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April 2017

# FPF2496 IntelliMAX™ 28 V, Over-Voltage, Over-Current Protection Load Switch with Adjustable Current-Limit Control

## Features

- $V_{IN}$ : 3.5 V~5.5 V
- 28 V Absolute Ratings at  $V_{IN}$
- Current Capability: 2.5 A
- Adjustable Current Limit: (Typ.) 0.1 A~2.5 A with 10% Accuracy
- $R_{ON}$ : Maximum 100 mΩ at 5  $V_{IN}$  and 1A  $I_{OUT}$
- Input OVP: Min.=5.6 V, Typ.=5.8 V, Max.=6 V
- Output Discharge During Off State
- Open-Drain OVP on FLAGB
- Thermal Shutdown
- Under-Voltage Lockout (UVLO)
- True Reverse-Current Blocking (TRCB)
- Logic CMOS IO Meets JESD76 Standard for GPIO Interface and Related Power Supply Requirements
- ESD Protected:
  - Human Body Model: >5.0 kV
  - Charged Device Model: >2.5 kV
  - IEC 61000-4-2 Air Discharge: >15 kV
  - IEC 61000-4-2 Contact Discharge: >8 kV

## Description

The FPF2496 advanced load-management switch targets applications requiring a highly integrated solution. It disconnects loads powered from the DC power rail (<6 V) with stringent off-state current targets and high load capacitances (<100 μF). The FPF2496 consists of a slew-rate controlled low-impedance MOSFET switch (100 mΩ maximum) and integrated analog features. The slew-rate controlled turn-on characteristic prevents inrush current and the resulting excessive voltage droop on power rails. FPF2496 has over-voltage and over-temperature protection.

The FPF2496 has a True Reverse-Current Blocking (TRCB) function that obstructs unwanted reverse current from  $V_{OUT}$  to  $V_{IN}$  during ON and OFF states. The exceptionally low off-state current drain (<2 μA maximum) facilitates compliance with standby power requirements. The input voltage range operates from 3.5 V to 5.5  $V_{DC}$  to support a wide range of applications in consumer, optical, medical, storage, portable, and industrial-device power management systems. Switch control is managed by a logic input (active LOW) capable of interfacing directly with low-voltage control signal / General-Purpose Input / Output (GPIO) without an external pull-down resistor.

The device is packaged in advanced, fully “green” compliant, 1.21 mm x 1.21 mm, Wafer-Level Chip-Scale Package (WLCSPP).

## Applications

- Smart Phones, Tablet PCs
- Storage, DSLR, and Portable Devices

## Ordering Information

Part Number	Operating Temperature Range	Package	Top Mark
FPF2496UCX	-40 to 85°C	1.21 mm x 1.21 mm, Wafer-Level Chip-Scale Package (WLCSPP)	TJ

FPF2496 — IntelliMAX™ 28 V Over-Voltage, Over-Current Protection Load Switch with Adjustable Current-Limit Control

### Application Diagram

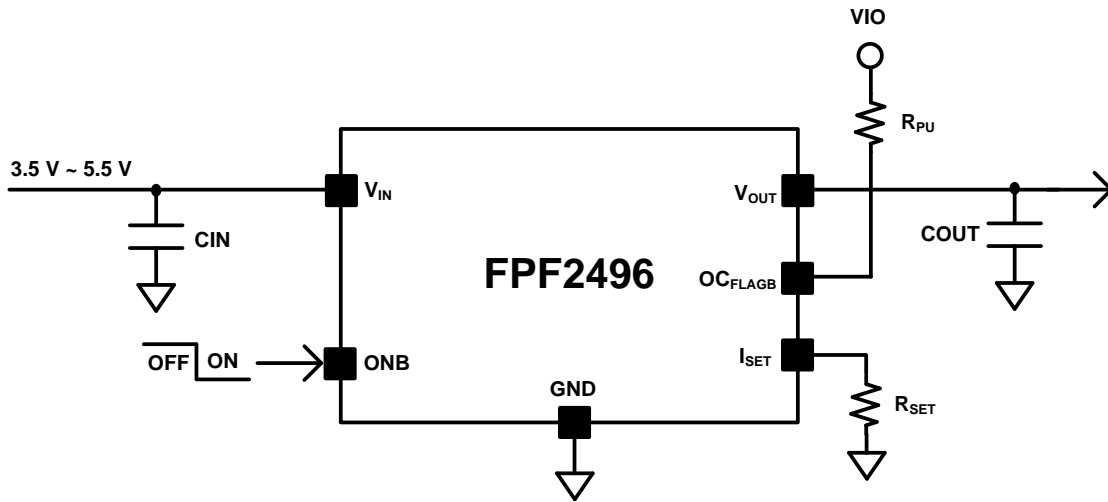


Figure 1. Typical Application

**Note:**

1.  $C_{IN}$  and  $C_{OUT}$  capacitors are recommended for improved device stability.

