ET3176 - 5.7V, 6A, 18mΩ Dual-Channel Load Switch

General Description

The ET3176 is a dual-channel load switch with controlled turn on. The device contains two N-channel MOSFETs that can operate over an input voltage range of 0.6V to 5.7V and can support a maximum continuous current of 6A per channel. Each switch is independently controlled by an on and off input (ON1 and ON2),which can interface directly with low-voltage control signals.

The ET3176 is capable of thermal shutdown when the junction temperature is above the threshold, turning the switch off. The switch turns on again when the junction temperature stabilizes to a safe range. The ET3176 also offers an optional integrated 230Ω on-chip load resistor for quick output discharge when the switch is turned off.

The ET3176 is available in a small DFN14 package with thermal pad allowing for high power dissipation.

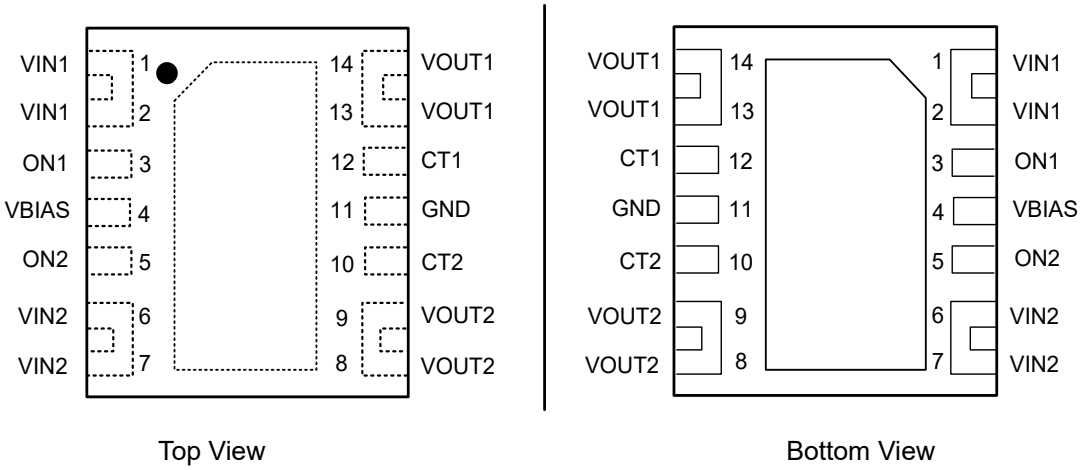
Features

- Integrated Dual- Channel Load Switch
- V_{BIAS} Voltage Range:2.5V to 5.7V
- Input Voltage Range: 0.6V to V_{BIAS}
- Ultra low R_{ON} Resistance :
  - R_{ON}=18mΩ (Typical) at V_{IN}=0.6V to 5V ,V_{BIAS}=5V
  - R_{ON}=22mΩ (Typical) at V_{IN}=0.6V to 2.5V, V_{BIAS}=2.5V
- 6A Maximum Continuous Switch Current per channel
- Low Quiescent Current :
  - 22μA (Typical, Both Channels) at V_{IN}=V_{BIAS}=5V
  - 20μA (Typical, Single Channel) at V_{IN}=V_{BIAS}=5V
- Control Input Threshold Enable Use of 1.2V/1.8V/2.5V/3.3V Logic
- Configurable Rise Time
- Thermal Shutdown
- Quick Output Discharge (QOD)
- DFN14 (3mm×2mm) Package with Thermal Pad
- ESD Protected:
  - HBM 4.0kV Pass
  - CDM 2.0kV Pass

Application

- Ultra-book TM / Notebooks and Tablet PCs
- Set-top Boxes and Residential Gateways
- Telecom Systems and Solid-State Drives (SSD)

