Application Report
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When to Use DRV10987 or DRV10983

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ABSTRACT

This application report highlights key features that differentiate brushless DC motor drivers DRV10987 and DRV10983. The focus of this report is to help designers choose one device over the other based on their system design requirements. This report includes a brief feature definition, benefits of each device, test comparisons, and the spec comparison, and recommended device per feature. In addition it includes a features table in Section 1 to quickly highlight the features, benefits, or differentiating factors between devices.

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1 Features Table

This feature comparison table is intended for a simple and quick comparison. For more information go to the feature's section or device datasheet.

Table 1. Features

FEATURE	DRV10987	DRV10983
Slew rate for EMI management	Adjustable slew rate	Fixed slew rate
Start-Up	Slower Acceleration Profiles for high inertia motors	Faster Acceleration Profile for low inertia motors
Maximum Operation Range	28-V maximum operation with protection up to 45 V	28-V maximum operation
Minimum Operation Range	Operation down to 6.2 V	Operation down to 8 V
Initial Position Detect (IPD)	IPD design for lower inductance motor	IPD design for higher inductance motor
Current Recirculation or Spin Down	Inductive anti-voltage surge for high current systems	Standard coasting for low current system
Power Conservation Mode	Optimize for sleep mode. Everything off	Optimize for standby mode. communication and regulators remain on
Step-Down Regulators	Fixed 5 V	Optional 3.3 V or 5 V
3.3-V LDO	Powers low current external components, I^2C interface and digital outputs.	Powers I^2C interface and digital outputs.
Overcurrent Protection (OCP)	3.5-A peak	3-A peak
	Phase shorts to GND, phase shorts to phase, or phase shorts to V_{CC}	Phase shorts to phase
Register Size	16-bit register size, fewer data write/read	8-bit register size
EEPROM (Minimum Programming Voltage)	6.2 V	22 V
1K Price	$1.72	$1.65

2 Features Description

2.1 Slew Rate for EMI Management

BLDC motors are driven at high switching frequency in the range of 10-100 kHz. At this high frequency, the combination of high dv/dt and parasitic inductance causes high-frequency ringing on the switching node. This ringing emits high-frequency noise that can interfere with other components in the system.

Adjusting the slew rate of the applied voltage can help reduce interference caused by ringing. In a discrete system, adjusting the gate-driver resistor modifies the slew rate of the voltage. The resistor value has to be changed manually and select an optimal value on the test result. The process of manually changing the resistor is tedious and requires multiple iterations of PCBs, which increase both overall size and complexity.

In the case of integrated drivers DRV10983 has a fixed slew rate while the DRV10987 has integrated slew-rate control; users can easily change this slew rate by changing the register value, which speeds up the whole exercise of testing modules for electromagnetic interference (EMI). With the addition of this feature cost can be saved from additional components needed to reduce EMI.

DRV10987 has four slew rate options users can select:

- 35 V/µs
- 50 V/µs
- 80 V/µs
- 120 V/µs

Test was done with a 12-V power supply. The slew rate is measured by Equation 1 where ΔV and ΔT is the difference from 20% to 80% of the phase voltage that is 2.4 V and 9.6 V, respectively.

$$\text{slew rate} = \Delta V\ (V) \Delta T\ (\mu s) \quad (1)$$

In Figure 1 and Figure 2 we can see the DRV10987 slew-rate control when selected at 35V/µs and 120V/µs, the results are 36.9V/µs and 127.4V/µs respectively. The results are close to its typical value as stated in the DRV10987 datasheet. On the other hand Figure 3 shows the DRV10983 with a fixed slew rate resulted in 116.1V/µs which is also close to it's typical value.

