HGTD PEB DC/DC Power Block in Low Temperature and Magnetic Field Operation

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  - Rise/fall edge at low temperature or in magnetic field
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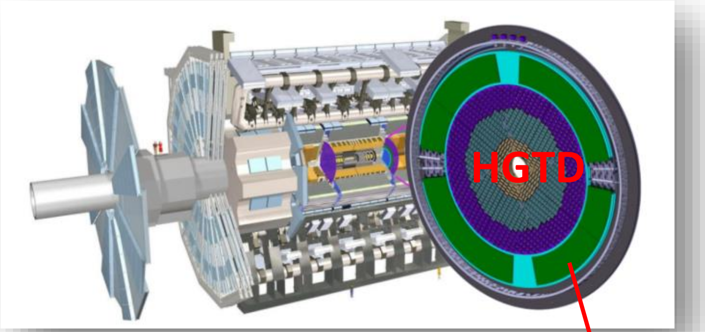
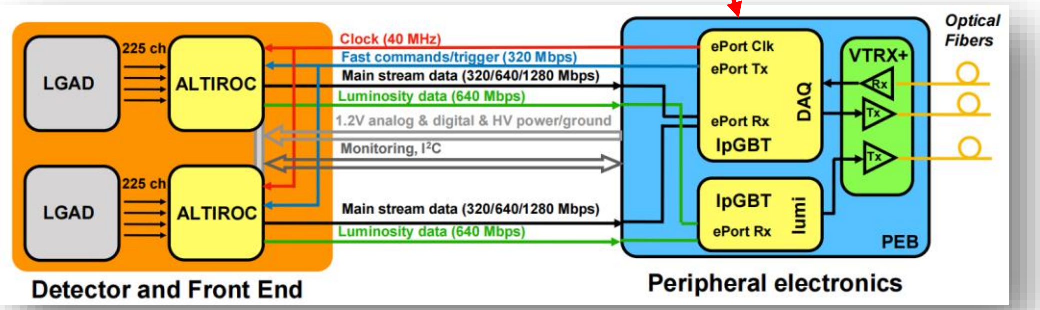
Introduction

- High Granularity Timing Detector (HGTD):
  - Aim to ATLAS Phase II.
  - Provide a time resolution of around 30 ps.

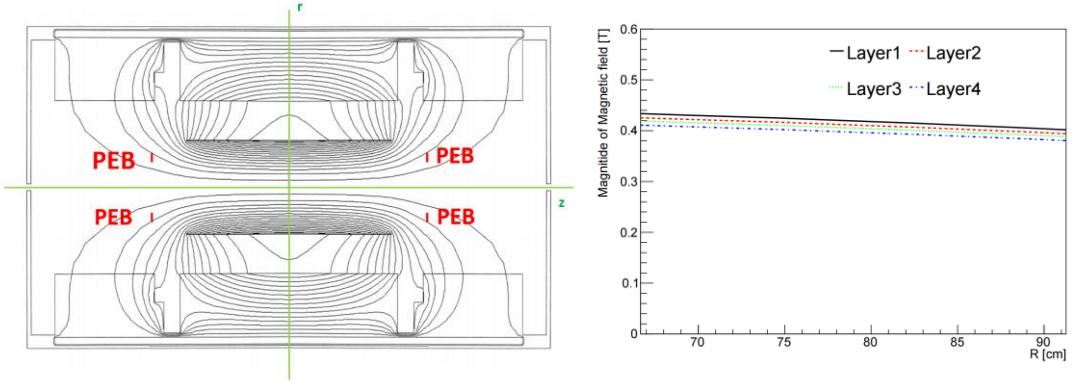


- Peripheral Electronics Boards (PEB) in HGTD:
  - Used for control, monitoring, data transmission, power-supply distribution, and temperature sensor routing for interlock system.



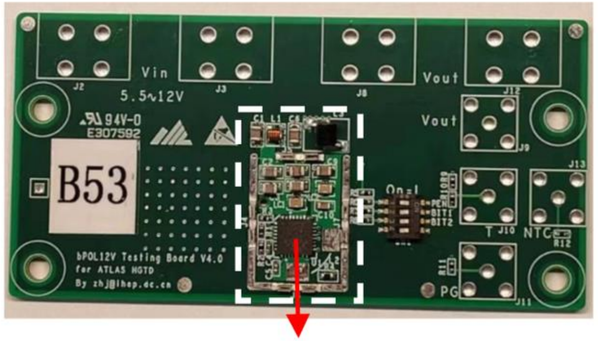
- BPOL12V Power Block in PEB:
  - DC-DC converter: Generate 1.2 V and 2.5 V for ATLAS Timing Read-Out Chip (ALTIROC) and other PEB components.
  - Crucial to test BPOL12V performance at its operation environment: low temperature (-30℃) and magnetic field (0.4T).

BPOL12V operation magnetic field



Test setup

- BPOL12V test board:
  - Full BPOL12V test board without inductor, shielding and wiring terminal

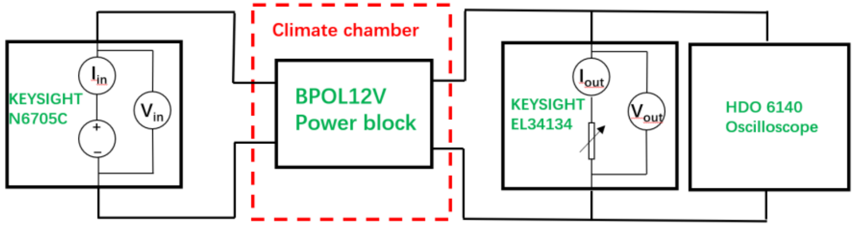


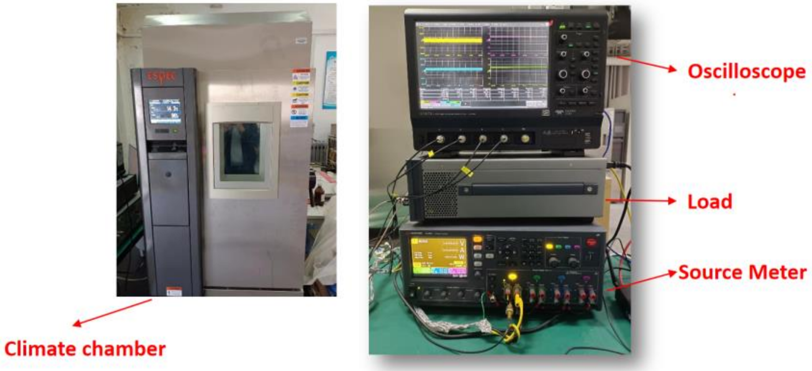
BPOL12V

  - Zoom in of the BPOL12V test board central part, with inductor added.