Pin Configuration



Top View Bottom View

Figure 1. Pin Configuration

Pin Function

Pin No.	Pin Name	I/O	Description
1, 2	VIN1	I	Switch 1 input.Recommended voltage range for these pins for optional R_{ON} performance is 0.6V to V_{BIAS}.Place an optional decoupling capacitor between these pins and GND to reduce VIN1 dip during turn on of the channel.
3	ON1	I	Active-High switch 1 control input. Do not leave floating
4	VBIAS	I	Bias voltage. Power supply to the device. Recommended voltage range for this pin is 2.5V to 5.7V
5	ON2	I	Active-High switch 2 control input. Do not leave floating
6,7	VIN2	I	Switch 2 input.Recommended voltage range for these pins for optional R_{ON} performance is 0.6V to V_{BIAS}.Place an optional decoupling capacitor between these pins and GND to reduce VIN2 dip during turn on of the channel.
8,9	VOUT2	O	Switch 2 output
10	CT2	O	Switch 2 slew rate control. Can be left floating.Capacitor used on this pin must be rated for a minimum of 25V for desired rise time performance
11	GND	/	Ground
12	CT1	O	Switch 1 slew rate control. Can be left floating.Capacitor used on this pin must be rated for a minimum of 25V for desired rise time performance
13,14	VOUT1	O	Switch 1 output
-	Thermal Pad	-	Thermal pad (exposed center pad) to alleviate thermal stress. Tie to GND.

Block Diagram

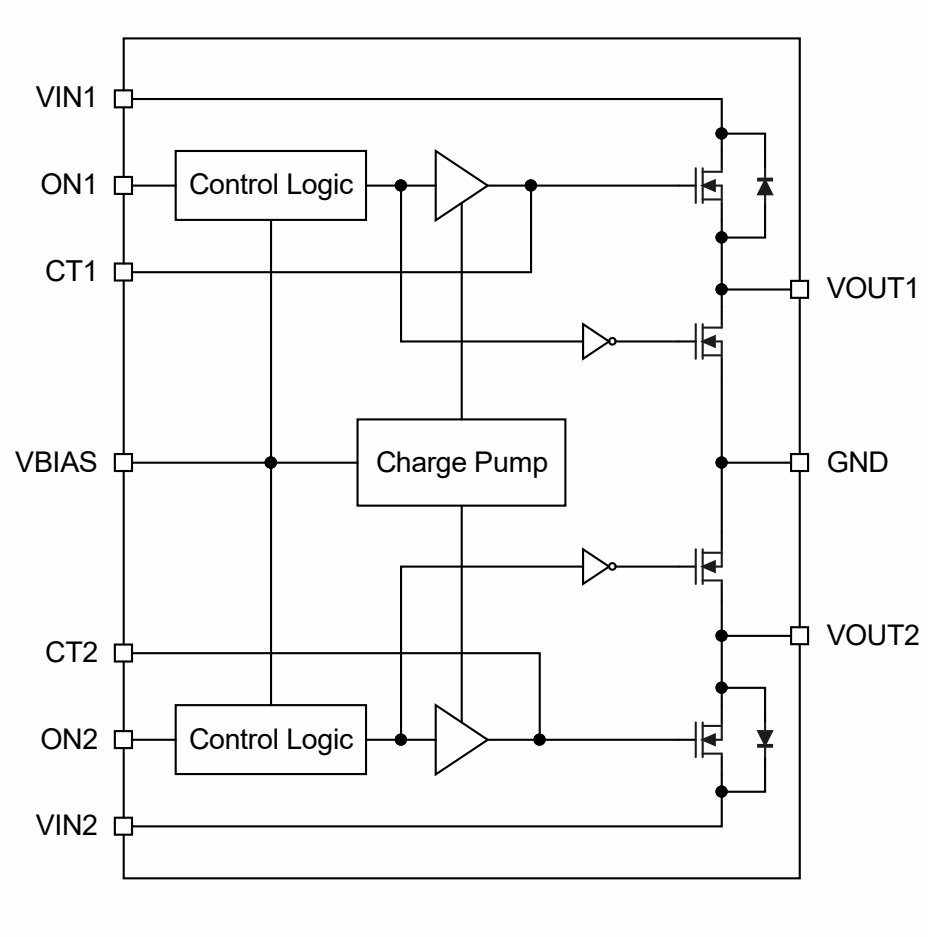


Figure 2. Functional Block Diagram

Functional Description

Input Capacitor

To limit the voltage drop on the input supply caused by transient inrush current when the switch turns on into a discharged load capacitor or short-circuit, a capacitor must be placed between the VIN and GND pins. A 1μF ceramic capacitor, C_{IN}, placed close to the pins is usually sufficient. Higher-value C_{IN} can be used to reduce the voltage drop in higher-current applications. When switching heavy loads, it is recommended to have an input capacitor 10 times higher than the output capacitor to avoid excessive voltage drop.

