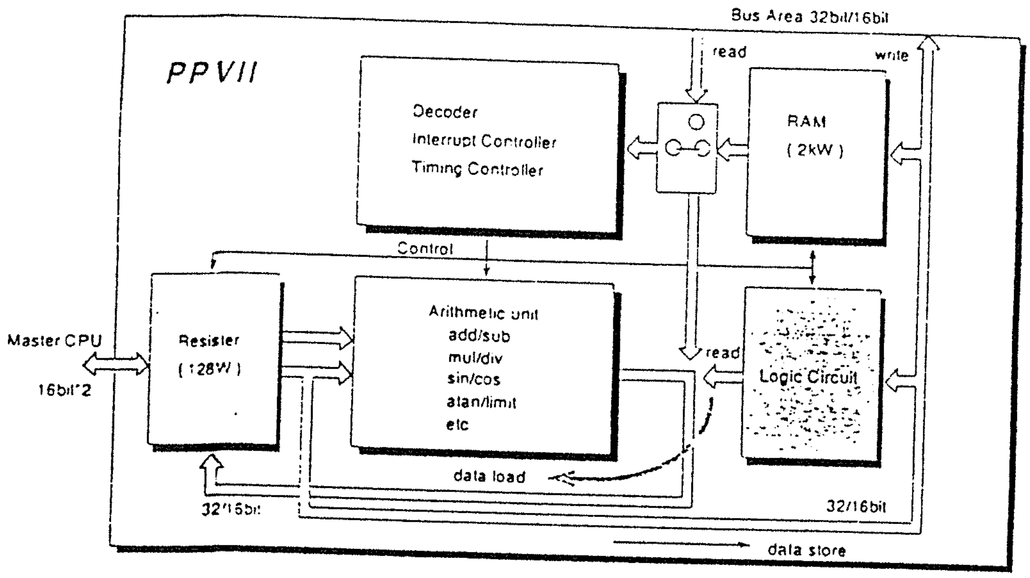


Fig. 2 Block diagram of microcontroller

To achieve high-speed and easy control operations, dedicated instructions were prepared which approximately express a control signal's limit processing instruction,coordinate conversion, and sine wave function operations, as well as the arithmetic operations in the form of a numerical formula.

2.2.2 Dedicated multi-function digital circuit for power electronics

In the PP7, a logic circuit is provided for power electronics to control a converter,and respond to a wide range of applications.

Fig. 3 is the functional block diagram. It has the following main functions:

(1) PWM function
(2) Vector control function
(3) Position sensor interface
(4) A/D converter interface
(5) Power source PLL function
(6) Interface for parallel processing

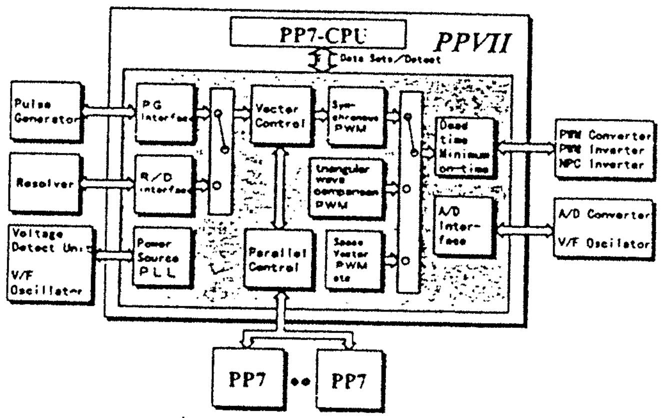


Fig.3 Block diagram of the PP7-Logic circuit

The PWM function is used to select the triangular wave comparison mode,the synchronous PWM mode or the space vector PWM. It also handles V/F control and sensorless control, as well as vector control.

3. HIGH-SPEED ELEVATOR DRIVE SYSYTEM USING PP7

3.1 CONVENTIONAL SYSTEM

Fig. 4 shows a conventional elevator drive system configuration. In this system, an all digital control was performed using a gate array (G.A.) for PWM control and a DSP (Digital Signal Processor) for current control, each dedicated respectively for the power side converter control and the motor side inverter control centered on the 16-bit main CPU.

