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3.1 Drone Detection System for Counter-Unmanned Aerial Systems

Outline of counter-unmanned aerial systems (C-UAS) solutions

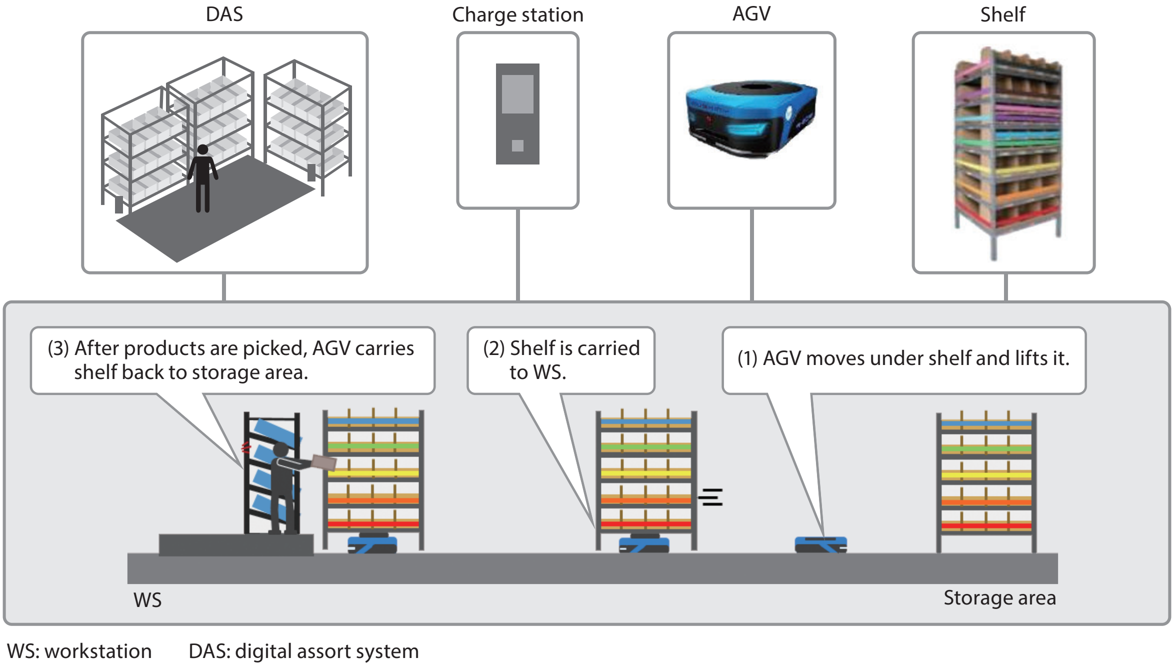
Prototype drone detection system without RF transmission

Drones are used more frequently than ever for logistics services and infrastructure inspections. On the other hand, critical facilities and airports have been attacked by illegal drones, necessitating counter-unmanned aerial systems (C-UAS) to detect and defend against such devices.

With this in mind, Toshiba Infrastructure Systems & Solutions Corporation has developed a drone detection system using an RF sensor. The new RF sensor receives radio waves emitted by drones and estimates their direction using radio wave visualization technology. RF sensors have an advantage over radar systems in terms of installation flexibility as they do not emit microwaves. Our new RF sensor can receive not only the 2.4 GHz band used in Japan but also the 5.8 GHz band used overseas.

We have already completed functional and performance evaluations of the prototype drone detection system with plans to release it shortly.

3.2 Warehouse Shelf Picking Robot Operation Optimization Software



Series of operations performed by shelf picking robot

The logistics industry is facing ever-harsher business conditions due to the increasing freight volume driven by the growth of electronic commerce, a declining birthrate, aging population, and the spread of infectious diseases, necessitating the mechanization of distribution warehouse operations.

With this in mind, the Toshiba Group is developing "asset-light" robots and a warehouse execution system (WES) that manages and controls the robots and equipment in a warehouse based on the concept of human-machine cooperation. As part of this initiative, we have developed software to optimize the picking order and the planning of automated guided vehicles (AGVs) in a warehouse.

