

## LOW POWER OFF LINE SMPS PRIMARY SWITCHER

## TYPICAL POWER CAPABILITY

Mains type	SO-8	DIP8
European (195 - 265 Vac)	8 W	13 W
US / Wide range (85 - 265 Vac)	5 W	8 W

- FIXED 60 KHZ SWITCHING FREQUENCY
- 9V TO 38V WIDE RANGE  $V_{DD}$  VOLTAGE
- CURRENT MODE CONTROL
- AUXILIARY UNDERVOLTAGE LOCKOUT WITH HYSTERESIS
- HIGH VOLTAGE START UP CURRENT SOURCE
- OVERTEMPERATURE, OVERCURRENT AND OVERVOLTAGE PROTECTION WITH AUTORESTART

### DESCRIPTION

The VIPer12A combines a dedicated current mode PWM controller with a high voltage Power



SO-8



**DIP-8**

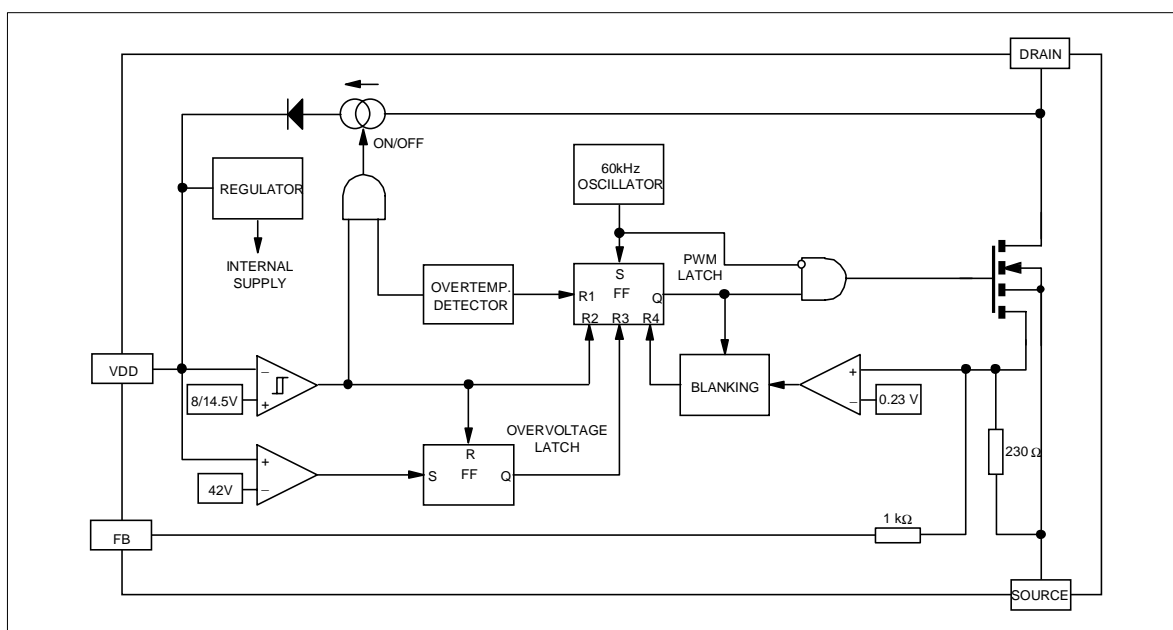
## ORDER CODES

ORDER CODES		
PACKAGE	TUBE	T&R
SO-8	VIPer12AS	VIPer12AS13TR
DIP-8	VIPer12ADIP	

MOSFET on the same silicon chip. Typical applications cover off line power supplies for battery charger adapters, standby power supplies for TV or monitors, auxiliary supplies for motor control, etc. The internal control circuit offers the following benefits:

- Large input voltage range on the  $V_{DD}$  pin accommodates changes in auxiliary supply voltage. This feature is well adapted to battery charger adapter configurations.
- Automatic burst mode in low load condition.
- Overvoltage protection in hiccup mode.

