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
Criteria for device selection
- LDO regulators with low drop-out characteristics are required to perform voltage conversion in a compact and efficient manner.
- The use of small packages reduces the circuit board area.
- Ultra-low noise operational amplifiers enable high-precision sensing.

Proposals from Toshiba
- **Small LDO regulator capable of applying a large current**
  Small surface mount LDO regulator
- **Processing analog signals with low noise**
  Ultra-low noise operational amplifier
- **Built-in analog input interface at low power consumption and efficient software development**
  MCU
Power supply circuit

- The transistor coupler is for signal isolation.
- Low power consumption can be realized by using a MOSFET with low on-resistance and high heat dissipation efficiency.
- The use of small packages reduces the circuit board area.

Proposals from Toshiba

- **MOSFET with low on-resistance and high heat dissipation**
  - π-MOSVII series MOSFET (planar type)

- **Contributing to higher efficiency and miniaturization of power supply**
  - SiC Schottky barrier diode

- **Optimal for MOSFET gate control**
  - Bipolar power transistors

- **Photocoupler with excellent environmental resistance**
  - Transistor output photocoupler

- **Realize a set with low power consumption by low on-resistance**
  - Small-signal MOSFET

※ Click the number in the circuit diagram to jump to the detailed description page
Criteria for device selection
- Low power consumption can be realized by using a MOSFET with low on-resistance and high heat dissipation efficiency.
- The use of small packages reduces the circuit board area.

Proposals from Toshiba
- Realize a set with low power consumption by low on-resistance
Small-signal MOSFET
**Criteria for device selection**
- The use of photorelays instead of mechanical relays eliminates the life limitation caused by contact wear and welding at the contact points, enabling long life and quieter operation.
- The use of small packages reduces the circuit board area.

**Proposals from Toshiba**
- **Optimal for replacing mechanical relays**
  - Photorelay
- **Built-in analog input interface at low power consumption and efficient software development**
  - MCU

※ Click the number in the circuit diagram to jump to the detailed description page
Panel display system

Criteria for device selection
- Driving series connection Hi-current type white LEDs for an LCD back light
- Data processing of various sensing data and feedback control of a system within very short time period

Proposals from Toshiba
- 1ch type LED driver is suitable for a small LCD for its back light.

Step up type LED driver
- Built-in analog input interface at low power consumption and efficient software development

MCU
Recommended Devices
As described above, in the design of thermostat, “Miniaturization of circuit boards”, “Low power consumption of the set” and “Robust operation” are important factors. Toshiba’s proposals are based on these three solution perspectives.
Device solutions to address customer needs

<table>
<thead>
<tr>
<th></th>
<th>Device Type</th>
<th>Compatible with compact packages</th>
<th>High efficiency - Low loss</th>
<th>Noise immunity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Small surface mount LDO regulator</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>2</td>
<td>Ultra-low noise operational amplifier</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>3</td>
<td>π-MOSVII series MOSFET (planar type)</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>4</td>
<td>SiC Schottky barrier diode</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>5</td>
<td>Bipolar power transistor</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>6</td>
<td>Transistor output photocoupler</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>7</td>
<td>Small-signal MOSFET</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>8</td>
<td>Photorelay</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>9</td>
<td>LED driver</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>10</td>
<td>MCU</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
</tbody>
</table>
Small surface mount LDO regulator
TCR2EF / TAR5SB series

Value provided

To meet high-performance demands with optimum products, we offer from general-purpose to ultra small package devices.

1. **Low dropout voltage**
   The newly developed new-generation process significantly improved the dropout characteristics.

2. **High ripple rejection ratio**
   “High ripple rejection ratio” remove the ripple effectively.

3. **Can be used with ceramic capacitors**
   With improved dropout characteristics, it is possible to use ceramic capacitors as external capacitors.

