High VOLT Interactive

Where power supply design meets collaboration

Implementation and Design Considerations of High Voltage Gate Drivers

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What will I get out of this session?

- Purpose:

- This session presents the high voltage half bridge drivers architecture and operation details, and common applications well suited for these drivers. Guidance for designing with high voltage half bridge drivers including bias considerations, start-up ,sequencing and other operation considerations are discussed. The cause of some common concerns or issues in high voltage power trains is presented, and recommendations to mitigate these issues. TI high voltage half bridge drivers attributes and features help overcome the challenges of a high noise power train environment.

- Part numbers mentioned:
  - UCC27710
  - UCC27712
  - UCC27714
- Relevant End Equipments:
  - Motor Drive
  - Appliance
  - Inductive Heating
  - HVAC

AGENDA

- TI high voltage driver portfolio summary
- High voltage half-bridge gate driver architecture
- High voltage half-bridge gate driver applications
- High voltage half-bridge gate driver design considerations
  - Bias and start up
  - Negative voltage spikes/ringing on HS
  - False triggering of driver output
    - Driver input noise
- Summary

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Driver Portfolio Summary

Low Side

UCC2732x/42x
UCC2752x
UCC2751x/53x

- Higher VDD for more headroom and robustness
- Low pulse transmission distortion

PFC	TIDA-00779 TIDA-00443 TIDA-00447
AC/DC Power	PMP-11064
DC/DC Converter	BIDIR TIDA-00705
Solar Micro Inverter	SOLAR
Flyback :	PMP10035

Half-Bridge

TPS28225
UCC2720x/A
LM510X

- Low power dissipation and lower switching loss
- Low pulse transmission distortion

LED Control	Auto_LED
DC/DC Converter	PMP4320A
Module Power	PMP7246

High Voltage

UCC27712
UCC27714
UCC27710

- Higher power density
- Best in class dynamic characteristics
- Offers design flexibility & robustness
- Replace bulky gate drive transformers

BLDC Motors	TIDA-00472
Battery Chargers	TIDA-00355
AC/DC Power	PMP11282
LLC Resonant Converter	PMP10949

Isolated

UCC21520
UCC53XX

- Universal drive capability
- Allow best in class efficiency
- High degree of isolation
- Best in class reliability and robustness
- Highest level of flexibility