### BLOCK DIAGRAM

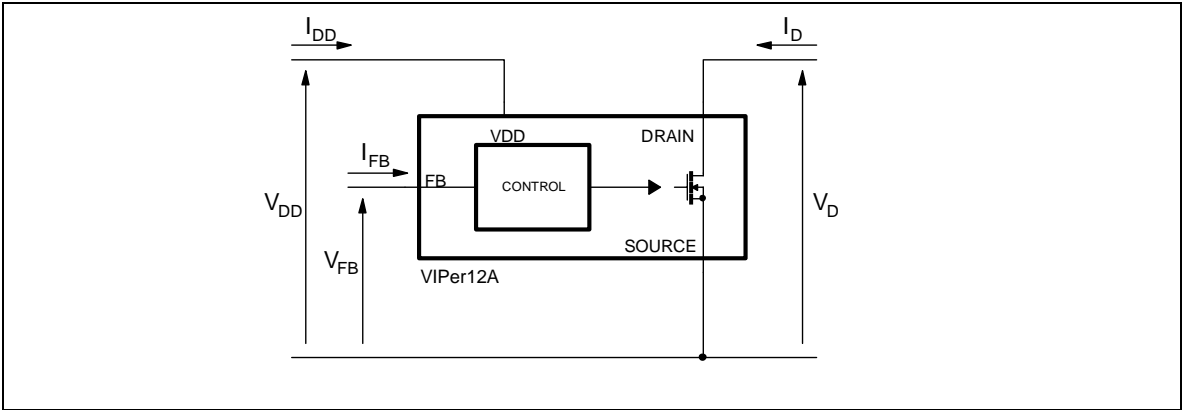


VIPer12ADIP / VIPer12AS

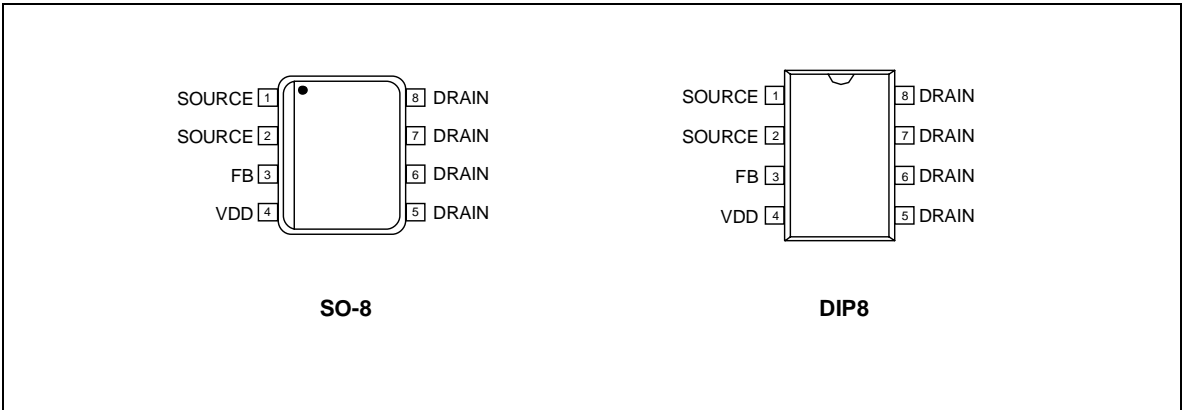
PIN FUNCTION

Name	Function
V <sub>DD</sub>	Power supply of the control circuits. Also provides a charging current during start up thanks to a high voltage current source connected to the drain. For this purpose, an hysteresis comparator monitors the V <sub>DD</sub> voltage and provides two thresholds: - V <sub>DDon</sub> : Voltage value (typically 14.5V) at which the device starts switching and turns off the start up current source. - V <sub>DDoff</sub> : Voltage value (typically 8V) at which the device stops switching and turns on the start up current source.
SOURCE	Power MOSFET source and circuit ground reference.
DRAIN	Power MOSFET drain. Also used by the internal high voltage current source during start up phase for charging the external V <sub>DD</sub> capacitor.
FB	Feedback input. The useful voltage range extends from 0V to 1V, and defines the peak drain MOSFET current. The current limitation, which corresponds to the maximum drain current, is obtained for a FB pin shorted to the SOURCE pin.

CURRENT AND VOLTAGE CONVENTIONS



CONNECTION DIAGRAM



**ABSOLUTE MAXIMUM RATINGS**

Symbol	Parameter	Value	Unit
$V_{DS(sw)}$	Switching Drain Source Voltage ( $T_j=25 \dots 125^\circ\text{C}$ ) (See note 1)	-0.3 ... 730	V
$V_{DS(st)}$	Start Up Drain Source Voltage ( $T_j=25 \dots 125^\circ\text{C}$ ) (See note 2)	-0.3 ... 400	V
$I_D$	Continuous Drain Current	Internally limited	A
$V_{DD}$	Supply Voltage	0 ... 50	V
$I_{FB}$	Feedback Current	3	mA
$V_{ESD}$	Electrostatic Discharge: Machine Model ( $R=0\Omega$ ; $C=200\text{pF}$ ) Charged Device Model	200 1.5	V kV
$T_j$	Junction Operating Temperature	Internally limited	$^\circ\text{C}$
$T_c$	Case Operating Temperature	-40 to 150	$^\circ\text{C}$
$T_{stg}$	Storage Temperature	-55 to 150	$^\circ\text{C}$

Note: 1. This parameter applies when the start up current source is off. This is the case when the  $V_{DD}$  voltage has reached  $V_{DDon}$  and remains above  $V_{DDoff}$ .  
 2. This parameter applies when the start up current source is on. This is the case when the  $V_{DD}$  voltage has not yet reached  $V_{DDon}$  or has fallen below  $V_{DDoff}$ .

**THERMAL DATA**

Symbol	Parameter	Max Value	Unit
Rthj-case	Thermal Resistance Junction-Pins for: SO-8 DIP8	25 15	$^\circ\text{C}/\text{W}$
Rthj-amb	Thermal Resistance Junction-Ambient for: SO-8 DIP8	(See note 1) (See note 1) 55 45	$^\circ\text{C}/\text{W}$

Note: 1. When mounted on a standard single-sided FR4 board with 200 mm<sup>2</sup> of Cu (at least 35  $\mu\text{m}$  thick) connected to all DRAIN pins.

**ELECTRICAL CHARACTERISTICS** ( $T_j=25^\circ\text{C}$ ,  $V_{DD}=18\text{V}$ , unless otherwise specified)**POWER SECTION**

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$BV_{DSS}$	Drain-Source Voltage	$I_D=1\text{mA}$ ; $V_{FB}=2\text{V}$	730			V
$I_{DSS}$	Off State Drain Current	$V_{DS}=500\text{V}$ ; $V_{FB}=2\text{V}$ ; $T_j=125^\circ\text{C}$			0.1	mA
$R_{DSon}$	Static Drain-Source On State Resistance	$I_D=0.2\text{A}$ $I_D=0.2\text{A}$ ; $T_j=100^\circ\text{C}$		27	30 54	$\Omega$
$t_f$	Fall Time	$I_D=0.1\text{A}$ ; $V_{IN}=300\text{V}$ (See fig.1) (See note 1)		100		ns
$t_r$	Rise Time	$I_D=0.2\text{A}$ ; $V_{IN}=300\text{V}$ (See fig.1) (See note 1)		50		ns
$C_{oss}$	Drain Capacitance	$V_{DS}=25\text{V}$		40		pF

Note: 1. On clamped inductive load

## VIPer12ADIP / VIPer12AS

### ELECTRICAL CHARACTERISTICS ( $T_J=25^\circ\text{C}$ , $V_{DD}=18\text{V}$ , unless otherwise specified)

#### SUPPLY SECTION

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$I_{DDch}$	Start Up Charging Current	$V_{DS}=100\text{V}$ ; $V_{DD}=5\text{V} \dots V_{DDon}$ (See fig. 2)		-1		mA
$I_{DDoff}$	Start Up Charging Current in Thermal Shutdown	$V_{DD}=5\text{V}$ ; $V_{DS}=100\text{V}$ $T_J > T_{SD} - T_{HYST}$	0			mA
$I_{DD0}$	Operating Supply Current Not Switching	$I_{FB}=2\text{mA}$		3	5	mA
$I_{DD1}$	Operating Supply Current Switching	$I_{FB}=0.5\text{mA}$ ; $I_D=50\text{mA}$ (Note 1)		4.5		mA
$D_{RST}$	Restart Duty Cycle	(See fig. 3)		16		%
$V_{DDoff}$	$V_{DD}$ Undervoltage Shutdown Threshold	(See fig. 2 & 3)	7	8	9	V
$V_{DDon}$	$V_{DD}$ Start Up Threshold	(See fig. 2 & 3)	13	14.5	16	V
$V_{DDhyst}$	$V_{DD}$ Threshold Hysteresis	(See fig. 2)	5.8	6.5	7.2	V
$V_{DDovp}$	$V_{DD}$ Overvoltage Threshold		38	42	46	V

Note: 1. These test conditions obtained with a resistive load are leading to the maximum conduction time of the device.