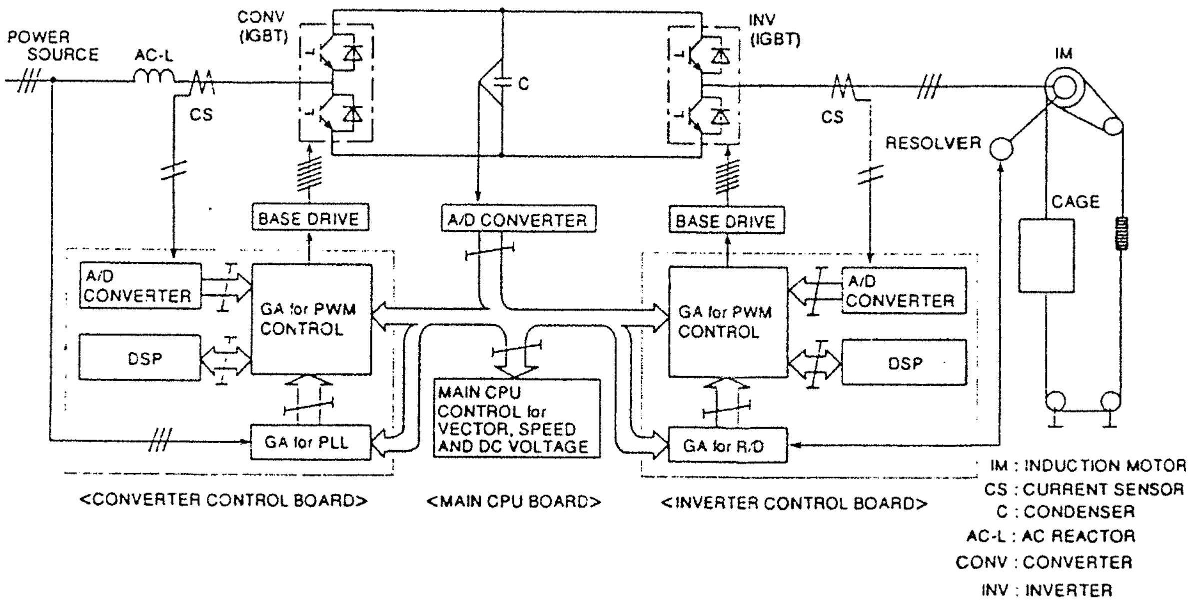


Fig. 4. Conventional High-speed Elevator Drive System

3.2 SYSTEM USING PP7

3.2.1 System configuration

Fig. 5 shows the configuration of the high-speed elevator drive system using the PP7. The single PP7 chip can process all of the power side converter control functions and the motor side inverter control functions,thus achieving a substantial simplification of the control board hardware configuration.

The following are the main functions of the high-speed elevator control system.

[Power side converter control]

(1) DC main circuit voltage control
(2) Power-supply constant power factor control
(3) Current control
(4) PWM control

[Motor side inverter control]

(1) Speed control
(2) Vector control
(3) Load balance control
(4) Vertical vibration suppression control
(5) Current control
(6) PWM control

It also incorporates the elevator speed command operational function, a protection function, and the sequence processing related to elevator running functions.

