XPA5146

5.5-V, 12-A, 3-mΩ On-Resistance Load Switch with Controlled Turn-on

1. Description

The XPA5146 is a single-channel load switch that provides a configurable rise time to minimize inrush current.

The device contains an N-channel MOSFET that can operate over an input voltage range of 0.2V to 5.5V and can support a maximum continuous current of 12A.

The switch is controlled by an on and off input (ON), which is capable of interfacing directly with low voltage control signals (V_{IH}=0.7V). The XPA5146 has an optional QOD pin for quick output discharge when switch is turned off, and the fall time (tFALL) of the output can be adjusted through an external resistor.

There is a Power Good signal on the device indicating when the main MOSFET is fully turned on, which can be used to enable the downstream load. Integrated thermal shutdown ensures protection against high temperature environments.

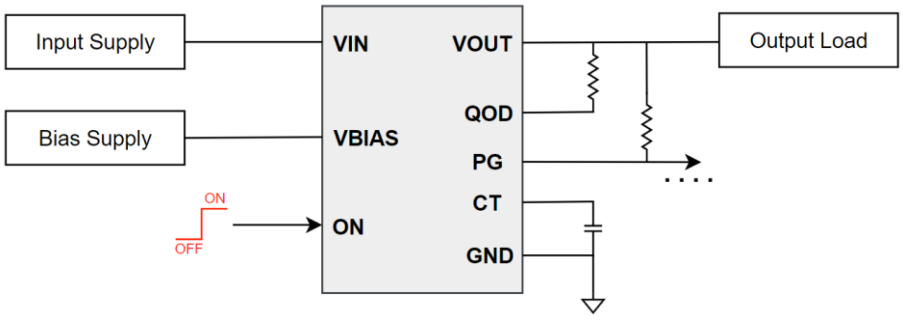
The XPA5146 is available in a 1.5mm x 2.0mm, 0.5mm pitch, 10-pin WQFN package and is characterized for operation over the extended free-air temperature range of -40°C to +125°C.

2. Applications

- Optical module
- Solid state drive
- Industrial PC
- PC and notebooks

3. Features

- Input voltage range (V_{IN}): 0.2V to 5.5V
- Bias voltage range: 2.2V to 5.5V
- Maximum continuous current: 12A
- ON-Resistance (R_{ON}): 3mΩ (typ.)
- Adjustable slew rate control
- Adjustable quick output discharge (QOD)
- Open drain Power Good (PG) signal
- Thermal shutdown
- Low power consumption:
  - ON state (I_Q): 27uA (typ.)
  - OFF state (I_{SD}): 2uA (typ.)
- Smart ON pin pulldown ($R_{PD, ON}$):
  - ON ≥ V_{IH} (I_{ON}): 25nA (typ.)
  - ON ≤ V_{IL} ($R_{PD,ON}$): 500kΩ (typ.)



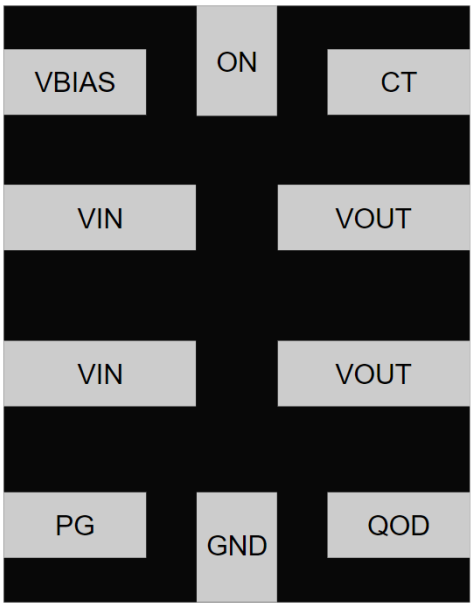
XPA5146 Typical Application Circuitry

4. Ordering Information

Family	Part Number	Current rating (A)	Top Marking	MPQ
XPA5146	XPA5146Q10R	12	5146	3000

MPQ means Minimum Packing Quantity.
For production orders greater than MPQ, the order must be a multiple of MPQ per package size above.