#### OSCILLATOR SECTION

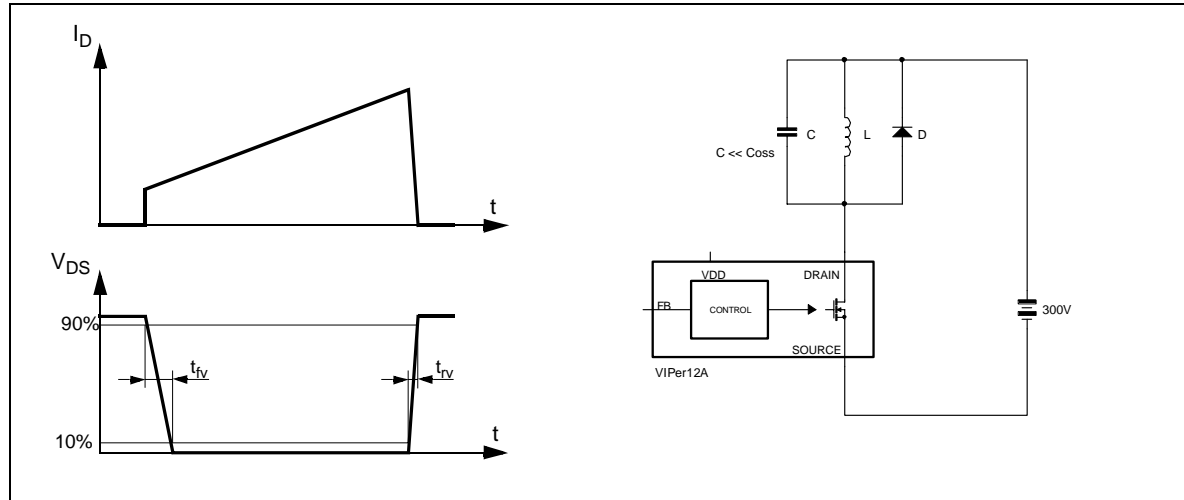
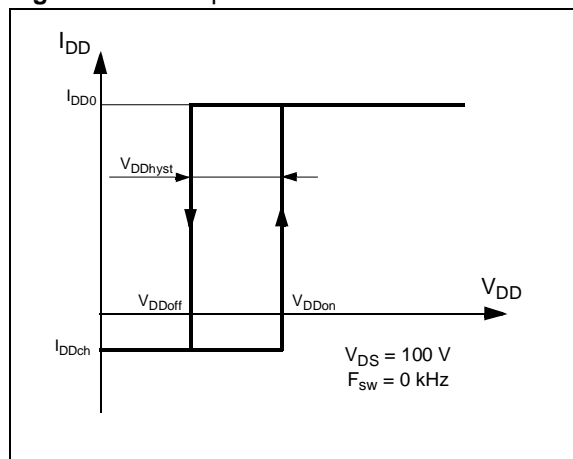
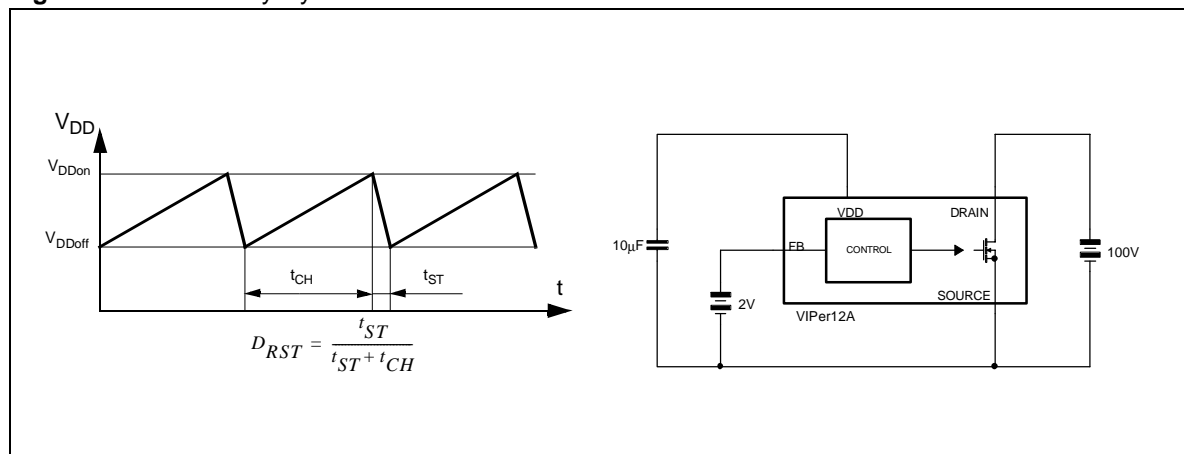
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$F_{OSC}$	Oscillator Frequency Total Variation	$V_{DD}=V_{DDoff} \dots 35\text{V}$ ; $T_J=0 \dots 100^\circ\text{C}$	54	60	66	kHz

