

Half-Bridge MOSFET Driver for Switching Power Supplies

FEATURES

- 4.5- to 5.5-V Operation
- Undervoltage Lockout
- 250-kHz to 1-MHz Switching Frequency
- Shutdown Quiescent Current $<5\ \mu\text{A}$
- One Input PWM Signal Generates Both Drive
- Bootstrapped High-Side Drive
- Operates from 4.5- to 30-V Supply
- TTL/CMOS Compatible Input Levels
- 1-A Peak Drive Current
- Break-Before-Make Circuit

APPLICATIONS

- Multiphase Desktop CPU Supplies
- Single-Supply Synchronous Buck Converters
- Mobile Computing CPU Core Power Converters
- Standard-Synchronous Converters
- High Frequency Switching Converters

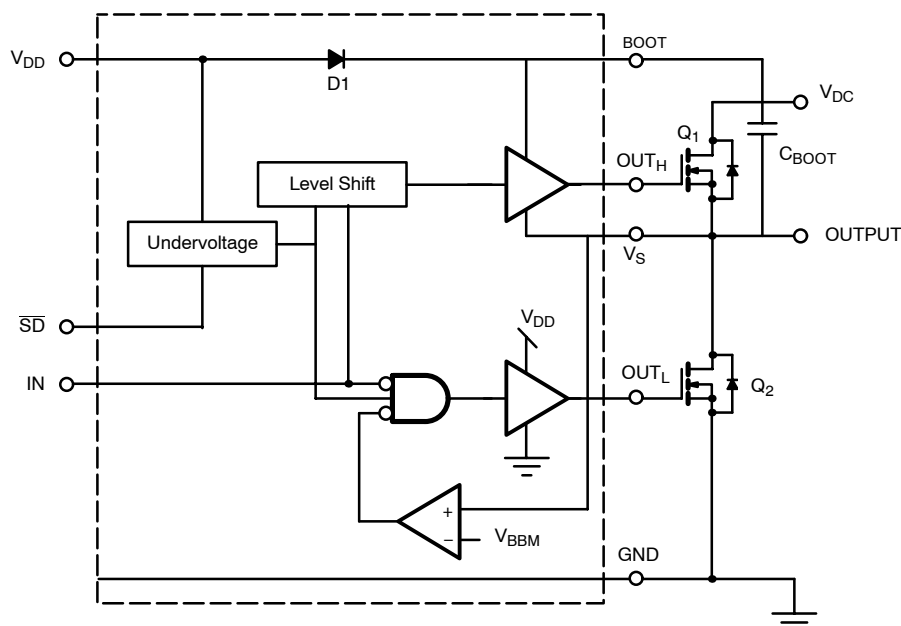
DESCRIPTION

The Si9912 is a dual MOSFET high-speed driver with break-before-make. It is designed to operate in high frequency dc-dc switchmode power supplies. The high-side driver is bootstrapped to handle the high voltage slew rate associated with “floating” high-side gate drivers. Each driver is capable of switching a 3000-pF load with 60-ns propagation delay and 25-ns transition time. The Si9912 comes with an internal break-before-make feature to prevent shoot-through current in the external MOSFETs. A shutdown pin is used to enable the

driver. When disabled, the quiescent current of the driver is less than 5 μA .

The Si9912 is available in both standard and lead (Pb)-free, 8-pin SOIC packages for operation over the industrial operation range (-40°C to 85°C).

FUNCTIONAL BLOCK DIAGRAM AND TRUTH TABLE



TRUTH TABLE				
V_S	\overline{SD}	IN	V_{OUTL}	V_{OUTH}
L	L	L	L	L
L	L	H	L	L
L	H	L	H	L
L	H	H	L	H
H	L	L	L	L
H	L	H	L	L
H	H	L	L	L
H	H	H	L	H

ABSOLUTE MAXIMUM RATINGS (T_A = 25 °C UNLESS OTHERWISE NOTED)