### Block Diagram

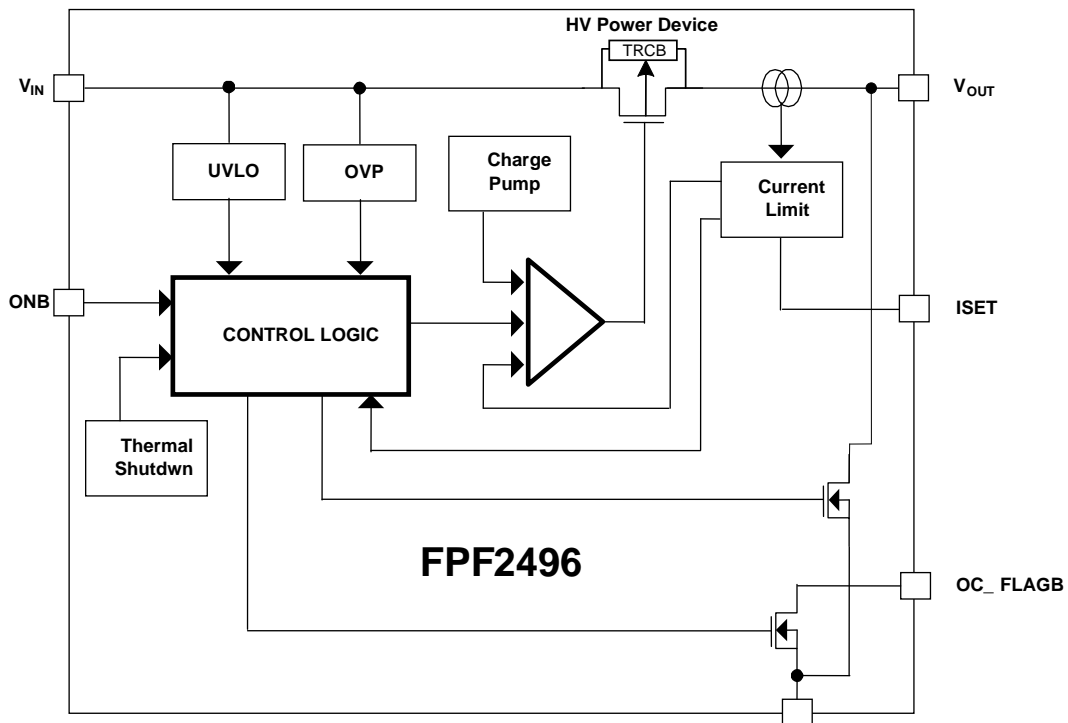


Figure 2. Functional Block Diagram

## Pin Configurations

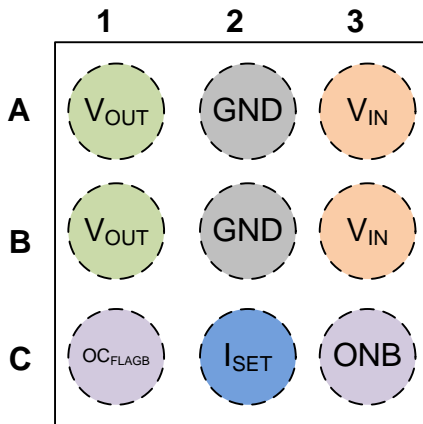


Figure 3. Pin Assignments (Top View)

