SGM2596/SGM2596D
5.7V, 6A, 16mΩ On-Resistance Dual-Channel Load Switches

GENERAL DESCRIPTION

The SGM2596 and SGM2596D are 16mΩ (TYP) on-resistance, integrated two N-MOSFETs, dual-channel load switches. The devices can operate over a wide input voltage range of 0.6V to 5.7V. Each channel can support a 6A maximum continuous load current and is independently controlled by the ONx pin (ON1 or ON2). The V_{OUTx} rise time can be programmed by setting an additional capacitor to the CTx pin.

The devices have thermal shutdown function. When the junction temperature exceeds +160 ℃, the inner N-MOSFET will be turned off through the thermal shutdown circuitry, and will remain off until the die temperature drops below +140℃. The SGM2596D also has quick output discharge function when the switch is disabled.

The SGM2596 and SGM2596D are both available in a Green TDFN-3×2-14AL package. They are rated over the -40℃ to +105℃ temperature range.

FEATURES

- **Input Voltage Range: 0.6V to V_{BIAS}**
- **V_{BIAS} Voltage Range: 2.5V to 5.7V**
- **On-Resistance: 16mΩ/Channel**
- **Maximum Continuous Load Current: 6A/Channel**
- **Quiescent Current: 22μA (TYP)**
- **Support with 1.2V, 1.8V, 2.5V and 3.3V GPIOs**
- **Programmable Output Ramp Time**
- **Thermal Shutdown**
- **Quick Output Discharge (SGM2596D Only)**
- **-40℃ to +105℃ Operating Temperature Range**
- **Available in a Green TDFN-3×2-14AL Package**

APPLICATIONS

Notebook and Tablet Computers
Portable and Handheld Devices
Set-Top Boxes and Residential Gateways
Solid-State Drives (SSD)

TYPICAL APPLICATION

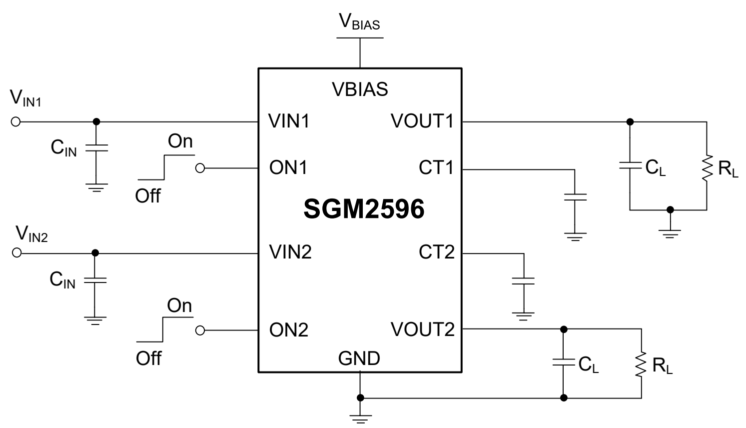


Figure 1. Typical Application Circuit

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM2596	TDFN-3×2-14AL	-40℃ to +105℃	SGM2596GTES14G/TR	2596 XXXX	Tape and Reel, 3000
SGM2596D	TDFN-3×2-14AL	-40℃ to +105℃	SGM2596DGTES14G/TR	2596D XXXX	Tape and Reel, 3000

MARKING INFORMATION

NOTE: XXXX = Date Code and Trace Code.

XXXX

Trace Code

Date Code - Year

Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

ABSOLUTE MAXIMUM RATINGS

Input Voltage, V_{INx} .... -0.3V to 6V
Bias Voltage, V_{BIAS} .... -0.3V to 6V
Output Voltage, V_{OUTx} .... -0.3V to 6V
ONx Pin Voltage, V_{ONx} .... -0.3V to 6V
Maximum Continuous Load Current 6A/Channel
Maximum Pulsed Switch Current, Pulse < 300μs, 3% Duty Cycle 8A/Channel
Package Thermal Resistance
TDFN-3×2-14AL, θ_{JA} .... 63℃/W
TDFN-3×2-14AL, $\theta_{JC\ (top)}$ .... 46℃/W
Junction Temperature ....+150℃
Storage Temperature Range ....-65℃ to +150℃
Lead Temperature (Soldering, 10s) ....+260℃
ESD Susceptibility
HBM 4000V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Input Voltage, V_{INx} .... 0.6V to V_{BIAS}
Bias Voltage, V_{BIAS} ....2.5V to 5.7V
Output Voltage, V_{OUTx} .... < V_{INx}
ONx Pin Voltage, V_{ONx} ....0V to 5.7V
High Level Input Voltage, V_{IH}
V_{BIAS} = 2.5V to 5V, T_J < +85℃ ....1.05V to 5.7V
V_{BIAS} = 2.5V to 5.7V, T_J < +105℃ ....1.2V to 5.7V
Low Level Input Voltage, V_{IL}
V_{BIAS} = 2.5V to 5.7V ....0V to 0.4V
Input Capacitor, C_{IN} .... > 1μF
Operating Ambient Temperature Range...... .-40℃ to +105℃
Operating Junction Temperature Range ......-40℃ to +125℃

OVERSTRESS CAUTION

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions section is not implied.

ESD SENSITIVITY CAUTION

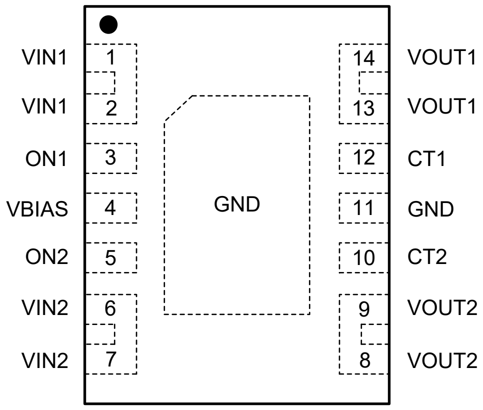
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because even small parametric changes could cause the device not to meet the published specifications.

DISCLAIMER

SG Micro Corp reserves the right to make any change in circuit design, or specifications without prior notice.

PIN CONFIGURATION

(TOP VIEW)



TDFN-3×2-14AL

PIN DESCRIPTION

PIN	NAME	TYPE	FUNCTION
1, 2	VIN1	I	Switch 1 Input Pin. Voltage range is 0.6V to V_{BIAS}. A decoupling capacitor between VIN1 and GND is recommended and the capacitor should be placed close to device pins.
3	ON1	I	Switch 1 Enable Pin. High level is active. Do not float this pin.
4	VBIAS	I	Power Supply Pin for Internal Circuitry. V_{BIAS} voltage range is 2.5V to 5.7V. It is recommended to decouple V_{BIAS} with 0.1μF or greater ceramic capacitor.
5	ON2	I	Switch 2 Enable Pin. High level is active. Do not float this pin.
6, 7	VIN2	I	Switch 2 Input Pin. Voltage range is 0.6V to V_{BIAS}. A decoupling capacitor between VIN2 and GND is recommended and the capacitor should be placed close to device pins.
8, 9	VOUT2	O	Switch 2 Output Pin.
10	CT2	O	Switch 2 Soft-Start Pin. A capacitor between this pin and GND determines the slew rate of V_{OUT2}. The capacitor voltage rating used on this pin must be 10V or above. It also can be left floating.
11	GND	G	Ground.
12	CT1	O	Switch 1 Soft-Start Pin. A capacitor between this pin and GND determines the slew rate of V_{OUT1}. The capacitor voltage rating used on this pin must be 10V or above. It also can be left floating.
13, 14	VOUT1	O	Switch 1 Output Pin.
Exposed Pad	GND	G	Ground.

NOTE: I: input, O: output, G: ground.

