

Power Distribution Switch

Features

- 60mΩ/70mΩ High-Side MOSFET
- Available with Current Limits with Foldback
- Operating Range: 2.7V to 5.5V
- 1mS Typical Rise Time
- Fast Overcurrent Response -1.5μs (TYPICAL)
- Under Voltage Lockout
- Logic Level Enable Pin, Available with Active-High or Active-Low Version
- No Reverse Current when Power Off
- Deglitched Open-Drain Over-Current Flag Output (FLAG)
- Output Reverse Current Protection
- TSOT-23-6, TDFN2x2-6 Packages (Halogen Free/Pb Free)

General Description

The XPA9553 is an integrated power switch for self-powered and bus-powered Universal Serial Bus (USB) applications.

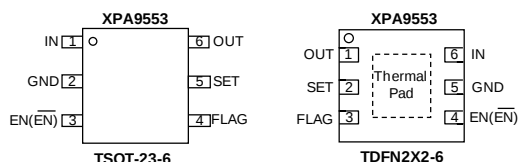
Several Protection features include current limiting and thermal shutdown to prevent catastrophic switch failure caused by increasing power dissipation when continuous heavy loads or short circuit occurs. A built-in charge pump is used to drive the N-channel MOSFET that is free of parasitic body diode to eliminate any reversed current flow across the switch when it is powered off. The output reverse-current protection turns off the MOSFET switch whenever the unexpected continuously reverse current occurs.

FLAG is an open-drain output report over-current or over-temperature event and has typical 9ms deglitch timeout period.

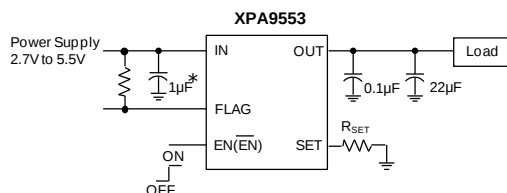
Applications

- High-Side Power Protection Switch
- USB Power Management
- USB Host and Self-Powered Hubs
- USB Bus-Powered Hubs
- Hot Plug-In Power Supplies
- Battery-Charger Circuits

Pin Configuration



Typical Application Circuit



*: 1μF of input capacitor is enough in most application cases.
If the PCB trace of power rail to IN is long, larger input capacitor is necessary.

Ordering Information

ORDER NUMBER	MARKING	ENABLE	Current Limit	Output MOS R _{DS(ON)}	Discharge Resistor	PACKAGE (Green)
XPA9553RA	53RA	Active High	SET	70mΩ	Yes	TSOT-23-6
XPA9553RB	53RB	Active Low	SET	70mΩ	Yes	TSOT-23-6
XPA9553RE	53RE	Active High	SET	60mΩ	Yes	TDFN2x2-6
XPA9553RF	53RF	Active Low	SET	60mΩ	Yes	TDFN2x2-6

Absolute Maximum Ratings

Terminal Voltage (with respect to GND)

IN Pin Voltage, V_{IN} -0.3V to +6.0V

OUT Pin Voltage, V_{OUT} -0.3V to +6.0V

EN Pin Voltage, V_{EN} -0.3V to +6.0V

SET Pin Voltage, V_{SET} -0.3V to $V_{IN}+0.3V$

FLAG Pin Voltage, V_{FLAG} -0.3V to +6.0V

Junction Temperature. 150°C

Storage Temperature (T_S) -65°C to +150°C

Reflow Temperature (soldering, 10sec) 260°C

ESD(HBM)⁽¹⁾ 2KV

ESD(MM) 200V

ESD(CDM) 1KV

Output ESD Protection 4KV

*Please refer to Minimum Footprint PCB Layout Section.

(1) Human body model is a 100pF capacitor discharged through a 1.5k Ω resistor into each pin.

Continuous Power Dissipation ($T_A=+25^\circ\text{C}$)*

TSOT-23-6 0.52W

TDFN2X2-6 0.55W

Thermal Resistance Junction to Ambient, (θ_{JA})*

TSOT-23-6 240°C/W

TDFN2X2-6 255°C/W

Thermal Resistance Junction to Case, (θ_{JC})

TSOT-23-6 60°C/W

TDFN2X2-6 63°C/W

Operating Ratings

Supply Voltage (V_{IN}) 2.7V to 5.5V

Operating Junction Temperature (T_J) . -40°C to 125°C

Electrical Characteristics

$V_{IN} = 5V$, $C_{IN} = 1\mu F$, $C_{OUT} = 1\mu F$, $R_L = 10\Omega$, $T_A = 25^\circ C$.

The device is not guaranteed to function outside its operating conditions. Parameters with MIN and/or MAX limits are 100% tested at $+25^\circ C$, unless otherwise specified.

