Dual MOSFET Bootstrapped Driver with Break-Before-Make

FEATURES

- 4.5- to 5.5-V Operation
- Undervoltage Lockout
- 250-kHz to 1-MHz Switching Frequency
- Synchronous Switch Enable
- 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

APPLICATIONS

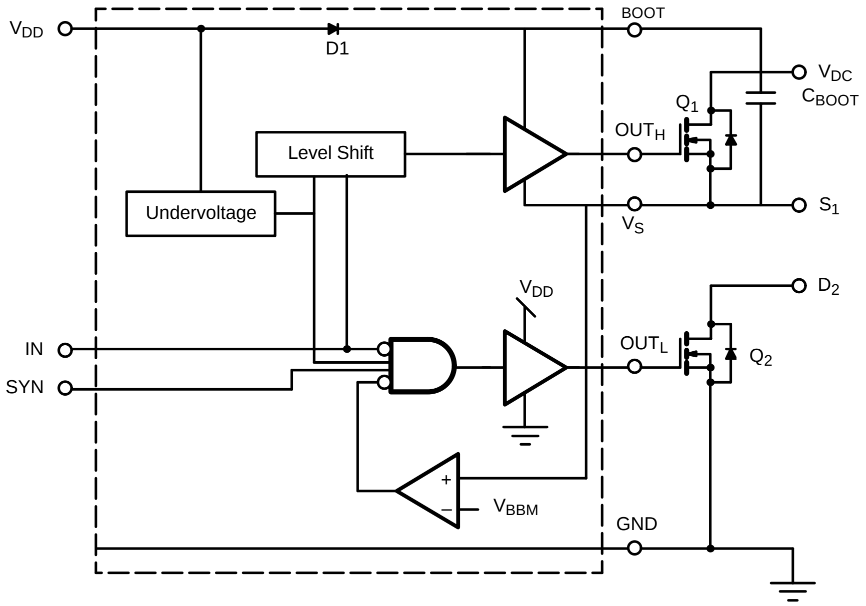
- Multiphase Desktop CPU Supplies
- Single-Supply Synchronous Buck Converters
- Mobile Computing CPU Core Power Converters
- Standard-to-Synchronous Converter Adaptations
- High Frequency Switching Converters

DESCRIPTION

The Si9913 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 propogation delay and 25-ns transition time. The Si9913 comes with internal break-before-make feature to prevent shoot-through current in the external MOSFETs. A syschronous enable pin is used to enable the low-side driver. When disabled, the OUT_L is logic low.

The Si9913 is available in an 8-pin SOIC package for operation over the industrial operation range (–40°C to 85°C).

FUNCTIONAL BLOCK DIAGRAM AND TRUTH TABLE



TRUTH TABLE

V_S	SYN	IN	V_{OUTL}	V_{OUTH}
L	L	L	L	L
L	L	H	L	H
L	H	L	H	L
L	H	H	L	H
H	L	L	L	L
H	L	H	L	H
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	
Synchronous Pin Voltage	V_{SYN}	–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)	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

