TPU6013DK

Dual Channel, Ultra-Low Resistance Load Switch

Features

- Input voltage range : 0.8V to 5.5V
- Integrated dual channel load switch
- 6A maximum continuous switch current per channel
- Ultra low RON resistance 20mΩ per channel
- Adjustable output rising time
- Low quiescent current 75uA (dual channel)
- Adjustable output rising time
- Quick Output Discharge (QOD)
- Bias voltage supports : 2.5V and 5.5V
- Over Temperature Protection
- DFN3X2-14-pin package with Thermal Pad

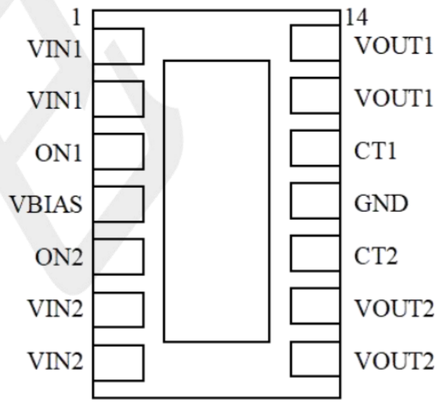
Applications

- USB Ports
- Notebook and Desktop Computers
- High-Side Power Protection Switchs
- Consumer Electronics
- Telecom Systems
- Digital TV
- USB Device Power Switch
- Set-top boxes/Residental gateway

General Description

The is a small, ultra-low RON, dual channel load switch with controlled turn on. The device contains two N-channel MOSFETs that can operate over an input voltage range of 0.8V to 5.5V and can support a maximum continuous current of 6A per channel. Each switch is independently controlled by an on/off input (ON1 and ON2), which is capable of interfacing directly with low-voltage control signals. a 220-Ω on-chip load resistor is added for quick output discharge when switch is turned off.

The is available in a small,space-saving DFN3X2 package with integrated thermal pad allowing for high power dissipation.



Pin Configurations

Pin Name	Pin No.	Pin Function
VIN1	1 / 2	Switch #1 input. Bypass this input with a ceramic capacitor to GND. Recommended voltage range for this pin for optimal R_{ON} performance is 0.8V to VBIAS. (VIN1≦VBIAS)
ON1	3	Active high switch #1 control input. Do not leave floating.
VBIAS	4	Bias voltage. Power supply to the device. Recommended voltage range for this pin is 2.5V to 5.5V.
ON2	5	Active high switch #2 control input. Do not leave floating.
VIN2	6 / 7	Switch #2 input. Bypass this input with a ceramic capacitor to GND. Recommended voltage range for this pin for optimal R_{ON} performance is 0.8V to VBIAS.(VIN2≦VBIAS)
VOUT2	8 / 9	Switch #2 output.
CT2	10	Switch #2 slew rate control. Can be left floating.
GND	11	Ground
CT1	12	Switch #1 slew rate control. Can be left floating.
VOUT1	13 / 14	Switch #1 output.
Thermal PAD	15	Thermal pad (exposed center pad) to alleviate thermal stress. Tie to GND.

Absolute Maximum Ratings (Note1)

		MIN	MAX	UNIT
VIN1,2	Continuous input voltage range	-0.3	6.0	V
VOUT1,2	Output voltage range	-0.3	6.0	
VBIAS	BIAS pin voltage range	-0.3	6.0	
VON1,2	ON pin voltage range	-0.3	6.0	
Maximum	Peak Switch Current Per Channel, Pulse<300uS, 2% Duty	8		A
	Switch Current Per Channel, I_{MAX}	6		
PD	Power Dissipation, PD @ TA = 25℃,	1.53		W
Temperature	Lead Temperature (Soldering, 10 sec.)	260		℃
	Junction Temperature , TJ	-40	150	
	Storage, Tstg	-65	150	
θ_{JA}	Thermal Resistance from Junction to ambient (Note 2)	65		°C/W
ESD susceptibility (Note3)	HBM (Human Body Mode)	2000		V
	MM (Machine Mode)	200		
	CDM (Charged-Device Model)	1000		

Recommended Operating Conditions (Note4)

		MIN	MAX	UNIT
VIN1,2	Supply Input Voltage	0.8	5.5	V
VOUT1,2	Output voltage range	2.5	5.5	
VBIAS	BIAS voltage	2.5	5.5	
VON1,2	High-level input voltage	1.2	5.5	
	Low-level input voltage	0	0.6	
Temperature	Junction Temperature , TJ	-40	125	℃
	Ambient Temperature	-40	85	
CIN1,2	Input capacitor	≧1		uF