DESCRIPTION	SYMBOL	CONDITION	MIN	TYP	MAX	UNIT
Operation Voltage	V_{IN}		2.7	---	5.5	V
Quiescent Current	I_Q	$V_{IN}=5V$, $I_{OUT}=0$, $EN(\overline{EN}) = \text{Active}$	$R_{SET} = 20k\Omega$	---	150	μA
			$R_{SET} = 100k\Omega$	---	135	
Off Supply Current	$I_{Q(OFF)}$	$V_{IN}=5.5V$, $EN(\overline{EN}) = \text{Inactive}$	---	0.6	1	μA
V_{IN} Under-Voltage Lockout	V_{UVLO}		1.7	2.1	2.4	V
Output MOS $R_{DS(ON)}$	$R_{DS(ON)}$	$I_{OUT}=2A$, $R_{SET}=10k\Omega$	TSOT-23-6	---	70	$m\Omega$
			TDFN2x2-6	---	60	
R_{SET} Resistor Range		$V_{IN}=3V$	20	---	100	$k\Omega$
		$V_{IN}=5V$	10	---	100	
Over Current Trigger Point	I_{LIM}	$R_{SET}=9.76k\Omega$	2.58	2.85	3.16	A
		$R_{SET}=11k\Omega$	2.25	2.5	2.75	
		$R_{SET}=24.9k\Omega$	0.9	1	1.1	
		$R_{SET}=37.4k\Omega$	0.6	0.7	0.8	
		$R_{SET}=49.9k\Omega$	0.425	0.5	0.575	
		$R_{SET}=75k\Omega$	0.264	0.3	0.4	
Short-Circuit Fold-Back Current	I_{SFB}	$R_{SET}=100k\Omega$	0.175	0.25	0.325	A
		$R_{SET}=11k\Omega$, $V_{IN}>3.5V$ and $V_{OUT}<1V$	---	1.67	---	
		$R_{SET}=24.9k\Omega$, $V_{IN}>3.5V$ and $V_{OUT}<1V$	---	0.67	---	
		$R_{SET}=37.4k\Omega$, $V_{IN}>3.5V$ and $V_{OUT}<1V$	---	0.47	---	
		$R_{SET}=49.9k\Omega$, $V_{IN}>3.5V$ and $V_{OUT}<1V$	---	0.33	---	
EN Input Threshold-High V_{IH}	$V_{EN(H)}$	$V_{IN}=2.7V$ to $5.5V$	1.4	---	---	V
			---	---	0.6	
EN Input Threshold-Low V_{IL}	$V_{EN(L)}$	$V_{IN}=2.7V$ to $5.5V$	---	---	0.6	V
Output Turn-on Rising Time	T_r	$R_{LOAD}=100\Omega$, $C_{OUT}=1\mu F$, 90% Settling	$V_{IN}=5V$	1.0	1.5	ms
			$V_{IN}=3.3V$	1.6	2	
FLAG Deglitch	T_{FLAG}	FLAG assertion or deassertion	5	8	15	ms
Shutdown OUT Pull Low Resistance			---	600	900	Ω
t_{IOS} Response Time to Short Circuit	t_{IOS}	$V_{IN}=5V$, see figure 1, 2	---	1.5	---	μs
Output Reverse-Current threshold			0.2	2	---	A
Output Reverse-Current Deglitch Time		$V_{IN}=5V$	---	5	---	ms
Over Current Regulation Time	T_{REG}	$V_{IN}=5V$	---	9	---	ms
Over Current Protection Time	T_{OCP}	$V_{IN}=5V$	---	64	---	ms
Thermal Shutdown	OT	Rising temperature	---	150	---	$^\circ C$
	OT _{HYS}	Hysteresis	---	20	---	

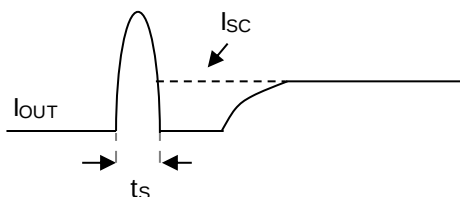


Figure 1

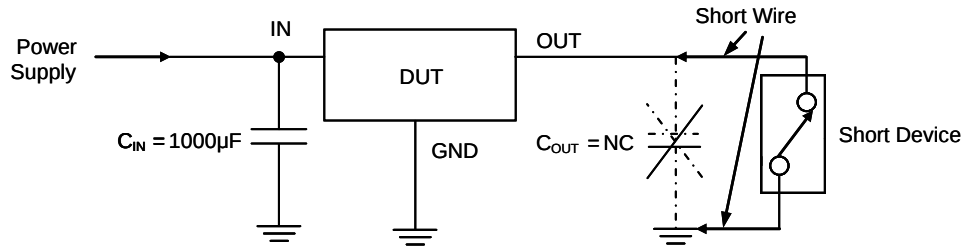


Figure 2

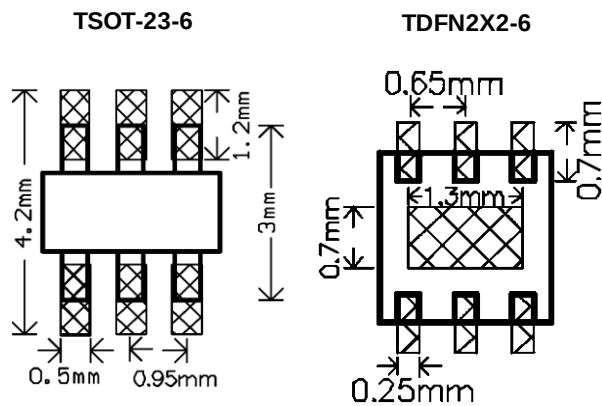
Note:

To exactly identify the short circuit characteristic of IC, avoid the test result interfered by parasitic inductor, output capacitor, and contact resistor. It is necessary to follow the recommendation as follows.

Please,

1. Add 1000μF of capacitor between V_{IN} and GND, and close to IC.
2. Remove output capacitor.
3. Shorter the short circuit device wire.
4. Measure output current (I_{OUT}).

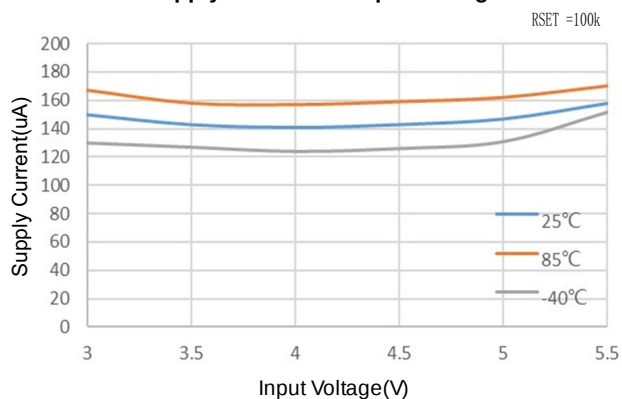
Minimum Footprint PCB Layout Section



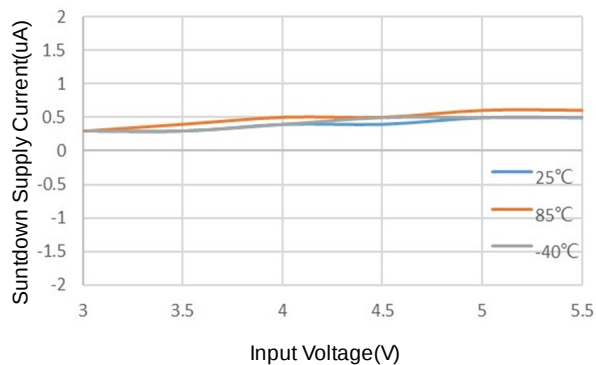
Typical Performance Characteristics

XPA9553, $V_{IN}=5V$, $C_{IN}=1\mu F$, $C_{OUT}=1\mu F$, $T_A=25^\circ C$, unless otherwise noted.

