4A, Synchronous Step-Down Converter

DESCRIPTION

The EUP3427 is a 1 MHz fixed frequency synchronous, current-mode, step-down dc-dc converter capable of providing up to 4A output current. The EUP3427 operates from an input range of 2.7V to 5.5V and provides a regulated output voltage from 0.6V to 5V. The internal synchronous power switch improves efficiency and eliminates the need for an external Schottky diode. The EUP3427 can be externally set for either forced PWM continuous mode or pulse skipping mode. Forced PWM operation provides very low output ripple voltage for noise sensitive applications while pulse skipping operation improves light load efficiency by reducing switching loss.

The EUP3427 features short circuit and thermal protection circuits to improve system reliability. Internally soft-start avoids input inrush current during startup. The EUP3427 is available in SOP-8 package with the exposed pad and TDFN-10 package.

FEATURES

- 2.7V to 5.5V Input Voltage Range
- High Efficiency up to 96%
- 4A Available Load Current
- 57/35mΩ Integrated PFET/NFET Switches
- 1MHz Switching Frequency
- 100% Duty Cycle Low Dropout Operation
- Short Circuit and Thermal Protection
- Integrated UVLO and Power Good
- Excellent Line and Load Transient Response
- Available in SOP-8 (EP) and TDFN-10 Packages
- RoHS Compliant and 100% Lead(Pb)-Free Halogen-Free

APPLICATIONS

- High Performance DSPs, FPGAs, ASICs and Microprocessors
- Base Station, Telecom, and Networking Equipment Power Supplies
- ePC and NetPCs

Typical Application Circuit

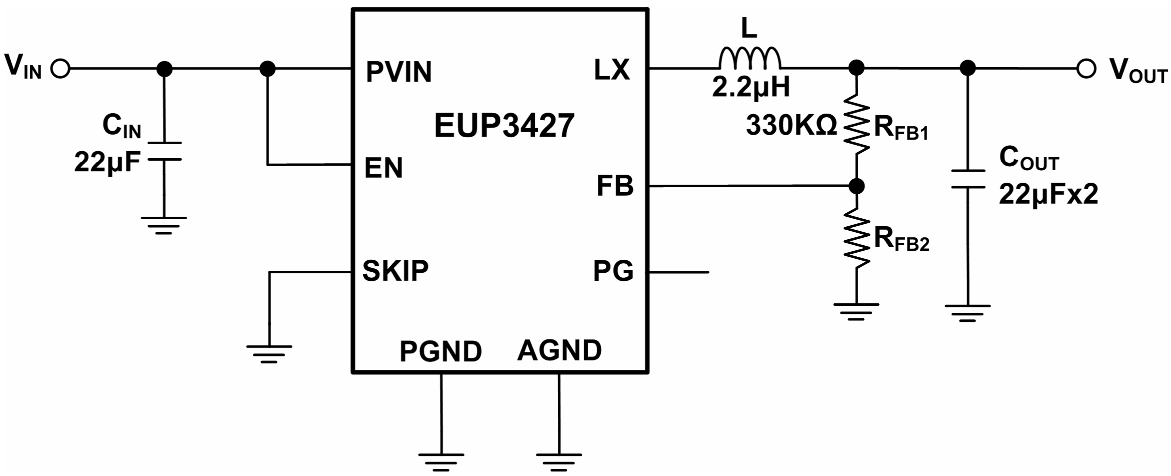


Figure1. SOP-8(EP) Typical Application Circuit

Typical Application Circuit (continued)

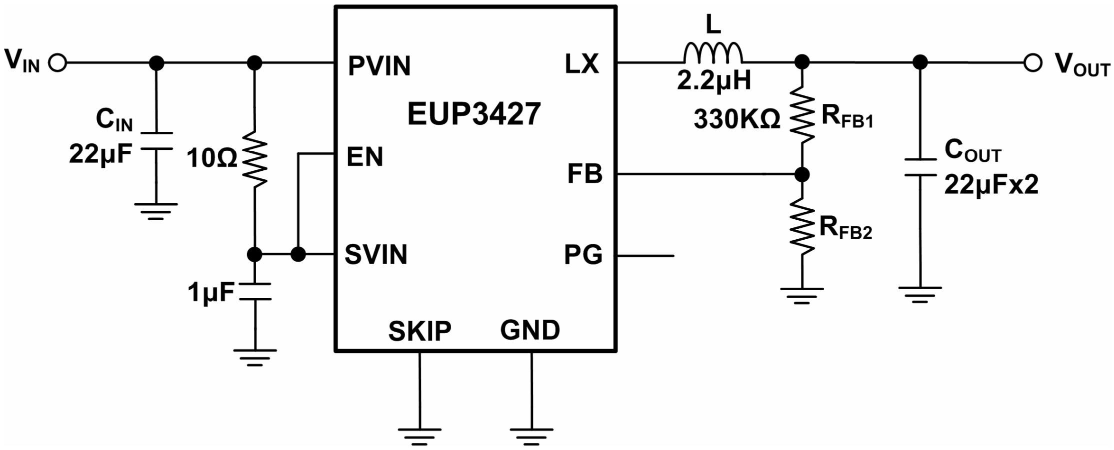
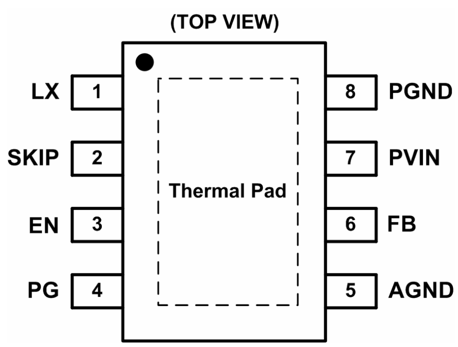
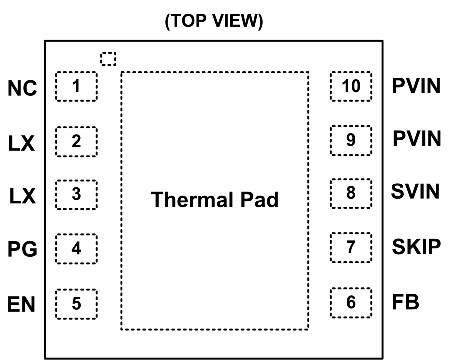