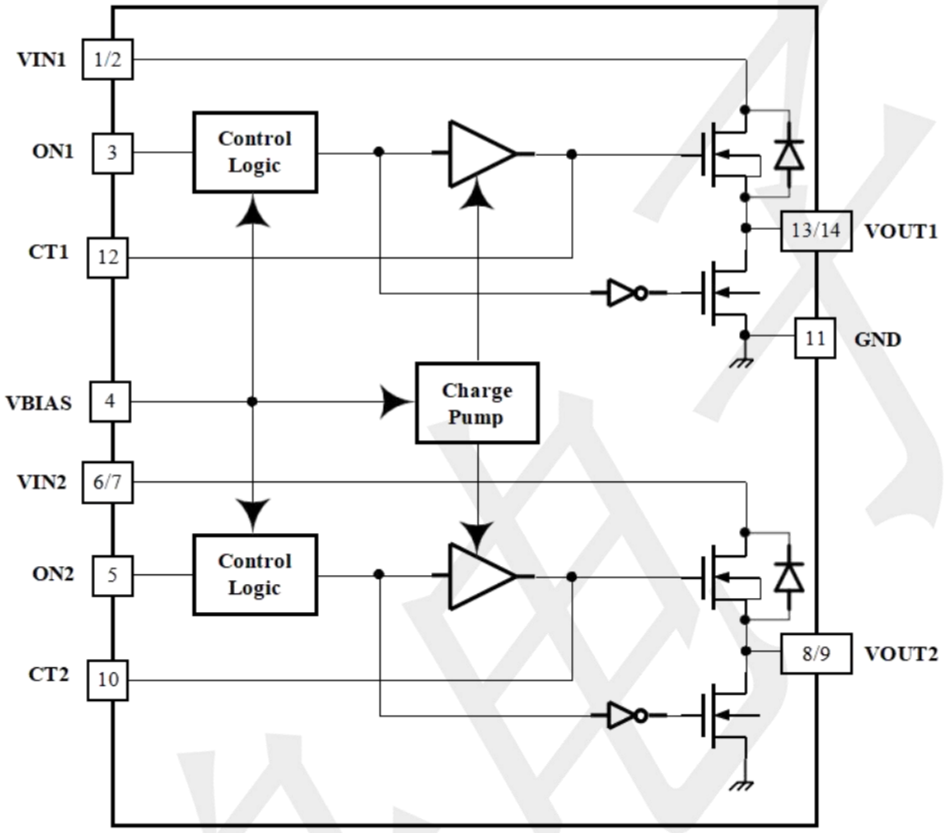
Note 1. Stresses listed as the above “Absolute Maximum Ratings” may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

Note 2. θ_{JA} is measured in the natural convection at TA =25℃ on a 4-layers high effective thermal conductivity test board with minimum copper area of JEDEC 51-7 thermal measurement standard.

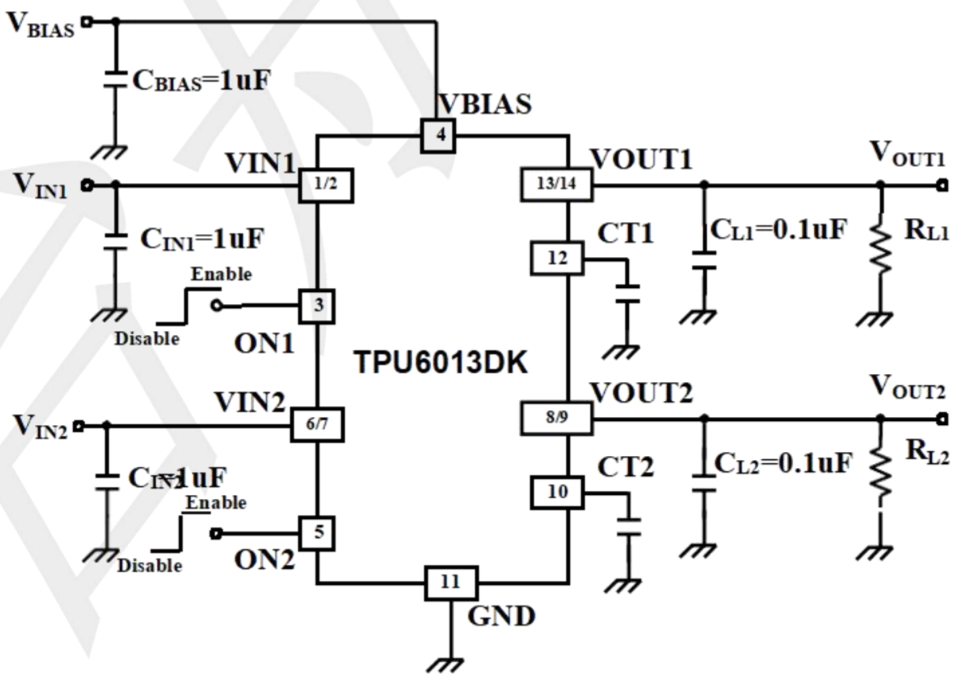
Note 3. Devices are ESD sensitive. Handling precaution is recommended.

Note 4. The device is not guaranteed to function outside its operating conditions.

