SIMPLIFY YOUR DRIVER

-Benefit of Tamura gate driver-
SIMPLIFY YOUR DRIVER
- Benefit of Tamura gate driver –

1. Company profile & Business overview of Tamura

2. Tamura Products History for Power Electronics
   2-1. History
   2-2. Application
   2-3. Global Network
   2-4. Summary

3. About TAMURA GDM Products
   3-1. Development progress
   3-2. Products Matrix
   3-3. pros and cons

4. Products line-up & Roadmap SiC Gate Driver
   4-1. Products line-up
   4-2. Roadmap SiC Gate Driver
■ SIMPLIFY YOUR DRIVER
- Benefit of Tamura gate driver –

1. Company profile & Business overview of Tamura

2. Tamura Products History for Power Electronics
   2-1. History
   2-2. Application
   2-3. Global Network
   2-4. Summary

3. About TAMURA GDM Products
   3-1. Development progress
   3-2. Products Matrix
   3-3. pros and cons

4. Products line-up & Roadmap SiC Gate Driver
   4-1. Products line-up
   4-2. Roadmap SiC Gate Driver
1. Company profile & Business overview

Company profile

<table>
<thead>
<tr>
<th>Region</th>
<th>Sale</th>
<th>Employee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>$58 million</td>
<td>264 people</td>
</tr>
<tr>
<td>Asia (Head Office: Tokyo)</td>
<td>$328 million</td>
<td>3,819 people</td>
</tr>
<tr>
<td>Japan</td>
<td>$346 million</td>
<td>1,157 people</td>
</tr>
<tr>
<td>North and South America</td>
<td>$30 million</td>
<td>170 people</td>
</tr>
</tbody>
</table>

Consolidated net sales $762 million | Number of employees 5,410 people | Capital $105 million | Listing on TSE First Section

Naoki Tamura, President and Representative Director
1. Company profile & Business overview

Our history & Business domains

- **1924 Established Tamura Radio Store in Shinjuku, Tokyo, Japan**
- **Development of transformers**
- **Electronic Components**
  - 1956~ Power supplies
  - 1956~ Piezoelectric transformers
  - 1994~ Current Sensors
  - 2016~ Gate driver

- **1924~ Radio receiving sets Gramophones**
  - Development of soldering technology
  - **Electronic Chemicals / FA Systems**
    - 1956~ Flux
    - 1957~ Solder paste
    - 1961~ Resist ink
    - 1968~ Soldering systems

- **1930~ Transformers**
  - Development of Information & Communication technology
  - **Information Equipment**
    - 1961~ Audio mixing console
    - 1976~ Transmission monitoring device
1. Company profile & Business overview

Electronic components

Sales

<table>
<thead>
<tr>
<th>Year</th>
<th>Sales (¥100 million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>556</td>
</tr>
<tr>
<td>2014</td>
<td>577</td>
</tr>
<tr>
<td>2015</td>
<td>546</td>
</tr>
<tr>
<td>2016</td>
<td>519</td>
</tr>
<tr>
<td>2017</td>
<td>559</td>
</tr>
</tbody>
</table>

Sales Revenue Ratio

- Electronic Components: 65%
- Information Equipment
- Electronic Chemicals / FA Systems

Products

- Transformers, Inductors, Reactors, Choke coils, Current sensors
- AC adaptors, Battery chargers, Power modules, Power supplies
- Piezoelectric ceramic products
- LED-related products
1. Company profile & Business overview

Electronic chemicals / FA Systems

Sales
(¥100 million)

<table>
<thead>
<tr>
<th>Year</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>226</td>
</tr>
<tr>
<td>2014</td>
<td>244</td>
</tr>
<tr>
<td>2015</td>
<td>247</td>
</tr>
<tr>
<td>2016</td>
<td>236</td>
</tr>
<tr>
<td>2017</td>
<td>254</td>
</tr>
</tbody>
</table>

Sales Revenue Ratio

- Information: 30%
- Equipment: 30%
- Electronic Components: 30%
- Electronic Chemicals / FA Systems: 30%

Products

- Solder paste & Post-flux, Self Assembling Material, OSP (Pre-flux),
- Solder resists for rigid & flexible PCBs, White reflective material,
- Reflow soldering system, Wave soldering system
1. Company profile & Business overview

Information equipment

Sales

<table>
<thead>
<tr>
<th>Year</th>
<th>Sales (100 million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>29</td>
</tr>
<tr>
<td>2014</td>
<td>41</td>
</tr>
<tr>
<td>2015</td>
<td>53</td>
</tr>
<tr>
<td>2016</td>
<td>40</td>
</tr>
<tr>
<td>2017</td>
<td>42</td>
</tr>
</tbody>
</table>

Sales Revenue Ratio

- Information Equipment: 5%
- Electronic Components
- Electronic Chemicals / FA Systems

Products

- Audio mixing console for broadcast use
- Wireless intercom & Wireless microphone
- Communication network equipment
- Security-related equipment
SIMPLIFY YOUR DRIVER
- Benefit of Tamura gate driver –

1. Company profile & Business overview of Tamura

2. Tamura Products History for Power Electronics
   2-1. History
   2-2. Application
   2-3. Global Network
   2-4. Summary

3. About TAMURA GDM Products
   3-1. Development progress
   3-2. Products Matrix
   3-3. pros and cons

4. Products line-up & Roadmap SiC Gate Driver
   4-1. Products line-up
   4-2. Roadmap SiC Gate Driver
2. Tamura Products History for Power Electronics

2-1. History

1924 RADIO

1930 Power Transformer

1939 Audio Transformer

1956 Power Supply

2007 ZERO watt standby Power Supply

2011 Power Module

2016~
SiC/IGBT Gate Driver

2011 Power Module

Integrated Products

L Series

S Series

F Series

Further Expansion!!

