IoT Sensor

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
IoT Sensor  Overall Block Diagram

AC adapter  5V/1A  USB

RESET  MCU  Wireless Interface

USB

Gas Sensor  Op-amp

MIC  Op-amp

Humidity and Temperature Sensor

Ambient Light Sensor

MOSFET  LED

MCU, RESET, AMP, Gas Sensor, Humidity and Temperature Sensor, Ambient Light Sensor, WLAN

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AC-DC flyback power

Device selection points

- VDSS ratings are critical to choosing a MOSFET. Applications that use more than a VDSS may destroy the MOSFET.
- The VDSS rating for a high MOSFET tends to be high on-resistance RDS (on).

Proposals from Toshiba

- **Optimal for high-efficiency power supply switching**
  Power MOSFET
- **Strong with efficiency figure of merit and surge current**
  SiC Schottky barrier diode
- **Optimal for high-speed gating of MOSFET**
  Bipolar power transistors
- **Photocoupler with excellent environmental resistance**
  IC output photocoupler
IoT Sensor  Details of sensor signal detection unit

Gas detection

- The voltage and current supplied are important for using the operational amplifier.
- The use of small packages reduces the board area.

Proposals from Toshiba

- Support for stable sensor operation
  High noise rejection performance, low consumption, compact LDO
- Amplify the detected small signal with low noise.
  General-purpose operational amplifier
IoT Sensor  Details of LED Drive unit

LED drive

Device selection points
- LED current, MCU output voltage, base-emitter voltage, and transistor DC current are important factors in selecting LED driving transistors.
- The use of small packages reduces the board area.

Proposals from Toshiba
- Compact packaging with high withstand voltage and high hFE
  Bipolar transistor

※ Click the number in the circuit diagram to jump to the detailed description page
Device selection points
- Multi-channel analog or digital interfaces are needed for monitoring various sensor output.
- High performance of data processing is required to analyze sensor data at realtime.
- Communication standard variation is needed to upload sensor data and/or its analyzation result.

Proposals from Toshiba
- High processing performance with multi-channel sensor interfaces and communication standard variety.
Recommended Devices
As described above, in the design of IoT sensors, "Miniaturization of circuit boards", "Low power consumption of sets" and "Robust operation" are important factors. Toshiba's proposals are based on three solution perspectives.
Device Solutions to address customer needs

<table>
<thead>
<tr>
<th></th>
<th>Small size packages</th>
<th>High efficiency • Low-loss</th>
<th>Noise immunity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Power MOSFET</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>SiC Schottky barrier diode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Bipolar power transistors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>IC output photocoupler</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Small surface mount LDO regulator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>General-purpose operational amplifier</td>
<td></td>
<td></td>
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<tr>
<td>7</td>
<td>Bipolar transistor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>MCU</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Power MOSFET
TK18A50D / TK12P50W

Value provided

Suitable for switching regulators and 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

Drain-cut-off current $I_{DSS} = 10\mu A$ (max.) ($V_{DS} = 500V$)

3 Enhancement type

It's easy to design because it is an enhancement type in which no collector current when no gate voltage is applied.

TK18A50D Characteristics Curves

Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>TK18A50D</th>
<th>TK12P50W</th>
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</thead>
<tbody>
<tr>
<td>Package</td>
<td>TO-220SIS</td>
<td>DPAK</td>
</tr>
<tr>
<td>$V_{DSS}$ (Max) [V]</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>$I_D$ (Max) [A]</td>
<td>18</td>
<td>11.5</td>
</tr>
<tr>
<td>$P_D$ (Max) [W]</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>$C_{iss}$ (Typ.) [pF]</td>
<td>2600</td>
<td>890</td>
</tr>
<tr>
<td>$R_{DS(ON)}$ (Max) [Ω]</td>
<td>0.27</td>
<td>0.34</td>
</tr>
<tr>
<td>Polarity</td>
<td>N-ch</td>
<td>N-ch</td>
</tr>
</tbody>
</table>

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SiC Schottky barrier diode

TRS4A65F / TRS4E65F

Contributing to higher efficiency and miniaturization of power supply.

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

2. Small leakage current
   \[ I_R (max) = 20 [\mu A] \]
   Leak current is reduced around 30% of the first generation by using improved JBS structure.