BLOCK DIAGRAM



Typical Application Circu



Electrical Characteristics

(VBIAS= 5V, TA=25℃, unless otherwise specified)

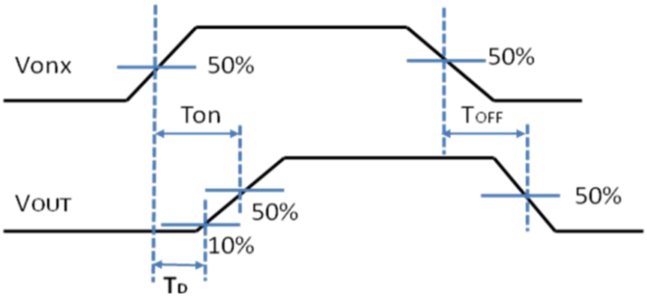
Parameter	Symbol	Test Conditions		Min	Typ	Max	Units
Power Supplies and Currents Section							
VBIAS Quiescent current (both channels)	$I_{BIAS-ON-both}$	$I_{OUT1} = I_{OUT2} = 0$, $V_{IN1,2} = V_{ON1,2} = V_{BIAS} = 5V$			75	100	uA
VBIAS Quiescent current (single channel)	$I_{BIAS-ON-single}$	$I_{OUT1} = I_{OUT2} = 0$, $V_{ON2} = 0V$ $V_{IN1,2} = V_{ON1} = V_{BIAS} = 5V$			60		uA
VBIAS Shutdown current	$I_{BIAS-OFF}$	$V_{OUT1,2} = 0V$, $V_{ON1,2} = 0V$ $V_{IN1,2} = V_{BIAS} = 5V$				2	uA
$V_{IN1,2}$ Off state supply current (per channel)	$I_{VIN-OFF}$	$V_{OUT1,2} = 0V$, $V_{ON1,2} = 0V$	$V_{IN1,2} = 5.0V$			2	uA
			$V_{IN1,2} = 3.3V$			2	
			$V_{IN1,2} = 1.8V$			2	
			$V_{IN1,2} = 0.8V$			1	
ON pin leakage current	I_{ON}	$V_{ON} = 5.5V$				1	uA
Resistance Section							
ON-state Resistance	R_{ON}	I_{OUT}=200 mA, $V_{BAIS} = 5.0V$	$V_{IN} = 5.0V$		20	25	mΩ
			$V_{IN} = 3.3V$		20	25	
			$V_{IN} = 1.8V$		20	25	
			$V_{IN} = 1.5V$		20	25	
			$V_{IN} = 1.2V$		20	25	
			$V_{IN} = 0.8V$		20	25	
Output Pull-down Resistance	R_{PD}	$V_{IN} = 5.0V$, $V_{ON} = 0V$, $I_{OUT} = 15mA$			220	300	Ω

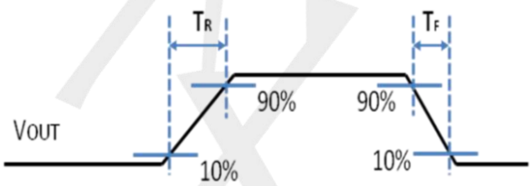
Electrical Characteristics

(VBIAS= 2.5V, TA=25℃, unless otherwise specified)

Parameter	Symbol	Test Conditions		Min	Typ	Max	Units
Power Supplies and Currents Section							
VBIAS Quiescent current (both channels)	$I_{BIAS\text{-}ON\text{-}both}$	$I_{OUT1} = I_{OUT2} = 0$, $V_{IN1,2} = V_{ON1,2} = V_{BIAS} = 2.5V$			25	37	uA
VBIAS Quiescent current (single channel)	$I_{BIAS\text{-}ON\text{-}single}$	$I_{OUT1} = I_{OUT2} = 0$, $V_{ON2} = 0V$ $V_{IN1,2} = V_{ON1} = V_{BIAS} = 2.5V$			20		uA
VBIAS Shutdown current	$I_{BIAS\text{-}OFF}$	$V_{OUT1,2} = 0V$, $V_{ON1,2} = 0V$ $V_{IN1,2} = V_{BIAS} = 2.5V$				2	uA
$V_{IN1,2}$ Off state supply current (per channel)	$I_{VIN\text{-}OFF}$	$V_{OUT1,2} = 0V$, $V_{ON1,2} = 0V$	$V_{IN1,2} = 2.5V$			2	uA
			$V_{IN1,2} = 1.8V$			2	
			$V_{IN1,2} = 1.2V$			2	
			$V_{IN1,2} = 0.8V$			1	
ON pin leakage current	I_{ON}	$V_{ON} = 5.5V$				1	uA
Resistance Section							
ON-state Resistance	R_{ON}	I_{OUT}=200 mA, $V_{BAIS} = 2.5V$	$V_{IN} = 2.5V$		22	29	mΩ
			$V_{IN} = 1.8V$		22	29	
			$V_{IN} = 1.5V$		22	29	
			$V_{IN} = 1.2V$		22	29	
			$V_{IN} = 0.8V$		22	29	
Output Pull-down Resistance	R_{PD}	$V_{IN} = 2.5V$, $V_{ON} = 0V$, $I_{OUT} = 1mA$			260	320	Ω
ON Input Supply							
High-level input voltage	$V_{ON\text{-}H}$			1.2			V
Low-level input voltage	$V_{ON\text{-}L}$					0.6	V
Over Temperature Protection							
Over Temperature Protection	T_{OTP}				150		℃
Hysteresis	T_{HYS}				30		℃

