Design Guide for GaNSlim Serial Products Used in LLC Circuit

Scope and purpose

This design guide is to help customers design LLC circuit using GaNSlim power IC. It provides guidelines on reference design, parameters related to special points, to void using risk.

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1. Introduction

This feature-rich 700 V GaNSlim™ Power IC includes a high performance eMode GaN FET, integrated gate drive, and extended features to create the fastest, smallest, most efficient, and most robust integrated powertrain in the world.

Integrated lossless current sensing eliminates external current sensing resistors and increases system efficiency, over-temperature protection increases system robustness, auto standby and sleep mode increase light/tiny/no-load efficiency.

The highest dV/dt immunity, high-speed integrated drive and industry-standard low-profile, low-inductance, DPAK package combine to enable designers to exploit Navitas GaN technology with simple, quick, reliable solutions achieving breakthrough power density and efficiency.

Navitas's GaNSlim™ power ICs extend the capabilities of traditional topologies and enable the commercial introduction of breakthrough designs.

2. Product highlights

- Integrated gate drive
- 3.3V/5V/15V PWM logic input compatible
- Programmable accurate GaN current sensing
- Over-temperature protection
- Wide V_{CC} range (6.2V to 24V typical)
- Low standby current (< 50uA typical)
- Sleep mode current (<10uA max)
- Built-in turn-on dV/dt optimization
- Built-in turn-off di/dt optimization
- Reliable hard and soft switching
- Zero reverse recovery charge

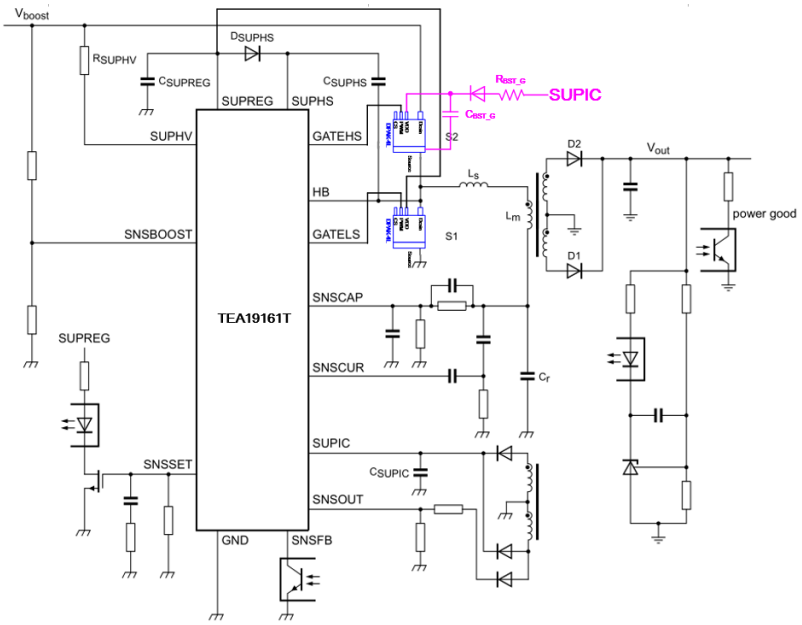
DPAK-4L package with grounded cooling pad

