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## MOSFET Pre-driver PWM Considerations



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### DESIGN NOTE

Table 1. DEVICE DETAILS

Device	Application	Load Dump	Channel Count	Gate Drive Voltage	Miscellaneous
NCV7513 NCV7517	Automotive MOSFET Pre-driver	40 V MAX	6	5 V Typ.	Fault Diagnosis

Table 2. KEY FEATURES

Compatibility	TTL Input, 3.3/5 V Serial Output
Serial Control	SPI – 16-bit, 4 MHz, Daisy Chain Compatible
Parallel Control	6 PWM Inputs
Shorted Load Detection	External Reference, Selectable Ratio
Open Load Detection	Internal Reference
Short to GND Detection	Internal Reference
Slew Rate Control	Externally Adjustable

Table 3. KEY PARAMETERS

$V_{CC1} = V_{CC2} = 5\text{ V}$	NCV7513	NCV7517
Gate Drive Output Current	2.8 mA TYP	14.3 mA TYP
Gate Drive Output Resistance	1800 $\Omega$ TYP	350 $\Omega$ TYP
Turn-on/off Delay	1.0 $\mu\text{s}$ MAX	
Turn-on Blanking Time	60 $\mu\text{s}$ MAX	31 $\mu\text{s}$ MAX
Turn-off Blanking Time	150 $\mu\text{s}$ MAX	

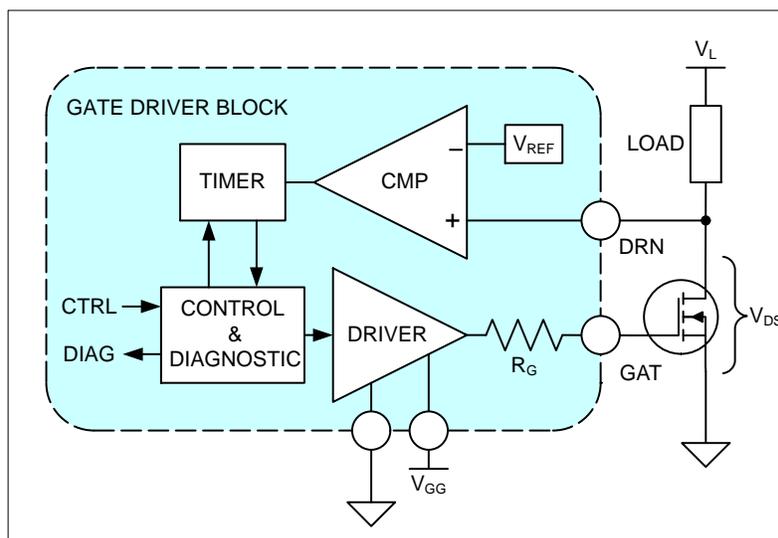


Figure 1. Simplified Pre-driver Block Diagram

### Pre-driver Overview

An example of the basic elements of a MOSFET pre-driver providing control, protection, and diagnostic functions is shown in Figure 1. During turn-on, a blanking timer is started while gate charge is delivered from the driver power supply ( $V_{GG}$ ) to the MOSFET through the driver output resistance ( $R_G$ ). During this time a comparator (CMP) senses the MOSFET's drain-source voltage ( $V_{DS}$ ) and compares it against a reference voltage ( $V_{REF}$ ). If the MOSFET's  $V_{DS}$  is greater than  $V_{REF}$  at the end of the turn-on blanking time, a possible shorted load has been detected. The MOSFET is then switched off by the pre-driver to protect it and a shorted load diagnostic state is recorded.

During turn-off, a blanking timer is started while the stored gate charge is removed from the MOSFET through  $R_G$  to ground. During this time CMP senses the MOSFET's  $V_{DS}$  and compares it against a different  $V_{REF}$ . If the MOSFET's  $V_{DS}$  is less than  $V_{REF}$  at the end of the turn-off blanking time, a possible open load or short to ground has been detected. In the short to ground case, load current can continue to flow but a short to ground diagnostic state is recorded.

### PWM Considerations

For correct function of the on/off-state diagnostics, the respective blanking timer must be allowed to finish. This

requirement places certain boundaries on the allowable PWM frequency and duty cycle. The maximum frequency ( $f_{PWM(MAX)}$ ) is limited by the reciprocal of the sum of the maximum turn-on and turn-off blanking times ( $t_{BL(ON,MAX)}$ ,  $t_{BL(OFF,MAX)}$ ), both of which are derived from the same internal timing reference:

$$f_{PWM(MAX)} \approx \frac{1}{t_{BL(ON,MAX)} + t_{BL(OFF,MAX)}} \quad (\text{eq. 1})$$

Using the values given in the "Key Parameters" table, the frequency limit for the NCV7513 is  $\approx 4.7$  kHz and for the NCV7517 is  $\approx 5.5$  kHz. PWM frequency in automotive applications is generally not higher than 2 kHz. The minimum and maximum duty cycle ( $D_{(MIN,MAX)}$ ) is then limited by:

$$D_{(MIN)} \approx t_{BL(ON,MAX)} \times f_{PWM} \times 100\% \quad (\text{eq. 2})$$

$$D_{(MAX)} \approx t_{BL(OFF,MAX)} \times f_{PWM} \times 100\%$$

The maximum turn-on blank time limits the *minimum* duty cycle for correct turn-on diagnostic operation. For correct turn-off diagnostic operation, the maximum turn-off time limits the *maximum* duty cycle. Minimum duty cycle in the 2 kHz case would be 12% for the NCV7513 and 6.2% for the NCV7517, and maximum duty cycle would be 30% for either product.

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