ELECTRICAL CHARACTERISTICS

(V_{BIAS} = 5V, typical values are at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Power Supplies and Currents							
VBIAS Quiescent Current (Both Channels)	I_{Q_VBIAS}	I_{OUT1} = I_{OUT2} = 0mA, V_{IN1} = V_{IN2} = V_{ON1} = V_{ON2} = 5V	T_J = -40℃ to +85℃		22	32	μA
			T_J = -40℃ to +105℃			33	
VBIAS Quiescent Current (Single Channel)		I_{OUT1} = I_{OUT2} = 0mA, V_{ON2} = 0V, V_{IN1} = V_{IN2} = V_{ON1} = 5V	T_J = -40℃ to +85℃		22	32	μA
			T_J = -40℃ to +105℃			33	
VBIAS Shutdown Current	I_{SD_VBIAS}	V_{ON1} = V_{ON2} = 0V, V_{OUT1} = V_{OUT2} = 0V	T_J = -40℃ to +105℃		0.006	0.5	μA
VIN Shutdown Current per Channel	I_{SD_VIN}	V_{ONx} = 0V, V_{OUTx} = 0V, V_{INx} = 5V	T_J = -40℃ to +85℃		0.009	0.7	μA
			T_J = -40℃ to +105℃			1.7	
		V_{ONx} = 0V, V_{OUTx} = 0V, V_{INx} = 3.3V	T_J = -40℃ to +85℃		0.008	0.5	
			T_J = -40℃ to +105℃			1.1	
		V_{ONx} = 0V, V_{OUTx} = 0V, V_{INx} = 1.8V	T_J = -40℃ to +85℃		0.003	0.5	
			T_J = -40℃ to +105℃			0.8	
		V_{ONx} = 0V, V_{OUTx} = 0V, V_{INx} = 0.6V	T_J = -40℃ to +85℃		0.001	0.4	
			T_J = -40℃ to +105℃			0.6	
ONx Pin Input Leakage Current	I_{ON}	V_{ONx} = 5.5V	T_J = -40℃ to +105℃			0.4	μA
Resistance Characteristics							
On-Resistance per Channel	R_{ON}	I_{OUTx} = -200mA, V_{INx} = 5V	T_J = +25℃		17	23	mΩ
			T_J = -40℃ to +85℃			27	
			T_J = -40℃ to +105℃			28	
		I_{OUTx} = -200mA, V_{INx} = 3.3V	T_J = +25℃		16	23	
			T_J = -40℃ to +85℃			26	
			T_J = -40℃ to +105℃			28	
		I_{OUTx} = -200mA, V_{INx} = 1.8V	T_J = +25℃		16	23	
			T_J = -40℃ to +85℃			26	
			T_J = -40℃ to +105℃			28	
		I_{OUTx} = -200mA, V_{INx} = 1.2V	T_J = +25℃		16	23	
			T_J = -40℃ to +85℃			26	
			T_J = -40℃ to +105℃			27	
		I_{OUTx} = -200mA, V_{INx} = 1.05V	T_J = +25℃		16	23	
			T_J = -40℃ to +85℃			26	
			T_J = -40℃ to +105℃			27	
		I_{OUTx} = -200mA, V_{INx} = 0.6V	T_J = +25℃		16	23	
			T_J = -40℃ to +85℃			26	
			T_J = -40℃ to +105℃			27	
ONx Pin Hysteresis	V_{ON_HYS}	V_{INx} = 5V	T_J = +25℃		48		mV
Output Pull-Down Resistance (SGM2596D Only)	R_{PD}	V_{INx} = V_{OUTx} = 5V, V_{ONx} = 0V	T_J = -40℃ to +105℃		198	268	Ω
Thermal Shutdown Temperature	T_{SD}	Temperature rising			160		℃
Thermal Shutdown Hysteresis	T_{HYS}	Temperature falling			20		℃

ELECTRICAL CHARACTERISTICS (continued)

(V_{BIAS} = 2.5V, typical values are at T_J = +25℃, unless otherwise noted.)

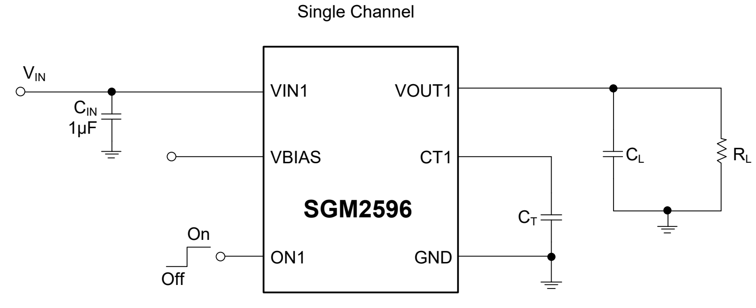
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Power Supplies and Currents							
VBIAS Quiescent Current (Both Channels)	I_{Q_VBIAS}	I_{OUT1} = I_{OUT2} = 0mA, V_{IN1} = V_{IN2} = V_{ON1} = V_{ON2} = 2.5V	T_J = -40℃ to +85℃		16	24	μA
			T_J = -40℃ to +105℃			25	
VBIAS Quiescent Current (Single Channel)		I_{OUT1} = I_{OUT2} = 0mA, V_{ON2} = 0V, V_{IN1} = V_{IN2} = V_{ON1} = 2.5V	T_J = -40℃ to +85℃		17	25	μA
			T_J = -40℃ to +105℃			26	
VBIAS Shutdown Current	I_{SD_VBIAS}	V_{ON1} = V_{ON2} = 0V, V_{OUT1} = V_{OUT2} = 0V	T_J = -40℃ to +105℃		0.002	0.5	μA
VIN Shutdown Current per Channel	I_{SD_VIN}	V_{ONx} = 0V, V_{OUTx} = 0V, V_{INx} = 2.5V	T_J = -40℃ to +85℃		0.006	0.5	μA
			T_J = -40℃ to +105℃			0.9	
		V_{ONx} = 0V, V_{OUTx} = 0V, V_{INx} = 1.8V	T_J = -40℃ to +85℃		0.005	0.5	
			T_J = -40℃ to +105℃			0.8	
		V_{ONx} = 0V, V_{OUTx} = 0V, V_{INx} = 1.05V	T_J = -40℃ to +85℃		0.003	0.4	
			T_J = -40℃ to +105℃			0.7	
		V_{ONx} = 0V, V_{OUTx} = 0V, V_{INx} = 0.6V	T_J = -40℃ to +85℃		0.002	0.5	
			T_J = -40℃ to +105℃			0.7	
ONx Pin Input Leakage Current	I_{ON}	V_{ONx} = 5.5V	T_J = -40℃ to +105℃			0.4	μA
Resistance Characteristics							
On-Resistance per Channel	R_{ON}	I_{OUTx} = -200mA, V_{INx} = 2.5V	T_J = +25℃		16	23	mΩ
			T_J = -40℃ to +85℃			27	
			T_J = -40℃ to +105℃			28	
		I_{OUTx} = -200mA, V_{INx} = 1.8V	T_J = +25℃		16	23	
			T_J = -40℃ to +85℃			26	
			T_J = -40℃ to +105℃			28	
		I_{OUTx} = -200mA, V_{INx} = 1.5V	T_J = +25℃		16	23	
			T_J = -40℃ to +85℃			26	
			T_J = -40℃ to +105℃			28	
		I_{OUTx} = -200mA, V_{INx} = 1.2V	T_J = +25℃		16	23	
			T_J = -40℃ to +85℃			26	
			T_J = -40℃ to +105℃			28	
		I_{OUTx} = -200mA,V_{INx} = 1.05V	T_J = +25℃		16	23	
			T_J = -40℃ to +85℃			26	
			T_J = -40℃ to +105℃			28	
		I_{OUTx} = -200mA, V_{INx} = 0.6V	T_J = +25℃		16	23	
			T_J = -40℃ to +85℃			26	
			T_J = -40℃ to +105℃			28	
ONx Pin Hysteresis	V_{ON_HYS}	V_{INx} = 2.5V	T_J = +25℃		45		mV
Output Pull-Down Resistance (SGM2596D Only)	R_{PD}	V_{INx} = V_{OUTx} = 2.5V, V_{ONx} = 0V	T_J = -40℃ to +105℃		369	526	Ω
Thermal Shutdown Temperature	T_{SD}	Temperature rising			160		℃
Thermal Shutdown Hysteresis	T_{HYS}	Temperature falling			20		℃

SWITCHING CHARACTERISTICS

(Typical values are at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
V_{INx} = V_{ONx} = V_{BIAS} = 5V						
Turn-On Time	t_{ON}	R_L = 10Ω, C_L = 0.1μF, C_T = 1000pF		1847		μs
Turn-Off Time	t_{OFF}	R_L = 10Ω, C_L = 0.1μF, C_T = 1000pF		17		
V_{OUT} Rise Time	t_R	R_L = 10Ω, C_L = 0.1μF, C_T = 1000pF		2110		
V_{OUT} Fall Time	t_F	R_L = 10Ω, C_L = 0.1μF, C_T = 1000pF		7		
On Delay Time	t_D	R_L = 10Ω, C_L = 0.1μF, C_T = 1000pF		670		
V_{INx} = 0.6V, V_{ONx} = V_{BIAS} = 5V						
Turn-On Time	t_{ON}	R_L = 10Ω, C_L = 0.1μF, C_T = 1000pF		614		μs
Turn-Off Time	t_{OFF}	R_L = 10Ω, C_L = 0.1μF, C_T = 1000pF		25		
V_{OUT} Rise Time	t_R	R_L = 10Ω, C_L = 0.1μF, C_T = 1000pF		322		
V_{OUT} Fall Time	t_F	R_L = 10Ω, C_L = 0.1μF, C_T = 1000pF		8		
On Delay Time	t_D	R_L = 10Ω, C_L = 0.1μF, C_T = 1000pF		454		
V_{INx} = 2.5V, V_{ONx} = 5V, V_{BIAS} = 2.5V						
Turn-On Time	t_{ON}	R_L = 10Ω, C_L = 0.1μF, C_T = 1000pF		1070		μs
Turn-Off Time	t_{OFF}	R_L = 10Ω, C_L = 0.1μF, C_T = 1000pF		43		
V_{OUT} Rise Time	t_R	R_L = 10Ω, C_L = 0.1μF, C_T = 1000pF		1088		
V_{OUT} Fall Time	t_F	R_L = 10Ω, C_L = 0.1μF, C_T = 1000pF		10		
On Delay Time	t_D	R_L = 10Ω, C_L = 0.1μF, C_T = 1000pF		525		
V_{INx} = 0.6V, V_{ONx} = 5V, V_{BIAS} = 2.5V						
Turn-On Time	t_{ON}	R_L = 10Ω, C_L = 0.1μF, C_T = 1000pF		587		μs
Turn-Off Time	t_{OFF}	R_L = 10Ω, C_L = 0.1μF, C_T = 1000pF		45		
V_{OUT} Rise Time	t_R	R_L = 10Ω, C_L = 0.1μF, C_T = 1000pF		325		
V_{OUT} Fall Time	t_F	R_L = 10Ω, C_L = 0.1μF, C_T = 1000pF		9		
On Delay Time	t_D	R_L = 10Ω, C_L = 0.1μF, C_T = 1000pF		425		