Parameter	Symbol	Limit	Unit
Low Side Driver Supply Voltage	V _{DD}	7.0	V
Input Voltage on IN	V _{IN}	-0.3 to V _{DD} +0.3	
Shutdown Pin Voltage	V _{SD}	-0.3 to V _{DD} +0.3	
Bootstrap Voltage	V _{BOOT}	35.0	
High Side Driver (Bootstrap) Supply Voltage	V _{BOOT} - V _S	7.0	
Operating Junction Temperature Range	T _J	-40 to 125	°C
Storage Temperature Range	T _{stg}	-40 to 150	
Power Dissipation (Note a and b)	P _D	830	mW
Thermal Impedance	θ _{JA}	125	°C/W
Lead Temperature (soldering 10 Sec)		300	°C

Notes

- a. Device mounted with all leads soldered to P.C. Board
b. Derate 8.3 W/°C above 25 °C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Limit	Unit
Bootstrap Voltage (High-Side Drain Voltage)	V _{BOOT}	4.5 to 30	V
Logic Supply	V _{DD}	4.5 to 5.5	
Bootstrap Capacitor	C _{BOOT}	100 n to 1 μ	F
Ambient Temperature	T _A	-40 to 85	°C

SPECIFICATIONS

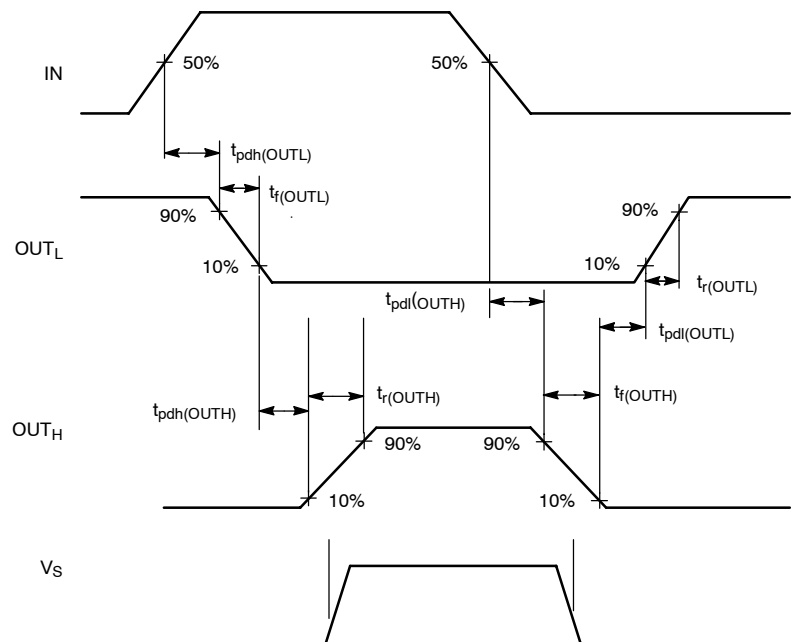
Parameter	Symbol	Test Conditions Unless Specified $V_{DD} = 4.5 \text{ to } 5.5 \text{ V}$ $V_{BOOT} = 4.5 \text{ to } 30 \text{ V}$, $T_A = -40 \text{ to } 85^\circ\text{C}$	Limits			Unit
			Min ^a	Typ ^b	Max ^a	
Power Supplies						
V _{DD} Supply	V _{DD}		4.5			μA
I _{DD} Supply	I _{DD1(en)}	$\overline{SD} = H$, $IN = H$, $V_S = 0 \text{ V}$			1000	
I _{DD} Supply	I _{DD2(en)}	$\overline{SD} = H$, $IN = L$, $V_S = 0 \text{ V}$			500	
I _{DD} Supply	I _{DD3(dis)}	$\overline{SD} = L$, $IN = X$, $V_S = 0 \text{ V}$			5	
I _{DD} Supply	I _{DD4(en)}	$\overline{SD} = H$, $IN = X$, $V_S = 25 \text{ V}$, $V_{BOOT} = 30 \text{ V}$			200	
I _{DD} Supply	I _{DD5(dis)}	$\overline{SD} = L$, $IN = X$, $V_S = 25 \text{ V}$, $V_{BOOT} = 30 \text{ V}$			5	
I _{DD} Supply	I _{DD(en)}	$F_{IN} = 300 \text{ kHz}$, $\overline{SD} = \text{High}$, Driving Si4412DY		9		mA
	I _{DD(dis)}	$F_{IN} = 300 \text{ kHz}$, $\overline{SD} = \text{Low}$, Driving Si4412DY		3		μA
Boot Strap Current	I _{BOOT}	$V_{BOOT} = 30 \text{ V}$, $V_S = 25 \text{ V}$, $V_{OUTH} = \text{High}$	0.9		3	mA
Reference Voltage						
Break-Before-Make Reference Voltage	V _{BBM}		1.1		3	V
Logic Inputs (\overline{SD} , IN)						
Input High	V _{IH}		$0.7 \times V_{DD}$		$V_{DD} + 0.3$	V
Input Low	V _{IL}		-0.3		$0.3 \times V_{DD}$	
Undervoltage Lockout						
V _{DD} Undervoltage	V _{UVL}	V _{DD} Rising	3.7		4.3	V
V _{DD} Undervoltage Hysteresis	V _{HYST}			0.4		