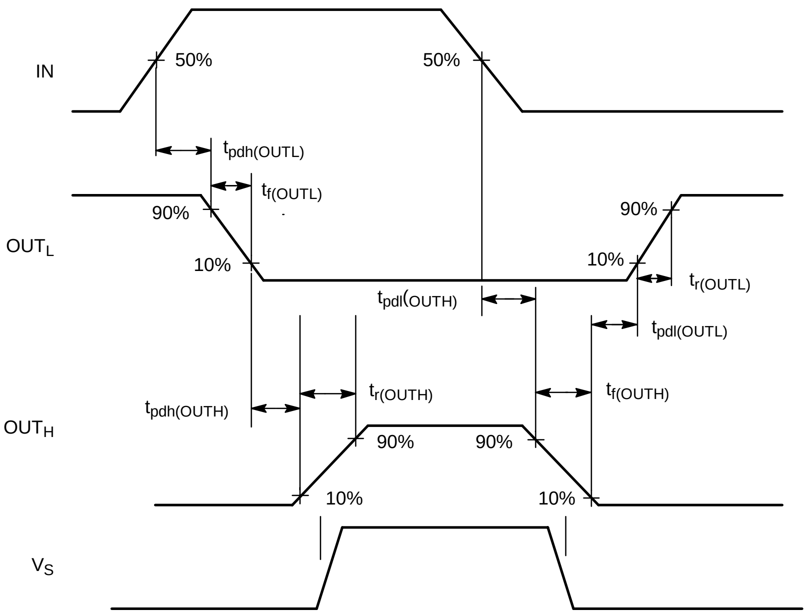
Parameter	Symbol	Test Conditions Unless Specified V_{BOOT} = 4.5 to 30 V, V_{DD} = 4.5 to 5.5 V T_A = –40 to 85°C	Limits			Unit
			Min[a]	Typ[b]	Max[a]	
Power Supplies						
V_{DD} Supply	V_{DD}		4.5		5.5	µA
I_{DD} Supply	I_{DD1} (en)	SYN = H, IN = H, V_S = 0 V			1000	
I_{DD} Supply	$I_{DD2(en)}$	SYN = H, IN = L, V_S = 0 V			500	
I_{DD} Supply	$I_{DD3(dis)}$	SYN = L, IN = X, V_S = V			500	
I_{DD} Supply	$I_{DD4(en)}$	SYN = H, IN = X, V_S = 25 V, V_{BOOT} = 30 V			200	
I_{DD} Supply	$I_{DD5(dis)}$	SYN = L, IN = X, V_S = 25 V, V_{BOOT} = 30 V			200	
I_{DD} Supply	$I_{DD(en)}$	F_{IN} = 300 kHz, SYN = High, Driving 2 X Si4412DY		9		mA
	$I_{DD(dis)}$	F_{IN} = 300 kHz, SYN = Low, Driving 2 X Si4412DY		5		
Boot Strap Current	I_{BOOT}	V_{BOOT} = 30 V, V_S = 25 V, V_{OUTH} = H	0.9		3	
Reference Voltage						
Break-Before-Make Reference Voltage	V_{BBM}		1.1		3	V
Logic Inputs (SYN, 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

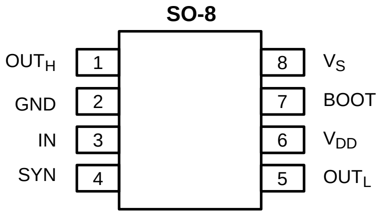
Parameter	Symbol	Test Conditions Unless Specified	Limits			Unit
		V_{BOOT} = 4.5 to 30 V, V_{DD} = 4.5 to 5.5 V T_A = –40 to 85°C	Min[a]	Typ[b]	Max[a]	
Bootstrap Diode						
Diode Forward Voltage	VF_{D1}	Forward Current = 100 mA		0.8	1	V
Output Drive Current						
OUT_H Source Current	$I_{OUT(H+)}$	$V_{BOOT} - V_S$ = 3.7 V, $V_{OUTH} - V_S$ = 2 V			–0.4	A
OUT_H Sink Current	$I_{OUT(H-)}$	$V_{BOOT} - V_S$ = 3.7 V, $V_{OUTH} - V_S$ = 1 V	0.4			
OUT_L Source Current	$I_{OUT(L+)}$	V_{DD} = 4.5 V, V_{OUTL} = 2 V			–0.4	
OUT_L Sink Current	$I_{OUT(L-)}$	V_{DD} = 4.5 V, V_{OUTL} = 1 V	0.6			
Timing (C_{LOAD} = 3 nF)						
OUT_L Off Propagation Delay	$t_{pdl(OUTL)}$	V_{DD} = 4.5 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 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%		30		

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



Top View

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	SYN	Synchronous enable. When logic is high, the low-side driver is enabled.
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.