PARAMETER MEASUREMENT INFORMATION



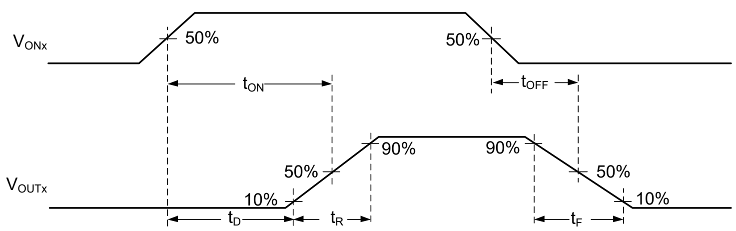
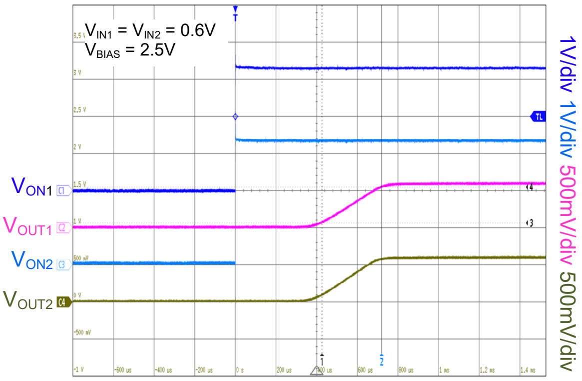


Figure 2. t_{ON} and t_{OFF} Waveforms

TYPICAL PERFORMANCE CHARACTERISTICS

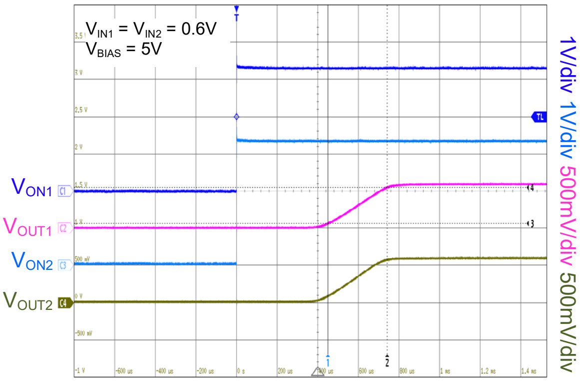
T_J = +25°C, C_T = 1000pF, C_{IN} = 1μF, C_L = 0.1μF, R_L = 10Ω, unless otherwise noted.

Turn-On Response Time



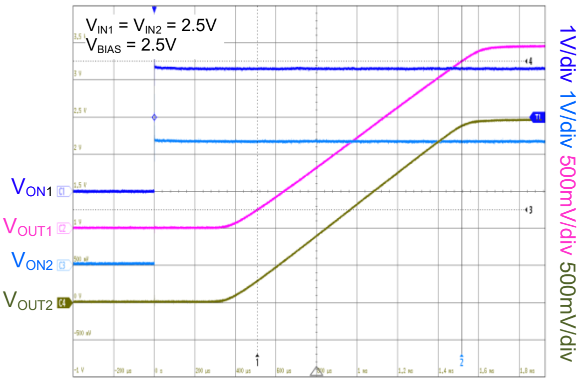
Time (200μs/div)

Turn-On Response Time



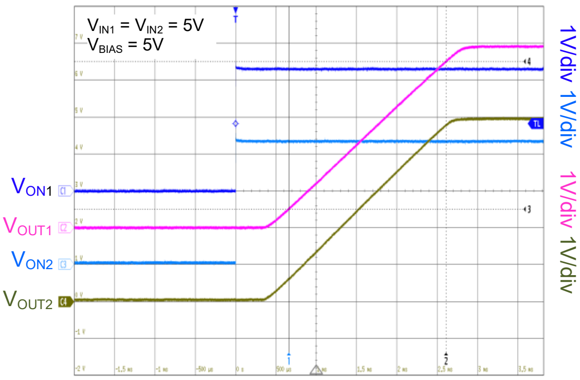
Time (200μs/div)

Turn-On Response Time



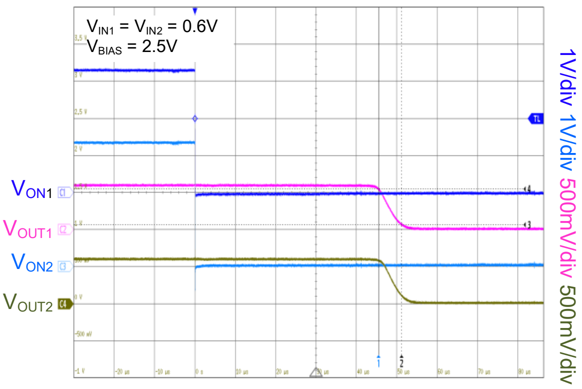
Time (200μs/div)

Turn-On Response Time



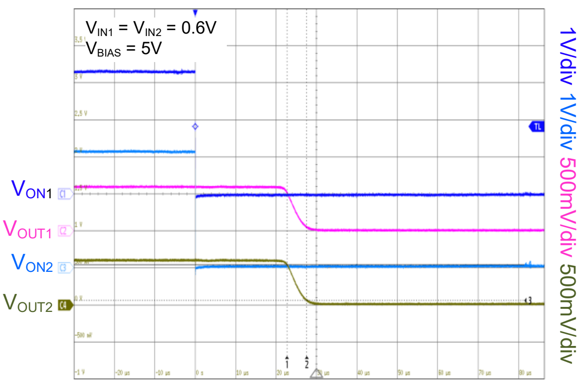
Time (500μs/div)

Turn-Off Response Time



Time (10μs/div)

Turn-Off Response Time

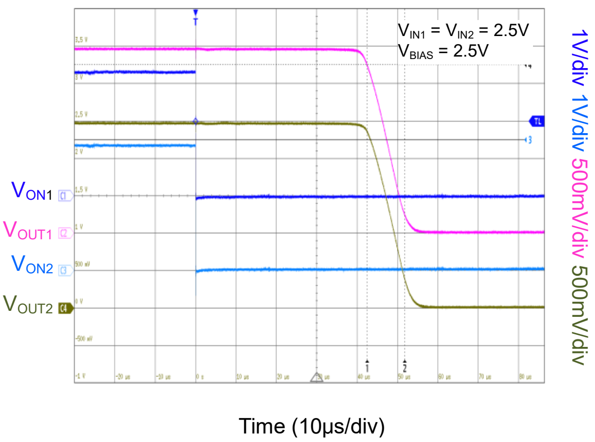


Time (10μs/div)

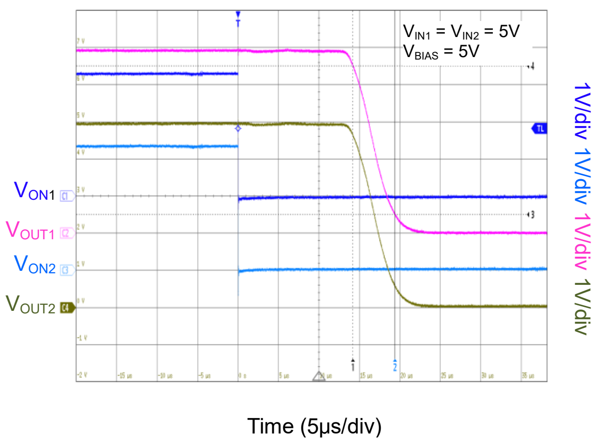
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T_J = +25℃, C_T = 1000pF, C_{IN} = 1μF, C_L = 0.1μF, R_L = 10Ω, unless otherwise noted.

