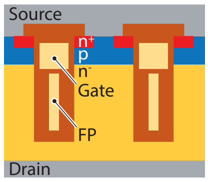
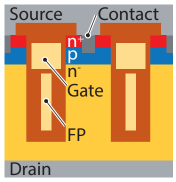
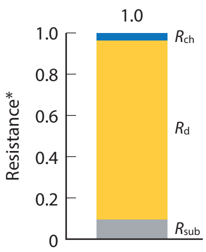
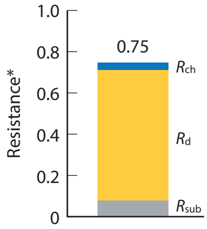
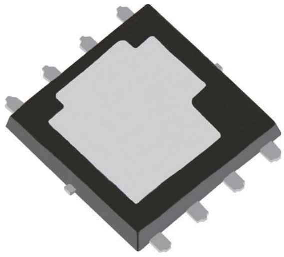
U-MOS X Manufacturing Process for Next-Generation Automotive Low-Voltage Power MOSFETs

Generation	U-MOS VIII	U-MOS X
Device structure		
$R_{on}A$ (V_{GS} =10 V)		

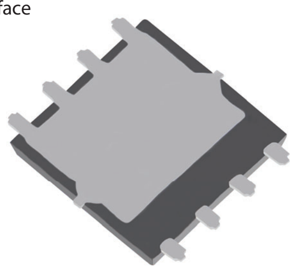
p: p-type semiconductor
n: n-type semiconductor
n^+: n-type semiconductor with higher impurity concentration
n^-: n-type semiconductor with lower impurity concentration
R_{ch}: channel resistance
R_d: drift resistance
R_{sub}: substrate resistance
V_{GS}: gate-source voltage

∗The $R_{on}A$ value is normalized relative to that of U-MOS VIII.

Comparison of device structure and on-resistance of U-MOS VIII and U-MOS X series MOSFETs for automotive products



Upper surface



Lower surface

DSOP Advance package with high thermal conductivity

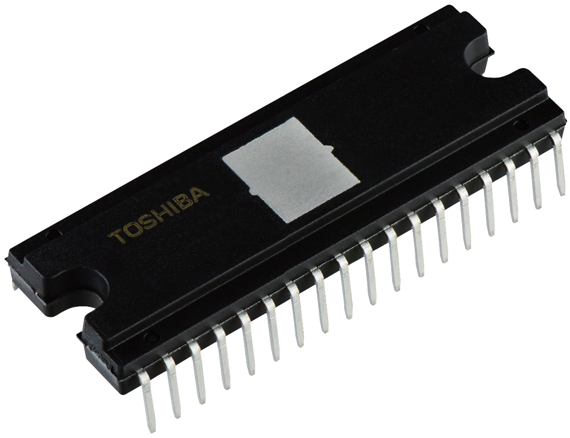
Green vehicles are becoming increasingly prevalent because of the tightening of carbon dioxide (CO_2) emission regulations in many countries. In addition, the automobile industry is committed to the development of safety technologies to realize autonomous driving. The resulting increase in the demand for automotive electronics is driving the expansion of the market for automotive low-voltage power metal-oxide-semiconductor field-effect transistors (MOSFETs).

Under these circumstances, Toshiba Electronic Devices & Storage Corporation has developed the 100 V-class U-MOS X wafer fabrication process and the DSOP Advance package (DSOP: double-side-cooling small-outline package) to meet the low power loss and size reduction requirements of the automotive market. U-MOS X is our proprietary wafer fabrication process for power MOSFETs that are designed for automotive applications with a 48 V battery power supply.

Automotive power MOSFETs with high output current density are required so as to combine low conduction loss and high ruggedness, which have a trade-off relationship. To achieve the best possible trade-off, the device structure has been optimized separately for MOSFETs with different absolute maximum voltage ratings. The newly developed U-MOS X process is based on the trench field plate (FP) structure of the 100 V-class U-MOS VIII process. The U-MOS X process provides a roughly 25% reduction in area-specific on-resistance ($R_{on}A$) thanks to its high device integration density due to its narrow body contact width and high dopant concentration in the drift layer. In addition, the U-MOS X process achieves high ruggedness as typified by high avalanche capability and a wide safe operating area (SOA) due to the optimized body contact.