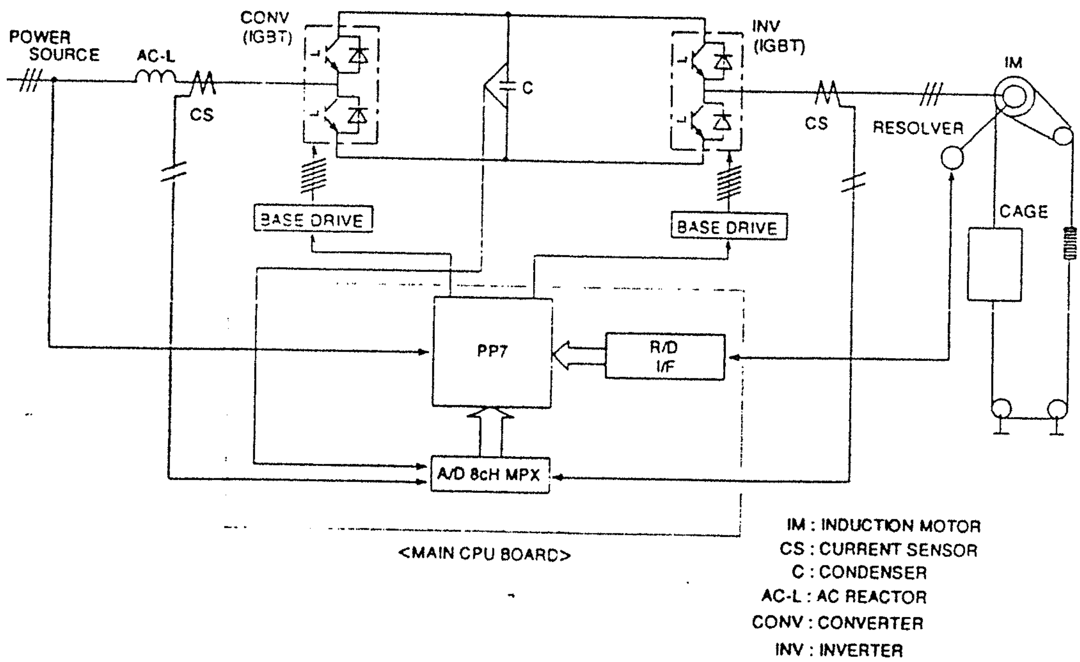


Fig. 5. High-speed Elevator Drive System Using PP7

3.2.2 Improvement of control performance

Comparison of the conventional and the new control operations' processing times are shown in Table 1 below.

Table 1. Processing Time

	Conventional	Using PP7
ACR (CONV+INV CONTROL)	128 μS	20 μS
ASR+VEC+PWM +AVR+PLL	200 μS	25 μS

ACR: Auto Current Regulator   ASR: Auto Speed Regulator   CONV:CONVERTER
VEC: Vector Control   PWM: PWM Control   INV:INVERTER
AVR: Auto Voltage Regulator   PLL: Phase Locked Loop

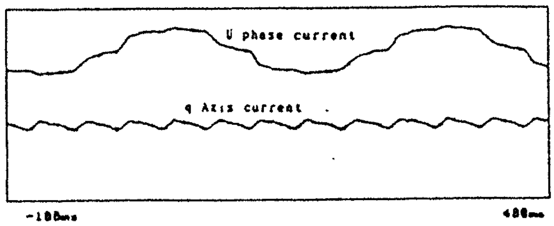
Use of the PP7 enables shortening the processing time of the speed control and current control and improvement of the system's performance as shown below.

(1) Current control

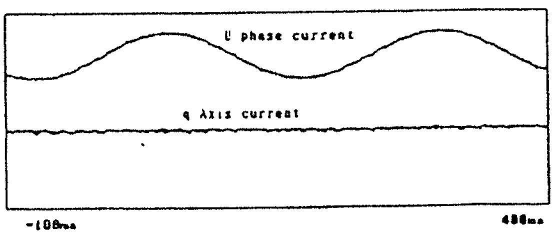
The shorter operation processing time made it possible to realize a high-speed, stable current control. Laboratory equipment tests confirmed the high-speed response up to1500 rad/s.

(2) Improvement of current waveform

In control schemes using switching devices such as IGBT, dead time is needed to prevent short-circuiting. It is however well known that such dead time may cause distortion in the current waveform. Processing to compensate for the effects of dead time is normally performed to prevent waveform distortion. Shortening of the operation processing time enables an improvement in this compensation. Fig.6 shows the current control waveform improvements by using the PP7 processor.