5. PIN Configuration and Functions



Top View

Pin	Name	Description
1	VBIAS	Device bias supply
2, 3	VIN	Switch input
4	PG	Open drain power good signal, asserted high when the output is full load ready.
5	GND	Device ground
6	QOD	Quick output discharge pin
7, 8	VOUT	Switch output
9	CT	Timing pin, can control the slew rate of the output through a capacitor to GND
10	ON	Enable pin

6. Absolute Maximum Ratings(1)

Parameter	Min	Max	Units
Input Voltage, V_{IN}	-0.3	6	V
Bias Voltage, V_{BIAS}	-0.3	6	V
Other Pins Voltage, V_{ON}, V_{CT}, V_{QOD} and V_{PG}	-0.3	6	V
Maximum Current, I_{MAX}		12	A
Storage Temperature	-65	+150	°C
Junction Temperature		Internally Limited	°C
Electrostatic Discharge (HBM)	-2000	+2000	V
Electrostatic Discharge (CDM)	-1000	+1000	V

Note: (1) Operation of the device outside of these parameters may cause permanent damage.

7. Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Units
Input Voltage	V_{IN}	0.2		5.5	V
Bias Voltage	V_{BIAS}	2.2		5.5	V
ON Pin High Voltage Range	V_{IH}	0.9		5.5	V
ON Pin Low Voltage Range	V_{IL}	0		0.35	V
Control Pin Voltage	V_{PG}, V_{QOD}	0		5.5	V
Ambient Temperature	T_A	-40		+105	°C
Junction Temperature	T_J	-40		+125	°C

8. Thermal Information

Junction to ambient thermal resistance is a function of board layout and ambient air flow condition. This data is based on two-layer PCB in still air box in accordance with JEDEC standard JESD51 on natural convection.

Parameter	Symbol	Typ	Units
Junction-to-ambient thermal resistance	θ_{JA}	110	°C/W
Junction-to-case thermal resistance	θ_{JC}	80	°C/W

9. Electrical Specifications (VBIAS=5V)

(Typical values are at TA = +25°C. Unless otherwise noted.)

Parameter	Symbol	Test Condition	T_A	Min Typ Max	Units
VBIAS Shutdown Current	$I_{SD,VBIAS}$	ON =0V	25°C	1.7	uA
			-40°C to 85°C	1.9	uA
			-40°C to 125°C	2.0	uA
VBIAS Quiescent Current	$I_{Q, VBIAS}$	ON>V_{IH}	25°C	27.5	uA
			-40°C to 85°C	31	uA
			-40°C to 125°C	32	uA
VIN Shutdown Current	$I_{SD,VIN}$	ON =0V	25°C	10	uA
			-40°C to 85°C	20	uA

			-40°C to 125°C			30	uA
ON pin leakage	I_{ON}	ON=VBIAS	-40°C to 125°C		0.1		uA
On-Resistance	R_{ON}	V_{IN} = 0.2V to 5V	25°C		3		mΩ
			-40°C to 85°C			4	mΩ
			-40°C to 125°C			5	mΩ
Turn on threshold, rising	V_{IH}		-40°C to 125°C	0.72	0.80	0.87	V
Turn off threshold, falling	V_{IL}		-40°C to 125°C	0.68	0.78	0.86	V
ON pin hysteresis	$V_{ON,HYST}$		-40°C to 125°C		20		mV
ON pin deglitch time	$T_{ON,DEGLITCH}$		-40°C to 125°C	2	5	7	us
$V_{OL,PG}$	PG VOL	I_{PG} = 1mA	-40°C to 125°C			0.2	V
$R_{PD,ON}$	Smart Pull Down Resistance		25°C		500		kΩ
			-40°C to 125°C			700	
R_{QOD}	QOD Resistance		25°C		50		Ω
			-40°C to 125°C			75	
Thermal Shutdown	TSD		-	150	170	190	°C
Thermal Shutdown Hysteresis	TSD_{HYS}		-		20		°C

10. Electrical Specifications (VBIAS=3.3V)

(Typical values are at TA = +25°C. Unless otherwise noted.)