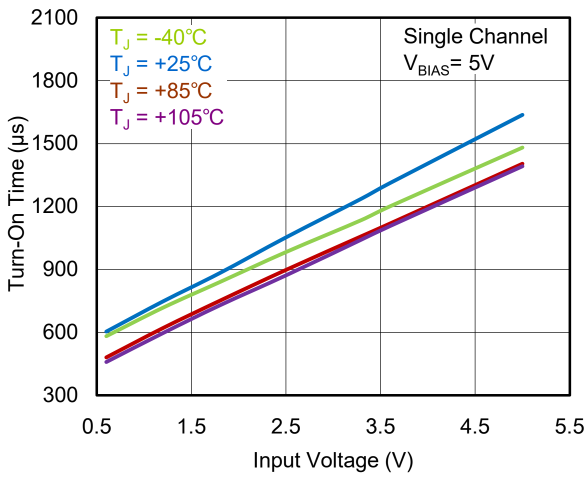
Turn-Off Response Time



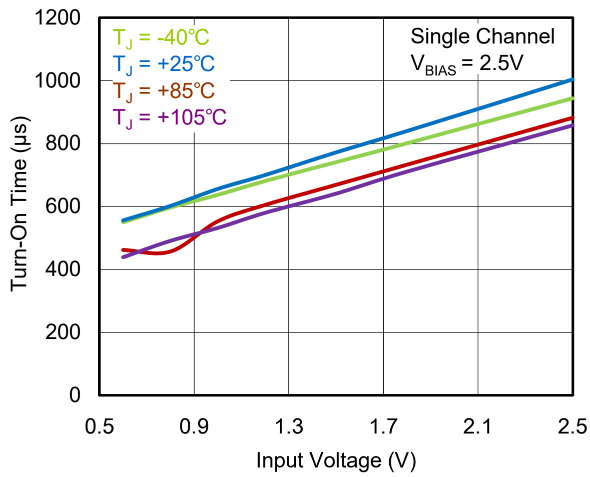
Turn-Off Response Time



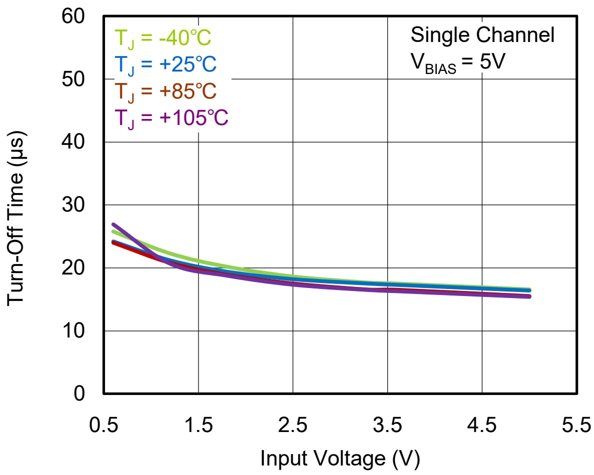
Turn-On Time vs. Input Voltage



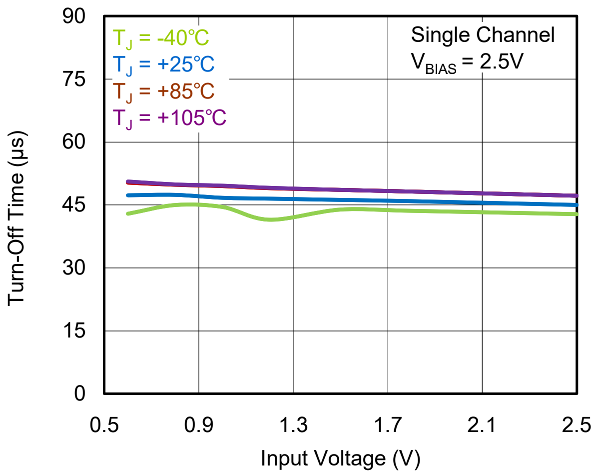
Turn-On Time vs. Input Voltage



Turn-Off Time vs. Input Voltage

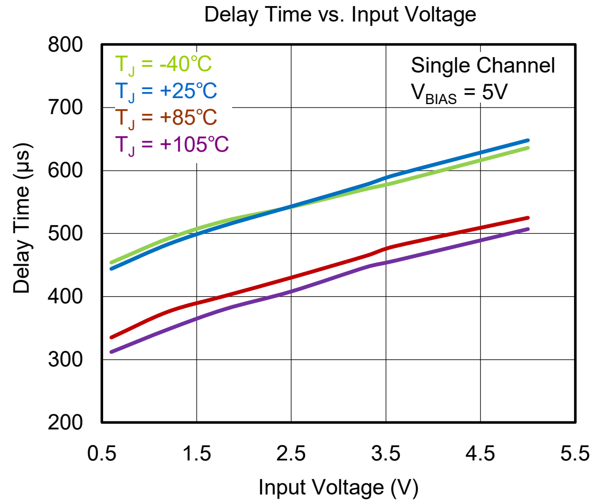


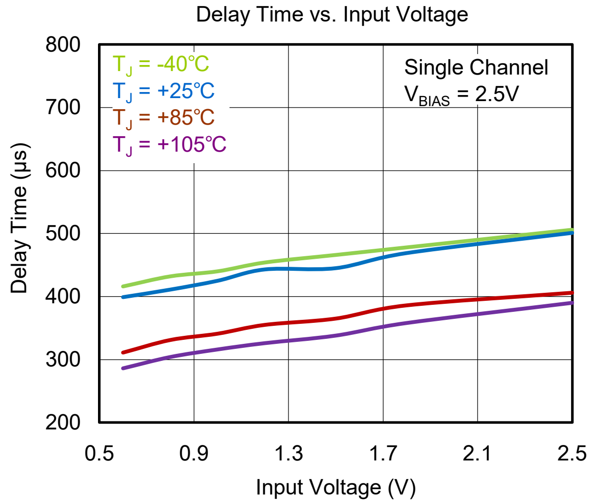
Turn-Off Time vs. Input Voltage

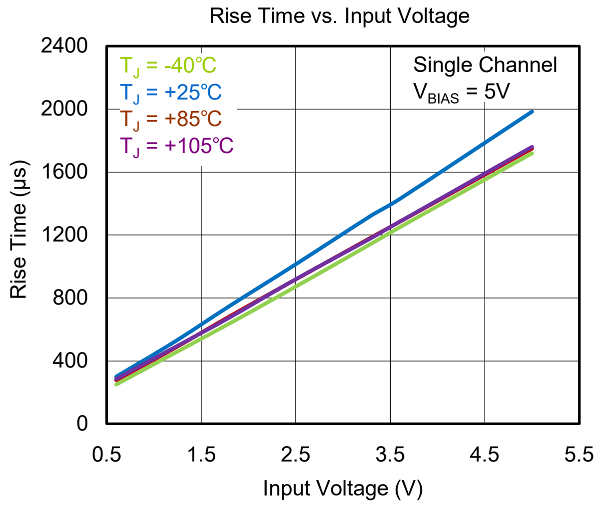


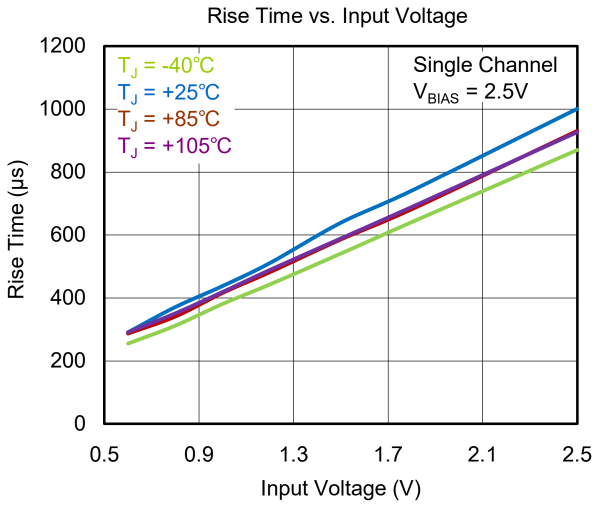
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

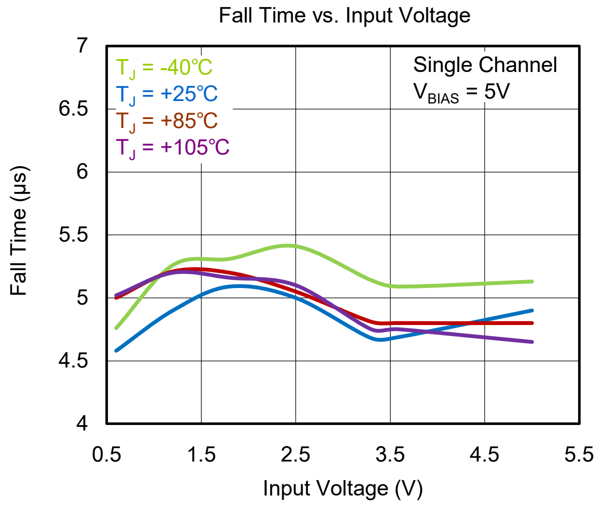
T_J = +25℃, C_T = 1000pF, C_{IN} = 1μF, C_L = 0.1μF, R_L = 10Ω, unless otherwise noted.