Switching Timing Diagrams





Switching characteristics

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
V_{IN}=V_{ON}=V_{BIAS}=5V, T_A=25°C						
Turn-on time	T_{ON}	R_L=10Ω, C_L=0.1uF, C_T=1000pF		1200		uS
Turn-off time	T_{OFF}	R_L=10Ω, C_L=0.1uF, C_T=1000pF		6		uS
Vout Rising time	T_R	R_L=10Ω, C_L=0.1uF, C_T=1000pF		1700		uS
Vout falling time	T_F	R_L=10Ω, C_L=0.1uF, C_T=1000pF		7		uS
ON Delay time	T_D	R_L=10Ω, C_L=0.1uF, C_T=1000pF		200		uS
V_{IN}=0.8V, V_{ON}=V_{BIAS}=5V, T_A=25°C						
Turn-on time	T_{ON}	R_L=10Ω, C_L=0.1uF, C_T=1000pF		360		uS
Turn-off time	T_{OFF}	R_L=10Ω, C_L=0.1uF, C_T=1000pF		10		uS
Vout Rising time	T_R	R_L=10Ω, C_L=0.1uF, C_T=1000pF		300		uS
Vout falling time	T_F	R_L=10Ω, C_L=0.1uF, C_T=1000pF		4		uS
ON Delay time	T_D	R_L=10Ω, C_L=0.1uF, C_T=1000pF		200		uS
V_{IN}=V_{ON}= V_{BIAS}=3.3V, T_A=25°C						
Turn-on time	T_{ON}	R_L=10Ω, C_L=0.1uF, C_T=1000pF		1900		uS
Turn-off time	T_{OFF}	R_L=10Ω, C_L=0.1uF, C_T=1000pF		8		uS
Vout Rising time	T_R	R_L=10Ω, C_L=0.1uF, C_T=1000pF		2300		uS
Vout falling time	T_F	R_L=10Ω, C_L=0.1uF, C_T=1000pF		7		uS
ON Delay time	T_D	R_L=10Ω, C_L=0.1uF, C_T=1000pF		500		uS
V_{IN}=0.8V, V_{ON}= V_{BIAS}=3.3V, T_A=25°C						
Turn-on time	T_{ON}	R_L=10Ω, C_L=0.1uF, C_T=1000pF		900		uS
Turn-off time	T_{OFF}	R_L=10Ω, C_L=0.1uF, C_T=1000pF		10		uS
Vout Rising time	T_R	R_L=10Ω, C_L=0.1uF, C_T=1000pF		700		uS
Vout falling time	T_F	R_L=10Ω, C_L=0.1uF, C_T=1000pF		4		uS
ON Delay time	T_D	R_L=10Ω, C_L=0.1uF, C_T=1000pF		500		uS

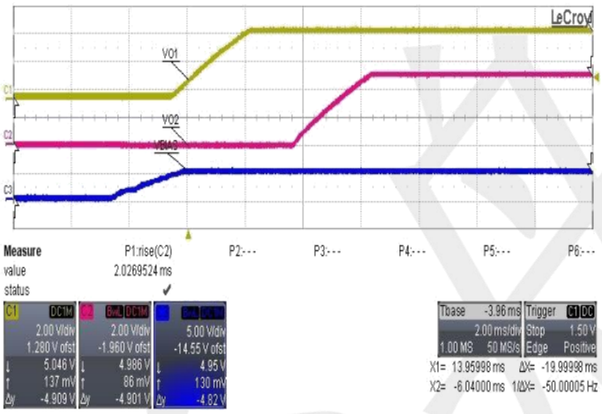
Output Rising Time Control

The table as below contains rise time values measured on a typical device. Rise time shown below are only valid for the power-on sequence where VIN and VBIAS are already in steady state condition, and the VON is high.

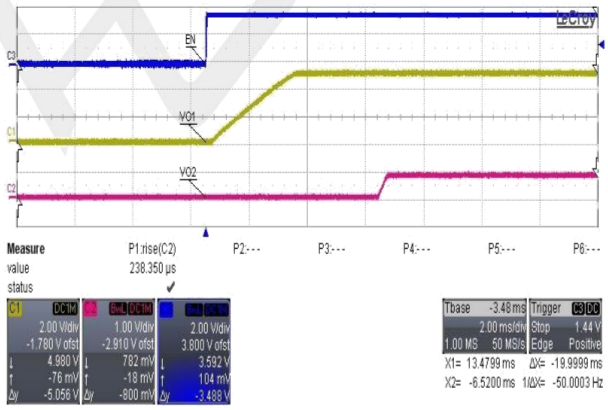
Rise Time (us)		10%-90% Vo Rising Time, V_{ON}=V_{BIAS}=5V,R_L=10Ω, C_{IN}=1uF, C_L=0.1uF, T_A=25℃						
	CT (nF)	**0.8V**	**1.05V**	**1.5V**	**1.8V**	**2.5V**	**3.3V**	**5V**
TPU6013DK	**0**	38.5	45.4	60.1	67.4	82.4	99.7	127.6
	0.22	101	123	169	189	273	343	501
	0.47	164	206	294	352	489	646	979
	1	315	398	526	651	861	1204	1890
	2.2	654	823	1140	1470	1930	2680	4180
	4.7	1370	1790	2590	3080	4280	5570	8680
	10	3080	4660	5290	6380	8930	12000	18100