Figure2. TDFN-10 Typical Application Circuit

Pin Configurations

Package Type	Pin Configurations	Package Type	Pin Configurations
SOP-8 (EP)		TDFN-10	

Pin Description

PIN	SOP-8 (EP)	TDFN-10	DESCRIPTION
LX	1	2,3	Switch node connected to inductor. This pin is connected to the drains of the internal main and synchronous power MOSFET switches.
SKIP	2	7	Operation Mode Select Input. Logic high selects pulse skipping mode, and logic low or floating chooses forced PWM mode. An internal 5µA current pull it down to ground.
EN	3	5	Chip enable pin. Forcing this pin above 1.5V enables the part. Forcing this pin below 0.3V or floating it shuts down the device.An internal 600kΩ Resistor pulls it down to ground.
PG	4	4	Power good output signal. Logic high when regulator output is within ±10% of target output voltage. A pull-up resistor of 10kΩ to 100kΩ is recommended for most applications.
AGND	5	-	Analog ground.
FB	6	6	Feedback pin. Connect it to an external resistor divider to set output voltage.
PVIN	7	9,10	Power supply input.
PGND	8	-	Power ground.
SVIN	-	8	Analog input supply which is connected to PVIN through a low pass RC filter.
NC	-	1	No connect.
Thermal Pad	-	-	Ground.(Thermal pad must be connected to the ground of PCB.)

Ordering Information

Order Number	Package Type	Marking	Operating Temperature Range
EUP3427WIR1	SOP-8 (EP)	xxxxx P3427 1A	-40 °C to +85°C
EUP3427JIR1	TDFN-10	xxxxx P3427 1A	-40 °C to +85°C

EUP3427 □ □ □ □

- Lead Free Code
  1: Lead Free, Halogen Free 0: Lead
- Packing
  R: Tape & Reel
- Operating temperature range
  I: Industry Standard
- Package Type
  W:SOP (EP)
  J:TDFN

Block Diagram

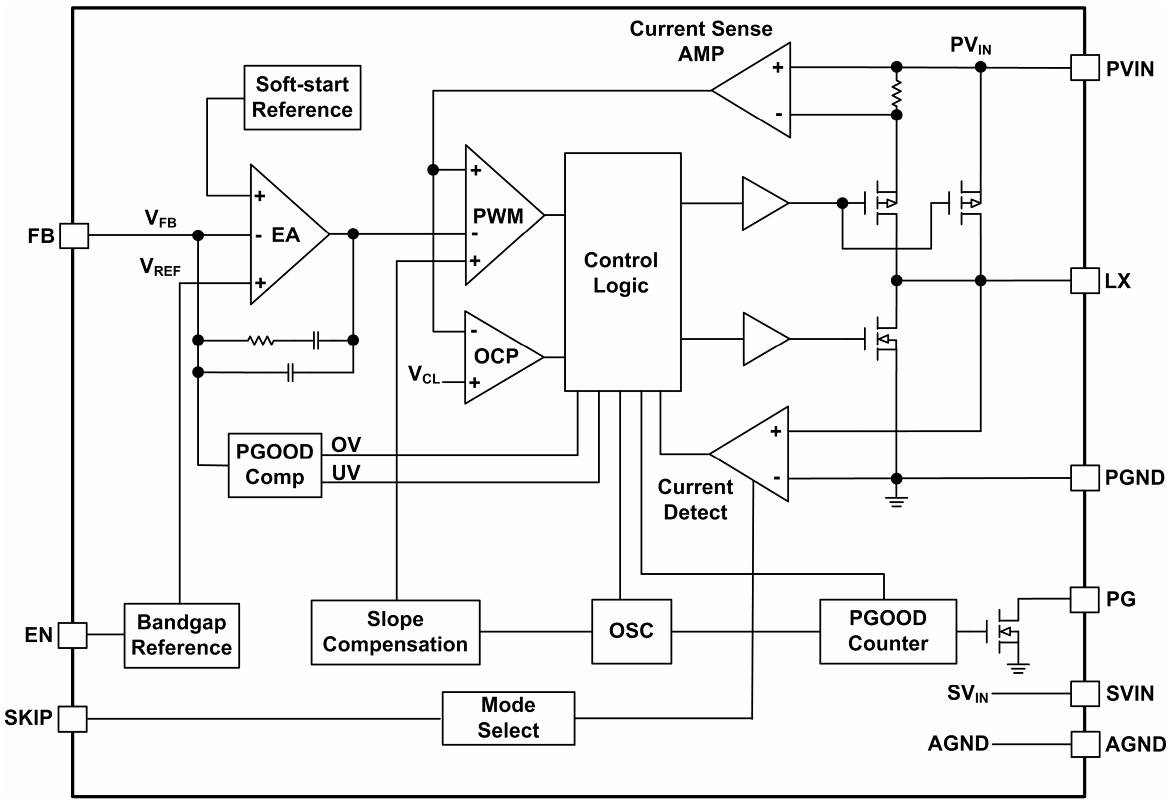


Figure3. Block Diagram

Absolute Maximum Ratings (1)

- Input Supply Voltage(SVIN,PVIN) -- -0.3V to 6V
- EN, FB -- -0.3V to 6V
- PG -- 0V to 6V
- LX, SKIP --- -0.3V to V_{PVIN}+0.3V
- Junction Temperature -- 150°C
- Package Thermal Resistance

  SOP-8 (EP),θ_{JA} --- 60°C/W

  TDFN-10,θ_{JA} -- 69°C/W
- Storage Temperature -- -65°C to 150°C
- Lead Temp (Soldering, 10sec) -- 260°C
- Minimum ESD Rating --- ±2kV

Recommended Operating Conditions (2)

- Supply Voltage --- 2.7V to 5.5V
- Operating Temperature Range --- -40°C to 85°C

Note(1): Stress beyond those listed under "Absolute Maximum Ratings" may damage the device.

Note(2): The device is not guaranteed to function outside the recommended operating conditions.

Electrical Characteristics

PVIN=VEN=5V, T_A=+25°C,unless otherwise specified. The ● indicates specifications which apply over the full operatimg range -40°C to +85°C.

