TI Webinar Series

• Agenda

Wenjia Liu: Product Marketing Engineer for High Power Driver Solutions
  • Discrete Driving Solution
  • More Integrated: Gate Driver ICs
  • Application of Gate Driver IC in Motor Drives
    • BDC, BLDC, PFC, ESC, Stepper Drives

Zhao Tang: Product Marketing Manager for Motor Drive Business Unit
  • Electric Motor Control System Overview
  • DRV Integrated Drivers & Gate-Drivers
  • Broad portfolio of Motor Drivers & Hall-Effect Sensors
  • DRV Motor Drivers Design-In Support

Manu Balakrishnan: System Engineer for Industrial Systems
  • Motor Driver TI Designs
• Discrete Driving Solution: NPN/PNP Totem Pole
  • Applications: Amplify signal to drive power switches.
  • Advantages: Usually cost effective and familiar.
  • Disadvantages: Thermal, potential shoot through issue, large PCB size and poor noise immunity.

3.3V/5V PWM signal from Microcontroller or DSP

Level Shifted 12V signal

Level Shift circuit

NPN/PNP Totem Pole

12V with High, Peak Source/Sink current
- Small form factor saves board size.
- Shortens design cycle.
- Saves assembly and test cost.

- Reduces design uncertainty.
- Ease of board layout

- Current drive capability is not limited to input base current & gain.
- UVLO increase system robustness.

### Texas Instruments UCC2751X Gate Driver

<table>
<thead>
<tr>
<th>Feature</th>
<th>NPN/PNP Totem Pole Driving</th>
<th>TI UCC2751X Gate Driver</th>
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<tbody>
<tr>
<td>UVLO Feature</td>
<td>No</td>
<td>Yes</td>
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<tr>
<td>Output Current</td>
<td>Directly proportional to input Base current &amp; Gain</td>
<td>Immaterial of Input current</td>
</tr>
<tr>
<td>Level-Shifting Capability</td>
<td>No, Emitter follower (not compatible with Digital Power trend, see next slide)</td>
<td>Yes</td>
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<tr>
<td>Internal Shoot-through Protection</td>
<td>No, add series resistor to limit current from Bias supply</td>
<td>Yes</td>
</tr>
<tr>
<td>Enable Function</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Noise Immunity</td>
<td>Poor, can turn-on if IN voltage &gt; 0.7V</td>
<td>Excellent, choice of CMOS &amp; TTL</td>
</tr>
<tr>
<td>Size</td>
<td>At least double the IC footprint</td>
<td>2.90 mm x 1.60 mm (UCC27517)</td>
</tr>
<tr>
<td>Prop Delay</td>
<td>Less than 10ns achievable, depends on load capacitor</td>
<td>12ns (typ)</td>
</tr>
<tr>
<td>Recommended Max VDD/Bias</td>
<td>Based on choice of NPN/PNP</td>
<td>18V</td>
</tr>
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Application of Gate Driver IC in Motor Drives

Brushed DC Drives

- MCU
- Gate Drivers (Half-bridge, Full-bridge)
- Power switches
- Brushed DC Motor
- ADC
- AMP

- Half-bridge gate driver
  - **LM5109B**: 100V, 1 to 3A, PWM or Dual input
  - **UCC27201A**: 120V, 4A, Negative voltage tolerance
  - **UCC27714**: 150V to 600V, 4A, Split GNDs

- Low side gate driver
  - **UCC27517**: 18V, 4A, Single channel
  - **UCC27531**: 35V, 5A, Single channel
  - **UCC27524A**: 18V, 5A, Dual channel

Brushless DC Drives

- MCU
- Gate Drivers
- Power switches
- Brushless DC Motor
- ADC
- AMP
- Isolated or Non-isolated Current Sensor
Application of Gate Driver IC in Motor Drives

Electronic Speed Control

Inverter-Fed motors in PFC

Stepper Drives

- MCU or integrated stepper gate driver
  - Current control and indexer (step & micro-stepping)

Gate Drivers
- Half-bridge
- Full-bridge
- Dual full-bridge

Power MOSFETs

Stepper Motor

Bias Control

PFC Controller UCC2810

Boost Follower control

Gate Driver UCC27517A

Boost PFC Power Stage

Bulk Storage Capacitor

390 VDC

195 - 270 VAC

EMI Filter

Bridge Rectifier

ADC

AMR

ESD

M

Texas Instruments
• TI Gate Driver Resources

**More Driver Solutions and Reference Designs**
Explore more than 100 simple gate driver devices to fit every motor driver design in your system.

[www.ti.com/gatedrivers](http://www.ti.com/gatedrivers)

**Need Technical Support?**
Reach out to our applications experts for any questions about gate drivers.

[https://e2e.ti.com/support/power_management/isolated_controllers/](https://e2e.ti.com/support/power_management/isolated_controllers/)

**Want to Learn More in Motor Drives and Power Electronics?**
Let our big database of application notes, white papers and other technical documents help you design your system.