#### PWM COMPARATOR SECTION

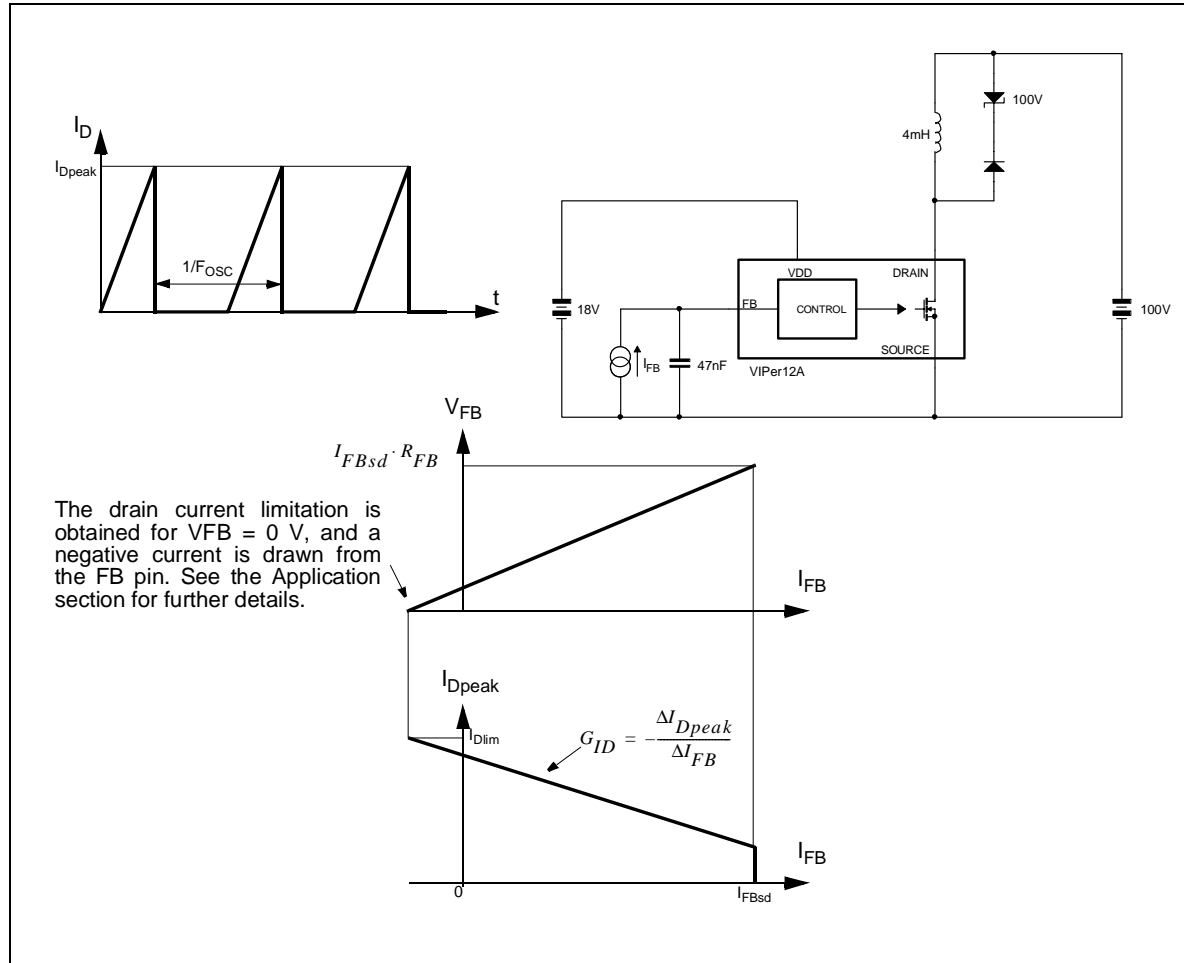
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$G_{ID}$	$I_{FB}$ to $I_D$ Current Gain	(See fig. 4)		320		
$I_{Dlim}$	Peak Current Limitation	$V_{FB}=0\text{V}$ (See fig. 4)	0.32	0.4	0.48	A
$I_{FBsd}$	$I_{FB}$ Shutdown Current	(See fig. 4)		0.9		mA
$R_{FB}$	FB Pin Input Impedance	$I_D=0\text{mA}$ (See fig. 4)		1.2		k $\Omega$
$t_d$	Current Sense Delay to Turn-Off	$I_D=0.2\text{A}$		200		ns
$t_b$	Blanking Time			500		ns
$t_{ONmin}$	Minimum Turn On Time			700		ns

#### OVERTEMPERATURE SECTION

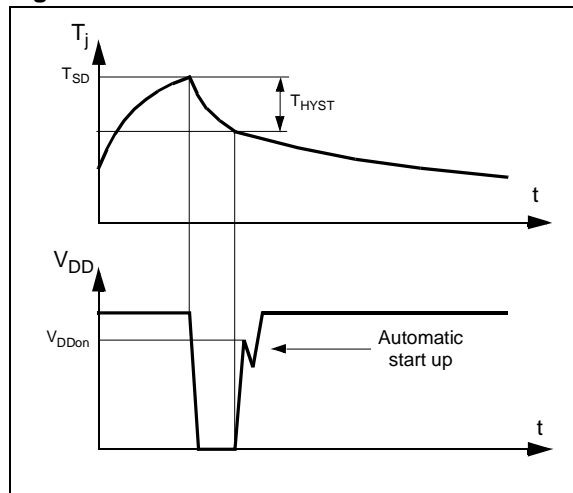
Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$T_{SD}$	Thermal Shutdown Temperature	(See fig. 5)	140	170		$^\circ\text{C}$
$T_{HYST}$	Thermal Shutdown Hysteresis	(See fig. 5)		40		$^\circ\text{C}$

