Air Conditioner
Solution Proposal by Toshiba
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

- **Nch MOSFET**
- Driver
- PWM Controller
- Photo coupler
- Reference

Indoor unit

- **Nch MOSFET**
- Driver
- PWM Controller
- Photo coupler
- Reference

12V

5V

3.3V

12V

5V

3.3V

3.3V

2.5V

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

**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-MOSVIII series power MOSFET
- **Environmentally resistant photocoupler**
- Transistor output
- **Resistant to power supply noise**
- Miniature surface-mounted LDO regulator

© 2019-2020 Toshiba Electronic Devices & Storage Corporation
Air Conditioner Details of PFC unit

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
- IGBT suitable for high withstand voltage and high current
- Easy software development using general-purpose CPU cores
  - Discrete IGBT
  - Microcontroller

**Device selection**

- 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

PFC circuit

**Partial switching system**

- Suitable for high-efficiency power supply switching
- IGBT suitable for high withstand voltage and high current
- Easy software development using general-purpose CPU cores
  - Discrete IGBT
  - Microcontroller

※ Click on the blue circled numbers above to view detailed explanations.
Air Conditioner  Details of Fan (indoor/outdoor), compressor unit

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

- High withstand voltage IPD
- MCD (controller) + high withstand voltage IPD
- MCU (3-phase integrated controller) + high withstand voltage IPD

**Compressor section**

- MCU (3-phase motor 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
- High withstand voltage motor driver circuit
- Easy control of motors
- Easy software development using general-purpose CPU cores
- Microcontroller
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
- Photocoupler
- Easy software development using general-purpose CPU cores
  Microcontroller

Cleaning section
- 7 MCU → Motor Control Driver → M Stepping

Louver section
- 7 MCU → Motor Control Driver → M Stepping Or Brush

Valve control section
- 7 MCU → Photocoupler → Triac → 2Way Valve/4Way Valve

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

Power control block for outdoor unit

Isolation circuit

Compressor block between outdoor/indoor units

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
- High noise resistance
- General purpose CPU core allows easy software development

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

Proposal from Toshiba
- General purpose CPU core allows easy software development
- Microcontroller
- Avoid faulty circuit operation by absorbing ESD from external connectors
- TVS diode
- Accurately track changes in current dissipation
- Ultra low noise Op-amp

Sensor input section
Indoor unit

- **Sensor Input**
- Temp. Sensor
- Op-Amp
- MCU

Outdoor unit

- **Sensor Input**
- Temp. Sensor
- Op-Amp
- MCU

Key Input
- **Keys**
- TVS

※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.
Device solutions to address customer requirements

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>3-phase motor with high withstand voltage</th>
<th>High efficiency + low loss</th>
<th>Small size packages</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>
RonA reduced by 24% - Power supply efficiency improved - Higher miniaturization

1. RonA reduced by 24%
   By using latest generation π-MOSⅢ 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-MOSⅢ chip design, Qg is reduced by 23% (π-MOSⅣ comparison of Toshiba products)
   Reduction of switching loss expected

3. Coss reduced by 18%
   By using latest generation π-MOSⅢ chip design, Coss is reduced by 18%
   Improvement for light-load conditions expected

**Turn-on waveform**

2SK3878

$R_{G(\text{off})}=25\Omega$

【condition】

$V_D=400\text{V}, I_D=4.5A(I_D \times 1/2), T_c=25^\circ\text{C}$

TK9J90E

**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>$V_D$ [V]</td>
<td>800</td>
<td>800</td>
<td>900</td>
</tr>
<tr>
<td>$I_D$ [A]</td>
<td>6</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>$R_{\text{DS(on)}}$ [Ω]</td>
<td>Typ. 1.35</td>
<td>0.7</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Max 1.7</td>
<td>1</td>
<td>1.3</td>
</tr>
<tr>
<td>Polarity</td>
<td>N-channel</td>
<td>N-channel</td>
<td>N-channel</td>
</tr>
</tbody>
</table>

© 2019-2020 Toshiba Electronic Devices & Storage Corporation
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.

