1.5MHz, 1.2A SYNCHRONOUS STEP-DOWN CURRENT MODE HIGH EFFICIENCY DC-DC CONVERTER

A7146

Description

The A7146 is a 1.5MHz constant frequency, high efficiency, high current, slope compensated current mode PWM step-down DC-DC converter. The A7146 integrates a main switch and a main switch and a synchronous rectifier for high efficiency without an external schottky diode.

The A7146 provides an adjustable version and fixed output voltage of 1.2V, 1.5V and 1.8V for design flexible.

The A7146 can operate from a 2.5V to 5.5V input voltage and is ideal for powering portable equipment that runs from a single cell lithium-Ion (Li+) battery. The A7146 can supply 1.2A output current and can also run at 100% duty cycle for low dropout operation, extending battery life in portable system. Pulse Skipping Mode operation at light loads provides very low output ripple voltage for noise sensitive application.

The A7146 is availabe10-Pin MSOP and DFN packages.

Ordering Information

MSOP10	A7146MS10 (Tube)
	A7146MSR10 (T/R)
DFN-10	A7146J10 (T/R)
Note	AiT provides all lead free parts

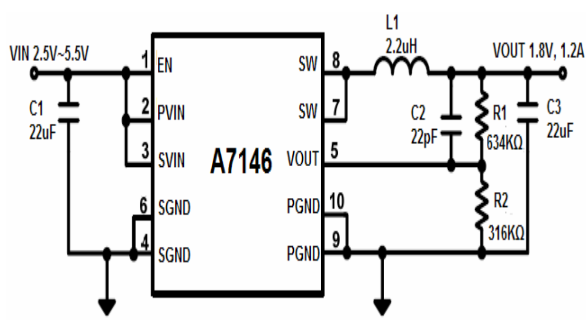
Features

- 1.5MHz Constant Switching Frequency
- 1.2A Output Current
- High Efficiency: Up to 95%
- 2.5V to 5.5V Input Voltage Range
- Output Voltages from 0.6V to 5V
- Low $R_{DS(ON)}$ Internal Switch: 0.12Ω
- Available in Fixed Output Voltages of 1.2V, 1.5V, 1.8V and Adjustable Version
- Allow Use of Ceramic Capacitors
- Current Mode Operation for Excellent Line and Load Transient Response
- Short-Circuit Protected
- Low Dropout Operation: 100% Duty Cycle
- Low Shutdown Current: $I_{SHUTDOWN}$<1uA
- Available in 10-Pin MSOP and DFN Package

Application

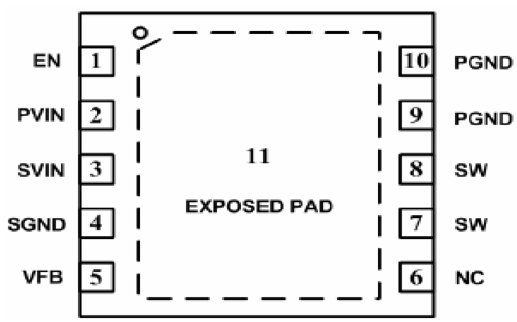
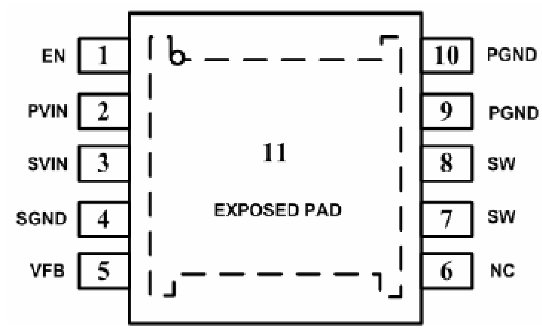
- PDA, PMP, DSC
- Cellular and Smart Phones
- Portable Instruments
- Microprocessors and DSP Core Supplies

Typical Application



A7146 Adjustable Version

Pin Assignment

DFN-10 (3x3mm) Package	MSOP-10 Package
	
Exposed Pad is PGND (Pin 11) must be connected to GND	Exposed Pad is PGND (Pin 11) must be connected to GND
Top View	