Parameter	Symbol	Test Condition	T_A	Min	Typ	Max	Units
VBIAS Shutdown Current	$I_{SD,VBIAS}$	ON =0V	25°C		0.9		uA
			-40°C to 85°C			1	uA
			-40°C to 125°C			1.1	uA
VBIAS Quiescent Current	$I_{Q,\ VBIAS}$	ON>V_{IH}	25°C		20.5		uA
			-40°C to 85°C			23.5	uA
			-40°C to 125°C			24.0	uA
VIN Shutdown Current	$I_{SD,VIN}$	ON =0V	25°C		10		uA
			-40°C to 85°C			20	uA
			-40°C to 125°C			30	uA
ON pin leakage	I_{ON}	ON=VBIAS	-40°C to 125°C		0.1		uA
On-Resistance	R_{ON}	V_{IN} = 0.2V to 3.3V	25°C		3		mΩ
			-40°C to 85°C			4	mΩ
			-40°C to 125°C			5	mΩ
Turn on threshold, rising	V_{IH}		-40°C to 125°C	0.67	0.77	0.84	V
Turn off threshold, falling	V_{IL}		-40°C to 125°C	0.64	0.75	0.83	V
ON pin hysteresis	$V_{ON,HYST}$		-40°C to 125°C		20		mV
ON pin deglitch time	$T_{ON,DEGLITCH}$		-40°C to 125°C	2	5	6.5	us
$V_{OL,PG}$	PG VOL	I_{PG} = 1mA	-40°C to 125°C			0.2	V
$R_{PD,ON}$	Smart Pull Down Resistance		25°C		500		kΩ
			-40°C to 125°C			700	
R_{QOD}	QOD Resistance		25°C		50		Ω
			-40°C to 125°C			100	

Thermal Shutdown	TSD		-	150	170	190	°C
Thermal Shutdown Hysteresis	TSD_{HYS}		-		20		°C

11. Electrical Specifications (VBIAS=2.2V)

(Typical values are at TA = +25°C. Unless otherwise noted.)