The DSOP Advance package offers lower package resistance and higher thermal conductivity than the conventional SOP Advance package. The DSOP package measures only 5 × 6 mm, which is equivalent to the size of the SOP-8 package. The use of a soldered low-resistivity copper (Cu) connector for the source connection provides a 0.35 mΩ reduction in package resistance, compared with the conventional package having an ultrasonically joined aluminum (Al) ribbon source connection. The newly developed DSOP Advance package, which has the same footprint as the SOP Advance package, provides high thermal conductivity because of the exposed thick Cu connector. The transient thermal impedance of the DSOP Advance package is roughly 76% lower than that of the SOP Advance package at a pulse width (t_w) of 3 seconds, which is typical for electric power steering systems.

600 V Sine Wave PWM Driver ICs for Brushless Fan Motors



600 V sine wave PWM driver IC for brushless fan motors

Toshiba Electronic Devices & Storage Corporation provides the TB67B000 series of sine wave pulse-width modulation (PWM) driver integrated circuits (ICs) that integrate a controller and a driver in one package. The TB67B000 series is designed for three-phase brushless fan motors in home appliance and industrial applications such as air conditioners and air purifiers. The single-package PWM driver IC simplifies motor control without the need for complicated circuit design.

We have now expanded the lineup of the TB67B000 series with next-generation 600 V/2 A PWM driver ICs. The demand for high-efficiency three-phase brushless fan motors is expected to increase because of growing diffusion of energy-saving consciousness.

In addition, the power supply voltage fluctuates significantly in emerging countries due to instability of the electricity grid. To ensure product reliability, PWM driver ICs with higher withstand voltage than the conventional 500 V/2 A TB67B000HG are required. The 600 V/2 A PWM driver IC meets this requirement and can easily replace the conventional PWM driver IC because they are pin-compatible.

There is also strong demand in the market for space and energy saving. To meet these needs, we are developing a small 36-pin shrink small-outline package with heat sink (HSSOP) having a footprint of 17.5 × 11.93 mm as well as motor drivers incorporating output-stage FETs.

Furthermore, we will expand the lineup of motor drivers incorporating InPAC, our proprietary intelligent phase control technology that simplifies high-efficiency motor control.

Nearline TDMR HDDs with Industry's Highest Capacity of 16 Tbytes

MG08ACA16T 16 Tbyte 3.5-inch HDD for nearline storage applications

With the fast-growing prevalence of cloud services, the volume of data generated is increasing. In this situation, demand for high-capacity hard disk drives (HDDs) for data centers is increasing.

To meet this industry requirement, Toshiba Electronic Devices & Storage Corporation released the MG08 series of 3.5-inch(*1) nearline HDDs in January 2019, which are the second generation of helium-sealed HDDs. Incorporating two-dimensional magnetic recording (TDMR) technology, the MG08 series has achieved the industry's highest capacity of 16 Tbytes(*2) for a conventional magnetic recording (CMR) HDD(*3).

The previous HDDs use one writer and one reader per head, whereas TDMR HDDs use two readers per head. The MG08 series incorporates a read channel IC that provides two-dimensional signal processing using two types of read signals from the media to improve the signal quality. The MG08 series incorporates many other innovations to increase recording density, including improved head architecture, an optimized media material to enhance the signal quality, controlled spacing between the head element and the media surface, and improved servo control technology and suspension to improve the head positioning accuracy.

In addition to its storage capacity of 16 Tbytes, a 14.3% increase from the previous 14 Tbyte MG07 series, the MG08 series provides a roughly 6% higher maximum sustained data rate and up to approximately 7% higher random write performance than the MG07 series through enhanced cache and servo technologies. Furthermore, the Serial Advanced Technology Attachment (SATA) model of the MG08 series provides up to 18% higher power consumption efficiency(*4) than the MG07 series. These improvements will contribute to a reduction of the power consumption of data storage systems.

(*1) The industry's standard form factor for HDDs

(*2) Definition of capacity: Toshiba Electronic Devices & Storage Corporation defines a terabyte (Tbyte) as 10^{12} (1 000 000 000 000) bytes.

(*3) As of January 2019 (as researched by Toshiba Electronic Devices & Storage Corporation)

(*4) Power efficiency is calculated by dividing active idle power consumption by the formatted capacity.