Pin Description

Pin	Name	Function
1	EN	Chip Enable, EN=V_{IN}, Enable; EN=GND, Disable
2	PV_{IN}	Power Supply Pin
3	SV_{IN}	Signal Supply Pin
4	SGND	Signal Ground Pin
5	V_{FB}	Feedback Input Pin. It receives the feedback voltage from the external resistive divider across the output
6	NC	No Connection
7,8	SW	Power Switch Output
9,10	PGND	Power Ground
11	Exposed Pad	Power Ground. It must be connect to ground properly.

Absolute Maximum Ratings

(Those values beyond which the life of a device may be impaired.)

PV_{IN},. SV_{IN} Voltage	-0.3V~+6V
V_{FB}, SW Voltage	-0.3V~(V_{IN}+0.3V)
EN Voltage	-0.3V ~ (V_{IN}+0.3V)
PGND, GND Voltage	-30V ~ +6V
Operating Temperature Range (note1)	-40^{o}C ~ +85^{o}C
Junction Temperature	+125^{o}C
Storage Temperature Range	-65^{o}C ~ +150^{o}C
Lead Temperature (Soldering, 10s)	+300^{o}C

Note1: T_J is calculated form the ambient temperature T_A and power dissipation P_D according to the following formula: $T_J = T_A + P_D \text{ X } \theta_{JA}$

Electrical Characteristics

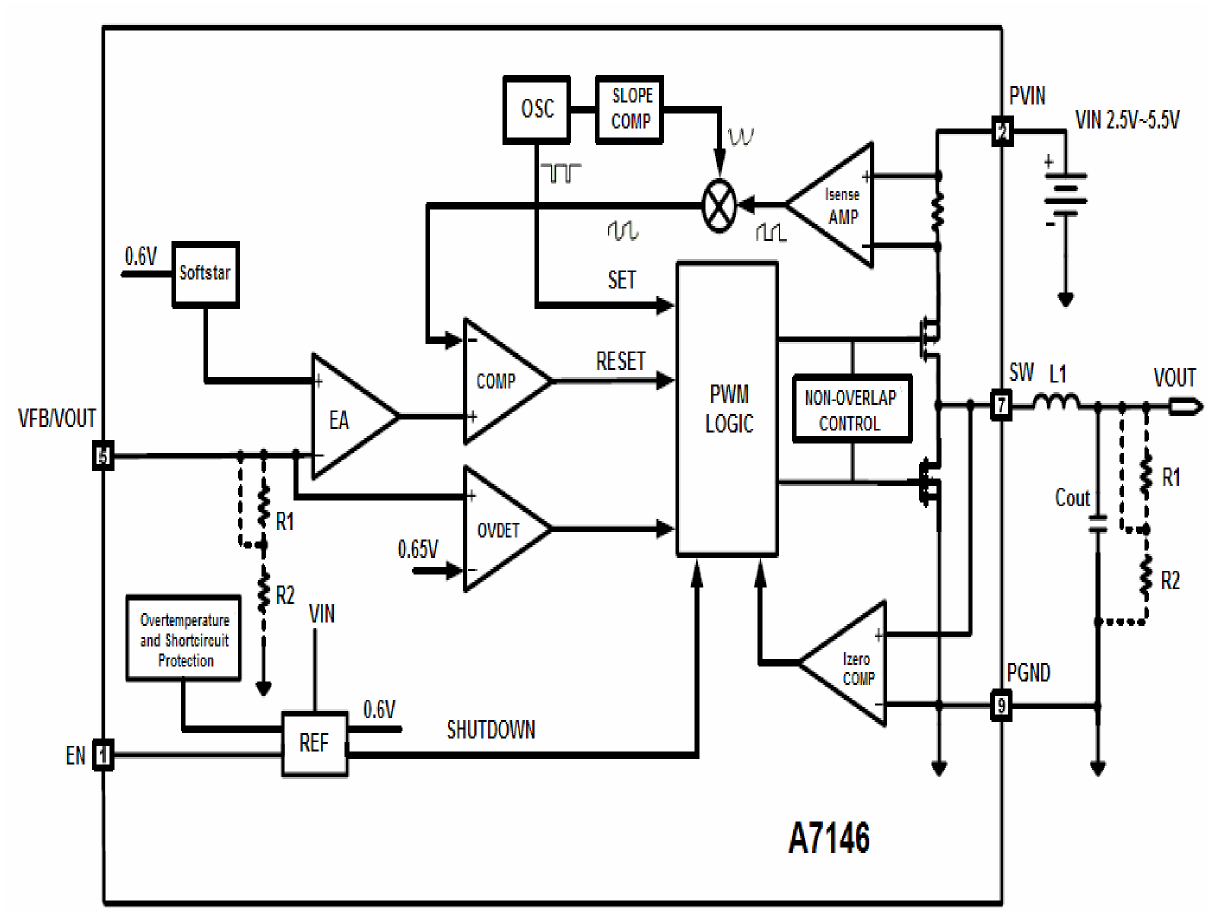
(PV_{IN}=SV_{IN}=V_{EN}=3.6V, V_{OUT}=1.8V, T_A=25^{o}C, unless otherwise noted)