**TI Designs**
- TIDA-00779
- TIDA-00443
- TIDA-00652
- TIDA-00472
- TIDA-00366
Motor Control
- Microcontroller
- Manages the control system, motor commutation, driver settings, fault handling

Gate Driver
- IGBT or MOSFET gate driver
- Level shifts logic control signals
- Power stage fault detection and handling

Power Stage
- IGBT or power MOSFET
- Interface main power rail to electric motor
- Often in half-bridge, H-bridge, or inverter configuration

Feedback
- Signals from motor
- Position, torque, voltage, current
DRV Integrated Drivers & Gate-Drivers

Integrated Driver
- Smallest board space
- Easy to design
- Excellent performance
- Fully protected

Gate-Driver
- Scalable / Higher currents
- Better thermals
- Lower RDSON
- Reduced board space
- Fully protected

Motor Control → Logic → Gate Drive → FETs → Protection & Current Control
On-chip motor commutation

Motor Control → Logic → Gate Drive → FETs
On-chip motor commutation

Texas Instruments
## Broad portfolio of Motor Drivers & Hall-Effect Sensors

### Brushed-DC

**Supply voltage support:**
- Low voltage, 12, 24, 36, 48 V

**Technologies:**
- Integrated Current Sensing,
- Smart Gate Drive

**Differentiation:**
- Small footprint & high efficiency
- Inrush current protection
- Low-cost

**Hero devices:**
- DRV8837
- DRV8870/8871
- DRV8701

### Stepper

**Supply voltage support:**
- Low voltage, 12, 24, 36, 48 V

**Technologies:**
- Integrated Current Sensing,
- AutoTune, & Smart Gate Drive

**Differentiation:**
- Automatic decay selection
- Indexers & precision microsteps
- Passive component integration

**Hero devices:**
- DRV8833
- DRV8885
- DRV8880

### Brushless-DC

**Supply voltage support:**
- Low voltage, 12, 24, 36, 48 V

**Technologies:**
- Integrated state machine control
- Low voltage support (start-stop)
- Smart Gate Drive

**Differentiation:**
- Sensorless & sensored support
- Integrated shunt amplifiers
- Integrated power management
- SafeTI™ ASILB, D

**Hero devices:**
- DRV8301
- DRV8305
- DRV10983/10970
- DRV3205

### Hall-Effect Sensor

**Supply voltage support:**
- Low voltage, 12, 24 V

**Technologies:**
- Superior sensor stability over wide temperature range
- Automotive Grade0

**Differentiation:**
- Industries widest op. voltage
- Worlds lowest power sensor
- Highly reliable and robust
  - Full integrated protection
  - Production tested at 165°C

**Hero devices:**
- DRV5013
- DRV5023
- DRV5033
- DRV5053
DRV Motor Drivers Design-In Support

Motor Drive E2E Support

Application Notes & Design Guides

Evaluation Modules

Reference Designs
18-V/400-W, 98% Efficient, Compact Brushless DC Motor Drive With Stall Current Limit Reference Design

**Features**
- Operates at Voltage Ranging from 5-V to 21-V (5s Li-ion Battery)
- 18-ARMS Continuous (60A Peak for 1s) Winding Current Without Heat Sink or Airflow
- Small PCB Form Factor of 45mm x 50mm
- Inverter Drive Efficiency >98%
- Cycle –by-Cycle Overcurrent Protection with <1us Response Time and Short Circuit Latch Protection by VDS Sensing
- Shoot-through, Under Voltage, Over Temperature & Blocked Rotor Protection
- Operating ambient: -20 to +55°C

**Target Applications**
- Cordless Power Tools
- Cordless Garden Tools
- Vacuum Robots

**Tools & Resources**
- **TIDA-00772 and Tools Folder**
- **Design Guide**
- **Design Files:** Schematics, BOM, Gerbers, and more
- **Device Datasheets:**
  - DRV8305
  - CSD18502Q5B
  - MSP430G2553
  - LMT87
  - SN74LVC126A
  - DRV5013
  - TPD1E10B06
  - LMT87

**Benefits**
- Small form factor enables flexible mounting and minimize impedance on connections with high current
- Low RDS_ON MOSFETs brings high efficiency and eliminates heat sink
- Optimum inverter efficiency and EMI performance using slew rate control of gate driver
- Three Phase Gate Driver with Internal Charge Pump Ensures Maximum Inverter Efficiency Even at 5V DC
- Low Component count and low BOM cost
24V, 100W/30W Dual Sensorless Brushless DC Motor Drive Reference Design

**TI Design:** TIDA-00447

### Features

- **DRV8303 + 3x CSD88539 for the main circulating pump motor (24V, 100W):**
  - Sensorless Trapezoidal BLDC
  - Fully protected: 2-stage thermal, CBC over current, UVLO, & shoot through protection with fault feedback
  - Adjustable dead time/slew rate; 100% duty cycle
- **DRV10983 completely integrated motor controller - drain pump motor (24V, 30W):**
  - Patented 180° sinusoidal sensorless control algorithm
  - Customizable spin up profile for quiet/reliable start-up
  - Fully Protected: OC, UV/OV, Lock detection & thermal shutdown