- Grounded cooling pad
- Minimized package inductance
- Low thermal resistance

3. Application with NXP LLC controller

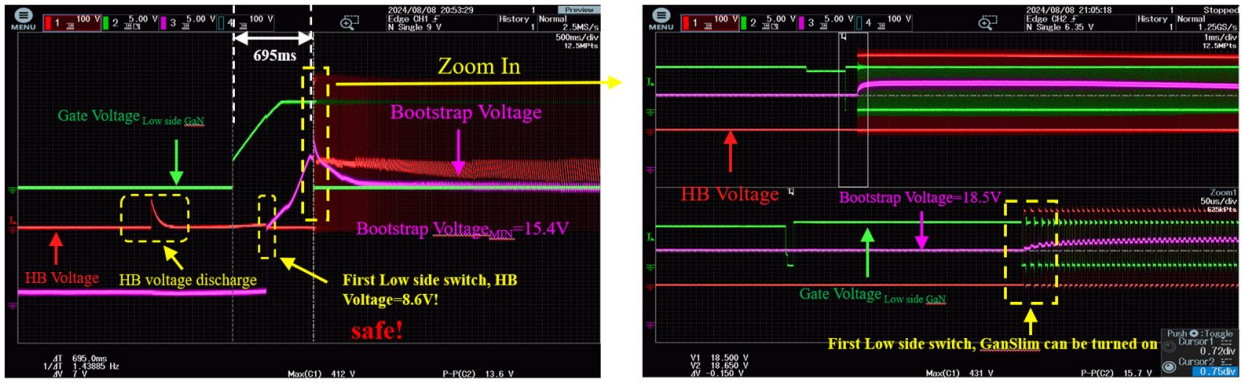
3.1 Reference design

- LLC IC: TEA19161T(NXP)
- LLC Switch: NV6148CQ01(high side) + NV6148CQ01(low side)
- V_{cc} capacitor for high side supply: 10uF
- V_{cc} voltage for high side switch:19V