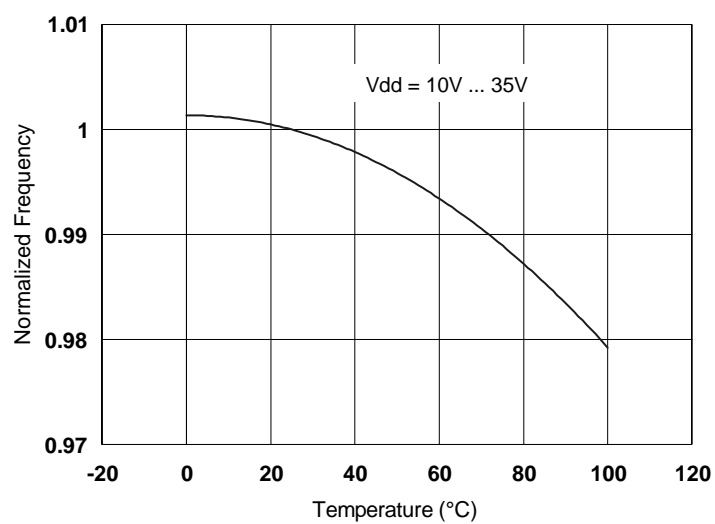
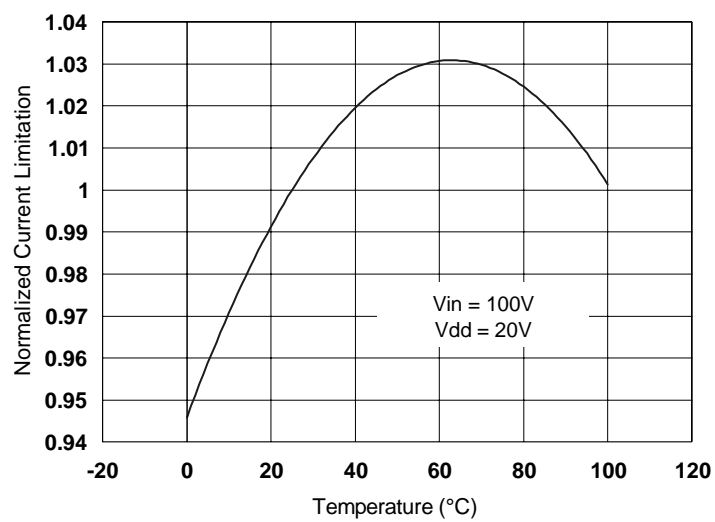
**Figure 1 : Rise and Fall Time**

**Figure 2 : Start Up VDD Current**

**Figure 3 : Restart Duty Cycle**


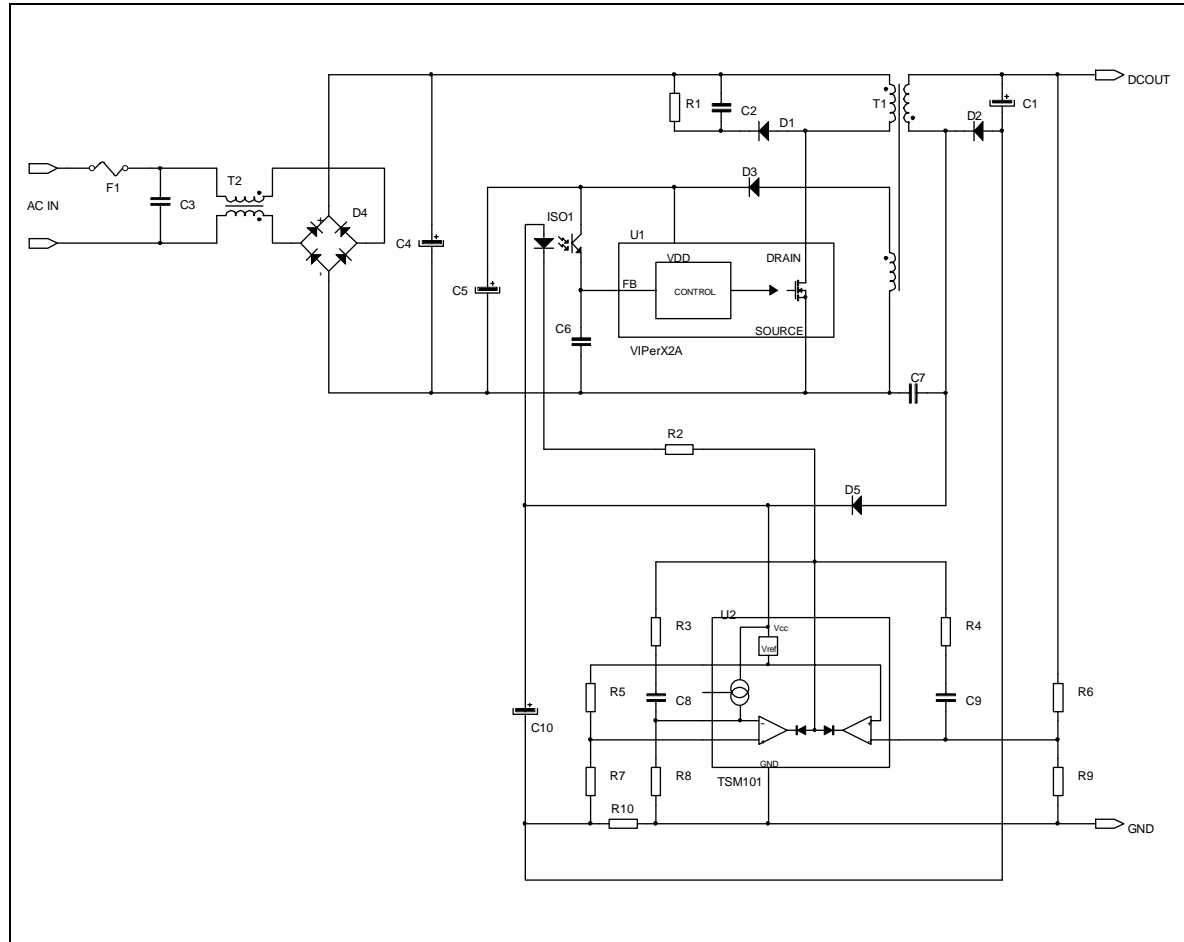
**Figure 4 : Peak Drain Current Vs. Feedback Current**



**Figure 5 : Thermal Shutdown**



**Figure 6 : Switching Frequency vs Temperature****Figure 7 : Current Limitation vs Temperature**

**Figure 8 :** Rectangular U-I output characteristics for battery charger

### RECTANGULAR U-I OUTPUT CHARACTERISTIC

A complete regulation scheme can achieve combined and accurate output characteristics. Figure 8 presents a secondary feedback through an optocoupler driven by a TSM101. This device offers two operational amplifiers and a voltage reference, thus allowing the regulation of both output voltage and current. An integrated OR function performs the combination of the two resulting error signals, leading to a dual voltage and current limitation, known as a rectangular output characteristic.

This type of power supply is especially useful for battery chargers where the output is mainly used in current mode, in order to deliver a defined charging rate. The accurate voltage regulation is also convenient for Li-ion batteries which require both modes of operation.

