



Yanmar Develops Generation 4 ECU for Agricultural Machinery, Construction Equipment and Boats

SAE J1939 Support a Determining Factor for Selecting MICROSAR

Yanmar Holdings Co., Ltd. (Yanmar Holdings) developed the Generation 4 ECU platform for common use in agricultural machinery, construction equipment and boats. To improve the efficiency of developing application software and to reuse the software assets, it has started using AUTOSAR Classic and selected Vector's MICROSAR Classic. What led to the decision was Vector's support for the SAE J1939 protocol for commercial vehicles and construction equipment and ISOBUS, a standardized communication protocol for agricultural machinery derived from SAE J1939, as well as NMEA 2000, a SAE J1939-based communication standard used in the marine industry.

ECU Platform Made for Common Use in Agricultural Machinery, Construction Equipment and Boats

As shown in its former name Yanmar Diesel, Yanmar Holdings had a strength in diesel engine, supplied engines and operated agricultural machinery business, construction equipment business and marine business. It changed to a holding company structure in 2013, and since then operating companies including the agricultural machinery company Yanmar Agribusiness Co., Ltd. (headquartered in Okayama, Okayama Prefecture), the construction equipment company Yanmar Construction Equipment Co.,

Ltd. (headquartered in Chikugo, Fukuoka Prefecture), and Yanmar Marine International Asia Co., Ltd. (headquartered in Kunisaki, Oita Prefecture), a developer and manufacturer of boats and marine equipment, have been placed under the umbrella of Yanmar Holdings Co., Ltd. (headquartered in Osaka, Osaka Prefecture).

"Product development and sales are handled by operating companies themselves, but it would be inefficient if each company developed an ECU platform, and therefore traditionally Yanmar Holdings has handled the ECU development for common use," said Mr. Akinori Kasuya,

ECU platform		Generation 3	Generation 4 ^[*1]
OS		None	AUTOSAR Classic (MICROSAR)
Computing power ^[*2]		1.0	Approximately 2.5 times
Memory capacity ^[*2]		1.0	2 to 4 times
Software per product		Proprietary structure	Developed as SW-C
J1939 compliance		○ (In-house development)	○ (MICROSAR BSW)
Product application (There are some exceptions)	Agricultural machinery	Applied	Gradually since 2023
	Construction equipment	Applied	Gradually since 2023
	Boats	Applied	Gradually since 2025

^[*1] Implement standard controller and motor controller are with AUTOSAR (See Figure 7) ^[*2]
When the Generation 3 ECU platform is set as 1.0 (See Figure 8)

Table 1. Yanmar Holdings' ECU platform

Electric & Electronics Control System Development Division, Innovation & Technology Division, Yanmar Holdings.
The Generation 3 ECU platform was commonly used by three operating companies. It was made the so-called "OS-less" and each operating company developed and implemented software per product (Left in the Table 1). However, sometime around 2014, a vendor announced that the microcontroller they were using would be EOL (end of life) in the near future.

AUTOSAR Classic Used to Re-use Software Assets

Yanmar Holdings took the microcontroller EOL announcement as an opportunity and started considering the Generation 4 platform (Right in Table 1). Although there were various choices for the architecture and structure, the company selected AUTOSAR Classic (AUTOSAR) (Figure 1). Mr. Kasuya explained the reason as follows: "When the ECU platform would be upgraded to Generation 5 and

Generation 6 in the future, we thought we would like to continue using the software on these platforms. Also because it was made in-house until the Generation 3 platform, we had to explain all specifications when outsourcing the development of the software. Given these issues, we concluded that we should use the industry standard architecture and selected AUTOSAR." AUTOSAR may need no explanation but it is a standardized software architecture set to promote the efficiency of automotive software development and reuse. Generally speaking, it consists of BSW (Basic Software), in which basic functions are implemented, and SW-C (Software Component), in which an application per vehicle model is implemented (Figure 1).

Yanmar Holdings drew a blueprint of ECU hardware, Microcontroller Abstraction Layer (MCAL) and BSW, etc. developed by itself and application software (SW-C) developed by each operating company to rollout products and officially decided to use AUTOSAR in 2019 in consultation with the operating companies.

