PGA26E07BA-SWEVB006  
Chopper Evaluation Board consisting:

1. PGA26E07BA 600V 56mΩ X-GaN Power Transistor  
2. AN34092B Single channel X-GaN Gate Driver IC  

For evaluation of X-GaN Power Transistor and Driver switching characteristics
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Features

PGA26E07BA

8.0mm
8.0mm
1.25mm

X-GaN Transistor

■ Blocking Voltage: 600V
■ Pulse Peak \( I_{DS} \): 61A
■ \( I_{DS} \) (cont): 31A
■ \( R_{DS(on)} \) typ: 56mΩ
■ Normally Off Device

X-GaN Gate Driver

■ Supports high switching frequency (~4MHz)
■ Achieved safe operation
  - negative voltage source, active miller clamp
■ Facilitate gate drive design
  - high precision gate current source

AN34092B
Description of the Evaluation Board

The PGA26E07BA-SWEV006 is a chopper evaluation board using a dedicated X-GaN driver (AN34092B) for measuring the high speed switching characteristics of turn-on and turn-off of the X-GaN power transistor. The dv/dt and di/dt using an inductive load can be measured by controlling the X-GaN power transistor with an external signal. There are test terminals prepared for easy monitoring of Vgs and Vds waveforms. To improve the accuracy of the current measurement, use the mounted semi-rigid connector and connect to a 50Ω terminated oscilloscope input. The evaluation board together with the user’s guide also serves as a reference design for the X-GaN gate driver circuit and PCB layout.

Recommended Operating Conditions

Table 1 shows the operating conditions used to achieve the switching performance reported in the Measurement Result. All the components used in the evaluation board are rated for the recommended operating conditions only.

Please read the measurement procedure before starting the evaluation. It is necessary to refer to the X-GaN transistor and driver datasheet when using this user’s guide. The detail operation of the gate driver IC and the design of its peripheral components are described in the OPERATION section of the datasheet.

Table 1: Recommended operating conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input voltage (DC power ①)</td>
<td>400V</td>
</tr>
<tr>
<td>Driver IC power supply voltage (DC power ②)</td>
<td>12V</td>
</tr>
<tr>
<td>External clock voltage (pulse generator input)</td>
<td>5V</td>
</tr>
</tbody>
</table>
| External clock frequency (Duty Cycle) (pulse generator input) | Double pulse 
(Do not perform continuous operation) |
| External inductor                                  | 95uH @ DC Current=15A                         |
| Temperature                                         | 25°C                                           |

①② Power supply equipment number as illustrated on page 9 and 10
Schematic Diagram

Refer to Figure 1 below for the circuit schematic of the evaluation board. All the terminals and components shown are mounted on the evaluation board including the power inductor.

![Schematic Diagram]