Typical Operating Characteristics(VBIAS=5V；CIN=1uF；CL=0.1uF；TA=25℃)

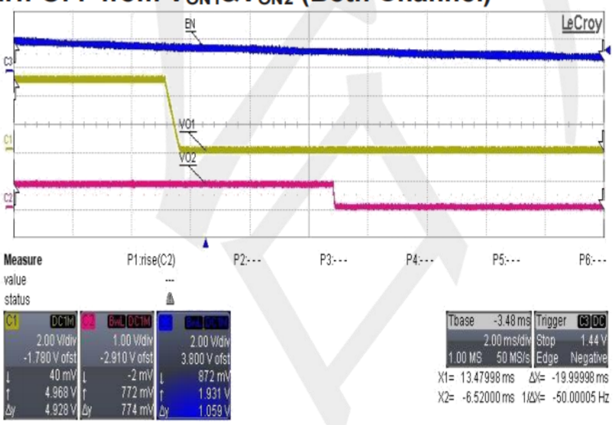
Turn-ON from V_{BIAS} (Both Channel)



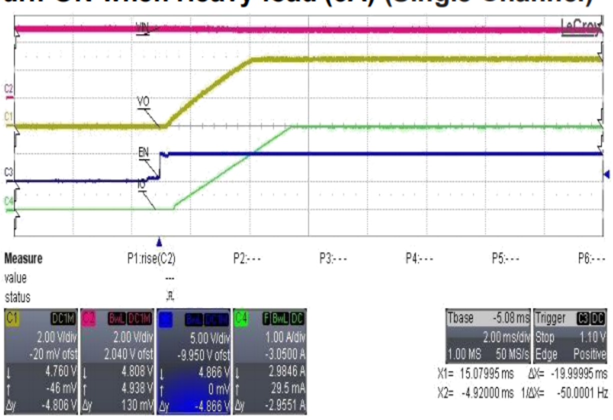
Turn-ON from V_{ON1}&V_{ON2} (Both Channel)



Turn-OFF from V_{ON1}&V_{ON2} (Both Channel)

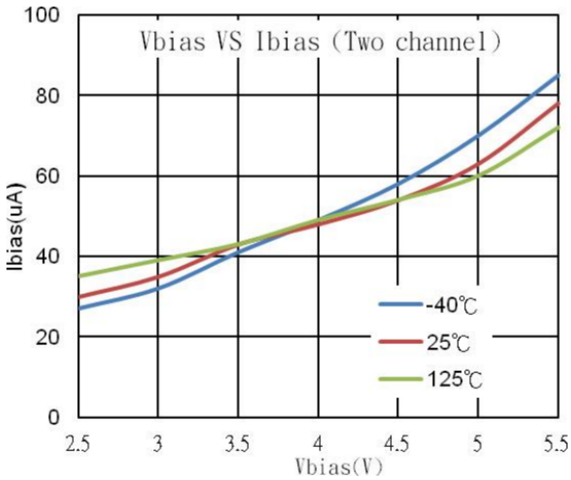


Turn-ON when Heavy load (3A) (Single Channel)

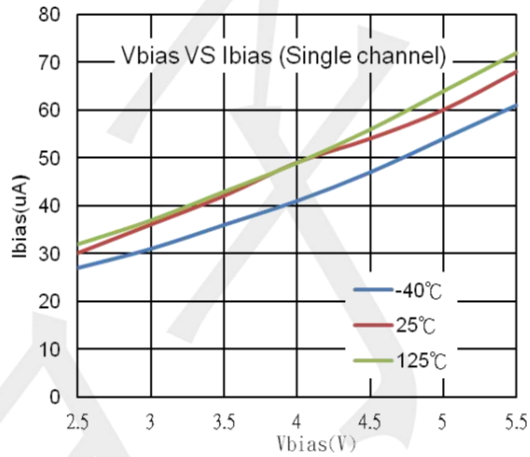


Typical Operating Characteristics

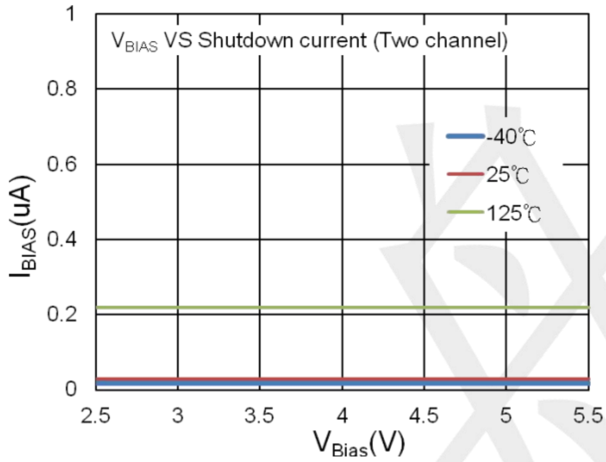
VBIAS vs. Quiescent Current
(Two Channel)