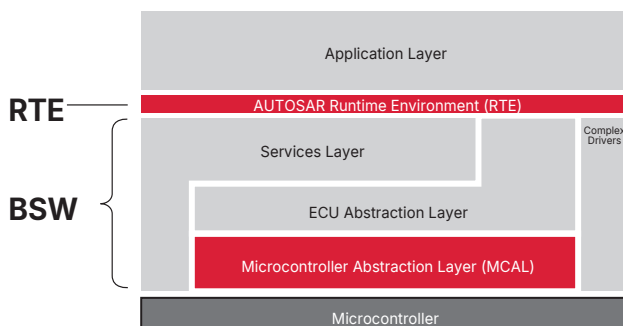


Figure 1. AUTOSAR Classic's basic software structure. Its notable feature is that BSW (Basic Software), which consists of common parts such as the diagnostic function and communication driver, and the application layer are separated. The application layer's software is also called SW-C.

Vector's MICROSAR, which Supports SAE J1939 and ISOBUS, Selected

There was a mandatory requirement in the development of the Generation 4 ECU platform commonly used in agricultural machinery, construction equipment and boats. That was compliance with SAE J1939, which had been used in each product.

J1939 is a network standard for trucks, trailers, buses and construction equipment, etc. and CAN is used as the physical layer and the data rate is 250kbps (J1939/11) or

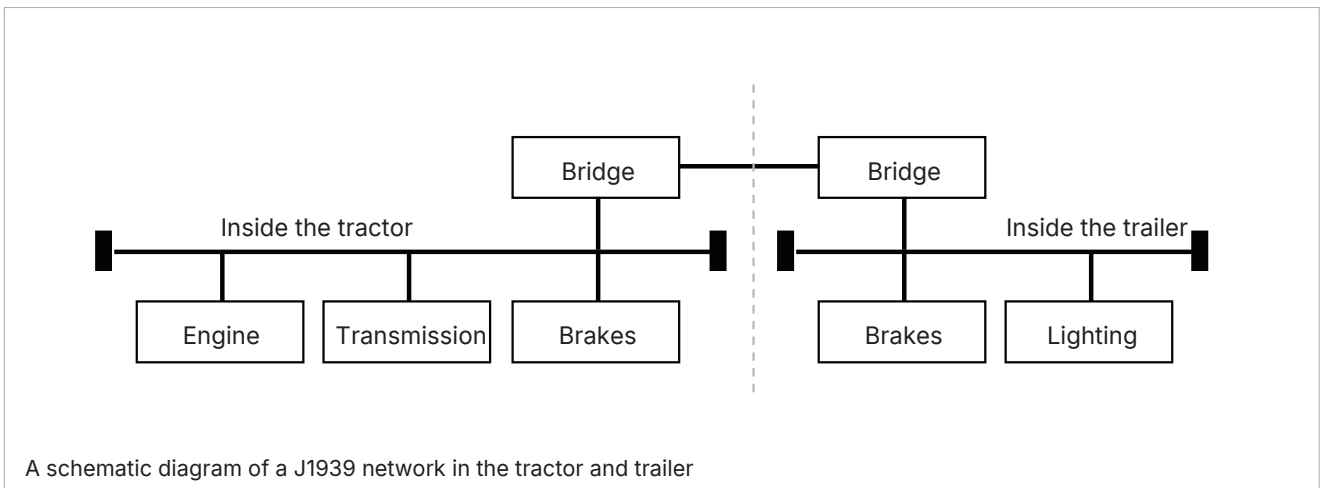


Figure 2. J1939 network schematic diagram

500kbps (J1939/14) (Figure 2). ISO11992 used for tractors, ISO11783 (known as ISOBUS) used for agricultural machinery and NMEA 2000 used for boats are standards all derived from J1939.

J1939 defines a mechanism called “address claim” in which a unique address is assigned to each ECU that connects with a J1939 network (Figure 3). After the power is on, each ECU claims an address before starting communication through CAN message. If several ECUs claim the same address, the address will be assigned to the ECU with high priority in the device name then other ECUs with low

priority claim different addresses. As a result of consecutive claims, a unique address with no overlap is assigned to each ECU.

However, the address claim function defined in J1939 (or other standards derived from J1939) was not fully covered by AUTOSAR Standard in 2019, and there was a restriction that addresses could not be dynamically assigned.