Output Capacitor

Due to the integrated body diode in the NMOS switch, a C_{IN} greater than C_L is highly recommended. A C_L greater than C_{IN} can cause V_{OUT} to exceed V_{IN} when the system supply is removed. This could result in current flow through the body diode from V_{OUT} to V_{IN}. A C_{IN} to C_{OUT} ratio of 10 to 1 is recommended for minimizing V_{IN} dip caused by inrush currents during startup, however a 10 to 1 ratio for capacitance is not required for proper functionality of the device. A ratio smaller than 10 to 1 (such as 1 to 1) could cause a V_{IN} dip upon turn-on due to inrush currents.

ON/OFF Control

The ON terminal controls the state of the load switch, and asserting the terminal high (active high) enables the switch. The ON terminal is compatible with standard GPIO logic threshold and can be used with any micro-controller or discrete logic with 1.2V or higher GPIO voltage. This terminal cannot be left floating and must be tied either high or low for proper functionality.

Quick Output Discharge (QOD)

The ET3176 includes a QOD feature. When the switch is disabled, an internal discharge resistance is connected between VOUT and GND to remove the remaining charge from the output. This resistance prevents the output from floating while the switch is disabled. For best result, it is recommended that the device gets disabled before VBIAS falls below the minimum recommended voltage.

Thermal Shutdown

Thermal shutdown protects the part from internally or externally generated excessive temperatures. When the device temperature exceeds TSD (Typical 160°C),the switch is turned off. The switch automatically turns on again if the temperature of the die drops 20 degrees below the TSD threshold.

Functions Table

ON State	VIN to VOUT	VOUT State
L	OFF	GND
H	ON	VIN

Power Sequencing

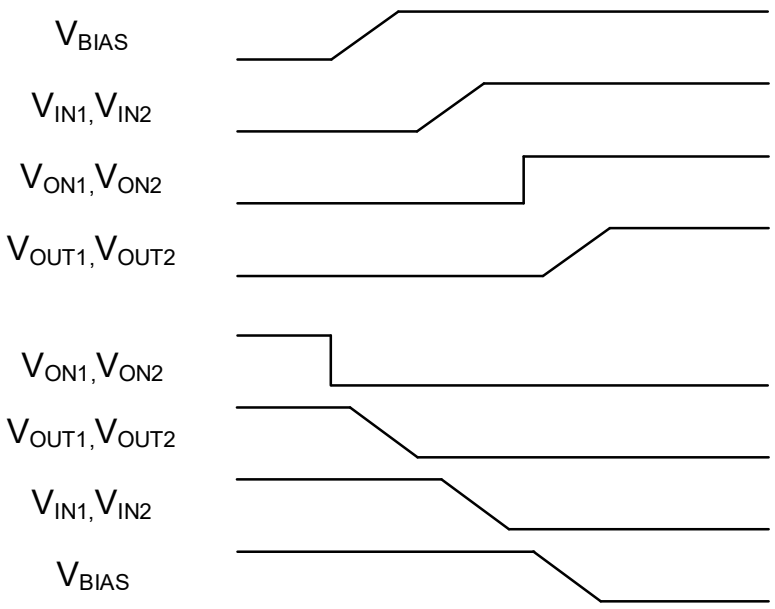


Figure 3. Power Sequencing

Adjustable Rise Time

A capacitor to GND on the CT pins sets the slew rate for each channel. To ensure desired performance, a capacitor with a minimum voltage rating of 25V must be used on either CT pins. An approximate formula for the relationship between CT and slew rate is shown in Equation1.

Equation 1 accounts for 10% to 90% measurement on V_{OUT} and does not apply for CT<100pF. Use Table1 to determine rise times for when CT = 0pF.

$$SR = 0.42 \times CT + 66 \quad (1)$$

Where

(1) SR is the slew rate(in us/V).

(2) CT is the capacitance value on the CT pin(in pF).

(3) The units for the constant 66 is in us/V.

Rise time can be calculated by multiplying the input voltage by the slew rate. Rise times shown below are only valid for the power-up sequence where V_{IN} and V_{BIAS} are already in steady state condition, and the ON pin is asserted high. The typical values at 25°C, V_{BIAS} = 5V, 25V X7R 10% Ceramic Cap.