Ron•Qgd performance trend

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_{DS} [V]</td>
<td>650</td>
</tr>
<tr>
<td>I_D [A]</td>
<td>57</td>
</tr>
<tr>
<td>R_{DS(ON)} [Ω] @V_{GS}=10V</td>
<td>Typ. 0.033</td>
</tr>
<tr>
<td>Polarity</td>
<td>N-channel</td>
</tr>
</tbody>
</table>

© 2019-2020 Toshiba Electronic Devices & Storage Corporation
**1c DTMOSIV (HSD) series power MOSFET**

**TK20A60WS**

**Value provided**

**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 DTMOSⅢ 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>TK20A60WS</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>$R_{ON}$ [Ω] @ $V_{GS}=10$V</td>
<td>0.15 (Typ.)</td>
</tr>
<tr>
<td></td>
<td>0.175 (Max.)</td>
</tr>
<tr>
<td>Polarity</td>
<td>N-channel</td>
</tr>
</tbody>
</table>

© 2019-2020 Toshiba Electronic Devices & Storage Corporation
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>$BV_v$ (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.

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.

**Example of AC switch using triac-output photo coupler**

**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>BV_s (Min) [Vrms]</td>
<td>5000</td>
</tr>
<tr>
<td>T_op [°C]</td>
<td>-40 to 100</td>
</tr>
</tbody>
</table>
**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

```
~
IGBT
Vout

fsw=20~35kHz
```

### Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>GT50JR22</th>
<th>GT50J123</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>TO-3 P(N)</td>
<td></td>
</tr>
<tr>
<td>$V_{CE}$ [V]</td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td>$I_{c}$ [A]</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>$V_{CE(MU)}$ [V]</td>
<td>Typ. 1.55</td>
<td>1.90</td>
</tr>
<tr>
<td></td>
<td>Max 2.20</td>
<td>2.50</td>
</tr>
<tr>
<td>Breakdown voltage</td>
<td>–</td>
<td>tsc, RB-SOA (full square)</td>
</tr>
</tbody>
</table>

© 2019-2020 Toshiba Electronic Devices & Storage Corporation
Value provided

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

1. **Low drop-out voltage**
   Dropout 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.

<table>
<thead>
<tr>
<th>Line up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part number</td>
</tr>
<tr>
<td>Package</td>
</tr>
<tr>
<td>( V_{\text{IN}} \text{ (Max)} ) [V]</td>
</tr>
<tr>
<td>( I_{\text{OUT}} \text{ (max)} ) [mA]</td>
</tr>
<tr>
<td>Output range [V]</td>
</tr>
</tbody>
</table>

© 2019-2020 Toshiba Electronic Devices & Storage Corporation
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.

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>$V_{BB}$ [V]</td>
<td>600</td>
</tr>
<tr>
<td>$I_{OUT}$ [A]</td>
<td>2.5</td>
</tr>
<tr>
<td>$V_{CC}$ [V]</td>
<td>13.5 to 16.5</td>
</tr>
</tbody>
</table>

© 2019-2020 Toshiba Electronic Devices & Storage Corporation
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>

© 2019-2020 Toshiba Electronic Devices & Storage Corporation
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) (Typ.) [Ω]</td>
<td>0.8</td>
</tr>
<tr>
<td>Control Interface</td>
<td>ENABE/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>TSSOP16</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.

---

**Value provided**

**Part Number**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>TC78B041FNG</th>
<th>TC78B042FTG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply voltage</td>
<td>6～16.5V</td>
<td>6～16.5V</td>
</tr>
<tr>
<td>Drive Type</td>
<td>Sinusoidal</td>
<td>Sinusoidal</td>
</tr>
<tr>
<td>Features &amp; Others</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auto lead angle control for optimizing voltage &amp; current phases</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>VQFN32</td>
<td>VQFN32</td>
<td></td>
</tr>
<tr>
<td>SSOP30</td>
<td>SSOP30</td>
<td></td>
</tr>
</tbody>
</table>

© 2019-2020 Toshiba Electronic Devices & Storage Corporation
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>Specifications</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 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.
Three-phase brushless motor driver
TB67B000AHG/AFG

Value provided

1 package of motor controller & 600V/2A IGBT for high voltage solution

1 SiP: 1 package solution

1 package of sinusoidal current drive motor controller & 600V/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 TB67B000AHG, which has high heat dissipation. HSSOP30 package is adopted for TB67B000AFG, which is smaller than HDIP30.

Line up

<table>
<thead>
<tr>
<th>Part Number</th>
<th>TB67B000AHG</th>
<th>TB67B000AFG</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>0～58 degrees 32 steps / 0～28 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>

6c

© 2019-2020 Toshiba Electronic Devices & Storage Corporation
**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.

---

**Line up**

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

---

* Arm and Cortex are registered trademarks of Arm Limited (or its subsidiaries) in the US and/or elsewhere.
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.

---

### 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.) [$\Omega$]</td>
<td>0.2</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

---

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.

