Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.
Block Diagram
Air Conditioner Details of AC-DC unit

AC-DC circuit

Outdoor unit

AC-DC circuit

Indoor unit

Device selection

- 650V MOSFETs are recommended for primary switching of AC-DC converters
- Transistor couplers are for output voltage feedback

Proposal from Toshiba

- Ideal for high-efficiency voltage switching
- π-MOS series power MOSFET
- Environmentally resistant photocoupler
- Transistor output
- Resistant to power supply noise
- Miniature surface-mounted LDO regulator

※Click on the blue circled numbers above to view detailed explanations.
**PFC circuit**

**Full switching system**
- MOSFETs are ideal for full switching solutions
- IGBTs are good for partial switching solutions
- Transistor couplers are for insulating signals
- Microcontrollers can be used for PFC control

**Proposal from Toshiba**
- Suitable for high-efficiency power supply switching
  - DTMOSVI series power MOSFET
- IGBT suitable for high withstand voltage and high current
  - Discrete IGBT
- Easy software development using general-purpose CPU cores
  - Microcontroller

**PFC circuit**

**Partial switching system**
- MOSFETs are ideal for full switching solutions
- IGBTs are good for partial switching solutions
- Transistor couplers are for insulating signals
- Microcontrollers can be used for PFC control

※ Click on the blue circled numbers above to view detailed explanations.
**Device selection**

- IPD are suitable for indoor & outdoor units
- FRD (Fast recovery diode) using MOSFET are suitable for compressors
- Transistor couplers are for insulating signals
- Using brushless motor drivers, 3-phase brushless motors can be easily controlled

**Proposal from Toshiba**

- **Suitable for high-efficiency power supply switching**
  DTMOS IV (HSD) series power MOSFET
- **High withstand voltage motor driver circuit**
  High withstand voltage IPD
- **Easy control of motors**
  Motor driver
- **Easy software development using general-purpose CPU cores**
  Microcontroller

---

**Fan section (indoor/outdoor units)**

High withstand voltage IPD

![Diagram of Fan section](image)

- MCU → IPD → M → Brushless
- MCD (controller) + high withstand voltage IPD
- MCU (3-phase integrated controller) + high withstand voltage IPD

**Compressor section**

![Diagram of Compressor section](image)

- MCU (3-phase motor control) → IPD → M → Brushless

※Click on the blue circled numbers above to view detailed explanations.
Air Conditioner Details of Cleaning, louver & valve control unit

**Cleaning section**

- **7** MCU → Motor Control Driver → M Stepping

**Louver section**

- **7** MCU → Motor Control Driver → M Stepping

**Valve control section**

- **7** MCU → Photocoupler → Triac → 2Way Valve/4Way Valve

**Device selection**

- Brushless motor driver allows easy control of 3-phase brushless motor using inverter control
- Stepping motor driver enables efficient motor control by optimizing real-time current to the motor
- Brush motor driver allows low power consumption

**Proposal from Toshiba**

- Easy motor operation
  - Motor driver
- Environmentally resistant photocoupler
- Easy software development using general-purpose CPU cores
  - Microcontroller

※Click on the blue circled numbers above to view detailed explanations.
Air Conditioner  Details of Microcontroller unit

**Microcontroller section**
Power control block for outdoor unit

![Diagram showing AC-DC, LDO, and MCU]

**Isolation circuit**
Compressor block between outdoor/indoor units

![Diagram showing Photocoupler and MCU connections]

※Click on the blue circled numbers above to view detailed explanations.

---

**Device selection**

- Isolation devices such as transistor couplers are effective when voltage differences exist between outdoor and indoor GND.
- Microcontrollers are suitable for system monitoring and control.

---

**Proposal from Toshiba**

- Environmentally resistant photocoupler
- Transistor output photocoupler
- High noise resistance
- Miniature surface-mounted LDO regulator
- General purpose CPU core allows easy software development

Microcontroller
To achieve good usability, voice commands require fast responses.

Stable system operation is assured by using op-amps and LDO power supplies having high motor noise immunity.

General purpose CPU core allows easy software development.

Avoid faulty circuit operation by absorbing ESD from external connectors.

Accurately track changes in current dissipation.

Ultra low noise Op-amp.

※Click on the blue circled numbers above to view detailed explanations.
Recommended Devices
As indicated earlier, air conditioner design must address “Quietness/efficiency of motors”, “Low power consumption of final product”, “Miniaturization of circuit board” as important criteria, which lead to three proposed device solutions.

