Smart Plug
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.
Smart Plug   Overall block diagram

AC Inlet

Power Supply

AC-DC Converter

Wireless Control

Wireless Module

LDO

Key Switch

TVS

Mechanical Relay

AC Outlet

AC Switch

SBD

MOSFET
Smart Plug  Detail of wireless / key input section

Criteria for device selection
- For components such as key switches and antennas which may be exposed to the outside environment, protection circuitry may be required.

Proposal from Toshiba
- Prevent circuit malfunctions by absorbing electrostatic discharge (ESD) from external terminals
  TVS diodes

※ Click on the blue circled numbers above to view detailed descriptions.
Criteria for device selection
- Schottky barrier diodes are used for surge protection of inductive loads such as relays.
- Low power AC switches can be realized using photo relays.

Proposal from Toshiba
- **Diodes for surge current protection**
  Schottky barrier diodes
- **Small package, low on-resistance MOSFET**
  Small-signal MOSFETs
- **Designed for high AC withstand voltage**
  Photo relays

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

Control of commercial AC requires regulatory compliance for each country.
Criteria for device selection

- Insulated AC switch can be realized using a MOSFET driven by a photovoltaic coupler.
- AC switch can be realized using a triac driven by a triac-output coupler.

Proposal from Toshiba

- **Photocoupler with direct MOSFET drive**
  Photovoltaic output photocoupler
- **Ideal for high-efficiency power switching**
  DTMOSIV MOSFET (super-junction type)
- **Suitable for AC controlled photocoupler**
  Triac-output photocoupler

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

Control of commercial AC requires regulatory compliance for each country.
Criteria for device selection
- Rectifier diodes for AC-DC power supplies generally require high reverse voltages and short reverse recovery time.
- For power supply ICs which include analog circuitry such as wireless, low noise is a requirement for stable operation.

Proposal from Toshiba
- **High reverse voltage, short reverse recovery time**
  Rectifier diodes
- **Resistant to power supply noise**
  Small surface mount LDO regulator

※ Click on the blue circled numbers above to view detailed descriptions.
Recommended Devices
Device solutions to address customer needs

For Smart Plug designs, basic solutions are proposed from the three perspectives of:

- **AC insulation**
- **High set efficiency**
- **Board miniaturization**
### Device solutions to address customer needs

<table>
<thead>
<tr>
<th></th>
<th>High voltage • Insulation</th>
<th>Efficiency • Low loss</th>
<th>Small packaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TVS diode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Schottky barrier diode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Small signal MOSFET</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Photo relay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Photovoltaic output photo coupler</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>DTMOS IV power MOSFET</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Triac output photo coupler</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Rectifier diode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Small surface mount LDO regulator</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**TVS diode**

*DF2B7ASL / DF2S14P1CT / DF2B5M4SL / DF2B6M4SL*

**Value provided**

**Protects devices and prevents circuit malfunctions by absorbing ESD entering from external terminals.**

1. **Increase ESD pulse absorption**

   Compared to our earlier products, ESD absorption is improved (operating resistance reduced by 50%). High signal quality and protection assured by means of low operating resistance and low capacitance.

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

   Using original technology, provides full protection of connected circuit components.

3. **High density mounting**

   Wide selection of packages available (single / multi flow-through).

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### Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>DF2B7ASL</th>
<th>DF2S14P1CT</th>
<th>DF2B5M4SL</th>
<th>DF2B6M4SL</th>
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</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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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.

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Schottky barrier diode (SBD)  
CUS01 / CUS02

Fast, low-loss, small package and ideal for many applications.

**Fast switching**
For fast switching applications.

**High reverse voltage**
High repetitive peak reverse voltage ($V_{RRM}$)  
(CUS01: rated at 30 V)

**Small package**
Small package form factor allows high density mounting.

### Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>CUS01</th>
<th>CUS02</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>US-FLAT</td>
<td>US-FLAT</td>
</tr>
<tr>
<td>$V_{RRM}$ (Max) [V]</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>$I_{(AV)}$ (Max) [A]</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>$V_{FM}$ (Max) [V]</td>
<td>0.37</td>
<td>0.45</td>
</tr>
<tr>
<td>$I_{(RMM)}$ (Max) [mA]</td>
<td>1.5</td>
<td>0.1</td>
</tr>
</tbody>
</table>

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Ideal for power management switching, with small package dimensions.