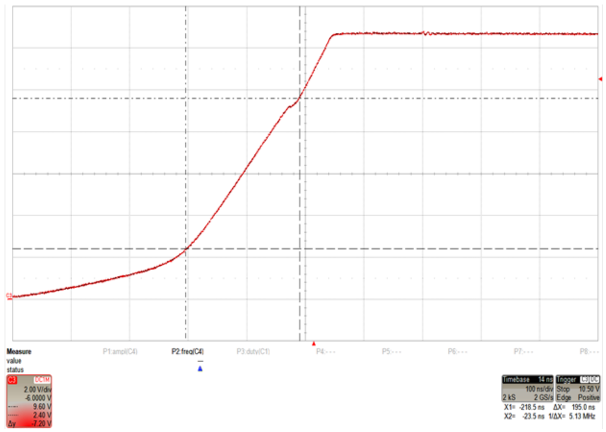

Figure 1. DRV10987 Slew-Rate Set to 35 V/µs; Measured 36.9 V/µs

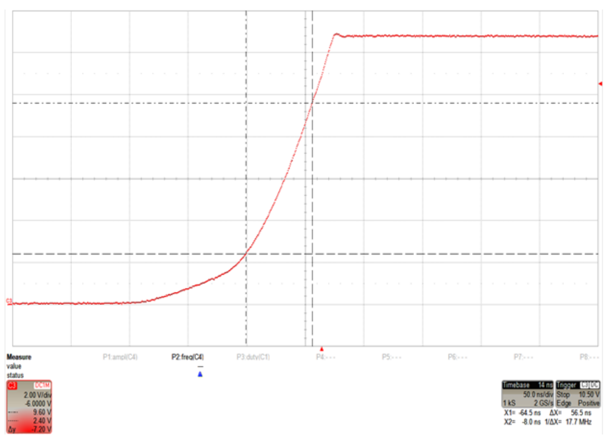

Figure 2. DRV10987 Slew-Rate Set to 120 V/µs; Measured 127.4 V/µs

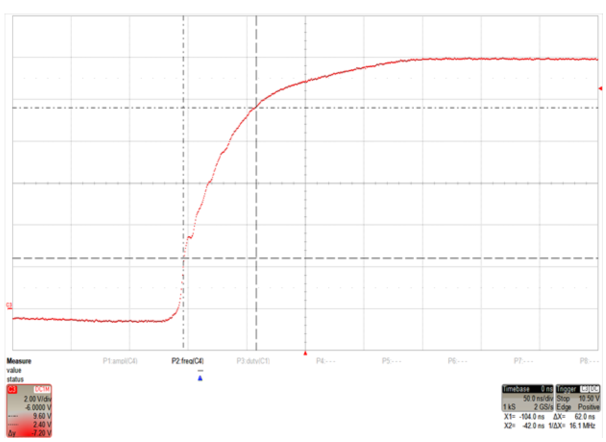

Figure 3. DRV10983 Fixed Slew Rate; Measured 116.1 V/µs

2.2 Start-Up

The accelerate time is defined by the open-to-closed loop threshold along with the first-order (A1) and second-order (A2) acceleration rates. **Figure** below shows the motor start-up process. The motor start-up process selects the first-order and second-order acceleration rates to allow the motor to reliably accelerate from zero velocity up to the closed-loop threshold in the shortest time possible. Using a slow acceleration rate during the first order acceleration stage can help improve reliability in applications where it is difficult to accurately initialize the motor with either align or IPD.

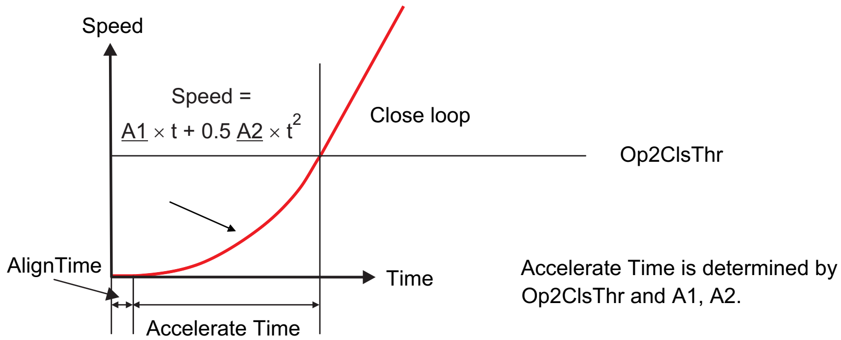

Figure 4. Motor Start-Up Process

Motors with high inertia loads have higher probability of start-up failure. With a slow acceleration DRV10987 can reduce start-up failure.

