Smart Speaker
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
Smart Speaker

Overall block diagram

Up to 3.3 V: CPU/GPU, Memory
5 V: Display Driver, LED Driver, Display Power, D-AMP, etc.
Up to 3.3 V: Camera, ALS, etc.
Smart Speaker Details of power supply and Wi-Fi® / Bluetooth® section

**Power supply circuit**

15 V/5 V DC

TVS

eFuse IC / Gate Driver IC & N-ch MOSFET

Power Management IC

Processor

Battery

**Wi-Fi / Bluetooth solution**

TVS

LDO

DC/DC

TVS

TVS

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

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**Criteria for device selection**

- PSRR (Power Supply Rejection Ratio) of LDO regulator is an important parameter for wireless system.
- Small package products contribute to the reduction of circuit board area.
- A small Transient Voltage Suppressor (TVS) with low C<sub>t</sub> is suitable for ESD protection without attenuating the antenna signal.

**Proposals from Toshiba**

- Supply the power with low noise
  Small surface mount LDO regulator
- Absorb Electro Static Discharge (ESD) from antennas and prevent malfunction of the circuit
  TVS diode
- Built-in protection function against short circuit, over current, over voltage, etc.
  Electronic fuse (eFuse IC)
- Small package and built-in over voltage protection function
  N-ch MOSFET gate driver IC
Smart Speaker  Details of sensor / camera section

Ambient light sensor

1. LDO
2. Op-amp
3. Image Processor

Photo Diode

Camera modules

1. LDO
2. TVS
3. Image Processor

PMIC / DCDC converter
Digital I/O Camera / Image Sensor
Analog

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

Criteria for device selection
- Operational amplifiers with low noise are suitable for the sensor block.
- PSRR (Power Supply Rejection Ratio) of LDO regulator is an important parameter for wireless system.
- The low C, small package transient voltage suppressor (TVS) is ideal for ESD protection.

Proposals from Toshiba
- Supply the power with low noise
  Small surface mount LDO regulator
- Absorb Electro Static Discharge (ESD) from external terminals and prevent malfunction of the circuit
  TVS diode
- Amplify the detected very small signal with low noise
  Low noise operational amplifier
Smart Speaker  Detail of boost converter for LCD backlight

**Criteria for device selection**
- Schottky Barrier Diode (SBD) requires low $V_F$ and low $I_R$.
- High voltage MOSFET is suitable for the boost converter.

**Proposals from Toshiba**
- **Realize a set with low power consumption by low on-resistance**
  Small signal MOSFET
- **High speed and low loss diode with a small surface mount package**
  Schottky barrier diode

※ Click the number in the circuit diagram to jump to the detailed description page
Criteria for device selection
- The low $C_r$, small package transient voltage suppressor (TVS) is suitable for ESD protection.

Proposals from Toshiba
- **Absorb Electro Static Discharge (ESD)** from external terminals and prevent malfunction of the circuit
  TVS diode

※ Click the number in the circuit diagram to jump to the detailed description page
Recommended
Devices
As described above, in the design of smart speakers, “Miniaturization of circuit boards”, “Low power consumption of 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>Small surface mount LDO regulator</th>
<th>TVS diode</th>
<th>Low noise operational amplifier</th>
<th>Small signal MOSFET</th>
<th>Schottky barrier diode</th>
<th>Electronic fuse (eFuse IC)</th>
<th>N-ch MOSFET gate driver IC</th>
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<tbody>
<tr>
<td>1</td>
<td><img src="image" alt="Small size packages" /> <img src="image" alt="High efficiency - Low loss" /> <img src="image" alt="Noise immunity" /></td>
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</tbody>
</table>
Wide lineup from general purpose type to small package type are provided. Contribute to realize a stable power supply not affected by fluctuation of battery.

1. **Low dropout voltage**

The originally developed latest process significantly improved the dropout voltage characteristics.

2. **High PSRR**

Many product series that realize both high PSRR (Power Supply Rejection Ratio) and low output noise voltage characteristics are provided. They are suitable for stable power supply for analog circuit.