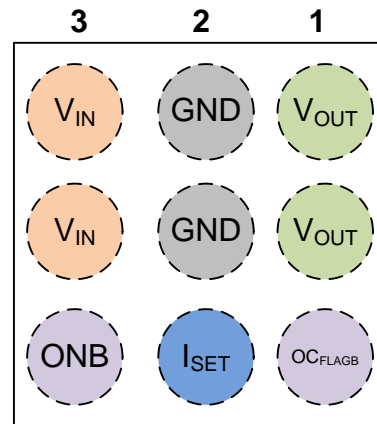


Figure 4. Pin Assignments (Bottom View)

## Pin Description

Pin #	Name	Description		
A1, B1	V <sub>OUT</sub>	<b>Switch Output</b>		
A3, B3	V <sub>IN</sub>	<b>Supply Input:</b> Input to the power switch		
A2	GND	<b>Ground</b> (Device Ground)		
B2				
C3	ONB	<b>ON/OFF Control Input:</b> Active LOW; GPIO compatible	<b>Logic HIGH</b>	Switch Disable
			<b>Logic LOW</b>	Switch Enable
C1	OC <sub>FLAGB</sub>	<b>Fault Output:</b> Active LOW, open-drain output that indicates an input over current. External pull-up resistor to V <sub>CC</sub> is required.		
C2	I <sub>SET</sub>	<b>Current Limit Set Input:</b> A resistor from ISET to ground sets the current limit for the switch.		

## 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 <sub>PIN</sub>	V <sub>IN</sub> to GND, V <sub>IN</sub> to V <sub>OUT</sub>		-0.3	28.0	V
	ONB, V <sub>OUT</sub> , FLAGB, I <sub>SET</sub> to GND		-0.3	6.0	
I <sub>SW</sub>	Maximum Continuous Switch Current			2.75	A
t <sub>PD</sub>	Total Power Dissipation at T <sub>A</sub> =25°C			1.0	W
T <sub>J</sub>	Operating Junction Temperature		-40	+150	°C
T <sub>STG</sub>	Storage Junction Temperature		-65	+150	°C
Θ <sub>JA</sub>	Thermal Resistance, Junction-to-Ambient (1-inch Square Pad of 2 oz. Copper)			95(2)	°C/W
				110(3)	
ESD	Electrostatic Discharge Capability	Human Body Model, ANSI/ESDA/JEDEC JS-001-2012	5.0		kV
		Charged Device Model, JESD22-C101	2.5		
	IEC61000-4-2 System Level	Air Discharge (V <sub>IN</sub> , V <sub>ON</sub> , V <sub>OUT</sub> to GND)	15		
		Contact Discharge (V <sub>IN</sub> , V <sub>ON</sub> , V <sub>OUT</sub> to GND)	8		

### Notes:

- Measured using 2S2P JEDEC std. PCB.
- Measured using 2S2P JEDEC PCB cold plate method.

## 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. ON Semiconductor does not recommend exceeding them or designing to Absolute Maximum Ratings.

Symbol	Parameters	Min.	Max.	Unit
V <sub>IN</sub>	Supply Voltage	3.5	5.5	V
T <sub>A</sub>	Ambient Operating Temperature	-40	85	°C

## Electrical Characteristics

Unless otherwise noted;  $V_{IN}=3.5$  to  $5.5$  V,  $T_A=-40$  to  $+85^\circ\text{C}$ ; typical values are at  $V_{IN}=5$  V and  $T_A=25^\circ\text{C}$ .