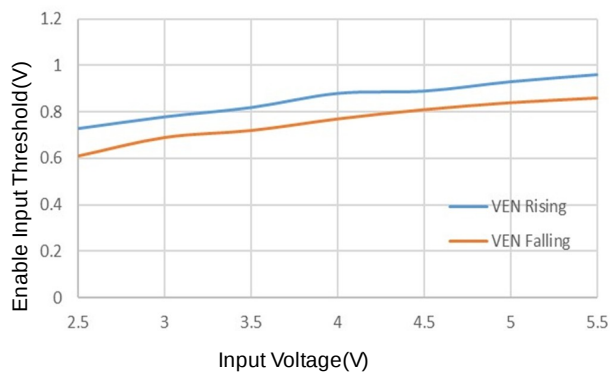
Supply Current vs. Input Voltage



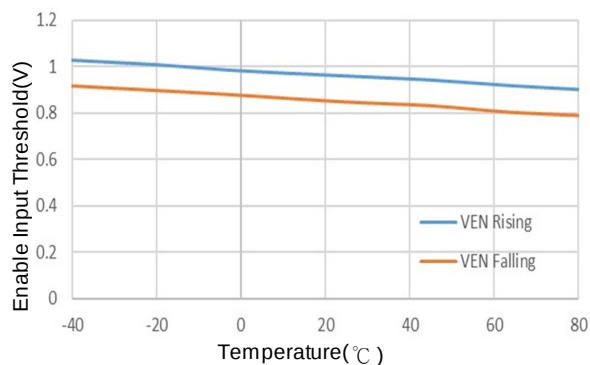
Shutdown Supply Current vs. Input Voltage



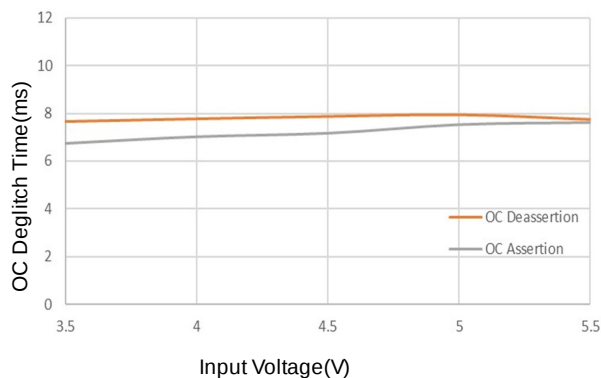
Enable Input Threshold vs. Input Voltage