3. **Low current consumption**

0.34 μA of $I_{B(ON)}$ is realized by utilizing CMOS process and unique circuit technology. (TCR3U Series)

---

### Lineup

<table>
<thead>
<tr>
<th>Part number</th>
<th>TCR15AG Series</th>
<th>TCR13AG Series</th>
<th>TCR8BM Series</th>
<th>TCR5BM Series</th>
<th>TCR5RG Series</th>
<th>TCR3RM Series</th>
<th>TCR3U Series</th>
<th>TCR2L Series</th>
<th>TAR5 Series</th>
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<tr>
<td>Features</td>
<td>Low dropout voltage</td>
<td>High PSRR</td>
<td>High PSRR</td>
<td>Low current consumption</td>
<td>15V Input voltage</td>
<td>Bipolar type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{OUT}$ (Max) [A]</td>
<td>1.5</td>
<td>1.3</td>
<td>0.8</td>
<td>0.5</td>
<td>0.3</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSRR (Typ.) [dB] $@f=1$ kHz</td>
<td>95</td>
<td>90</td>
<td>98</td>
<td>98</td>
<td>100</td>
<td>100</td>
<td>70</td>
<td>-</td>
<td>70</td>
</tr>
<tr>
<td>$I_{B}$ (Typ.) [μA]</td>
<td>25</td>
<td>56</td>
<td>20</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>0.34</td>
<td>1</td>
<td>170</td>
</tr>
</tbody>
</table>

---

Note: Toshiba internal comparison

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Value provided

Absorbs static electricity (ESD) from external terminals, prevents circuit malfunction and protects devices.

**1. High ESD pulse absorption performance**

Improved ESD absorption compared to our conventional products. (50 % reduction in operating resistance) For some products, both low operating resistance and low capacitance are realized and ensures high signal protection performance and signal quality.

**2. Suppress ESD energy by low clamp voltage**

Protect the connected circuits/devices using Toshiba own technology.

**3. Suitable for high density mounting**

A variety of compact packages are available.

### Lineup

<table>
<thead>
<tr>
<th>Part number</th>
<th>DF2B6M4SL</th>
<th>DF2B6M4BSL</th>
<th>DF2B20M4SL</th>
<th>DF2B5BSL</th>
<th>DF2B5PCT</th>
<th>DF2B7PCT</th>
</tr>
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<tbody>
<tr>
<td>Package</td>
<td>SL2</td>
<td>CST2</td>
<td>SL2</td>
<td>CST2</td>
<td>SL2</td>
<td>CST2</td>
</tr>
<tr>
<td>( V_{\text{ESD}} ) [kV]</td>
<td>±20</td>
<td>±8</td>
<td>±15</td>
<td>±23</td>
<td>±30</td>
<td>±30</td>
</tr>
<tr>
<td>( V_{\text{RWM}} ) (Max) [V]</td>
<td>5.5</td>
<td>5.5</td>
<td>18.5</td>
<td>3.3</td>
<td>3.6</td>
<td>5.5</td>
</tr>
<tr>
<td>( C_t ) (Typ.) [pF]</td>
<td>0.2</td>
<td>0.12</td>
<td>0.2</td>
<td>0.2</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>( R_{\text{DYN}} ) (Typ.) [Ω]</td>
<td>0.5</td>
<td>1.05</td>
<td>0.2</td>
<td>0.2</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Purpose</td>
<td>Signal line</td>
<td>Signal line</td>
<td>Signal line</td>
<td>Power line</td>
<td>Power line</td>
<td>Power line</td>
</tr>
</tbody>
</table>

(Note): This product is an ESD protection diode and cannot be used for purposes other than ESD protection.
Low noise operational amplifier
TC75S67TU

Value provided

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

1 Low noise

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

Very small signals detected by various sensors [Note 1] can be amplified with low noise using CMOS operational amplifier by optimizing the processing. We achieved low input equivalent noise voltage.