Figure 1: Schematic diagram of evaluation board

Bill of Materials

<table>
<thead>
<tr>
<th>Parts</th>
<th>Symbol</th>
<th>Specification</th>
<th>Part Number</th>
<th>Manufacturer</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chip</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resistor</td>
<td>R1</td>
<td>8.2Ω</td>
<td>ERJ3GEYJ8R2V</td>
<td>Panasonic</td>
<td>SMD1608</td>
</tr>
<tr>
<td></td>
<td>R3</td>
<td>1.0Ω</td>
<td>ERJ3GEYJ1R0</td>
<td>Panasonic</td>
<td>SMD1608</td>
</tr>
<tr>
<td></td>
<td>R5</td>
<td>39kΩ</td>
<td>ERJ3EKF3902V</td>
<td>Panasonic</td>
<td>SMD1608</td>
</tr>
<tr>
<td></td>
<td>R9</td>
<td>47kΩ</td>
<td>ERJ3EKF4702V</td>
<td>Panasonic</td>
<td>SMD1608</td>
</tr>
<tr>
<td></td>
<td>R12</td>
<td>47mΩ</td>
<td>RL7520WR-R047-F</td>
<td>Susumu</td>
<td>SMD3008</td>
</tr>
<tr>
<td>Capacitor</td>
<td>C0</td>
<td>2.2uF / 450V</td>
<td>ECWFE2W225K</td>
<td>Panasonic</td>
<td>Radial Thru Hole</td>
</tr>
<tr>
<td></td>
<td>C1</td>
<td>0.47uF / 630V</td>
<td>C5750X7T2J474K</td>
<td>TDK</td>
<td>SMD5750</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>2200pF / 50V</td>
<td>GRM1885C1H222JA01</td>
<td>Murata</td>
<td>SMD1608</td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>220nF / 25V</td>
<td>GRM188R71E224KA88</td>
<td>Murata</td>
<td>SMD1608</td>
</tr>
<tr>
<td></td>
<td>C4</td>
<td>0.47uF / 16V</td>
<td>GRM188R71C474KA88</td>
<td>Murata</td>
<td>SMD1608</td>
</tr>
<tr>
<td></td>
<td>C5</td>
<td>4.7uF / 16V</td>
<td>GRM21BB31E475K</td>
<td>Murata</td>
<td>SMD1608</td>
</tr>
<tr>
<td>Parts</td>
<td>Symbol</td>
<td>Specification</td>
<td>Part Number</td>
<td>Manufacturer</td>
<td>Package</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------</td>
<td>---------------</td>
<td>------------------</td>
<td>--------------</td>
<td>---------</td>
</tr>
<tr>
<td>Chip Capacitor</td>
<td>C6</td>
<td>1uF / 25V</td>
<td>GRM188B31E105KA75</td>
<td>Murata</td>
<td>SMD1608</td>
</tr>
<tr>
<td></td>
<td>C9</td>
<td>10uF / 35V</td>
<td>GRM32ER7YA106KA12</td>
<td>Murata</td>
<td>SMD3225</td>
</tr>
<tr>
<td></td>
<td>C10</td>
<td>0.1uF / 50V</td>
<td>GRJ188R71H104KE11D</td>
<td>Murata</td>
<td>SMD1608</td>
</tr>
<tr>
<td>Rectifier Diode</td>
<td>D1</td>
<td>1200V / 12A</td>
<td>C4D08120E</td>
<td>CREE</td>
<td>TO-252DPAK</td>
</tr>
<tr>
<td>Inductor</td>
<td>L1</td>
<td>95uH</td>
<td>LHDM010101DYBV1E</td>
<td>Nippon Chemicon</td>
<td></td>
</tr>
<tr>
<td>Screw Terminal</td>
<td>CON1</td>
<td>-</td>
<td>OP-045-M4</td>
<td>Osada</td>
<td></td>
</tr>
<tr>
<td>Terminal Block</td>
<td>CON2</td>
<td>-</td>
<td>1727052</td>
<td>Phoenix Contact</td>
<td></td>
</tr>
<tr>
<td>Semi-rigid</td>
<td>-</td>
<td>-</td>
<td>SMA(PJ)─X-UT47-63</td>
<td>APEX Technology</td>
<td></td>
</tr>
<tr>
<td>GaN Transistor</td>
<td>Q1</td>
<td>600V / 56mΩ</td>
<td>PGA26E07BA</td>
<td>Panasonic</td>
<td>SMD (8x8)</td>
</tr>
<tr>
<td>Gate Driver</td>
<td>IC1</td>
<td>Gate driver</td>
<td>AN34092B</td>
<td>Panasonic</td>
<td>QFN (4x4)</td>
</tr>
</tbody>
</table>
Appearance

- Double-sided
- Size: 100mm x 70mm
- Copper thickness: 70um
- Board thickness: 1.6mm

Figure 2: Top Side View

Figure 3: Bottom Side View
PCB Layout

Figure 4: Top Layer

Figure 5: Bottom Layer
Test circuits

Figure 6 shows the evaluation test circuit schematic with all the necessary connections. Figure 7 shows the actual evaluation board with all the terminals for connecting to the equipment. For detailed description of the connection, refer to Measurement Procedures on page 11.