1. Low voltage operation
   Can operate at $V_{DS} = 1.5\, V$

2. Strong ESD tolerance
   ESD (HBM) tolerance up to 2 kV

3. Low ON resistance
   By reducing source-drain on-resistance, heat radiation and power dissipation is minimized.

Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>SSM3K36FS</th>
<th>SSM3K56FS</th>
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<tbody>
<tr>
<td>Package</td>
<td>SSM</td>
<td>SSM</td>
</tr>
<tr>
<td>$V_{DS}$ [V]</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>$I_D$ [A]</td>
<td>0.5</td>
<td>0.8</td>
</tr>
<tr>
<td>$P_D$ [W]</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>$R_{DS(ON)}$ [Ω]</td>
<td>0.63</td>
<td>0.235</td>
</tr>
<tr>
<td>Polarity</td>
<td>N-ch</td>
<td>N-ch</td>
</tr>
</tbody>
</table>

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8-pin DIP photo relay using a photo MOSFET optically connected to an infrared LED.

1. **Low on-resistance $R_{ON}$**
   
   Maximum on-resistance $R_{ON}$ at turn-on is 2 $\Omega$ (at $I_{ON} = 0.6$ A)

2. **Wide range of ON current $I_{ON}$**
   
   Wide range of allowed ON current $I_{ONp}$ suitable for power line control (maximum 0.6 A : A connected)

3. **Wide package selection**
   
   Small package allowing design freedom and forming option (through-hole type, lead forming option, taping option. Five total selections)

**Internal equivalent circuit**

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**Line up**

<table>
<thead>
<tr>
<th>Part number</th>
<th>TLP3549</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>DIP8</td>
</tr>
<tr>
<td>$V_{OFF}$ [V]</td>
<td>600</td>
</tr>
<tr>
<td>$V_{DD}$ (Max) [V]</td>
<td>480</td>
</tr>
<tr>
<td>$I_{I}$ (Max) [mA]</td>
<td>25</td>
</tr>
<tr>
<td>$I_{ON}$ (Max) [A]</td>
<td>0.6</td>
</tr>
<tr>
<td>$BV_z$ (Max) [Vrms]</td>
<td>2500</td>
</tr>
</tbody>
</table>
Photovoltaic output photocoupler
TLP3906

Photocoupler containing optically connected photo diode array and infrared LED.

1. Suitable for MOS driver
Photodiode is connected in series, suitable for driving the gate of MOS devices

2. No need for external dissipation resistor
Since the control circuit is on the detector side, there is no need to connect an external dissipation resistor.

3. Improved switching speed
t<sub>ON</sub>/t<sub>OFF</sub> is 1 ms maximum.

Internal equivalent circuit

<table>
<thead>
<tr>
<th>Line up</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Part number</td>
<td>TLP3906</td>
</tr>
<tr>
<td>Package</td>
<td>SO6 4pin</td>
</tr>
<tr>
<td>I&lt;sub&gt;I&lt;/sub&gt; (Max) [mA]</td>
<td>15</td>
</tr>
<tr>
<td>V&lt;sub&gt;CC&lt;/sub&gt; (Min) [V]</td>
<td>7</td>
</tr>
<tr>
<td>I&lt;sub&gt;C&lt;/sub&gt; (Min) [μA]</td>
<td>12</td>
</tr>
<tr>
<td>BV&lt;sub&gt;S&lt;/sub&gt; (Max) [Vrms]</td>
<td>3750</td>
</tr>
<tr>
<td>Lateral spacing (Min) [mm]</td>
<td>5.0</td>
</tr>
</tbody>
</table>

(Note): To specify a VDE certified model, request a (V4) model

UL certified UL1577, File No.E67349
cUL certified CSA Component Acceptance Service No.5A File No.E67349
VDE certified EN60747-5-5, EN60065, EN60950-1 (Note)

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Performance index RonA reduced by 30 %*, power supply improved, allowing smaller set form factor.

1. **30 % reduction of RonA**

Using a new single epitaxial process, performance index Ron·A is reduced by 30 % (DTMOSⅢ comparison*).

2. **Reduced increase in on-resistance at high temperature**

Using a new single epitaxial process, rise of on-resistance at high temperature is kept low.

3. **Optimized gate switching speed**

Reduction of Coss (12 % *) and On resistance (super junction structure DTMOS) allows optimized gate switching speed.

### Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>TK5P60W</th>
<th>TK8P60W</th>
<th>TK16G60W</th>
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<tbody>
<tr>
<td>Package</td>
<td>DPAK</td>
<td>DPAK</td>
<td>D2PAK</td>
</tr>
<tr>
<td>V_DSS [V]</td>
<td>600</td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td>I_D [A]</td>
<td>5.4</td>
<td>8.0</td>
<td>15.8</td>
</tr>
<tr>
<td>P_D [W]</td>
<td>60</td>
<td>80</td>
<td>130</td>
</tr>
<tr>
<td>Ciss [pF]</td>
<td>380</td>
<td>570</td>
<td>1350</td>
</tr>
<tr>
<td>R_DSON (Max) [Ω]</td>
<td>0.9</td>
<td>0.5</td>
<td>0.19</td>
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<tr>
<td>Polarity</td>
<td>N-ch</td>
<td>N-ch</td>
<td>N-ch</td>
</tr>
</tbody>
</table>

* Toshiba product comparison

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Triac output photocoupler
TLP265J / TLP266J / TLP267J / TLP268J

Value provided

Photocoupler ideal for AC switching.

1 Small package (SO6 4pin)
Thin SO6 4pin (3.7 × 7.0 × 2.1 mm) package allows high density mounting

2 High withstand voltage (3750 V)
Insulator thickness is 0.4 mm, creepage and clearance distances are 5.0 mm, compliant with reinforced insulation safety standards.

3 Compatible with zero-cross output
Maximum output current is 70 mA. Higher output is possible using main triac connection. Zero-cross (ZC) compatible output is also available.

Pin layout

<table>
<thead>
<tr>
<th>TLP265J / TLP267J</th>
<th>TLP266J / TLP268J</th>
</tr>
</thead>
</table>

Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>TLP265J</th>
<th>TLP266J</th>
<th>TLP267J</th>
<th>TLP268J</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>4pin SO6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output</td>
<td>Non-ZC</td>
<td>ZC</td>
<td>Non-ZC</td>
<td>ZC</td>
</tr>
<tr>
<td>V_{DRM} (Min) [V]</td>
<td>600</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I_{f} (Max) [mA]</td>
<td>10</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I_{FBMOS} (Max) [mA]</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B_{V_{z}} (Max) [Vrms]</td>
<td>3750</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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General purpose silicon diffused rectifier diode for efficient, compact power supply.

1. High reverse voltage
   - High repetitive peak reverse voltage ($V_{RRM}$) CMF05: rated at 1000 V

2. Fast recovery time
   - Short reverse recovery time (trr), suitable for fast circuit requirements (CMF05: 100 ns (Max))

3. Small package
   - Small package (S-FLAT: 1.6 × 3.5 mm, M-FLAT: 2.4 × 4.7 mm) suitable for high density mounting

Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>CRG05</th>
<th>CMF05</th>
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</thead>
<tbody>
<tr>
<td>Package</td>
<td>S-FLAT</td>
<td>M-FLAT</td>
</tr>
<tr>
<td>$V_{RRM}$ (Max) [V]</td>
<td>800</td>
<td>1000</td>
</tr>
<tr>
<td>$I_{F(AV)}$ (Max) [A]</td>
<td>1.0</td>
<td>0.5</td>
</tr>
<tr>
<td>$V_{FM}$ (Max) [V]</td>
<td>1.2</td>
<td>2.7</td>
</tr>
<tr>
<td>$I_{RRM}$ (Max) [μA]</td>
<td>10</td>
<td>50</td>
</tr>
</tbody>
</table>
Small surface mount LDO regulator
TCR5AM / TCR15AG / TCR4DG / TCR3DG series

Value provided

For high performance requirements from general purpose to ultra small packages.

1. Low dropout voltage

Dropout characteristics are greatly improved using new generation process.

2. High ripple compression

With a high ripple compression R.R, ripple is efficiently removed.

3. External ceramic capacitors

With improved dropout characteristics, it is now possible to use external ceramic capacitors.

Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>TCR5AM</th>
<th>TCR15AG</th>
<th>TCR4DG</th>
<th>TCR3DG</th>
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<tr>
<td>Package</td>
<td>DFNSB</td>
<td>WCSP6F</td>
<td>WCSP4E</td>
<td>WCSP4E</td>
</tr>
<tr>
<td>$V_{IN}$ (Max) [V]</td>
<td>5.5</td>
<td>5.5</td>
<td>5.5</td>
<td>5.5</td>
</tr>
<tr>
<td>$I_{OUT}$ (Max) [mA]</td>
<td>0.5</td>
<td>1.5</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>Output range [V]</td>
<td>0.55 to 3.6</td>
<td>0.65 to 3.6</td>
<td>1.0 to 4.5</td>
<td>1.0 to 4.5</td>
</tr>
</tbody>
</table>

Large improvement

High voltage ・ Insulation
Efficiency ・ Low loss
Small packaging

◆ Return to Block Diagram TOP
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