First, we optimized the order processing sequence to improve the hit rate, i.e., the percentage of products picked from one shelf at one time. This is expected to increase throughput as it reduces waiting time for AGVs carrying shelves to arrive at the workstation (WS). According to our simulation, this provides an estimated 21% hit rate increase.

Next, we developed control technology to search for feasible, optimal solutions to adjust travel routes and travel timing in order to avoid AGV traffic jams and deadlocks. We evaluated the general versatility and usefulness of the new control technology at two warehouses where AGV systems from other vendors were in use, including (1) the time required for shelf-carrying robots to complete their tasks, (2) the shelf stay rate at the WS (= work time / (work time + waiting time)), and (3) the AGV utilization rate. We conducted this evaluation while varying the number of AGVs and the number of WS performing the retrieval work.

According to our simulation, the above optimization techniques provide a 10% improvement in picking operation(*) productivity. We will continue to improve the functions and further enhance WES performance to achieve practical application at distribution warehouses.

(*) Parameter indicating how many lines of a picking order can be processed per hour

3.3 Delivery of Electrical Equipment for 315 Series Trains at Central Japan Railway Company

Toshiba Infrastructure Systems & Solutions Corporation offers environmentally friendly rolling stock systems developed on the concepts of safety and comfort. We received an order from Central Japan Railway Company (JR Tokai) for electrical equipment on 315 series trains, the first new commuter train in 23 years for JR Tokai, including (1) an automatic learning server, (2) a train control system, (3) an air-conditioning system, (4) a battery system for emergency operation, (5) a train control management system (TCMS), a main controller, various communication devices and on-board global navigation satellite system (GNSS) communication devices, and main electric motors. At present, we are in the process of delivering the order.

The features of the above electrical equipment are as follows:

(1) Automatic learning server: This supports Japan's first automatic artificial-intelligence (AI)-based air-conditioning system[*1] learning and control. The AI algorithm learns crew operations using various data transmitted from the on-board train control management system (TCMS) to the ground server. The results are fed back to the on-board TCMS to control the air-conditioning system automatically. The learning process is repeated with further feedback from the on-board TCMS to achieve optimal control.

(2) Train control system: To achieve redundancy, high efficiency, and energy saving, the train control system incorporates a hybrid silicon carbide (SiC) inverter system[*2] for dual-mode operation with a proven track record on existing trains.

(3) Air-conditioning system: This incorporates a new inverter control system featuring fine-tune control to save energy. This inverter control system provides an approximately 30% higher cooling capacity than the one used on the conventional 211 series and consumes approximately 35% less energy than our conventional system based on operating rate control.

(4) Battery system for emergency operation: This uses SCiB™ lithium-ion rechargeable batteries from Toshiba Corporation. Trains are powered via batteries to go to the nearest station in the event of a grid power failure. Battery energy is also used to operate the air-conditioning system and other auxiliary equipment to maintain passenger comfort.

(5) The vehicle information system uses the TCMS whereas the main controller uses a contact system. The driver dashboard screen incorporates an analog meter and consists of two display units for conciseness.

(∗1) As of March 2022 (according to Toshiba Infrastructure Systems & Solutions Corporation research)

(∗2) A system with an alternative circuit to maintain running performance and passenger services even in the event of auxiliary power circuit malfunction

