Fast Turn-Off, High-Performance Synchronous Rectifier Switch

FEATURES

- **Integrated with 100V MOSFET**
- **Support DCM, QR and CCM Operation**
- **Integrated with 180V HV Voltage Sense and VDD Supply Circuit, and Aux-winding for VDD Supply Can be Eliminated**
- **Integrated with Intelligent Dual LDOs for VDD Supply, SR will Work even When Output Voltage Drops Down to Zero**
- **Support Wide Output Range, Especially Fit for Quick Charger Application with QC, PD Protocol**
- **Support High-Side and Low-Side Configuration**
- **<30ns Fast Turn-Off Delay**
- **Intelligent Turn-on Detection Function**
- **Intelligent ZCD Function**
- **Intelligent Gate Clamp before Start-up**
- **Available with SOP-8 Package**

GENERAL DESCRIPTION

FC4051X is a high-performance secondary side synchronous rectifier switch that replaces Schottky diodes in high-efficiency Fly-back converters

FC4051X supports High-Side and Low-Side configuration. It also has built-in HV supplies which can eliminate the aux-winding of VDD supply for cost saving.

FC4051X supports DCM, QR and CCM Operations due to fast turn-off delay of SR MOSFET control.

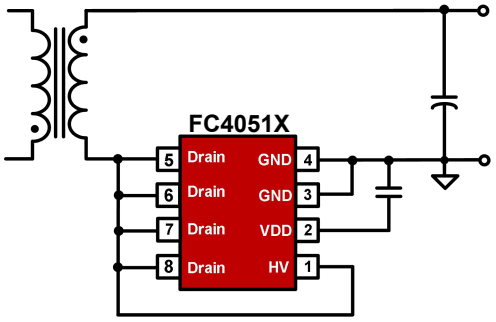
FC4051X integrates intelligent turn-on detection function which can prevent FC4051X from turning on falsely due to VDS oscillations at DCM operations.

APPLICATIONS

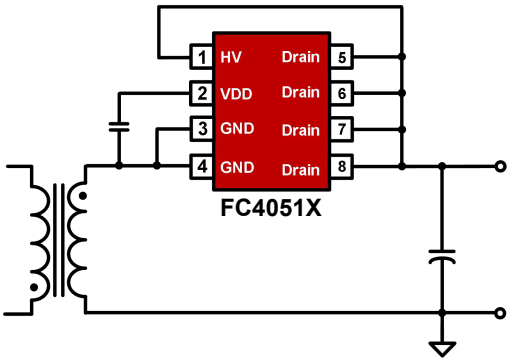
- **USB PD Quick Chargers**
- **Adaptors**

TYPICAL APPLICATION CIRCUIT

Low Side Configuration



High Side Configuration



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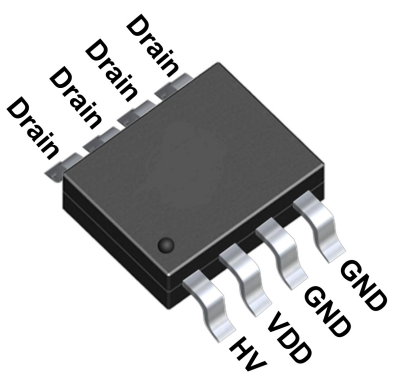
Pin Configuration



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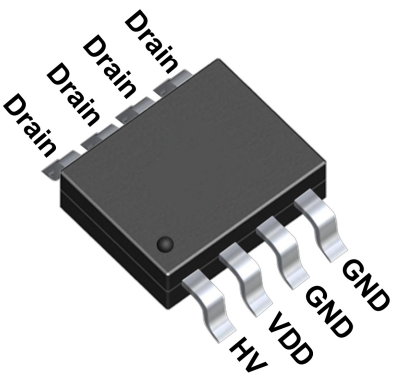

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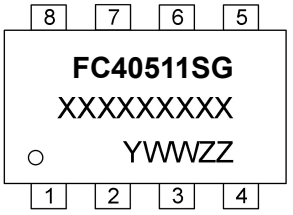
Marking Information