Low noise characteristic
(Toshiba internal comparison)

[Note 1] Sensor types: vibration detection sensor, shock sensor, accelerometer, pressure sensor, infrared sensor, and temperature sensor, etc.
[Note 2] Compared with Toshiba’s operational amplifier using bipolar processing

2 Low current consumption

\[ I_{DD} = 430 \text{ [μA] (Typ.)} \]

The low current consumption characteristics of CMOS processing contributes to the extension of battery life of the compact IoT devices [Note 2].

Lineup

<table>
<thead>
<tr>
<th>Part number</th>
<th>TC75S67TU</th>
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<tbody>
<tr>
<td>Package</td>
<td>UFV</td>
</tr>
<tr>
<td>( V_{DD,SS} \text{ (Max)} \text{ [V]} )</td>
<td>±2.75</td>
</tr>
<tr>
<td>( V_{DD,SS} \text{ (Min)} \text{ [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 = 1 \text{ kHz} )</td>
<td>6</td>
</tr>
</tbody>
</table>

[Note 1] Sensor types: vibration detection sensor, shock sensor, accelerometer, pressure sensor, infrared sensor, and temperature sensor, etc.
[Note 2] Compared with Toshiba’s operational amplifier using bipolar processing
Suitable for power management switches and greatly contributes to miniaturization.

1. **Low voltage operation**
   
   Operates down to $V_{GS} = 4.0$ V.
   (SSM3K15ACT)

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

3. **Small package**
   
   Small package is suitable for high density mounting.

---

**Lineup**

<table>
<thead>
<tr>
<th>Part number</th>
<th>SSM3K341R</th>
<th>SSM6K514NU</th>
<th>SSM3K15ACT</th>
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<tr>
<td>Package</td>
<td>SOT-23F</td>
<td>UDFN6B</td>
<td>CST3</td>
</tr>
<tr>
<td>Polarity</td>
<td>N-ch</td>
<td>N-ch</td>
<td>N-ch</td>
</tr>
<tr>
<td>$V_{DSS}$ [V]</td>
<td>60</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>$I_{D}$ [A]</td>
<td>6</td>
<td>12</td>
<td>0.1</td>
</tr>
<tr>
<td>$R_{DS(ON)}$ [mΩ] @ $V_{GS} = 4.5$ V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typ.</td>
<td>36</td>
<td>11.2</td>
<td>2.3</td>
</tr>
<tr>
<td>Max.</td>
<td>51</td>
<td>17.3</td>
<td>3.6</td>
</tr>
</tbody>
</table>

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Schottky barrier diode with low $V_F$ and low $I_R$ is suitable for high efficiency diode rectification application.

1. High speed switching

Suitable for high speed switching applications.

2. Small package

Small package is suitable for high density mounting.

CTS05F40 Characteristics Curves

<table>
<thead>
<tr>
<th>Part number</th>
<th>CUS10F30</th>
<th>CTS05F40</th>
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<tbody>
<tr>
<td>Package</td>
<td>USC</td>
<td>CST2</td>
</tr>
<tr>
<td>Absolute maximum ratings</td>
<td>$V_A$ [V]</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>$I_0$ [A]</td>
<td>1.0</td>
</tr>
<tr>
<td>$V_{f}$ (Max) [V]</td>
<td></td>
<td>0.50</td>
</tr>
<tr>
<td>$I_{R}$ (Max) [$\mu$A]</td>
<td></td>
<td>50</td>
</tr>
</tbody>
</table>

◆Return to Block Diagram TOP
Electronic fuse (eFuse IC) can be used repeatedly to protect circuits from abnormal conditions such as overcurrent and overvoltage.

1. Can be used repeatedly

When overcurrent flows through the electronic fuse (eFuse IC), the internal detection circuit operates and switches off the internal MOSFET. It is not destroyed by a single overcurrent and can be used repeatedly.

2. IEC 62368-1 certified

Toshiba’s eFuse ICs are certified to the international safety standard IEC 62368-1 (G9: Integrated circuit (IC) current limiters) and contribute to robust protection and simplification of circuit design.

3. Rich protection functions

TCKE8 Series: short-circuit protection, overcurrent protection, overcurrent clamp function, overvoltage clamp function, thermal shut down, inrush current suppression, backflow prevention (optional), etc.