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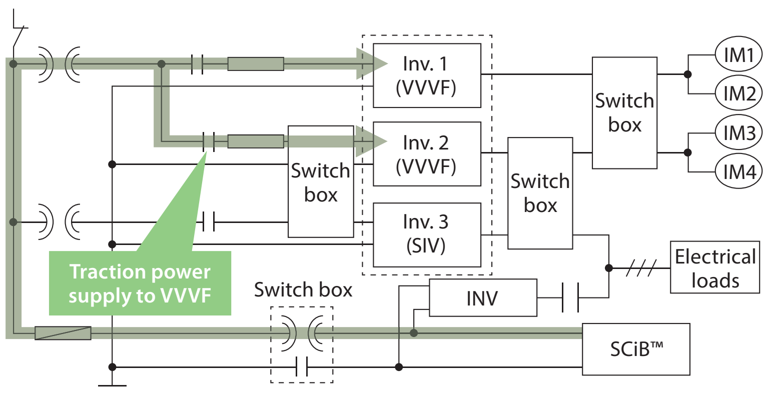
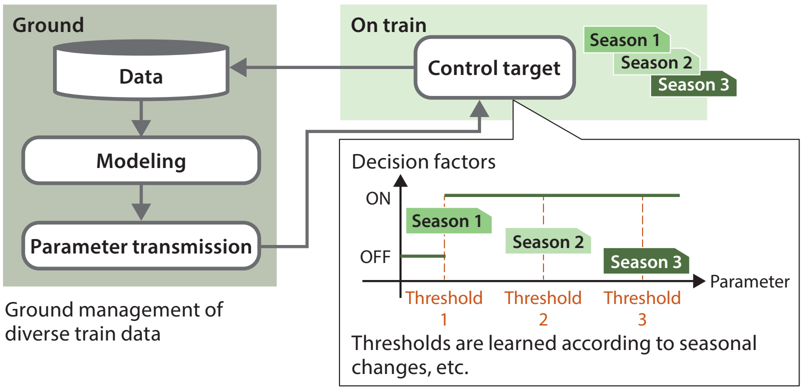
VVVF: variable-voltage, variable-frequency ES: energy storage SIV: static inverter

Electrical equipment for 315 series commuter trains at Central Japan Railway Company



INV: inverter SW: switch IM: induction motor

Emergency power supply route in emergency operation mode



Automatic learning for air-conditioning control

3.4 Replacement of Electronic Frequency Converter (EFC) and Static Var Generator (SVG) at Tsunashima Frequency Conversion Substation for Tokaido Shinkansen

The Tokaido Shinkansen is designed to run on 60 Hz single-phase electric power. However, Japan has two electrical grids that operate at different frequencies: 60 Hz in western Japan and 50 Hz in eastern Japan. Because the Tokaido Shinkansen travels through both eastern and western Japan, frequency conversion substations (FCs) are installed in the 50 Hz region to convert the electrical frequency to 60 Hz.

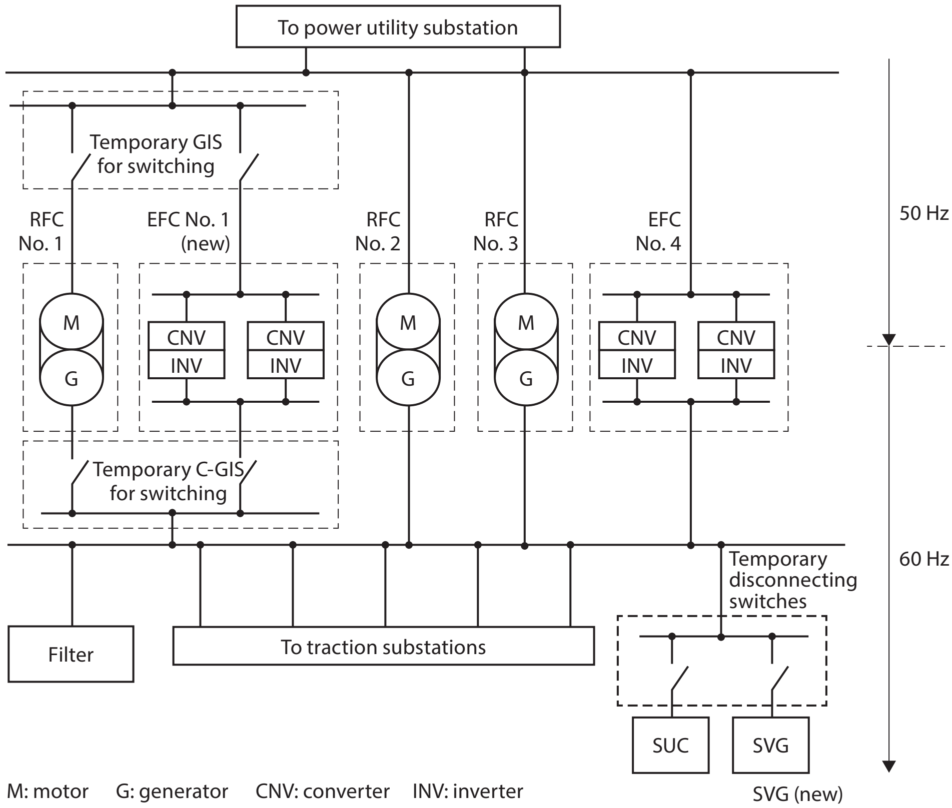
Toshiba Infrastructure Systems & Solutions Corporation has replaced one of the rotary frequency changers (RFCs) in the Tsunashima FC for the Tokaido Shinkansen with an electronic frequency converter (EFC), which provides advantages in terms of flexible power control, low energy loss, and low maintenance costs. We have also replaced a static unbalanced power compensator (SUC) with a static var generator (SVG), which supports both negative phase sequence power compensation and reactive power compensation.