To realize the unrestricted address claim function on AUTOSAR, the purchased AUTOSAR’s function needed to be customized or BSW with higher coverage of the J1939 standard than the framework of AUTOSAR Standard needed to be selected. “When we looked for AUTOSAR that supports the J1939 standard and dynamic address assignment (address claim), Vector’s MICROSAR Classic (MICROSAR) was the only one we found in our search,” said Mr. Kyohei Nishikawa, Electric & Electronics Control System Development Division, Innovation & Technology Division, Yanmar Holdings. “Furthermore, the fact that the

Address Claim Dynamic

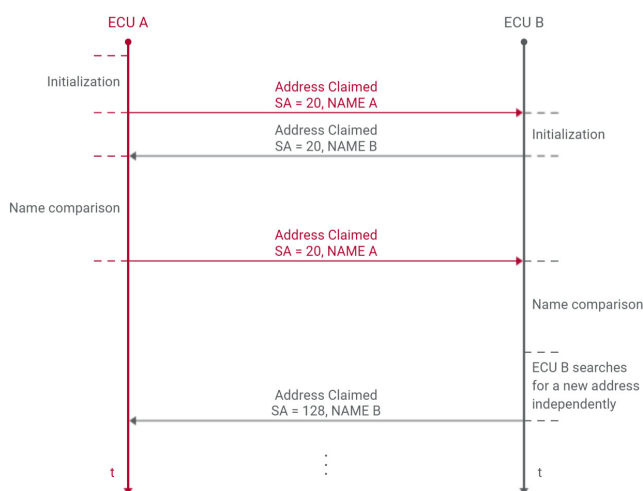


Figure 3. How address claims work in J1939. If ECU A and ECU B claim the use of the same address (20 in this example), ECU A, which has high priority in the device name, obtains the address, and then ECU B claims the use of a different address (128 in this example).

[<https://elearning.vector.com/mod/page/view.php?id=1676>]

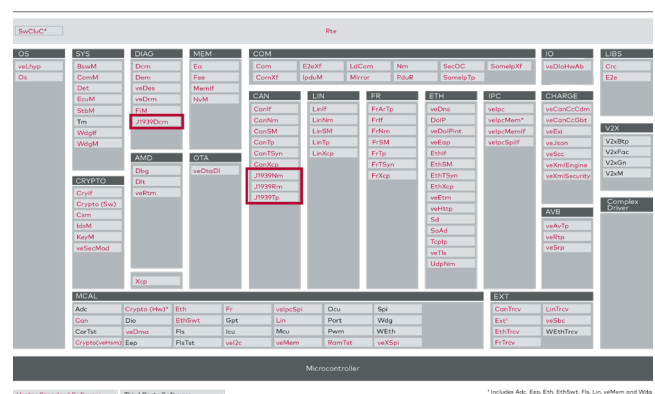


Figure 4. SAE J1939 module (marked with a red frame) provided as an option for MICROSAR

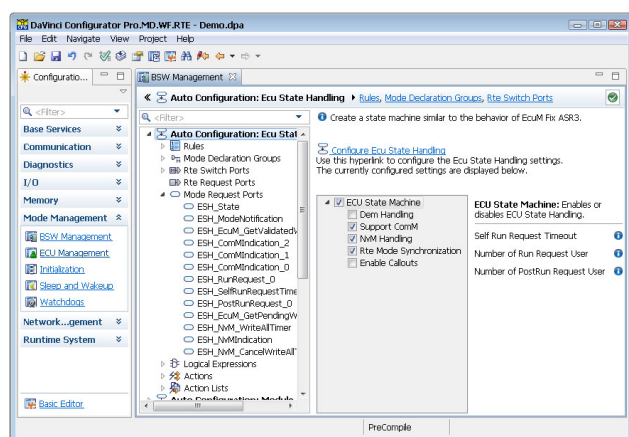


Figure 5. DaVinci Configurator Classic, a setting tool for BSW and RTE of MICROSAR

functions such as Fast-Packet set in the derived standards had already been implemented was a major factor and meeting J1939 specifications as easily as we wanted was a determining factor to select MICROSAR," he also said. "Initially, we were considering another vendor's AUTOSAR as well but additional development was required to comply with J1939 and we concluded it would be difficult to do so due to cost and time constraints," he added.

Vector has started offering J1939 support on the assumption of application in construction equipment and agricultural machinery from an early stage. Specifically, as MICROSAR BSW (Figure 4), it provides the network management module J1939Nm, which supports address claim and other functions, the request management module J1939Rm, which processes the J1939 protocol request and response, the transport layer module J1939Tp, which deals with each transport protocol, and the diagnostic communication manager J1939Dcm, which handles diagnostic messages (Figure 4).

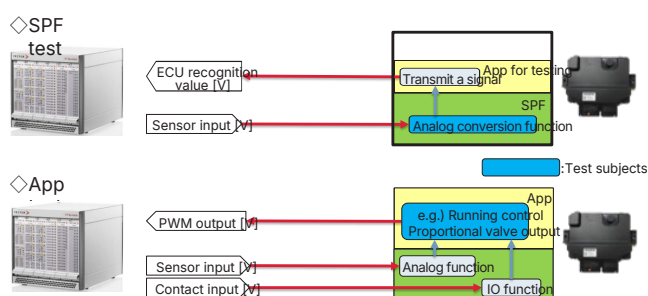


Figure 7. The Generation 4 ECU platform unit testing environment. With the use of Vector's CANoe and VT System, automated testing of the software platform (BSW) part and the application software (SW-C) part has been realized.