- **Quiet, efficient motor**: 3-phase motor with high withstand voltage
- **Low power dissipation**: High efficiency + low loss
- **Miniature board**: Miniature packaging
## Device solutions to address customer requirements

<table>
<thead>
<tr>
<th></th>
<th>Device</th>
<th>3-phase motor with high withstand voltage</th>
<th>High efficiency + low loss</th>
<th>Miniature packaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Medium withstand voltage power MOSFET</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Photocoupler</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Discrete IGBT - silicon N channel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Miniature surface-mount LDO regulator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>IPD（Intelligent Power Device）</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Motor driver</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Microcontroller</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>TVS diode</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Ultra low noise op-amp</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**π-MOSⅧ series power MOSFET**

**TK6A80E/TK10A80E/TK9J90E**

---

**Value provided**

**RonA reduced by 24% - Power supply efficiency improved - Higher miniaturization**

1. **RonA reduced by 24%**

   By using latest generation π-MOSⅧ chip design, figure of merit Ron·A is reduced by 24% (π-MOSⅣ comparison of Toshiba products)

2. **Qg reduced by 23%**

   By using latest generation π-MOSⅧ chip design, Qg is reduced by 23% (π-MOSⅣ comparison of Toshiba products)

3. **Coss reduced by 18%**

   By using latest generation π-MOSⅧ chip design, Coss is reduced by 18%

**Line up**

<table>
<thead>
<tr>
<th>Part number</th>
<th>TK6A80E</th>
<th>TK10A80E</th>
<th>TK9J90E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>TO-220SIS</td>
<td>TO-3P(N)</td>
<td></td>
</tr>
<tr>
<td>V_{DS} [V]</td>
<td>800</td>
<td>800</td>
<td>900</td>
</tr>
<tr>
<td>I₀ [A]</td>
<td>6</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>R_{DS(on)} [Ω] @V_{GS} = 10 V</td>
<td>Typ. 1.35</td>
<td>0.7</td>
<td>1</td>
</tr>
<tr>
<td>Polarity</td>
<td>N-channel</td>
<td>N-channel</td>
<td>N-channel</td>
</tr>
</tbody>
</table>

**Turn-on waveform**

- 2SK3878
- V_{GS}: 10V/div
- V_{DS}: 100V/div
- I₀: 2A/div
- t: 40ns/div
- R_{G(on)} = 25Ω

**[condition]**

- V_{DD} = 400V
- I₀ = 4.5A(I₀ × 1/2)
- T_{c} = 25°C

---

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Ron•Qgd reduced by 40% - Power supply efficiency improved

1 Ron*Qgd reduced by 40%

Using a single epitaxial process, the figure of merit Ron-Qgd was reduced by 40% by optimizing the structure (DTMOS IV - H 600V withstand voltage). By realizing low Ron*Qgd, device switching loss was reduced contributing to improvements in power supply efficiency of equipment.

2 RonA reduced by 18%

The figure of merit RonA of the latest generation DTMOS VI has been reduced by 18% compared with the previous generation (DTMOS IV 650V withstand voltage products). Achieving low on-resistance while maintaining high withstand voltage contributes to high efficiency of equipment.

Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>TK040N65Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>TO-247</td>
</tr>
<tr>
<td>V_DSS [V]</td>
<td>650</td>
</tr>
<tr>
<td>I_D [A]</td>
<td>57</td>
</tr>
<tr>
<td>R_DSON [Ω]</td>
<td>Typ. 0.033 Max 0.04</td>
</tr>
<tr>
<td>Polarity</td>
<td>N-channel</td>
</tr>
</tbody>
</table>

Test Condition
- R_DSON : I_D=28.5A, V_GS=10V
- Q_GD : V_D=400V, I_D=57A, V_GS=10V
※Average value of measurement data

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RonA reduced by 30% - Power supply efficiency improved – Higher miniaturization

1 RonA reduced by 30%
Using a newly developed single epitaxial process, the figure of merit RonA was reduced by 30% (based on DTMOS III product comparison).

2 Ron increase suppressed at high temperatures
Using a single epitaxial process, the increase in Ron is suppressed at high temperatures.

3 Optimized gate switching speed
Coss reduction (12% compared to earlier model) and low Ron (super junction DTMOS structure) allows optimized gate switching speed.

Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>TK20A60W5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>TO-220SIS</td>
</tr>
<tr>
<td>V_{DSS} [V]</td>
<td>600</td>
</tr>
<tr>
<td>I_D [A]</td>
<td>20</td>
</tr>
<tr>
<td>R_{ONON} [Ω]</td>
<td></td>
</tr>
<tr>
<td>@V_{GS}=10V</td>
<td></td>
</tr>
<tr>
<td>Typ.</td>
<td>0.15</td>
</tr>
<tr>
<td>Max</td>
<td>0.175</td>
</tr>
<tr>
<td>Polarity</td>
<td>N-channel</td>
</tr>
</tbody>
</table>

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Reduction of board space and maintenance-free reliability are major merits

1. High conversion efficiency \((at \ I_F = 0.5mA)\)

The TLP383/TLP293 is a high-isolation photo coupler optically coupled with a phototransistor and a high-power infrared LED, enabling low input current control and high conversion efficiency compared to conventional electromagnetic relays and isolation transformers.

2. Designed for high temperature operation

The TLP383/TLP293 are designed to operate under extreme conditions of ambient temperature such as inverter devices, robots, machine tools and high output power supplies.

### Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>TLP383</th>
<th>TLP293</th>
<th>TLP785</th>
<th>TLP385</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>SO6L (4pin)</td>
<td>SO4</td>
<td>DIP4</td>
<td>SO6L (4pin)</td>
</tr>
<tr>
<td>BV1 (Min) [Vrms]</td>
<td>5000</td>
<td>3750</td>
<td>5000</td>
<td>5000</td>
</tr>
<tr>
<td>T_{op} [°C]</td>
<td>-55 to 125</td>
<td>-55 to 125</td>
<td>-55 to 110</td>
<td>-55 to 110</td>
</tr>
</tbody>
</table>
Using a triac with high dv/dt pre-driver for solenoid control suppresses false turn-on

1. Low input and zero-crossing input control

This device optically couples a photo triac and a high-power infrared LED, providing high isolation equivalent to an electromagnetic relay. Capable of low input operation, the photo coupler can be directly controlled by a microcontroller.

- Example of AC switch using triac-output photo coupler

2. High dv/dt

The TLP 3083 is a triac having a high dv/dt of 2000V/μs (Typ.). With a high OFF-state withstand voltage of 800V, it can work with a variety of AC power supply lines.

### Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>TLP3083</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>5pin DIP6</td>
</tr>
<tr>
<td>BVₜ (Min) [Vrms]</td>
<td>5000</td>
</tr>
<tr>
<td>Tₜop [°C]</td>
<td>-40 to 100</td>
</tr>
</tbody>
</table>

◆ Return to Block Diagram TOP
**Value provided**

**Suitable for high withstand voltages and large currents, device can control high power with low drive power**

1. **High speed, low saturation voltage**

   By adopting a thin wafer punch-through structure, high speed turn-off characteristics and low $V_{CE}$ (sat) characteristics are realized.

2. **High breakdown tolerance**

   We offer a product line that is easy to use, with high breakdown tolerance (short circuit withstand capability tsc & reverse bias safe operating area RB-SOA).

3. **Enhancement Typ.e**

   Since collector current does not flow when gate voltage is not applied for enhancement devices, handling is easy.

- **Full switching PFC circuit example using discrete IGBT**

![Full switching PFC circuit example using discrete IGBT](image)

**Line up**

<table>
<thead>
<tr>
<th></th>
<th>GT50JR22</th>
<th>GT50J123</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Package</strong></td>
<td>TO-3 P(N)</td>
<td></td>
</tr>
<tr>
<td><strong>$V_{CC}$ [V]</strong></td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td><strong>$I_C$ [A]</strong></td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td><strong>$V_{CE(sat)}$ [V]</strong></td>
<td>Typ. 1.55</td>
<td>1.90</td>
</tr>
<tr>
<td>@$I_C=50A$, $V_{GE}=15V$, $T_a=25^\circ C$</td>
<td>Max 2.20</td>
<td>2.50</td>
</tr>
<tr>
<td><strong>Breakdown voltage</strong></td>
<td>–</td>
<td>tsc,RB-SOA(full square)</td>
</tr>
</tbody>
</table>

---

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19
Miniature surface-mount LDO regulator
TCR3DF/TCR2EF Series

Value provided
Wide product line to meet high performance requirements from general usage to ultra-compact package needs

1 Low drop-out voltage
Dropdown characteristics are greatly improved by means of a newly developed process.

2 High ripple compression
With a high ripple compression, ripple is efficiently removed.

3 Compatible with ceramic capacitors
Thanks to improved dropout characteristics, external ceramic capacitors can be used.

Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>TCR3DF series</th>
<th>TCR2EF series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>SMV</td>
<td>SMV</td>
</tr>
<tr>
<td>VIN (Max) [V]</td>
<td>5.5</td>
<td>4.4</td>
</tr>
<tr>
<td>IOUT (max) [mA]</td>
<td>300</td>
<td>200</td>
</tr>
<tr>
<td>Output range [V]</td>
<td>1.0 to 4.5</td>
<td>1.0 to 5.0</td>
</tr>
</tbody>
</table>

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High Withstand Voltage IPD (180-degree commutation) TPD4204F

Value provided

High withstand voltage brushless motors can be driven using Toshiba’s proprietary high withstand voltage IC process

1 Various circuits for driving the motor are included

High-side driver, low-side driver, and output MOSFET for level-shifting are included.

2 Pin placement separated by control and drive functions

Complexity of the wiring are eliminated by separating the high-voltage/high-current pins and the control pins.

3 Advanced protection circuits

Over-current protection, over-temperature protection, and over-voltage protection function are built in.

TPD4204F

Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>TPD4204F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>SSOP30</td>
</tr>
<tr>
<td>VBB [V]</td>
<td>600</td>
</tr>
<tr>
<td>IOUT [A]</td>
<td>2.5</td>
</tr>
<tr>
<td>VCC [V]</td>
<td>13.5 to 16.5</td>
</tr>
</tbody>
</table>

Return to Block Diagram TOP
High withstand voltage brushless motors can be driven using Toshiba’s proprietary high withstand voltage IC process

1. **3-phase controller for brushless motor included**
   - Includes controller, PWM circuit, 3-phase distribution circuit, level-shift Type high side driver and low side drivers, output IGBT and FRD

2. **Separate pin placement for control and drive functions**
   - Complexity of the wiring are eliminated by separating the high-voltage/high-current pins and the control pins

3. **Advanced protection circuits**
   - Over-current protection, over-temperature protection, and over-voltage protection function are built in.

---

**Line up**

<table>
<thead>
<tr>
<th>Part number</th>
<th>TPD4152F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>HSSOP31</td>
</tr>
<tr>
<td>$V_{BB}$ [V]</td>
<td>600</td>
</tr>
<tr>
<td>$I_{OUT}$ [A]</td>
<td>0.7</td>
</tr>
<tr>
<td>$V_{CC}$ [V]</td>
<td>13.5 to 17.5</td>
</tr>
</tbody>
</table>

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Support for low voltage motor driving (2.5V min.) with low power consumption.

1. **Low voltage operation**
   Motor driving voltage is 2.5V min. for low voltage applications such as battery operation devices.

2. **Low current consumption**
   Stand-by current is below 2uA (IC total) for power saving of devices.

3. **Abnormality detection functions**
   Over current detection (ISD), Over heat detection (TSD) & Low voltage detection (UVLO) are available for safe motor driving.

**Line up**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>TC78H621FNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{IN} ) [Max] [V]</td>
<td>18</td>
</tr>
<tr>
<td>( I_{OUT} ) [Max] [A]</td>
<td>1.1</td>
</tr>
<tr>
<td>( R_{on,upper and lower sum} ) [Typ.] [Ω]</td>
<td>0.8</td>
</tr>
<tr>
<td>Control Interface</td>
<td>ENABLE/PHASE inputs</td>
</tr>
<tr>
<td>Step</td>
<td>Two-phase excitation</td>
</tr>
<tr>
<td>Feature</td>
<td>Motor driving voltage: 2.5V min.</td>
</tr>
<tr>
<td>Abnormality detection function</td>
<td>Over heat, Over current, Low voltage</td>
</tr>
<tr>
<td>Package</td>
<td>TSOP16</td>
</tr>
</tbody>
</table>

TSOP16 Package (5.0mm×6.4mm×1.2mm)
Toshiba’s proprietary technology eliminates the need for phase adjustment and achieves high efficiency for a wide range of rotation speeds

1. High efficiency in a wide range of rotation speeds

Toshiba’s automatic lead angle control technology realizes a high-efficiency drive regardless of motor speed, load torque or power supply voltage.

2. Motor control with low noise, and low vibration

The use of a sinusoidal drive system featuring a smooth current waveform contributes to the low noise and low vibration of the motor, as compared to a square wave drive system.