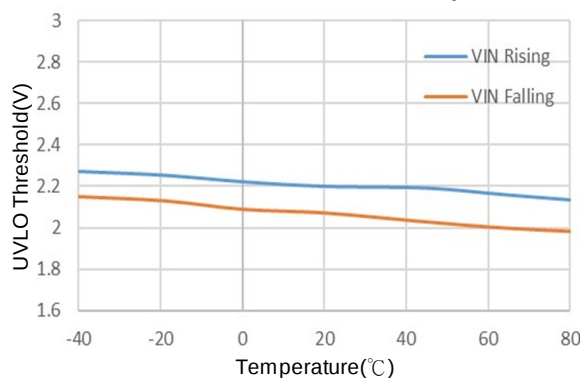
Enable Input Threshold



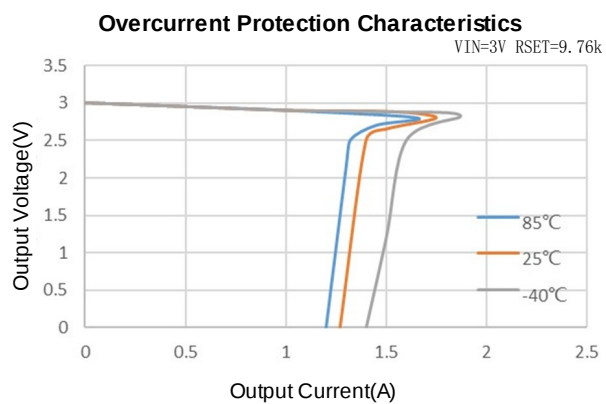
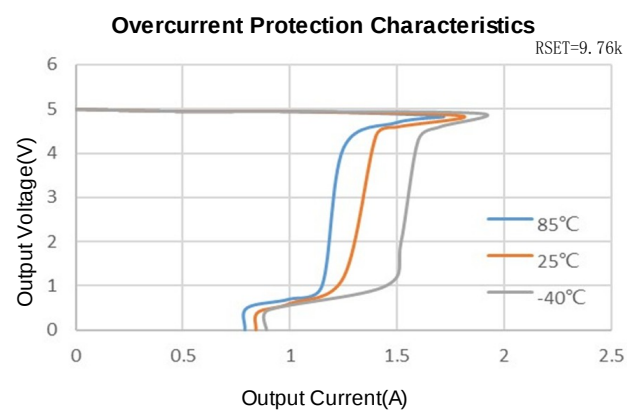
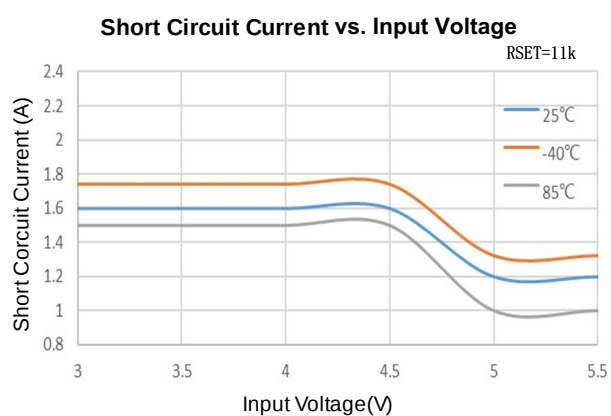
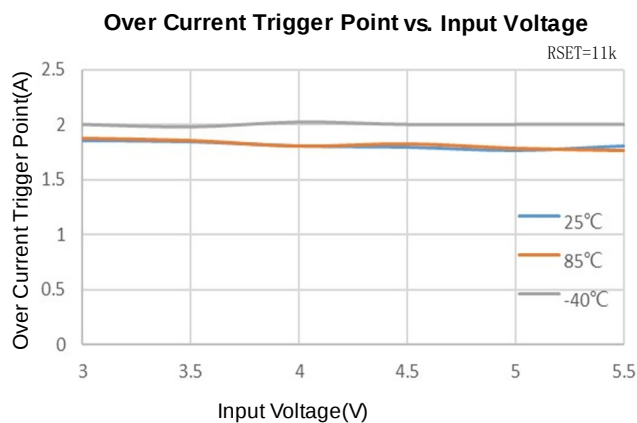
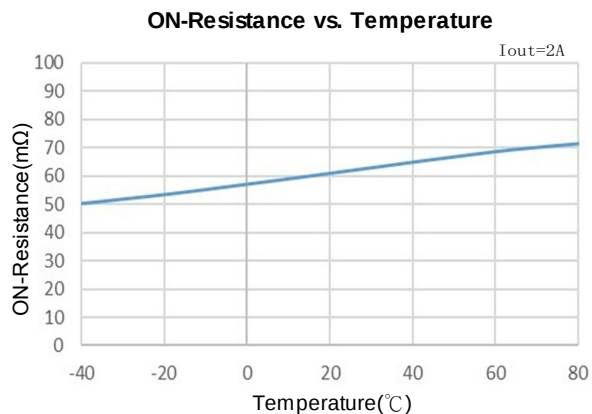
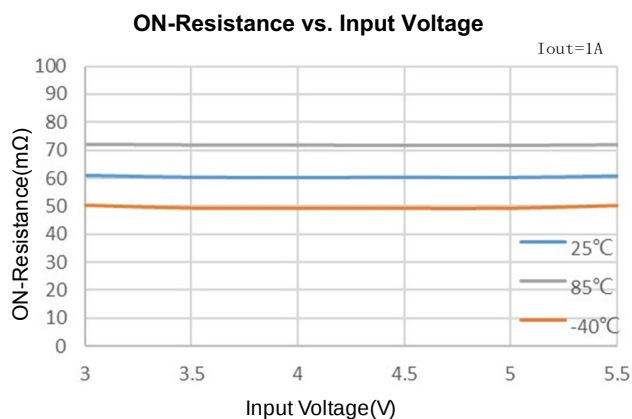
OC Deglitch Time vs. Input Voltage



VIN UVLO Threshold vs. Temperature

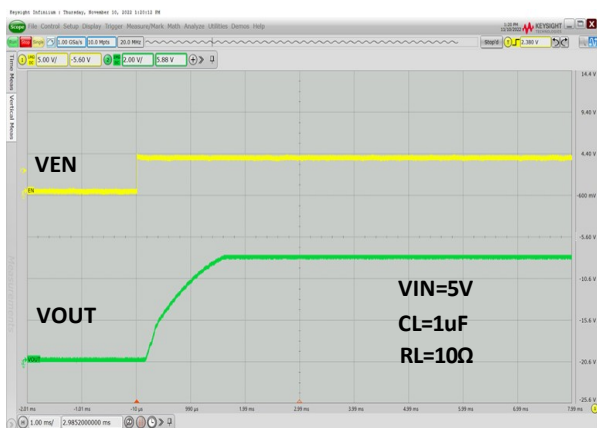


Typical Performance Characteristics (Continued)



Typical Performance Characteristics (Continued)

