INNEHB150A1
Evaluation Board Manual
150V GaN HEMT
Open Loop Half-Bridge EVB
CAUTION

Please carefully read the following content since it contains critical information about safety and the possible hazard it may cause by incorrect use.

⚠️ ELECTRICAL SHOCK HAZARD
There is a dangerous voltage on the demo board, and exposure to high voltage may lead to safety problems such as injury or death. Proper operating and safety procedures must be adhered to and used only for laboratory evaluation demonstrations and not directly to end-user equipment.

⚠️ HOT SURFACE
The surface of PCB can be hot and could cause burns. DO NOT TOUCH THE PCB WHILE OPERATING!!

⚠️ REMINDER
This product contains parts that are susceptible to electrostatic discharge (ESD). When using this product, be sure to follow antistatic procedures.
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1. Overview

1.1. Introduction

INNEHB150A1 is a half-bridge evaluation board equipped with NCP51820 half-bridge gate driver to evaluate the performance of 150V GaN HEMT INN150LA070A. This board can simplify the test process, it can easily realize Buck or Boost converter with single or dual PWM input. The board includes all the necessary information you need, and the layout has been optimized to achieve the best performance. Test points are also included for the waveform measurement and efficiency evaluation.

1.2. Test Equipment Requirement

To evaluate the performance properly, you need to prepare the following test equipment:

1) High speed digital oscilloscope (>200MHz Bandwidth)
2) High voltage DC power supply (>150V 600W)
3) Low voltage DC power supply
4) PWM generator
5) Digital Multimeter
6) DC load (E-load or Power Resistor, >600W)
2. Parameters

Table 1 Electrical Characteristic (Ta=25°C)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameters</th>
<th>Min</th>
<th>Nom</th>
<th>Max</th>
<th>Units</th>
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<tbody>
<tr>
<td>VDD</td>
<td>Gate Drive Regulator Supply Range</td>
<td>7</td>
<td>12</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Vin</td>
<td>Input Voltage</td>
<td></td>
<td>120</td>
<td>V</td>
<td></td>
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<tr>
<td>Iout</td>
<td>Switch Node Output Current</td>
<td></td>
<td>15</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Vpwm</td>
<td>Input Logic ‘High’</td>
<td>3.5</td>
<td>5</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Input Logic ‘Low’</td>
<td>0</td>
<td>1.5</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>fsw</td>
<td>Switching Frequency</td>
<td></td>
<td>100</td>
<td>KHz</td>
<td></td>
</tr>
</tbody>
</table>
3. Block Diagram

Figure 1 INNEHB150A1 Block Diagram
4. PCBA Overview and Schematic

4.1. PCBA Overview

Figure 2 Top view of INNEHB150A1

Figure 3 Top Side Silkscreen of INNEHB150A1
Figure 4 Bottom view of INNEHB150A1

Figure 5 Bottom Side Silkscreen of INNEHB150A1
4.2. Schematic

Figure 6 Driver Circuit

Figure 7 Power Circuit
LDO auxiliary Supply

Figure 8 Auxiliary Supply

Dead Time adjustment

Figure 9 Dead Time Adjustment
5. Testing Guide

5.1. Test point location

![Test point location diagram]

Figure 10 Test points for single PWM input mode

5.2. Test setup

5.2.1. Buck Mode

![Test setup diagram for Buck mode]

Figure 11 Test points for single PWM input Buck mode
Before tests, single or dual PWM input modes could be selected. When selecting the single PWM input mode, please solder 0Ω resistor to R11 & R18. Then the PWM1 & GND pin should be connected to a single generator, and the single generator should be set to logic ‘low’ when idle.

To select dual PWM mode, please solder 0Ω resistor to R11 & R21. Figure 12 Test points for dual PWM input Buck mode shows the required PWM signals; PWM1 and PWM2 should be complementary. While idle, the PWM1 should be constantly low to prevent any possible short circuit from happening.