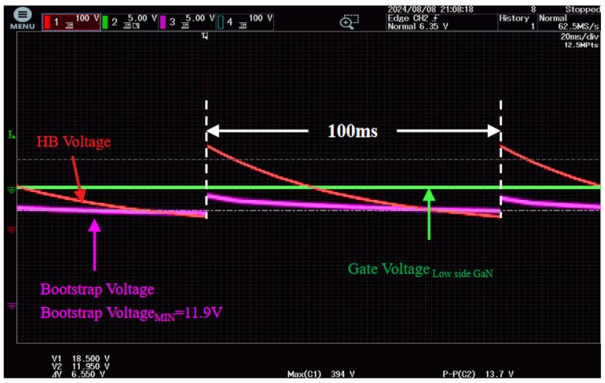
Typical applications circuit

3.2 Start-up

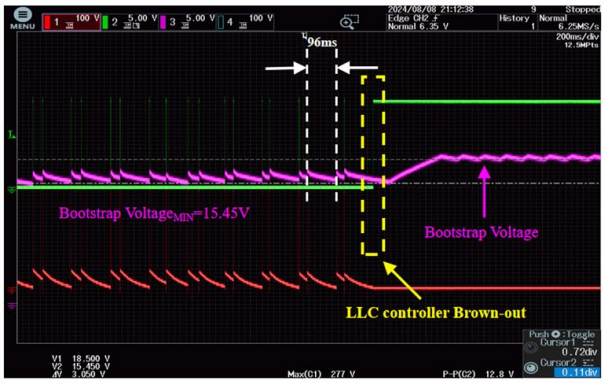


No Load Start-up @Vbus=0V

3.3 Turn off

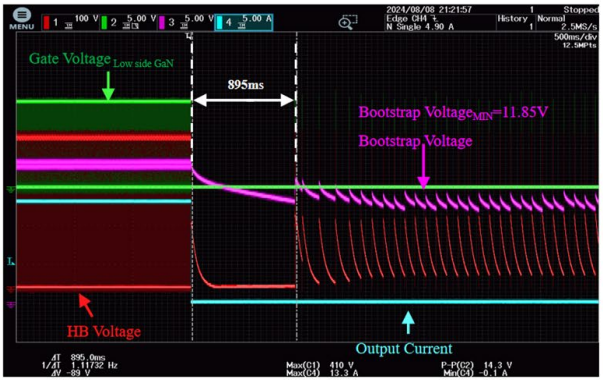


No load operation

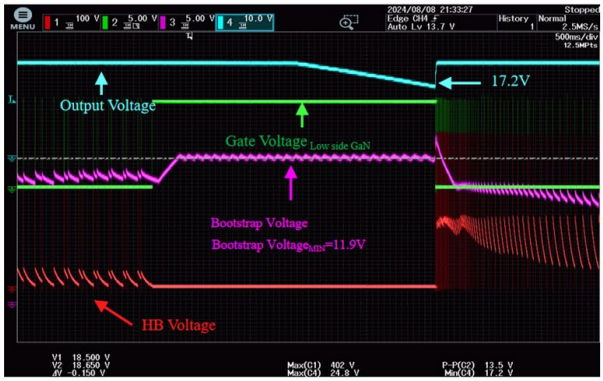


Turn off @ No load

3.4 Quickly on/off



Full Load to No-Load



No-Load Start-up @ High Output Voltage

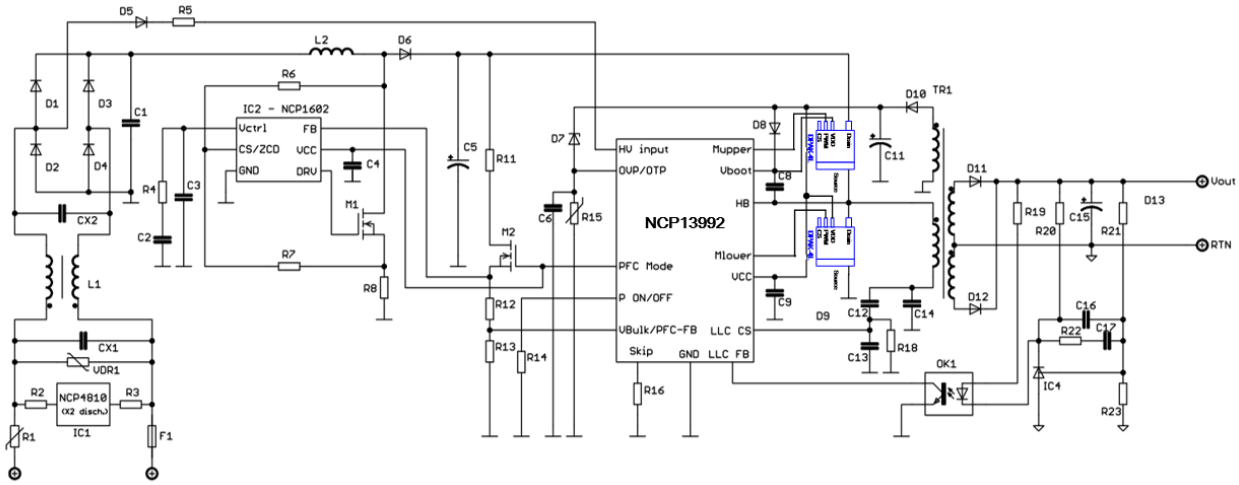
3.5 Summary

Before driver signal, the HB voltage was pulled down to GND. It has plenty of time high V_{CC} capacitor. That the GaNSlim was applied on LLC circuit with NXP controller is no problem.