  - Full BPOL12V test board with inductor, shielding and wiring terminal

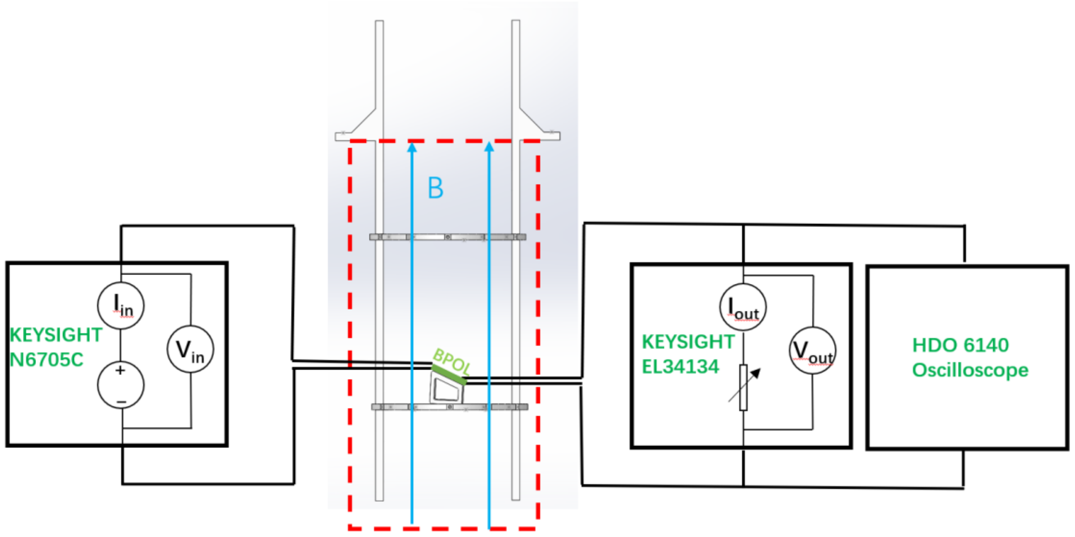
- Test at low temperature (no magnetic field):
  - Climate chamber: control the temperature
  - Source meter (KEYSIGHT N6705C): provide and measure the input voltage and current
  - Load (KEYSIGHT EL34134): control and measure the output current and voltage
  - Oscilloscope (HDO 6140): examine the ripple and rise/fall edge.



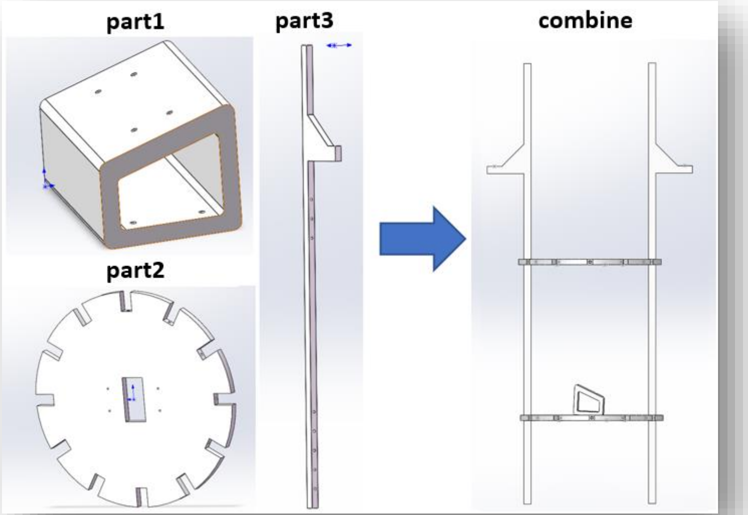


Test setup

- Test in magnetic field (room temperature):
  - Magnetic barrel: produce adjustable (0 - 4T) magnetic fields based on Superconducting solenoid. In the middle of the barrel, the magnetic fields are evenly distributed and the direction is up.
  - Supporting material: fix the BPOL12V at the middle of the barrel and adjust the angle between BPOL12V and magnetic field.
  - Source meter, load and oscilloscope are the same as low temperature test.