To control the dead time, the value of R12 and R19 could be changed to achieve various dead times. The default value for R12 and R19 is 300Ω, corresponding to 20ns of dead time.
5.2.2. Boost Mode

![Diagram of Boost Mode](image)

Figure 13 Test points for single PWM input Boost mode

![Diagram of Dual PWM Input Boost Mode](image)

Figure 14 Test points for dual PWM input Boost mode
5.3. Power up and down sequence

5.3.1. Power-up sequence (Buck Mode)

1. Check that every power supply is off
2. Connect the output pin J3&Vout to a load (Pay attention to the polarity)
3. Connect the port P1 to the LV power supply (Pay attention to the polarity)
4. Connect the pin P2&P4 to the HV power supply (Pay attention to the polarity)
5. Connect the oscilloscope probe to port TP1 and TP3
6. Set the LV power supply to 12V with a current limit of 0.1A
7. Set the PWM voltage to 0-4V, then set the wave type to pulse wave with 30% duty cycle and 100kHz frequency (Recommended working condition)
8. Check the Vgs voltage to make sure the PWM wave is set correctly, and the dead time is long enough to prevent short circuit
9. Connect the input pin J1&J2 and output pin J3&J4 to the digital multimeter to measure the input and output voltage, then connect another current meter in series with the HV power supply and the input pin J1&J2 to measure the input current
10. Set the HV power supply to a low voltage with 0.1A current limit to make sure that there is no fault on the board.
11. After all the connection and check, set the HV power supply to 120V/4A then start your test.
12. Turn on the E-load and set the required load current

5.3.2. Power-up sequence (Boost Mode)

1. Check that every power supply is off
2. Connect the output pin P2&P4 to a load (Pay attention to the polarity)
3. Connect the port P1 to the LV power supply (Pay attention to the polarity)
4. Connect the pin J3&Vout to the HV power supply (Pay attention to the polarity)
5. Connect the oscilloscope probe to port TP1 and TP3
6. Set the LV power supply to 12V with a current limit of 0.1A
7. Set the PWM voltage to 0-4V, then set the wave type to pulse wave with 30% duty cycle and 100kHz frequency
8. Check the Vgs voltage to make sure the PWM wave is set correctly, and the dead time is long enough to prevent short circuit
9. Connect the output pin J1&J2 and input pin J3&J4 to the digital multimeter to measure the input and output voltage, then connect another current meter in series with the HV power supply and the input pin J3&Vout to measure the input current
10. Set the HV power supply to a low voltage with 0.1A current limit to make sure that there is no fault on the board.
11. After all the connection and check, set the HV power supply to 120V/4A then start your test.
12. Turn on the E-load and set the required load current

5.3.3. Power-down sequence

1. Turn off the E-load first
2. Turn off the HV power supply
3. Turn off the PWM generator
4. Turn off the LV power supply
6. Evaluation Results

6.1.1. Switching Waveforms (Rgon=4.7Ω, Rgoff=0.47Ω)

**Test conditions**
- Vin=120Vdc
- Vout=36Vdc
- Iout=0A
- fsw=100kHz
- Duty cycle=30%

**Results**
- Vgsmx: 5.30V
- Vdsmx: 120.4V
- ILmax: 0.68A

**Test conditions**
- Vin=120Vdc
- Vout=36Vdc
- Iout=0A
- fsw=100kHz
- Duty cycle=30%

**Result**
- Trise_gs: 21.24ns
- Tfall_sw: 3.36ns

**Test conditions**
- Vin=120Vdc
- Vout=36Vdc
- Iout=0A
- fsw=100kHz
- Duty cycle=30%

**Result**
- Tfall_gs: 4.52ns
- Trise_sw: 3.56ns
### Test conditions
- $V_{in} = 120V_{dc}$
- $V_{out} = 36V_{dc}$
- $I_{out} = 4A$
- $f_{sw} = 100kHz$
- Duty cycle = 30%

### Result
- $V_{gs_{max}} = 5.30V$
- $V_{ds_{max}} = 119.6V$
- $I_{L_{max}} = 4.880A$

### Test conditions
- $V_{in} = 120V_{dc}$
- $V_{out} = 36V_{dc}$
- $I_{out} = 4A$
- $f_{sw} = 100kHz$
- Duty cycle = 30%

### Result
- $T_{rise_{gs}} = 21.02ns$
- $T_{fall_{sw}} = 11.91ns$
- Deadtime = 18.16ns

### Test conditions
- $V_{in} = 120V_{dc}$
- $V_{out} = 36V_{dc}$
- $I_{out} = 4A$
- $f_{sw} = 100kHz$
- Duty cycle = 30%