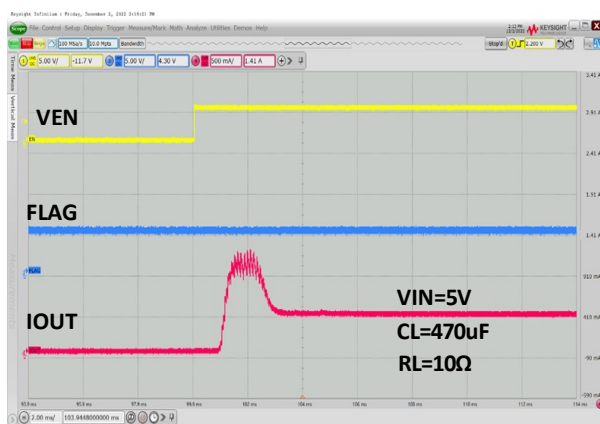
Turn on Delay Time and Rise Time



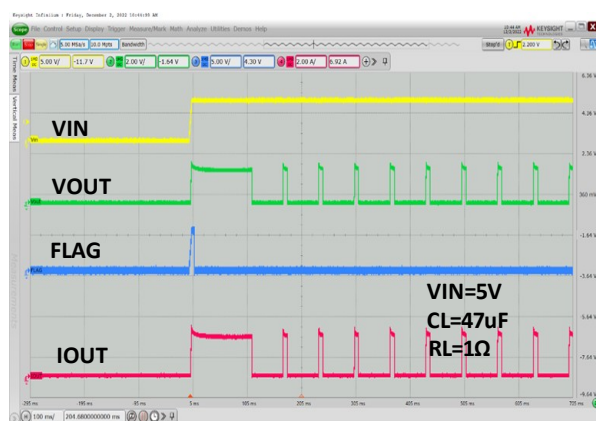
Turn off Delay Time and Fall Time



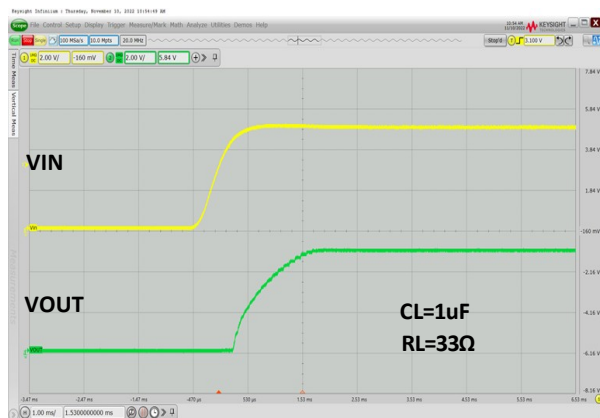
Inrush Current with Load Capacitance



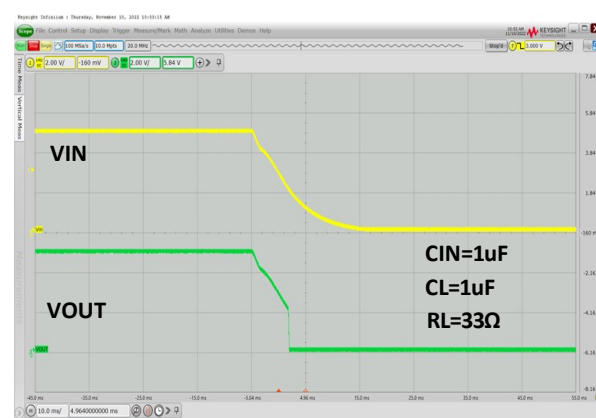
Thermal shut down Response



UVLO Protection at Rising

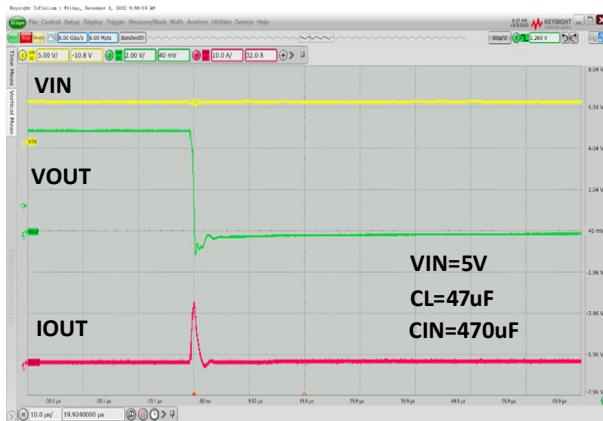


UVLO Protection at Falling

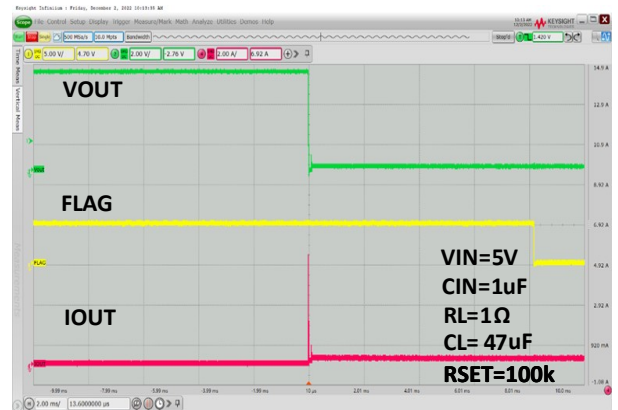


Typical Performance Characteristics (Continued)

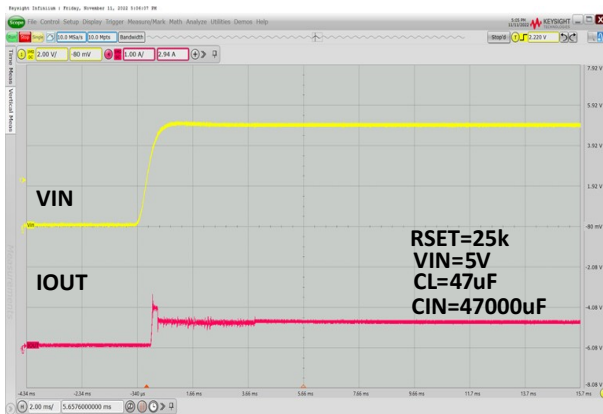
Inrush Short Circuit Response



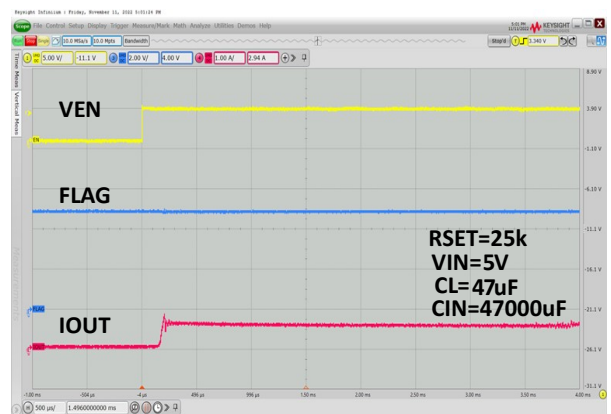
Resistance Load Inrush Response



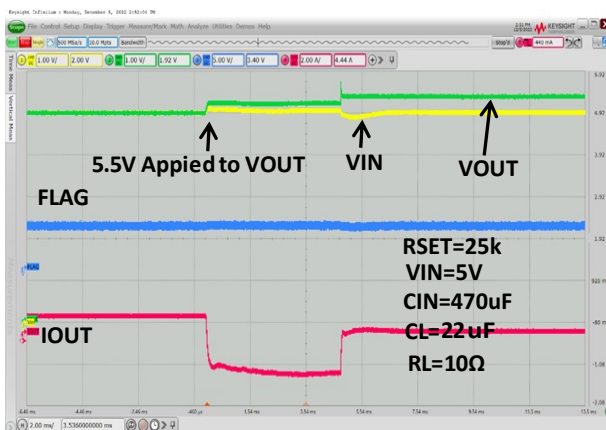
Short-Circuit Current, Device Enable into Short