Because this was the first replacement of an existing RFC with an EFC, there were several challenges to overcome not only for the construction of a new EFC but also for the changeover from the RFC to the EFC. To enable a smooth changeover, we temporarily installed gas-insulated switchgear (GIS) and cubicle-type GIS (C-GIS) in the main circuit as well as disconnecting switches in the control circuit.

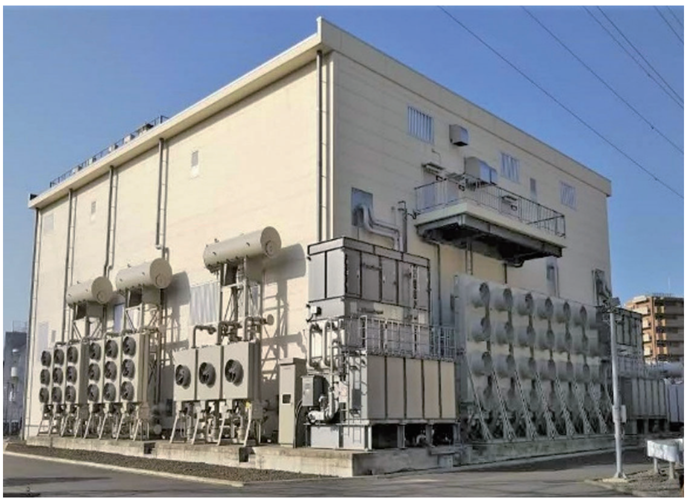
In addition, we developed new software to cater to both RFC and EFC control systems. We also modified the software of the programmable logic controller (PLC) to identify the type of frequency converter via an input signal while upgrading the supervisory control and data acquisition (SCADA) software to support monitoring and control of the new EFC although it did not originally support the existing RFC.

As a result, we achieved smooth switching between the RFC and the EFC during the construction period, with the existing RFC being used for commercial operation in the daytime and the new EFC being used for on-site testing and commissioning in the nighttime. We also implemented similar measures to replace the existing SUC with the new SVG.

Following successful testing and commissioning, the new EFC and SVG commenced operation simultaneously in March 2022.



Main circuit switching diagram of replacement electronic frequency converter (EFC) No. 1 and static var generator (SVG) installed at Tsunashima Frequency Conversion Substation for Tokaido Shinkansen



Building housing EFC No. 1 and SVG

3.5 Expansion of PMSM Sales in South Korean Railway Market

Permanent magnet synchronous motor (PMSM) for new trains on Seoul Metro Line 7, South Korea

Delivered PMSM

In February 2022, Seoul Transportation Corporation in South Korea commenced commercial operations of Seoul Metro Line 7, on which trains equipped with a permanent magnet synchronous motor (PMSM) propulsion system run.