Inverters, UPS	TIDA-01160
Three Phase inverter	TIDA-00366

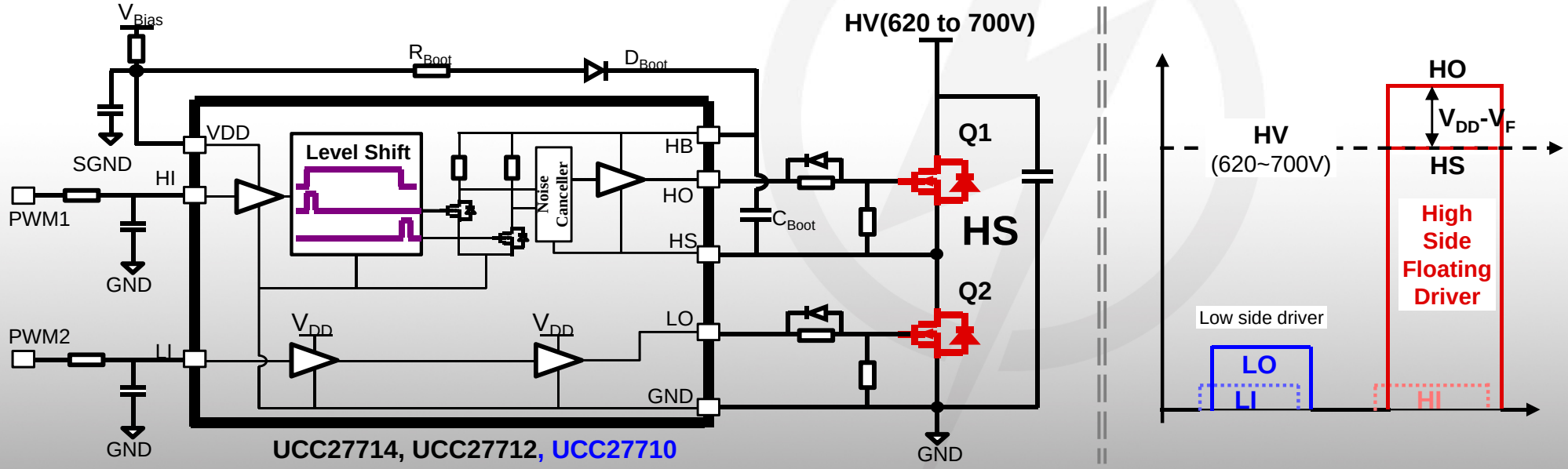
SiC

UCC27531
UCC21521C

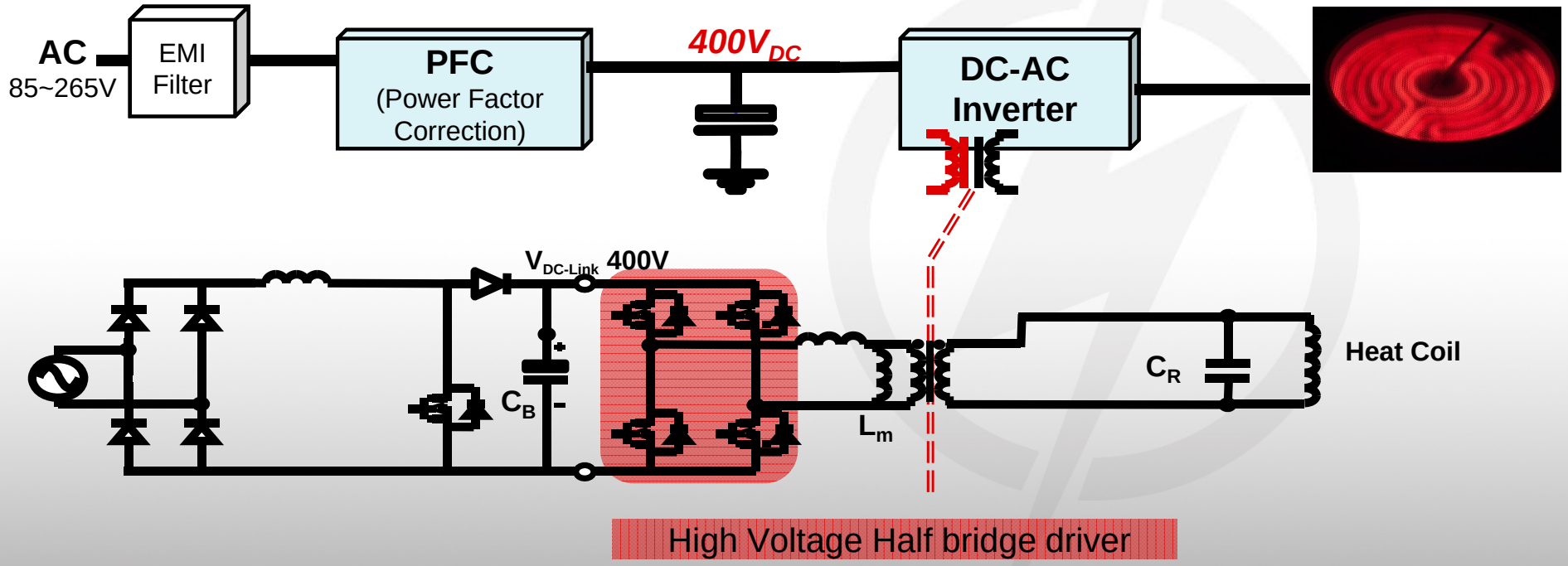
- High efficiency
- Small form factor
- User-friendly interface
- Optimized pinout for easy PCB layout

SiC Driver EVM	UCC21521CE VM-286

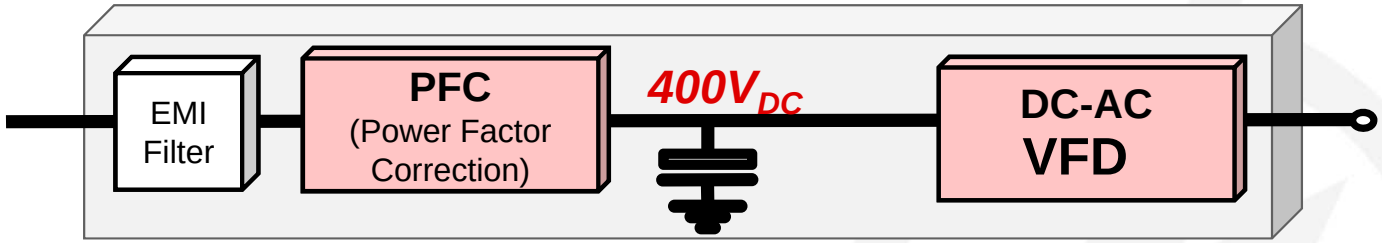
High Voltage High-Side Low Side Driver Architecture