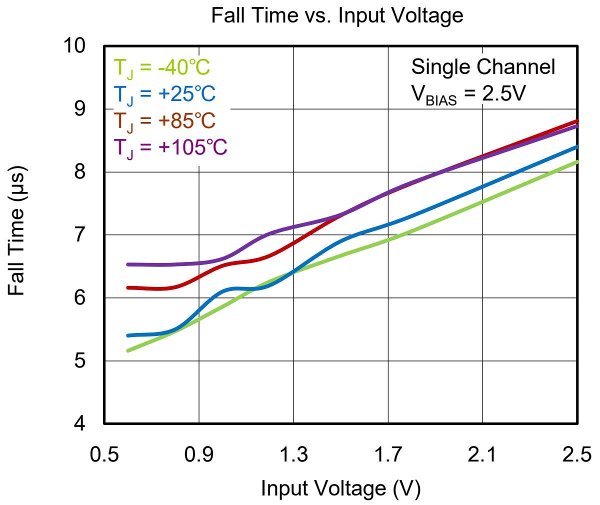




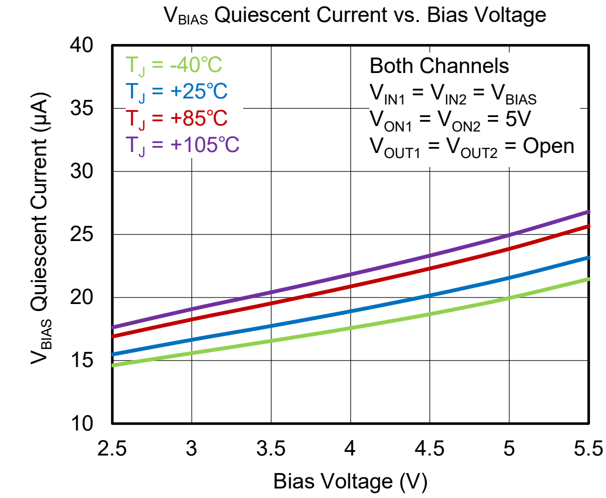


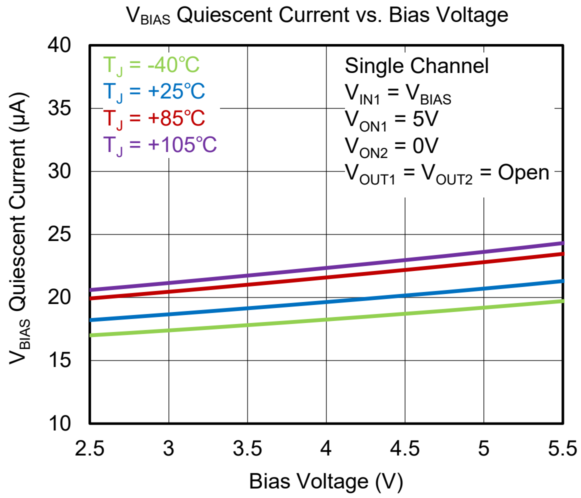


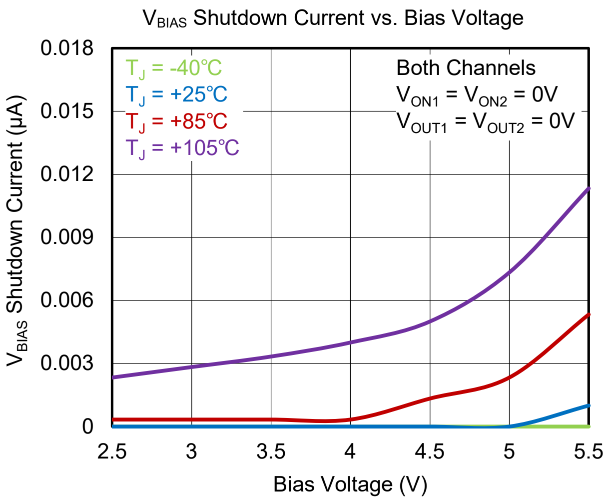


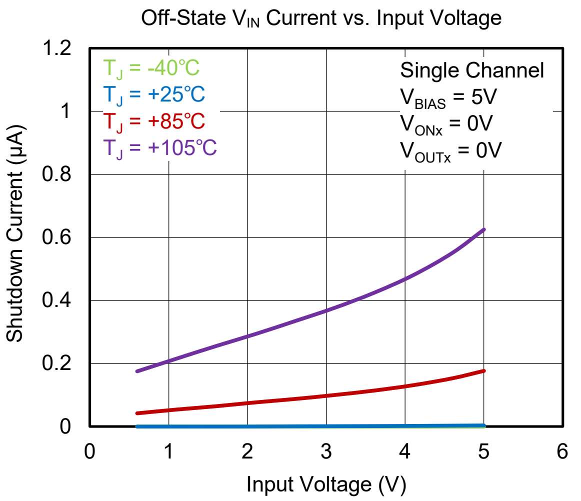


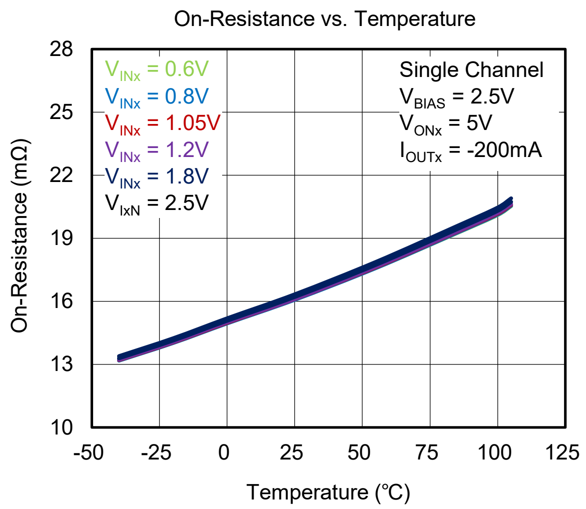
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

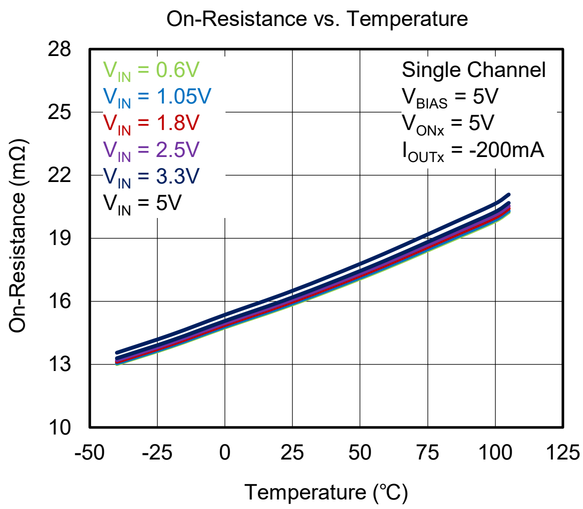




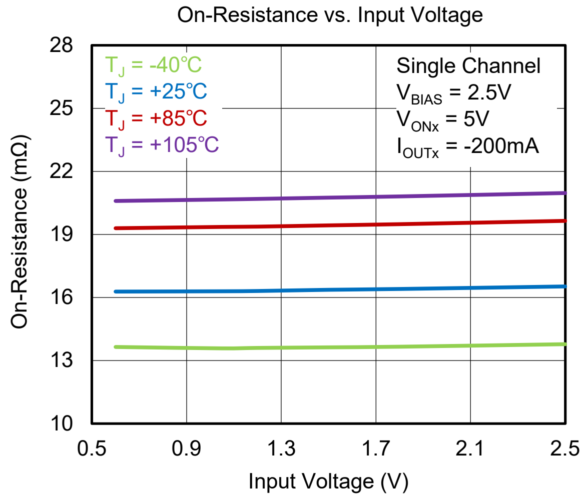


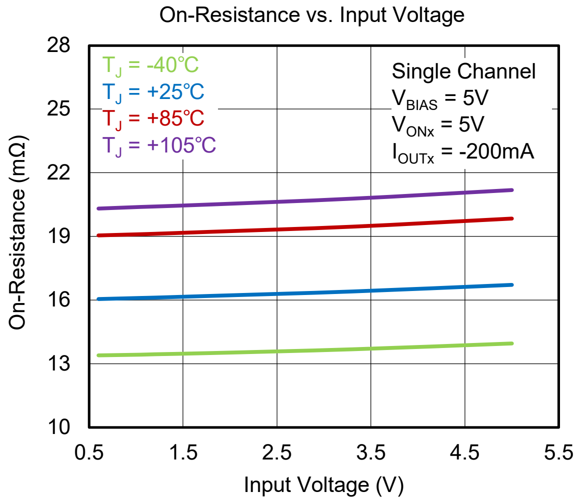


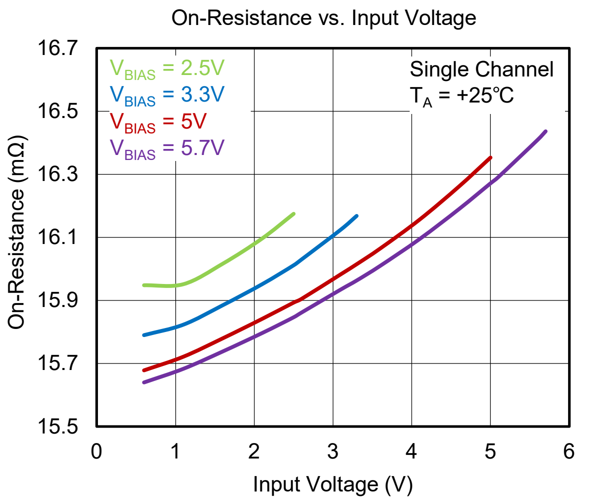


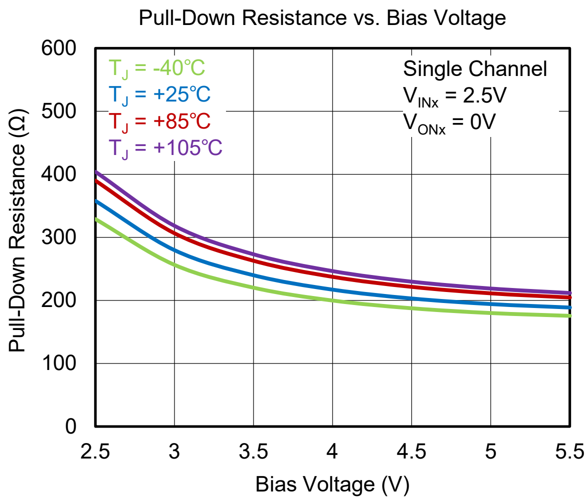


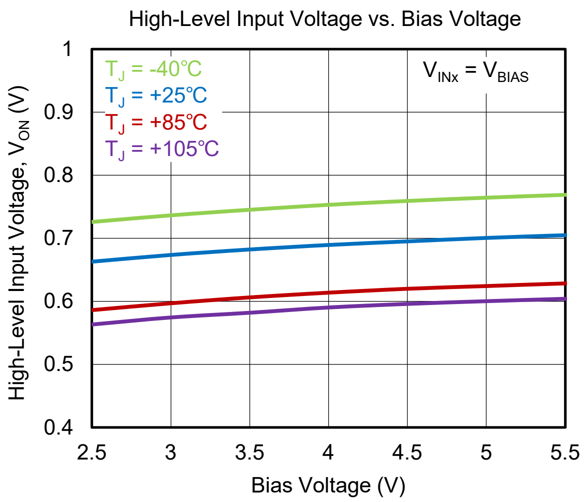
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