### WIDE RANGE OF $V_{DD}$ VOLTAGE

The  $V_{DD}$  pin voltage range extends from 9V to 38V. This feature offers a great flexibility in design to achieve various behaviors. In figure 8 a forward configuration has been chosen to supply the device with two benefits:

- as soon as the device starts switching, it immediately receives some energy from the auxiliary winding. C5 can be therefore reduced and a small ceramic chip (100 nF) is sufficient to insure the filtering function. The total start up time from the switch on of input voltage to output voltage presence is dramatically decreased.
- the output current characteristic can be maintained even with very low or zero output voltage. Since the TSM101 is also supplied in forward mode, it keeps the current regulation up whatever the output voltage is. The  $V_{DD}$  pin voltage may vary as much as the input voltage, that is to say with a ratio of about 4 for a wide range application.



### FEEDBACK PIN PRINCIPLE OF OPERATION

A feedback pin controls the operation of the device. Unlike conventional PWM control circuits which use a voltage input (the inverted input of an operational amplifier), the FB pin is sensitive to current. Figure 9 presents the internal current mode structure.

The Power MOSFET delivers a sense current  $I_S$  which is proportional to the main current  $I_D$ .  $R_2$  receives this current and the current coming from the FB pin. The voltage across  $R_2$  is then compared to a fixed reference voltage of about 0.23 V. The MOSFET is switched off when the following equation is reached:

$$R_2 \cdot (I_S + I_{FB}) = 0.23 \text{ V}$$

By extracting  $I_S$ :

$$I_S = \frac{0.23 \text{ V}}{R_2} - I_{FB}$$

Using the current sense ratio of the MOSFET  $G_{ID}$ :

$$I_D = G_{ID} \cdot I_S = G_{ID} \cdot \left( \frac{0.23 \text{ V}}{R_2} - I_{FB} \right)$$

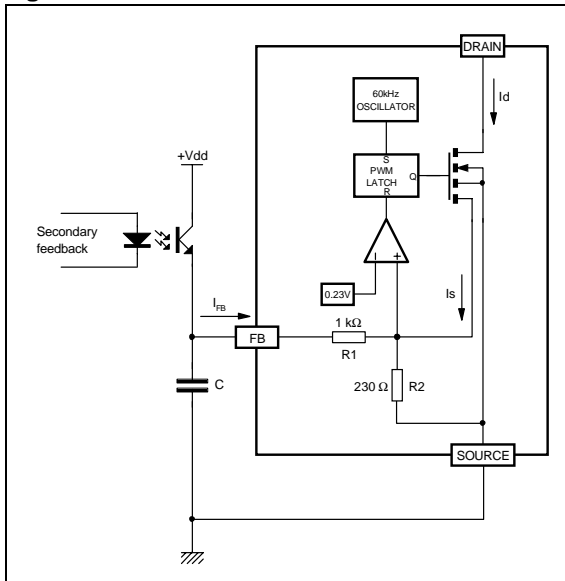
The current limitation is obtained with the FB pin shorted to ground ( $V_{FB} = 0 \text{ V}$ ). This leads to a negative current sourced by this pin, and expressed by:

$$I_{FB} = -\frac{0.23 \text{ V}}{R_1}$$

By reporting this expression in the previous one, it is possible to obtain the drain current limitation  $I_{Dlim}$ :

$$I_{Dlim} = G_{ID} \cdot 0.23 \text{ V} \cdot \left( \frac{1}{R_2} + \frac{1}{R_1} \right)$$

**Figure 9 : Internal Current Control Structure**



In a real application, the FB pin is driven with an optocoupler as shown on figure 9 which acts as a pull up. So, it is not possible to really short this pin to ground and the above drain current value is not achievable. Nevertheless, the capacitor C is averaging the voltage on the FB pin, and when the optocoupler is off (start up or short circuit), it can be assumed that the corresponding voltage is very close to 0 V.

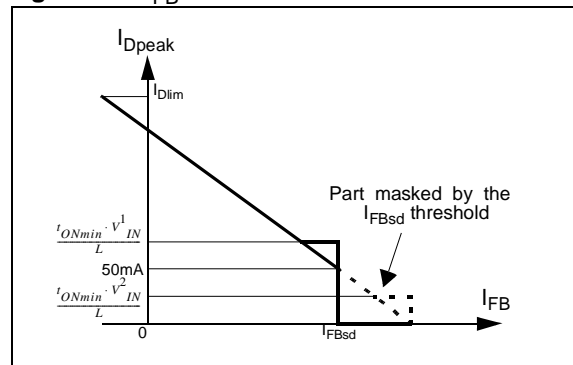
For low drain currents, the formula (1) is valid as long as  $I_{FB}$  satisfies  $I_{FB} < I_{FBsd}$ , where  $I_{FBsd}$  is an internal threshold of the VIPer12A. If  $I_{FB}$  exceeds this threshold the device will stop switching. This is represented on figure 4, and  $I_{FBsd}$  value is specified in the PWM COMPARATOR SECTION. Actually, as soon as the drain current is about 12% of  $I_{Dlim}$ , that is to say 50 mA, the device will enter a burst mode operation by missing switching cycles. This is especially important when the converter is lightly loaded.

It is then possible to build the total DC transfer function between  $I_D$  and  $I_{FB}$  as shown on figure 10. This figure also takes into account the internal blanking time and its associated minimum turn on time. This imposes a minimum drain current under which the device is no more able to control it in a linear way. This drain current depends on the primary inductance value of the transformer and the input voltage. Two cases may occur, depending on the value of this current versus the fixed 50 mA value, as described above.