Table 2. Start-Up

Open loop Acceleration	DRV10987	DRV10983	Units
1st order	0.019 - 76	0.3 - 76	Hz/s
2nd order	0.0026 - 57	0.22 - 57	Hz/s^2

The comparison between DRV10987 and DRV10983 acceleration profiles shows the slowest acceleration profiles for each of these devices.

The figures below show FG (Pink), I_U (Green) and FG/Time (Yellow) corresponding respectively to the motor speed (PWM signal), phase u current and FG track time which measures the acceleration time until open-to-closed loop threshold is reached. Each block in Figure 5 and Figure 6 is equal to 10 seconds on the X axis.

Both devices tested at their slowest acceleration profile, the DRV10987 in Figure 5 has a minimum of approximately 72 seconds while DRV10983 in Figure 6 has a minimum of 6.2 seconds. DRV10987 is approximately 11x slower than DRV10983.

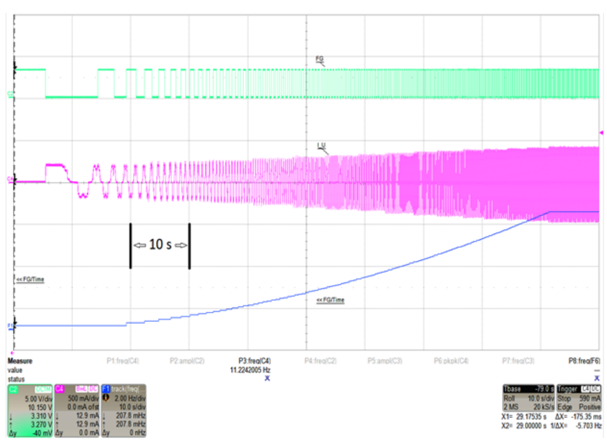

Figure 5. DRV10987 at Slowest Acceleration Constants A1 – 0.019 Hz/s and A2 – 0.0026 Hz/s2

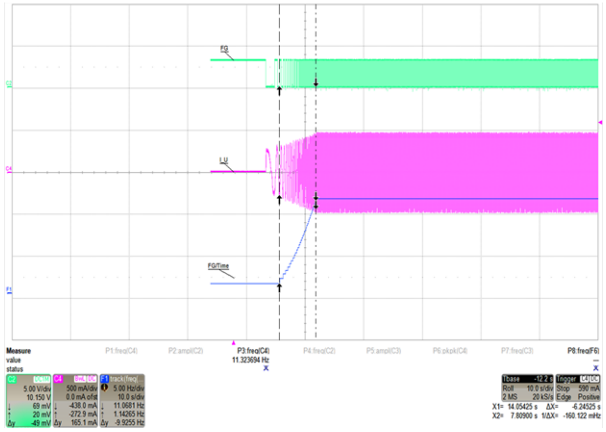

Figure 6. DRV10983 at Slowest Acceleration Constants A1 – 0.3 Hz/s and A2 – 0.22 Hz/s2

2.3 Maximum Operation Range

The maximum operation voltage of the DRV10987 and DRV10983 is 28 V. The devices are able to drive the motor under this voltage. In the overvoltage condition, Vcc can rise up to 45 V. Once the device detects that Vcc is higher than the overvoltage threshold, it stops driving the motor and protects its own circuitry. When Vcc drops below overvoltage threshold, the device continues to operate the motor based on the user's command. If 45-V pulses were injected into a device without overvoltage protection the device could be damaged. This protection system is available for the DRV10987 saving cost on additional safety circuitry.

Testing the DRV10987 for overvoltage protection was effectively enabled by the device when the 45-V pulse was injected from the supply. The device shut down to protect its circuitry and then turned back on again.