Table1 Rise Time Values

CT (pF)	Rise Time(μs) 10% - 90%, C_L = 0.1μF, C_{IN} = 1μF, R_L = 10Ω						
	5V	3.3V	1.8V	1.5V	1.2V	1.05V	0.6V
0	134	114	85	76	70	58	45
220	558	396	247	212	183	162	108
470	940	655	384	336	276	242	164
1000	1760	1200	722	614	510	443	276
2200	3956	2692	1582	1355	1078	936	620
4700	8058	5446	3159	2688	2231	1942	1220
10000	15600	10400	6000	5121	4100	3782	2356

Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

Symbol	Parameters		Min	Max	Unit
$V_{IN1,2}$	V_{IN} to GND		-0.3	6.0	V
V_{BIAS}	V_{BIAS} to GND		-0.3	6.0	V
$V_{OUT1,2}$	V_{OUT} to GND		-0.3	6.0	V
$V_{ON1,2}$	ON to GND		-0.3	6.0	V
I_{MAX}	Maximum Continuous Switch Current per Channel			6.0	A
I_{PLS}	Maximum Pulsed Switch Current,Pulse <300us,3% Duty Cycle			8.0	A
T_J	Maximum junction temperature			150	°C
T_{STG}	Storage Junction Temperature		-65	+150	°C
θ_{JA}	Junction-to-ambient thermal resistance		51		°C/W
V_{ESD}	Electrostatic Discharge Capability	Human Body Model, JESD22-A114	±4.0		kV
		Charged Device Model, JESD22-C101	±2.0		

Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. ETEK does not recommend exceeding them or designing to Absolute Maximum Ratings.

Symbol	Parameters		Min	Max	Unit
$V_{IN1,2}$	Input Voltage		0.6	V_{BIAS}	V
V_{BIAS}	Bias voltage range		2.5	5.7	V
$V_{ON1,2}$	ON voltage range		0	5.7	V
$V_{OUT1,2}$	Output voltage range			V_{IN}	V
V_{IH}	High-level voltage ON	V_{BIAS}=2.5V to 5V, T_A<85°C	1.05	5.7	V
		V_{BIAS}=2.5V to 5.7V, T_A<105°C	1.2	5.7	
V_{IL}	Low-level voltage ON	V_{BIAS}=2.5V to 5.5V	0	0.5	V
$C_{IN1,2}$	Input Capacitor (1)		1		µF
T_A	Ambient Operating Temperature(2)		-40	+105	°C

Note(1) See the Input Capacitor section

Note(2) In applications where high power dissipation and/or poor package thermal resistance is present, the maximum ambient temperature may have to be derated. Maximum ambient temperature (T_{A_MAX}) is dependent on the maximum operating junction temperature (T_{J_MAX}), the maximum power dissipation of the device in the application(P_{D_MAX}), and the junction-to-ambient thermal resistance of the part/package in the application (θ_{JA}), as given by the following equation: $T_{A_MAX} = T_{J_MAX} - (\theta_{JA} \times P_{D_MAX})$.

Electrical Characteristics, V_{BIAS}=5.0V

The specification in below table applies V_{BIAS} = 5.0V, typical values are for T_A = 25°C (unless otherwise noted).