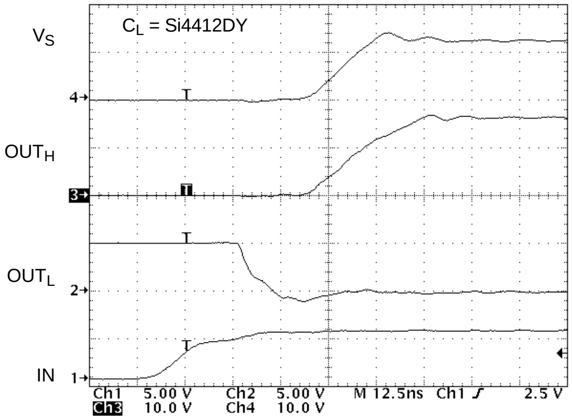
ORDERING INFORMATION

Part Number	Temperature Range	Package
Si9913DY	–40 to 85°C	Bulk
Si9913DY-T1		Tape and Reel

Eval Kit	Temperature Range	Board Type
Si9913DB	–40 to 85°C	Surface Mount

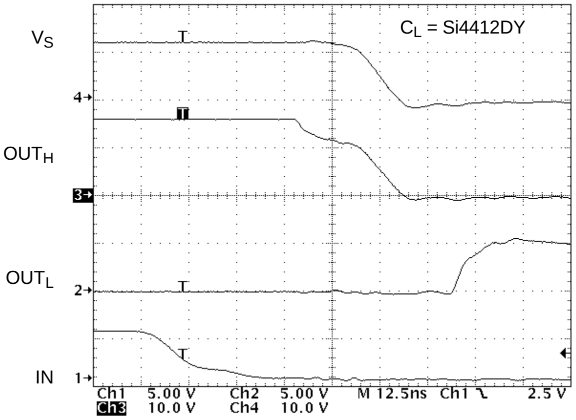
TYPICAL WAVEFORMS

Driver On Switch Delay