XXXXXXXXX：Wafer Lot Code
Y：Year Code
WW：Week Code，01-52
ZZ：Serial Number，01-99 or A0-ZZ



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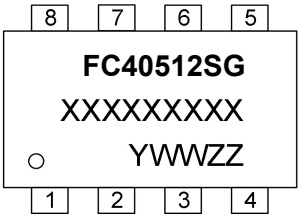

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Pin Description

Pin Number	Pin Name	I/O(1)	Description
1	HV	I	MOSFET Drain Voltage Sense
2	VDD	P	IC Power Supply Pin
3, 4	GND	P	IC Ground Pin
5, 6, 7, 8	Drain	P	Drain of Internal MOSFET

(1) P - Power; I - Input.

Ordering Information

Part Number(2)	Description
FC40511SGA	SOP-8, Halogen Free in T&R, 4000 Pcs/Reel
FC40512SGA	SOP-8, Halogen Free in T&R, 4000 Pcs/Reel

(2) Suffix "A" - Tape&Reel.

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Absolute Maximum Ratings (3)

Parameter	Value	Unit
HV Pin Voltage Range	-1 to 180	V
Drain Pin Voltage Range	-1 to 100	V
VDD Pin Voltage Range	-0.3 to 12	V
VDD DC Clamp Current	5	mA
Package Thermal Resistance----Junction to Ambient (SOP-8)	165	℃/W
Maximum Junction Temperature	150	℃
Storage Temperature Range	-40 to 150	℃
Lead Temperature (Soldering, 10sec.)	260	℃
ESD Capability, HBM (Human Body Model)	2	kV
ESD Capability, CDM (Charge Devices Model)	2	kV

(3) Exceeding the "limit parameters" in the list may cause permanent damage to the device. The limit parameter is the stress rating. The device may not work properly beyond the recommended operating conditions and stresses, so it is not recommended to let the device work under these conditions. Overexposure to the recommended maximum operating conditions may affect the reliability of the device.

Recommended Operation Conditions

Parameter	Value	Unit
Operating Junction Temperature	-40 to 125	℃

Electrical Characteristics (Ta = 25℃, if not otherwise noted)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
Supply Voltage Section (VDD Pin)						
V_{DD_ON}	VDD under Voltage Lockout Exit		3.5	3.8	4.1	V
V_{DD_OFF}	VDD under Voltage Lockout Enter		3.2	3.5	3.8	V
I_Q	Quiescent Operation Current	VDD=9V	170	213	255	μA
V_{DD_reg}	VDD Regulation Voltage	HV=12V	8.5	9	9.5	V
I_{op}	Operating Current	VDD=9V, fsw = 100kHz	0.6		4	mA
Control Section (HV Pin)						
V_{th_off}	SR Turn off Threshold Voltage		-6	0	4	mV
V_{th_on}	SR Turn on Threshold Voltage(4)		-264	-220	-176	mV

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T_{d_on}	Turn-on Delay	C_L=2.2nF		25		ns
T_{d_off}	Turn-off Delay	C_L=2.2nF		22		ns
LEB	Leading Edge Blanking(4)		0.96	1.2	1.44	μs
T_{off_min}	Minimum Turn-off Time(4)		160	200	240	ns
Gate Drive						
V_{Gate_L}	Gate Driver Low Voltage			0	100	mV
V_{Gate_H}	Gate Driver High Voltage			VDD		V
I_{Pull_Up}	Gate Driver Maximum Sourcing Current			0.8		A
I_{Pull_Down}	Gate Driver Maximum Sinking Current			5		A
R_{Pull_Down}	Pull-down Impedance				0.4	Ω
Internal MOSFET						
V_{BR}	Internal MOSFET Drain-Source Breakdown Voltage		102	110	114	V
I_{D_Pulse}	Internal MOSFET Pulse Drain Current	FC40511		100	120	A
		FC40512		137	165	A
I_D	Internal MOSFET Continuous Drain Current	FC40511		33	40	A
		FC40512		45	55	A
R_{ds_on}	Internal MOSFET Drain-ource on-state Resistance	FC40511 (V_{GS}=10V, I_D=20A)		16	20	mΩ
		FC40512 (V_{GS}=10V, I_D=10A)		9	10.5	mΩ

(4) The parameters depend on the design and pass the functional test in mass production.