4. Application with Onsemi LLC controller

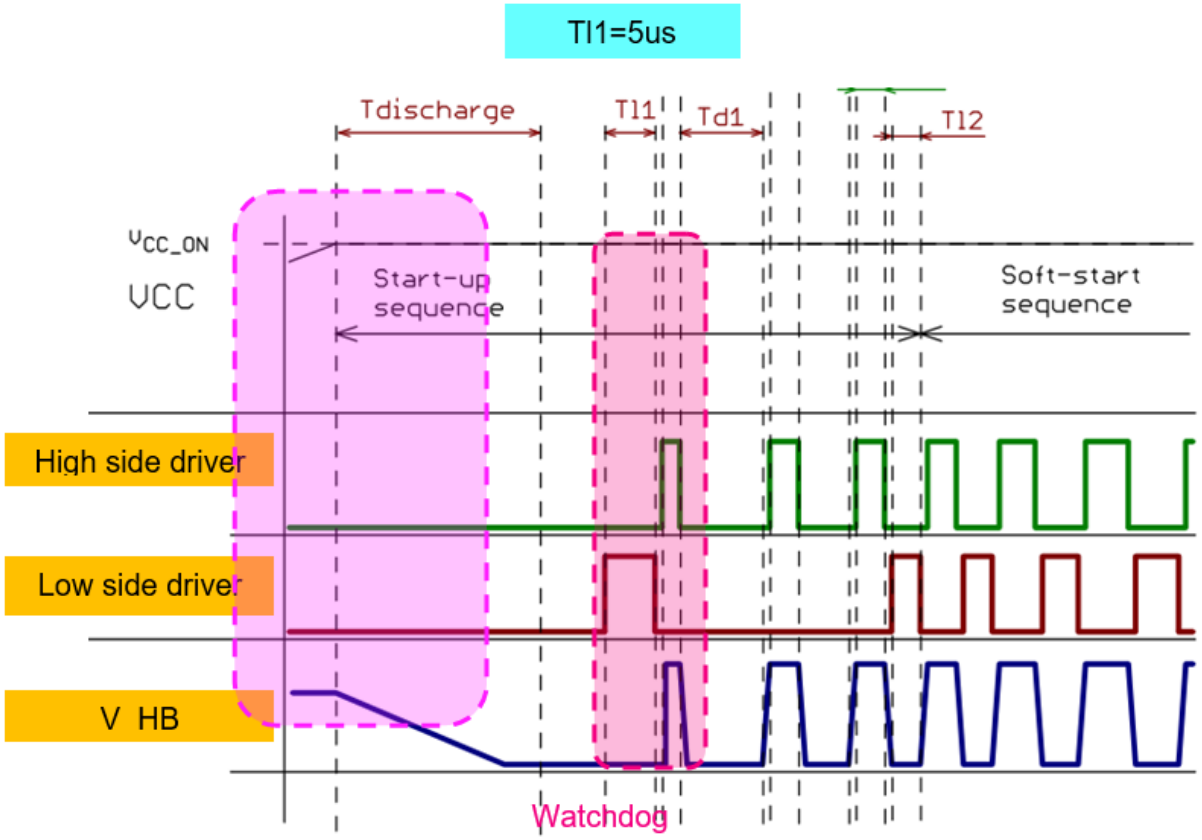
4.1 Reference design

- LLLC IC: Onsemi NCP13992 except version (AB, AD, AH, AR, AS)
- LLC Switch: NV6148CQ01(high side) + NV6148CQ01(low side)
- V_{cc} capacitor for high side switch: 10uF
- V_{cc} voltage for high side switch:16V



Typical applications circuit

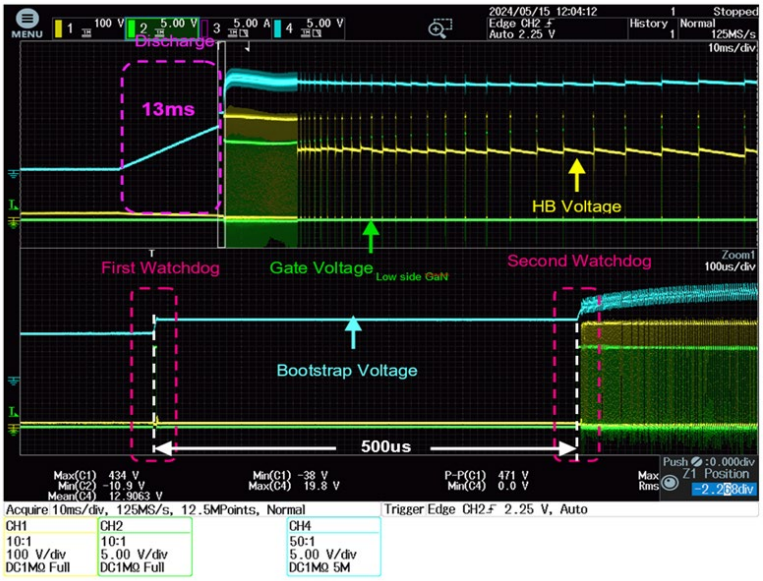
4.2 Start-up


Tl1=5us
Tdischarge
Tl1
Td1
Tl2
VCC_ON
VCC
Start-up sequence
Soft-start sequence
High side driver
Low side driver
V HB
Watchdog

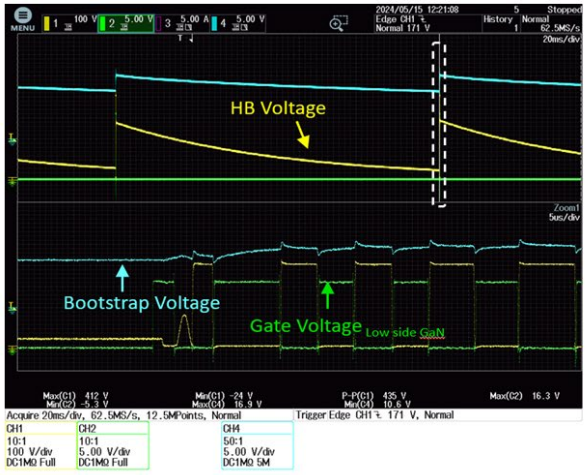
Start-up flow

T The first step is to release V_HB below VHB_MIN (10V), during this period can charge the Bootstrap capacitor.

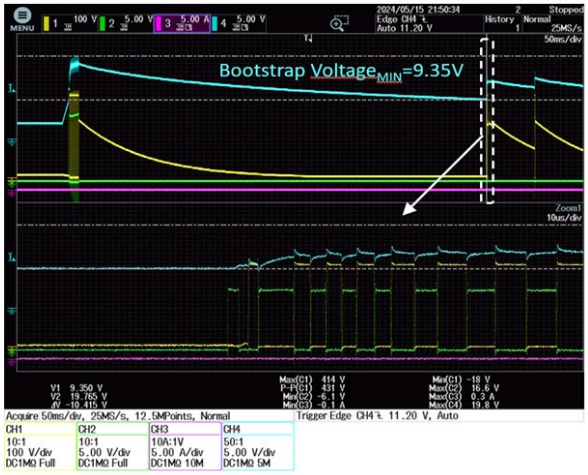
The second step is to program check, consisting of a 5us low side gate and 500ns high side gate. If the high side gate is not opened, it will wait for another 500us to check again.