---

### Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>TCR2EF</th>
<th>TAR5SB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>SMV</td>
<td>SMV</td>
</tr>
<tr>
<td>$V_{IN}$ (Max) [V]</td>
<td>5.5</td>
<td>15</td>
</tr>
<tr>
<td>$I_{OUT}$ (Max) [mA]</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Output voltage lineup [V]</td>
<td>1.0 to 5.0</td>
<td>1.5 to 5.0</td>
</tr>
</tbody>
</table>

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Ultra-low noise operational amplifier

TC75S67TU

Value provided

Very small signals detected by various sensors can be amplified with very low noise.

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

   Very small signals detected by various sensors [Note 1] can be amplified with low noise using CMOS Op-amp by optimizing the processing. We achieved one of the industry's lowest [Note 2] input equivalent noise voltage.

2. **Low current consumption**
   - $I_{DD} \text{ (Typ.)} = 430 \, [\mu A]$

   The low current consumption characteristics of CMOS processing contributes to the extension of battery life of the compact IoT devices [Note 3].

3. **Enhancement type**

   It is easy to handle because it is an enhancement type in which no drain current flows when no gate voltage is applied.

**Ultra-low noise characteristic**

Conventional products: TC75S63TU

New product: 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>$V_{DD(SS)} \text{ (Max)} , [V]$</td>
<td>±2.75</td>
</tr>
<tr>
<td>$V_{DD(SS)} \text{ (Min)} , [V]$</td>
<td>±1.1</td>
</tr>
<tr>
<td>$I_{DD} \text{ (Max)} , [\mu A]$</td>
<td>700</td>
</tr>
<tr>
<td>$V_{NI} \text{ (Typ.)} , [nV/\sqrt{Hz}]$ @f = 1 kHz</td>
<td>6</td>
</tr>
</tbody>
</table>

[Note 1] Various sensors: vibration detection sensors, shock sensors, acceleration sensors, pressure sensors, infrared sensors, and temperature sensors

[Note 2] Based on our survey (as of May 2017).

[Note 3] Comparison with our bipolar process operational amplifier

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This MOSFET is suitable for switching regulators and is easy to handle and greatly contributes to miniaturization.

1. **Low on-resistance**
   
   By keeping the on-resistance between the source and drain low, heat generation and power consumption can be kept low.

2. **Low leakage current**
   
   \[ I_{DSS} = 10 \mu A \text{ (Max)} \] @ \[ V_{DS} = 500 \text{ V} \]

3. **Enhancement type**
   
   It is easy to handle because it is an enhancement type in which no collector current flows when no gate voltage is applied.
Contributing to higher efficiency and miniaturization of power supply.

1. **High current surge resistance**
   \[ I_{FSM} = 37 / 39 \text{ A} \text{ [Note 1]} \]
   Surge current is increased around 2 times of the first generation by using improved JBS structure.

2. **Small leakage current**
   \[ I_R \text{ (Max)} = 20 \text{ μA} \text{ [Note 1]} \]
   Leak current is reduced around 30% of the first generation by using improved JBS structure.

3. **Low switching loss**
   \[ Q_{cj} \text{ (Typ.)} = 10.4 \text{ nC} \text{ [Note 1][Note 2]} \]
   Reduce the total charge amount by thinning wafer technology, switching loss is reduced around 30% of the first-generation product.

---

**Line up**

<table>
<thead>
<tr>
<th>Product name</th>
<th>TRS4A65F</th>
<th>TRS4E65F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>TO-220F-2L (Isolation type)</td>
<td>TO-220-2L</td>
</tr>
<tr>
<td>( V_{BRM} \text{ (Max)} \text{ [V]} )</td>
<td>650</td>
<td>650</td>
</tr>
<tr>
<td>( I_{RDC} \text{ (Max)} \text{ [A]} )</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>( I_{FSM} \text{ (Max)} \text{ [A]} )</td>
<td>37</td>
<td>39</td>
</tr>
<tr>
<td>( I_{MAX} \text{ (Max)} \text{ [μA]} )</td>
<td>0.2 / 20</td>
<td>0.2 / 20</td>
</tr>
<tr>
<td>( Q_{cj} \text{ (Typ.)} \text{ [nC]} )</td>
<td>10.4</td>
<td>10.4</td>
</tr>
</tbody>
</table>

---

[Note 1]: TRS4A65F / TRS4E65F product data
[Note 2]: \( Q_{cj} = \int C_j \times V_R \text{d}V \) \( V_R = 0.1 \text{ to } 400 \text{ V} \)
Bipolar power transistor for high-speed switching applications, suitable for MOSFET gate control.