### Result
- $T_{fall_{gs}} = 4.41ns$
- $T_{rise_{sw}} = 3.29ns$
- Deadtime = 16ns
- $V_{gs}$ ring = 1.351V
6.1.2. Efficiency Results

Test conditions
Vin=120Vdc
Vout=36Vdc
Iout=10A
fsw=100kHz/200kHz

6.1.3. Thermal performance

Test conditions
Vin=120Vdc
Vout=36Vdc
Iout=10A
fsw=100kHz
Ambient temp 25°C
No airflow

Result
High-side GaN: 80.8°C
Low-side GaN: 101.7°C
<table>
<thead>
<tr>
<th>Test conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vin=120Vdc</td>
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<tr>
<td>Vout=36Vdc</td>
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<tr>
<td>Iout=15A</td>
</tr>
<tr>
<td>fsw=100kHz</td>
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<td>Ambient temp: 25°C</td>
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<tr>
<td>Airflow: 1200LFM</td>
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<table>
<thead>
<tr>
<th>Result</th>
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</thead>
<tbody>
<tr>
<td>High-side GaN: 70.3°C</td>
</tr>
<tr>
<td>Low-side GaN: 90.0°C</td>
</tr>
</tbody>
</table>
Appendix

Appendix A. PCB Layout

Figure 15 The top layer of INNEHB150A1

Figure 16 The first middle layer of INNEHB150A1
Figure 17 The second middle layer of INNEHB150A1

Figure 18 The bottom layer of INNEHB150A1
# Appendix B. BOM

## Table 2 BOM

<table>
<thead>
<tr>
<th>Comment</th>
<th>Description</th>
<th>Designator</th>
<th>Footprint</th>
<th>Quantity</th>
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<tr>
<td>C1, C2</td>
<td>2.2uF/25V Cap</td>
<td>C0603R</td>
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<td>C3</td>
<td>1uF/25V Cap</td>
<td>C0603</td>
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<tr>
<td>C4, C5, C6</td>
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<td>C0402</td>
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<tr>
<td>C7</td>
<td>4.7uF/25V Cap</td>
<td>C0603</td>
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<tr>
<td>C8</td>
<td>10nF/25V Cap</td>
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<td>C9, C10</td>
<td>100pF/50V Cap</td>
<td>C0402</td>
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<tr>
<td>C11</td>
<td>100nF/25V Cap</td>
<td>C0402</td>
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<tr>
<td>C12, C20</td>
<td>100nF/25V Cap</td>
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<td>C21, C22, C23, C24, C25, C26, C27, C28, C29, C30</td>
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<td>COUT1, COUT2, COUT3, COUT4</td>
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<tr>
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<td>PCLGA 3.2*2.2</td>
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<tr>
<td>R1, R4, R11, R18, R23</td>
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<td>R0603</td>
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<td>R2, R3, R15, R22</td>
<td>0R Resistor</td>
<td>R0402</td>
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<td>R5, R8, R13</td>
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<td>R0402</td>
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<td>R6, R10</td>
<td>4.7R Resistor</td>
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<td>R7</td>
<td>10K Resistor</td>
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<td>300R Resistor</td>
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<td>U1</td>
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<td>NCP51820</td>
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<td>U3</td>
<td>SN74LVC1G08BDV</td>
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<tr>
<td>U4</td>
<td>NC7S200M5X</td>
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<tr>
<td>P1</td>
<td>2-Pin header</td>
<td>HDR1X2</td>
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<tr>
<td>P2</td>
<td>Input Header, 5-Pin, Dual row</td>
<td>HDR2X5_CEN</td>
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<td>P3</td>
<td>5W Header, 5-Pin, Dual row</td>
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<td>GND Header, 5-Pin, Dual row</td>
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<td>P5</td>
<td>4-Pin header</td>
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<tr>
<td>P6</td>
<td>2-pin socket</td>
<td>KFI12B-5.08-2P</td>
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<td>D2, D3</td>
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<td>L1</td>
<td>TBD Inductor</td>
<td>WE-XHMI_1510</td>
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</tr>
</tbody>
</table>
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