Symbol	Parameter	Conditions		EUP3427			Unit
				Min.	Typ.	Max.	
V_{IN}	Input Voltage Range	-40°C ≤T_A≤+85°C	●	2.7		5.5	V
UVLO	Input Undervoltage Lockout	Rising, -40°C ≤T_A≤+85°C	●	2.25	2.45	2.65	V
UVLO_Hys	UVLO Hysteresis				200		mV
I_{FB}	Feedback Current	V_{FB}=0.6V		-50	0	+50	nA
V_{FB}	Regulated Feedback Voltage	T_A=+25°C		0.594	0.600	0.606	V
		-40°C≤T_A≤+85°C	●	0.588	0.600	0.612	
ΔV_{OUT}	Output Voltage Line Regulation	V_{IN}=3V to 5V			0.15		%/V
$V_{LOADREG}$	Output Voltage Load Regulation	I_{LOAD}=0A to 4A			0.1		%/A
V_{PGH}	Power Good High Threshold	With Respect To V_{FB}		+7	+10	+13	%
V_{PGL}	Power Good Low Threshold	With Respect To V_{FB}		-13	-10	-7	%
T_{PG}	Power Good Delay Time				16		Cycles
V_{LPG}	Power Good Low Voltage	I_{SINK}=1mA			0.1	0.3	V
I_{PG}	Power Good Leakage Current	High Impedance, V_{PG}=5V				1	μA
V_{EN}	EN Threshold	-40°C≤T_A≤+85°C	●	0.3	0.8	1.5	V
R_{EN}	EN Pull Down Resistor				600		KΩ
V_{SKIP}	SKIP Threshold	-40°C≤T_A≤+85°C	●	0.3	1.0	1.5	V
I_{SKIP}	SKIP Pull Down Current			2	5	8	μA
I_Q	Quiescent Current	V_{FB}=0.65V,V_{SKIP}=5V or 0V, -40°C≤T_A≤+85°C	●		0.5	0.6	mA
I_{SHDN}	Shutdown Current	V_{EN}=0V				3	μA
f_{OSC}	Oscillator Frequency	V_{FB}=0.55V, -40°C≤T_A≤+85°C	●	0.8	1	1.2	MHz
		V_{FB}=0V			380		KHz
D_{MAX}	Maximum Duty Cycle				100		%

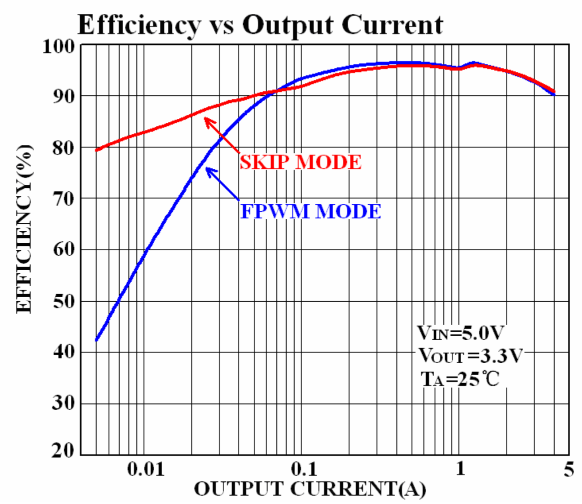
Electrical Characteristics (continued)

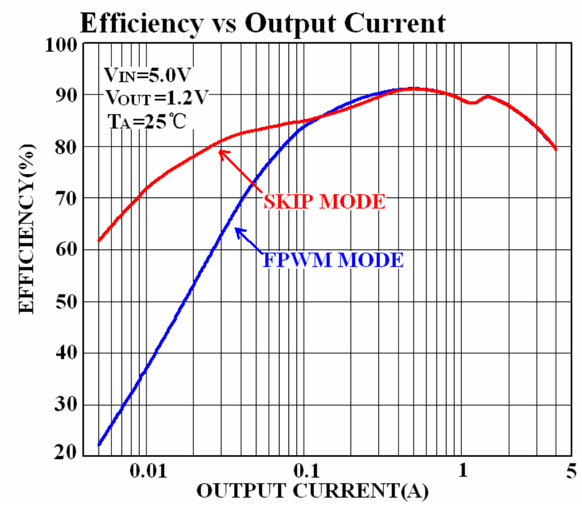
PVIN=VEN=5V, T_A=+25°C,unless otherwise specified. The ● indicates specifications which apply over the full operatimg range -40°C to +85°C.

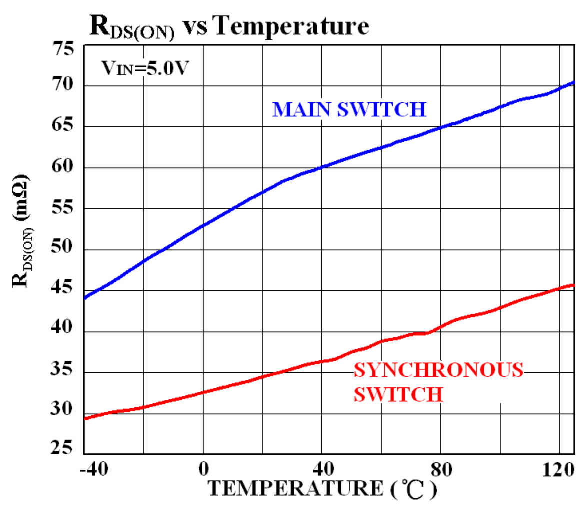
Symbol	Parameter	Conditions		EUP3427			Unit
				Min.	Typ.	Max.	
$T_{ON(Min)}$	Minimum On Time				100		ns
I_{PEAK}	Hside PCH Switch Peak Current	V_{FB}=0.55V			6		A
I_{NEG}	Lside NCH Negative Current Limit	V_{SKIP} =0V, FPWM Mode			-1		A
R_{LX}	LX Pull Down Resistor				1.25		KΩ
R_{PFET}	$R_{DS(ON)}$ of P-Channel FET	I_{LX}=0.5A			57	70	mΩ
R_{NFET}	$R_{DS(ON)}$ of N-Channel FET	I_{LX}=0.5A			35	50	mΩ
T_{SD}	Thermal Shutdown				160		°C