Parameter	Conditions	Min	Typ	Max	Unit
Input Voltage Range	(note2)	2.5		5.5	V
Output Voltage Range		0.6		V_{IN}-$V_{DROPOUT}$	V
Input DC Supply Current PWM Mode Shutdown Mode	 V_{FB}=0.5V EN=0V, SV_{IN}=5.5V		 300 0.1		 uA uA
Feedback Input Bias Current	V_{FB}=0.65V			30	nA
Regulated Feedback Voltage	T_A=25^{o}C	0.5880	0.6000	0.6120	V
(note3)	T_A=0^{o}C□T_A□85 ^{o}C	0.5865	0.6000	0.6135	V
	T_A=-40^{o}C□T_A□85 ^{o}C	0.5850	0.6000	0.6150	V
Reference Voltage Line Regulation	SV_{IN}=2.5V ~ 5.5V,I_{OUT}=10mA		0.30		%/V
Output Voltage Load Regulation	I_{OUT}=100mA ~ 1200mA		0.5		%/A
Oscillator Frequency	V_{FB}=0.6V		1.5		MHz
Peak Switch Current			2.5		A
$R_{DS(ON)}$ of P-CH MOSFET	SV_{IN}=3.6V		150		mΩ
$R_{DS(ON)}$ of N-CH MOSFET	SV_{IN}=3.6V		95		mΩ
SW Leakage Current	SV_{IN}= PV_{IN} =5V, V_{EN}=0V, V_{FB}=0V		0.01		uA
EN Threshold Voltage	-40^{o}C□T_A□85 ^{o}C	0.3	1	1.5	V
EN Leakage Current			0.1		uA

Note2: V_{IN} should be not less than V_{OUT}+$V_{DROUPOUT}$, where $V_{DROPOUT}$=I_{OUT} x ($R_{DS(ON),PMOS}$ +$ESR_{INDUCTOR}$), typically $V_{DROPOUT}$=0.3V

Note3: The regulated feedback voltage is tested in an internal test mode that connects V_{FB} to the output of the error amplifier.