TCKE7 Series: short-circuit protection, overcurrent protection, overvoltage protection, thermal shut down, FLAG signal output, backflow prevention (built-in), etc.

Reference circuit example of TCKE8 Series

Reference circuit example of TCKE7 Series

Lineup

<table>
<thead>
<tr>
<th>Part number</th>
<th>TCKE800NA/NL</th>
<th>TCKE805NA/NL</th>
<th>TCKE812NA/NL</th>
<th>TCKE712BNL</th>
</tr>
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<tbody>
<tr>
<td>Package</td>
<td>WSON10B</td>
<td>WSON10</td>
<td>WSON10</td>
<td></td>
</tr>
<tr>
<td>V&lt;sub&gt;IN&lt;/sub&gt; [V]</td>
<td>4.4 to 18</td>
<td>4.4 to 13.2</td>
<td>4.4 to 13.2</td>
<td></td>
</tr>
<tr>
<td>R&lt;sub&gt;ON&lt;/sub&gt; (Typ.) [mΩ]</td>
<td>28</td>
<td>53</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>Return function</td>
<td>NA: Automatic return</td>
<td>NL: Latch type (external signal control)</td>
<td>Latch type (external signal control)</td>
<td></td>
</tr>
<tr>
<td>V&lt;sub&gt;OV&lt;/sub&gt; (Typ.) [V]</td>
<td>NA</td>
<td>6.04</td>
<td>15.1</td>
<td></td>
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**N-ch MOSFET gate driver IC**

**TCK4xx Series**

**Value provided**

It is N-ch MOSFET gate driver IC with OVP [Note 1] function. It contributes to reduction of power consumption and miniaturization of load switch circuit.

**1 3 types of connection of N-ch MOSFET can be driven**

The following types of connection of N-ch MOSFET can be driven:
- TCK40xG : Single high side connection
- Common source connection
- TCK42xG : Single high side connection
- Common drain connection

**2 Wide operating voltage range and various OVLO [Note 2] threshold voltage**

Operating voltage $V_{\text{opr}}$ : 2.7 to 28 V
Maximum input voltage : 40 V
$V_{\text{IN,OVLO}}$ [Note 3] lineups suitable for 5 to 24V power supply line.

**[Note 1] OVP : Over Voltage Protection**

$V_{\text{IN,OVLO}}$ : $V_{\text{IN}}$ OVLO threshold

**3 Small packages**

It contributes to reduction of the mounting area and miniaturization of the circuit board:

- WCSP6E : 1.2 x 0.8 mm, t : 0.55 mm
- WCSP6G : 1.2 x 0.8 mm, t : 0.35 mm

### Circuit example of TCK42xG with N-ch common drain connection MOSFET

![Circuit diagram](image)

- Five variations of threshold voltage
- Gate voltage 5.6 V or 10 V

### Lineup

<table>
<thead>
<tr>
<th>Part number</th>
<th>$V_{\text{IN,OVLO}}$ Min / Max [V]</th>
<th>$V_{\text{GS}}$ Typ. / Max [V]</th>
<th>N-ch MOSFET type can be driven</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCK401G</td>
<td>Over 28</td>
<td>Max 10 (V_{\text{IN}} \geq 12 V)</td>
<td>Single high side Common Source</td>
<td>WCSP6E</td>
</tr>
<tr>
<td>TCK402G</td>
<td>TCK420G</td>
<td>26.50 / 28.50</td>
<td>Single high side Common Drain</td>
<td>WCSP6G</td>
</tr>
<tr>
<td>TC422G</td>
<td>13.61 / 14.91</td>
<td>10 / 11 (V_{\text{IN}} \geq 5 V)</td>
<td>5.6 / 6.3</td>
<td></td>
</tr>
<tr>
<td>TCK423G</td>
<td>13.61 / 14.91</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TCK424G</td>
<td>10.35 / 11.47</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TCK425G</td>
<td>5.76 / 6.87</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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[Note 2] OVLO : Over Voltage Lock Out

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*Return to Block Diagram TOP*
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