© 2019-2020 Toshiba Electronic Devices & Storage Corporation
Amplifying very weak signals detected by sensors with ultra low-noise op-amps

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

   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 \( V_{DD}=2.2 \) to 5.5 V

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

[Note 1] Sensor Typ.es: 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
If you are interested in these products and have questions or comments about any of them, please do not hesitate to contact us below:

Contact address: [https://toshiba.semicon-storage.com/ap-en/contact.html](https://toshiba.semicon-storage.com/ap-en/contact.html)
Terms of use

This terms of use is made between Toshiba Electronic Devices and Storage Corporation (“We”) and customers who use documents and data that are consulted to design electronics applications on which our semiconductor devices are mounted (“this Reference Design”). Customers shall comply with this terms of use. Please note that it is assumed that customers agree to any and all this terms of use if customers download this Reference Design. We may, at its sole and exclusive discretion, change, alter, modify, add, and/or remove any part of this terms of use at any time without any prior notice. We may terminate this terms of use at any time and for any reason. Upon termination of this terms of use, customers shall destroy this Reference Design. In the event of any breach thereof by customers, customers shall destroy this Reference Design, and furnish us a written confirmation to prove such destruction.

1. Restrictions on usage
1. This Reference Design is provided solely as reference data for designing electronics applications. Customers shall not use this Reference Design for any other purpose, including without limitation, verification of reliability.
2. This Reference Design is for customer's own use and not for sale, lease or other transfer.
3. Customers shall not use this Reference Design for evaluation in high or low temperature, high humidity, or high electromagnetic environments.
4. This Reference Design shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable laws or regulations.

2. Limitations
1. We reserve the right to make changes to this Reference Design without notice.
2. This Reference Design should be treated as a reference only. We are not responsible for any incorrect or incomplete data and information.
3. Semiconductor devices can malfunction or fail. When designing electronics applications by referring to this Reference Design, customers are responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of semiconductor devices could cause loss of human life, bodily injury or damage to property, including data loss or corruption. Customers must also refer to and comply with the latest versions of all relevant our information, including without limitation, specifications, data sheets and application notes for semiconductor devices, as well as the precautions and conditions set forth in the “Semiconductor Reliability Handbook”.
4. When designing electronics applications by referring to this Reference Design, customers must evaluate the whole system adequately. Customers are solely responsible for all aspects of their own product design or applications. WE ASSUME NO LIABILITY FOR CUSTOMERS’ PRODUCT DESIGN OR APPLICATIONS.
5. No responsibility is assumed by us for any infringement of patents or any other intellectual property rights of third parties that may result from the use of this Reference Design. No license to any intellectual property right is granted by this terms of use, whether express or implied, by estoppel or otherwise.
6. THIS REFERENCE DESIGN IS PROVIDED “AS IS”. WE (a) ASSUME NO LIABILITY WHATSOEVER, INCLUDING WITHOUT LIMITATION, INDIRECT, CONSEQUENTIAL, SPECIAL, OR INCIDENTAL DAMAGES OR LOSS, INCLUDING WITHOUT LIMITATION, LOSS OF PROFITS, LOSS OF OPPORTUNITIES, BUSINESS INTERRUPTION AND LOSS OF DATA, AND (b) DISCLAIM ANY AND ALL EXPRESS OR IMPLIED WARRANTIES AND CONDITIONS RELATED TO THIS REFERENCE DESIGN, INCLUDING WARRANTIES OR CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY OF INFORMATION, OR NONINFRINGEMENT.

3. Export Control
Customers shall not use or otherwise make available this Reference Design for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). This Reference Design may be controlled under the applicable export laws and regulations including, without limitation, the Japanese Foreign Exchange and Foreign Trade Law and the U.S. Export Administration Regulations. Export and re-export of this Reference Design are strictly prohibited except in compliance with all applicable export laws and regulations.

4. Governing Laws
This terms of use shall be governed and construed by laws of Japan.
RESTRICTIONS ON PRODUCT USE

Toshiba Electronic Devices & Storage Corporation, and its subsidiaries and affiliates (collectively “TOSHIBA”), reserve the right to make changes to the information in this document, and related hardware, software and systems (collectively “Product”) without notice.

This document and any information herein may not be reproduced without prior written permission from TOSHIBA. Even with TOSHIBA's written permission, reproduction is permissible only if reproduction is without alteration/omission.