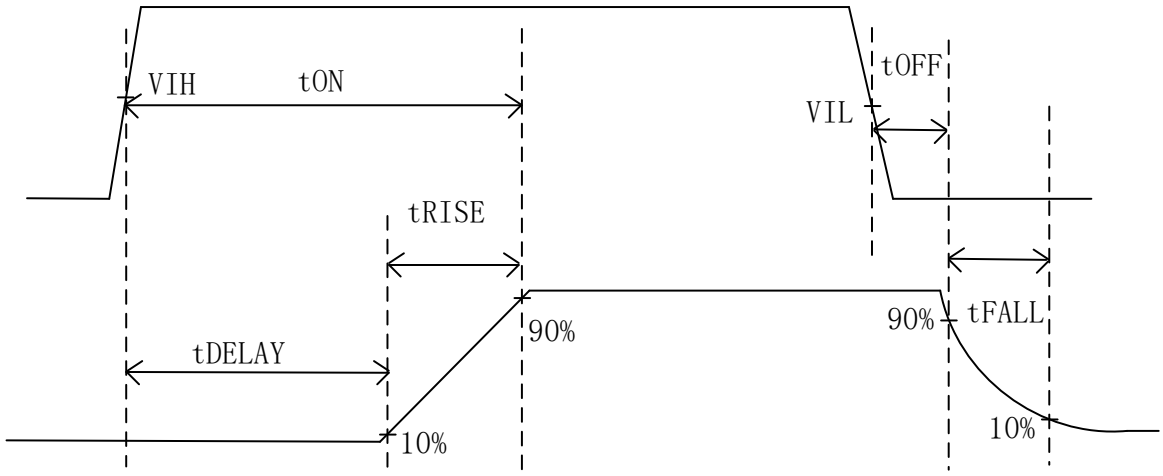
Parameter	Symbol	Test Condition	T_A	Min	Typ	Max	Units
VBIAS Shutdown Current	$I_{SD,VBIAS}$	ON =0V	25°C		0.45		uA
			-40°C to 85°C			0.5	uA
			-40°C to 125°C			0.6	uA
VBIAS Quiescent Current	$I_{Q, VBIAS}$	ON>V_{IH}	25°C		17		uA
			-40°C to 85°C			19	uA
			-40°C to 125°C			20	uA
VIN Shutdown Current	$I_{SD,VIN}$	ON =0V	25°C		10		uA
			-40°C to 85°C			20	uA
			-40°C to 125°C			30	uA
ON pin leakage	I_{ON}	ON=VBIAS	-40°C to 125°C		0.1		uA
On-Resistance	R_{ON}	V_{IN} = 0.2V to 2.2V	25°C		3		mΩ
			-40°C to 85°C			4	mΩ
			-40°C to 125°C			5	mΩ
Turn on threshold, rising	V_{IH}		-40°C to 125°C	0.63	0.73	0.80	V
Turn off threshold, falling	V_{IL}		-40°C to 125°C	0.60	0.71	0.79	V
ON pin hysteresis	$V_{ON,HYST}$		-40°C to 125°C		20		mV
ON pin deglitch time	$T_{ON,DEGLITCH}$		-40°C to 125°C	2	4.5	6.5	us
Output pulldown resistance	R_{PD}	VOUT=VIN	25°C		50		Ω
			-40°C to 125°C	40		65	Ω
$V_{OL,PG}$	PG VOL	I_{PG} = 1mA	-40°C to 125°C			0.2	V
$R_{PD,ON}$	Smart Pull Down Resistance		25°C		500		kΩ
			-40°C to 125°C			700	
R_{QOD}	QOD Resistance		25°C		55		Ω
			-40°C to 125°C			100	
Thermal Shutdown	TSD		-	150	170	190	°C
Thermal Shutdown Hysteresis	TSD_{HYS}		-		20		°C

12. Switching Characteristics (VBIAS=2.2V to 5V)

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
TA = +25°C, VIN=5.0V, unless otherwise noted						
Turn-on Time	t_{ON}	C_L=10uF, R_L=100Ω, C_T=1000pF		1200		us
Vout rise time	t_r	C_L=10uF, R_L=100Ω, C_T=1000pF		800		us
Delay time	t_D	C_L=10uF, R_L=100Ω, C_T=1000pF		330		us
Vout fall time	t_f	C_L=10uF, R_L=100Ω, C_T=1000pF		1980		us
Turn-off Time	t_{OFF}	C_L=10uF, R_L=100Ω, C_T=1000pF		99		us
TA = +25°C, VIN=3.3V, unless otherwise noted						