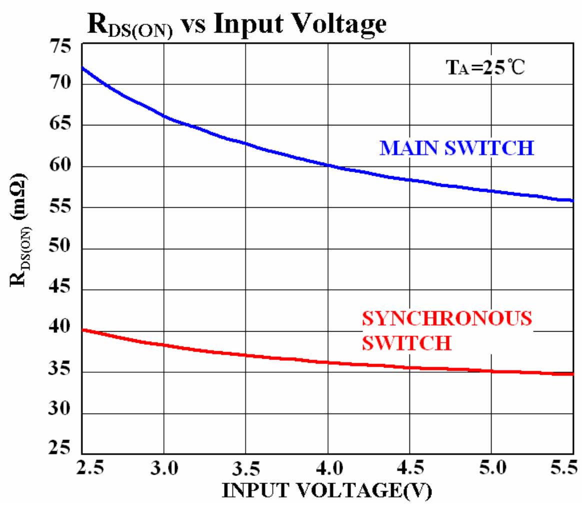
Typical Operating Characteristics

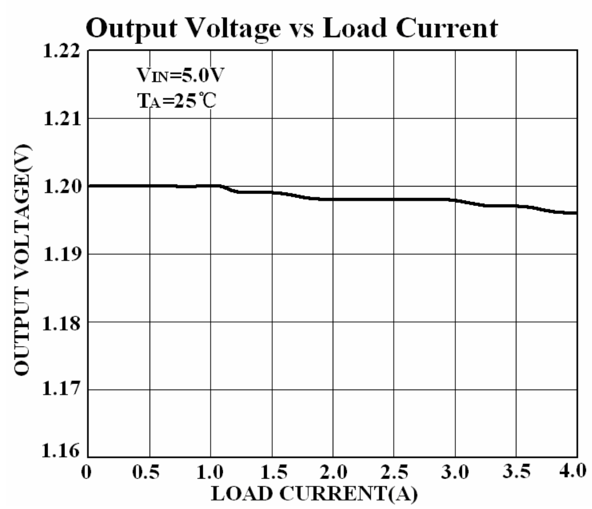
Unless otherwise specified: C_{IN}=22µF, C_{OUT}=22×2µF, L=2.2µH, V_{IN}=5V, V_{OUT}=1.2V, T_A=25°C.