No Load Start-up @Vbus=0V

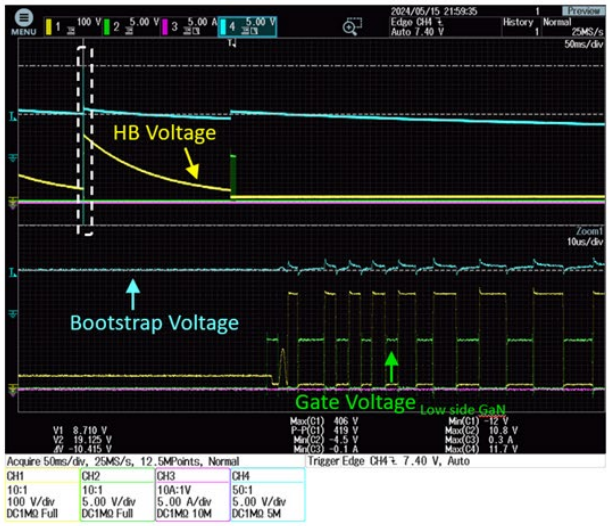


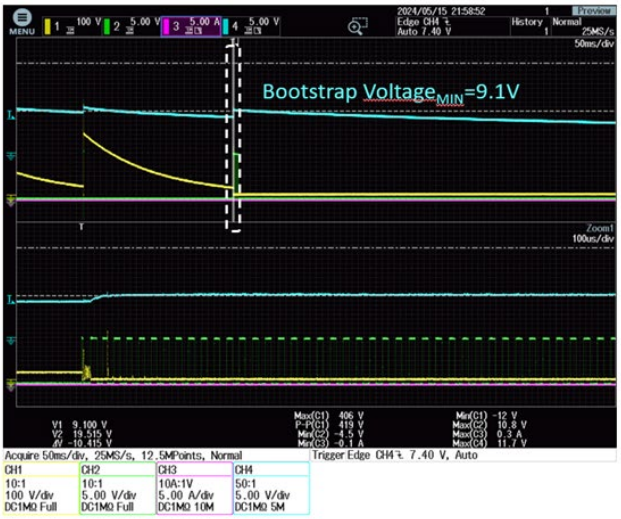
Quiet skip mode



Start-up @ High Output Voltage

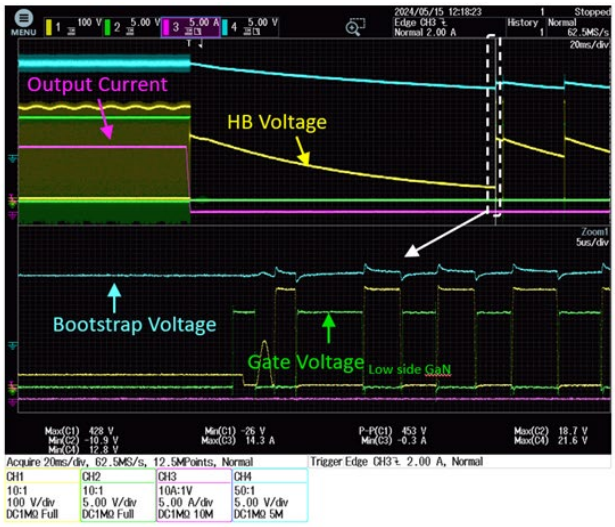
4.3 Turn off

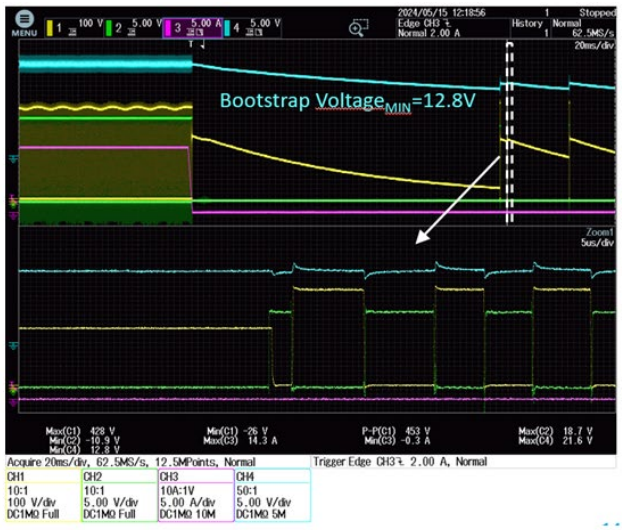




AC off @ No load

4.4 Load transient





Full load to No load

4.5 Summary

During normal soft-startup, high side GaNSlim cannot be opened at the first watchdog signal, but it does not affect the normal operation of the soft-start up. After the IC triggers the protection, the IC goes through a soft startup again, so it can also work well.

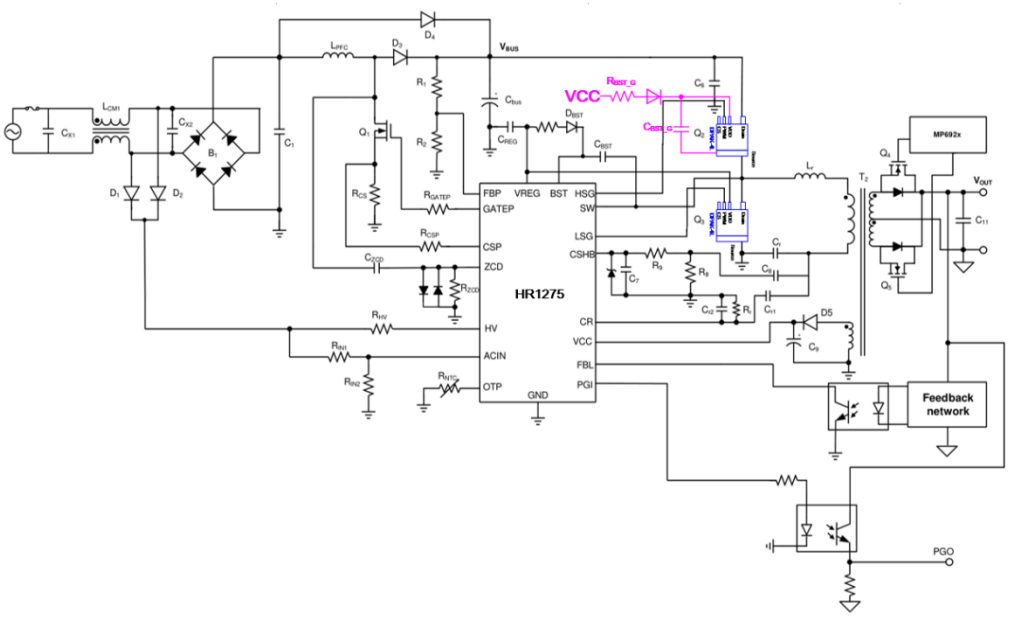
Onsemi LLC controller have a HB voltage discharge function before Startup. So, when the Onsemi LLC controller is paired with GanSlim, both the spilt resonant capacitor and the single resonant capacitor wiring methods are applicable.

In the Onsemi NCP13992 series of LLC controllers, there is a type of controller that cannot be compatible with our GaNSlim serial products. That is NCP13992(AB, AD, AH, AR, AS).

5. Application with MPS LLC controller

5.1 Reference design

- LLC IC: HR1275(MPS)
- LLC Switch: NV6148CQ01(high side) + NV6148CQ01(low side)
- V_{cc} capacitor for high side supply: 10uF
- V_{cc} voltage for high side switch:19V