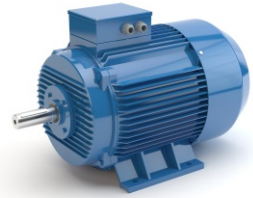


Applications: Inductive Heater

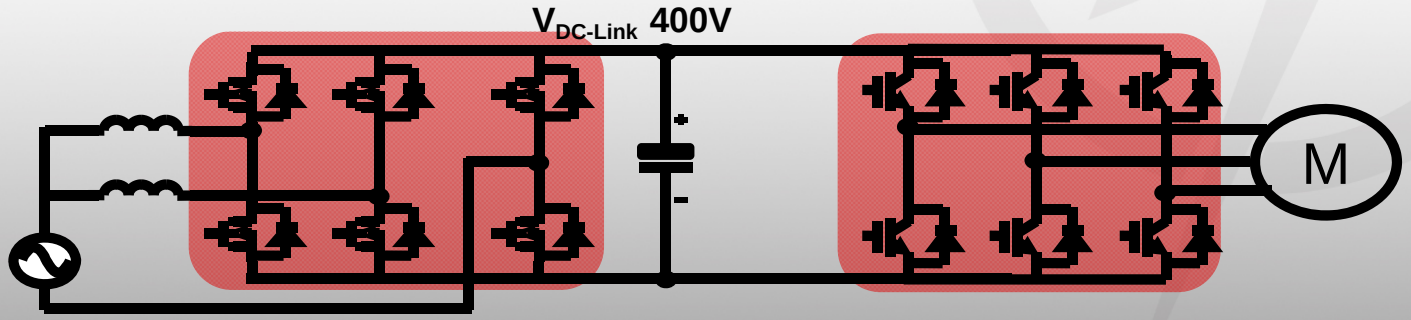


Applications: Motor Drive





High Voltage Half bridge driver

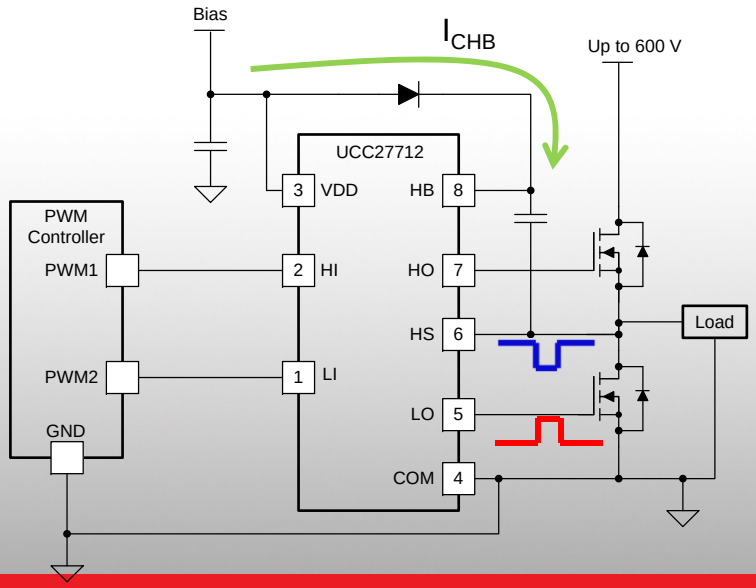


Question #2: During start up of the bridge power train, what would cause the low side to switch before the high side?

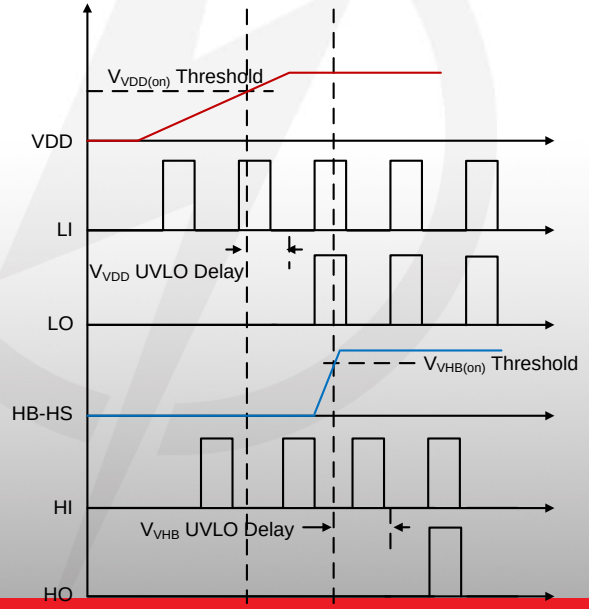
- A) Input signals not present or below threshold?
- B) Different delays in the driver IC?
- C) Timing of the bias supplies to the IC?
- D) Other?

Design Considerations: Half-Bridge Driver With Boot-Strap Bias

- ❑ High side bias bootstrap from VDD
- ❑ HB capacitor charges when HS goes low
- ❑ Used in many applications, usually no concerns

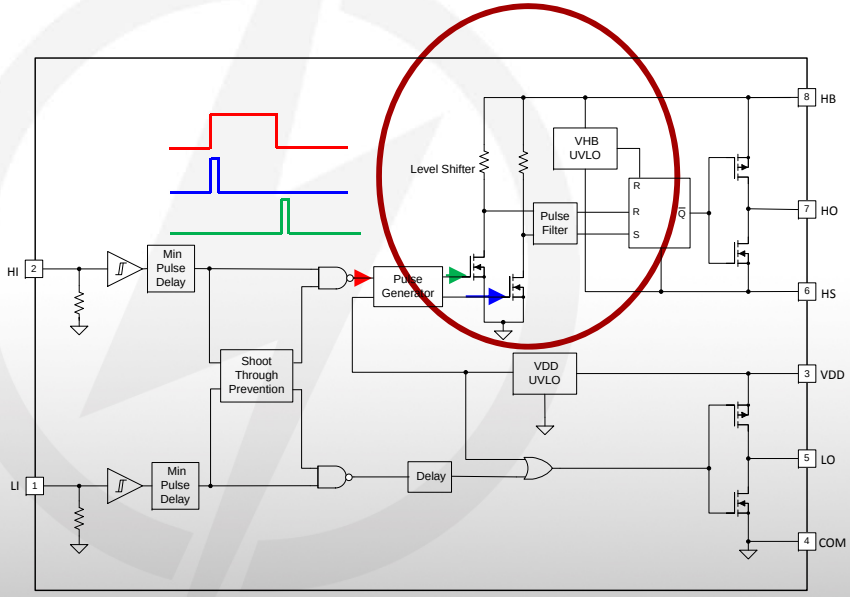


- ❑ VDD and VHB both have UVLO delays
- ❑ HS must go low for HB to charge. In most cases LO must switch to charge HB cap



