Becoming #1 Product Quality in the Industry

Yuuji Ide Yasutaka Narusawa Naoaki Takizawa Yoshitomo Murayama

Masami Andou Shunsuke Niimi Hiroaki Yanagisawa Michiaki Kobayashi

1. Introduction

With the “SANMOTION R” Series ADVANCED MODEL developed to increase the resource saving and the productivity of the applicable equipment, it has installed relatively large software to enhance the performance and the function, but at the same time, mounted very small parts to minimize its size. This section explains the measures of designing, production, and quality control in accordance with the software and high-density mounting of the small parts for the product development of the AC servo amplifier “SANMOTION R” Series ADVANCED MODEL, and explains the measures to become #1 in the industry through improvement of the designing and product quality.

2. “SANMOTION R” Series ADVANCED MODEL

The AC servo amplifier “SANMOTION R” Series ADVANCED MODEL is equipped with new function such as high responsiveness, high accuracy, vibration suppression control, auto tuning, easiness of usage, new setup software, improved safety, and improved maintainability.

As for the high responsiveness, it has installed a high power torque control to improve the torque of the motor, a high response position and velocity control that has improved the frequency response to twice the conventional model, and a model following control that will realize the optimal operation by moving the actual control system tracking the model.

As for the high accuracy, it has installed a disturbance observer that will control the effect of the external force, a position command movement average filter, a high segmentation compliant electronic gear, a high resolution position signal output, and an independent forward and reverse internal torque limit function.

As for the damping control, it has installed a feed-forward damping control to control the extremity vibration and a model following damping control to control the vibration of the equipment base.

As for the auto tuning, it has installed a model following auto tuning that will perform the tuning including the model control system and feed forward gain manual setting function for auto tuning.

Also, to make it easier to use, it has installed a daisy chain connector and motor auto-identification function.

Setup software was made multiwindow, and has installed project management function, multiple channel operating trace function, and system analysis function to measure the frequency characteristics of the equipment using the M-sequence signal.

It also has hardware gate-off function to improve the safety of the operating equipment, alarm status display function, and alarm history timestamp function.

However, small chip parts, narrow pitch QFP type ASIC, and BGA type CPU is adopted as the hardware to take measures for the resource saving. It has also decreased up to 15% in volume by optimizing the cooling, reduction in a number of components, and minimizing the power supply circuit by using the bootstrap-switching power.

Fig. 1: AC servo amplifier “SANMOTION R” Series ADVANCED MODEL

3. Measures to improve the design quality

With the development of this product, reliability technique and simulation technology were used exhaustively to improve the designing quality.

As for the reliability technique, quality was taken into account at the developing phase by the DR, FMEA, and FTA based on the quality management system.

As for the simulation technology, designing of the control circuit was performed by the PSpice [1], designing of the power circuit was performed by the PSIM [2], and the designing of the control system was performed by the MATLAB & Simulink[3]. Especially with the MATLAB & Simulink, not only the continuous system simulation but simulation considering discrete system is performed, allowing to analyze the simulation of the effect of the multi rate sampling in the model following control captured by the discrete system. Also, considering the implementation of the software, reliability of the software was improved by performing a detailed simulation using a fixed point simulation considering the location of decimal point for the calculation.