Symbol	Parameters	Condition	Min.	Typ.	Max.	Unit
<b>Basic Operation</b>						
$V_{IN}$	Input Voltage		3.5		5.5	V
$I_{Q(OFF)}$	Off Supply Current	$V_{ONB}=\text{HIGH}$ , $V_{OUT}=\text{Open}$		1	2	$\mu\text{A}$
$I_{SD(OFF)}$	Shutdown Current	$V_{IN}=5.5$ V, $V_{OUT}=0$ V, $V_{ONB}=\text{HIGH}$		0.1	4.0	$\mu\text{A}$
$I_Q$	Quiescent Current	$I_{OUT}=0$ mA		65	100	$\mu\text{A}$
$R_{ON}$	On Resistance	$V_{IN}=5.0$ V, $I_{OUT}=1$ A		70	100	m $\Omega$
		$V_{IN}=3.7$ V, $I_{OUT}=1$ A		75	105	
$V_{IH}$	ONB Input Logic HIGH Voltage	$V_{IN}=3.5$ V to $5.5$ V	1.15			V
$V_{IL}$	ONB Input Logic LOW Voltage	$V_{IN}=3.5$ V to $5.5$ V			0.65	V
$V_{IL\_FLAG}$	FLAGB Output Logic LOW Voltage	$V_{IN}=5$ V, $I_{SINK}=10$ mA		0.1	0.2	V
		$V_{IN}=3.5$ V, $I_{SINK}=10$ mA		0.15	0.30	
$I_{FLAGB\_LK}$	FLAGB Output HIGH Leakage Current	$V_{IN}=5$ V, Switch On			1	$\mu\text{A}$
$I_{ON}$	ONB Input Leakage	0 V to $V_{IN}$			1.0	$\mu\text{A}$
$R_{ON\_PD}$	Pull-Down Resistance at ONB Pin	$V_{IN}=3.5\text{--}5.5$ V, $V_{ONB}=\text{HIGH}$ , $T_A=-40$ to $85^\circ\text{C}$		14		M $\Omega$
RPD	Output Discharge $R_{PULL\_DOWN}$	$V_{IN}=3.5$ V, $V_{ONB}=\text{HIGH}$ , $I_{FORCE}=20$ mA, $T_A=-40$ to $85^\circ\text{C}$		100		$\Omega$
<b>Over-Voltage Protection</b>						
$V_{OVP\_TRIP}$	Input OVP Lockout	$V_{IN}$ Rising Threshold	5.60	5.80	6.00	V
		$V_{IN}$ Falling Threshold		5.50		
$V_{OVP\_HYS}$	Input OVP Hysteresis			0.3		V
$t_{OVP}$	Response Time	$I_{OUT}=0.5$ A, $C_L=1$ $\mu\text{F}$ , $T_A=25^\circ\text{C}$ , $V_{IN}=5.5$ V to $6.0$ V	1			$\mu\text{s}$
<b>Over-Current Protection</b>						
$I_{LIM}$	Current Limit	$V_{IN}=5$ V, $R_{SET} = 2100$ $\Omega$ , $V_{OUT} > 1.68$ V with 10% Accuracy	450	500	550	mA
		$V_{IN}=5$ V, $R_{SET} = 1070$ $\Omega$ , $V_{OUT} > 1.68$ V with 10% Accuracy	900	1000	1100	
$V_{UVLO}$	Under-Voltage Lockout	$V_{IN}$ Increasing		3.2		V
		$V_{IN}$ Decreasing		3.0		
$V_{UVLO\_HYS}$	UVLO Hysteresis			200		mV
$V_{T\_RCB}$	RCB Protection Trip Point	$V_{OUT} - V_{IN}$		50		mV
$V_{R\_RCB}$	RCB Protection Release Trip Point	$V_{IN} - V_{OUT}$		50		mV

Continued on the following page...

## Electrical Characteristics (Continued)

Unless otherwise noted;  $V_{IN}=3.5$  to  $5.5$  V,  $T_A=-40$  to  $+85^\circ\text{C}$ ; typical values are at  $V_{IN}=5$  V and  $T_A=25^\circ\text{C}$ .

Symbol	Parameters	Conditions	Min.	Typ.	Max.	Unit
$V_{RCB\_HYS}$	RCB Hysteresis			100		mV
$t_{RCB}$	Default RCB Response Time	$V_{IN}=5$ V, $V_{ONB}=\text{HIGH}/\text{LOW}$		2		$\mu\text{s}$
$I_{RCB}$	RCB Current	$V_{ONB}=\text{HIGH}$ , $V_{OUT}=5.5$ V		14		$\mu\text{A}$
$t_{HOCP}$	Hard Over-Current Response Time	Moderate Over-Current Condition, $I_{OUT} \geq I_{LIM}$ , $V_{OUT} \leq 0$ V		6		$\mu\text{s}$
$t_{OCP}$	Over-Current Response Time	Moderate Over-Current Condition, $I_{OUT} \geq I_{LIM}$ , $V_{OUT} \leq V_{IN}$		7		$\mu\text{s}$
$t_{OC\_FLAG}$	Over-Current Flag Response Time	When Over-Current Occurs to Flag Pulling LOW		8		ms
TSD	Thermal Shutdown	Shutdown Threshold		150		$^\circ\text{C}$
		Return from Shutdown		130		
		Hysteresis		20		