Block Diagram



Detailed Information

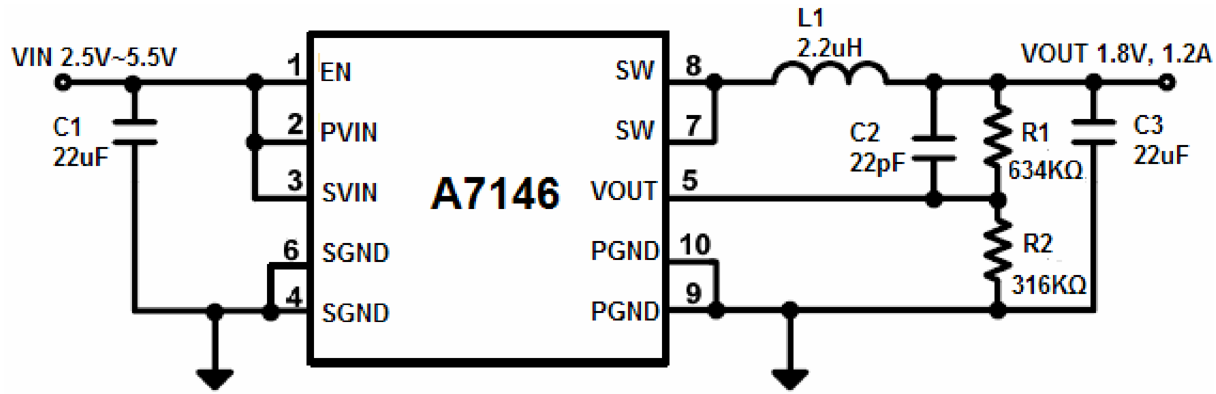


Fig 1. A7146 adjustable output version typical application

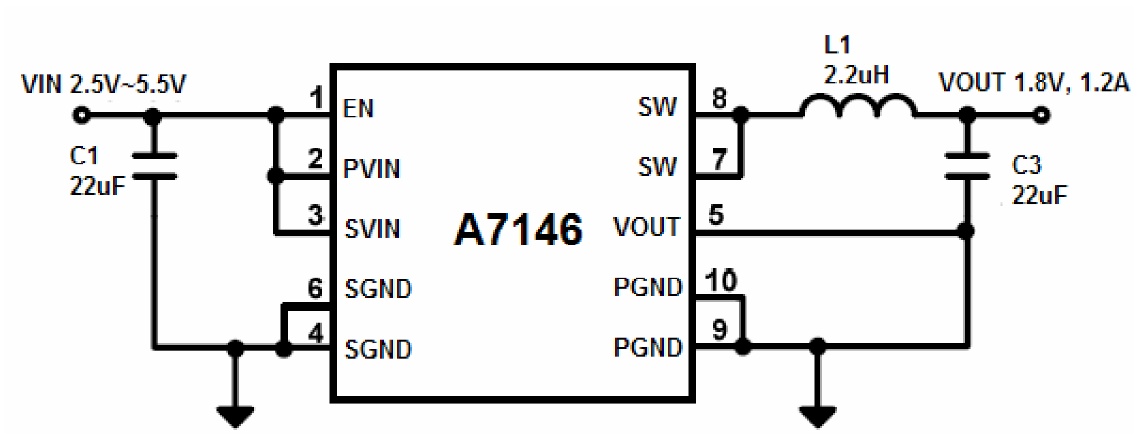


Fig 2. A7146 fixed output version typical application

Output Voltage Setting

Figure 1 shows A7146 adjustable output version typical application and Fig 2. shows A7146 fixed output version typical application. The external resistor sets the output voltage according to the following equation:

$$V_{OUT} = 0.6V \times \left(1 + \frac{R2}{R1}\right)$$

Table 1 shows the resistors selection for output voltage setting.

V_{OUT}	R1 (Ω)	R2 (Ω)
1.2V	316K	316K
1.5V	316K	470K
1.8V	316K	634K
2.5V	316K	1.0M
3.3V	316K	1.43M

Table 1. Resistor select for output voltage setting

Inductor Selection

For most designs, the A7146 operates with inductors of 1µH to 4.7µH. Low inductance values are physically smaller but require faster switching, which results in some efficiency loss. The inductor value can be derived from the following equation:

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times f_{OSC}}$$

Where ΔI_L is inductor Ripple Current. Large value inductors lower ripple current and small value inductors result in high ripple currents. Choose inductor ripple current approximately 30%
of the maximum load current 1200mA, or

ΔI_L=360mA.