**SPECIFICATIONS**

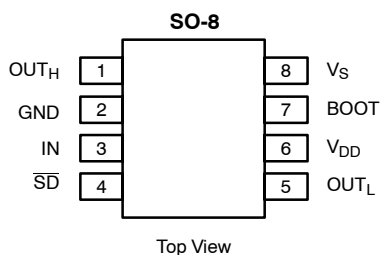
Parameter	Symbol	Test Conditions Unless Specified $V_{DD} = 4.5 \text{ to } 5.5 \text{ V}$ $V_{BOOT} = 4.5 \text{ to } 30 \text{ V}$, $T_A = -40 \text{ to } 85^\circ\text{C}$	Limits			Unit
			Min ^a	Typ ^b	Max ^a	
Bootstrap Diode						
Diode Forward Voltage	V_{FD1}	Forward Current = 100 mA		0.8	1	V
Output Drive Current						
OUT _H Source Current	$I_{OUT(H+)}$	$V_{BOOT} - V_S = 3.7 \text{ V}$, $V_{OUTH} - V_S = 2 \text{ V}$			-0.4	A
OUT _H Sink Current	$I_{OUT(H-)}$	$V_{BOOT} - V_S = 3.7 \text{ V}$, $V_{OUTH} - V_S = 1 \text{ V}$	0.4			
OUT _L Source Current	$I_{OUT(L+)}$	$V_{DD} = 4.5 \text{ V}$, $V_{OUTL} = 2 \text{ V}$			-0.4	
OUT _L Sink Current	$I_{OUT(L-)}$	$V_{DD} = 4.5 \text{ V}$, $V_{OUTL} = 1 \text{ V}$	0.6			
Timing (C _{LOAD} = 3 nF)						
OUT _L Off Propagation Delay	$t_{pdl(OUTL)}$	$V_{DD} = 4.5 \text{ V}$		30		ns
OUT _L On Propagation Delay	$t_{pdh(OUTL)}$			20		
OUT _H Off Propagation Delay	$t_{pdl(OUTH)}$	$V_{BOOT} - V_S = 4.5 \text{ V}$		30		
OUT _H On Propagation Delay	$t_{pdh(OUTH)}$			20		
OUT _L Turn On Time	$t_r(OUTL)$	OUT _L = 10 to 90%		25		
OUT _L Turn Off Time	$t_f(OUTL)$	OUT _L = 90 to 10%		25		
OUT _H Turn On Time	$t_r(OUTH)$	OUT _H - V _S = 10 to 90%		30		
OUT _H Turn Off Time	$t_f(OUTH)$	OUT _H - V _S = 90 to 10%		20		

Notes

- a. The algebraic convention whereby the most negative value is a minimum and the most positive a maximum, is used in this data sheet.
b. Typical values are for DESIGN AID ONLY, not guaranteed nor subject to production testing.