(a)without dead time conpensation

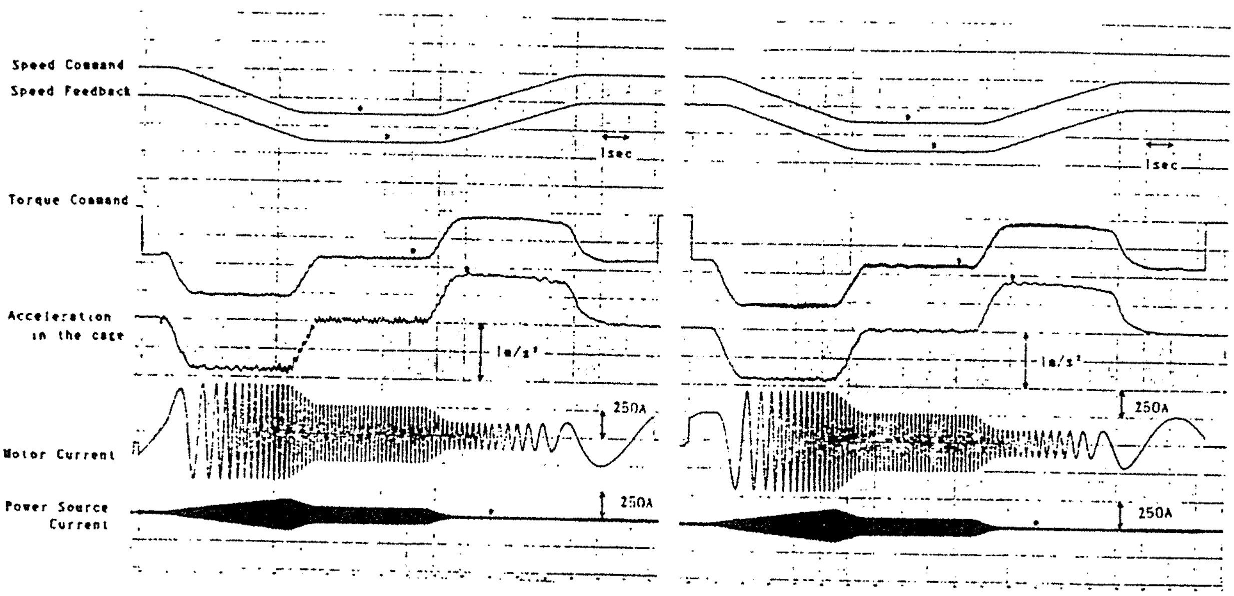


(b)with dead time conpensation

Fig.6 Current Control Waveform

(3)Improvement of vibration suppression control

In the conventional high-speed elevator drive system, vibration within a cage produced by resonance between the elevator machine system and the control system, is suppressed by control operation processing of the speed control system. That is to say, in this method an ideal speed signal obtained by a simulation operation is compared with the real speed signal. Vibration elements contained in the real speed are extracted, and torque control is performed using this signal as part of the command values. (SFC: Simulator Following Control). As the SFC is executed in synchronization with the speed control, its performance has been very dependent on the speed control operation's sampling time.
The use of PP7 has made it possible to shorten the speed control operation's sampling time to one fifth. This has led to an improvment in the SFC performance.
Fig. 7 shows the improved effects of SFC using the PP7.



(a) Conventional system (b) System using PP7

Fig. 7 Elevator Running Waveform

In addition, shortening of the processing time with the PP7 enables improvement of the PLL (Phase Locked Loop) mechanism needed for the converter's power synchronous control and improvement of the DC main circuit voltage control response.

3.3 APPLICATION TO A LARGE CAPACITY SYSTEM

3.3.1 System configuration

It is necessary to drive a large capacity motor with more than 100kW in a 1000m/min. ultra-high-speed elevator and a super-high-speed double-deck elevator.
Fig. 8 shows the configuration of a large capacity drive system using the PP7.