Test conditions:

- Voltage supply input with pulses of 45 V with 400-ms pulse width
- Ran at five pulses per minute for over 15 minutes

Waveform description:

- Top: FGpin
- 2nd from top: Supply voltage
- 3rd from top: Phase voltage
- Bottom: Phase current

Figure 7. Overvoltage Protection After Injecting 45-V Pulses

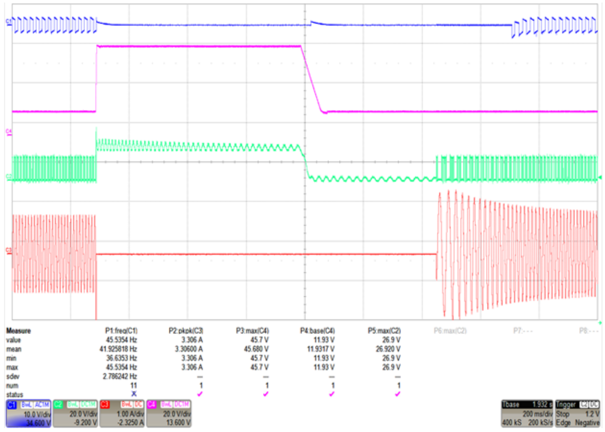

Figure 8. Overvoltage Protection Waveform Zoomed In

2.4 Minimum Operation Range

The DRV10987 and DRV10983 devices have minimum operation voltage of 6.2 V and 8 V, respectively. Lower voltage range allows more variation in power supply selection by triggering undervoltage lockout (UVLO) protection at lower voltage. The device is locked out when V_{CC} is below UVLO threshold. In addition to the main supply, the step-down regulator, charge pump, and 3.3-V LDO all have UVLO monitors. For 12 V application both devices can operate, but for lower than 12-V systems DRV10987 is more suitable since it has a lower UVLO trigger.

Table 3. Minimum Operation Range

Feature	DRV10987	DRV10983	Units
UVLO	6.2	8	V

2.5 Initial Position Detect (IPD) to Prevent Reverse Spin During Start-up

The inductive sense method is used to determine the initial position of the motor when initial position detection is enabled. IPD can be used in applications where reverse rotation of the motor is unacceptable, for example ceiling fan and pedestal fan where users can see the fan blades. Because IPD is not required to wait for the motor to align with the commutation, it can allow for a faster motor start sequence. IPD works well when the inductance of the motor varies as a function of position. Because it works by pulsing current to the motor, it can generate acoustics which must be taken into account when determining the best start method for a particular application.

Motors with low inductance variation can cause reverse spin. With augmented IPD resolution the DRV10987 reduces reverse spinning. Devices with IPD are able to replace sensored solutions saving cost.

Table 4. Initial Position Detect (IPD)

Feature	DRV10987	DRV10983	Units
IPD Resolution	0.32 - 2.56	10	µs

2.6 Current Re-circulation or Spin Down

When the motor driver device transitions from driving the motor into a high-impedance state (commanded to coast or spin down), the inductive current in the motor windings continues to flow and the energy returns to the power supply through the intrinsic body diodes in the FET output stage. This can damage the supply or the motor driver. Inductive Anti-Voltage Surge (AVS) prevents this by actively driving the low side FETs in a manner that returns the energy to ground protecting the system.

Systems that operate on higher current will have higher current returning to power supply when coasting and potentially damaging the system if no protection is available. The DRV10987 is recommended for high current system with inductive AVS protection.

2.7 Power Conservation Mode

The DRV10987 and DRV10983 devices come in two power conservation mode, the sleep and standby mode. These devices enter either sleep or standby mode to conserve energy. When the device enters either sleep or standby, the device stops driving the motor. In the sleep mode version the switching regulator is disabled to conserve energy, the I^2C interface is disabled, and any register data not stored in EEPROM is reset. In standby mode version the switching regulator remains active, the register data is maintained, and the I^2C interface remains active.

Depending on the system DRV10987 is optimized for sleep mode while DRV10983 is optimized for standby mode.