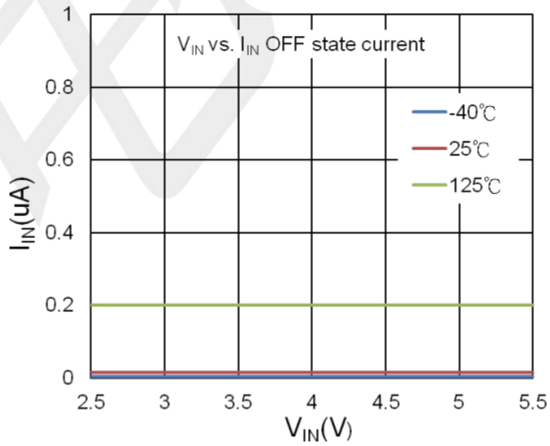
VBIAS vs. Quiescent Current
(Single Channel)



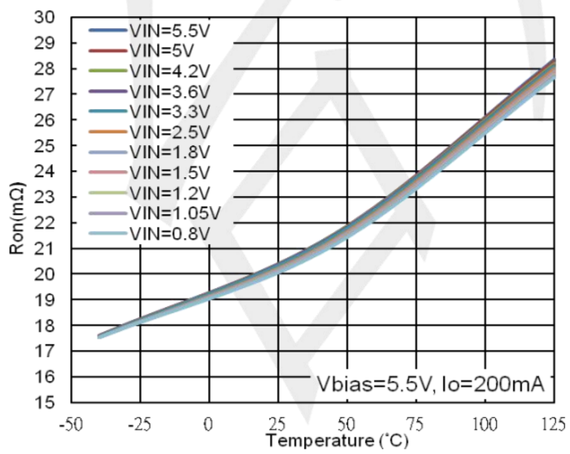
V_{BIAS} vs. Shutdown Current (Two Channel)



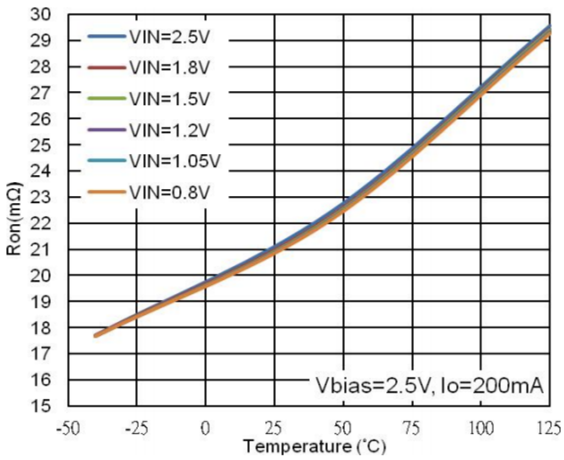
V_{IN} vs. OFF-State Supply Current



R_{ON} vs. Temperature (V_{BIAS}=5.5V)

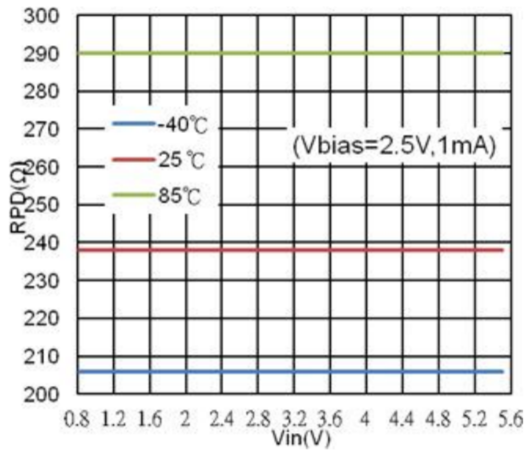


R_{ON} vs. Temperature (V_{BIAS}=2.5V)