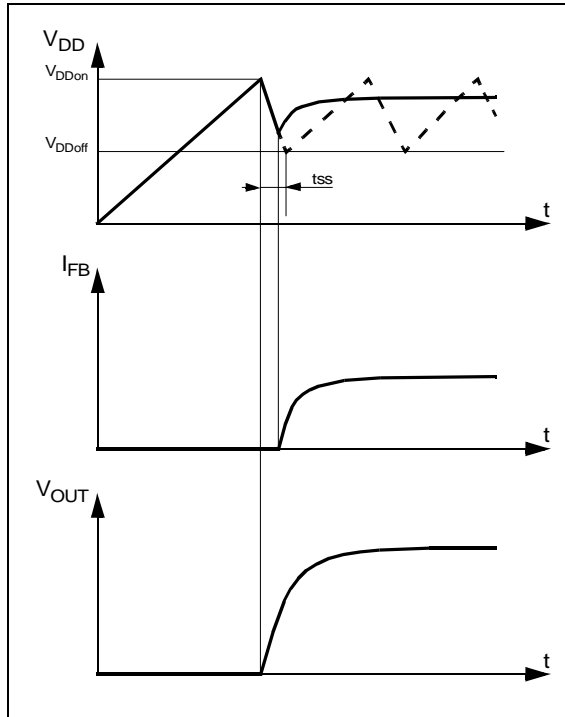
### START UP SEQUENCE

This device includes a high voltage start up current source connected on the drain of the device. As soon as a voltage is applied on the input of the converter, this start up current source is activated as long as  $V_{DD}$  is lower than  $V_{DDon}$ . When reaching  $V_{DDon}$ , the start up current source is switched off and the device begins to operate by turning on and off its main power MOSFET. As the FB pin does not receive any current from the optocoupler, the device operates at full current capacity and the output voltage rises until reaching

**Figure 10 :  $I_{FB}$  Transfer function**



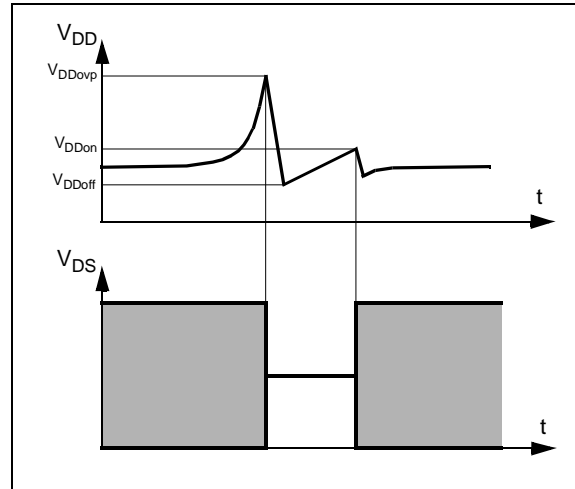
**Figure 11 : Start Up Sequence**



the regulation point where the secondary loop begins to send a current in the optocoupler. At this point, the converter enters a regulated operation where the FB pin receives the amount of current needed to deliver the right power on secondary side.

This sequence is shown in figure 11. Note that during the real starting phase  $t_{ss}$ , the device consumes some energy from the  $V_{DD}$  capacitor, waiting for the auxiliary winding to provide a continuous supply. If the value of this capacitor is too low, the start up phase is terminated before receiving any energy from the auxiliary winding and the converter never starts up. This is illustrated also in the same figure in dashed lines.

**Figure 12 : Overvoltage Sequence**

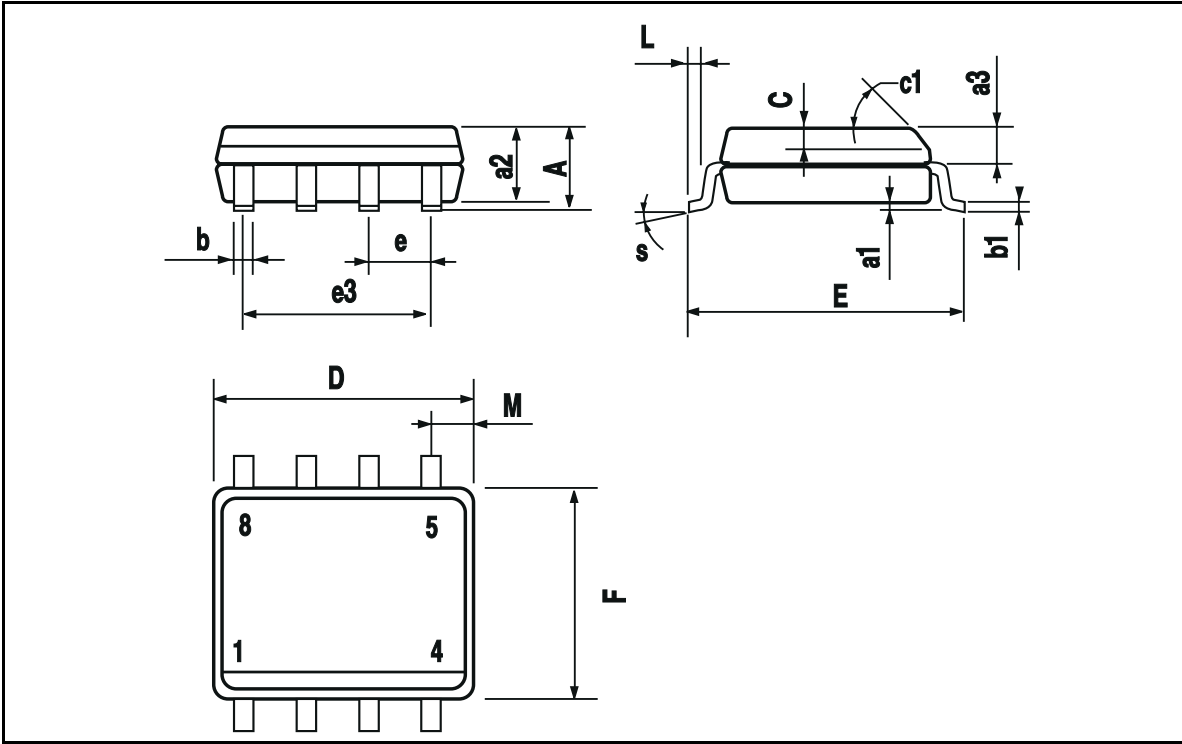


#### OVERVOLTAGE THRESHOLD

An overvoltage detector on the  $V_{DD}$  pin allows the VIPer12A to reset itself when  $V_{DD}$  exceeds  $V_{DDovp}$ . This is illustrated in figure 12, which shows the whole sequence of an overvoltage event. Note that this event is only latched for the time needed by  $V_{DD}$  to reach  $V_{DDoff}$ , and then the device resumes normal operation automatically.