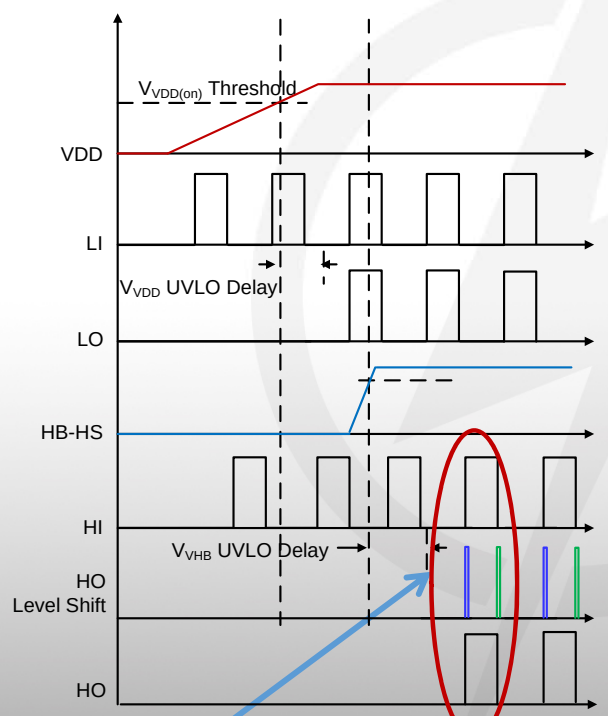
Level Shifter Implementation

- High voltage half bridge drivers have edge triggered level shifter.
  - Low cost high voltage level shifter
  - Reduces power dissipation
- TI provides robust level shifter function
  - 70ns pulse and 40ns edge pulse filters for noise immunity
  - 6mA pulse trigger current for robust dV/dt induced current immunity

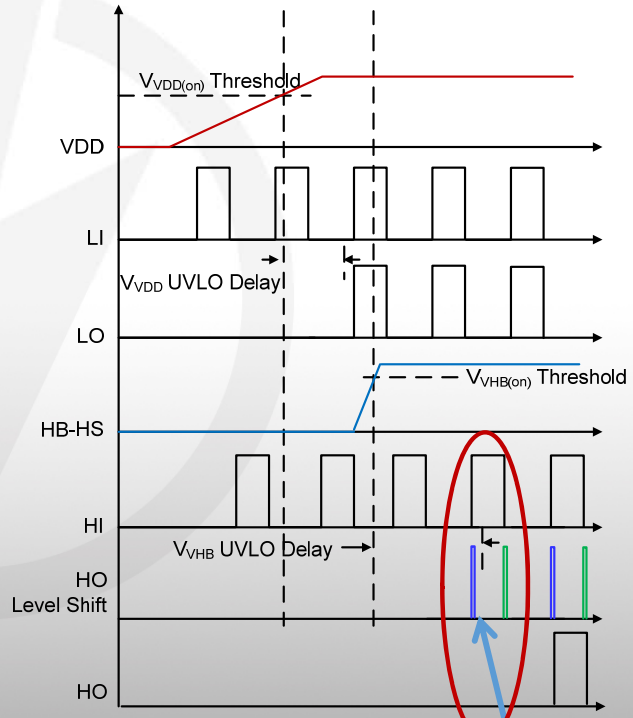


Level Shifter Sequence Considerations

- Edge triggered level shifter.
  - High side HB-HS voltage must be above UVLO
  - There is a UVLO delay
- HI rising edge generates turn on pulse
  - HB must be above UVLO and beyond delay on rising edge of HI.



HB UVLO and delay before HI rising



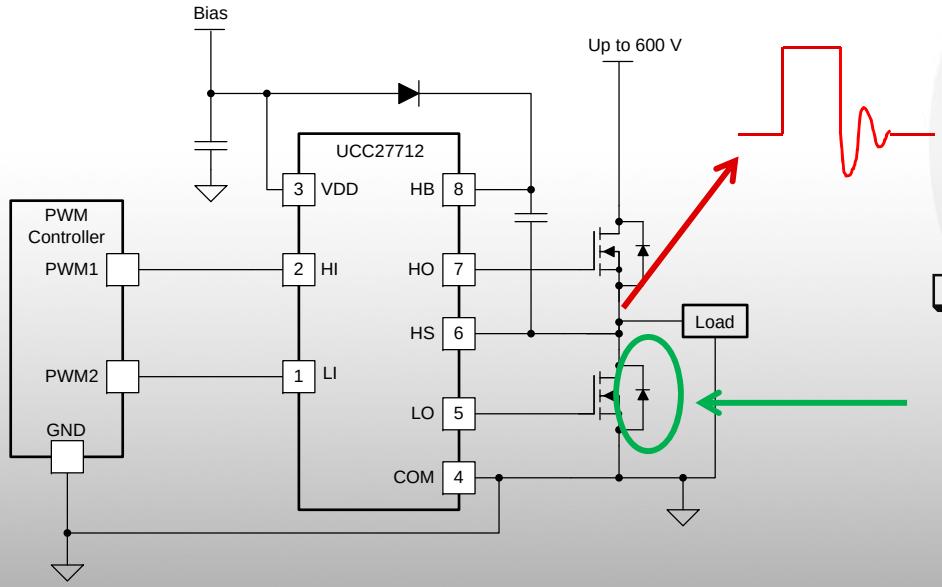
HB UVLO and delay after HI rising

Question #3: What could cause high voltage spikes and/or ringing in the power train switch node?