Though TOSHIBA works continually to improve Product's quality and reliability, Product can malfunction or fail. Customers are responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which Minimize risk and avoid situations in which a malfunction or failure of Product could cause loss of human life, bodily injury or damage to property, including data loss or corruption. Before customers use the Product, create designs including the Product, or incorporate the Product into their own applications, customers must also refer to and comply with (a) the latest versions of all relevant TOSHIBA information, including without limitation, this document, the specifications, the data sheets and application notes for Product and the precautions and conditions set forth in the “TOSHIBA Semiconductor Reliability Handbook” and (b) the instructions for the application with which the Product will be used with or for. Customers are solely responsible for all aspects of their own product design or applications, including but not limited to (a) determining the appropriateness of the use of this Product in such design or applications; (b) evaluating and determining the applicability of any information contained in this document, or in charts, diagrams, programs, algorithms, sample application circuits, or any other referenced documents; and (c) validating all operating parameters for such designs and applications. TOSHIBA ASSUMES NO LIABILITY FOR CUSTOMERS’ PRODUCT DESIGN OR APPLICATIONS.

PRODUCT IS NEITHER INTENDED NOR WARRANTED FOR USE IN EQUIPMENTS OR SYSTEMS THAT REQUIRE EXTRAORDINARILY HIGH LEVELS OF QUALITY AND/OR RELIABILITY, AND/OR A MALFUNCTION OR FAILURE OF WHICH MAY CAUSE LOSS OF HUMAN LIFE, BODILY INJURY, SERIOUS PROPERTY DAMAGE AND/OR SERIOUS PUBLIC IMPACT (“UNINTENDED USE”). Except for specific applications as expressly stated in this document, Unintended Use includes, without limitation, equipment used in nuclear facilities, equipment used in the aerospace industry, medical equipment, equipment used for automobiles, trains, ships and other transportation, traffic signaling equipment, equipment used to control combustions or explosions, safety devices, elevators and escalators, devices related to electric power, and equipment used in finance-related fields. IF YOU USE PRODUCT FOR UNINTENDED USE, TOSHIBA ASSUMES NO LIABILITY FOR PRODUCT. For details, please contact your TOSHIBA sales representative.

Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy Product, whether in whole or in part.

Product shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable laws or regulations.

The information contained herein is presented only as guidance for Product use. No responsibility is assumed by TOSHIBA for any infringement of patents or any other intellectual property rights of third parties that may result from the use of Product. No license to any intellectual property right is granted by this document, whether express or implied, by estoppel or otherwise.

ABSENT A WRITTEN SIGNED AGREEMENT, EXCEPT AS PROVIDED IN THE RELEVANT TERMS AND CONDITIONS OF SALE FOR PRODUCT, AND TO THE MAXIMUM EXTENT ALLOWABLE BY LAW, TOSHIBA (1) ASSUMES NO LIABILITY WHATSOEVER, INCLUDING WITHOUT LIMITATION, INDIRECT, CONSEQUENTIAL, SPECIAL, OR INCIDENTAL DAMAGES OR LOSS, INCLUDING WITHOUT LIMITATION, LOSS OF PROFITS, LOSS OF OPPORTUNITIES, BUSINESS INTERRUPTION AND LOSS OF DATA, AND (2) DISCLAIMS ANY AND ALL EXPRESS OR IMPLIED WARRANTIES AND CONDITIONS RELATED TO SALE, USE OF PRODUCT, OR INFORMATION, INCLUDING WARRANTIES OR CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY OF INFORMATION, OR NONINFRINGEMENT.

GaAs (Gallium Arsenide) is used in Product. GaAs is harmful to humans if consumed or absorbed, whether in the form of dust or vapor. Handle with care and do not break, cut, crush, grind, dissolve chemically or otherwise expose GaAs in Product.

Do not use or otherwise make available Product or related software or technology for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). Product and related software and technology may be controlled under the applicable export laws and regulations including, without limitation, the Japanese Foreign Exchange and Foreign Trade Law and the U.S. Export Administration Regulations. Export and re-export of Product or related software or technology are strictly prohibited except in compliance with all applicable export laws and regulations.

Please contact your TOSHIBA sales representative for details as to environmental matters such as the RoHS compatibility of Product. Please use Product in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. TOSHIBA ASSUMES NO LIABILITY FOR DAMAGES OR LOSSES OCCURRING AS A RESULT OF NONCOMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS.
TOSHIBA

* PSpice is a registered trademark of Cadence Design Systems, Inc.
* Arm and Cortex are registered trademarks of Arm Limited (or its subsidiaries) in the US and/or elsewhere.
* Other company names, product names, and service names may be trademarks of their respective companies.