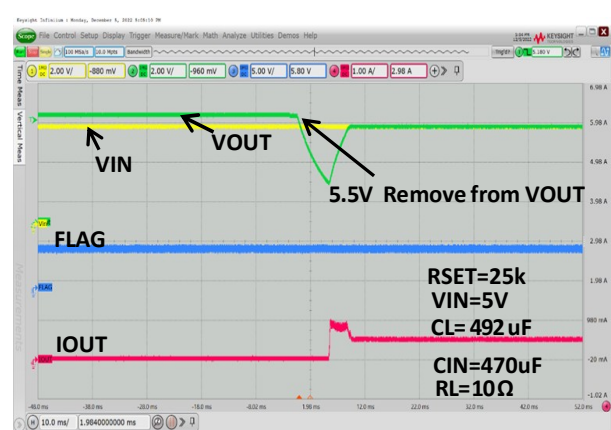
Short Circuit Response at Start up



Reverse-Current Protection Response



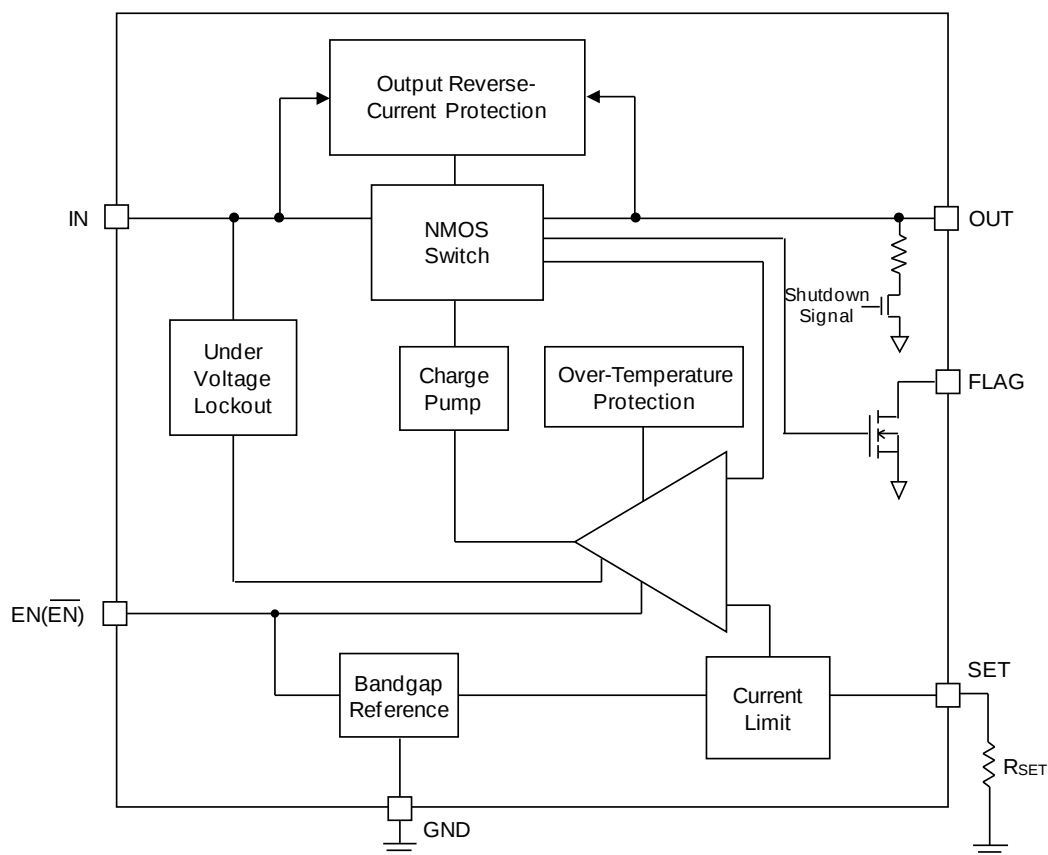
Reverse-Current Protection Recovery



Pin Description

PIN		NAME	FUNCTION
TSOT-23-6	TDFN2x2-6		
6	1	OUT	Switch Output
2	5	GND	Ground
4	3	FLAG	Open-Drain Fault Flag (Output): Indicates overcurrent, thermal shutdown
3	4	EN($\overline{\text{EN}}$)	Enable Logic Input
5	2	SET	Current limit set input
1	6	IN	Supply Voltage
	Thermal Pad		Recommend connecting the Thermal Pad to the GND for excellent power dissipation.

Block Diagrams



Functional Description

Input and Output

IN (input) is the power supply connection to the logic circuitry and the drain of the output MOSFET. OUT (output) is the source of the output MOSFET. In a typical application, current flows through the switch from IN to OUT toward the load. Both OUT pins must be connected together to the load.

Thermal Shutdown

Thermal shutdown protects XPA9553 from excessive power dissipation. If the die temperature exceeds aforementioned over-temperature spec, the MOSFET switch is shut off. The hysteresis prevents the switch from turning on until the die temperature drops to OT_{HYS} . Thermal shutdown circuit functions only when the switch is enabled.

Undervoltage Lockout

UVLO (undervoltage lockout) prevents the output MOSFET from turning on until IN (input voltage) exceeds 2.1/2.4V typically. After the switch turns on, if the voltage drops below 2.1/2.4V typically, UVLO shuts off the output MOSFET.

Over Current Trigger Point

The XPA9553 over current trigger point is programmed with a resistor from SET to ground. The typical value is determined by R_{SET} . We can choose the proper R_{SET} by Table1. There is short-circuit fold-back current limit when $V_{IN} > 3.5V$ and $V_{OUT} < 1V$.

Output Reverse Current Protection

The output reverse-current protection turns off the MOSFET switch whenever the unexpected continuously reverse current is higher than the 0.8/1.9/0.8A (typ) for 0.7/5/5ms (typ) and the MOSFET switch will turn on when output reverse-current condition is removed for 0.7/5/5ms (typ).

Discharge Function

When the device is disabled or IN is below UVLO threshold, the discharge function is active. The discharge function provides a discharge path for external storage capacitor by connecting a resistor between OUT and DSG.