Confidential and Proprietary Information of TAMURA CORPORATION
2. Tamura Products History for Power Electronics

2-2. Application: Industry

- Power supply For brake
- Inverter Controller
- Power supply For controller
- Motor Controller
- UPS Controller
- Power supply For IoT
- Robot
- Motor control unit
- Inverter
- UPS

Tamura products
- Current sensor
- Gate driver
- Reactor
2. Tamura Products History for Power Electronics


- Solar
- Wind
- Storage
- Monitoring
- DC transmission

PV Inverter

Wind power generation

Tamura products
- Current sensor
- Gate driver
- Reactor
2. Tamura Products History for Power Electronics

2-4. Summary - Why we are developing gate drivers -

- Transformer technology
- Circuit design
- Potting technology
- EMI/EMC
- Market
INDEX

■ SIMPLIFY YOUR DRIVER
   - Benefit of Tamura gate driver –

1. Company profile & Business overview of Tamura

2. Tamura Products History for Power Electronics
   2-1. History
   2-2. Application
   2-3. Global Network
   2-4. Summary

3. About TAMURA GDM Products
   3-1. Development progress
   3-2. Products Matrix
   3-3. pros and cons

4. Products line-up & Roadmap SiC Gate Driver
   4-1. Products line-up
   4-2. Roadmap SiC Gate Driver
3. About TAMURA GDM Products

3-1. Development progress

Max ~1MW

Max ~150kW

For SiC module

2016

2017

2018

For IGBT module

2in1 Driver module

2in1 Driver unit

2in1 Driver unit Expansion

DC Power Supply (2in1)
Low profile

2in1 Driver module
Low profile

4in1 Driver unit

2in1 Driver unit
3. About TAMURA GDM Products

3-2. Products Matrix

<table>
<thead>
<tr>
<th>Driver Maker</th>
<th>2in1 DC-Power supply</th>
<th>Gate Driver Module</th>
<th>Gate Driver Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAMURA</td>
<td>◯</td>
<td>◯</td>
<td>◯</td>
</tr>
<tr>
<td>Company A</td>
<td>×</td>
<td>◯</td>
<td>◯</td>
</tr>
<tr>
<td>Company B</td>
<td>×</td>
<td>×</td>
<td>◯</td>
</tr>
<tr>
<td>Company C</td>
<td>×</td>
<td>×</td>
<td>◯</td>
</tr>
<tr>
<td>Company D</td>
<td>◯</td>
<td>◯</td>
<td>◯</td>
</tr>
</tbody>
</table>
INDEX

SIMPLIFY YOUR DRIVER  
- Benefit of Tamura gate driver –

1. Company profile & Business overview of Tamura

2. Tamura Products History for Power Electronics
   2-1. History
   2-2. Application
   2-3. Global Network
   2-4. Summary

3. About TAMURA GDM Products
   3-1. Development progress
   3-2. Products Matrix
   3-3. pros and cons

4. Products line-up & Roadmap SiC Gate Driver
   4-1. Products line-up
   4-2. Roadmap SiC Gate Driver
### 3. About TAMURA GDM Products

<table>
<thead>
<tr>
<th>Target customers</th>
<th>Products</th>
<th>1st Generation (Up to 1200V)</th>
<th>2nd Generation (Up to 1700V and 3Level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design by oneself</td>
<td>DC-DC Power Supply</td>
<td>All-in-one</td>
<td></td>
</tr>
<tr>
<td>Use the gate driver</td>
<td>Driver Module</td>
<td>Low stray capacity</td>
<td></td>
</tr>
<tr>
<td>Use the Plug &amp; Play unit</td>
<td>Driver Unit</td>
<td>High response time</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low impedance drive circuit</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Small package</td>
<td></td>
</tr>
</tbody>
</table>
3. About TAMURA GDM Products

3-3. Pros and cons

Trouble with design man-hour

- Designing a drive circuit for each inverter. But no time …
- It cannot correspond to a lot of variety …

1. All-in-One

This module has a built-in DC-DC converter and a drive circuit! It is possible to drive only by using a few external components.
3. About TAMURA GDM Products

2. Low Stray Capacity

Stray capacity is about 12pF included power supply for gate driver. It suppresses the common mode noise due to high dV / dt by reducing the stray capacity. It prevents equipment malfunction or damage by suppressing the noise propagated to the input side and the other channels.
Low capacitance

C_{STRAY} (2DD series) = 9pF
C_{STRAY} (2DMB series) = 12pF

No malfunctions against high dV/dt

\[ i_{\text{Noise}} = C_{\text{stray}} \times dV/dt \]

Low common mode noise!
Suitable for high dV/dt such as next generation IGBT and SiC!
3. About TAMURA GDM Products

3-3. Pros and cons

Trouble with response speed ...