Symbol	Parameter	Test Conditions			Min	Typ	Max	Unit
Power Supply and Current								
I_{Q_BIAS}	V_{BIAS} Quiescent Current (both channels)	I_{OUT1}=I_{OUT2}=0mA, $V_{IN1,2}$=$V_{ON1,2}$=5V		T_A=-40 to +85°C		22	32	µA
				T_A=-40 to +105°C			35	
	V_{BIAS} Quiescent Current (single channel)	I_{OUT1}=I_{OUT2}=0mA, V_{ON2}=0V $V_{IN1,2}$=V_{ON1}=5V		T_A=-40 to +85°C		20	30	µA
				T_A=-40 to +105°C			33	
I_{S_VBIAS}	V_{BIAS} Shutdown Current	$V_{ON1,2}$=0V, $V_{OUT1,2}$=0V		T_A=-40 to +105°C		1.0	2.3	µA
I_{S_VIN}	V_{IN} Shutdown Current (per channel)	V_{ON}=0V V_{OUT}=0V	V_{IN}=5.0V	T_A=-40 to +85°C		0.005	5.5	µA
				T_A=-40 to +105°C			8.0	
			V_{IN}=3.3V	T_A=-40 to +85°C		0.002	1.4	
				T_A=-40 to +105°C			3.4	
			V_{IN}=1.8V	T_A=-40 to +85°C		0.002	0.5	
				T_A=-40 to +105°C			1.7	
			V_{IN}=0.6V	T_A=-40 to +85°C		0.001	0.3	
				T_A=-40 to +105°C			1.5	
I_{ON}	ON-pin Input Leakage Current	V_{ON}=5.5V		T_A=-40 to +105°C			0.1	µA
Resistance Characteristics								
R_{ON}	On-Resistance (per channel)	I_{OUT}=-0.2 A	V_{IN}=5.0V	T_A=25°C		18	29	mΩ
				T_A=-40 to +85°C			32	
				T_A=-40 to +105°C			35	
			V_{IN}=3.3V	T_A=25°C		18	29	
				T_A=-40 to +85°C			32	
				T_A=-40 to +105°C			35	
			V_{IN}=1.8V	T_A=25°C		18	29	
				T_A=-40 to +85°C			32	
				T_A=-40 to +105°C			35	
			V_{IN}=1.2V	T_A=25°C		18	29	
				T_A=-40 to +85°C			32	
				T_A=-40 to +105°C			35	
			V_{IN}=1.05V	T_A=25°C		18	29	
				T_A=-40 to +85°C			32	
				T_A=-40 to +105°C			35	
			V_{IN}=0.6V	T_A=25°C		18	29	
				T_A=-40 to +85°C			32	
				T_A=-40 to +105°C			35	

Electrical Characteristics, V_{BIAS}=5.0V (Continued)

Symbol	Parameter	Test Conditions		Min	Typ	Max	Unit
V_{ON_HYS}	ON-pin Hysteresis	V_{IN}=5V	T_A=25°C		60		mV
R_{PD}	Output Pull-down Resistance	V_{IN}=5.0V, V_{ON}=0V, V_{OUT}=5.0V	T_A=-40 to +105°C		230	280	Ω
T_{SD}	Thermal Shutdown	Junction temperature rising			160		°C
T_{SD_HYS}	Thermal Shutdown Hysteresis	Junction temperature falling threshold			20		°C

Electrical Characteristics, V_{BIAS}=2.5V

The specification in below table applies V_{BIAS} = 5.0V, typical values are for T_A = 25°C (unless otherwise noted).

Symbol	Parameter	Test Conditions			Min	Typ	Max	Unit
Power Supply and Current								
I_{Q_BIAS}	V_{BIAS} Quiescent Current (both channels)	I_{OUT1}=I_{OUT2}=0mA, $V_{IN1,2}$=$V_{ON1,2}$=2.5V		T_A=-40 to +85°C		8.5	14	μA
				T_A=-40 to +105°C			14	
	V_{BIAS} Quiescent Current (single channel)	I_{OUT1}=I_{OUT2}=0mA, V_{ON2}=0V $V_{IN1,2}$=V_{ON1}=2.5V		T_A=-40 to +85°C		7.5	13	μA
				T_A=-40 to +105°C			13	
I_{S_VBIAS}	V_{BIAS} Shutdown Current	$V_{ON1,2}$=0V, $V_{OUT1,2}$=0V		T_A=-40 to +105°C		0.4	1.0	μA
I_{S_VIN}	V_{IN} Shutdown Current (per channel)	V_{ON}=0V V_{OUT}=0V	V_{IN}=2.5V	T_A=-40 to +85°C		0.005	0.8	μA
				T_A=-40 to +105°C			2.1	
			V_{IN}=1.8V	T_A=-40 to +85°C		0.002	0.5	
				T_A=-40 to +105°C			1.4	
			V_{IN}=1.05V	T_A=-40 to +85°C		0.002	0.3	
				T_A=-40 to +105°C			1	
			V_{IN}=0.6V	T_A=-40 to +85°C		0.001	0.3	
				T_A=-40 to +105°C			0.8	
I_{ON}	ON-pin Input Leakage Current	V_{ON}=5.5V		T_A=-40 to +105°C			0.1	μA

Electrical Characteristics, V_{BIAS}=2.5V (Continued)