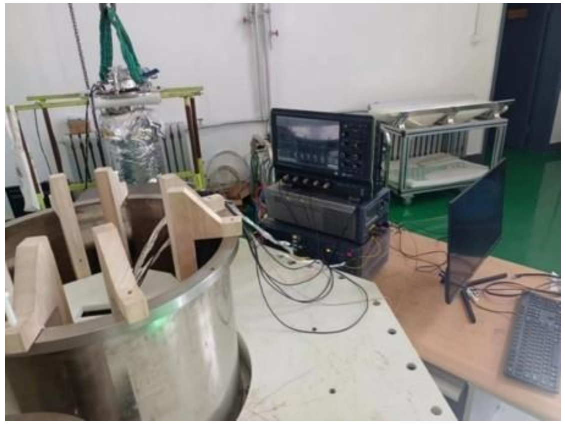


Supporting part design



magnetic barrel

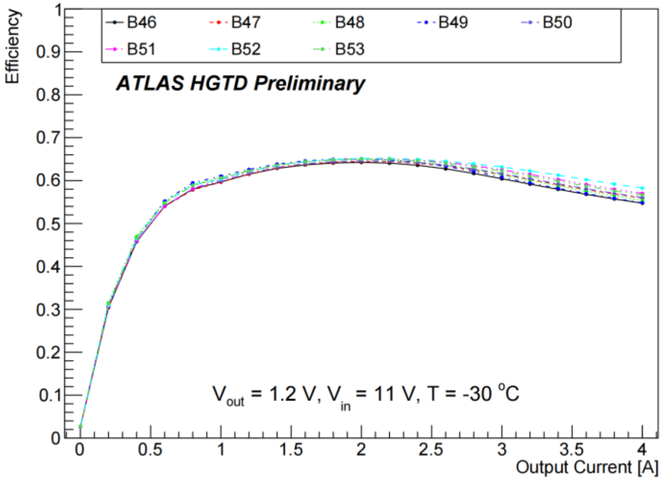
Supporting part

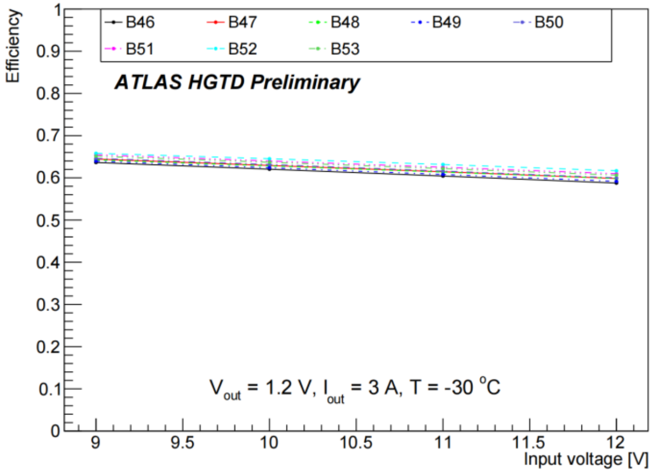


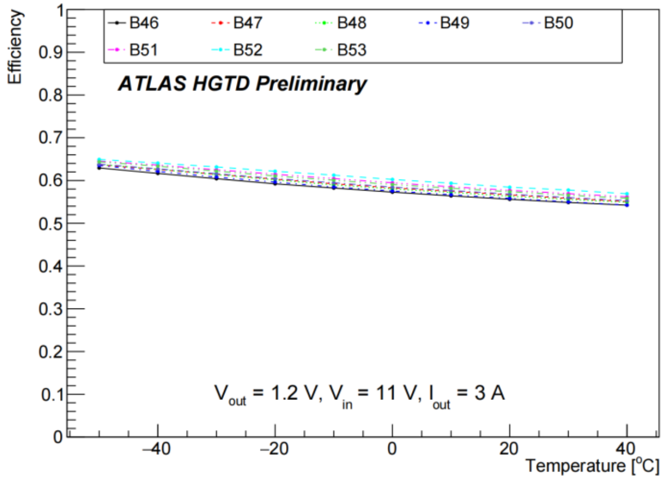
Efficiency at low temperature

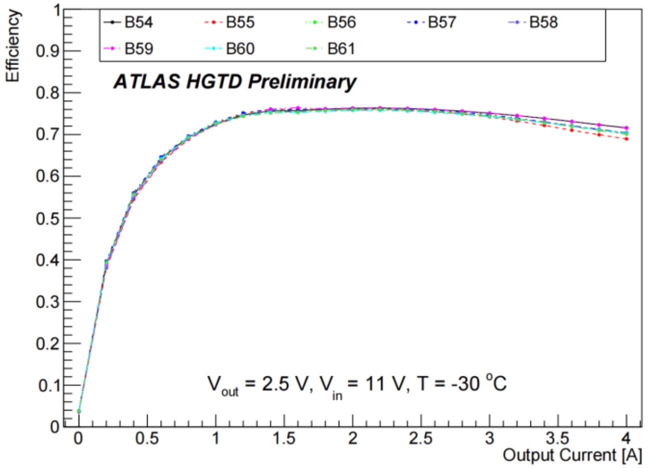
- Efficiency = $\frac{V_{out} * I_{out}}{V_{in} * I_{in}}$, is vital to understanding HGTD power supply and heat dissipation.

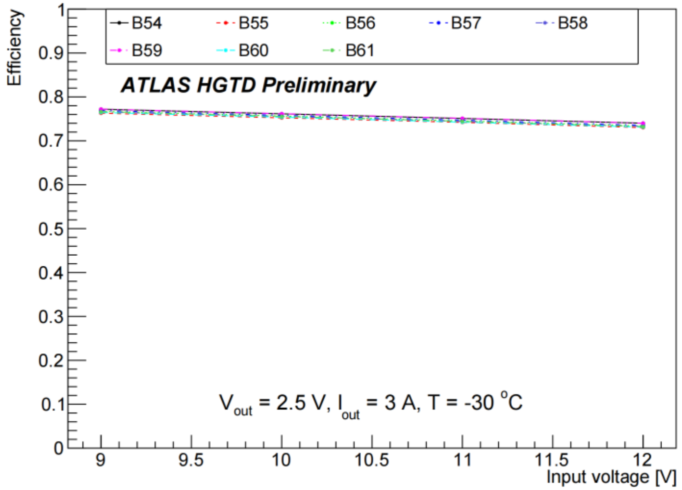
Efficiency vs I_{out} | **Efficiency vs V_{in}** | **Efficiency vs T**