- A) Power device parasitics?
- B) Poor board layout?
- C) Power device switching edges too fast?
- D) Other?

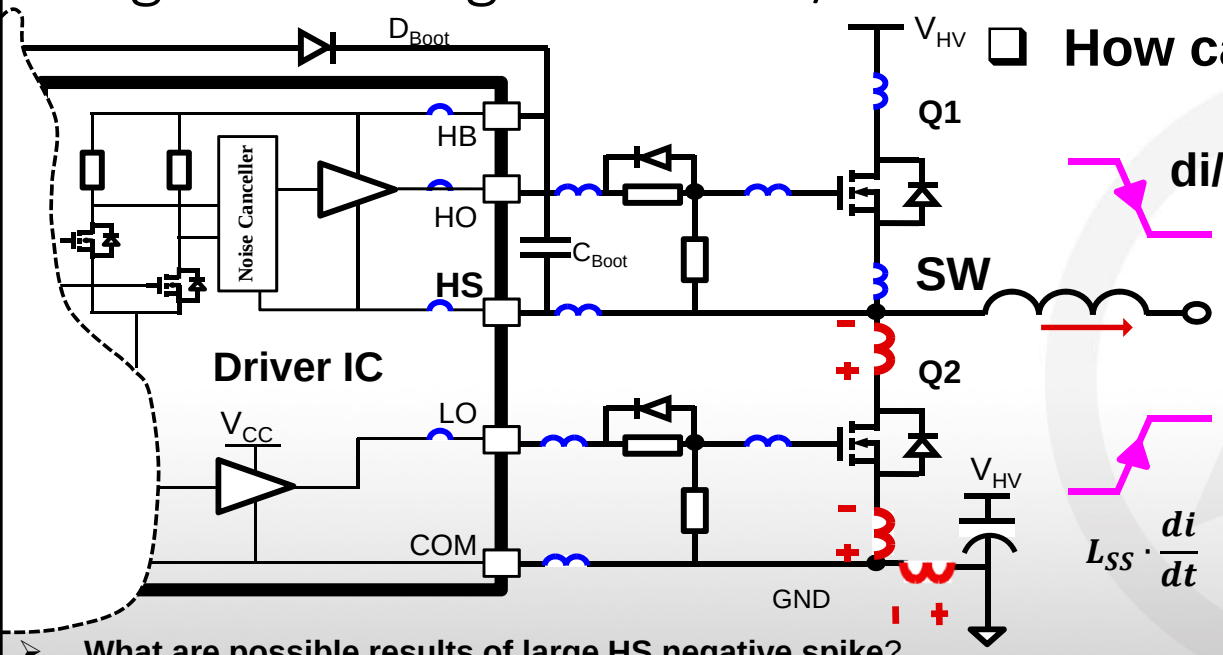
Design Considerations: Negative Voltage on HS

- Question: Do you see significant negative voltage on the power train switch node?

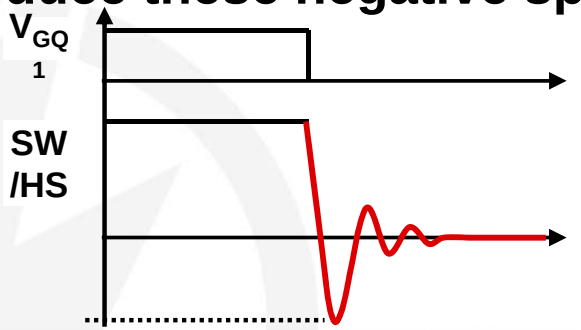


- Why doesn't the low side FET body diode limit the voltage?

Negative voltage on HS: di/dt Effect on Driver



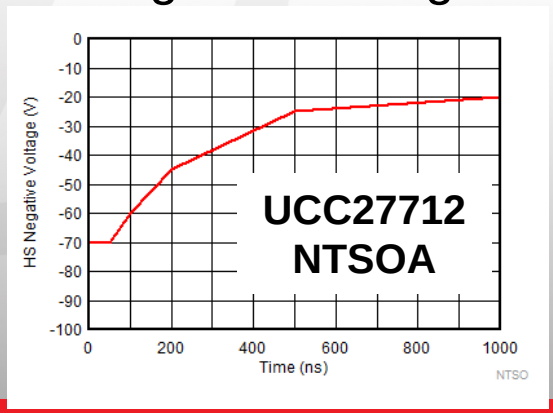
❑ **How can I reduce these negative spikes?**