FLAG Function

The FLAG open-drain output is asserted (active low) when an over current condition is encountered after a 9-ms deglitch timeout. The output remains asserted until the overcurrent condition is removed. Over temperature condition is also reported immediately by FLAG open-drain output.

Over Current Regulation and Protection

In over current condition, the temperature of the chip will rise. It results in thermal shutdown of the MOSFETs switch as over current condition is not removed. Then, the device enters in over current regulation and protection modes. In over current regulation mode, the current is regulated to the desired over current level and the MOSFETs switch is turned off in over current protection mode. The over current regulation and protection modes allow the device to release high thermal dissipation within temperature operation condition.

Soft-Start Protection

When power switch turns on, the soft-start protection is utilized to ensure 5ms(typ) on-time of power switch and all operation is recommended to be performed after this soft-start protection.

Applications Information

Supply Filtering

A 1 μ F bypass capacitor from IN to GND, located near the XPA9553, is strongly recommended to control supply transients. Without a bypass capacitor, an output short may cause sufficient ringing on the input (from supply lead inductance) to damage internal control circuitry.

Input transients must not exceed the absolute maximum supply voltage ($V_{IN\ max} = 6V$) even for a short duration.

EN, the Enable Input

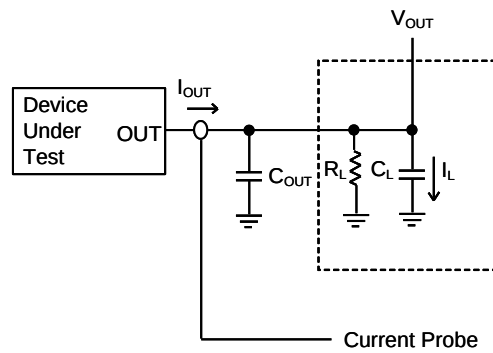
EN must be driven logic high or logic low for a clearly defined input. Floating the input may cause unpredictable operation. EN should not be allowed to go negative with respect to GND.

Table 1. Current Limit RSET Value

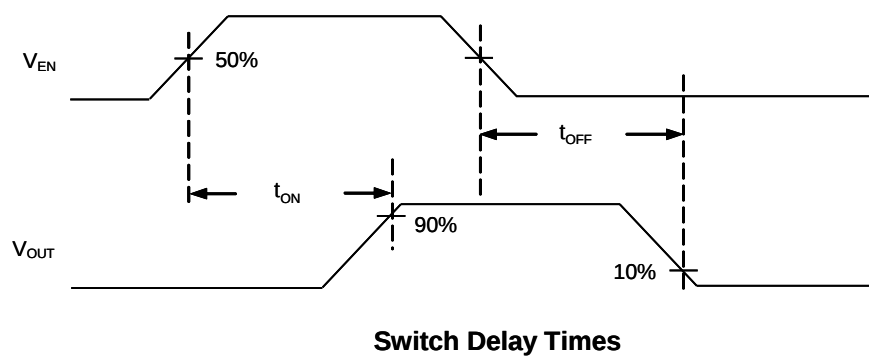
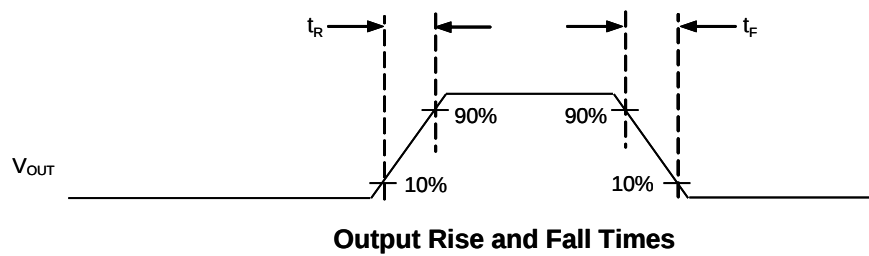
RSET(k Ω)	Current Limit Min (A)	Current Limit Typ (A)	Current Limit Max (A)
9.76	2.58 (-10%)	2.85	3.16 (+10%)
11	2.25 (-10%)	2.5	2.75 (+10%)
24.9	0.9 (-10%)	1.0	1.1 (+10%)
37.4	0.6 (-15%)	0.7	0.8 (+15%)
49.9	0.425 (-15%)	0.5	0.575 (+15%)
100	0.175 (-30%)	0.25	0.325 (+30%)

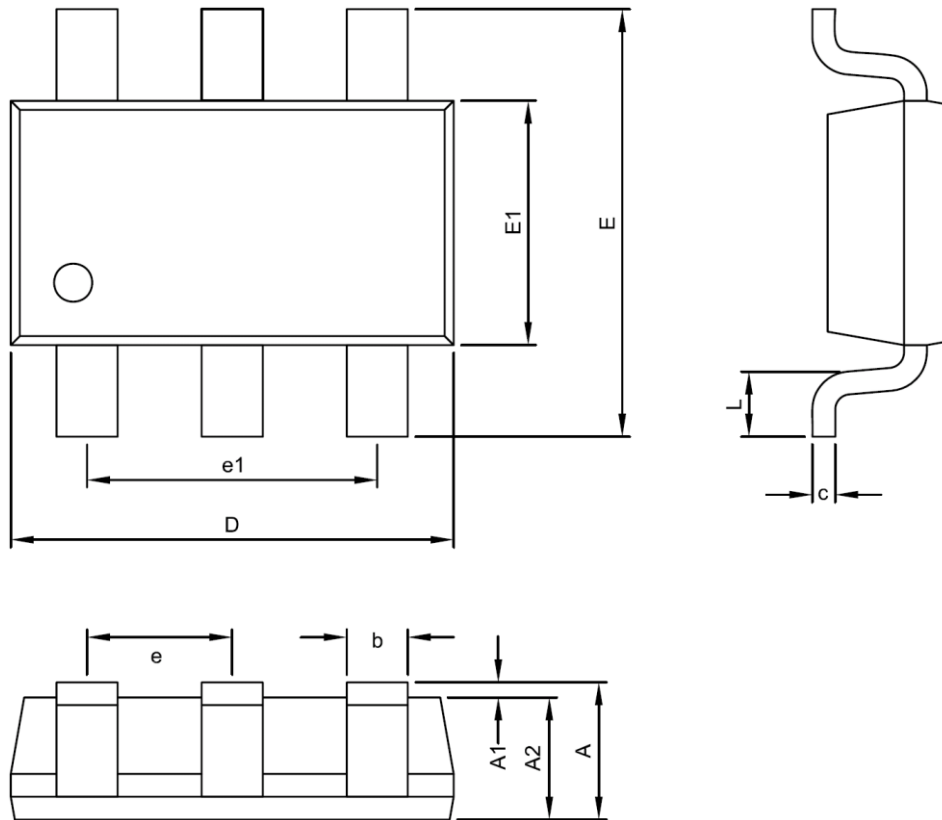
Note: The Relationship between RSET (K Ω) and Typical Current Limit (A) is about $Current\ Limit = 30.9/(RSET)^{1.05}$