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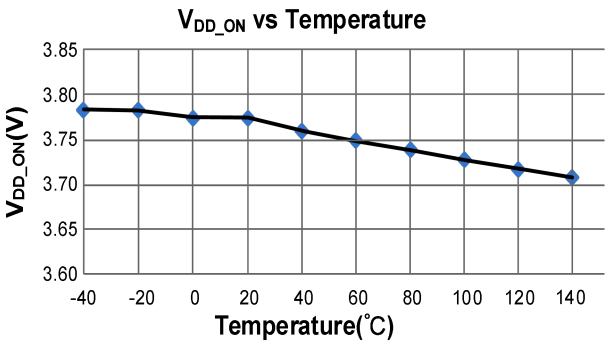
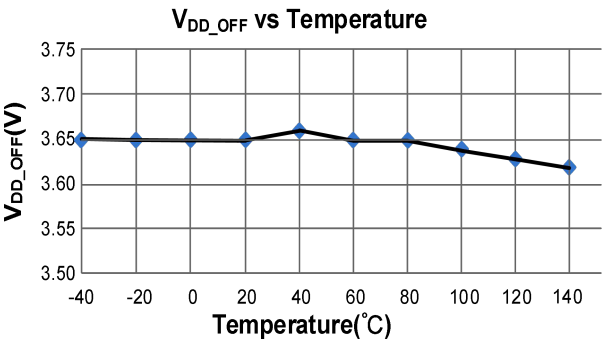
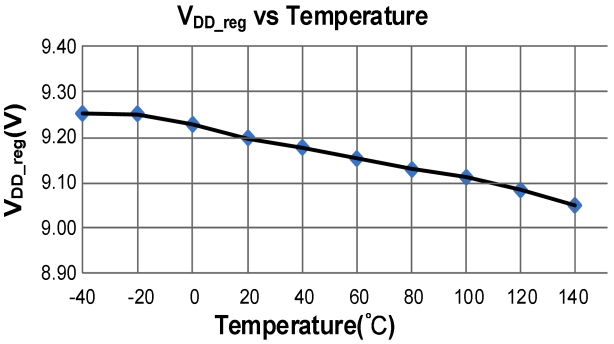
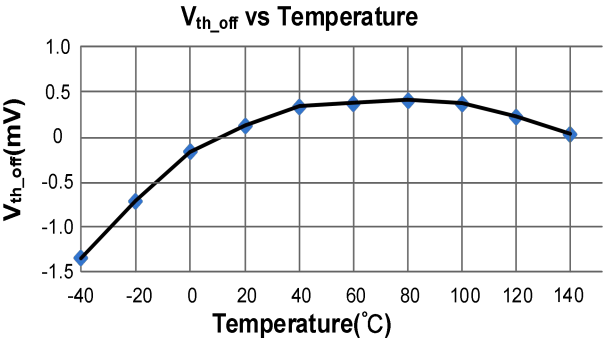
Typical Characteristic









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Operation Description

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● System Start-Up Operation

When VDD pin voltage is below UVLO threshold (3.5V typically), the IC is in sleep mode and the current flows through body diode of the internal MOSFET. When VDD pin voltage reaches the turn on threshold (3.8V typically), the IC begins working.

● Turn-on Phase

At the beginning of the rectification phase, the internal synchronous MOSFET is kept off, and the secondary current is conducted through the body diode of the MOSFET. At the same time, a negative Vds voltage (<-500 mV) is formed across the body diode. The negative Vds voltage is much lower than the threshold of the internal MOSFET opening detection threshold (-220 mV typically) of FC4051X, so the internal MOSFET is turned on after the turn-on delay (25 ns typically) (Shown in Fig. 1).

● Turn-off Phase

During the conduction phase of the internal synchronous MOSFET, FC4051X senses Vds across the MOSFET. When Vds is higher than the turn-off threshold (0mV typically), the internal synchronous MOSFET will be turned off after turn-off delay (22ns typically) (Shown in Fig.1).