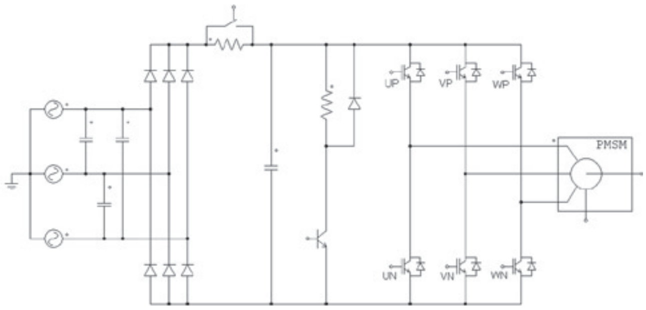

Fig. 2: Main circuit simulation model by the PSIM

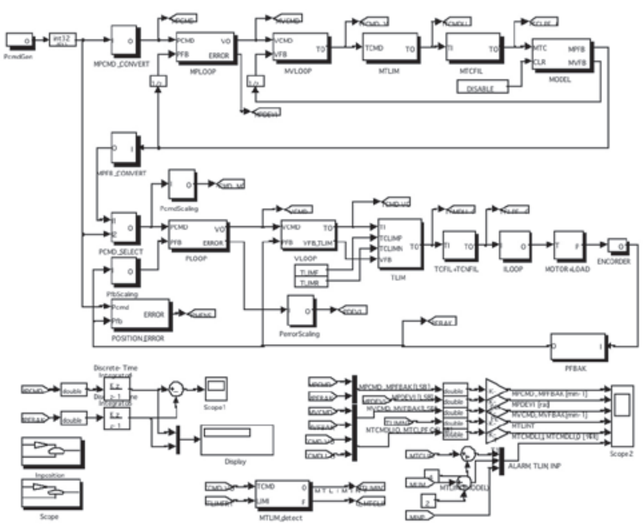

Fig. 3: Fixed point simulation model by MATLAB & Simulink

As for the software implementation, improvement of the designing quality was attempted by implementing the design process based on the V-Model shown in Fig. 4.

Also, in development of this product, improvement of the software quality and development efficiency was realized by improving following points.

- Efficiency of the workability was improved by newly implementing a project management tool suited for concurrent job by multiple developer teams.
- Architecture of the software was reexamined, realized layering wherever possible. By this, flexible measure to change in hardware or similar became possible, improving the portability and maintainability.
- A PC-based virtual environment for the servo amplifier was created, and by preceding the software designing on this virtual environment, it has improved the development efficiency.

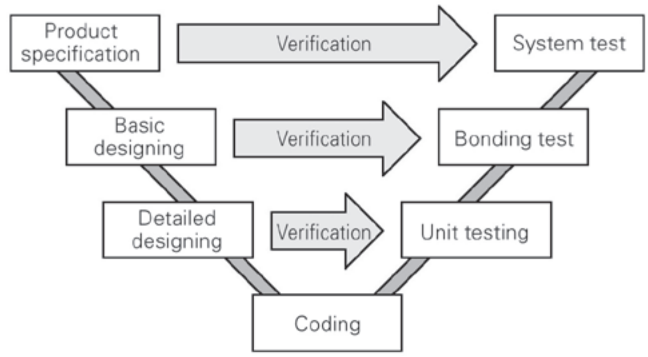

Fig. 4: Software development V-Model

As for the enclosure designing, architecture to make the assembly of the product easy, such as 3 divisible plastic case and die cast that was designed positioning guide pin for printed circuit board, is adopted. Small size high density amplifier was developed with high reliability by taking account of each part three dimensionally and considering the interference of each parts and creepage surface between the high voltage and low voltage circuits.

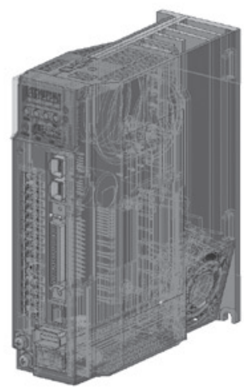

Fig. 5: Enclosure designing by the 3D-CAD

4. Measures to improve the product quality

As for the production, it was made to comply with high density implementation and narrow pitch, and it is produced with following schemes to perform stable production.

As for the printed circuit board production process, the stability of the print condition is monitored with solder paste printing inspection device (Fig. 6) to increase the accuracy of the solder paste printing, in accordance with high density implementation. And after the surface mount parts are implemented, soldering inspection for the very small chip parts and narrow pitch QFP, which was very difficult conventionally, are performed with high resolution laser inspector (Fig. 7). Determination process is made efficient also by simultaneously using the visual inspection support system (Fig. 8). As for the lead insertion parts, vision inspection device (Fig. 9) is used simultaneously, confirming the implementation condition and polarity for each parts. Any production failure found in each inspection process will be fed back to previous process in real time, pursuit of the cause, measure, and plan for preventing recurrence will be taken, creating a system to continuously improve the quality.