TIMING WAVEFORMS

PIN CONFIGURATION



PIN DESCRIPTION

Pin Number	Name	Function
1	OUT _H	Output drive for upper MOSFET.
2	GND	Ground supply
3	IN	CMOS level input signal. Controls both output drives.
4	\overline{SD}	Shutdown pin
5	OUT _L	Output drive for lower MOSFET.
6	V _{DD}	Input power supply
7	BOOT	Floating bootstrap supply for the upper MOSFET
8	V _S	Floating GND for the upper MOSFET. V _S is connected to the buck switching node and the source side of the upper MOSFET.

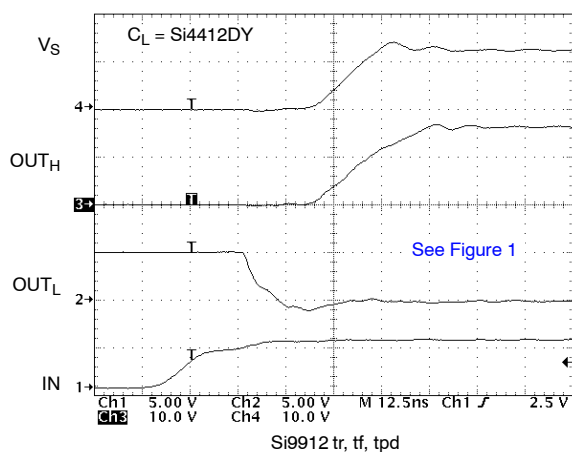
ORDERING INFORMATION

Part Number	Temperature Range	Package
Si9912DY	-40 to 85°C	Bulk
Si9912DY-T1		Tape and Reel
Si9912DY-T1—E3 (Lead (Pb)-Free)		

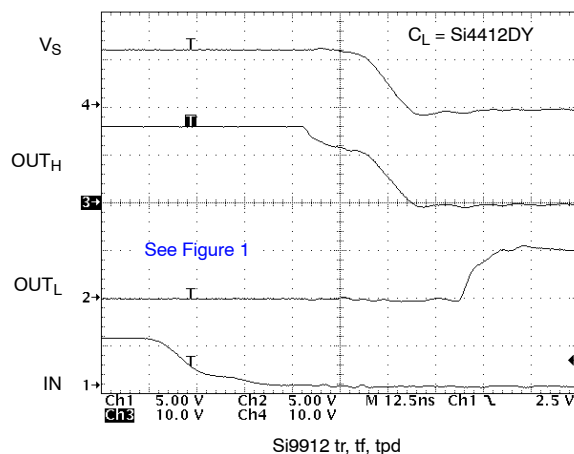
Eval Kit	Temperature Range	Board Type
Si9912DB	-40 to 85°C	Surface Mount