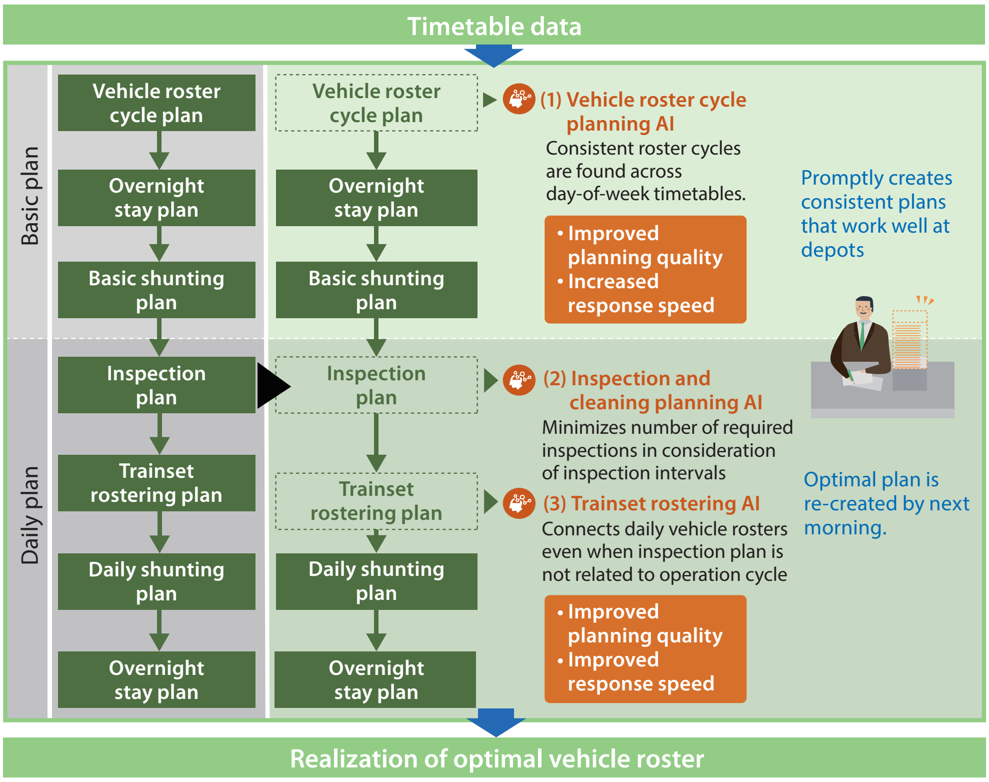
The PMSM, a high-efficiency motor that uses permanent magnets in the rotor, consumes much less power and requires less maintenance than conventional motor systems. The PMSM is expected to deliver a 30% reduction in power consumption in comparison with a conventional motor.

In 2018, the Busan Transportation Corporation adopted PMSM systems for the Busan Metro for the first time in South Korea. The Busan Transportation Corporation chose PMSM systems to reduce power consumption due to growing environmental awareness.

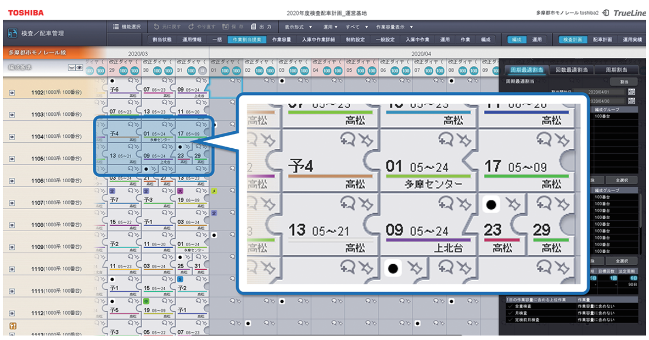
Although Toshiba Infrastructure Systems & Solutions Corporation has received orders for electrical equipment in the South Korean railway market, it is difficult to maintain sales simply by leveraging long-standing knowledge and experience in Japan. It was therefore essential to build a strong relationship with local partners, explain the benefits of PMSM systems to satisfy the customer, and gain an accurate understanding of market demand.

We will continue to earnestly engage with our customers and contribute to the development of the railway industry.

3.6 Optimization of Vehicle Roster Planning for Tama Monorail Using AI



Process for vehicle rostering operation plan creation employing AI technologies



Example of inspection planning and trainset rostering service display

Tokyo Tama Intercity Monorail Co., Ltd. applied artificial intelligence (AI) to vehicle roster planning when it revised the timetables of the Tama Monorail in March 2022. This revision is expected to deliver an approximate 5% reduction in annual operating costs.