### Target Applications

- Dish washer
- Refrigerator
- Fans, blowers

### Tools & Resources

- **TIDA-00447 and Tools Folder**
- **Design Guide**
- **Design Files:** Schematics, BOM, Gerbers, and more
- **Device Datasheets:**
  - DRV10983
  - DRV8303
  - CSD88539ND
  - CSD17578Q3A
  - LMT84
  - TLV803S
  - ISO7421D
  - TPD4S009
  - CSD17578Q3A
  - ISO7421D
  - TPD4S009

### Benefits

- Reduced efforts on EMI
- Reduction of audible noise
- Enables single design to be used for different line inputs
- Cost savings from hall sensors and their wiring
- Classic challenges of sensorless BLDC (start-up & stall) resolved
- High efficiency
- High integration level simplifies safety qualification
230-V, 250-W, High Efficiency BLDC Motor Drive with DC Bus Voltage Ripple Compensation Reference Design

**Features**
- 250W Mains Powered BLDC Motor Drive with Sensor-less Trapezoidal Control using InstaSPIN-BLDC
- Sensor-less 120 Degree Trapezoidal control.
- Software implementation for DC bus ripple compensation.
- UCC27714 as 600V High Side, Low side Gate driver with 4A Sink and Source capacity.
- Thermal design to enable the system to work up to 65 degree ambient

**Target Applications**
- Cooker Hood/ Range Hood/ Kitchen hood
- Air conditioner Fan
- Exhaust Fans

**Tools & Resources**
- **TIDA-00472 and Tools Folder**
- **Design Guide**
- **Design Files**: Schematics, BOM, Gerbers, and more
- **Device Datasheets**:
  - UCC27714
  - OPA374
  - MSP430F5132
  - TLV70433
  - LMT87
  - ISO7421
  - TPD1E10B06

**Benefits**
- High current gate drivers with Miller region boost enables faster turn on & turn-off for lower switching losses enabling elimination of heat sinks
- DC bus ripple compensation resulting in 30% less DC bus capacitor requirement and hence reduced cost.
- Ready sensorless InstaSPIN-BLDC software implementation on MCU.
- Tested hardware design to meet conducted emission standard EN55022 Class B, EFT Nor IEC61000-4-4 and surge norm IEC-61000-4-5
Reference Design for Reinforced Isolation 3-Phase Inverter with Current, Voltage and Temp Protection

**Features**
- Reinforced isolated Inverter suited for 200 – 690V AC drives rated up to 10kW
- Simple yet effective gate driver with 4A source, 6A sink output current capability
- 250kHz isolated amplifier for Inverter current, DC link voltage and IGBT module temperature measurement
- Calibrated current measurement accuracy of ±0.5% across temperature range from -25°C to 85°C
- Protection against DC bus Under-Voltage, Over-Voltage, Over-Current, Ground Fault and Over-Temperature

**Target Applications**
- Variable Speed AC Drives
- Three-Phase UPS
- Industrial Power Supplies

**Tools & Resources**
- **TIDA-00366 and Tools Folder**
- **Design Guide**
- **Design Files**: Schematics, BOM, Gerbers, and more
- **Device Datasheets**:
  - UCC21520
  - OPA320
  - TLC372
  - REF2033
  - AMC1301
  - TLV1117-33
  - TLV70433
  - TL431B

**Benefits**
- Using AMC1301 enables use of internal ADC of MCU
- Bootstrap based power supply for high side gate driver reduces overall cost for power supply requirements
- 19ns typical Propagation Delay optimizes dead band distortion
230-V, 3.5-kW PFC with >98% Efficiency, Optimized for BOM and Size Reference Design

**TI Design: TIDA-00779**

### Features

- Peak efficiency ≥ 98.5% enable a smaller heat sink
- Wide full load operating input range of 190 VAC to 270 VAC
- Up to 3.5-kW high power output to cover most of single phase input PFC application
- High power factor ≥ 0.99 and less then 5% THDi from medium-to-full load (50-100%)
- Reduced current sense threshold minimizes power dissipation
- High power density enable a very small product size (2.5 W/cm$^3$)
- 8-Pin PFC solution (No AC line sensing Needed) enable a very simply design

### Target Applications

- Room Air-Conditioner
- Industrial AC-DC > 480W
- Single Phase UPS

### Tools & Resources

- **TIDA-00779 and Tools Folder**
- **Design Guide**
- **Design Files**: Schematics, BOM, Gerbers, and more
- **Device Datasheets**:
  - UCC28180
  - UCC27531D
  - LMT01

### Benefits

- High converter efficiency help get smaller thermal consumption cost
- Reduced current sense threshold minimizes power dissipation
- Competitive BOM cost without any SiC components, especially suit for major appliances
- High power density enable a smaller products size
- The hardware is designed and tested to pass surge, and EFT testing as per the IEC61000 requirements for household appliances
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<thead>
<tr>
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</tr>
</thead>
<tbody>
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</tr>
<tr>
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