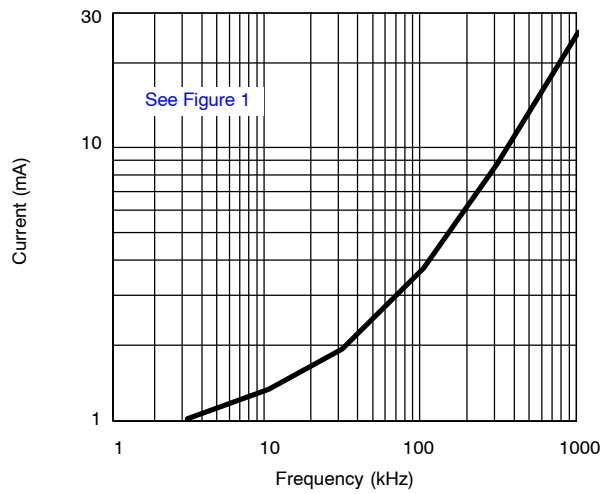
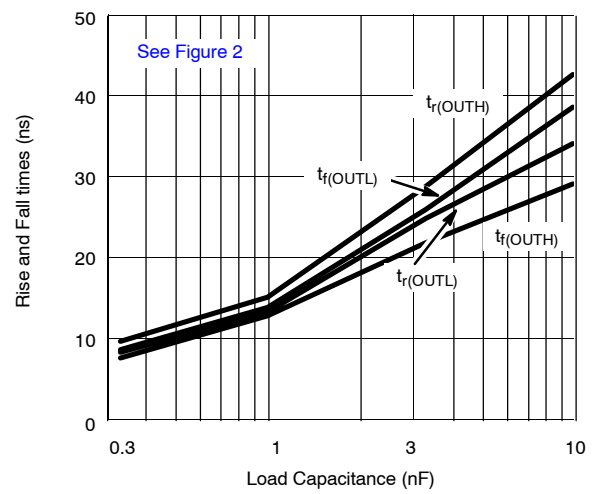
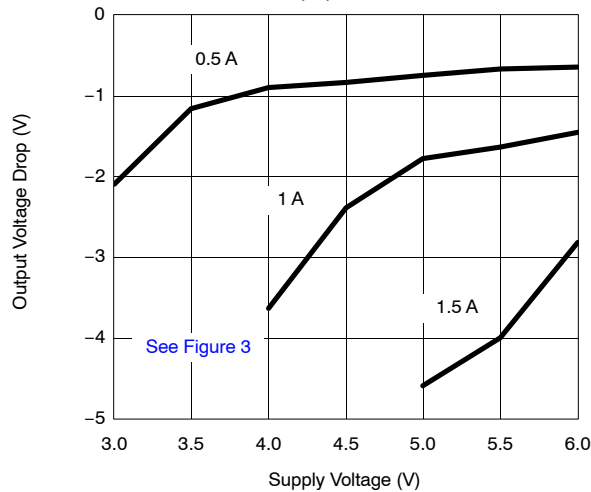
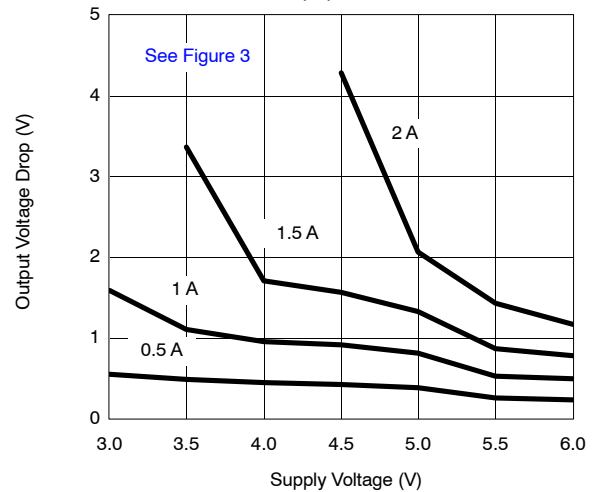
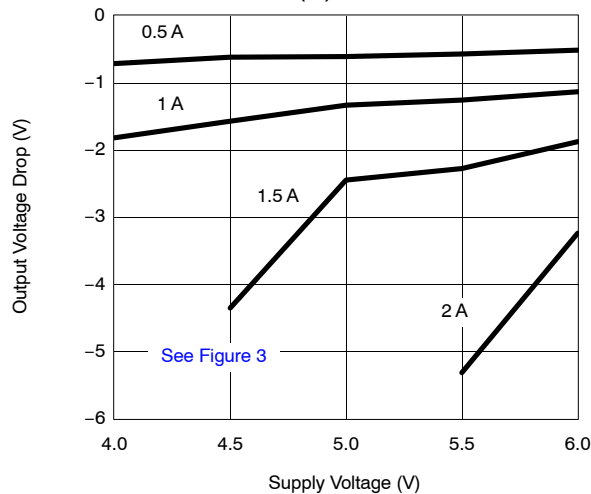
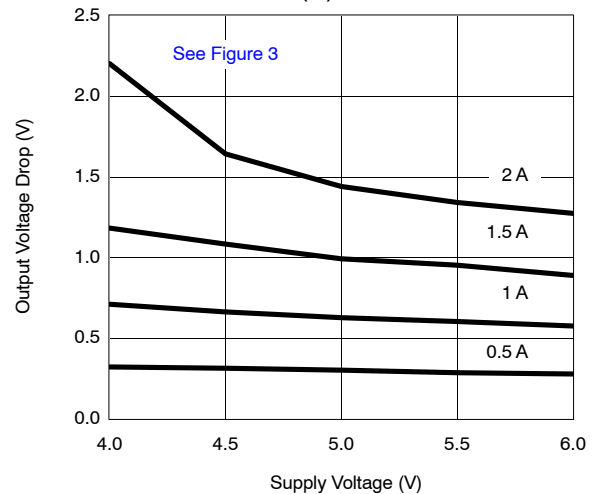
TYPICAL WAVEFORMS