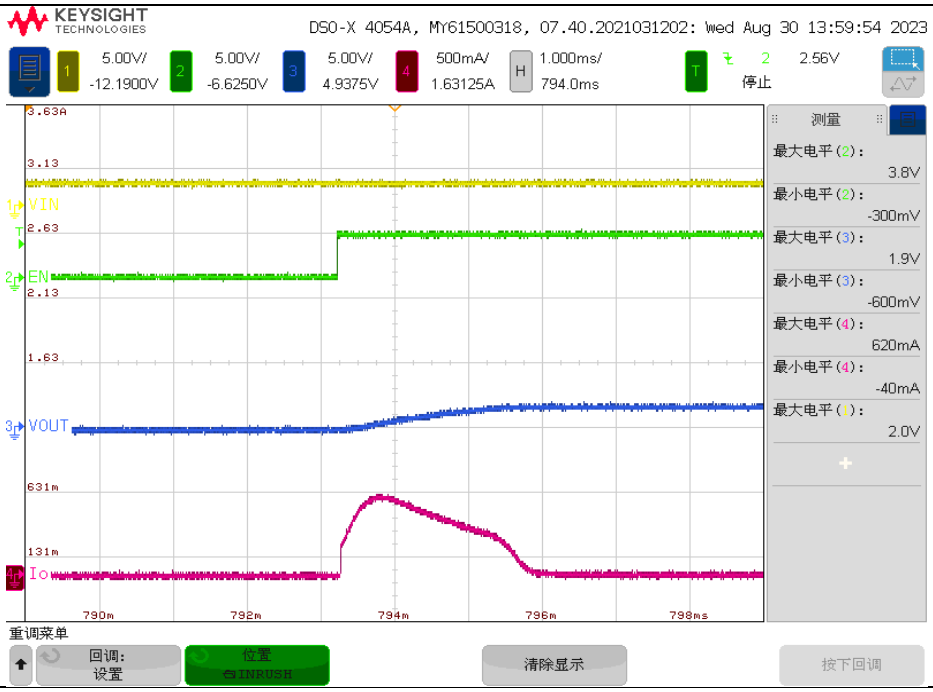
Turn-on Time	t_{ON}	C_L=10uF, R_L=100Ω, C_T=1000pF	901	us
Vout rise time	t_r	C_L=10uF, R_L=100Ω, C_T=1000pF	499	us
Delay time	t_D	C_L=10uF, R_L=100Ω, C_T=1000pF	331	us
Vout fall time	t_f	C_L=10uF, R_L=100Ω, C_T=1000pF	1995	us
Turn-off Time	t_{OFF}	C_L=10uF, R_L=100Ω, C_T=1000pF	101	us
TA = +25°C, VIN=1.8V, unless otherwise noted				
Turn-on Time	t_{ON}	C_L=10uF, R_L=100Ω, C_T=1000pF	594	us
Vout rise time	t_r	C_L=10uF, R_L=100Ω, C_T=1000pF	336	us
Delay time	t_D	C_L=10uF, R_L=100Ω, C_T=1000pF	401	us
Vout fall time	t_f	C_L=10uF, R_L=100Ω, C_T=1000pF	2110	us
Turn-off Time	t_{OFF}	C_L=10uF, R_L=100Ω, C_T=1000pF	102	us
TA = +25°C, VIN=0.6V, unless otherwise noted				
Turn-on Time	t_{ON}	C_L=10uF, R_L=100Ω, C_T=1000pF	645	us
Vout rise time	t_r	C_L=10uF, R_L=100Ω, C_T=1000pF	181	us
Delay time	t_D	C_L=10uF, R_L=100Ω, C_T=1000pF	363	us
Vout fall time	t_f	C_L=10uF, R_L=100Ω, C_T=1000pF	2145	us
Turn-off Time	t_{OFF}	C_L=10uF, R_L=100Ω, C_T=1000pF	121	us