For output voltages above 2.0V, when light-load efficiency is important, the minimum recommended inductor is 2.2µH. For optimum voltage-positioning load transients, choose an inductor with DC series resistance in the 20mΩ to 100mΩ range. For higher efficiency at heavy loads (above 200mA), or minimal load regulation (but some transient overshoot), the resistance should be kept below 100mΩ. 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 (1200mA+360mA). Table 2 lists some typical surface mount inductors that meet target applications for the A7146.

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Part Number	L (μH)	Max DCR (mΩ)	Rated D.C. Current (A)
Sumida CDRH4D22	1.5	31.3	3.90
Sumida CDRH5D16	2.2	35.9	3.00
Sumida CDRH5D28	3.3	20.3	2.30
Sumida CDRH5D16	4.7	64.1	2.15

Table 2. Typical Surface Mount Inductors

Input Capacitor Selection

The input capacitor reduces the surge current drawn from the input and switching noise from the A7146device. The input capacitor impedance at the switching frequency should be less than input source impedance to prevent high frequency switching current passing to the input. A low ESR input capacitor sized for maximum RMS current must be used. Ceramic capacitors with X5R or X7R dielectrics are highly recommended because of their low ESR and small temperature coefficients. A 22μF ceramic capacitor for most applications is sufficient. A large value may be used for improved input voltage filtering.

Output Capacitor Selection

The output capacitor is required to keep the output voltage ripple small and to ensure regulation loop stability. The output capacitor must have low impedance at the switching frequency. Ceramic capacitors with X5R or X7R dielectrics are recommended due to their low ESR and high ripple current ratings. The output ripple V_{OUT} is determined by:

$$\Delta V_{OUT} \le \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times f_{OSC} \times L} \times \left(ESR + \frac{1}{8 \times f_{osc} \times C3} \right)$$

A 22μF ceramic capacitor can satisfy most applications.

Operation

The A7146 is a monolithic switching mode Step-Down DC-DC converter. It utilizes internal MOSFETs to achieve high efficiency and can generate very low output voltage by using internal reference at 0.6V. The A7146 operates at a fixed switching frequency, and uses the slope compensated current mode architecture. This Step-Down DC-DC Converter supplies 1200mA output current at V_{IN} = 3V with input voltage range from 2.5V to 5.5V. With the Pulse Skipping Mode feature, users can optimize ripple at light load for noise sensitive applications.

Current Mode PWM Control

Slope compensated current mode PWM control provides stable switching and cycle-by-cycle current limit for excellent load and line responses and protection of the internal main switch (P-ch MOSFET) and synchronous rectifier (N-ch MOSFET). During normal operation, the internal P-ch MOSFET is turned on for a certain time to ramp the inductor current at each rising edge of the internal oscillator, and switched off when the peak inductor current is above the error voltage. The current comparator, $I_{COMP,}$ limits the peak inductor current. When the main switch is off, the synchronous rectifier will be turned on immediately and stay on until either the inductor current starts to reverse, as indicated by the current reversal comparator, I_{ZERO}, or the beginning of the next clock cycle. The OVDET comparator controls output transient overshoots by turning the main switch off and keeping it off until the fault is no longer present.

Pulse Skipping Mode Operation

The A7146 can automatically switch to Pulse Skipping Mode operation at light load to improve efficiency. In the Pulse Skipping Mode, the inductor current may reach zero or reverse on each pulse. The PWM control loop will automatically skip pulses to maintain output regulation. The bottom MOSFET is turned off by the current reversal comparator, $I_{ZERO,}$ and the switch voltage will ring. This is discontinuous mode operation, and is normal behavior for the switching regulator.