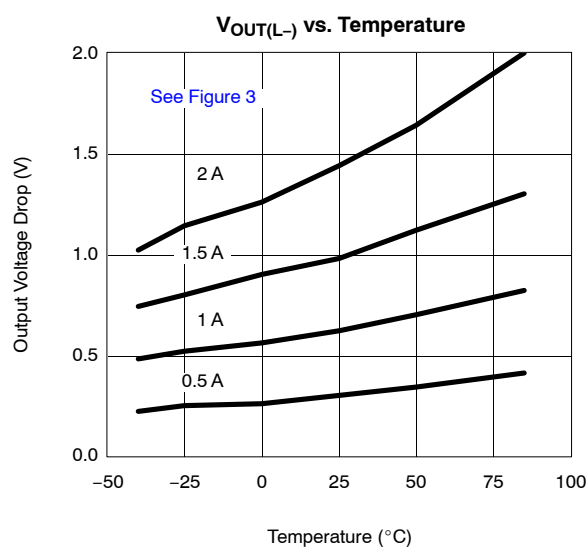
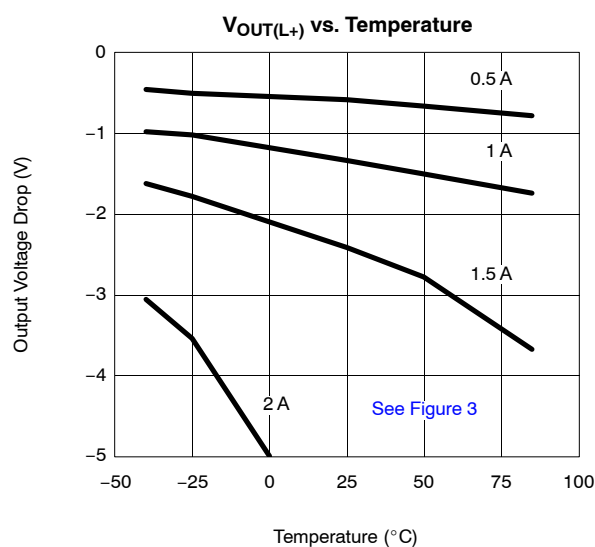
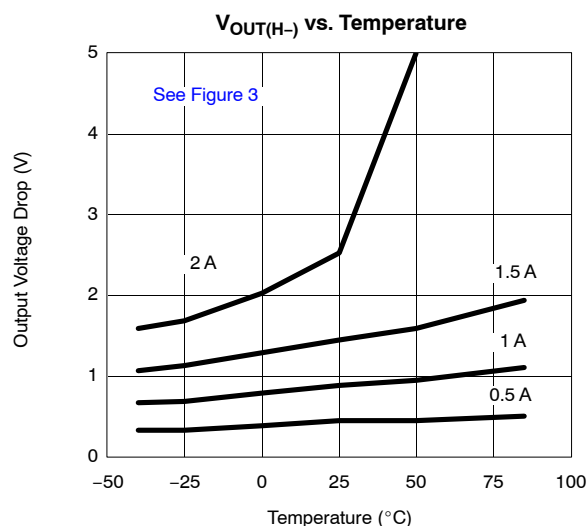
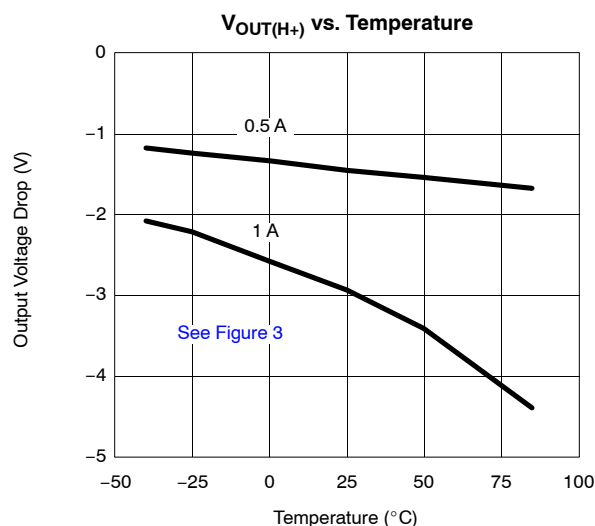
Driver On Switch Delay