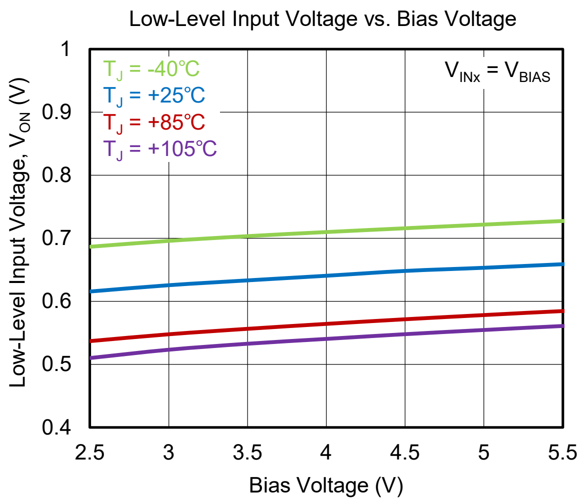




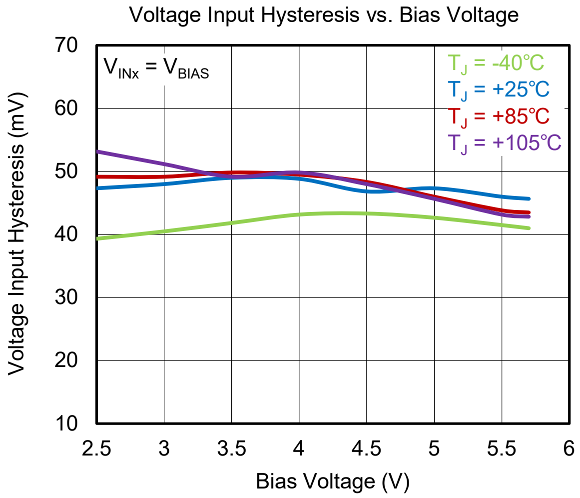








TYPICAL PERFORMANCE CHARACTERISTICS (continued)



FUNCTIONAL BLOCK DIAGRAM

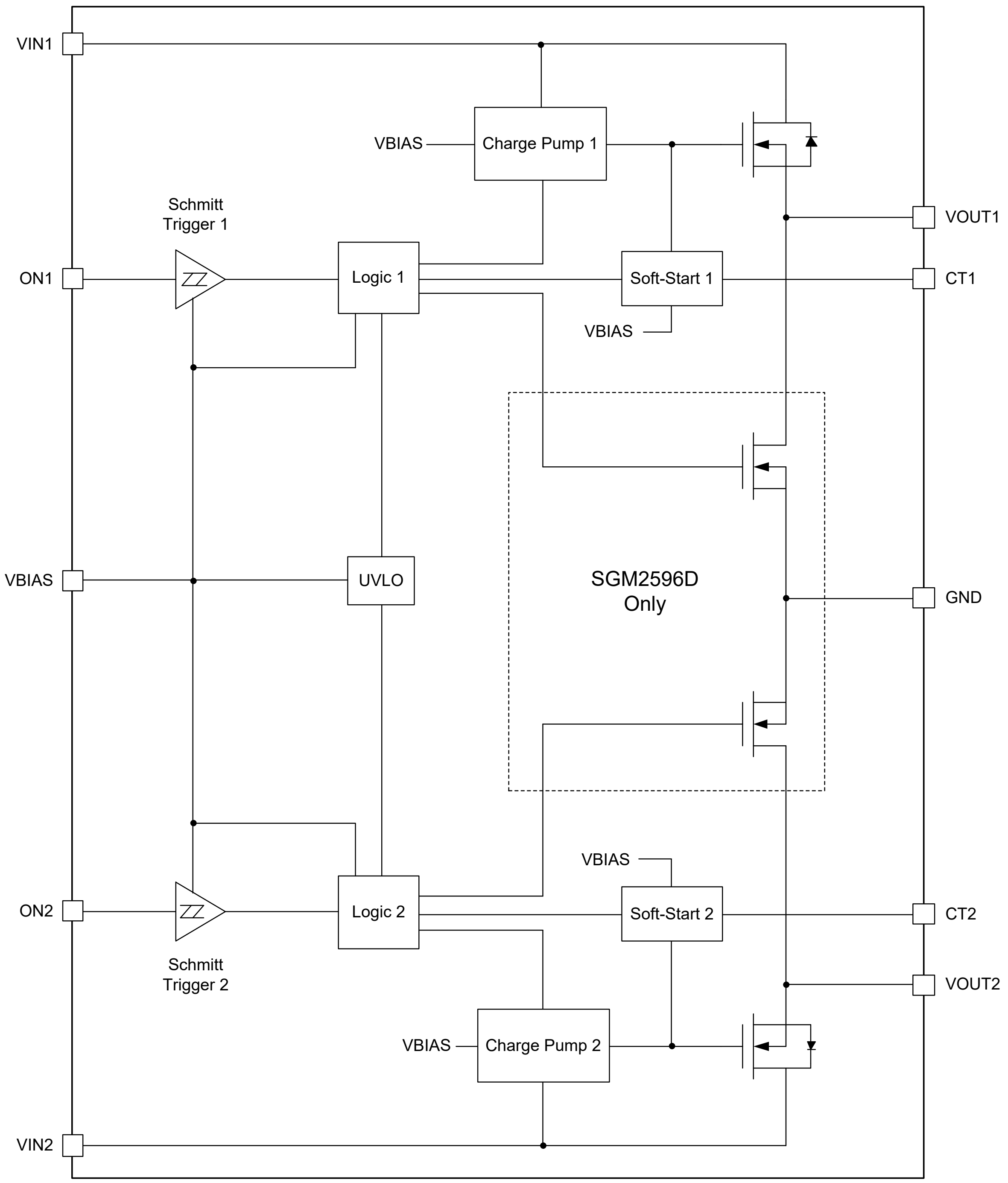


Figure 3. Block Diagram

DETAILED DESCRIPTION

Overview

The SGM2596 and SGM2596D are 5.7V, 16mΩ (TYP) on-resistance, integrated two N-MOSFETs, dual-channel load switches. Each channel can support a 6A maximum continuous load current and be enabled independently by the ONx pin. The devices have independent control pin to set the slew rate (or the soft-start time) of V_{OUTx} for each channel, which can control the inrush current and reduce the voltage drop. The devices also have the thermal shutdown function. Only SGM2596D includes internal integrated quick output discharge (QOD) to remove the remaining charge from the output when the switch is disabled.

SGM2596 and SGM2596D are highly integrated. Using SGM2596 or SGM2596D can reduce the PCB area and the BOM count greatly, even the cost.

V_{BIAS} Power Supply

V_{BIAS} is the power supply to the inner circuit including control logic, quick output discharge and charge pump. The support voltage range is from 2.5V to 5.7V. For most applications, a 0.1μF capacitor is sufficient. It is recommended to use X5R or X7R dielectrics ceramic capacitor.

Input Capacitor

Turning on the N-MOSFET to charge load capacitor will generate inrush current, which may cause the V_{IN} drop. In order to prevent the drop, a capacitor must be placed between the VINx and GND pins. Usually, a 1μF input capacitor (C_{IN}) placed close to the pins is sufficient. However, higher capacitance values could further reduce the voltage drop. So, larger C_{IN} can be used to reduce the voltage drop in high current applications.

Output Capacitor

A 0.1μF output capacitor (C_{OUT}) should be placed between the VOUTx and GND pins. This capacitor can prevent parasitic board inductance from forcing V_{OUTx} below GND when the switch is turned on. It is recommended that C_{IN} is greater than C_{OUT}.

Control Pin

There is an independent control pin ONx to turn on or turn off the corresponding N-MOSFET for each channel. When the ONx pin is driven high, the switch will be turned on, and when the ONx pin is driven low, the switch will be turned off. The ONx pin is compatible with standard GPIO logic level threshold, such as 1.2V, 1.8V, 2.5V or 3.3V.

The recommended start-up sequence is: V_{BIAS} power on first, then V_{INx} power on, and finally to enable the ONx. Or V_{INx} and V_{BIAS} power on simultaneously, then the ONx is enabled.