Figure 6: Setup of Evaluation Environment

Figure 7: Connectors of Evaluation Board
Equipment

The equipment used in the evaluation test circuits is shown in Table 3. This is for reference only.

Table 3: List of Equipment used

<table>
<thead>
<tr>
<th>No.</th>
<th>Equipment</th>
<th>Specifications</th>
<th>Suggested Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DC Power ①</td>
<td>OUTPUT DC640V 1600W</td>
<td>Takasago ZX-400H</td>
</tr>
<tr>
<td>2</td>
<td>DC Power ②</td>
<td>OUTPUT DC18V 1.5A</td>
<td>Kenwood PW18</td>
</tr>
<tr>
<td>3</td>
<td>*Pulse Generator</td>
<td>-</td>
<td>Agilent 33220A</td>
</tr>
<tr>
<td>4</td>
<td>**Oscilloscope</td>
<td>-</td>
<td>Tektronix DPO7104C</td>
</tr>
<tr>
<td>5</td>
<td>Probe</td>
<td>-</td>
<td>TCP0030 Current Probe</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-</td>
<td>P6139B Voltage Probe</td>
</tr>
</tbody>
</table>

- *Use only burst mode function from the pulse generator. Do not use continuous pulse mode as this will cause damage to the components and evaluation board.
- **For VGS and VDS monitoring, use the coil wire mounted on the evaluation board to minimize any ringing in the waveform.
Measurement Procedures

Initial steps:
Do all the necessary connection between the evaluation board, components and equipment.
- Connect DC power ① to P/N of the board with the terminal block.
- Connect pulse generator to the IN+/GND terminal of the board.
- The IN- terminal must be shorted to GND and not possible to input any signal.
- Connect DC power ② to VCC/GND terminal of the board.
- Probe the point where you want to monitor and observe the waveform using oscilloscope.
  Be careful not to short with other parts. Use the coil wire fixture mounted on the evaluation board for VGS, VDS1 & VDS2 monitoring.

Start-up:
- Set up the pulse generator with the amplitude 0-5V and having the double pulse profile as shown below:

  ![Drive Signal Diagram](image)

  **Table 4: Double Pulse Setting with L=95uH**

<table>
<thead>
<tr>
<th>IL</th>
<th>#1</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5A</td>
<td>0.6us</td>
</tr>
<tr>
<td>5A</td>
<td>1.3us</td>
</tr>
<tr>
<td>10A</td>
<td>2.6us</td>
</tr>
<tr>
<td>15A</td>
<td>3.8us</td>
</tr>
</tbody>
</table>

- Again, ensure that the pulse generated occurs only in the burst mode. If the pulse is generated continuously, the transistor will be damaged by high current flows.
- Set the DC power ② to 12V gradually.
- Check VGS waveform when a double pulse is inputted from pulse generator. Please carry out this step with DC power ① is set to 0V.
- Then, the voltage of DC power ① is gradually increased from 0V to predetermined voltage (400V). Monitor the VDS1 voltage with oscilloscope and confirm that the VDS1 voltage rises to the set value.
- Input a double pulse with the pulse generator again and check the VGS, VDS1 and IL waveform.
- Observation of waveform will be easier if the trigger is applied at the rising / falling edge of VGS or VDS1 as shown on Figure 9 above.
- If different inductor value is used other than the one provided, please set the pulse width until the desired IL value is achieved.
Shutdown:
- Set the DC power \(^1\) slowly to 0V and then follow by the DC power \(^2\) to 0V.
- Turn off the power. Check the VDS waveform and ensure that the capacitor between P/N terminals has fully discharged. There is risk of electric shock due to the residual charge.