Driver Off Switch Delay



TYPICAL CHARACTERISTICS (25 °C UNLESS NOTED)
 I_{DD} Supply Current vs. Frequency

Rise and Fall Time vs. C_{LOAD}

 $V_{OUT(H+)}$ vs. Supply

 $V_{OUT(H-)}$ vs. Supply

 $V_{OUT(L+)}$ vs. Supply

 $V_{OUT(L-)}$ vs. Supply


TYPICAL CHARACTERISTICS (25 °C UNLESS NOTED)

THEORY OF OPERATION
Break-Before-Make Function

The Si9912 has an internal break-before-make function to ensure that both high-side and low-side MOSFETs are not turned on at the same time. The high-side drive (OUT_H) will not turn on until the low-side gate drive voltage (measured at the OUT_L pin) is less than V_{BBM}, thus ensuring that the low-side MOSFET is turned off. The low-side drive (OUT_L) will not turn on until the voltage at the MOSFET half-bridge output (measured at the V_S pin) is less than V_{BBM}, thus ensuring that the high-side MOSFET is turned off.

Under Voltage Lockout Function

The Si9912 has an internal under-voltage lockout feature to prevent driving the MOSFET gates when the supply voltage (at V_{DD}) is less than the under-voltage lockout specification (V_{UVL}). This prevents the output MOSFETs from being turned on without sufficient gate voltage to ensure they are fully on. There is hysteresis included in this feature to prevent lockout from cycling on and off.

Bootstrap Supply Operation (see Functional Block Diagram)

The power to drive the high-side MOSFET (Q2) gate comes from the bootstrap capacitor (C_{BOOT}). This capacitor charges through D1 during the time when the low-side MOSFET is on (V_S is at GND potential), and then provides the necessary charge to turn on the high-side MOSFET. C_{BOOT} should be sized to be greater than ten times the high-side MOSFET gate capacitance, and large enough to supply the bootstrap current (I_{BOOT}) during the high-side on time, without significant voltage droop.

Shutdown (\overline{SD}) (shutdown input, active low)

When this pin is high, the IC operates normally. When this pin is low, both high- and low-side MOSFETs are turned off.

Layout Considerations

There are a few critical layout considerations for these parts. Firstly, the IC must be decoupled as closely as possible to the power pins. Secondly the IC should be placed physically close to the high- and low-side MOSFETs it is driving. The major consideration is that the MOSFET gates must be charged or discharged in a few nanoseconds, and the peak current to do this is of the order of 1 A. This current must flow from the decoupling and bootstrap capacitors to the IC, and from the output driver pin to the MOSFET gate, returning from the MOSFET source to the IC. The aim of the layout is to reduce the parasitic inductance of these current paths as much as possible. This is accomplished by making these traces as short as possible, and also running trace and its current return path adjacent to each other.