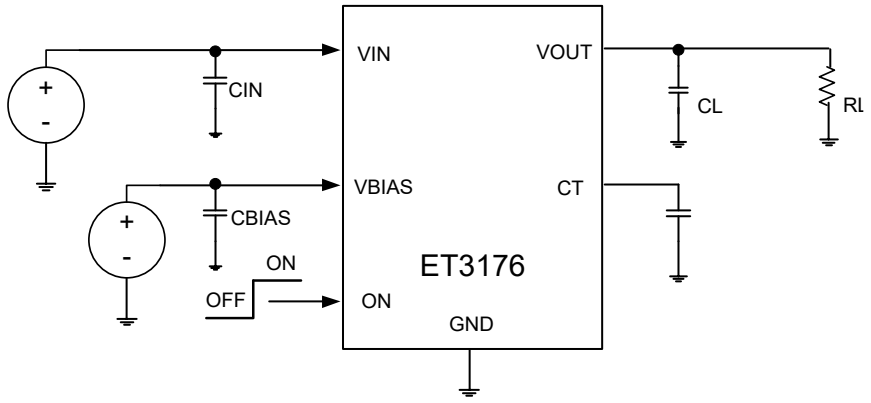
Symbol	Parameter	Test Conditions			Min	Typ	Max	Unit
Resistance Characteristics								
R_{ON}	On-Resistance (per channel)	I_{OUT}=-0.2 A	V_{IN}=2.5V	T_A=25°C		22	30	mΩ
				T_A=-40 to +85°C			36	
				T_A=-40 to +105°C			40	
			V_{IN}=1.8V	T_A=25°C		21	30	
				T_A=-40 to +85°C			35	
				T_A=-40 to +105°C			40	
			V_{IN}=1.5V	T_A=25°C		20	30	
				T_A=-40 to +85°C			35	
				T_A=-40 to +105°C			40	
R_{ON}	On-Resistance (per channel)	I_{OUT}=-0.2 A	V_{IN}=1.2V	T_A=25°C		20	30	mΩ
				T_A=-40 to +85°C			35	
				T_A=-40 to +105°C			40	
			V_{IN}=1.05V	T_A=25°C		20	29	
				T_A=-40 to +85°C			34	
				T_A=-40 to +105°C			39	
			V_{IN}=0.6V	T_A=25°C		20	29	
				T_A=-40 to +85°C			34	
				T_A=-40 to +105°C			39	
V_{ON_HYS}	ON-pin Hysteresis	V_{IN}=2.5V		T_A=25°C		45		mV
R_{PD}	Output Pull-down Resistance	V_{IN}=2.5V, V_{ON}=0V, V_{OUT}=2.5V		T_A=-40 to +105°C		250	300	Ω
T_{SD}	Thermal Shutdown	Junction temperature rising				160		°C
T_{SD_HYS}	Thermal Shutdown Hysteresis	Junction temperature falling threshold				20		°C

Switching Characteristics

Refer to the timing test circuit in the Figure 4 and t_{ON} / t_{OFF} waveforms in the Figure 5 for references to external components used for the test condition in the switching characteristics table.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{IN}=V_{ON}=V_{BIAS}=5V,T_A=25°C (unless otherwise noted)						
t_{ON}	Turn-on time	R_L=10Ω, C_L=0.1μF,C_T=1000pF		1400		us
t_{OFF}	Turn-off time			4		
t_R	V_{OUT} rise time			1740		
t_F	V_{OUT} fall time			2		
t_D	Delay time			600		
V_{IN}=0.6V, V_{ON}=V_{BIAS}=5V,T_A=25°C (unless otherwise noted)						
t_{ON}	Turn-on time	R_L=10Ω, C_L=0.1μF,C_T=1000pF		600		us
t_{OFF}	Turn-off time			4		
t_R	V_{OUT} rise time			285		
t_F	V_{OUT} fall time			2		
t_D	Delay time			460		
V_{IN}=2.5V, V_{ON}=5V,V_{BIAS}=2.5V,T_A=25°C (unless otherwise noted)						
t_{ON}	Turn-on time	R_L=10Ω, C_L=0.1μF,C_T=1000pF		2750		us
t_{OFF}	Turn-off time			6.5		
t_R	V_{OUT} rise time			2800		
t_F	V_{OUT} fall time			2.5		
t_D	Delay time			1300		
V_{IN}=0.6V, V_{ON}=5V,V_{BIAS}=2.5V,T_A=25°C (unless otherwise noted)						
t_{ON}	Turn-on time	R_L=10Ω, C_L=0.1μF,C_T=1000pF		1550		us
t_{OFF}	Turn-off time			9		
t_R	V_{OUT} rise time			950		
t_F	V_{OUT} fall time	R_L=10Ω, C_L=0.1μF,C_T=1000pF		2		us
t_D	Delay time			1050		