Measurement of dV/dt for Turn On/Off Switching Characteristics:
- The range used is 10%~90%
- IL condition is set at 2.5A / 5A / 10A / 15A with 16 times averaging
- Therefore, the dv/dt at turn on: 320V / T-on and the dv/dt at turn off: 320V / Toff

![Figure 10: Measurement of dv/dt](image)

![Figure 11: Measurement points](image)
Measurement Results
Condition: VPN=400V, VCC=12V, R1:8.2Ω, R3:1Ω, C2:2200pF

i) dV/dt Measurement Data

![T-off 10-90% Chopper](image1)

![T-on 10-90% Chopper](image2)

ii) VGS, VDS and IDS Measurement Waveform

<table>
<thead>
<tr>
<th>Turn ON</th>
<th>VPN=400V,Ids=2.5A</th>
<th>VPN=400V,Ids=5A</th>
</tr>
</thead>
<tbody>
<tr>
<td>dV/dt=</td>
<td>-123.1 [V/ns]</td>
<td>-114.1 [V/ns]</td>
</tr>
<tr>
<td>Turn OFF</td>
<td>dV/dt=14.9 [V/ns]</td>
<td>dV/dt=31.3 [V/ns]</td>
</tr>
</tbody>
</table>

[Results are for reference only and measured data maybe different depending on evaluation environment]
For **VPN=400V, Ids=10A**

**Turn ON**
- \(dV/dt = -101.9 \text{ [V/ns]}\)

**Turn OFF**
- \(dV/dt = 62.9 \text{ [V/ns]}\)

For **VPN=400V, Ids=15A**

**Turn ON**
- \(dV/dt = -92.8 \text{ [V/ns]}\)

**Turn OFF**
- \(dV/dt = 94.3 \text{ [V/ns]}\)
Important Notice
Please read and understand the following items, "Restriction", and "Caution" before using the evaluation board:

Restriction

- The evaluation board is intended for use as engineering development, verification or evaluation purposes only.
- This evaluation board is not intended for a finished end-product fit for general consumer use.
- Do not operate in condition other than the recommended settings.
- The evaluation board must be used only by qualified engineers and technicians that have electronics training, familiar with handling of high-voltage electrical systems and observe good engineering practise standards.
- The evaluation board is meant to be operated in lab environment under the safe conditions.
- Please use a protective case (accessory) during evaluation.
- All of the specifications and evaluation data in this manual are for reference only and not guaranteed. The information may subject to change without notice. Please contact to Panasonic representative for the latest information.
- The user assumes all responsibility and liability for proper and safe handling of this evaluation board. Further, the user indemnifies Panasonic from all claims arising from the handling or use of the evaluation boards.
- The technical information described in this document is intended only to show the main characteristics and application circuit examples of the products. No license is granted in and to any intellectual property right or other right owned by Panasonic Corporation or any other company. Therefore, no responsibility is assumed by our company as to the infringement upon any such right owned by any other company which may arise as a result of the use of technical information described in this document.

Caution

- The evaluation board carries hazardous high voltage. Do not touch when power is applied. Otherwise, it may cause severe injury, disability or death.
- Electric charge may be accumulated in the capacitors. To prevent electrical shock, please ensure all the capacitors are properly discharged before touching the evaluation board.
- It is the user’s responsibility to confirm that the voltages, isolation requirements, and rated value are identified and understood, prior to handling the evaluation board.
- Do not leave the evaluation board unattended while power is applied and do not perform other activity near the evaluation board while power is applied.
- This board contains parts that are susceptible to damage by electrostatic discharge (ESD). It is the user’s responsibility to take any and all appropriate precautions with regard to electrostatic discharge when using the evaluation board.
- Should the evaluation board does not meet the specification indicated in the User’s Guide, the board may be exchanged with a new one within 30 days from the date of delivery. When exchanging the evaluation board, please return the board with all items included.
- The warranty on this evaluation board is considered void once a part on the board is removed or modified.
- The evaluation board does not fall within the scope of the technical requirements of the following directives or other related directives:
  - Restriction of Hazardous Substances (RoHS)
  - Directive on Waste Electrical and Electronic Equipment (WEEE)
  - Mandatory conformity marking for products sold in the European Economic Area (CE)
  - Federal Communications Commission (FCC)
  - Underwriters Laboratories, Inc. (UL)
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