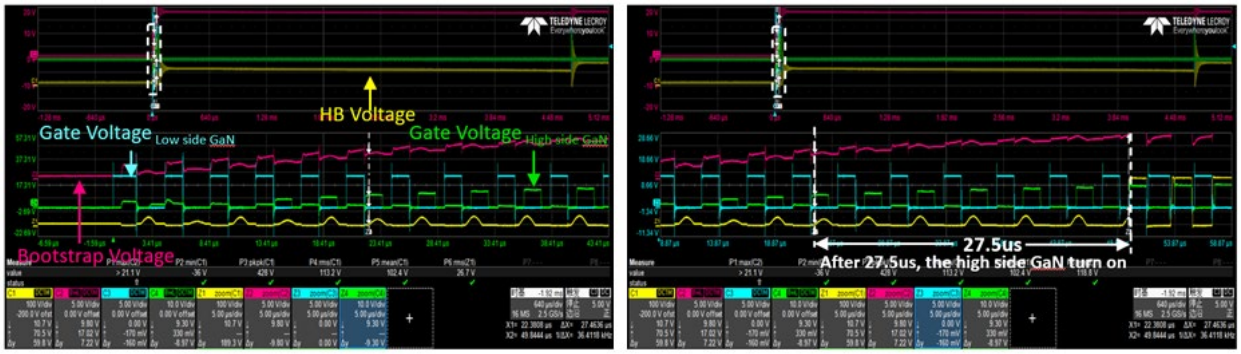
Typical applications circuit

5.2 Start-up

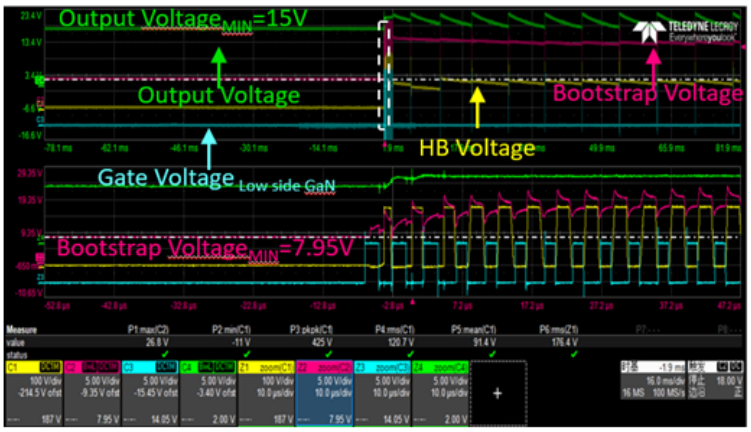
HR1275 start-up flow

The controller detects Vbst voltage, After the voltage of Vbst is higher than 5V, the high side gate signal was given.

The pulse of low side and high side were aways given, and the LLC controller do not go through protection mode.

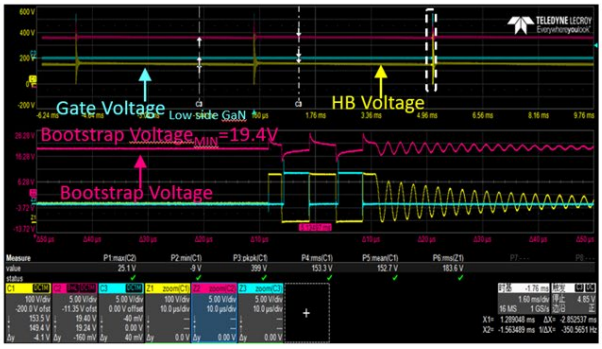


NO load start-up when output voltage is 0

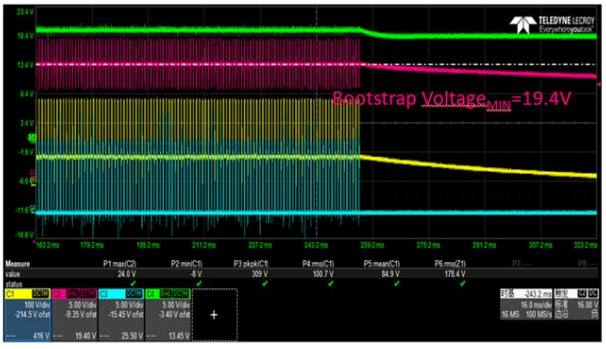


Shut down and restart, when output voltage is high voltage

5.3 Turn off

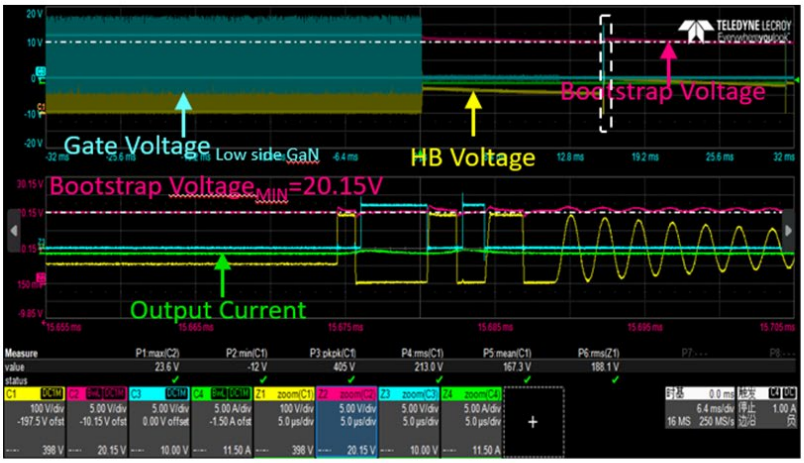


In Burst mode, Vbst voltage is around 19V.