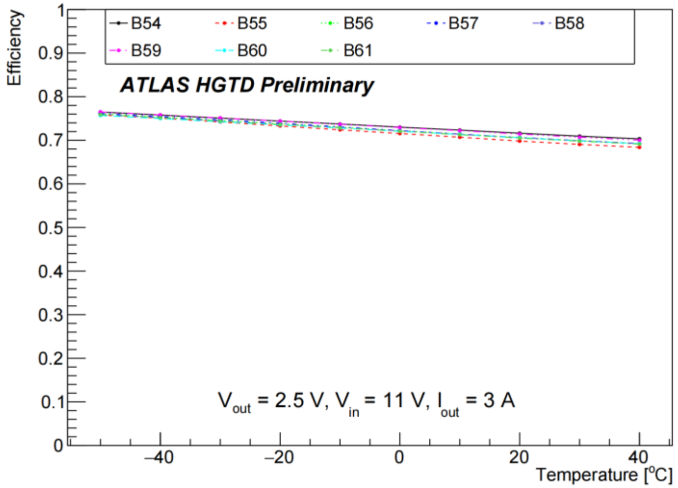








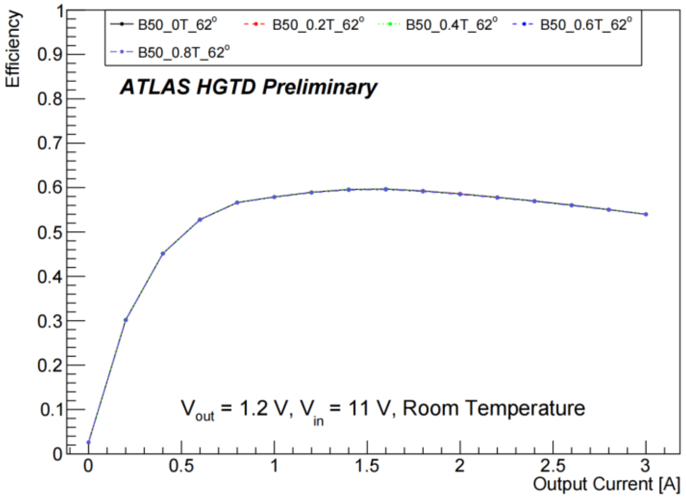


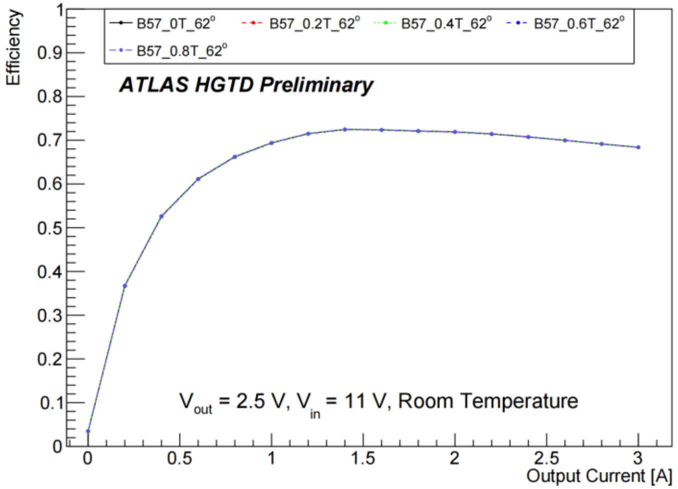


Efficiency can reach 65% (75%) when V_{out} = 1.2V (2.5V) at -30℃.

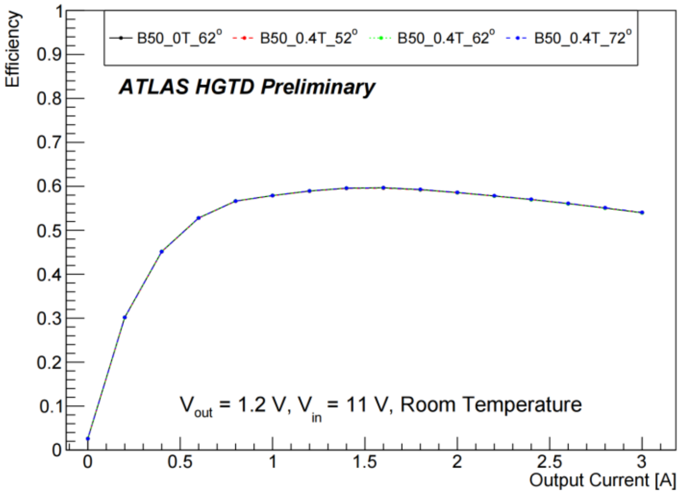
Efficiency in magnetic field

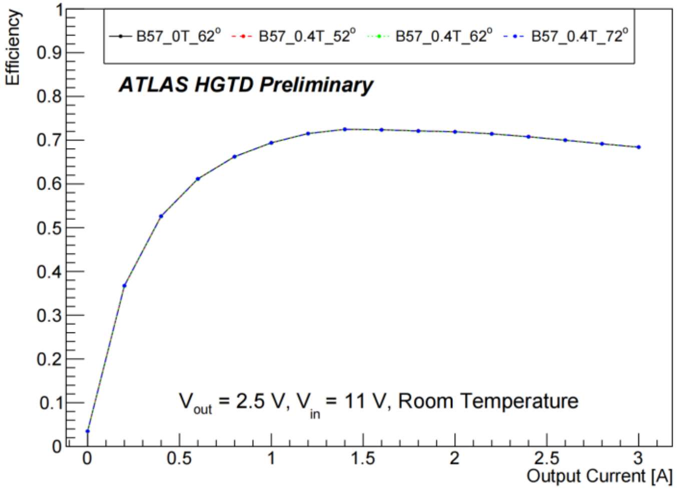
B = 0~0.8T (Angle = 62°)



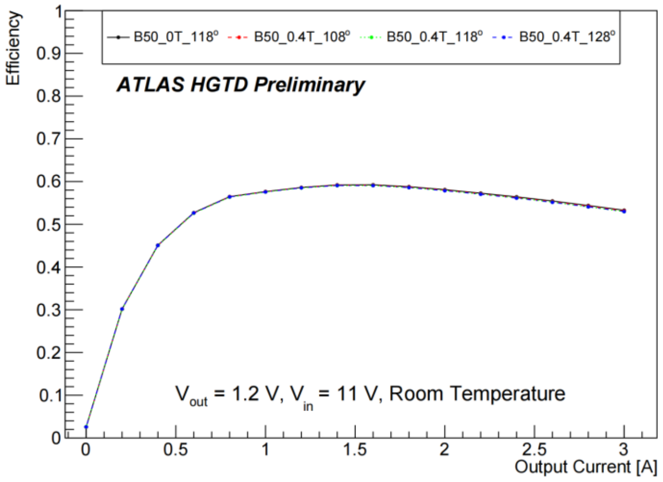


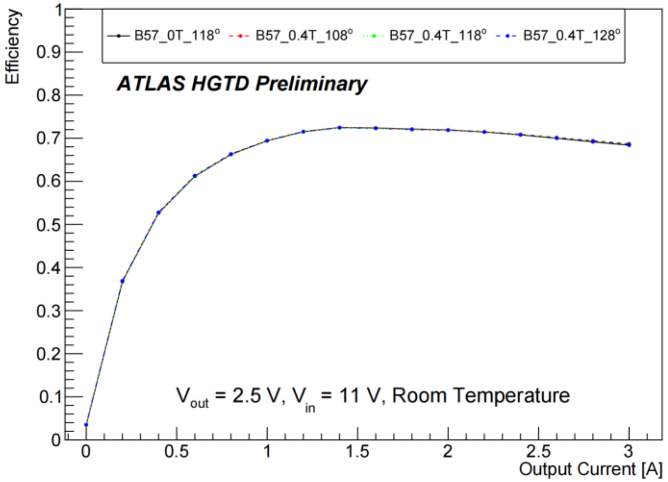
Ang = 52~72° (B = 0.4T)