Negative Voltage on HS

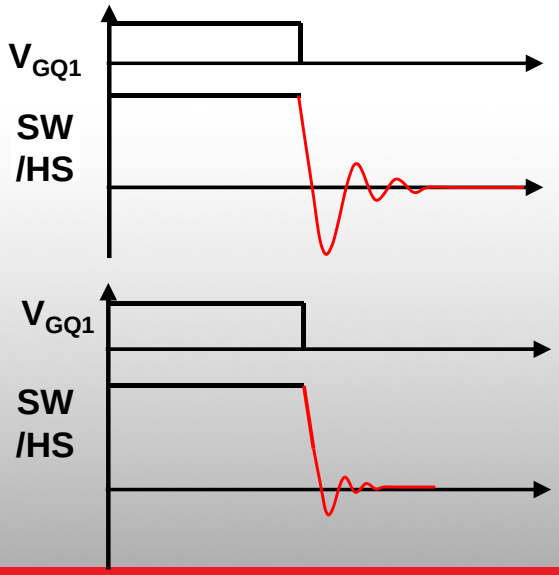
- **What are possible results of large HS negative spike**?
- Driver malfunction (i.e. faulty input pulse translation)
- D_{BOOT} over current
- Overvoltage V_{HB-HS}……

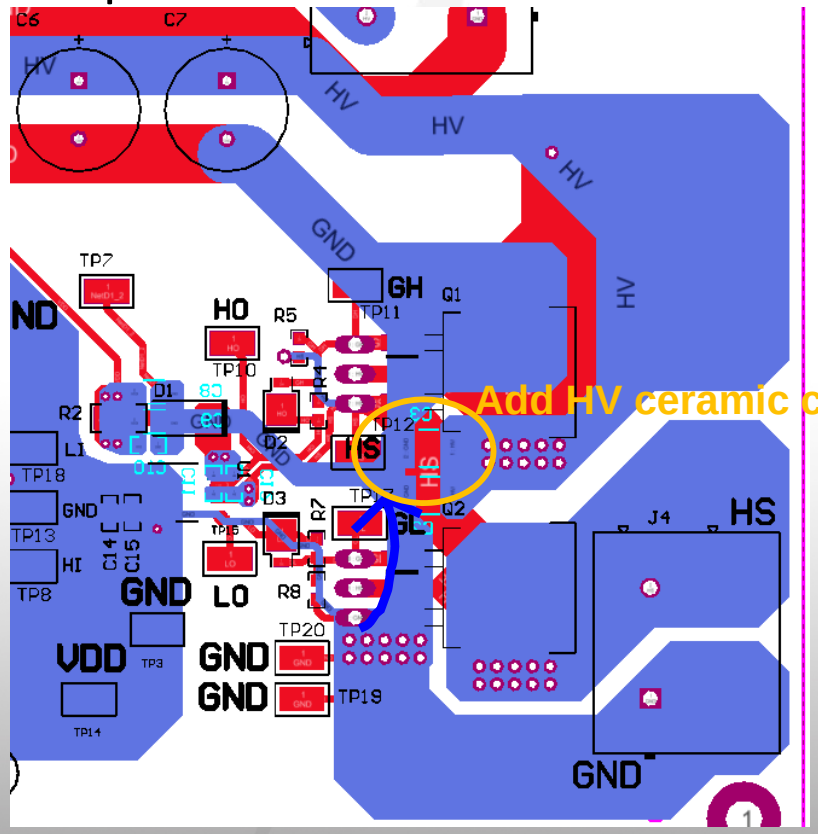
Negative Voltage Capability (V)



Negative HS spikes: Reduce the parasitic L

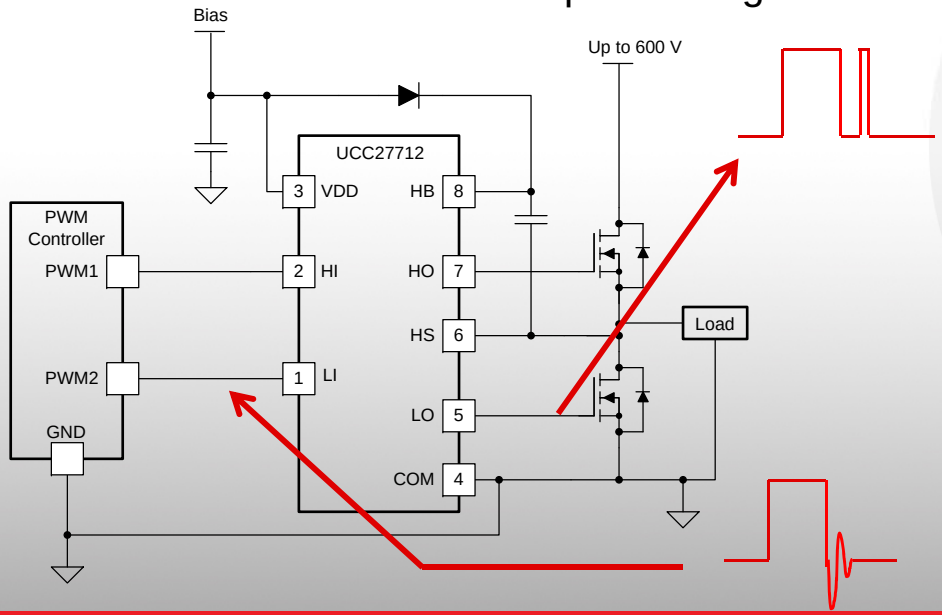
- Most of the parasitic inductance is from the layout, not device leads (typically)
- Layout of HB FETs can be tight.
- What about path to HV bulk cap?…