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

Internal Circuit

Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>TRS4A65F</th>
<th>TRS4E65F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>TO-220F-2L</td>
<td>TO-220-2L</td>
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<tr>
<td>( V_{RMS} ) (Max) [V]</td>
<td>650</td>
<td>650</td>
</tr>
<tr>
<td>( I_{R(DS)} ) (Max) [A]</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>( I_{FSM} ) (Max) [A]</td>
<td>37</td>
<td>39</td>
</tr>
<tr>
<td>( I_{r} ) (Typ./Max) [\mu A]</td>
<td>0.2 / 20</td>
<td>0.2 / 20</td>
</tr>
<tr>
<td>( Qc ) (Typ.) [nC]</td>
<td>10.4</td>
<td>10.4</td>
</tr>
</tbody>
</table>

Note 1: TRS4A65F / TRS4E65F product data
Note 2: \( Qc = \int C_j \times V_R \, dv \quad V_R = 0.1 \) to 400V

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Bipolar power transistor for high speed switching
HN4B101J / HN4B102J

A high-speed switching bipolar power transistor suitable for MOSFET gating.

1. High-speed switching
   - HN4B101J
     - $t_f = 45/50$ [ns] (Typ.) (PNP/NPN)
   - HN4B102J
     - $t_f = 40/45$ [ns] (Typ.) (PNP/NPN)

2. High DC current gain
   - HN4B101J, HN4B102J
     - PNP: $h_{FE} = 200$ to $500$ @ $I_C = -0.12$ [A]
     - NPN: $h_{FE} = 200$ to $500$ @ $I_C = 0.12$ [A]

3. Low collector-emitter saturation
   - HN4B101J
     - $V_{CE(sat)} = -0.20/0.17$ [V] (Max) (PNP/NPN)
   - HN4B102J
     - $V_{CE(sat)} = -0.20/0.14$ [V] (Max) (PNP/NPN)

HN4B101J
Circuit Configuration

<table>
<thead>
<tr>
<th>Part number</th>
<th>HN4B101J</th>
<th>HN4B102J</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>SMV</td>
<td>SMV</td>
</tr>
<tr>
<td>$V_{CEO}$ (Max) [V] @Q1/Q2</td>
<td>$-30/50$</td>
<td>$30/30$</td>
</tr>
<tr>
<td>$I_C$ (Max) [A] @Q1/Q2</td>
<td>$-1.0/1.2$</td>
<td>$-1.8/2$</td>
</tr>
<tr>
<td>$h_{FE}$ (Min/Max)</td>
<td>$200/500$</td>
<td>$200/500$</td>
</tr>
<tr>
<td>Polarity</td>
<td>Q1:PNP + Q2:NPN</td>
<td>Q1:PNP + Q2:NPN</td>
</tr>
</tbody>
</table>

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This photocoupler combines an infrared light-emitting diode with high optical output and an integrated circuit light-receiving IC chip with high gain and high speed.

1. **Analog output**
   The output current changes in an analog manner according to the input LED current. It is suitable for power supply feedback circuits.

2. **Common-mode transient immunity 10 kV/μs**
   For applications where high dV/dt is applied to both ends of the photocoupler, high CMTI is required. Our device guarantee the CMTI of 10 kV/μs(min) by adapting shield between the input and output.

3. **High speed**
   Propagation delay time is guaranteed at 2 μs (max) in operation temperature range. The design is easier than normal photo-transistor coupler.

### Internal circuit configuration
![IC output photocoupler diagram](image)

### Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>TLP2719(LF4)</th>
</tr>
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<tbody>
<tr>
<td><strong>Package</strong></td>
<td>SO6L(LF4)</td>
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<tr>
<td><strong>BVf (Min) [Vrms]</strong></td>
<td>5000</td>
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<tr>
<td><strong>NRZ (Typ.) [Mbps]</strong></td>
<td>1</td>
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<tr>
<td><strong>CMH, CML (Min) [kV/μs]</strong></td>
<td>±10</td>
</tr>
</tbody>
</table>

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*Return to Block Diagram TOP*
Small current LDO regulator
TCR3UG series / TCR3UM series

Value provided

Ideal LDO capable of low-power and long-life operation with low output voltage fluctuation by eliminating switching noise.

1 High ripple rejection
Our LDO regulator has a high degree of ripple compression, eliminates switching noise generated in the power supply circuit, and achieves stable power supply.

2 Low loss (low current consumption)
Our LDO regulators can minimize internal current consumption and maximize device operating time with limited batteries.