1. Fast switching time
   - HNB4B101J
     - PNP: $t_f = 45$ ns (Typ.)
     - NPN: $t_f = 50$ ns (Typ.)

2. High $h_{FE}$
   - HNB4B101J
     - $h_{FE} = 200 \sim 500$ A @ $I_C = -0.12$ A

3. Low collector-emitter saturation voltage
   - HNB4B101J
     - PNP: $V_{CE(sat)} = -0.20$ V (Max)
     - NPN: $V_{CE(sat)} = 0.17$ V (Max)

HN4B101J
Internal connection diagram

<table>
<thead>
<tr>
<th>Line up</th>
<th>HN4B101J</th>
<th>HN4B102J</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>SMV</td>
<td>SMV</td>
</tr>
<tr>
<td>$V_{CEO}$ (Q1/Q2) (Max) [V]</td>
<td>-30 / 30</td>
<td>30 / -30</td>
</tr>
<tr>
<td>$I_C$ (Q1/Q2) (Max) [A]</td>
<td>-1.0 / 1.2</td>
<td>2 / -1.8</td>
</tr>
<tr>
<td>$h_{FE}$</td>
<td>200 to 500</td>
<td>200 to 500</td>
</tr>
<tr>
<td>Polarity</td>
<td>PNP + NPN</td>
<td>NPN + PNP</td>
</tr>
</tbody>
</table>

Return to Block Diagram TOP

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High conversion efficiency ($I_F = 0.5 \text{ mA}$)

The TLP383/TLP293 is a high-isolation photocoupler that optically couples a phototransistor and high-output infrared LED. Compared to conventional electromagnetic relays and insulating transformers, it provides low-input current and higher conversion efficiency.

High temperature operation guarantee

The TLP383/TLP293 is designed to operate under severe conditions of ambient temperature environment, such as inverters, robots, machinery, and high-output power supplies.

Industrial equipment

- General-purpose inverter
- Servo amplifier
- Robot
- Machine Tool
- High-output power supply
- Security equipment
- Semiconductor tester
- PLC (Programmable Logic Controller)

High level of isolation and noise blocking

<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>

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Value provided

Suitable for power management switches and greatly contributes to miniaturization.

1 Low voltage drive
Drive at $V_{GS} = 1.5$ V.

2 Low on-resistance
Heat generation and power consumption can be kept low by keeping the on-resistance between the source and drain low.

3 Small package
UDFN6B type packages.

SSM6J501NU
Equivalent circuit diagram

Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>SSM6J501NU</th>
<th>SSM6K513NU</th>
<th>SSM6K514NU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>UDFN6B</td>
<td>UDFN6B</td>
<td>UDFN6B</td>
</tr>
<tr>
<td>Polarity</td>
<td>P-ch</td>
<td>N-ch</td>
<td>N-ch</td>
</tr>
<tr>
<td>$V_{DSS}$ [V]</td>
<td>-20</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>$I_D$ [A]</td>
<td>-10</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>$R_{DS(ON)}$ (Max) [mΩ] @$V_{GS} = 4.5$ V</td>
<td>15.3</td>
<td>8</td>
<td>11.2</td>
</tr>
</tbody>
</table>

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Photorelay consists of an infrared light emitting diode optically coupled to a photo-MOSFET and is suitable for replacing mechanical relays.

1. Low on-resistance $R_{ON}$
   
   On-resistance $R_{ON} = 0.04 \, \Omega$ (Typ.)
   
   (TLP3103: A connection)

2. Wide current range $I_{ON}$
   
   The range of on-state current $I_{ON}$ is wide and suitable for power-line control.
   