The ONx pin cannot be left floating and must be connected to either high or low level as requirement.

Soft-Start Control

A capacitor between CT_X and GND pins determines the slew rate of V_{OUT} for each channel. The slew rate can be calculated using the below equation.

$$SR = 0.55 \times C_T \tag{1}$$

So, the soft-start time of V_{OUT} is:

$$t_{SS} = SR \times V_{OUT} = 0.55 \times C_T \times V_{OUT} \tag{2}$$

where:

SR is the slew rate (in μs/V).

C_T is the capacitance value on the CTx pin (in pF).

t_{SS} is the soft-start time of V_{OUT}.

For the desired rise time performance, the capacitor voltage rating used on this pin must be 10V or above. When C_T < 100pF, the equation cannot be applied. The recommended value of C_T is bigger than 100pF. If C_T = 0pF or left floating, use Table 4 to determine rise times. The soft-start time is valid only when the ONx pin is enabled after V_{INx} and V_{BIAS} are ready.

DETAILED DESCRIPTION (continued)

Quick Output Discharge (QOD)

The QOD feature is only available for SGM2596D. Each channel has a resistor which is not activated to discharge by default. When the ONx pin is pulled low or V_{BIAS} is lower than 2.2V (TYP) or over-temperature happens, the resistor will be connected between the VOUTx and GND to discharge the output quickly. This resistor pulls down the output and prevents it from floating when the switch is turned off.

Thermal Shutdown

Thermal shutdown protects the device from excessive temperature and can recovery automatically. When die temperature exceeds +160℃ (TYP), both MOSFETs will be shut down and remained off until die temperature drops below +140℃ (TYP).

Device Functional Modes

The connection of the VOUTx pin is shown in Table 1 and Table 2.

Table 1. SGM2596D Functions Table

ONx	VINx to VOUTx	VOUTx
L	N-MOSFET Off	GND
H	N-MOSFET On	VINx

Table 2. SGM2596 Functions Table

ONx	VINx to VOUTx	VOUTx
L	N-MOSFET Off	Floating
H	N-MOSFET On	VINx

APPLICATION INFORMATION

Power Sequencing

In some systems, especially including processors or subsystems, the power sequence must be followed. The device provides a simple solution to meet the power sequencing. As shown in Figure 4, V_{OUT2} is powered on after V_{OUT1}.

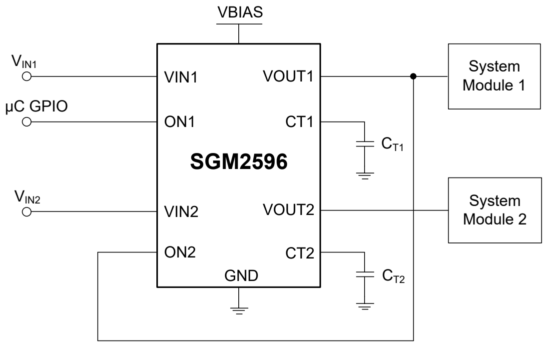


Figure 4. Power Sequencing

Saving Standby Power

In battery-powered equipment, the strict power budget must be met under different operating modes. In standby or sleep mode, leakage current of some modules such as LCD displays, Wi-Fi, power amplifiers and GPS may be up to several mA or more. The large consumption is far from meeting the application requirements. Using load switches ahead of these modules can reduce this leakage current to μA level, which can save the standby power consumption greatly. The configuration is illustrated in Figure 5.

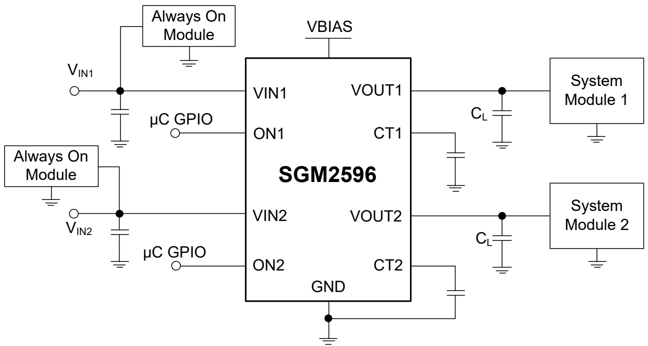


Figure 5. Standby Power Reduction

Parallel Configuration

The device can be parallel connected to achieve lower R_{ON} and higher maximum continuous load current as seen in Figure 6. The CT1 and CT2 pins should be tied together to use one capacitor (C_T).

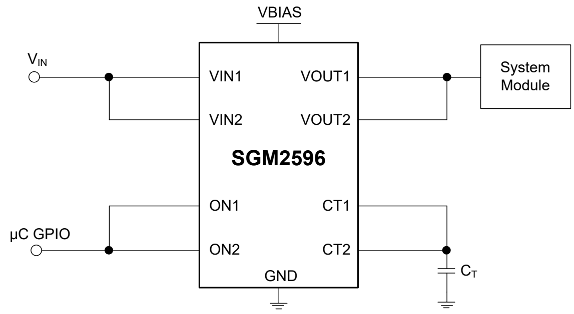


Figure 6. Parallel Configuration

Reverse Current Protection

The device can be combined into a single-channel load switch with reverse current blocking. The configuration is illustrated in Figure 7. V_{IN1} is the input and V_{IN2} is the output or vice verse. When ON1 and ON2 are high, the both internal N-MOSFETs are turned on. When ON1 and ON2 are low, the both internal N-MOSFETs are turned off, and the body diode blocks the reverse current.

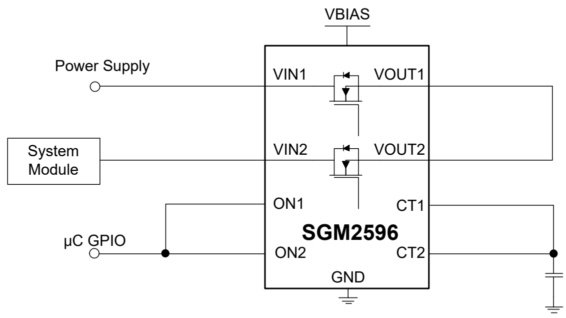


Figure 7. Reverse Current Blocking

APPLICATION INFORMATION (continued)

Design Example

This example illustrates how to choose C_T in details to limit inrush current within the requirement. The SGM2596 and SGM2596D are the similar, so the Figure 8 only shows the SGM2596.

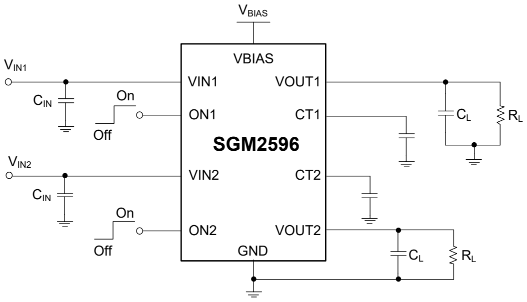


Figure 8. Typical Application Circuit

Design Requirements

Table 3 shows the SGM2596 design parameters of one channel.

Table 3. Design Parameters

Design Parameter	Value
Input Voltage (V_{INx})	3.3V
Bias Voltage (V_{BIAS})	5V
Load Capacitance (C_L)	22μF
Maximum Acceptable Inrush Current (I_{INRUSH})	500mA

Detailed Design Procedure

Inrush Current

When the switch is enabled, V_{OUTx} begins to soft-start from 0V linearly. Inrush current can be calculated by the following formula.

$$I_{INRUSH} = C_L \times dV_{OUT}/dt \quad (3)$$

Soft-Start Time

From the Equation 3, we can also calculate the soft-start time.

$$t_{SS} = C_L \times V_{OUT}/I_{INRUSH} \quad (4)$$

In this example: C_L = 22μF, V_{OUTx} = V_{INx} = 3.3V, I_{INRUSH} = 500mA.

So,

$$t_{SS} = 22\mu F \times 3.3V/500mA \approx 145.2\mu s \quad (5)$$

To ensure an inrush current is less than 500mA, the soft-start time cannot be less than 145.2μs. The next, we only need to choose a C_T value to meet the desired soft-start time.

C_T Selection

From equation,

$$t_{SS} = 0.55 \times C_T \times V_{OUT} \quad (6)$$

We can calculate the $C_T \approx$ 80pF.

From the section of soft-start control, we know that when C_T < 100pF, the equation cannot be applied and the calculated value is not accurate. So we need to choose more than 100pF capacitor which value is close and universal. Finally, C_T = 220pF is chosen.

We can also refer the following Table 4 to choose C_T. The t_R (the rise time from 10% to 90% of V_{OUTx}) at different C_T have been measured under C_L = 0.1μF, C_{IN} = 1μF and R_L = 10Ω.

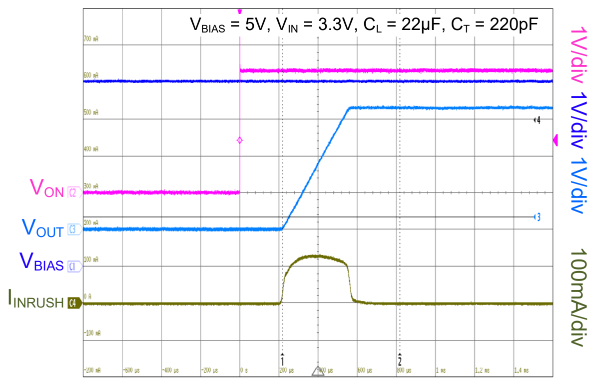
If t_{SS} is known, we can also know $t_R = 0.8 \times t_{SS} \approx$ 116.2μs.