- A large delay time
- I want to reduce dead time

3. High-speed response

Signal transmission between the input and output adopts magnetic coupling. The delay time has been achieved 90ns and high-speed response by using the magnetic coupling. It is possible to reduce the dead time, and contributes to high efficiency of the entire system.
3. About TAMURA GDM Products

3-3. Pros and cons

High response time

Input signal

Vge

90ns

Variation in delay time: ±5ns (3σ, n=100)

Parallel drive application
3. About TAMURA GDM Products

3-3. Pros and cons

**Trouble with Gate impedance ...**

- It can not be high frequency because gate impedance is inhibited
- I wonder if not somehow

**4. Low Impedance drive circuit**

Drive circuit internal impedance (Internal module; Buffer ~ Connect pin): 50mΩ or less even by increasing the switching frequency, it does not inhibit the switching speed, because there is almost no influence due to the internal impedance.
3. About TAMURA GDM Products

3-3. Pros and cons

Trouble with package

Driving circuit is disturbed, it is impossible to design the inverter efficiency

I want to freely set the system

5. Small package

It fits within the footprint of the various types of power module. It will contribute to the high efficiency and low noise of the entire system because it is possible to freely arrange the power module.
3. About TAMURA GDM Products

High dielectric withstand voltage

Low profile

Planar transformer

supports 1700V module!

Constant voltage

Block Diagram
3. About TAMURA GDM Products

3-3. Pros and cons

Small package

Comparison with a competitor

2DUB series (TAMURA)

Competitor

19.8mm

29.0mm

※IGBT module: NX series (MITSUBISHI)

34% down
3. About TAMURA GDM Products

3-3. Pros and cons

Various protections
Soft turn off

No Soft turn off

Soft turn off

2DMBxxxxxxCC

DESATx
VOHx
VOLx
STOx
COMx

Vce

Ic

Vge

No Soft turn off

Soft turn off

2DMBxxxxxxCC

DESATx
VOHx
VOLx
STOx
COMx

Vce

Ic

Vge

1040V

980V
3. About TAMURA GDM Products

3-3. Pros and cons

Various protections
Miller clamp

No Miller clamp

Miller clamp

Miller clamp function prevents malfunction of SiC power module with low Vth and high dV/dt

Confidential and Proprietary Information of TAMURA CORPORATION
Various protections
Active clamp gate

Optional

Protect IGBT from VCE surge

Active Clamp gate
Surge clamp
SIMPLIFY YOUR DRIVER
- Benefit of Tamura gate driver –

1. Company profile & Business overview of Tamura

2. Tamura Products History for Power Electronics
   2-1. History
   2-2. Application
   2-3. Global Network
   2-4. Summary

3. About TAMURA GDM Products
   3-1. Development progress
   3-2. Products Matrix
   3-3. pros and cons

4. Products line-up & Roadmap SiC Gate Driver
   4-1. Products line-up
   4-2. Roadmap SiC Gate Driver
## 4. Products line-up & Roadmap SiC Gate Driver

### 4-1. Products line-up (Gate Driver Family)

<table>
<thead>
<tr>
<th>Target customers</th>
<th>Products</th>
<th>1\textsuperscript{st} Generation (Up to 1200V)</th>
<th>2\textsuperscript{nd} Generation (Up to 1700V and 3Level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design by oneself</td>
<td>DC-DC Power Supply</td>
<td>—</td>
<td>2DD series</td>
</tr>
<tr>
<td>Use the gate driver</td>
<td>Driver Module</td>
<td>2DM series</td>
<td>2DMB series</td>
</tr>
<tr>
<td>Use the Plug &amp; Play unit</td>
<td>Driver Unit</td>
<td>2DU series</td>
<td>2DUB Series</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4DUC series</td>
</tr>
</tbody>
</table>

Confidential and Proprietary Information of TAMURA CORPORATION
4. Products line-up & Roadmap SiC Gate Driver

4-2. Roadmap SiC Gate Driver

- **2017**: Inverter Power (W)
- **2018**: SiC Power Module
- **2019**: 3rd generation
- **2020**: 4th generation

**Key-point**
- Higher Frequency
- Large power source

**Under development**

**Tamura Gate driver**

**DC-PS** (for discrete design)

**Module (On Board)**

**Unit (On Module)**

[Diagram showing different generations of SiC Gate Driver with icons and text boxes indicating developments and features.]
For further questions please contact:

Wolfgang Rath
Sales Manager

Tamura-Europe Limited
German Information Office:
Dorfstrasse 23
27386 Hemsbünde
Mobile: +49 151 21 22 49 26
E-Mail: w.rath@tamura-europe.co.uk
Website: http://www.tamura-ss.co.jp/electronics/en/