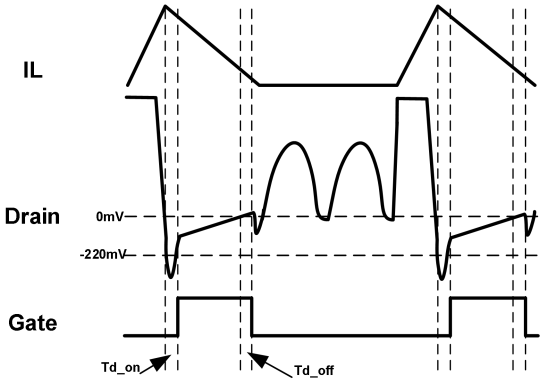

Fig.1

● Leading Edge Blanking (LEB)

Each time the internal synchronous MOSFET is switched on, a turn-on spike occurs across Vds. To avoid premature termination of the switching pulse, an internal leading edge blanking circuit is built in. During this blanking period (1.2μs typically), the turn-off comparator is disabled and cannot switch off the internal synchronous MOSFET.

● Intelligent Turn-on Detection Function

The intelligent turn-on detection function can prevent FC4051X from turning on falsely due to Vds oscillations at DCM operations, and improve system efficiency and reliability.

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Application Information

- **PCB Layout Guidelines**

PCB design has a significant impact on the performance of synchronous rectification. It is recommended to refer to Figure 2 and Figure 3 when designing synchronous rectification circuit.

1. Make the main power loop Loop1 as small as possible.
2. It is recommended to use ceramic capacitor for VDD supply, and Loop2 should be as small as possible.
3. The HV sensing loop should include as much power trace length as possible to improve the system performance in the case of CCM.
4. Figure 3 shows a layout example using a synchronous rectifier switch, a transformer and output capacitor. R1 and C1 are the RC snubber network for the SR MOSFET, make the RC loop as small as possible.

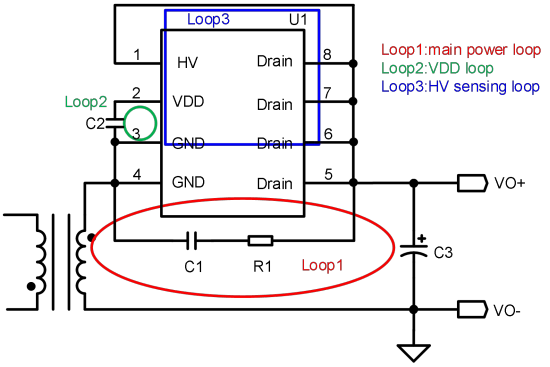

Fig.2

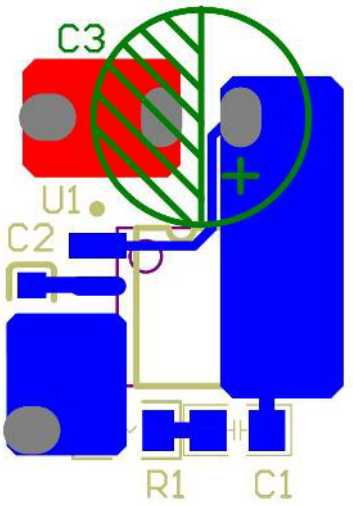

Fig.3

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Package Dimension

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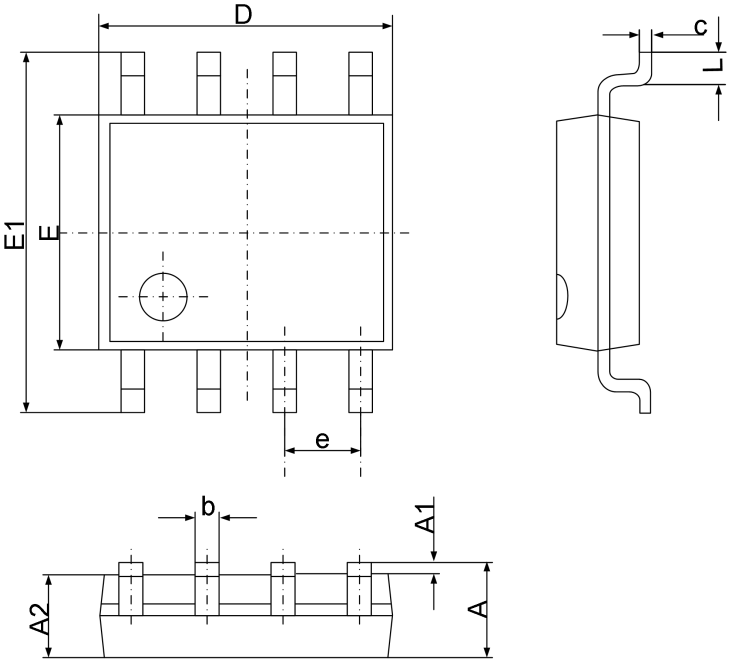