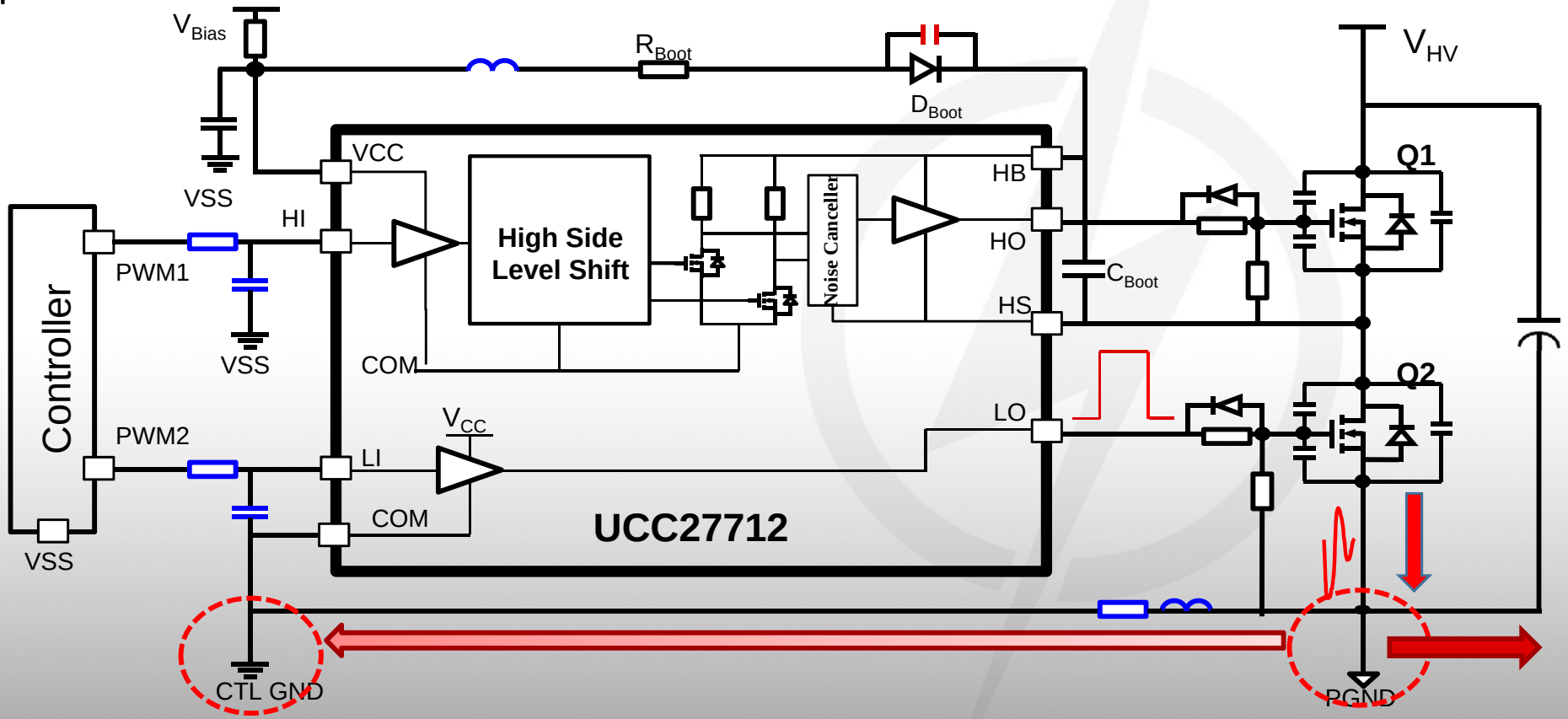


Design Considerations: Driver Input Noise

- dV/dt coupling through parasitic capacitance
- Switching transition HF noise on driver inputs
- Ground bounce from control to power stage