Test Circuit



Timing Diagrams

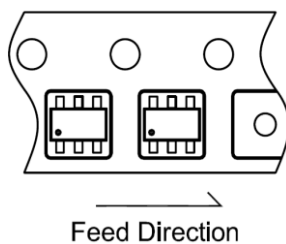




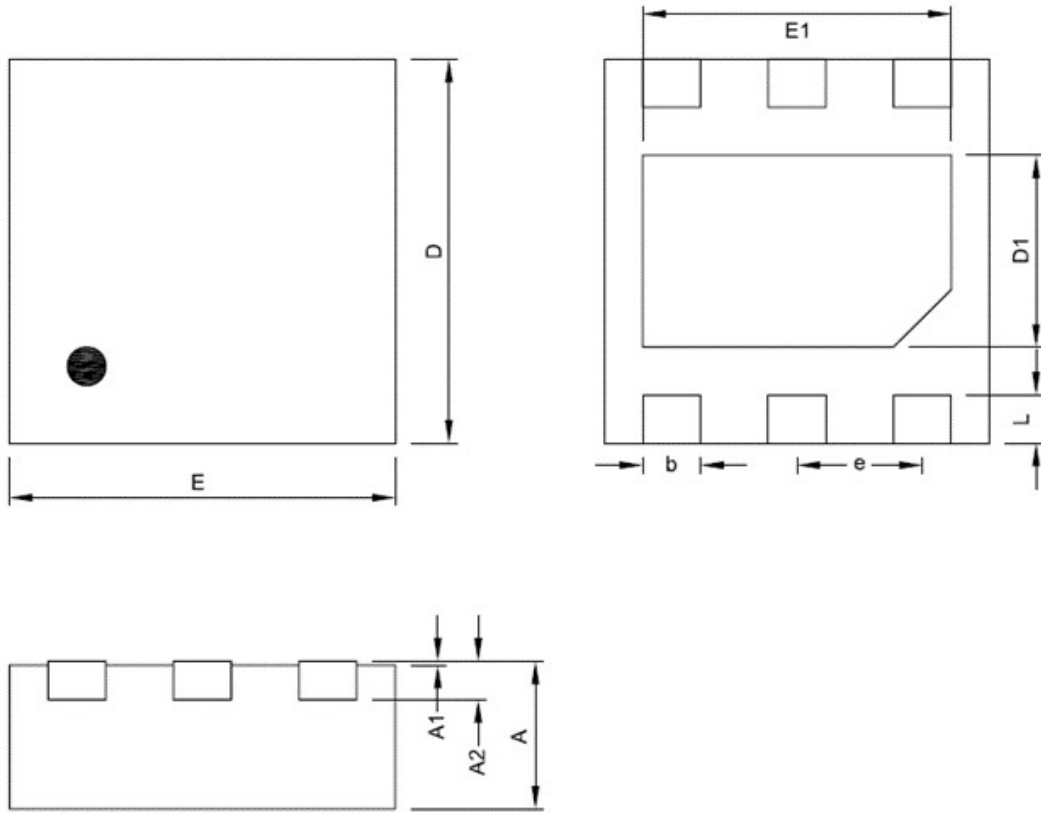
TSOT-23-6 Package

Symbol	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	---	---	0.90	---	---	0.035
A1	0.00	0.05	0.10	0.000	0.002	0.004
A2	0.70	0.75	0.80	0.028	0.030	0.031
D	2.70	2.90	3.10	0.106	0.114	0.122
E	2.60	2.80	3.00	0.102	0.110	0.118
E1	1.50	1.60	1.70	0.059	0.063	0.067
c	0.08	0.15	0.25	0.003	0.006	0.010
b	0.30	0.40	0.50	0.012	0.016	0.020
e	0.95 BSC			0.037 BSC		
e1	1.90 BSC			0.075 BSC		
L	0.30	0.45	0.60	0.012	0.018	0.024

Taping Specification



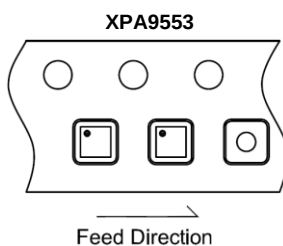
PACKAGE	Q'TY/REEL
TSOT-23-6	3,000 ea



TDFN2X2-6 Package

Symbol	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.0276	0.0295	0.0315
A1	0.00	---	0.05	0.0000	---	0.0020
A2	0.20 REF			0.0079 REF		
D	1.95	2.00	2.05	0.0768	0.0787	0.0807
E	1.95	2.00	2.05	0.0768	0.0787	0.0807
D1	0.90	1.00	1.10	0.0354	0.0394	0.0433
E1	1.50	1.60	1.65	0.0591	0.0630	0.0650
b	0.25	0.30	0.35	0.0098	0.0118	0.0138
e	0.65 BSC			0.0256 BSC		
L	0.20	0.25	0.30	0.0079	0.0098	0.0118

Taping Specification



PACKAGE	Q'TY/REEL
TDFN2X2-6	3,000 ea