Dropout Operation

When the input voltage decreases toward the value of the output voltage, the A7146 allows the main switch to remain on for more than one switching cycle and increases the duty cycle until it reaches 100%. The duty cycle D of a step-down converter is defined as:

$$D = T_{ON} \times f_{OSC} \times 100\% \approx \frac{V_{OUT}}{V_{IN}} \times 100\%$$

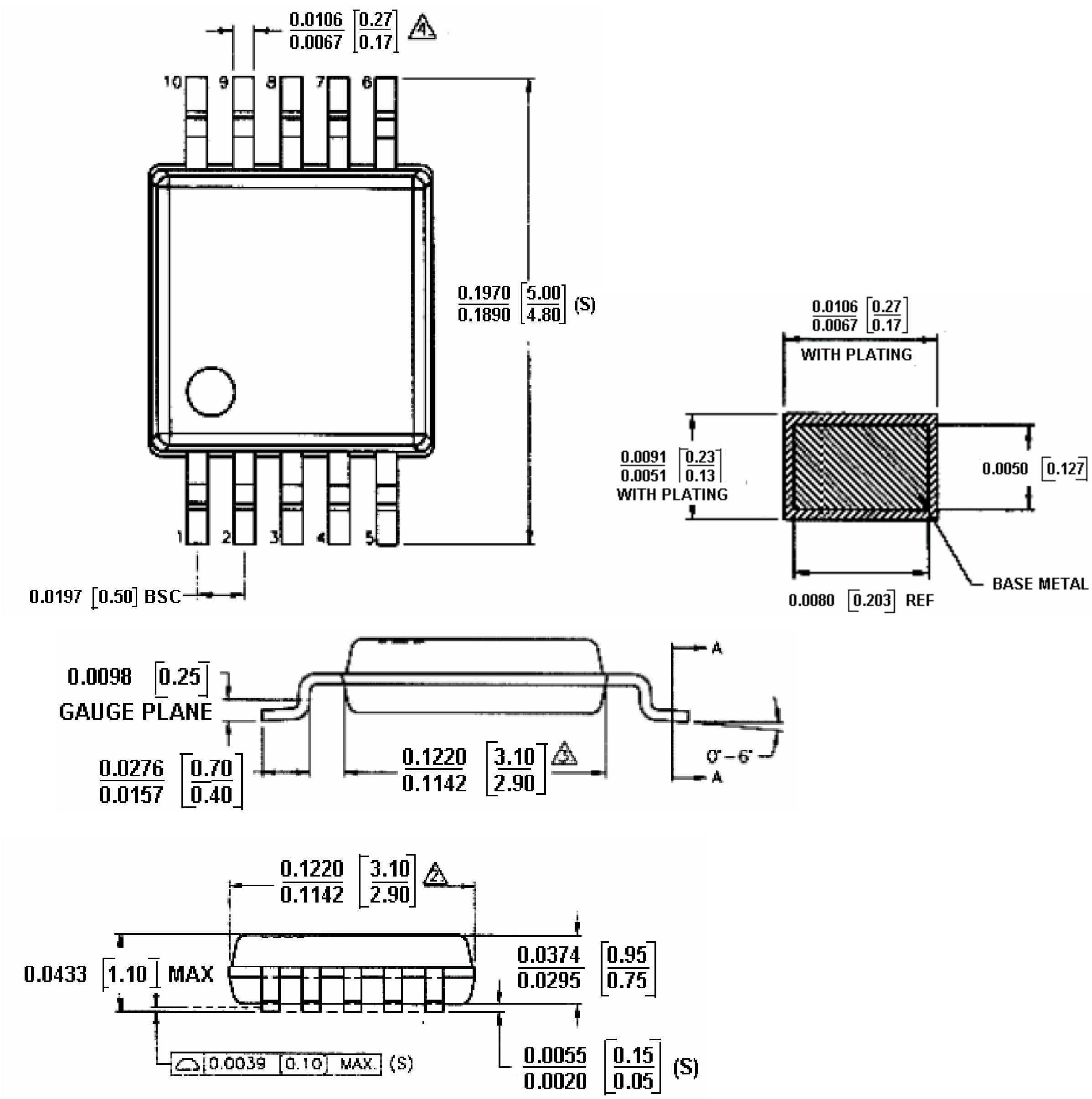
Where T_{ON} is the main switch on time and f_{OSC} is the oscillator frequency. The output voltage then is the input voltage minus the voltage drop across the main switch and the inductor. At low input supply voltage, the $R_{DS(ON)}$ of the P-channel MOSFET increases, and the efficiency of the converter decreases. Caution must be exercised to ensure the heat dissipated not to exceed the maximum junction temperature of the A7146.