13. Parameter Measurement Information



Timing Diagram

14. Typical Characteristics

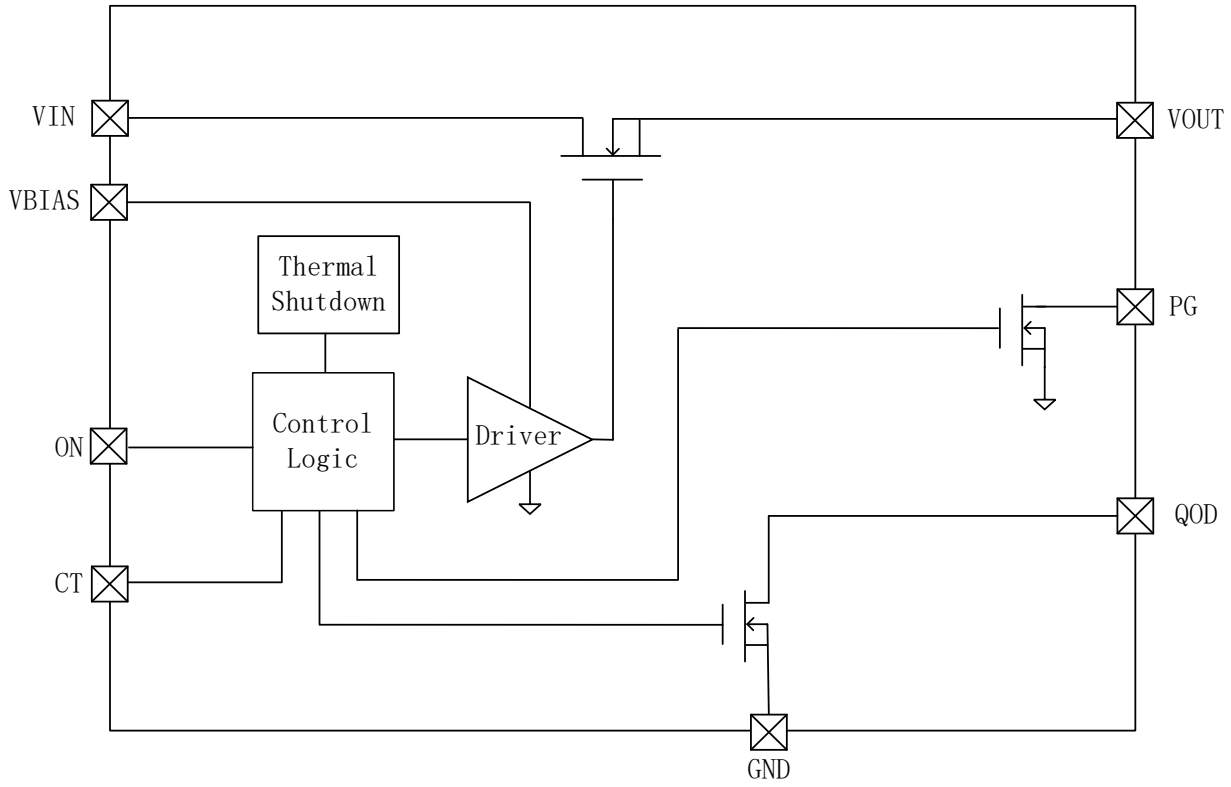


Inrush current, XPA5146 turn-on into 560uF Cout
VIN=1.8V, VBIAS=3.3V

15. Functional Description

The XPA5146 device is a single-channel load switch with a 3- mΩ power MOSFET designed to operate up to 12A. The voltage range is 0.2V to 5.5V. A configurable rise time provides flexibility for power sequencing and minimizes inrush current for high capacitance loads.

The switch is controlled by an enable pin (ON), which is capable of interfacing directly with low voltage GPIO signals down to its VIH level of 0.9 V. The XPA5146 device has an optional QOD pin for quick output discharge when switch is turned off, and the fall time (tFALL) of the output can be adjusted through an external capacitor. There is a Power Good signal on the device indicating when the main MOSFET is fully turned on and the on-resistance is at its final value.



Block Diagram

ON and OFF Control

The ON pin controls the state of the switch. The ON pin is compatible with standard GPIO logic threshold so it can be used in a wide variety of applications. When this pin is pulled high, the device is enabled, and when it is low, the device is switched off.

Adjustable Slew Rate

A capacitor to GND on the CT pin sets the slew rate, and the higher the capacitance the lower the slew rate. Rise times for VBIAS = 5V are shown below.

CT Capacitor	VIN=5V	VIN=3.3V	VIN=1.8V	VIN=1.2V	VIN=0.8V
0pF	160us	120us	80us	60us	49us
220pF	300us	220us	125us	90us	69us
1000pF	800us	550us	310us	220us	169us
4700pF	3200us	2100us	1159us	810us	570us

Adjustable Quick Output Discharge

The XPA5146 device includes a QOD feature that can be configured in one of three ways:

1. QOD pin shorted to VOUT pin. Using this method, the discharge rate after the switch becomes disabled is controlled with the value of the internal resistance RQOD. The value of this resistance is listed in the Electrical Characteristics table.