3. Small package

VQFN32 package is adopted for TC78B042FTG, which requires small space. SSOP30 package is adopted for TC78B041FNG as conventional Type.

Line up

<table>
<thead>
<tr>
<th>Feature</th>
<th>TC78B041FNG</th>
<th>TC78B042FTG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply voltage</td>
<td>6～16.5V</td>
<td></td>
</tr>
<tr>
<td>Drive Type</td>
<td>Sinusoidal</td>
<td></td>
</tr>
<tr>
<td>Features &amp; Others</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auto lead angle control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hall element or hall IC input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forward / reverse rotation switch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor lock detection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selectable pulse number of rotation pulse signal output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Built-in 5V regulator, VREF / VREF2 pins</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Built-in 5V regulator, VREF pin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error detection positive / negative input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error detection positive input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package</td>
<td>SSOP30</td>
<td>VQFN32</td>
</tr>
</tbody>
</table>

VQFN32 Package (5mm × 5mm × 1mm)

SSOP30 Package (10.2mm × 7.6mm × 1.6mm)
High voltage, large current brushless motor drive using external MOSFET

1. Efficient motor control using auto lead angle control

In addition to fixed angle control using voltage input (32 steps), auto lead angle control using current feedback is possible.

2. Low noise, low vibration motor control

A sinusoidal drive system with a smooth current waveform contributes to low noise and low vibration of the motor compared with conventional rectangular drive systems.

3. Full development support

Third party evaluation boards and PSpice® data can be provided to support customer development and design.

Line up

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage range</td>
<td>6～16.5V</td>
</tr>
<tr>
<td>Output current range</td>
<td>0.002A (for MOSFET driver)</td>
</tr>
<tr>
<td>Drive mode</td>
<td>Sine wave drive</td>
</tr>
<tr>
<td>Other features</td>
<td>Lead angle control: Auto phase control (current feedback)</td>
</tr>
<tr>
<td></td>
<td>Sensor input: Hall device/ Hall IC compatible</td>
</tr>
<tr>
<td></td>
<td>Internal regulator: 5V/30mA (max)</td>
</tr>
<tr>
<td></td>
<td>Error detection: over current protection, position signal error, low</td>
</tr>
<tr>
<td></td>
<td>voltage/current, motor constraint detection (TB6634FNG)</td>
</tr>
</tbody>
</table>

TSOP30 package (10.2mm×7.6mm×1.6mm)

* PSpice is a registered trademark of Cadence Design Systems, Inc.
One package of motor controller & 500V/2A IGBT for high voltage solution

1. SiP: 1 package solution
   - 1 package of sinusoidal current drive motor controller & 500V/2A IGBT to reduce mounting PCB space.

2. Motor control with low noise, and low vibration
   - The use of a sinusoidal drive system featuring a smooth current waveform contributes to the low noise and low vibration of the motor, as compared to a square wave drive system.

3. High heat dissipation
   - HDIP30 package is adopted for TB67B000HG, which has high heat dissipation. HSSOP30 package is adopted for TB67B000FG, which is smaller than HDIP30.

### Line up

<table>
<thead>
<tr>
<th>Part Number</th>
<th>TB67B000HG</th>
<th>TB67B000FG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating voltage range</td>
<td>Power supply for control: 13.5~16.5V</td>
<td>Power supply for motor drive: 50~450V</td>
</tr>
<tr>
<td>Output current</td>
<td>2A</td>
<td></td>
</tr>
<tr>
<td>Drive Type</td>
<td>Sinusoidal current drive / Pseudo sinusoidal current drive</td>
<td></td>
</tr>
<tr>
<td>PWM frequency</td>
<td>14kHz~23kHz</td>
<td></td>
</tr>
<tr>
<td>Lead angle control</td>
<td>0<del>58 degrees 32 steps / 0</del>28 degrees 16 steps</td>
<td></td>
</tr>
<tr>
<td>Speed command input voltage</td>
<td>Motor operation: 2.1V~5.4V</td>
<td></td>
</tr>
<tr>
<td>Features &amp; Others</td>
<td>IGBT 3-Phase bridge, Oscillation circuit, Built-in bootstrap resistor, Current limit, Thermal shutdown, Low voltage monitor, Lock detection</td>
<td></td>
</tr>
<tr>
<td>Package</td>
<td>HDIP30</td>
<td>HSSOP34</td>
</tr>
</tbody>
</table>
System cost reduction, noise reduction, higher efficiency and less development work

1. Equipped with motor control co-processor

Toshiba’s original co-processor vector engine (VE) for motor control reduces CPU load and allows control of multiple motors and peripherals.