Ang = 108~128° (B = 0.4T)



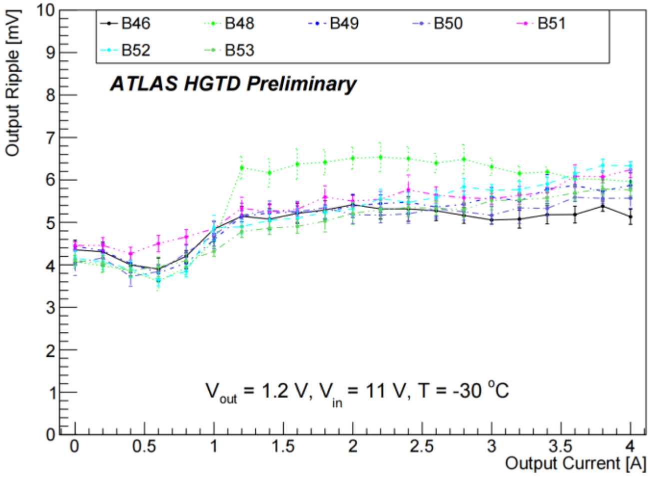


- The angle and magnitude is selected based on BPOL12V operation environment.
- Magnetic field with different angle and magnitude has little impact on efficiency.

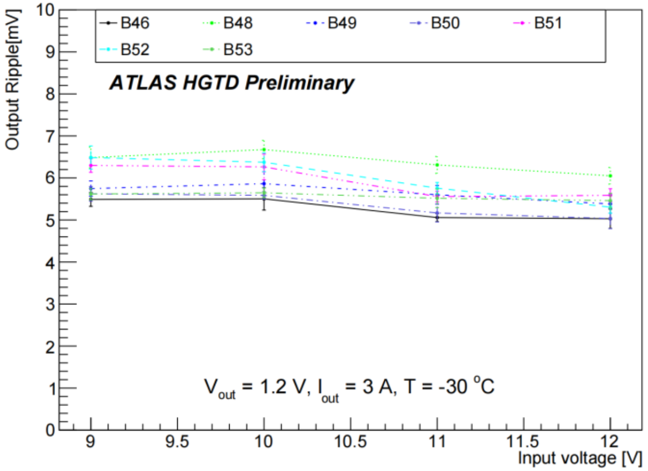
Output ripple at low temperature

- Output ripple, defined as the peak-to-peak value of the output voltage, can influence the performance of devices connected to the BPOL12V.