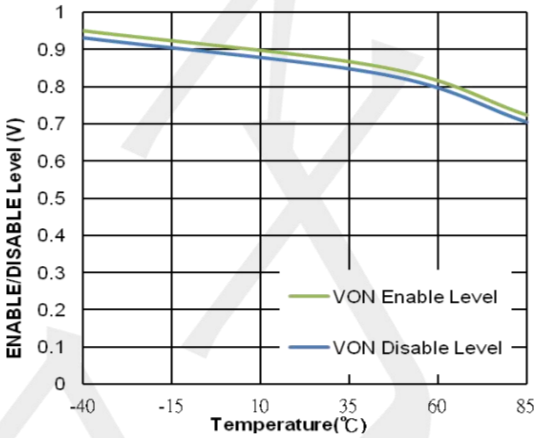


Typical Operating Characteristics

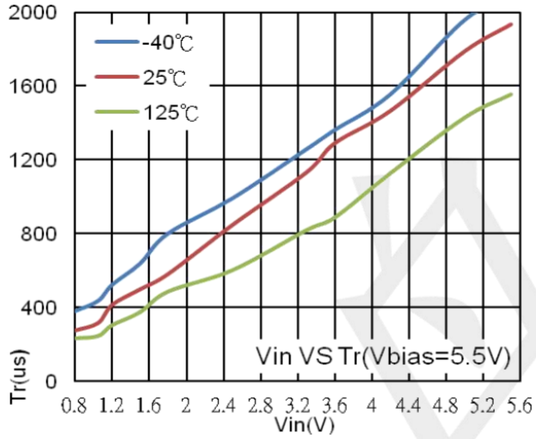
V_{IN} vs. RPD (V_{BIAS}=2.5V)



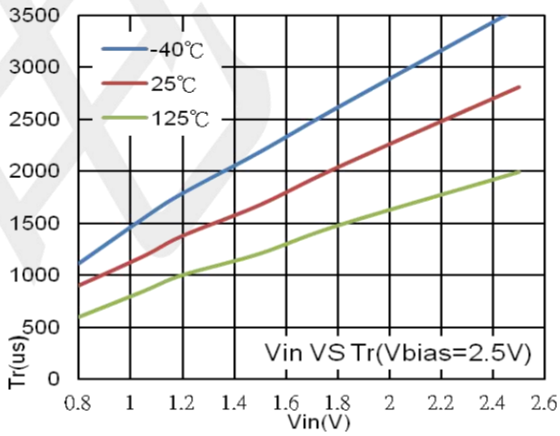
V_{ON} Threshold vs. Temperature



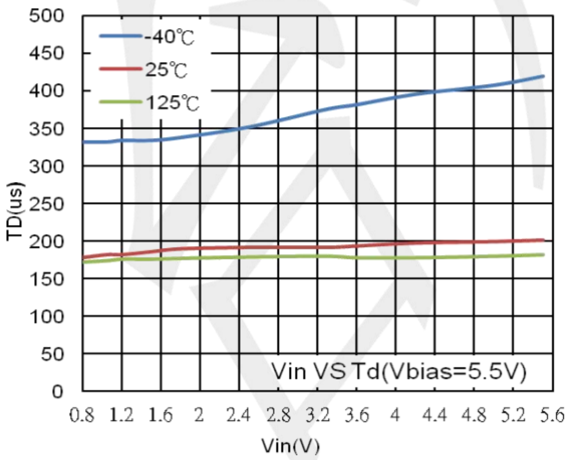
V_{IN} vs. TR (CT=1nF, V_{BIAS}=5.5V)



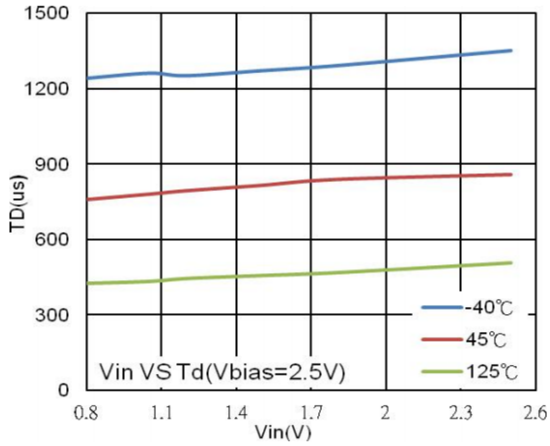
V_{IN} vs. TR (CT=1nF, V_{BIAS}=2.5V)



V_{IN} vs. TD (CT=1nF, V_{BIAS}=5.5V)



V_{IN} vs.TD (CT=1nF, V_{BIAS}=2.5V)



Functional Description

On-Resistance

The MOSFET gate voltage in the is driven by an internal charge pump. The output voltage of the charge pump is dependent on the voltage on VBIAS pin. Care must be taken to ensure a sufficient VBIAS is used to keep the desired R_{ON} when given the anticipated input voltage.

ON/OFF Control

The is enabled if the voltage of the Von pin is greater than logic high level and the VBIAS voltage has an adequate applied. If the voltage of the ON pin is less than logic low level, the device will be disabled.

Input Capacitor

The do not require an input capacitor. In order to limit the voltage drop on the input supply caused by transient inrush current, an input bypass capacitor is recommended.A 1uF cerami capacitor should be placed as closed as possible to the VIN pin. Higher values capacitor can help to further reduce the voltage drop.

Output Capacitor

Due to the integrated body diode in the NMOS switch, the CIN greater than CL is highly recommended. A CIN to CL ratio of 10 to 1 is recommended for minimizing VIN drop caused by inrush during startup. It also helps to prevent parasitic inductance forces VOUT below GND when switching off. Output capacitor has minimal affect on device’s turn on slew rate time.

Slew Rate Control

The slew rate of each channel output voltage can be controlled by the capacitor on the CT pin to GND which provides soft start functionality. This limits the inrush current caused by capacitor charging.