Developed by Toshiba Corporation, in collaboration with Toshiba Infrastructure Systems & Solutions Corporation and Toshiba Digital Solutions Corporation, this AI solution for vehicle roster planning consists of the following three AI components:

(1) Vehicle roster cycle planning AI

This AI tool creates a plan for vehicle roster cycles that help reduce variations in operation plans caused by vehicle inspection requirements while satisfying the constraints of the depot.

(2) Inspection and cleaning planning AI

This AI tool creates daily plans for vehicle inspection and cleaning so that such tasks are performed at the designated interval when vehicles are available.

(3) Trainset rostering AI

This AI tool creates plans for daily trainset rostering based on the vehicle roster cycles and inspection and cleaning plans.

Toshiba Infrastructure Systems & Solutions Corporation has confirmed that this AI solution creates plans close to those of an expert. It simplifies the creation of various daily plans and facilitates re-planning when changes occur.

Toshiba Infrastructure Systems & Solutions Corporation will continue to contribute to railway operations through various digital technologies, including the TrueLine railway transit scheduling service that incorporates the AI technology of the Toshiba Group.

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3.7 Launch of New Motor and Generator Factory for Electrified Vehicles in Vietnam

New factory in Vietnam for mass production of motors and generators for electrified vehicles

Toshiba Infrastructure Systems & Solutions Corporation has constructed a new factory handling the mass production of traction motors and generators for electrified vehicles(*) at Toshiba Industrial Products Asia Co., Ltd. Located on the outskirts of Ho Chi Minh City in Vietnam, this factory commenced generator production in April 2022.

The building area of the new factory measures 13 600 m^2, and its production capacity can be scaled up to 600 000 units per year. We optimized the building design by simulating the transfer of finished products and parts according to the production capacity, considering the movement of operators and parts.

We have established mass-production bases to supply our products across the globe by adding the new factory to two existing production sites: Toshiba Industrial Products and Systems Corporation plants in Asahi-cho, Mie-gun, Mie, Japan and Toshiba International Corporation in Houston, Texas, U.S.A.

Demand for electrified vehicles is growing rapidly around the world, especially in Asia. We will expand the production of traction motors and generators to contribute to the promotion of electrified vehicles and thereby help to achieve a carbon-neutral society.

(*) "Electrified vehicle" is a general term that represents vehicles powered by electric energy stored in an onboard battery, such as electric and hybrid vehicles.

3.8 Compact Unified Controller nv-pack Series typeCP Industrial Controller for Parallel Information Processing

Control systems are the backbone of the manufacturing industry. They are designed to collect and analyze data from field devices such as sensors and valves using an industrial controller and control the field devices according to the analysis results. In recent years, demand for cyber-physical systems (CPS) has grown to transfer data from industrial computers to a host system such as a server and control field devices based on the results of an analysis of the accumulated data.

A CPS creates added value by using a massive amount of data. To achieve a CPS, it is necessary to solve problems such as an increase in data traffic from field devices to a host system and real-time performance degradation due to delay times between a control system and a data collection and analysis system.

With this in mind, Toshiba Infrastructure Systems & Solutions Corporation has commercialized the Unified Controller nv-pack series typeCP, which accommodates the requirements of the CPS. The nv-pack series integrates both control and computing functions to reduce data traffic and improve real-time performance. The nv-pack series control and computing functions work in tandem to perform numerical analysis and image processing for visualization while collecting data. Data transfer to/from a host system can be performed by a single nv-pack series computer without the need for an industrial computer or controller.

The new typeCP is approximately half the size of the existing typeFA. Despite being a software-enabled controller, the typeCP can automatically perform operating system (OS) shutdown upon power interruption because it is equipped with an OS shutdown battery. Therefore, the typeCP facilitates system construction.

The typeCP supports parallel operation of real-time control of field devices and data collection and analysis. It saves space, supports normal OS shutdown upon power interruption, and facilitates the construction of elaborate systems.