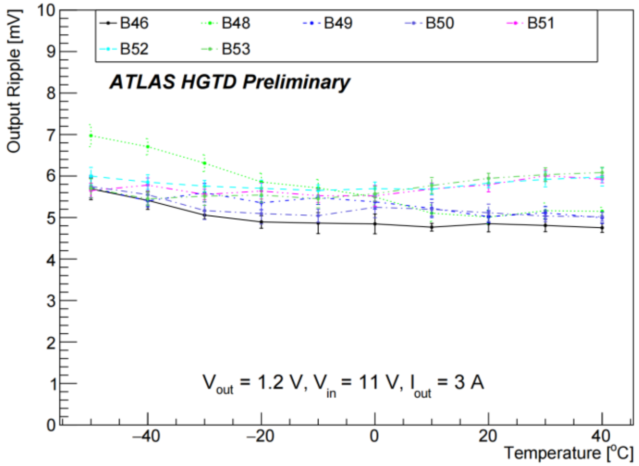
Ripple vs I_{out}

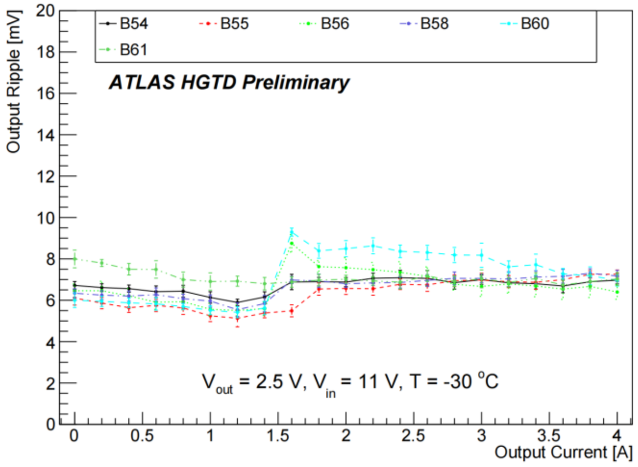


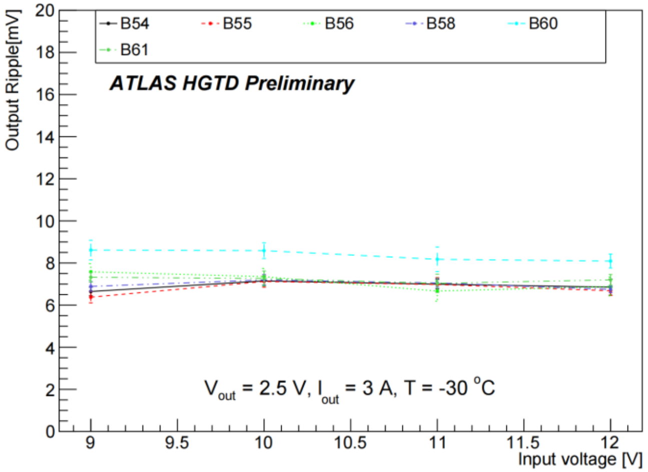
Ripple vs V_{in}

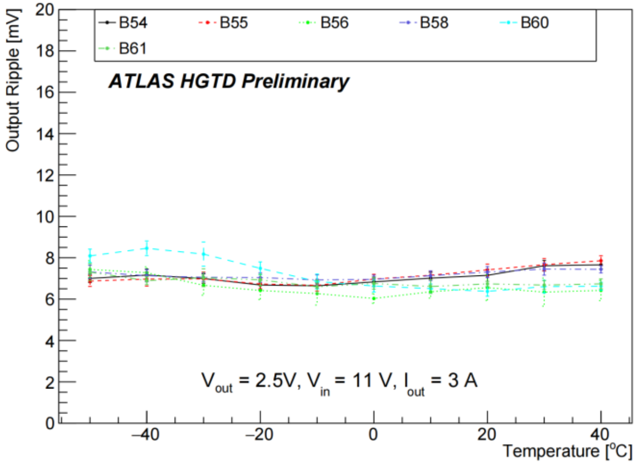


Ripple vs T





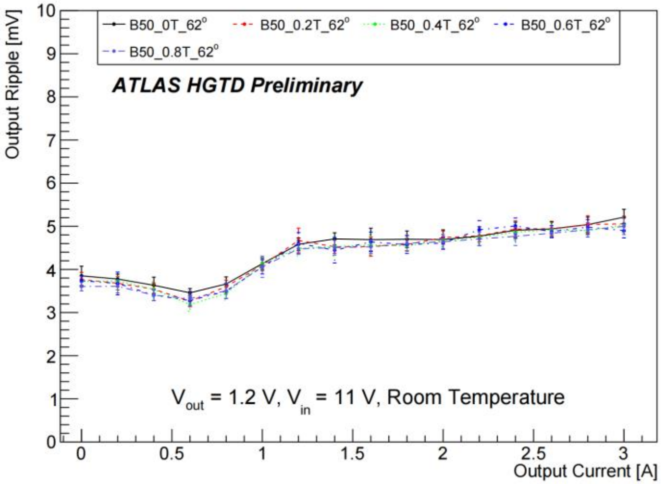


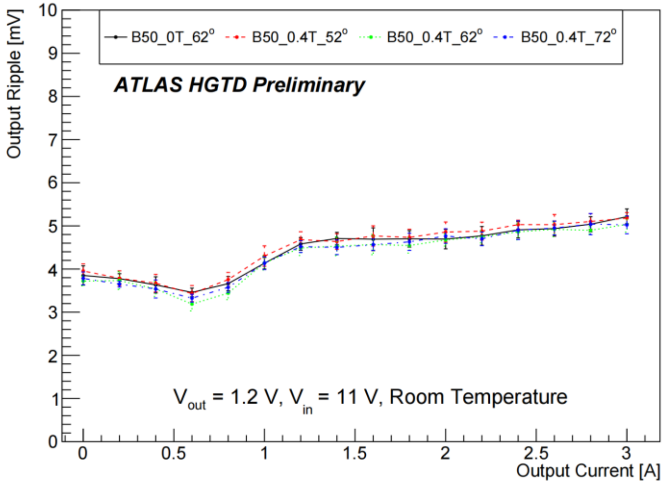


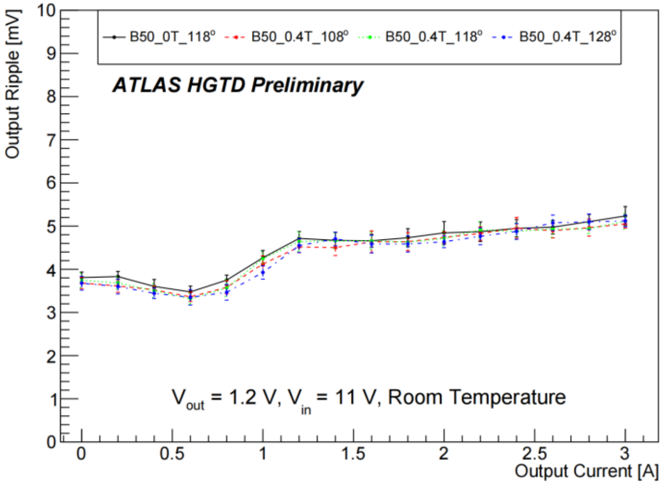
Output ripple is smaller than 7mV (10mV) when V_{out} = 1.2V (2.5V) at -30℃.

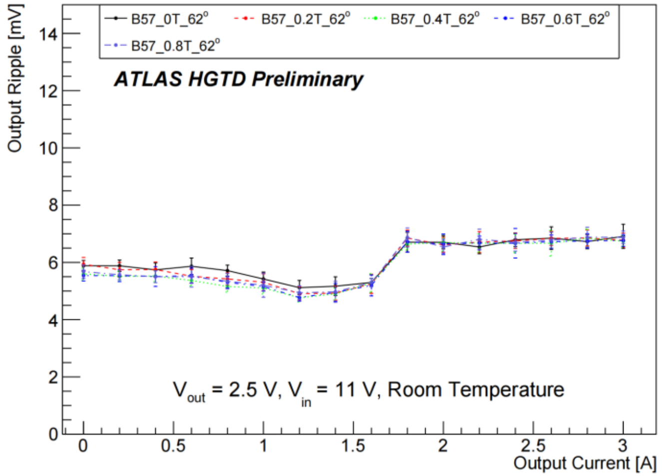
Output ripple in magnetic field

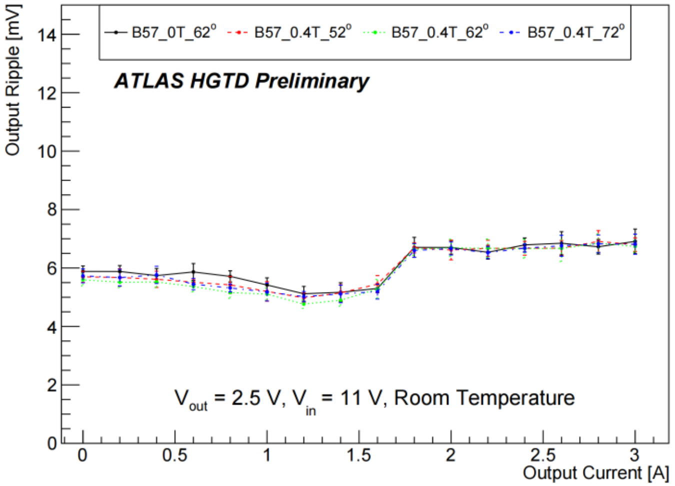
B = 0~0.8T (Angle = 62°) | **Ang = 52~72° (B = 0.4T)** | **Ang = 108~128° (B = 0.4T)**