2. QOD pin connected to VOUT pin using an external resistor REXT. After the switch becomes disabled, the discharge rate is controlled by the value of the total resistance of the QOD.

3. QOD pin is unused and left floating. Using this method, there is no quick output discharge functionality, and the output remains floating after the switch is disabled. Fall time is dependent on the strength of the configured pulldown resistance on the output.

Thermal Shutdown

When junction temperature of the XPA5146 reaches 170°C (typical), the device shuts itself off to prevent thermal damage. After it cools off by about 20°C, the device turns back on.

Power Good Signal

The XPA5146 device has a Power Good output signal to indicate the gate of the pass FET is driven high and the switch is on with the on-resistance close to its final value (full load ready). The signal is an active high and open drain output which can be connected to a voltage source through an external pullup resistor, RPU. This voltage source can be VOUT from the XPA5146 device or another external voltage. VBIAS is required for PG to have a valid output.

Device Function Modes

ON	Fault Condition	Vout State
L	N/A	Hi-Z
H	None	V_{IN} (through R_{ON})
X	Thermal Shutdown	Hi-Z

16. Application Information

Input and Output Capacitors

When the switch being enabled, the output capacitors are immediately charged up from 0V to VIN voltage. This charge arrives in the form of inrush current.

Higher output capacitance can be used but inrush current during startup should be considered and managed. Inrush current can be calculated by below formula.

$$\text{I\_Inrush} = Cout \times \frac{dv}{dt}$$

Where:

- C_{OUT} is Output capacitance
- d_V = Output voltage
- d_t = Rise time

Power Dissipation

The MOSFET power dissipation is the main contributor to device junction temperature.
Assuming this, the power dissipation and the junction temperature in stable status can be calculated with the following equations.

$$P_D = R_{ON} \times {I_{OUT}}^2$$

Where:

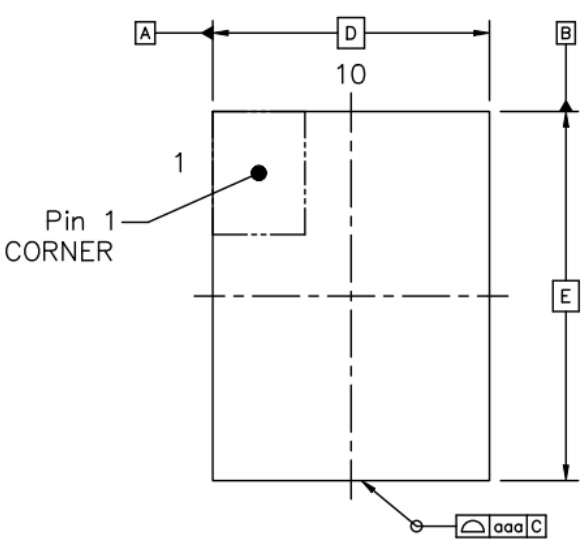
- P_D = Power dissipation (W)
- R_{ON} = Power MOSFET on-resistance (Ω)
- I_{OUT} = Output current (A)

$$T^J = P_D \times \theta_{JA} + T_A$$

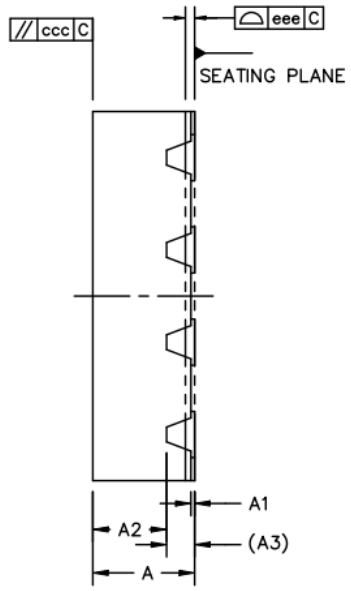
Where:

- T_J = Junction temperature (°C)
- θ_{JA} = Junction-to-Ambient Thermal Resistance (°C/W)
- T_A = Ambient temperature (°C)