2. Equipped with motor control logic circuit

Versatile three-phase PWM (*) output with high efficiency and low noise control made possible by sense timing. The advanced encoder lightens CPU load of each PWM processing.

3. Equipped with analog circuit for motor control

Multiple high speed, high accuracy AD converter are integrated, allowing conversion timing and PWM output to be linked. External functions such as high-performance op-amps are on-chip.

* PWM: Pulse Width Modulation

Line up

TX03 series M370 group: Arm® Cortex®-M3, includes 1st gen VE
TX04 series M470 group: Arm® Cortex®-M4, includes 2nd gen VE

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Value provided

Protecting devices from static electricity and preventing circuit malfunctions

1 Higher ESD absorbency

Our new devices absorb ESD better than conventional models, with a 50% decrease in operating resistance. Together with a lower capacitance, this ensures high signal protection and quality.

2 Suppresses ESD energy with a low clamp voltage

Thanks to proprietary technology, connected devices are firmly protected.

3 Suitable for high-density mounting

Various packages (single to multi flow-through) are available.

![Graph: ESD Pulse Absorption Performance](image)

- Uni-directional
- Bi-directional

Note: This device is for ESD protection only and cannot be used for other purposes such as, but not limited to, constant voltage source circuits.

### Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>DF2B7ASL</th>
<th>DF2S14P1CT</th>
<th>DF2B5M4SL</th>
<th>DF2B6M4SL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>SL2</td>
<td>CST2</td>
<td>SL2</td>
<td>SL2</td>
</tr>
<tr>
<td>$V_{ESD}$ [kV]</td>
<td>±30</td>
<td>±30</td>
<td>±20</td>
<td>±20</td>
</tr>
<tr>
<td>$V_{RWM}$ (Max) [V]</td>
<td>5.5</td>
<td>12.6</td>
<td>3.6</td>
<td>5.5</td>
</tr>
<tr>
<td>$C_t$ (Typ.) [pF]</td>
<td>8.5</td>
<td>40</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>$R_{DYN}$ (Typ.) [Ω]</td>
<td>0.2</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

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Amplifying very weak signals detected by sensors with ultra low-noise op-amps

1. **Ultra low noise**
   - $V_{NI}(\text{Typ.}) = 6.0 \text{ [nV/√Hz]} @ f=1kHz$

   This ultra low-noise CMOS op-amp is capable of amplifying low-level signals detected by various sensors [Note 1]. By optimizing the process, the industry’s top level equivalent input noise performance was achieved [Note 2].

2. **Low dissipation current**
   - $I_{DD}(\text{Typ.}) = 430 \text{[μA]}$

   The low current dissipation of CMOS devices enables the long battery life of small IoT equipment [Note 3].

3. **Low voltage power supply**

   Can operate at $V_{DD} = 2.2 \sim 5.5 \text{ V}$

[Note 1] Sensor Types: vibration sensor, shock sensor, accelerometer, pressure sensor, infrared sensor, temperature sensor
[Note 2] Based on Toshiba survey on May 2017.
[Note 3] Comparison with Toshiba’s bipolar process op-amp models

---

**Ultra low-noise characteristics**

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Equivalent input noise voltage $V_{NI}$ [nV/√Hz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>100</td>
<td>30</td>
</tr>
<tr>
<td>1000</td>
<td>20</td>
</tr>
<tr>
<td>10000</td>
<td>10</td>
</tr>
</tbody>
</table>

Old model: TC75S63TU
New model: TC75S67TU

---

**Line up**

<table>
<thead>
<tr>
<th>Part number</th>
<th>TC75S67TU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>UFV</td>
</tr>
<tr>
<td>$V_{DD,\text{SS}}$ (Max) [V]</td>
<td>±2.75</td>
</tr>
<tr>
<td>$V_{DD,\text{SS}}$ (Min) [V]</td>
<td>±1.1</td>
</tr>
<tr>
<td>$I_{DD}$ (Max) [μA]</td>
<td>700</td>
</tr>
<tr>
<td>$V_{NI}(\text{Typ.})$ [nV/√Hz] @f=1kHz</td>
<td>6</td>
</tr>
</tbody>
</table>
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