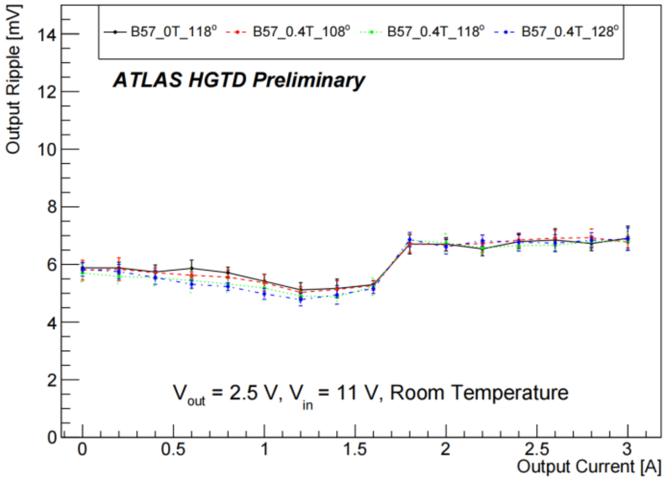








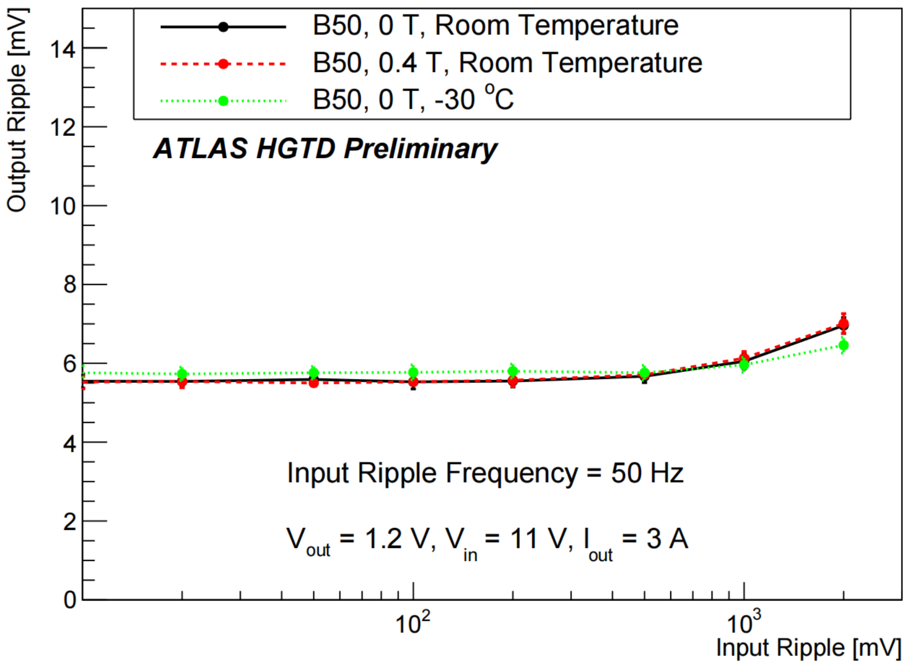


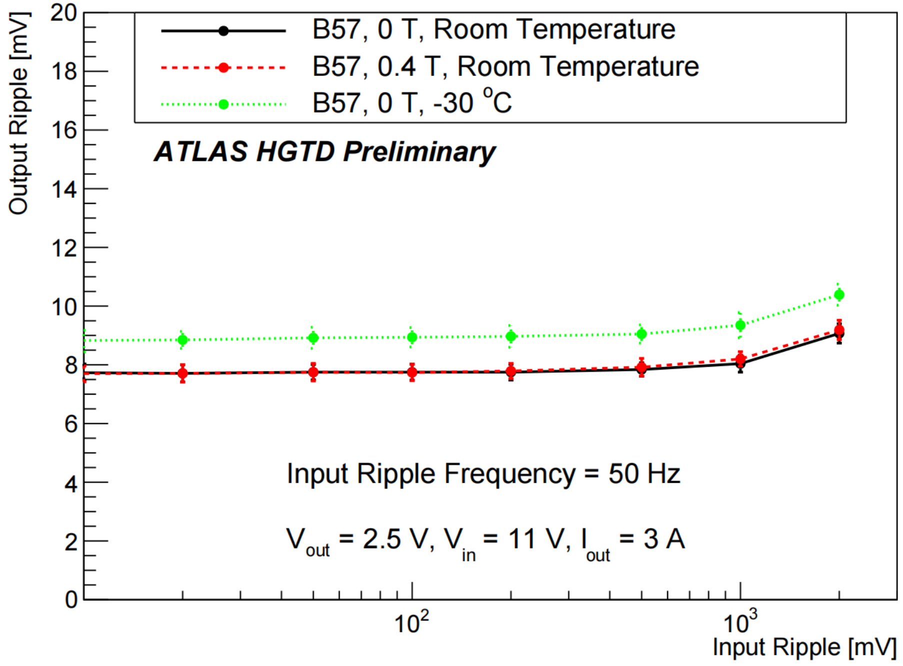


- The angle and magnitude is selected based on BPOL12V operation environment.
- Magnetic field with different angle and magnitude has little impact on ripple.

Ripple suppression ability

- Given the input voltage fluctuations during operation, it is crucial for the BPOL12V to have effective ripple suppression ability.