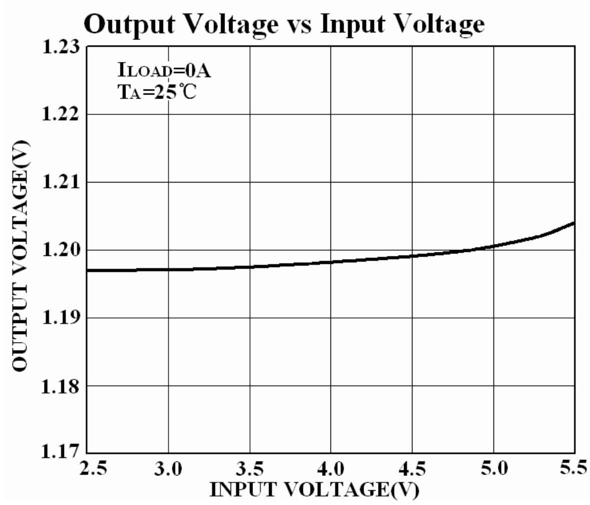




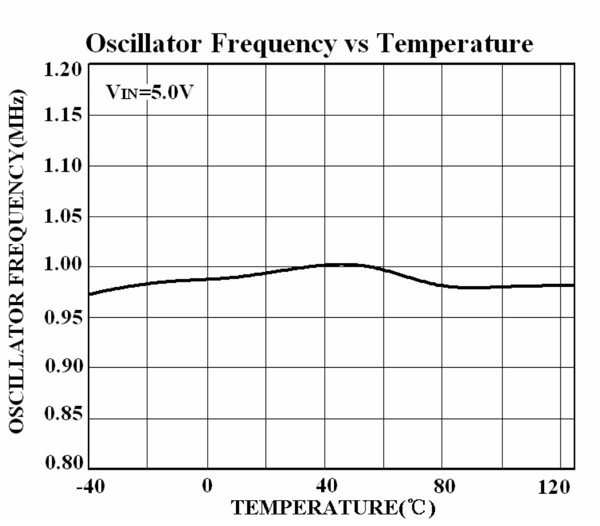


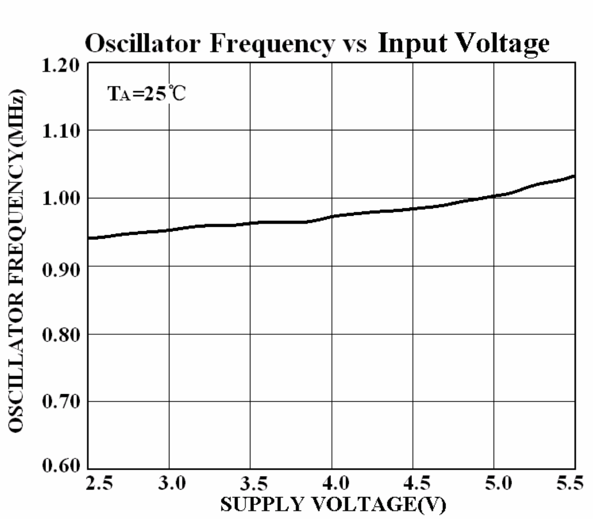


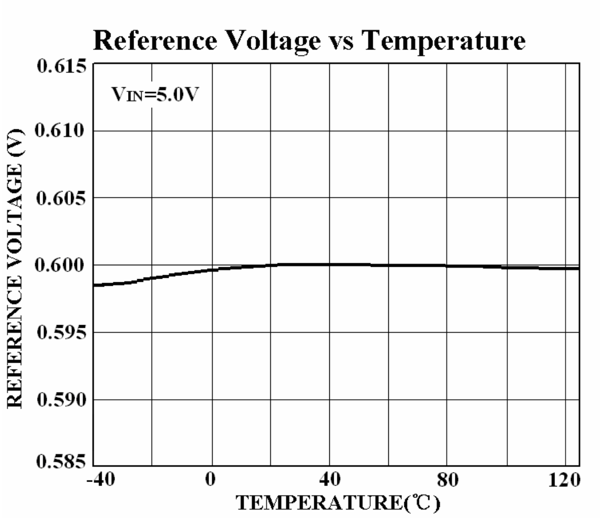


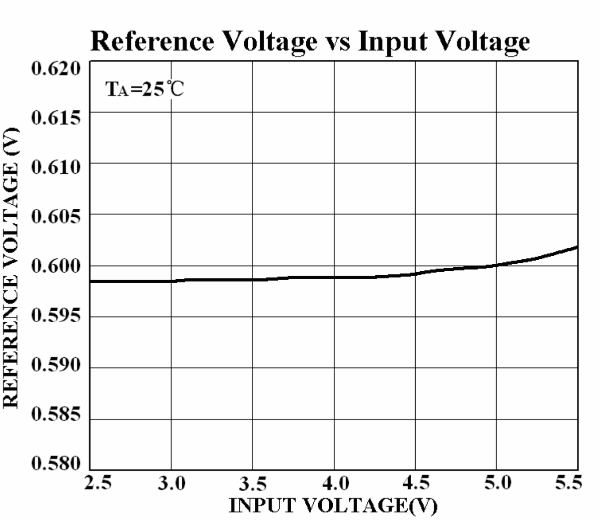


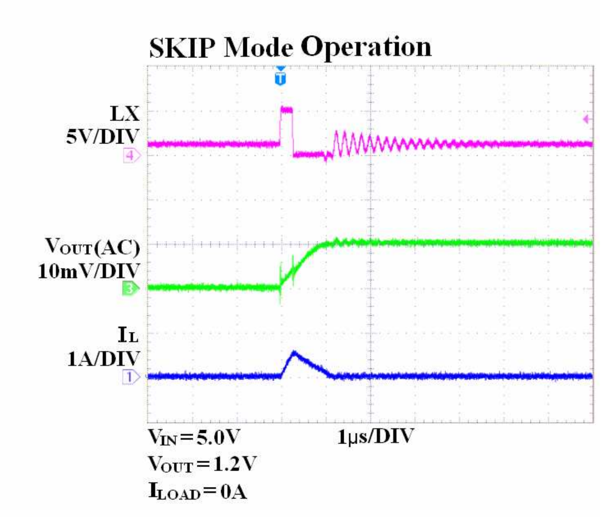
Typical Operating Characteristics (continued)

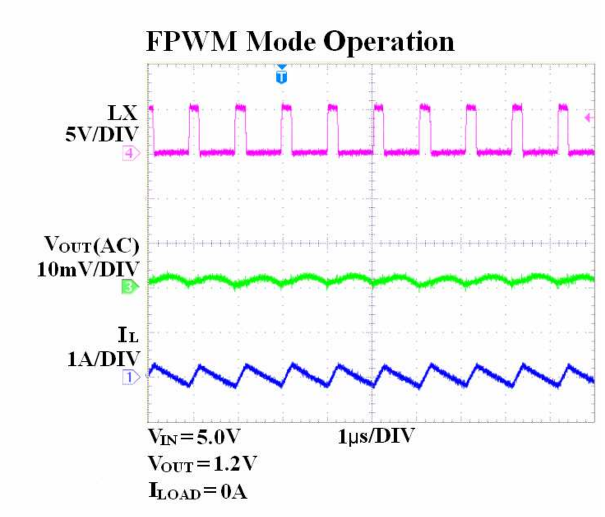








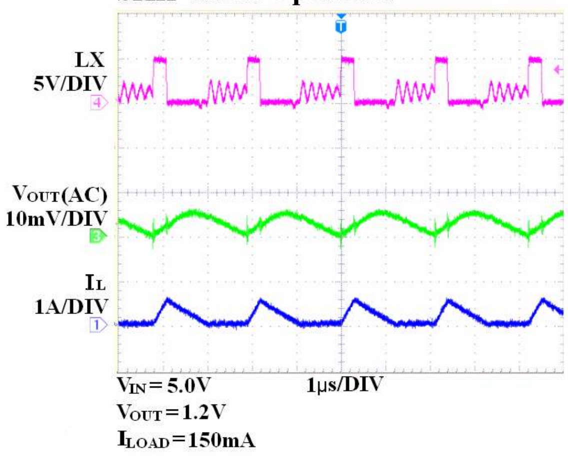




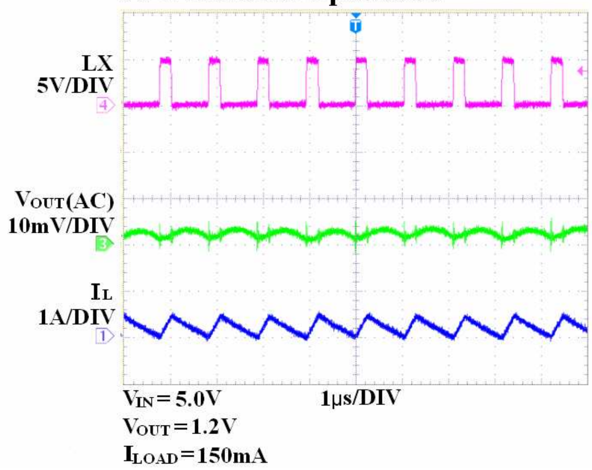
EUTECH MICROELECTRONICS

Typical Operating Characteristics (continued)