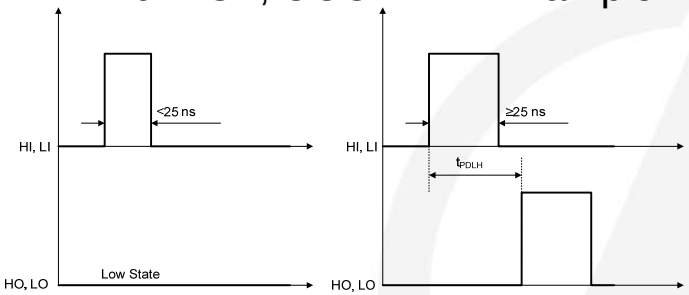
Separate Power Ground noise



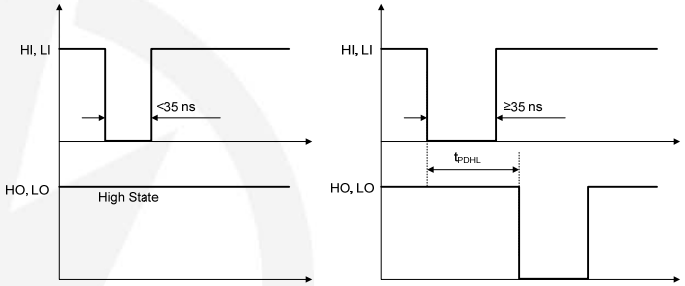
IC Features to Mitigate Input Noise

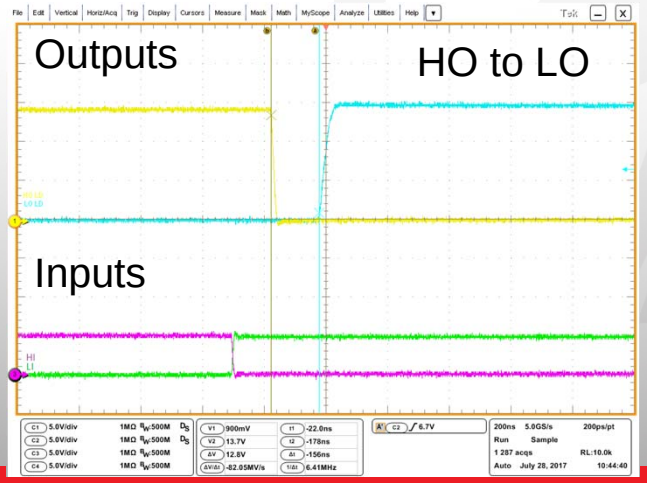
- Minimum Input Pulse Rejection
  - UCC27712: 25ns
  - UCC27714: 40ns
  - UCC27710: 40ns
- Input Interlock and Deadtime
  - Prevents both outputs from being on with overlapping inputs
  - UCC27712, UCC27710: 150ns deadtime

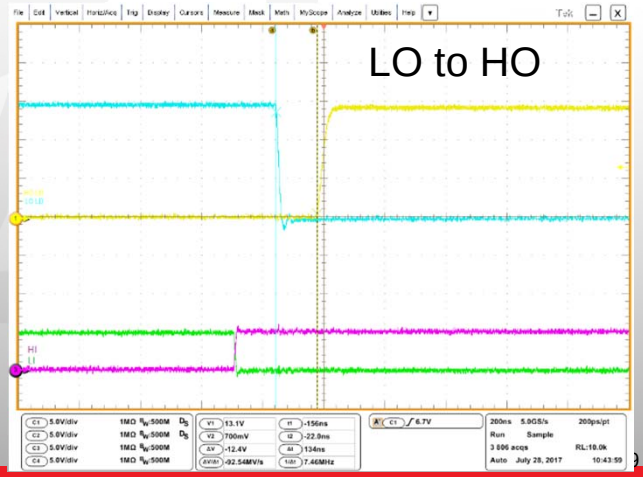
Turn On, UCC27712 Example



Turn Off

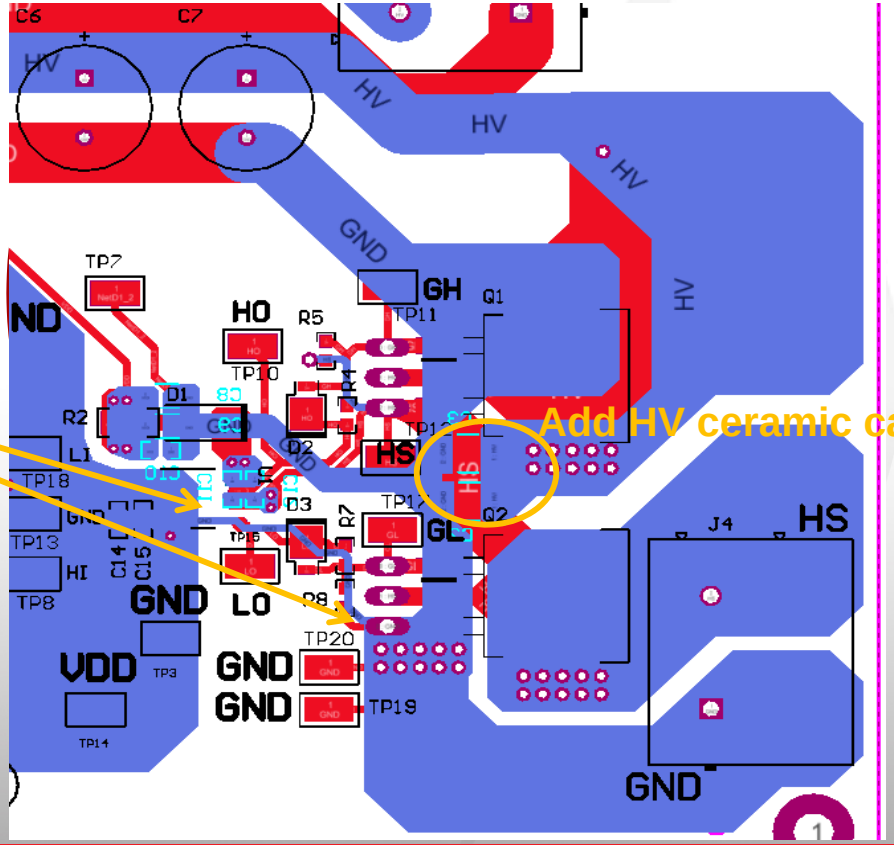






Control Power Ground noise –PCB

- R/C filter on LI HI pins
- HF impedance (small inductance) RTN from FET source and COM
- Ceramic HF capacitors on VIN to GND. Previous suggestion on for HS negative voltage



SUMMARY

- High voltage half-bridge gate driver architecture is a cost effective solution well suited for many applications
- Design considerations include startup sequencing, power train ringing and control noise
- TI drivers incorporate features and offer transient voltage capabilities important in high noise environments
- Mitigating noise and voltage spikes in the application is easily achieved in many applications