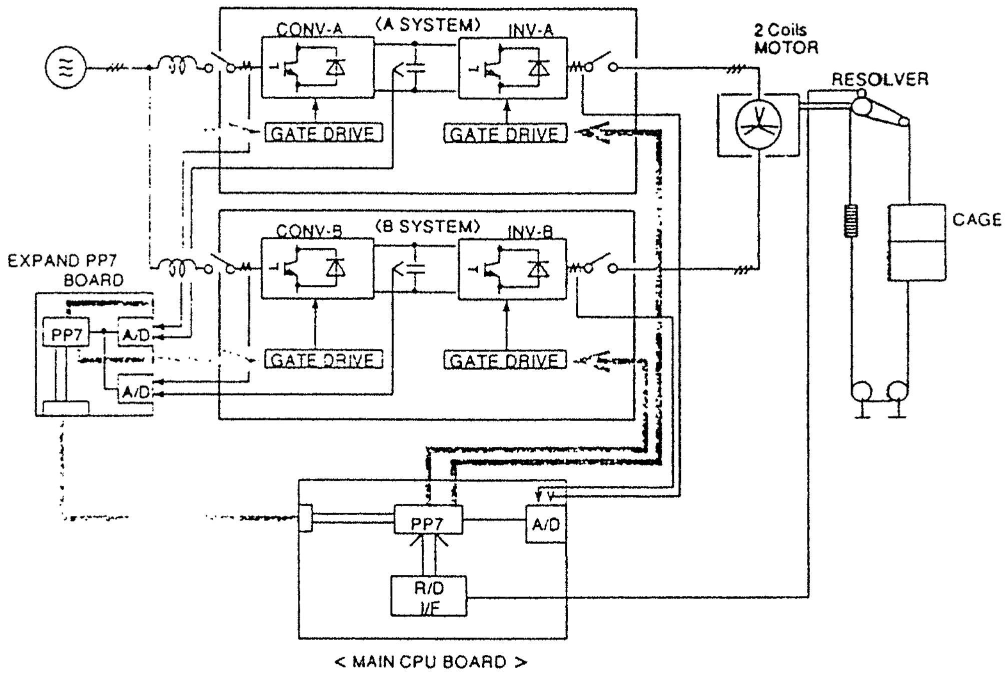


Fig. 8 Large Capacity Drive System

This system is a twin inverter system using an induction motor with two insulated coils.Each coil is driven by the respective inverters of system A and system B.

3.3.2 System features

(1) The use of a second PP7 board in the system described in section 3.2.1 above permits easy formation of a twin inverter system. Connection between the two boards is established by a bus line. It is possible to perform data transfer and mutual monitoring.

(2) The following two methods provide the basis for controlling the twin inverter system with two PP7s.

i) A structure in which one PP7 controls system A's converter/inverter and another controls system B';

ii) A structure in which one PP7 controls two converters of system A and system B, and another PP7 controls two inverters of system A and system B.

Considering the simple input/output structure of sensors such as speed sensors and current sensors, we adopted the system shown in Paragraph ii) since it does not require synchronous control between the two PP7s. The system structure shown in Fig. 8. Above.

(3) Even when system B's converter /inverter fails, adopting the twin inverter permits the elevator's rescue operation to be carried out by system A's converter/inverter.
Fig. 9 shows the running waveform in the rescue operation.

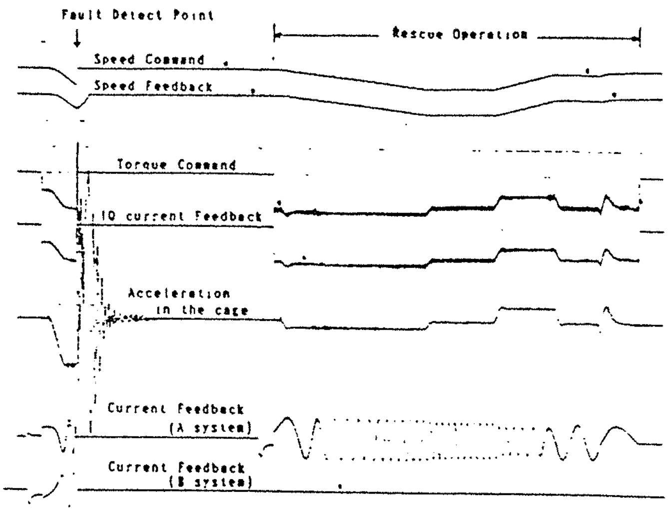


Fig. 9 Rescue Operation Waveform

4. Conclusion

Application of the dedicated highly functional processor for power electronics, the PP7, to an elevator drive system, enabled the simplification of the control system and its development into a large capacity system.
The high-speed operation processing also made it possible to improve the current waveform and the vertical vibration suppression performance. This leads to the improvment in the reliability of the elevator system.

In the super-high-rise(more than 400m) building, simulation results show that the extension of old technologies cannot effectively bring about the stabilization of control and vibration suppression. In order to solve these problems, we have proceeded with studies of improvement of control performance by modern control theory which could not he realized with the old systems because of restrictions such as operation processing speed and CPU load factory by using PP7.

5.REFERENCE:

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6.BIOGRAPHY:

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