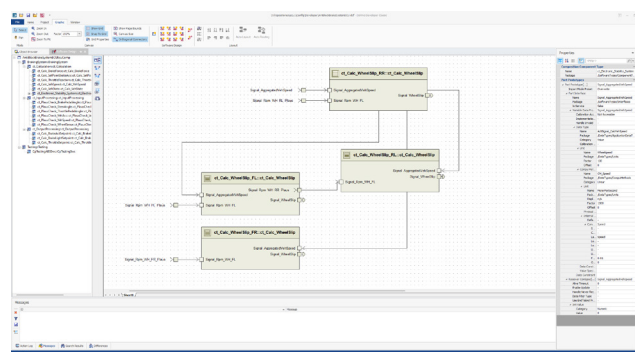


Figure 6. SW-C graphical definition also possible with DaVinci Developer

Participating in Vector's MICROSAR Seminars with Operating Companies' Staff

Partly because it used AUTOSAR (MICROSAR) for the first time, Yanmar Holdings outsourced the basic implementation of the Generation 4 ECU hardware to a European engineering company, with which it had done business. "We also studied AUTOSAR (MICROSAR) by reading AUTOSAR specifications and MICROSAR source codes," said Mr. Nishikawa. "Vector Japan's seminars were particularly helpful."

About 20 people from operating companies responsible for application software development took the AUTOSAR Basic course (8 hours) and some of them also took the AUTOSAR Classic in Practice course (7.5 hours × 3 days). As development tools, the MICROSAR setting tool DaVinci Configurator Classic (Figure 5) and the SW-C development tool DaVinci Developer Classic (Figure 6) have been introduced. Mr. Takashi Watanabe, Electric & Electronics Control System Development Division, Innovation & Technology Division, Yanmar Holdings had this to say

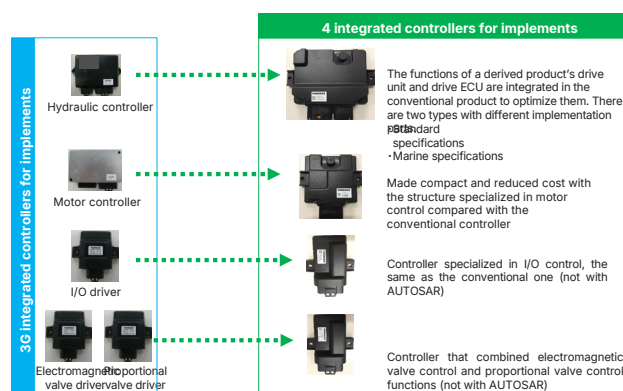


Figure 8. The structure of the Generation 4 ECU platform (4 integrated controllers for implements). The implement standard controller, which handles the main function, and the motor controller, which handles motor control, are with MICROSAR.

Product	Item	Performance comparison (vs. 3.5G)
Implement standard controller	Computing power	x2.5 ↑
	Memory	x2~4 ↑
	Number of inputs/outputs	x2 ↑
Motor controller	Computing power	x2.5 ↑
	Memory	x2~4 ↑
	Number of inputs/outputs	x0.6 ↓
I/O driver	Computing power	x2 ↑
	Memory	x4~5 ↑
Electromagnetic valve / proportional valve driver	Computing power	x2 ↑
	Memory	x4~5 ↑
	Number of outputs	x1.5 ↑

Computing power and memory enhanced greatly

Number of inputs/outputs enhanced as a system

Figure 9. Comparison of performance and memory capacity between the Generation 3 ECU platform and the Generation 4 ECU platform

about the development tools. "The DaVinci Configurator Classic can be operated from a script and called from the command line, which we find convenient, and more specifically, we have improved the efficiency such as by automating error correction and parameter change," he said. "The DaVinci Developer Classic doesn't have such functions, so we hope these functions will be implemented in the future."

VT System and CANoe Used in Unit Testing of the Generation 4 ECU

The development of application software equivalent to SW-C (transplanted from the Generation 3) was handled by each operating company. "ECU itself is the same hardware but how the microcontroller I/O pin is assigned is different for each product and also the CAN database is different for each operating company, and therefore we have asked each operating company to implement the DaVinci Developer Classic and the DaVinci Configurator Classic," said Mr. Nishikawa.