Fig. 6: Solder paste printing inspection device

Fig. 7: Laser inspector

Fig. 8: Visual inspection support system

Fig. 9: Vision inspection device

As for the assembly process, computerized work instructions (electronic support of the assembly process) was adopted, increasing the certainty of the operation. Operation methods, orders, notes, and cautions are displayed in the PC screen of the computerized work instructions (Fig. 10). Also, it is made not possible to move to next process until the torque up signal is detected from the electric screwdriver when screw cramp process, preventing the flaw by failing to attach screws, not seated, and skipping of the process. With this computerized work instructions, it is now possible to maintain stable quality regardless of the proficiency or skill level of the operators.

As for the inspection process, automatic inspection device is installed, and functional test is being performed.

By this, it is possible to maintain quality at high level and equalizing of the man-hour is realized regardless of the skill of the operator, just like the computerized work instructions.

Fig. 10: Computerized work instructions PC screen

Also, at the production factory, production system and sub systems such as process management, inventory management, and delivery management system, are installed and utilized, making it possible to take fulfill customers' request in real time. As a result, it is possible to produce requested products, as many as requested, and as soon as possible when requested, perfecting the production of multi product in small lot production to a higher level.

5. Conclusion

Outline of the measures taken to become #1 in the industry with AC servo amplifier “SANMOTION R” Series ADVANCED MODEL was explained in this section.

This product has installed new functions targeting resource saving and improvement of the productivity of the equipment, and an effort was made to make the amplifier high density. For the development of these functions or high density, designing quality is raised by using various simulations, new designing process, and new tools such as 3D-CAD. Product quality is improved also by high resolution inspection device, inspection from various aspects, system to prevent carelessness of the manual procedures, and system to rationalize the production. AC servo amplifier “SANMOTION R” Series ADVANCED MODEL is realized by these high quality productions based on various measures in designing, production, and quality managements.

We would like to improve the product quality by improving the designing quality applying these streamlining development tools. And adopting precision inspection devices. We also will keep our effort to prove customers a high performance, high quality, and competitive products that is considered to be #1 in the industry by challenging to keep the delivery time, reduce the inventory, and lower the costs.

Trademarks

(1) PSpice is a registered trademark of the Cadence Design Systems Inc.

(2) PSIM is a registered trademark of the Powersim Inc.

(3) MATLAB/Simulink is a registered trademark of The Math Works Inc.

Yuuji Ide
Joined Sanyo Denki in 1984.
Servo Systems Division, 2nd Design Dept.
Worked on the design of the servo motor control device.

Yasutaka Narusawa
Joined Sanyo Denki in 1991.
Servo Systems Division, 2nd Design Dept.
Worked on the design of the servo motor control device.

Naoaki Takizawa
Joined Sanyo Denki in 1978.
Servo Systems Division, 2nd Design Dept.
Worked on the design of the servo motor control device.

Yoshitomo Murayama
Joined Sanyo Denki in 1980.
Servo Systems Division, Quality Control Dept.
Worked on the quality control of the servo motor control device.

Masami Andou
Joined Sanyo Denki in 1985.
Servo Systems Division, 2nd Production Dept.
Worked on the production management and production technology of the servo motor control device.

Shunsuke Niimi
Joined Sanyo Denki in 2007.
Servo Systems Division, 2nd Production Dept.
Worked on the production management of the servo motor control device.

Hiroaki Yanagisawa
Joined Sanyo Denki in 1988.
Servo Systems Division, 2nd Production Dept.
Worked on the production management of the servo motor control device.

Michiaki Kobayashi
Joined Sanyo Denki in 1992.
Servo Systems Division, 2nd Production Dept.
Worked on the production technology of the servo motor control device.