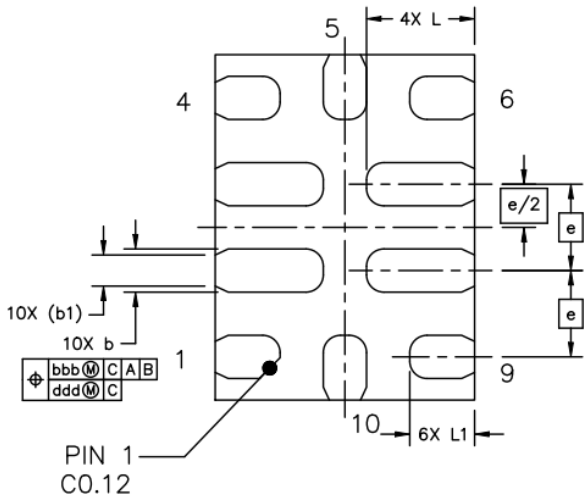
17. Physical Dimensions



TOP VIEW



SIDE VIEW

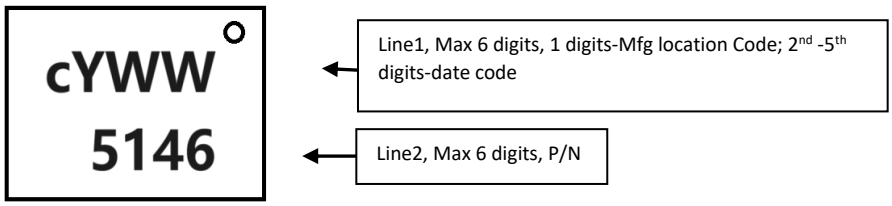


BOTTOM VIEW

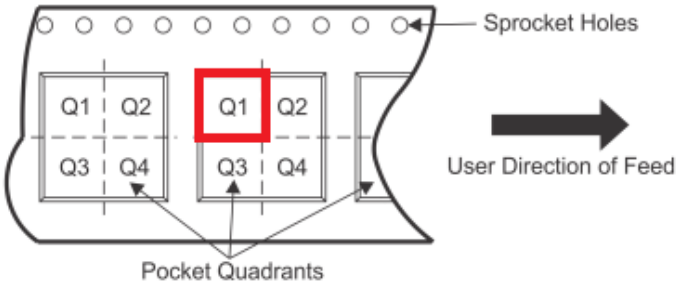
		SYMBOL	MIN	NOM	MAX
TOTAL THICKNESS		A	0.5	0.55	0.6
STAND OFF		A1	0	0.02	0.05
MOLD THICKNESS		A2	---	0.4	---
L/F THICKNESS		A3	0.152 REF		
LEAD WIDTH		b	0.2	0.25	0.3
		b1	0.18 REF		
BODY SIZE	X	D	1.5 BSC		
	Y	E	2 BSC		
LEAD PITCH		e	0.5 BSC		
LEAD LENGTH		L	0.575	0.625	0.675
		L1	0.325	0.375	0.425
PACKAGE EDGE TOLERANCE		aaa	0.1		
MOLD FLATNESS		ccc	0.1		
COPLANARITY		eee	0.05		
LEAD OFFSET		bbb	0.1		
		ddd	0.05		

18. Tape and Reel Information

Format:



Pin 1 located in Q1 direction in T&R



LOGO

Due to limited space, there is no logo on this marking.

Trace-ability Code:

1. Manufacturing Location Code + Date code Line 1
The first digit named as Manufacturing Location Code, 2nd -4th digit named date code .

a) Assembly location code: Hexin: c
b) 2nd digit: Year code, Last digit of the year should be marked as year code.

Year	2020	2021	2022	2023	2024	2025
Code	0	1	2	3	4	5

3rd & 4th digit: Week code, 01 means the 1st Work Week base on Xinji's calendar.

2. Product Number Code: Line 2

Product Name	P/N Code	Remark
XPA5146Q10R	5146	