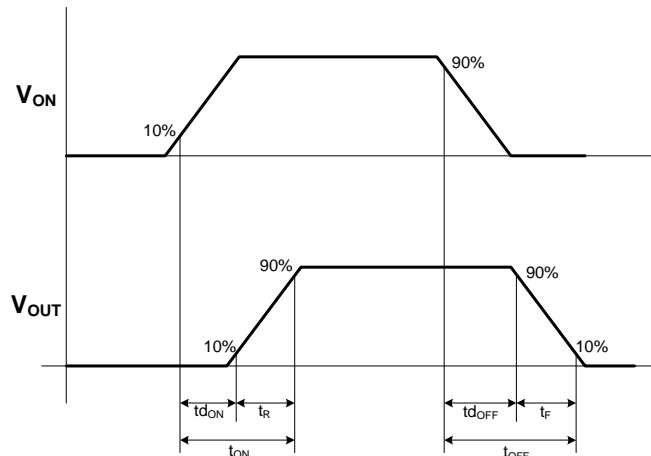
### Dynamic Characteristics

$t_{DON}$	Turn-On Delay <sup>(4,5)</sup>	$V_{IN}=5$ V, $R_L=100$ $\Omega$ , $C_L=1$ $\mu\text{F}$ , $T_A=25^\circ\text{C}$		4.39		ms
$t_R$	$V_{OUT}$ Rise Time <sup>(4,5)</sup>			7.26		ms
$t_{ON}$	Turn-On Time <sup>(4,7)</sup>			11.65		ms
$t_{DOFF}$	Turn-Off Delay <sup>(5)</sup>			1.85		ms
$t_F$	$V_{OUT}$ Fall Time <sup>(5)</sup>			37.60		ms
$t_{OFF}$	Turn-Off Time <sup>(7)</sup>			39.45		ms

#### Notes:

- This parameter is guaranteed by design and characterization; not production tested.
- $t_{DON}/t_{DOFF}/t_R/t_F$  are defined in Figure 5 below.
- $t_{ON}=t_R + t_{DON}$ .
- $t_{OFF}=t_F + t_{DOFF}$ .

## Timing Diagram



#### where:

- $t_{DON}$  = Delay On Time
- $t_R$  =  $V_{OUT}$  Rise Time
- $t_{ON}$  = Turn-On Time
- $t_{DOFF}$  = Delay Off Time
- $t_F$  =  $V_{OUT}$  Fall Time
- $t_{OFF}$  = Turn Off Time

Figure 5. Timing Diagram

## Operation and Application Description

### Input Capacitor

To limit the voltage drop on the input supply caused by transient inrush current when the switch turns on into discharge load capacitor; a capacitor must be placed in between the  $V_{IN}$  and GND pins. A high-value  $C_{IN}$  capacitor can be used to reduce the voltage drop in high-current applications.

### Output Capacitor

An output capacitor should be placed between the  $V_{OUT}$  and GND pins. This capacitor prevents parasitic board inductance from forcing  $V_{OUT}$  below GND when the switch is on. This capacitor also prevents reverse inrush current from creating a voltage spike that could damage the device in the case of a  $V_{OUT}$  short.

### Fault Reporting

Upon the detection of an over-current, OC\_FLAGB signals the fault by activating LOW.

### Current Limiting

The current limit ensures that the current through the switch does not exceed the maximum set value, while not limiting the minimum value. The current limit is adjustable through the selection of an external resistor connected to ISET. Information for selecting the resistor is found in the sections below. The device acts as a constant-current source when the load draws more than the maximum value set by the device until thermal shutdown occurs. The device recovers if the die temperature drops below the threshold temperature.

### Under-Voltage Lockout (UVLO)

The under-voltage lockout turns the switch off if the input voltage drops below the lockout threshold. With the ONB pin active, the input voltage rising above the UVLO threshold releases the lockout and enables the switch.

### True Reverse-Current Blocking

The true reverse-current blocking feature protects the input source against current flow from output to input, whether the load switch is on or off.

### Thermal Shutdown

The thermal shutdown protects the die from internally or externally generated excessive temperature. During an over-temperature condition, the switch is turned off. The switch automatically turns on again if the temperature of the die drops below the threshold temperature.