Timing Diagram



Single Channel Shown for Clarity

Figure 4. Timing Test Circuit

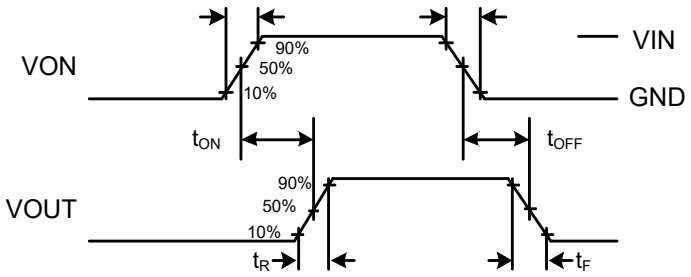


Figure 5. t_{ON} and t_{OFF} Waveforms

Application Circuit

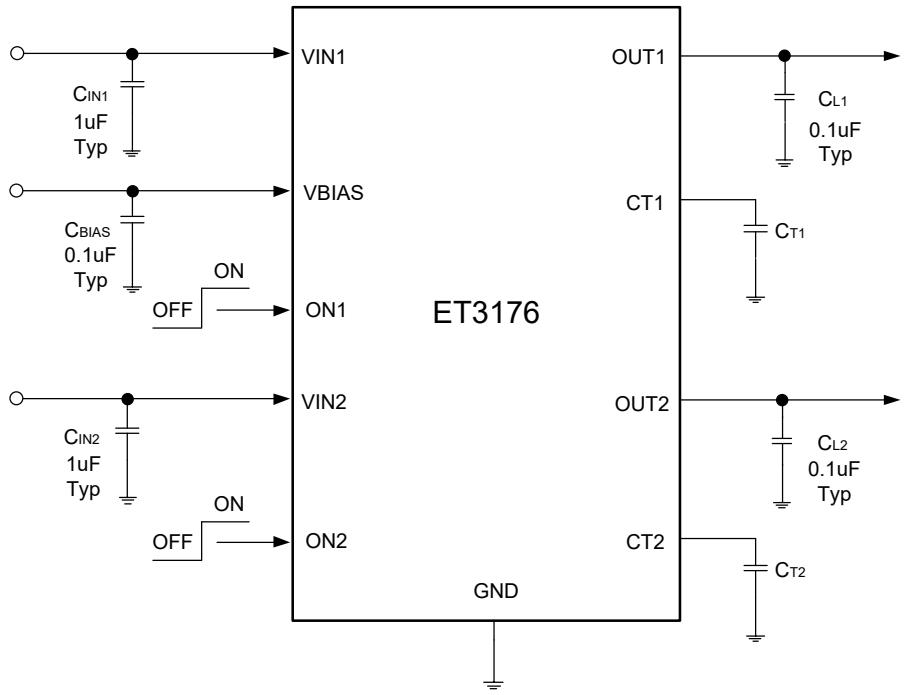
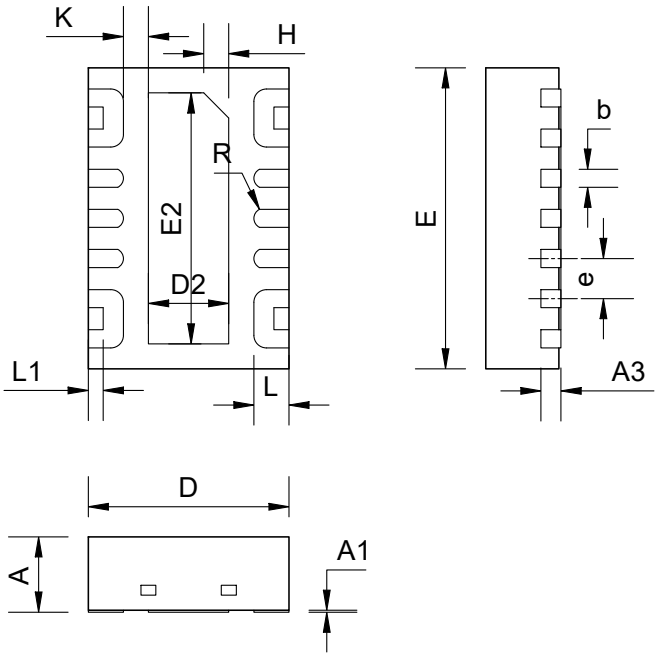


Figure 6. Typical Application*

*：This electric circuit only supplies for reference.