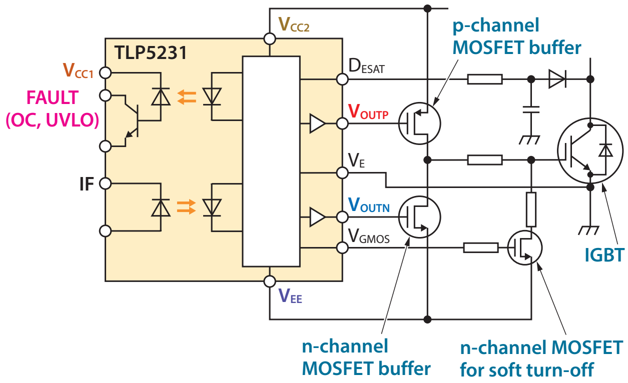
TLP5231 IGBT Gate Driver Photocoupler for Low-Power-Consumption Inverter Applications

Insulated gate bipolar transistor (IGBT) gate driver photocouplers with overcurrent protection and soft turn-off functions are widely used in various fields, including industrial and photovoltaic inverter applications.

Toshiba Electronic Devices & Storage Corporation has developed the TLP5231 IGBT gate driver photocoupler with a MOSFET buffer configuration that provides a peak output of ±1 A.

The conventional photocouplers (TLP5214 and TLP5214A) are not capable of full-swing operation since they use a bipolar buffer for current amplification whereas the newly developed TLP5231 provides full-swing output, making it possible to reduce the power consumption of inverter systems. The TLP5231 is designed to be able to drive external discrete MOSFETs (n-channel and p-channel MOSFET buffers, and an n-channel MOSFET for soft turn-off) as well as IGBTs in inverter designs. The TLP5231 also incorporates overcurrent protection and IGBT soft turn-off functions, reducing the costs of external components and the required board area.

With its innovative features as described above, the TLP5231 is ideal for low-power-consumption inverter applications.



V_{CC1}: power supply for primary side
FAULT: fault signal output
OC: overcurrent
UVLO: undervoltage lockout
IF: light-emitting diode (LED) input current
V_{CC2}: positive power supply for secondary side
D_{ESAT}: desaturation-sensing input
V_{OUTP}: gate drive output for p-channel MOSFET buffer
V_E: voltage reference for IGBT emitter
V_{OUTN}: gate drive output for n-channel MOSFET buffer
V_{GMOS}: gate drive output for p-channel MOSFET for soft turn-off
V_{EE}: negative power supply for secondary side

Example of application circuit of TLP5231 IGBT gate driver photocoupler for factory automation inverters

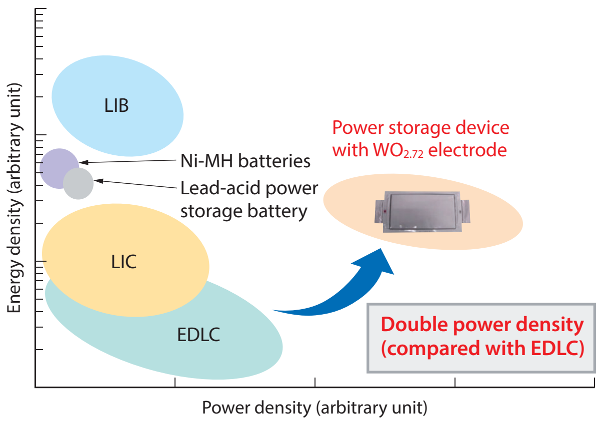
Application of Tungsten Oxide Electrode Material to Power Storage Devices

In recent years, the market for power storage devices typified by lithium-ion batteries (LIBs) and electric double-layer capacitors (EDLCs) has been expanding. Against this background, efforts are accelerating to increase the capacity and charge/discharge speed of power storage devices.

Toshiba Materials Co., Ltd. has already developed oxygen-deficient tungsten oxide ($WO_{2.72}$) powder as an electrode material for power storage devices. $WO_{2.72}$ powder has outstanding electron conductivity and enables ultrafast charging and discharging by forming tunnels in crystal structures that act as ion diffusion paths.

As the next step, we have created a prototype of a laminated power storage device using $WO_{2.72}$ and evaluated its charge/discharge characteristics. The evaluation results showed that it has higher energy density than and double the power density of an EDLC. We have begun distributing this material to power storage device manufacturers.

This material will be applied to power storage devices in automotive energy regenerating systems and large current sources. It is expected to improve fuel efficiency and contribute to the realization of a green society.



LIC: lithium-ion capacitor
Ni-MH: nickel-metal hydride

Characteristics of electricity storage device using $WO_{2.72}$ electrode