### Setting Current Limit

The current limit is set with an external resistor connected between the ISET and GND pins. The resistor is selected using Table 1. Resistor tolerance of 1% or less is recommended

**Table 1. Current Limit Settings by RSET<sup>(8)</sup>**

R <sub>SET</sub> Ω	Min. Current Limit (mA)	Typ. Current Limit (mA)	Max. Current Limit (mA)
420	2250	2500	2750
469	2020	2250	2407
528	1800	2000	2200
604	1570	1750	1920
680	1350	1500	1650
866	1125	1250	1375
1070	900	1000	1100
1200	810	900	990
1330	720	800	880
1500	630	700	770
1740	540	600	660
2100	450	500	550
2320	405	450	495
2550	360	400	440
2940	315	350	385
3400	370	300	330
4020	225	250	275
4990	180	200	220
6490	135	150	165
9530	90	100	110

**Note:**

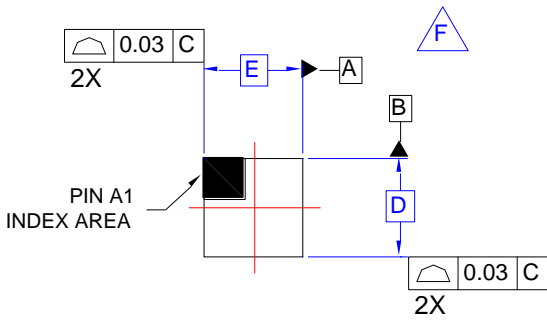
8. Table values based on 1% tolerance resistor.

### Board Layout

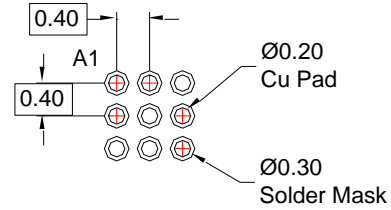
For best performance, all traces should be as short as possible. The input and output capacitors should be placed close to the device to minimize the effect that parasitic trace inductance may have on normal and short-circuit operation. Using wide traces for  $V_{IN}$ ,  $V_{OUT}$ , GND helps minimize parasitic electrical effects along with minimizing the case-to-ambient thermal impedance.



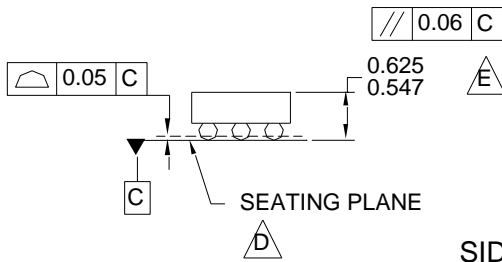
### Physical Dimensions



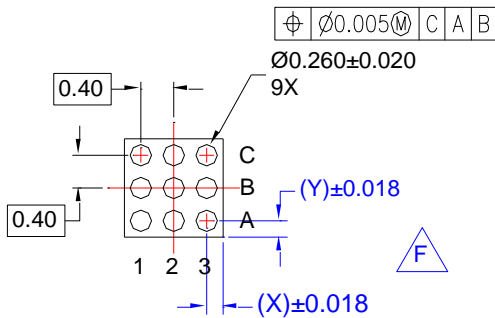
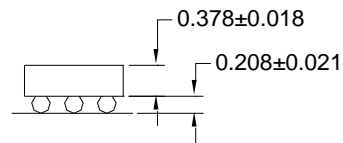
TOP VIEW



LAND PATTERN RECOMMENDATION  
(NSMD PAD TYPE)



SIDE VIEWS



BOTTOM VIEW

#### NOTES:

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- B. DIMENSIONS ARE IN MILLIMETERS.
- C. DIMENSIONS AND TOLERANCE PER ASMEY14.5M, 1994.
- D. DATUM C IS DEFINED BY THE SPHERICAL CROWNS OF THE BALLS.
- E. PACKAGE NOMINAL HEIGHT IS 586 MICRONS ±39 MICRONS (547-625 MICRONS).
- F. FOR DIMENSIONS D, E, X, AND Y SEE PRODUCT DATASHEET.
- G. DRAWING FILNAME: MKT-UC009ABrev2

### Product-Specific Dimensions

Product	D	E	X	Y
FPF2496	1210 µm ±30 µm	1210 µm ±30 µm	205 µm	205 µm

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