3 Optimal for high-density packaging
A wide range of small packages are available.

Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>TCR3UG Series</th>
<th>TCR3UM Series</th>
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</thead>
<tbody>
<tr>
<td>Package</td>
<td>WCSP4F</td>
<td>DFN4</td>
</tr>
<tr>
<td>I_{OUT} (Max) [mA]</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td>V_{D0} (Typ.) [mV] @ I_{OUT}=300 mA</td>
<td>140</td>
<td>196</td>
</tr>
<tr>
<td>R.R. (Typ.) [dB]</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>I_{B(ON1)} (Typ.) [μA]</td>
<td>0.34</td>
<td>0.34</td>
</tr>
</tbody>
</table>

Conventional product

TCR3U series

New product

Significant improvement

Low quiescent current

INPUT VOLTAGE V_{IN} (V)

I_{OUT} (μA)

Quiescent current

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Low-consumption, low-noise operational amplifier
TC75S55FU / TC75S67TU

Low-power-consumption type and low-noise type operational amplifiers that maximize the performance of high-performance sensors

1. **Low voltage operation**

We have a lineup of low power supply voltage-driven operational amplifiers using CMOS process for low power supply voltage-driven IoT equipment.

2. **Low current power supply (TC75S55FU) I_{DD}(typ.) =10[μA]**

CMOS processes have been used to achieve lower current dissipation. This contributes to lower power consumption and longer life of IoT equipment.

3. **Ultra low noise (TC75S67TU) V_{IN}(Typ.)=6.0 [nV/√Hz] @f=1kHz**

This CMOS operational amplifier can amplify minute signals detected by various sensors with very low noises. By optimizing the process, we have achieved the industry's top-level low equivalent input noise voltage.

TC75S55FU/TC75S67TU Internal pictorial connection diagram

TC75S67TU noise characteristic (Company comparison)

<table>
<thead>
<tr>
<th>Line up</th>
<th>Part number</th>
<th>TC75S55FU</th>
<th>TC75S67TU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>USV</td>
<td>USV</td>
<td>UFV</td>
</tr>
<tr>
<td>V_{DD}, V_{SS} [V]</td>
<td>1.8 to 7.0</td>
<td>2.2 to 5.5</td>
<td></td>
</tr>
<tr>
<td>V_{NC} (Max) [mV]</td>
<td>10</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>CMVRH (Max) [V]</td>
<td>V_{DD} - 0.9</td>
<td>V_{DD} - 1.1</td>
<td></td>
</tr>
<tr>
<td>I_{DD} (Max) [μA]</td>
<td>20</td>
<td>700</td>
<td></td>
</tr>
<tr>
<td>CMRR (Typ.) [dB]</td>
<td>70</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>f_{z} (Typ.) [MHz]</td>
<td>0.14</td>
<td>3.5</td>
<td></td>
</tr>
</tbody>
</table>

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Bipolar transistor

2SA1313

Value provided

Suitable for low-frequency, low-power amplification and greatly contributes to miniaturization.

1. High voltage

$V_{CEO}$ can be applied up-to -50V (Max).

2. Complementary products

It is complementary to 2SC3325.

3. Larger collector current

$I_C$ can be applied up-to -500mA (Max).

2SA1313 Characteristics

Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>2SA1313</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>S-Mini</td>
</tr>
<tr>
<td>$V_{CEO}$ (Max) [V]</td>
<td>-50</td>
</tr>
<tr>
<td>$I_C$ (Max) [mA]</td>
<td>-500</td>
</tr>
<tr>
<td>$P_C$ (Max) [mW]</td>
<td>200</td>
</tr>
<tr>
<td>Polarity</td>
<td>PNP</td>
</tr>
</tbody>
</table>

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Monitoring sensor at low power consumption by using built-in ADCs, Timers and various communication interfaces.

1. **Built-in ARM® Cortex®-M3 CPU core**
   TMPM368FDFG implements Cortex®-M3 core with 80MHz maximum operation frequency. It is suitable for processing sensor data at real-time. Various development tool and their partners allow users many options.

2. **System cost down and development efficiency improvement**
   TMPM368FDFG executes sensing data monitoring and processing efficiently by combining built-in analog function such as ADC, and CPU system. The original NANO FLASH™ is possible to rewrite at high-speed. It reduces user software development time period.

3. **Various communication interfaces**
   TMPM368FDFG supports major communication interfaces such as USB, CAN, UART and SPI. User can construct a communication system easily with a cloud.

### Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>TMPM368FDFG</th>
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<tbody>
<tr>
<td>Maximum operation frequency</td>
<td>80MHz</td>
</tr>
<tr>
<td>Instruction ROM</td>
<td>512KB</td>
</tr>
<tr>
<td>RAM</td>
<td>128KB</td>
</tr>
<tr>
<td>Timer</td>
<td>16bit x 8ch</td>
</tr>
<tr>
<td>ADC</td>
<td>8ch x 12bit</td>
</tr>
<tr>
<td>USB</td>
<td>Host 1ch, Device 1ch</td>
</tr>
<tr>
<td>CAN, UART/SIO</td>
<td>1ch, 4ch</td>
</tr>
</tbody>
</table>

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