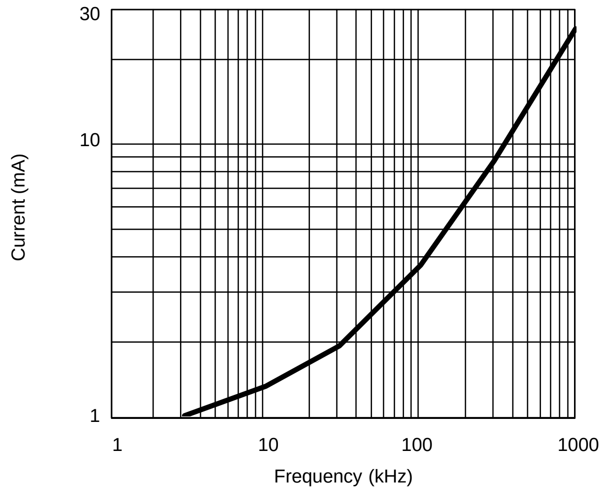
Si9912 tr, tf, tpd

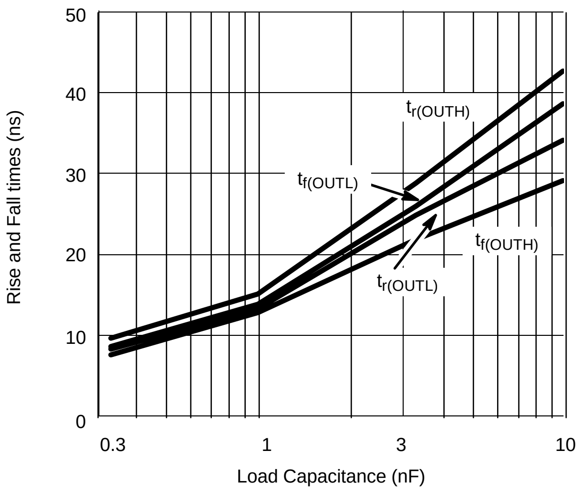
Driver Off Switch Delay

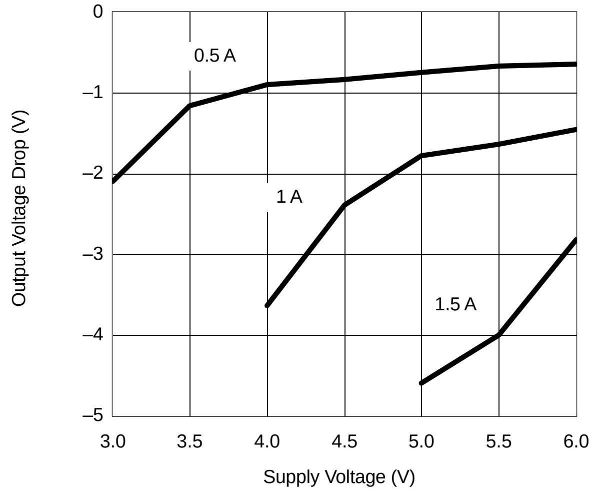


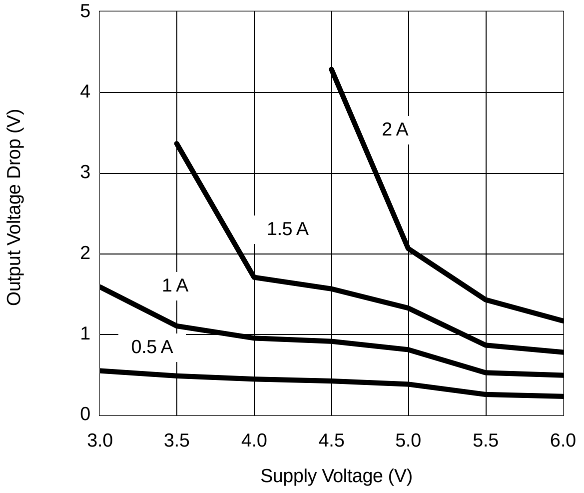
Si9912 tr, tf, tpd

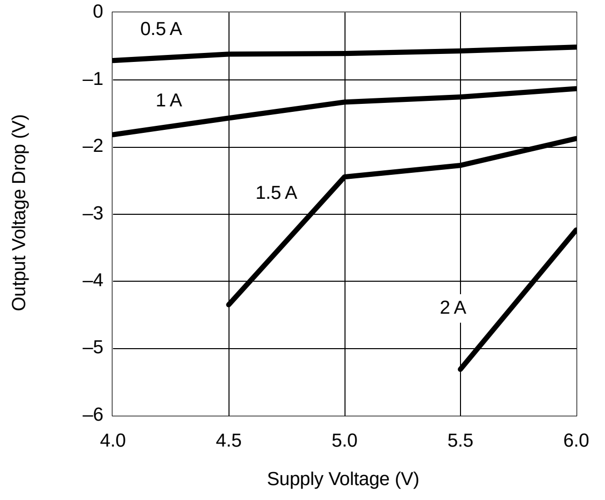
TYPICAL CHARACTERISTICS (25°C UNLESS NOTED)