APPLICATIONS

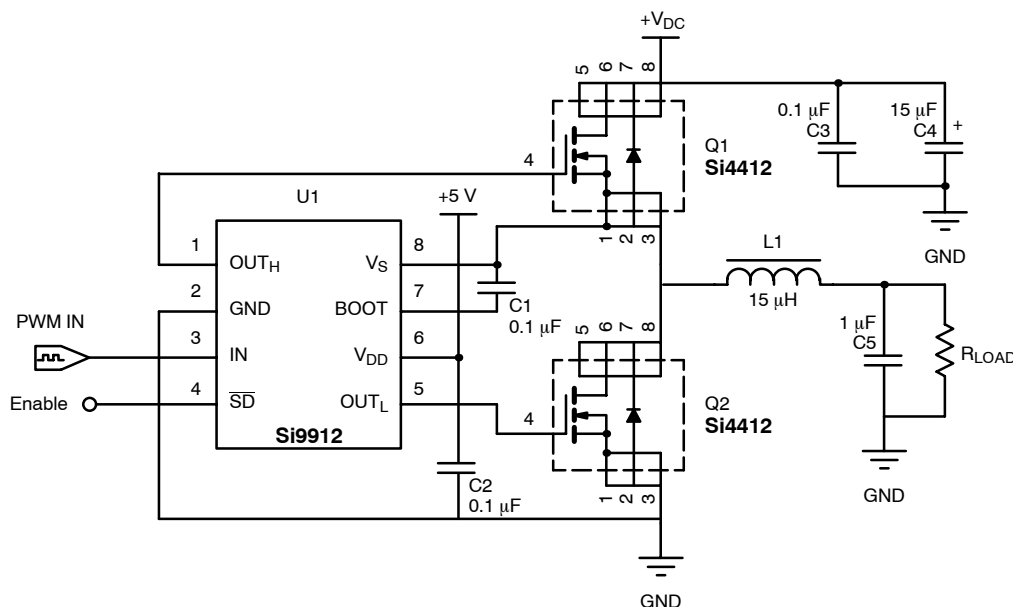


FIGURE 1. Typical Applications Schematic Circuit Used to Obtain Typical Rising and Falling Switching Waveforms

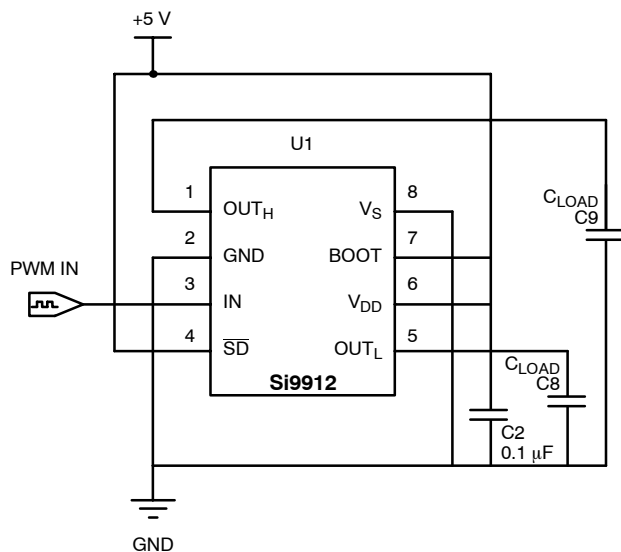


FIGURE 2. Capacitive Load Test Circuit Used to Measure Rise and Fall Times vs. Capacitance

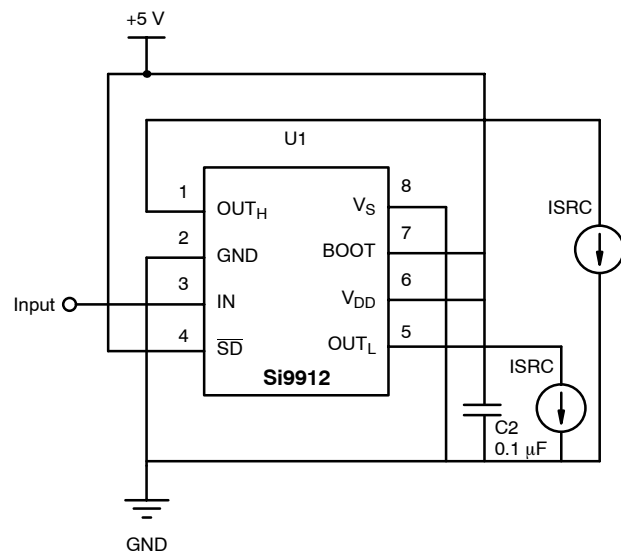


FIGURE 3. Load Test Schematic Circuit Used to Measure Driver Output Impedance



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