Maximum Load Current

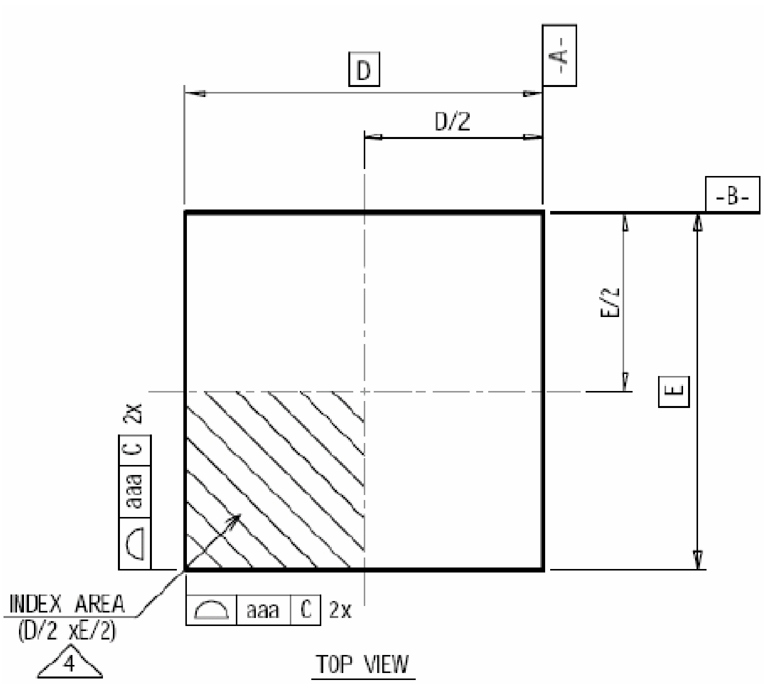
The A7146 will operate with input supply voltage as low as 2.5V, however, the maximum load current decreases at lower input due to large IR drop on the main switch and synchronous rectifier. The slope compensation signal reduces the peak inductor current as a function of the duty cycle to prevent sub-harmonic oscillations at duty cycles greater than 50%. Conversely the current limit increases as the duty cycle decreases.

Package Information

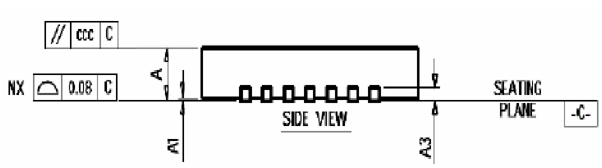
Dimension in MSOP10 (Unit: mm)

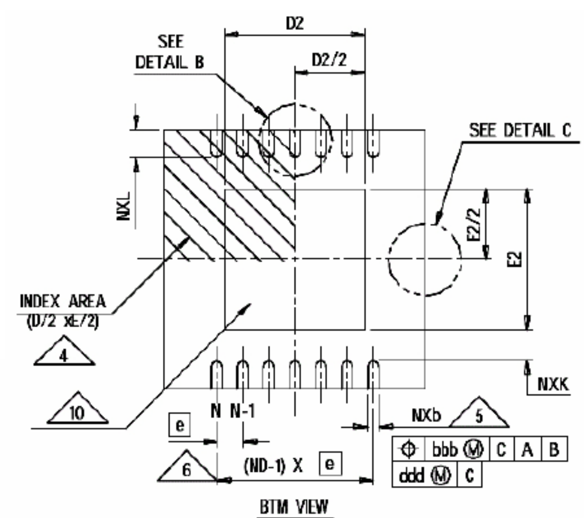


Dimension in DFN10 (Unit: mm)



A	0.75
A1	0.02
A3	0.20 ref
aaa	0.15
bbb	0.10
ccc	0.10
ddd	0.05
eee	0.08
ggg	0.10
D BSC	3.00
E BSC	3.00
D2	2.20-2.70
E2	1.40-1.75
L	0.40
N	10
ND	5





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