   $I_{ON} = 0.6 \, \text{A (Max)}$
   
   (TLP3103: A connection)

3. Package
   
   Packages to reduce the size of the set and improve the degree of freedom for design are provided.

---

**Line up**

<table>
<thead>
<tr>
<th>Part number</th>
<th>Package</th>
<th>TLP3103</th>
<th>TLP3107</th>
<th>TLP3109</th>
<th>TLP3555A</th>
<th>TLP3823</th>
<th>TLP3825</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.54 SOP6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| $I_{ON}$ (Max) [A] | 2.3 | 3.3 | 2.0 | 2.5 | 3.0 | 1.5 |
| $V_{OFF}$ (Max) [V] | 60 | 60 | 100 | 60 | 100 | 200 |
| $R_{ON}$ (Typ.) [mΩ] | 70 | 60 | 70 | 120 | 150 | 500 |
| $BVs$ (Max) [Vrms] | 1500 | 1500 | 1500 | 1500 | 1500 | 1500 |

---

Safety Standards

UL approved: UL1577, File No.E67349

cUL approved: CSA Component Acceptance Service No. 5A, File No.E67349

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Driving series connection Hi-current type white LEDs. There are 1ch and 4ch drive type drivers.

1 Suitable driving a white LED for an LCD back light
Line up are 1ch and 4ch type drivers. 1ch type is suitable for mobile LCD and 4ch one is for small LCD PC.

2 Capable driving series connection white LEDs
1ch type maximum driving number of series connection LED is 6, 4ch one is 9/ch. Built-in step up type power supply adjusts LED driving voltage according to the LED Vf.

3 PWM dimming function
Minimum high level time period is 330 ns about 4ch PWM control based on constant current power supply. 1ch type is possible to dim by few kHz PWM.

Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>TB62763FMG</th>
<th>TB62771FTG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>SON8</td>
<td>WQFN24</td>
</tr>
<tr>
<td>Driving ch number</td>
<td>1 ch</td>
<td>4 ch</td>
</tr>
<tr>
<td>Maximum LED driving number</td>
<td>6</td>
<td>36</td>
</tr>
<tr>
<td>Operation voltage</td>
<td>2.8 to 5.5 V</td>
<td>4.75 to 40 V</td>
</tr>
<tr>
<td>LED driving current</td>
<td>~ 80 mA</td>
<td>~ 150 mA</td>
</tr>
<tr>
<td>Built-in constant current power supply</td>
<td>N/A</td>
<td>Available</td>
</tr>
<tr>
<td>Built-in FET for stepping up power supply</td>
<td>Available</td>
<td>N/A</td>
</tr>
</tbody>
</table>

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**System cost down, high efficiency system, development efficiency improvement**

1. **Built-in ARM® Cortex®-M0 CPU core**
   
   Built-in Arm Cortex®-M0 core with Thumb instruction set improves energy efficiency. Various development tool and their partners allow users many options.

2. **Suitable for sensing analog signal**
   
   Built-in multi-channel ADC and CPU system executes sensing data processing efficiently at low cost.

3. **Small package and very low power consumption**
   
   Cortex®-M0 and original NANO Flash™ technology bring to the small package and low power consumption. They contribute footprint and power consumption reduction.

---

**Line up**

<table>
<thead>
<tr>
<th>Part number</th>
<th>TMPM036FWFG</th>
<th>TMPM037FWUG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum operation frequency</td>
<td>20 MHz</td>
<td>20 MHz</td>
</tr>
<tr>
<td>Instruction ROM</td>
<td>128 KB</td>
<td>128 KB</td>
</tr>
<tr>
<td>RAM</td>
<td>16 KB</td>
<td>16 KB</td>
</tr>
<tr>
<td>Timer</td>
<td>14 ch</td>
<td>10 ch</td>
</tr>
<tr>
<td>UART / SIO</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>I2C</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>ADC</td>
<td>8 ch (10 bit)</td>
<td>8 ch (10 bit)</td>
</tr>
</tbody>
</table>

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