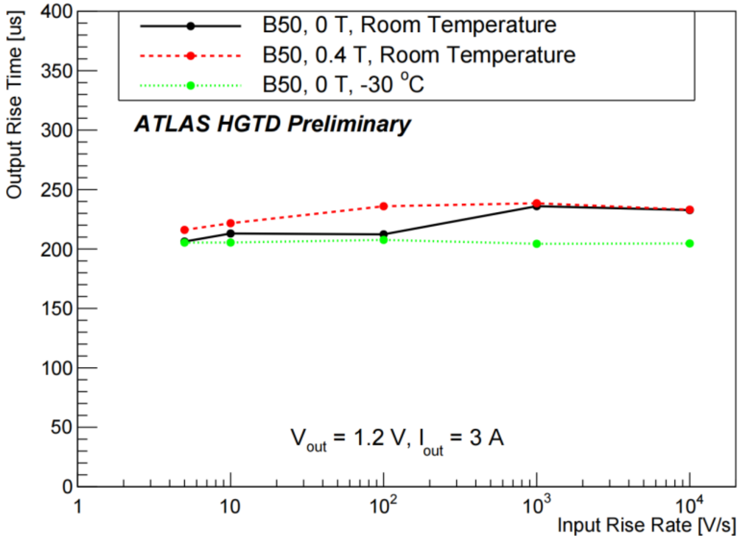


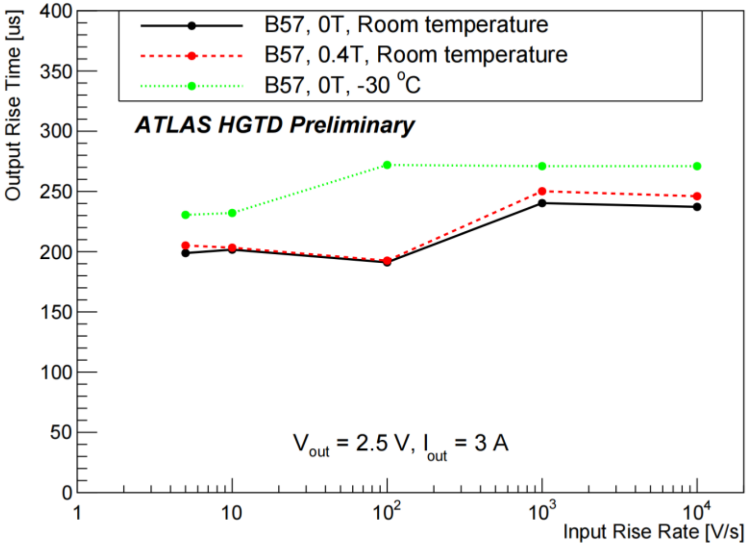


The output ripple keeps stable as the input ripple (50HZ) increases, either at low temperature or in magnetic field.

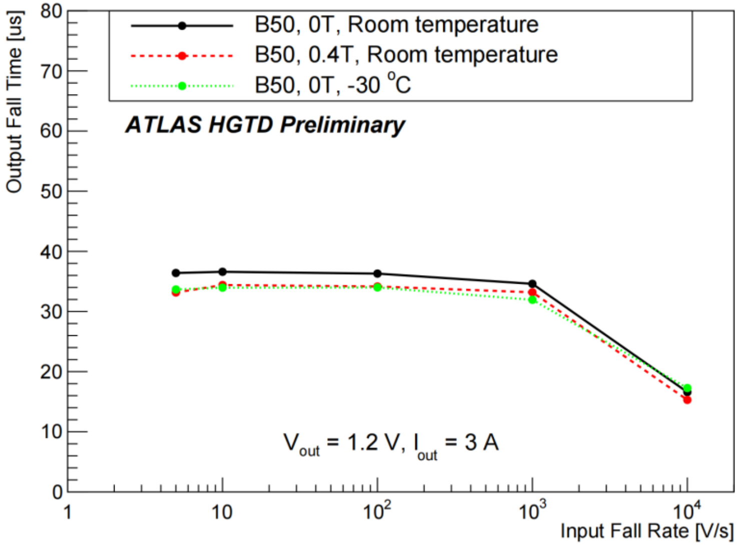
Rise/fall edge

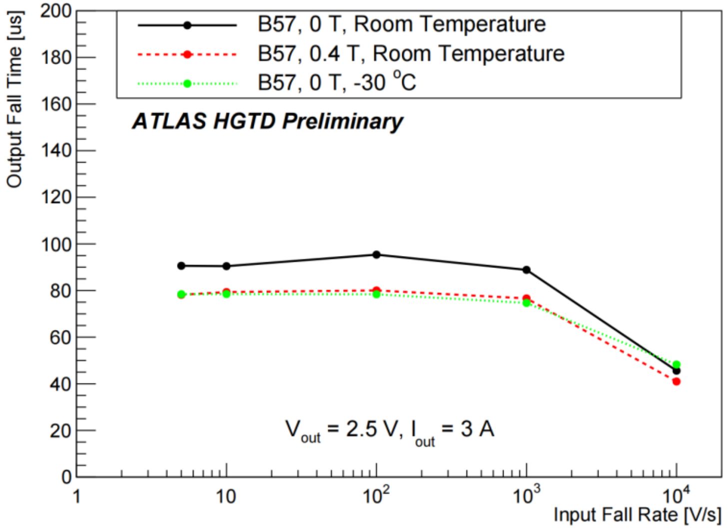
Rise edge





Fall edge





- The rise/fall rate of input power can vary during the startup and shutdown of the BPOL12V. -> It is essential to assess the rise/fall edge of the BPOL12V under various input rise/fall rates.

- The output rise (fall) time is less than 300 (100) μs either at low temperature or in magnetic field.

Summary

- The performance of the BPOL12V was evaluated under low temperature or magnetic field conditions:
  - Efficiency can reach 65% (75%) when V_{out} = 1.2V (2.5V) at -30℃.
  - Output ripple is smaller than 7mV (10mV) when V_{out} = 1.2V (2.5V) at -30℃.
  - Magnetic field with different angle and magnitude has little impact on efficiency and ripple.
  - BPOL12V displayed excellent ripple suppression ability.
  - BPOL12V maintained consistent operation across different input voltage rise/fall rates.
- This comprehensive study affirms that the BPOL12V fully meets the requirements of HGTD.