Package Dimension

DFN14(3mm×2mm)

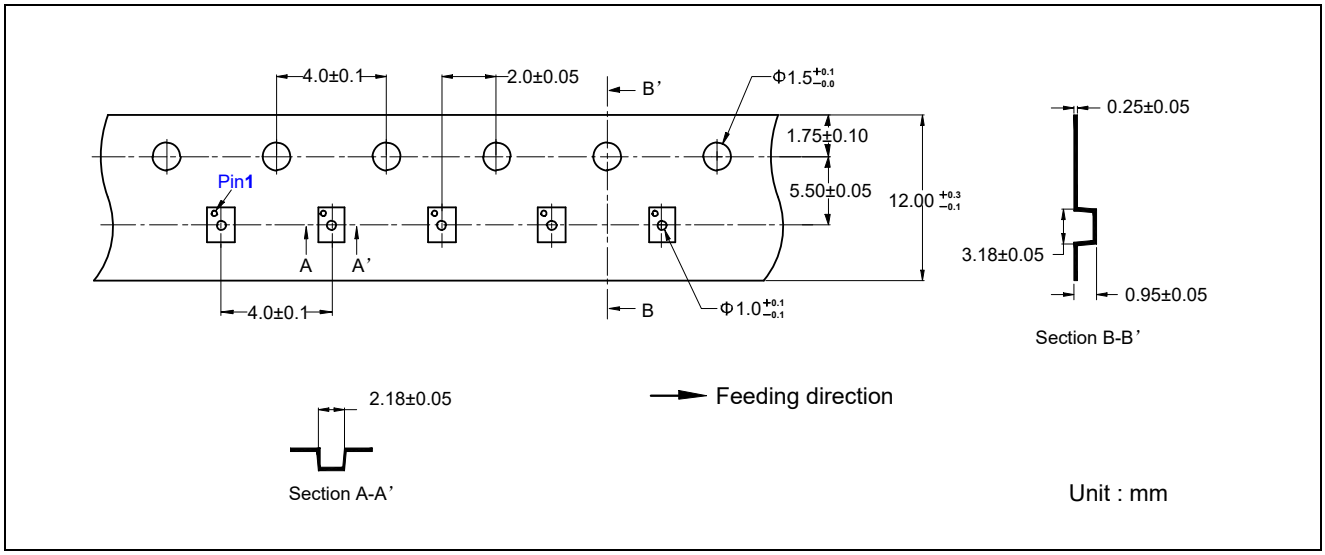


COMMON DIMENSIONS

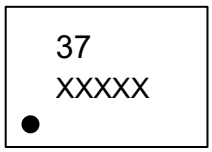
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A3		0.20REF	
b	0.13	0.18	0.23
D	1.95	2.00	2.05
E	2.95	3.00	3.05
D2	0.70	0.80	0.90
E2	2.40	2.50	2.60
e	0.30	0.40	0.50
H		0.20REF	
K	0.15	0.25	-
L	0.30	0.35	0.40
L1	0.10	0.15	0.20
R	0.05	-	-

Tape



Marking



37 - Part Number

XXXXX - Tracking Number

Revision History and Checking Table

Version	Date	Revision Item	Modifier	Function & Spec Checking	Package & Tape Checking
1.0	2021-11-11	Initial Version	Luh	Luh	Liujy
1.1	2022-08-30	Update Typeset	Shib	Luh	Liujy
1.2	2023-04-20	Update Package	Tugz	Luh	Liujy
1.3	2023-05-24	Update Reel	Shib	Luh	Liujy
1.4	2023-08-31	Update Typeset	Tugz	Luh	Liujy
1.5	2026-09-17	Update Equation1 and Power Sequence	Lusj	Luh	Liujy