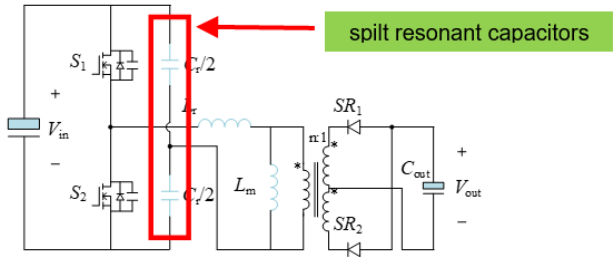
When AC is off, the Vbst is steady at 19V.

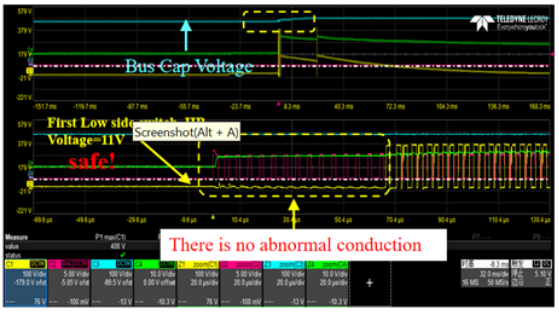
5.4 Load transient



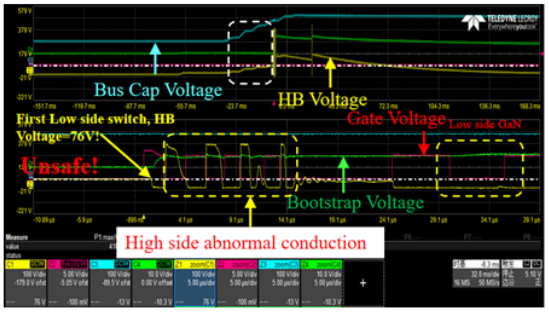
When high load transient to no load, the Vbst is higher than 20V, there is no risk of power failure

5.5 Attention for SHB LLC topology application for HR1275 with GaNSlim

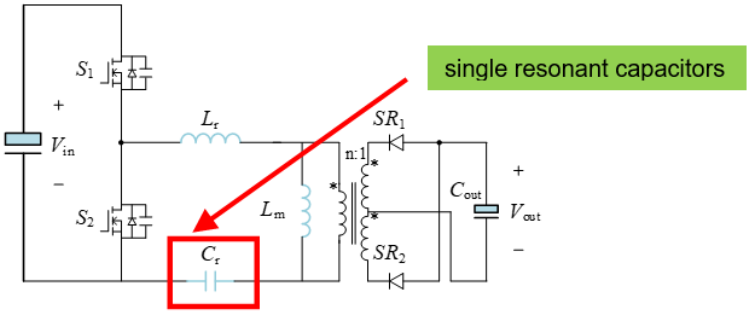




No Load Start-up @Vbus=370V



No Load Start-up @Vbus=0V



No Load Start-up @Vbus=0V

5.6 Summary

Because MPS LLC controller does not have a HB voltage discharge function before Startup. it is not suitable to use the spilt resonant capacitors.

When the MPS LLC controller is paired with GanSlim, it is recommended to use the single resonant capacitors.

During normal soft-startup, high side GaNslim cannot be opened at the first gate signal, but it does not affect the normal operation of the soft-startup.

After the IC triggers the protection, the IC goes through a soft startup again, so it can also work well.

6. Notes

1) When you use GaNSlim to design LLC circuit, the controller you selected must be able to soft start, even at the first drive signal.

2) The controller must be able to keep giving the drive signal until it works properly at start-up. When the controller is started, it must send several high-side and low-side drive signals to ensure the normal power supply of the high-side drive.

3) The first high side drive pulse width given by controller must be greater than 350ns.

If you have any questions, please contact Navitas's FAE.

Additional Information

Contact: info@navitassemi.com