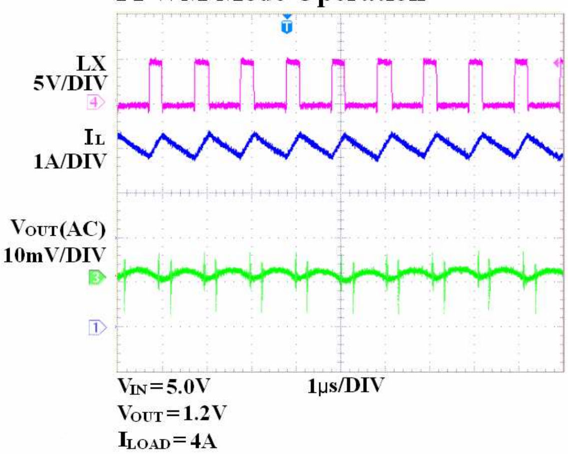
SKIP Mode Operation



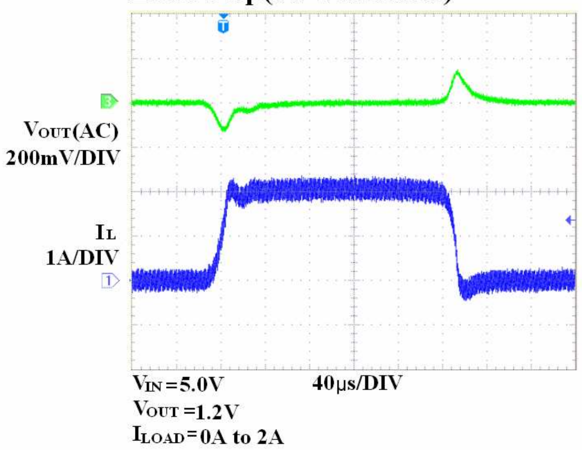
FPWM Mode Operation



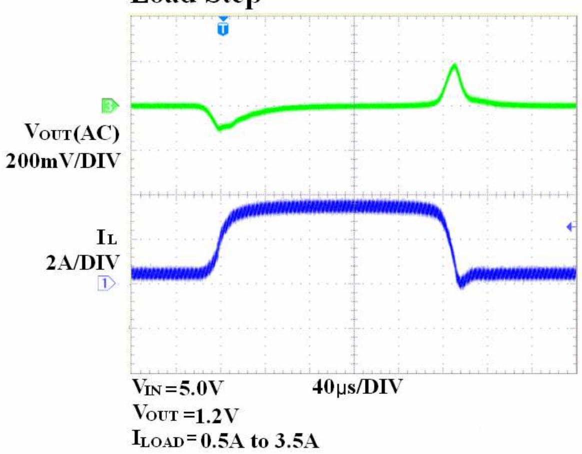
FPWM Mode Operation



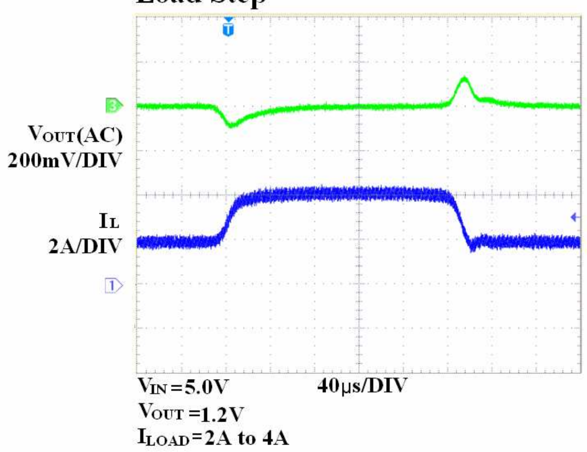
Load Step(FPWM Mode)



Load Step

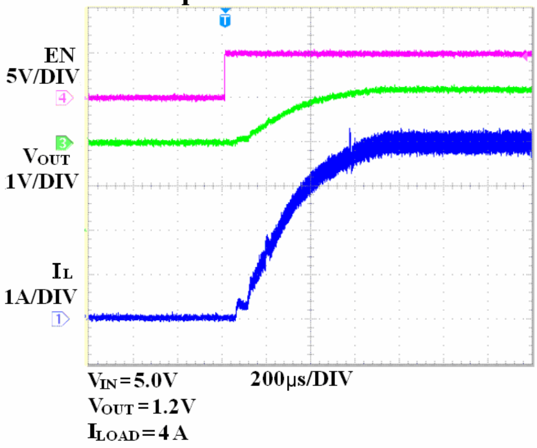


Load Step

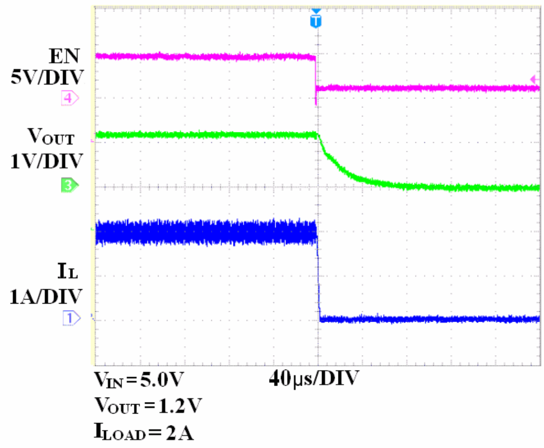


Typical Operating Characteristics (continued)

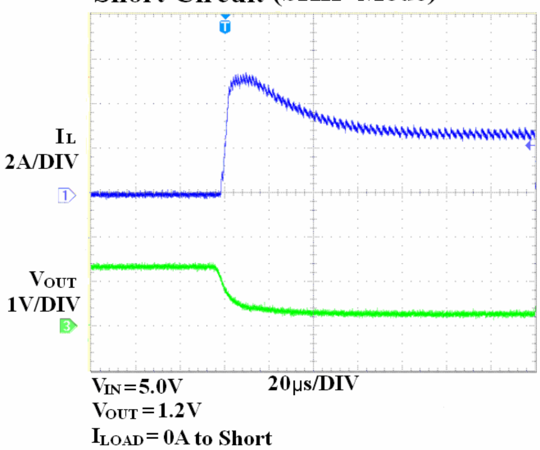
Start Up



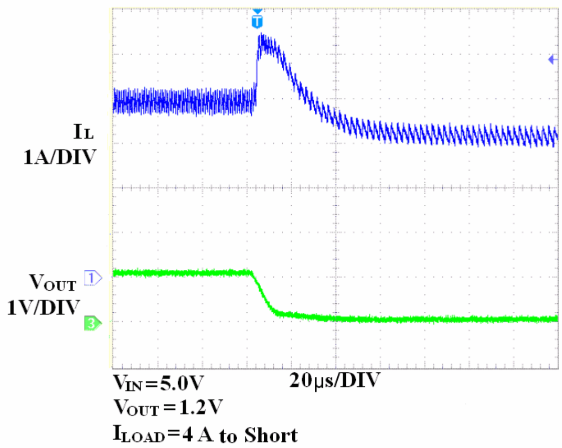
Shut Down



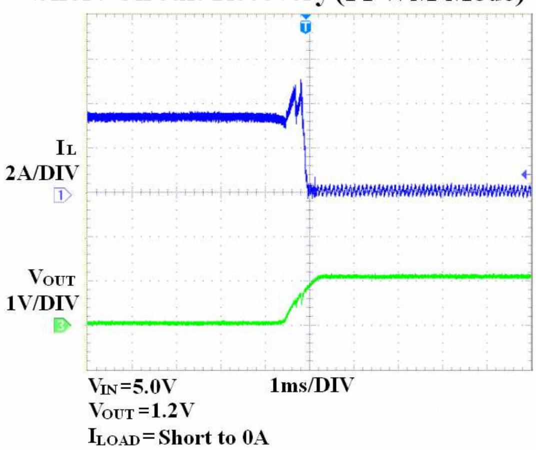
Short Circuit (SKIP Mode)