There was a difference in the level of difficulty in transplanting the Generation 3 ECU software asset in the Generation 4 ECU, depending on the product. Mr. Kasuya said: "I've heard that for the products in which software has been made into a component per function since the Generation 3, each function has turned into SW-C as it is and relatively smoothly transplanted in MICROSAR but there have been some difficulties for other products."

Vector's VT System and CANoe were used in ECU unit testing (Figure 7). Signals that imitated the sensor and switch are given to an ECU by the VT System and sampling

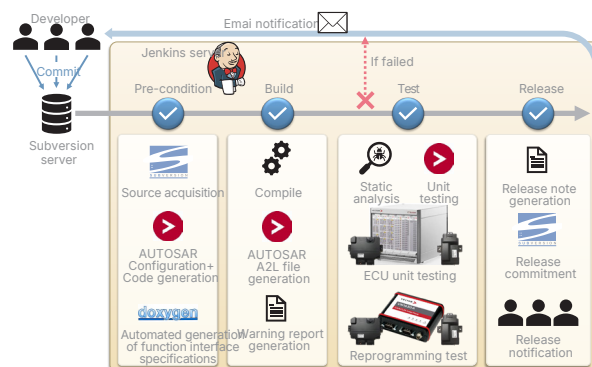


Figure 10. The conceptual diagram of the CI/CD loop Yanmar Holdings aims for. The DaVinci Configurator, which sets MICROSAR, the ASAP2 Tool-set, which generates an A2L file, the VT System, which conducts ECU testing, CANoe, and VectorCAST, which conducts software testing, are to be used from Vector's tools.

of outputs for the inputs is done by the VT System to determine whether the function is properly implemented. The same environment is used for testing of the software platform (BSW) part at Yanmar Holdings and testing of the application software (SW-C) part at each operating company and CANoe is used to conduct a test script and determine the result, realizing automated testing. Given that determining pass or fail becomes complex with application testing, in which multiple signals are handled, Yanmar Holdings is considering creating a template to improve the efficiency of building test cases.

In using Vector's tool chain including MICROSAR, Mr. Kasuya evaluated Vector Japan's response as follows: "When we ask questions, other vendors' responses are slow, and in some cases, we cannot receive an answer until we urge them to do so. Vector Japan's response is very quick." Mr. Watanabe also said: "Because questions about J1939 are escalated to Vector's head office in Germany, it takes a little more time but it often takes about 30 minutes to receive an answer about a tool related question, so it has been of great help."

Products with MICROSAR Released Gradually since 2023

The Generation 4 ECU platform consists of four devices: the implement standard controller, which handles mainly hydraulic control, the motor controller specialized in motor control, the I/O driver specialized in I/O control (not with AUTOSAR), and the electromagnetic valve and proportional valve driver (not with AUTOSAR), which combined electromagnetic valve control and proportional valve control (Figure 8). As the microcontroller was overhauled after the

EOL announcement, the performance has improved about 2.5 times and memory capacity has been up 2 times to 4 times (Figure 9).

The products with the Generation 4 ECU platform are agricultural machinery and construction equipment and have already been commercialized. Boats with the Generation 4 ECU platform are to be released in 2025.

In summarizing the development of the Generation 4 ECU platform, Mr. Kasuya said: "Partly due to time constraints, development work this time was mainly implementing MICROSAR and transplanting each application software and we have not been able to make the most of AUTOSAR's advantage. That said, the introduction of the Generation 4 ECU platform has prompted operating companies to review their architecture and proceed with ECU integration. In the future, we will work to improve development efficiency including separating BSW and SW-C and capitalizing SW-C in cooperation with the operating companies."

Yanmar Holdings is working to build a CI/CD environment to improve development efficiency further (Figure 10). In addition to Vector's tools for MICROSAR configuration, A2L file generation and unit testing, it plans to combine the use of other companies' tools and operates them all with Jenkins.

Vector has made available the Introduction to AUTOSAR^[*3] and the Introduction to J1939^[*4], which explain the basics of AUTOSAR and J1939, respectively, on its website^[*5]. We continue to provide support for various automotive networks including J1939.

[*3] Introduction to AUTOSAR :
https://www.vector.com/ds_beginners-autosar_jp/

[*4] Introduction to J1939 :
https://www.vector.com/ds_beginners-j1939_jp/

[*5] SAE J1939 Know-how :
<https://www.vector.com/jp/ja/know-how/protocols/sae-j1939/>

Sources :

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