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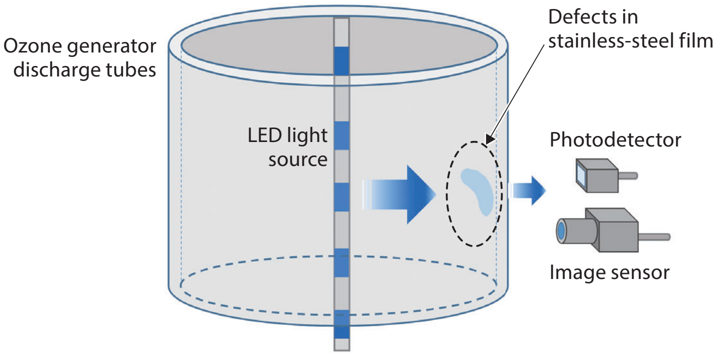
Unified Controller nv-pack series typeCP industrial controller

Item		Specifications	Remarks
Processor	Main processor	Intel Atom® X5-E3940 (1.6 GHz)	
	Cores/threads	4/4	
	Cache memory	2 MB	
Main memory		8 GB	With ECC
Auxiliary storage device	Storage drive	512 GB SSD	
Interfaces	COM interface	RS-232C: 1 channel (backside) (9-pin D-sub, asynchronous, up to 115.2 kbps)	
	USB interfaces	USB 3.0 (Type A): 2 ports USB 2.0 (Type A): 2 ports Two ports are used for keyboard and mouse.	
	LAN interfaces	10BASE-T / 100BASE-TX / 1000BASE-T: 2 ports (backside) (auto switching, RJ45)	
	Graphic interface	DisplayPort×1 ch	
RAS functions		CPU temperature rise detection, chassis temperature detection, internal voltage detection, CMOS battery status monitoring, memory error detection, PCI bus error detection, WDT monitoring (during system startup and operation), soft power-off (shutdown), error log saving in RAS memory, battery status detection for OS shutdown, switching to backup power supply by OS shutdown battery	
Dimensions		114 (W) × 222 (H) × 221 (D) mm (Dimensions do not include rubber feet or protrusions)	

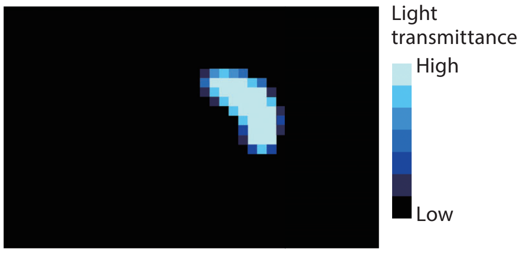
SSD: solid-state drive
COM: communication port
USB: Universal Serial Bus
PCI: Peripheral Component Interconnect
RAS: reliability, availability, and serviceability
CMOS: complementary metal-oxide-semiconductor
WDT: watchdog timer
ECC: error correction code

Main typeCP specifications

3.9 Technique to Evaluate Deterioration of Ozone Generator Discharge Tubes



Device configuration of deterioration diagnosis method for ozone generator discharge tubes



Example of display showing two-dimensional light transmittance distribution image

For ozone generators to maintain an ozone level for a long period of time, it is necessary to replace discharge tubes that have deteriorated. As they do so, defects in the thin stainless-steel film on the inner surface gradually spread because of the effects of electrical discharges and chemical components.

Toshiba Infrastructure Systems & Solutions Corporation has developed a technique to evaluate the level of discharge tube deterioration by measuring the degree of the defects in the stainless-steel film. The new technique uses light-emitting diodes (LEDs) placed inside a discharge tube as light sources. The light they emit travels through the defects in the stainless-steel film and reaches a photodetector and an image sensor placed on the outer surface of the discharge tube. The received light is photographed while its intensity is measured. Doing so makes it possible to evaluate the level of deterioration by quantifying the distribution of light transmittance for the stainless-steel thin film. It is also possible to set a deterioration threshold by comparing the light transmittance distribution of a sound discharge tube with that of a faulty one.

To further improve the evaluation accuracy and estimate the remaining lifetime of discharge tubes, we will collect data on the level of defects and analyze the characteristics of defect shapes.