According to the t_R, look up Table 4 to get the recommended value C_T which sets the rise time not be less than the calculated.

When C_T is left floating, the rise times can be obtained from C_T = 0pF listed in Table 4.

Typical Curves

Inrush Current



Time (200μs/div)

APPLICATION INFORMATION (continued)

Table 4. Rise Time vs. C_T Capacitor

C_T (pF)	Rise Time (μs) 10% - 90% (1)						
	V_{INx} = 0.6V	V_{INx} = 1.05V	V_{INx} = 1.2V	V_{INx} = 1.5V	V_{INx} = 1.8V	V_{INx} = 3.3V	V_{INx} = 5V
0	38	55	62	65	75	113	180
220	70	110	122	146	172	305	470
470	140	216	243	295	345	605	895
1000	295	495	545	675	791	1454	2010
2200	675	1055	1185	1445	1700	3000	4520
4700	1415	2250	2520	3080	3610	6362	9515
10000	3035	4773	5325	6542	7756	13515	20062

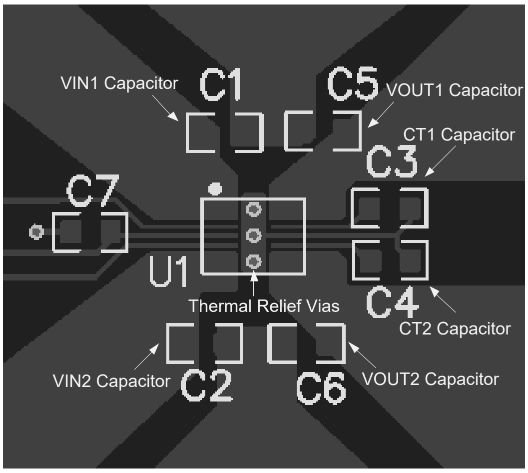
NOTE 1: Typical values are at T_J = +25℃, V_{BIAS} = 5V, C_L = 0.1μF, C_{IN} = 1μF, R_L = 10Ω, 10V X7R 10% ceramic capacitor.

Layout Guidelines

For the best operation of device, the following guidelines must be strictly followed:

- All high-current traces (VINx and VOUTx) could be as short and wide as possible. It is recommended to use ground copper pour. Special attention should be paid to that size and number of via must be enough for a given current.
- The input and output capacitors should be placed as close as possible to the device.
- Decoupling capacitors of VBIAS should be placed next to the VBIAS pin.
- Place the C_T capacitor close to the CTx pin.
- Use sufficient thermal vias to directly connect the exposed thermal pad to the ground plane on the bottom layer under the body of IC, which can relieve the thermal further and achieve better thermal performance.

Layout Example



Thermal Considerations

Assuming a given ambient temperature and package thermal resistance, the maximum allowable power dissipation is calculated by:

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

where:

- $P_{D(MAX)}$ is the maximum power dissipation.
- $T_{J(MAX)}$ is the maximum operating junction temperature.
- T_A is the operating ambient temperature.
- θ_{JA} is the package thermal resistance.

The maximum operating junction temperature must be restricted to +125℃ under normal operating conditions. Care should be taken that the thermal vias are placed under the exposed pad of the device, thus allowing for thermal dissipation away from the device.

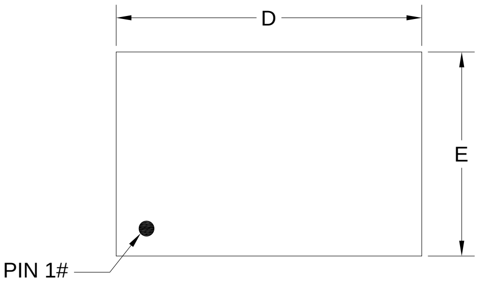
REVISION HISTORY

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

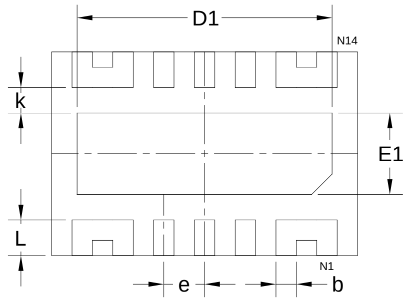
Changes from Original (FEBRUARY 2022) to REV.A	Page
Changed from product preview to production data	All

PACKAGE OUTLINE DIMENSIONS

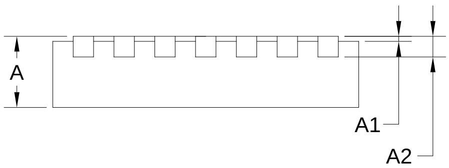
TDFN-3×2-14AL



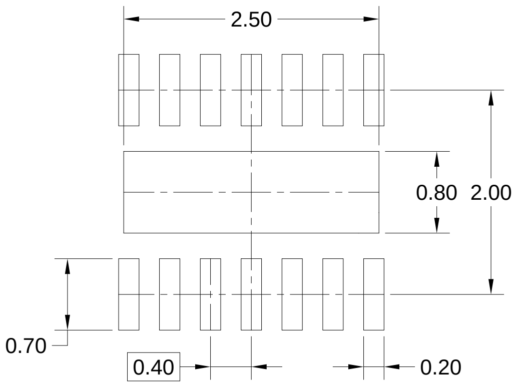
TOP VIEW



BOTTOM VIEW



SIDE VIEW



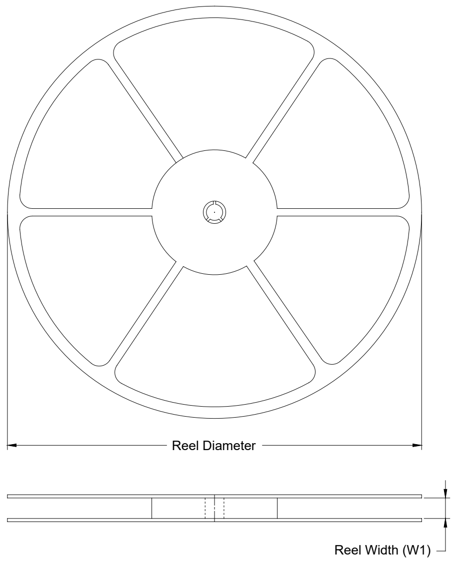
RECOMMENDED LAND PATTERN (Unit: mm)

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		

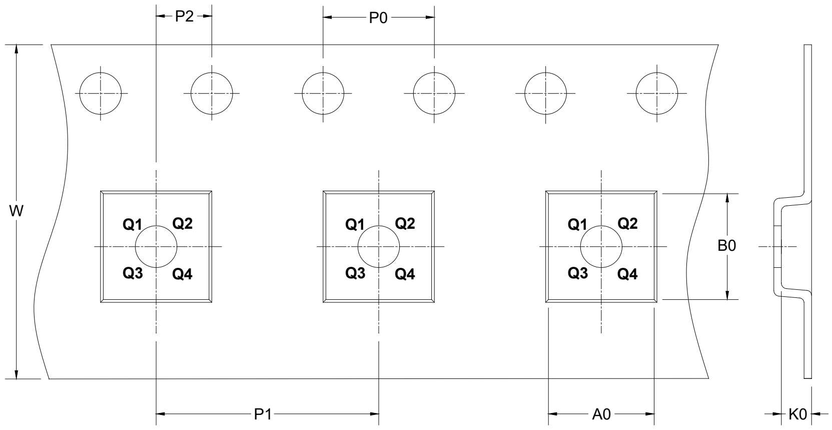
NOTE: This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



DIRECTION OF FEED

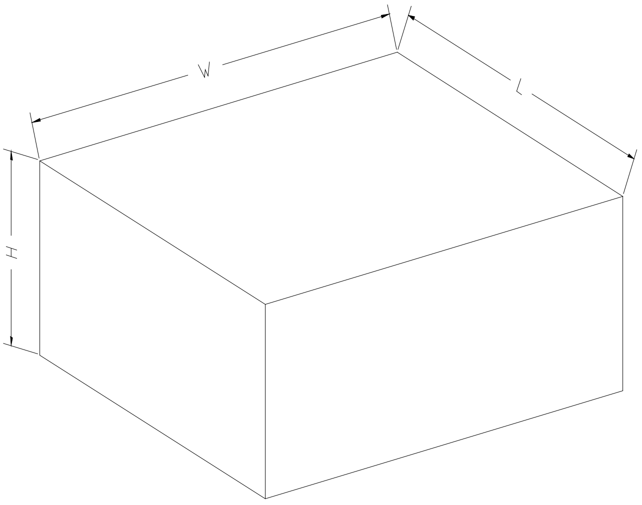
NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
TDFN-3×2-14AL	7″	9.5	2.30	3.30	1.10	4.0	4.0	2.0	8.0	Q1

DD0001

CARTON BOX DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF CARTON BOX

Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
7″ (Option)	368	227	224	8
7″	442	410	224	18

DD0002