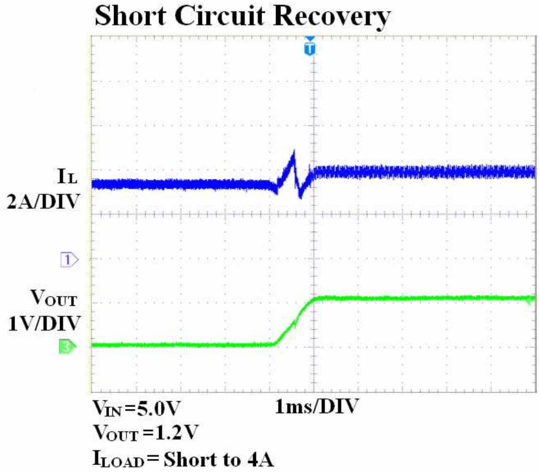
Short Circuit



Short Circuit Recovery (FPWM Mode)



Short Circuit Recovery



Application Information

The EUP3427 uses a slope-compensated constant frequency, current mode architecture. Both the main (P-Channel MOSFET) and synchronous (N-channel MOSFET) switches are internal. During normal operation, the EUP3427 regulates output voltage by switching at a constant frequency and then modulating the power transferred to the load each cycle using PWM comparator. The duty cycle is controlled by three weighted differential signals: the output of error amplifier, the main switch sense voltage and the slope-compensation ramp. It modulates output power by adjusting the inductor peak-current during the first half of each cycle. An N-channel, synchronous switch turns on during the second half of each cycle. When the inductor current starts to reverse in pulse skipping mode operation or when the PWM reaches the end of the oscillator period in forced PWM mode operation, the synchronous switch turns off.

Soft-Start

The EUP3427 has an internal soft-start circuit to limit the inrush current and output voltage overshoot during startup. The soft-start time is about 800µS.

Short-Circuit Protection

As soon as the output voltage drops below 50% of the nominal output voltage, the switching frequency and the current limit are reduced.

Output Overvoltage Protection

The output voltage is monitored by a comparator through FB pin. It guards against transient overshoots >10% by turning the main switch off .

Input Undervoltage Lockout

The undervoltage lockout circuit prevents device misoperation at low input voltages. It prevents the converter from turning on the main and synchronous switches under undervoltage state.

Thermal Protection and Lockout

The internal thermal protection and lockout circuit prevents device in the event that the maximum junction tempetaure is exceeded. If the device temperature is higher than 160°C (typical), it will be shut down. Only if the power is reprovided or the EN pin is reactived can the device rework.

Inductor Selection

The EUP3427 typically uses a 2.2µH output inductor. The output inductor is selected to limit the ripple current to some predetermined value, typically 20%~40% of the full load current at the maximum input voltage. Large value inductors lower ripple currents. Higher V_{IN} or V_{OUT} influence the ripple current as shown in equation.

$$\Delta I_L = \frac{1}{(f)(L)} V_{OUT}\left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

The DC current rating of the inductor should be at least equal to the maximum load current plus half the ripple current to prevent core saturation.
The DC-resistance of the inductor directly influences the efficiency of the converter. Therefore for better efficiency, choose a low DC-resistance inductor.

C_{IN} and C_{OUT} Selection

In continuous mode, the source current of the top MOSFET is a square wave of duty cycle V_{OUT}/V_{IN}. The primary function of the input capacitor is to provide a low impedance loop for the edges of pulsed current drawn by the EUP3427. A low ESR input capacitor sized for the maximum RMS current must be used. The size required will vary depending on the load, output voltage and input voltage source impedance characteristics. A typical value is around 22µF.
The input capacitor RMS current varies with the input voltage and the output voltage. The equation for the maximum RMS current in the input capacitor is:

$$I_{RMS} = I_{OUT} \times \sqrt{\frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)}$$

The output capacitor C_{OUT} has a strong effect on loop stability.

The selection of C_{OUT} is driven by the required effective series resistance (ESR).

ESR is a direct function of the volume of the capacitor; that is, physically larger capacitors have lower ESR. Once the ESR requirement for C_{OUT} has been met, the RMS current rating generally far exceeds the $I_{RIPPLE(P-P)}$ requirement. The output ripple ΔV_{OUT} is determined by:

$$\Delta V_{OUT} \cong \Delta I_L\left(ESR + \frac{1}{8fC_{OUT}}\right)$$

When choosing the input and output ceramic capacitors, choose the X5R or X7R dielectric formulations. These dielectrics have the best temperature and voltage characteristics of all the ceramics for a given value and size.

Output Voltage Programming

The output voltage is set by a resistive divider according to the following formula, where R_{FB1} value is kept 330KΩ:

$$R_{FB2} = R_{FB1}\left(\frac{0.6}{V_{OUT} - 0.6}\right)$$

The external resistive divider is connected to the output, allowing remote voltage sensing as shown below.

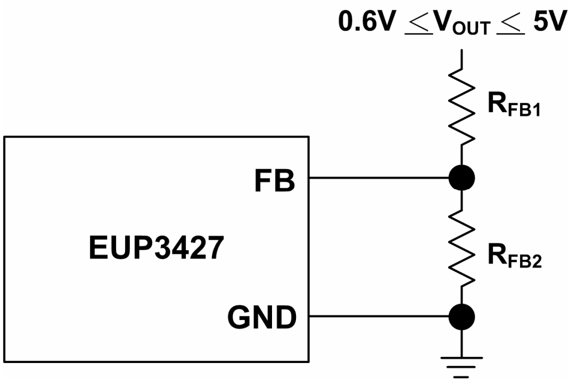


Table1. Recommended Components with PVIN=AVIN=5V

V_{OUT} (V)	C_{IN} (μF)	C_{OUT} (μF)	L (μH)	R_{FB1} (kΩ)	R_{FB2} (kΩ)
3.3	22	22*2	2.2	330	73
2.5	22	22*2	2.2	330	104
1.8	22	22*2	2.2	330	165
1.5	22	22*2	2.2	330	220
1.2	22	22*2	2.2	330	330
1	22	22*2	2.2	330	495

Thermal Considerations

To avoid the EUP3427 from exceeding the maximum junction temperature, the user will need to do a thermal analysis. The goal of the thermal analysis is to determine whether the operating conditions exceed the maximum junction temperature of the part. The temperature rise is given by:

$$T_R=(P_D)(\theta_{JA})$$

Where $P_D=I_{LOAD}^2 \times R_{DS(ON)}$ is the power dissipated by the regulator ; θ_{JA} is the thermal resistance from the junction of the die to the ambient temperature.
The junction temperature, T_J, is given by:

$$T_J=T_A+T_R$$

Where T_A is the ambient temperature.
T_J should be below the maximum junction temperature of 150°C.