Symbol	Dimensions in Millimeters		Dimensions in Inches	
	Min.	Max.	Min.	Max.
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.300	1.500	0.051	0.059
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270 (BSC)		0.050 (BSC)	
L	0.400	1.270	0.016	0.050

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Tape and Reel Information

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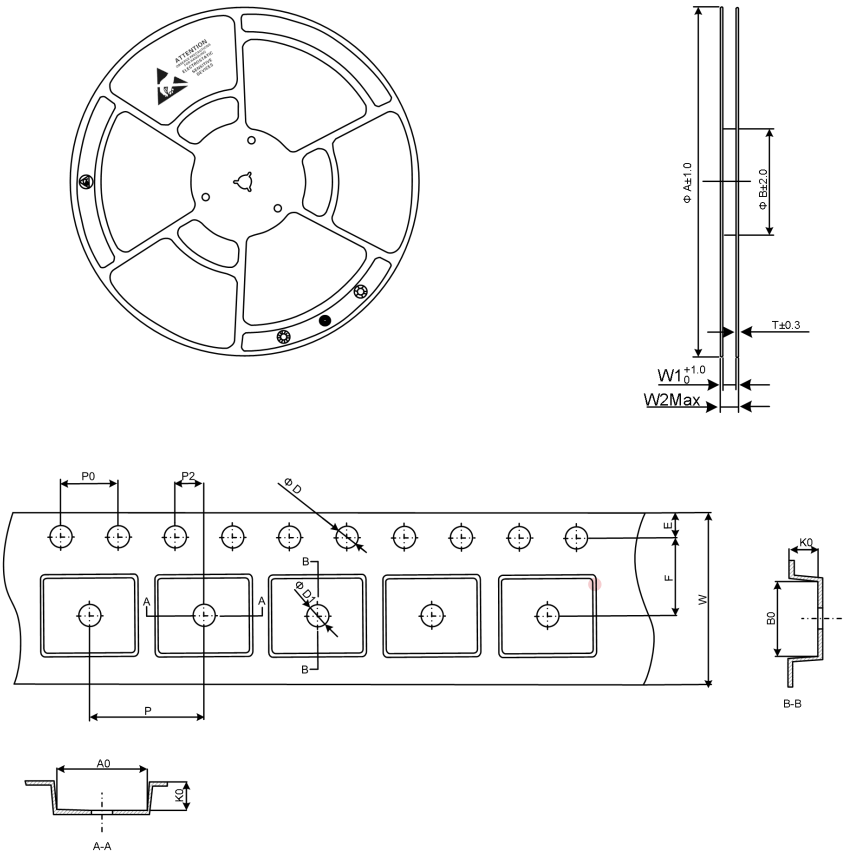

Reel Dimensions (mm)				
A	**B (Inner Diameter)**	**W1**	**W2 Max**	**T**
330	100	12.4	18.4	1.5

Tape Dimensions			
Symbol	**Dimensions (mm)**	**Symbol**	**Dimensions (mm)**
E	1.75±0.10	W	12.00±0.10
F	5.50±0.10	P	8.00±0.10
P2	2.00±0.10	A0	6.60±0.10
D	$1.50^{+0.1}_{-0}$	B0	5.30±0.10
D1	1.55±0.05	K0	1.90±0.10
P0	4.00±0.10		