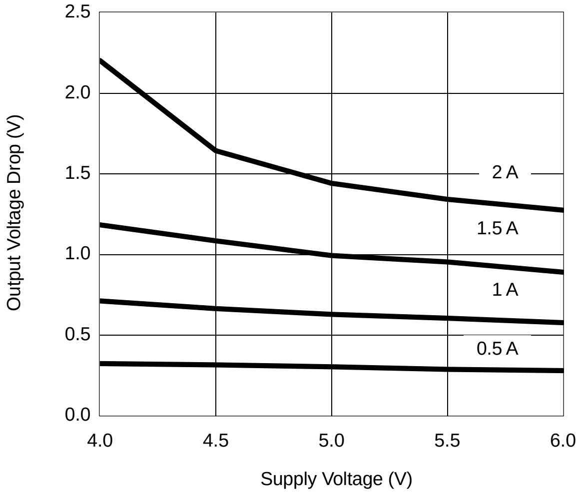

I_{DD} Supply Current vs. Frequency


Rise and Fall Time vs. C_{LOAD}


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

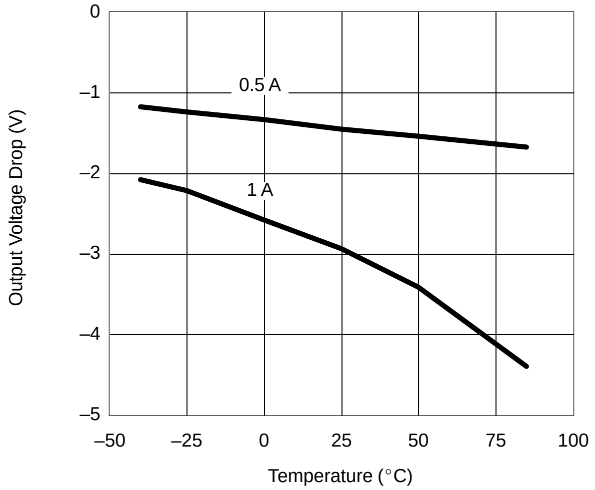

$V_{OUT(H-)}$ vs. Supply


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

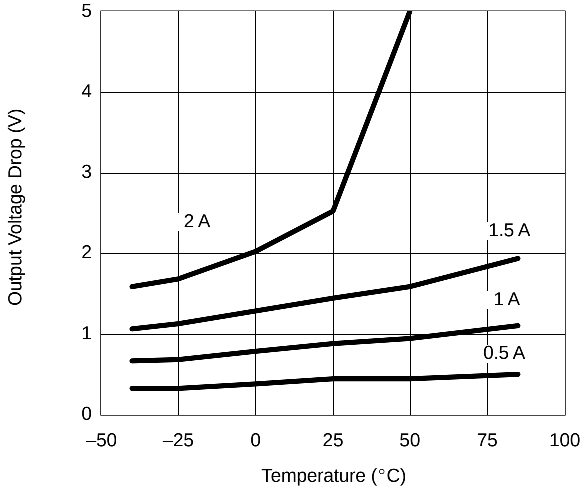

$V_{OUT(L-)}$ vs. Supply

TYPICAL CHARACTERISTICS (25°C UNLESS NOTED)

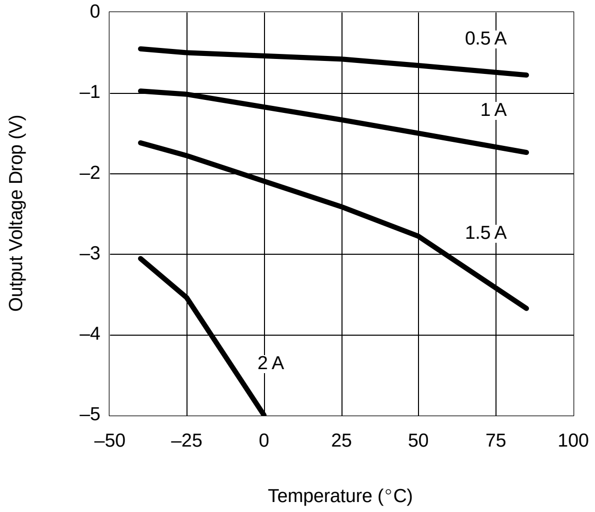
$V_{OUT(H+)}$ vs. Temperature



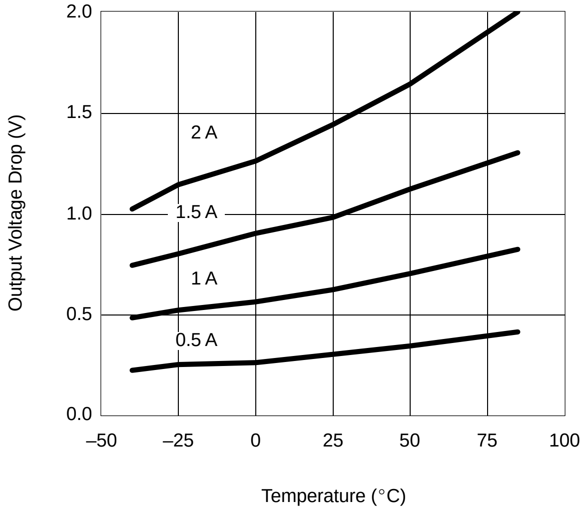
$V_{OUT(H-)}$ vs. Temperature



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



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



THEORY OF OPERATION

Break-Before-Make Function

The Si9913 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 Si9913 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.