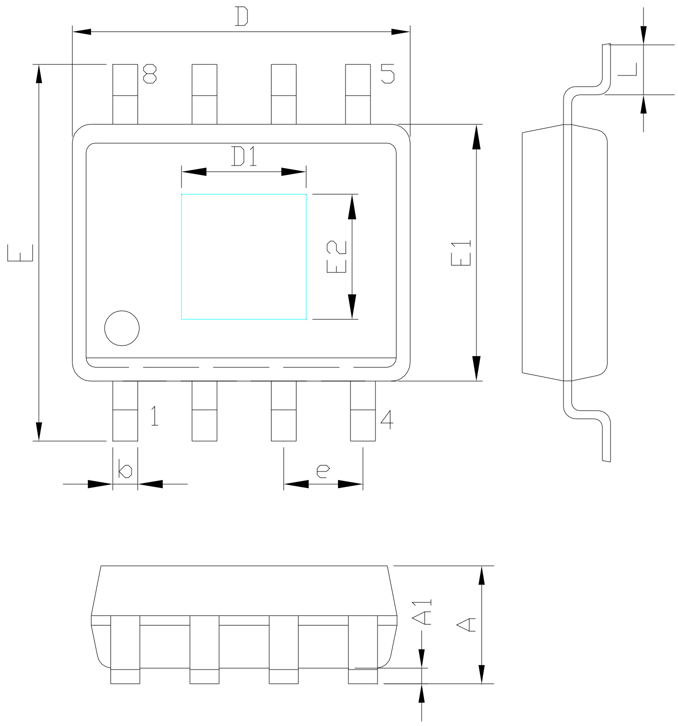
PC Board Layout Checklist

For all switching power supplies, the layout is an important step in the design especially at high peak currents and switching frequencies. If the layout is not carefully done, the regulator might show stability problems as well as EMI problems.
When laying out the printed circuit board, the following guidelines should be used to ensure proper operation of the EUP3427.

1. The input capacitor C_{IN} should connect to PVIN as closely as possible. This capacitor provides the AC current to the internal power MOSFETs.
2. The power traces, consisting of the GND trace, the LX trace and the VIN trace should be kept short, direct and wide.
3. The FB pin should connect directly to the feedback resistors. The resistive divider R_{FB1}/R_{FB2} must be connected between the C_{OUT} and ground.
4. Keep the switching node, LX, away from the sensitive FB node.

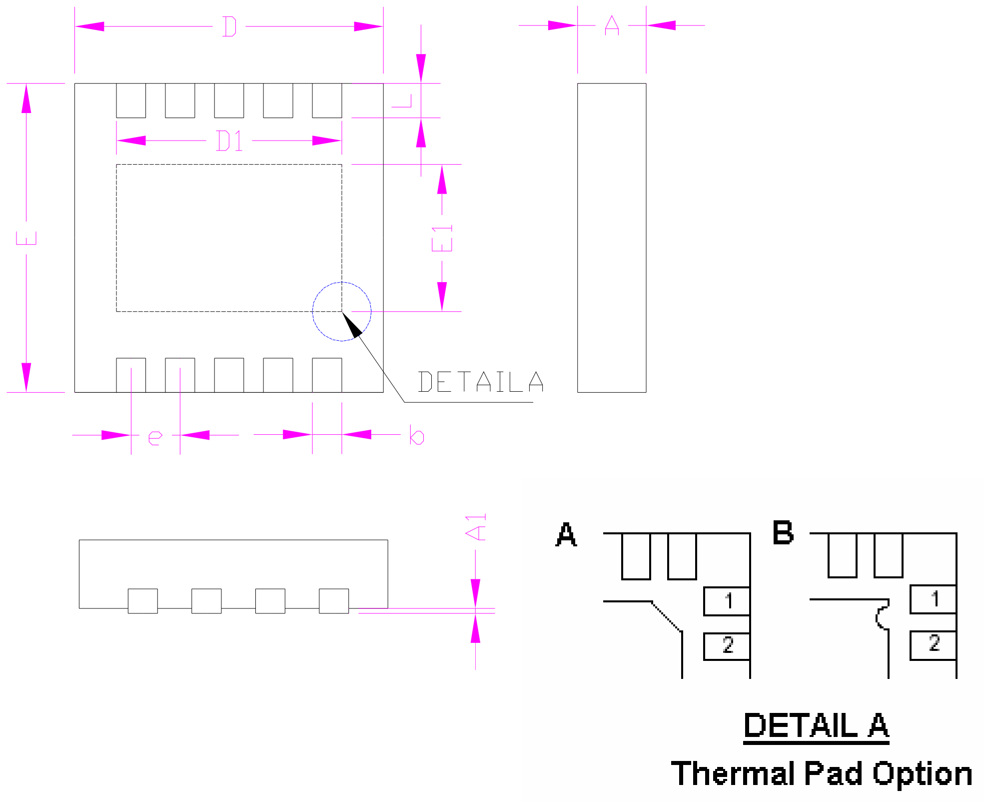
Packaging Information

SOP-8 (EP)



SYMBOLS	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
D	4.90		0.193	
E1	3.90		0.153	
D1	2.97		0.117	
E2	2.18		0.086	
E	5.80	6.20	0.228	0.244
L	0.40	1.27	0.016	0.050
b	0.31	0.51	0.012	0.020
e	1.27		0.050	

TDFN-10



SYMBOLS	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.70	0.80	0.028	0.031
A1	0.00	0.05	0.000	0.002
D1	2.50		0.098	
D	2.90	3.10	0.114	0.122
E1	1.70		0.067	
E	2.90	3.10	0.114	0.122
L	0.30	0.50	0.012	0.020
b	0.18	0.30	0.007	0.012
e	0.50		0.020	
D1	2.40		0.094	