Thermal and Layout Consideration

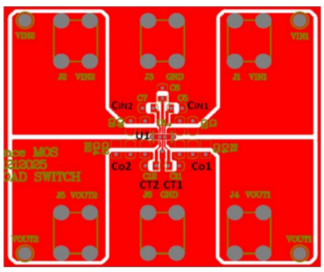
The is designed to maintain a constant output load current. Due to physical limitations of the chip layout and assembly of the device the maximum switch current is 6A for each channel, the figure below show an example of typical PCB layout. All copper traces for the VIN and VOUT pin should be widely and short to carry the maximum continuous current and obtain the best effect. The input and output capacitor (option) should be close to the device as possible to minimize the parasitic trace inductances and prevents the voltage drop when load transient.

The maximum IC junction temperature should be restricted to 125 ℃ under normal operating conditions. To calculate the maximum allowable dissipation, PD(MAX) for a given output current and ambient temperature, used the following equation

$$P_{D(MAX)} = \frac{T_{J(MAX)} - T_A}{\theta_{JA}}$$

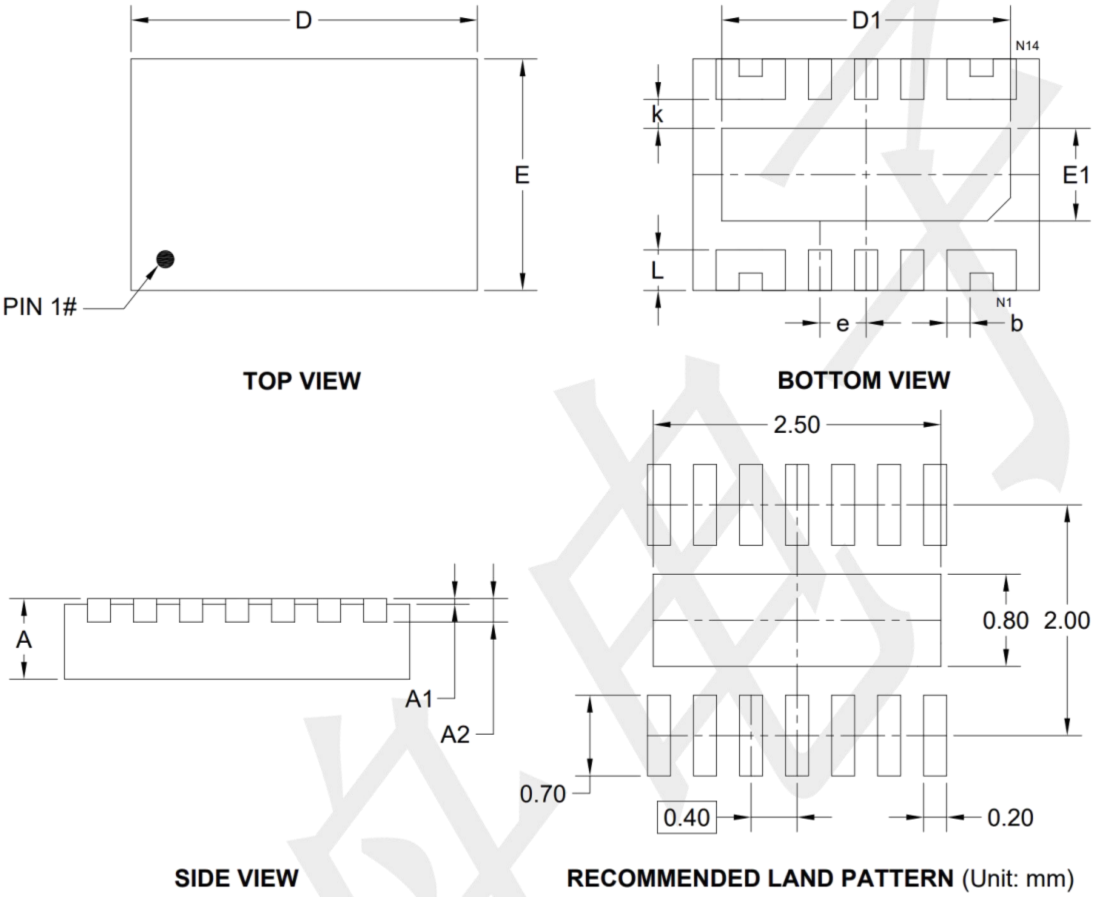
Where:

PD(MAX)=Maximum allowable power dissipation TJ(MAX)=Maximum allowable junction temperature (125℃)TA=Ambient Temperature of the device ΘJA= Junction to air thermal impedance. This parameter is also dependent upon PCB laypout.



Package informantion (unit: mm)

DFN3X2-14L



Symbol	Dimensions In Millimeters		
	MIN	MOD	MAX
A	0.700	0.750	0.800
A1	0.000	-	0.050
A2	0.203 REF		
b	0.130	0.200	0.250
D	3.000 BSC		
D1	2.400	2.500	2.600
E	2.000 BSC		
E1	0.700	0.800	0.900
k	0.250 REF		
L	0.300	0.350	0.400
e	0.400 BSC		