Table 5. Power Conservation Mode

Feature	DRV10987	DRV10983	Units
I_{CC} Sleep	48	200	µA
I_{CC} Standby	8.5	3	mA

2.8 Step-Down Regulators

A step-down regulator efficiently steps down the supply voltage. The output of this regulator provides power for the internal circuits and can also be used to provide power for an external circuit such as a microcontroller.

The DRV10983 provides two different voltage options for step-down regulator, 3.3 V and 5 V. This allows users design flexibility and cost save from additional circuitry. The regulator output voltage can be configured by register bit V_{regSel}. On the other hand the DRV10987 has a fixed 5-V step-down regulator. If the system needs to power an external load from 20 mA to 100 mA at 3.3 V, the DRV10983 is the way to go.

Table 6. Step-Down Regulators

Feature	DRV10987	DRV10983	Units
Step-Down Regulator	5 V	3.3 or 5	V
	100	100	mA

2.9 3.3V LDO

Additionally from the step-down regulators the DRV10987 and DRV10983 devices includes a 3.3-V LDO and a 1.8-V LDO. The 1.8-V LDO is for internal circuits only. The 3.3-V LDO is mainly for internal circuits, but can also drive external loads not to exceed the maximum load current. For example on both devices, it can work as a pullup voltage for the FG, DIR, SDA, and SCL interfaces.

The DRV10987 has a 20-mA maximum load which can also power a low current external component like an microcontroller. If the system needs to power an external load up to 20 mA at 3.3 V, the DRV10987 is the way to go.

Table 7. 3.3 V LDO

Feature	DRV10987	DRV10983	Units
LDO	3.3	3.3	V
	20	5	mA

2.10 Overcurrent Protection (OCP)

The overcurrent shutdown function acts to protect the device if the current, as measured from the FETs, exceeds the $I_{OC\text{-}limit}$ threshold. It protects the device in the event of a short-circuit condition on the motor phases. Higher minimum value of OCP helps motor to be operated near full capability and can sustain higher transient peak current. DRV10987 will be able to operate at full power around 50 W.

Table 8. Overcurrent Protection (OCP)

Feature	DRV10987	DRV10983	Units
Overcurrent Protection	3.5	3	A (peak)

Other than the peak current protection a motor driver can have multiple OCP protections in the FETs. These are protection to the high- and low-side FETs, this protects phase shorts to GND, phase shorts to phase, or phase shorts to V_{CC}. If the system requires higher level of safety, the DRV10987 incorporates all of the protections mentioned.

The DRV10983 includes protection to High side FETs protecting phase to phase short-circuit conditions.

Table 9. Overcurrent Protection FETs

Feature	DRV10987	DRV10983	Units
Overcurrent Protection FETs	High + Low side	High side	FETs

2.11 Register Size

The DRV10987 and DRV10983 have different register sizes. The DRV10987 has a data packet size of 16 bits opposed to DRV10983, which is 8 bits. Larger register size reduces the number of transmissions required to transfer data (read/write) between the device and MCU, which reduces bandwidth of the processor.

Table 10. Register Size

Feature	DRV10987	DRV10983	Units
Register Size	16	8	bits

2.12 EEPROM (Minimum Programming Voltage)

Electrically Erasable Programmable Read-Only Memory (EEPROM) voltage is the minimum supply voltage to program EEPROM register settings into the device. Having a programming voltage that spans the operating voltage range reduces overall system complexity. For example if device minimum EEPROM voltage is 22 V and the application is 12 V, user will need additional supply to program the EEPROM; however, this may only impact in the testing phase of the design rather than the production phase. DRV10987 EEPROM voltage spans the full length of the operating voltage range.

Table 11. EEPROM (Minimum Programming Voltage)

Feature	DRV10987	DRV10983	Units
EEPROM minimum voltage	6.2	22	V

3 References

- DRV10987 Data sheet
- DRV10983 Data sheet
- Integrated intelligence part 1: EMI Management
- Integrated intelligence part 2: motor startup open loop acceleration
- Integrated intelligence part 3: motor startup from standstill

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