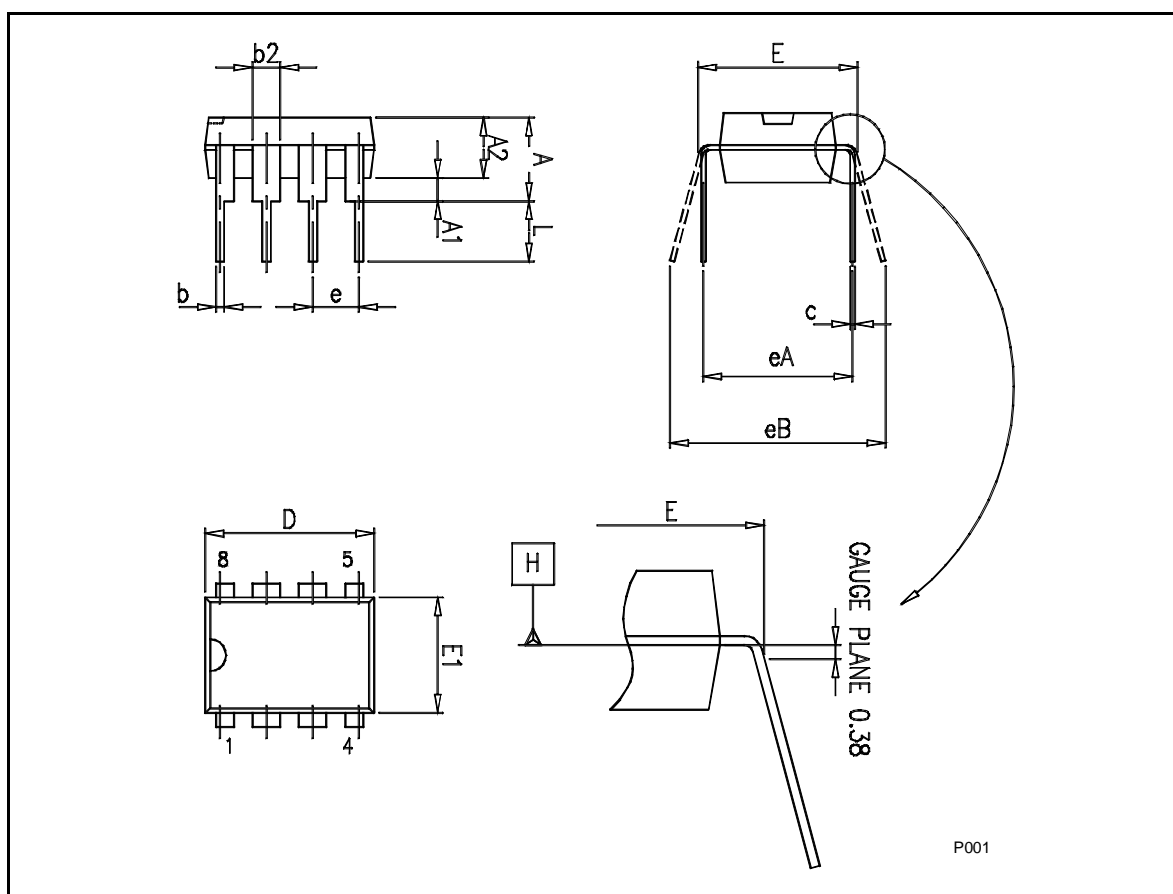
SO-8 MECHANICAL DATA

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A			1.75			0.068
a1	0.1		0.25	0.003		0.009
a2			1.65			0.064
a3	0.65		0.85	0.025		0.033
b	0.35		0.48	0.013		0.018
b1	0.19		0.25	0.007		0.010
C	0.25		0.5	0.010		0.019
c1	45 (typ.)					
D	4.8		5	0.188		0.196
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		3.81			0.150	
F	3.8		4	0.14		0.157
L	0.4		1.27	0.015		0.050
M			0.6			0.023
S	8 (max.)					
L1	0.8		1.2	0.031		0.047

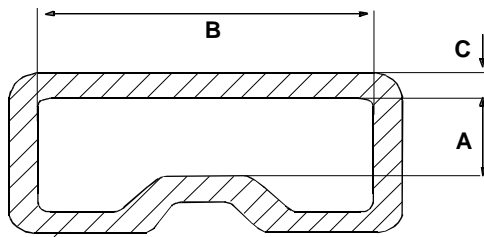


# Plastic DIP-8 MECHANICAL DATA

DIM.	mm.		
	MIN.	TYP	MAX.
A			5.33
A1	0.38		
A2	2.92	3.30	4.95
b	0.36	0.46	0.56
b2	1.14	1.52	1.78
c	0.20	0.25	0.36
D	9.02	9.27	10.16
E	7.62	7.87	8.26
E1	6.10	6.35	7.11
e		2.54	
eA		7.62	
eB			10.92
L	2.92	3.30	3.81
Package Weight	Gr. 470		



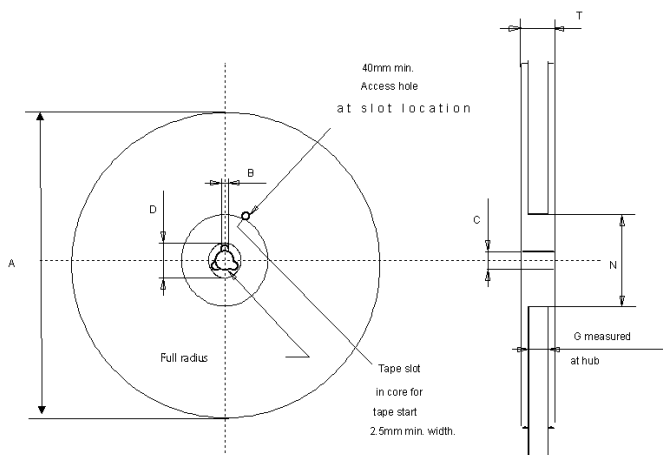
### SO-8 TUBE SHIPMENT (no suffix)



Base Q.ty	100
Bulk Q.ty	2000
Tube length ( $\pm 0.5$ )	532
A	3.2
B	6
C ( $\pm 0.1$ )	0.6

All dimensions are in mm.

### TAPE AND REEL SHIPMENT (suffix "13TR")



#### REEL DIMENSIONS

Base Q.ty	2500
Bulk Q.ty	2500
A (max)	330
B (min)	1.5
C ( $\pm 0.2$ )	13
F	20.2
G (+ 2 / -0)	12.4
N (min)	60
T (max)	18.4

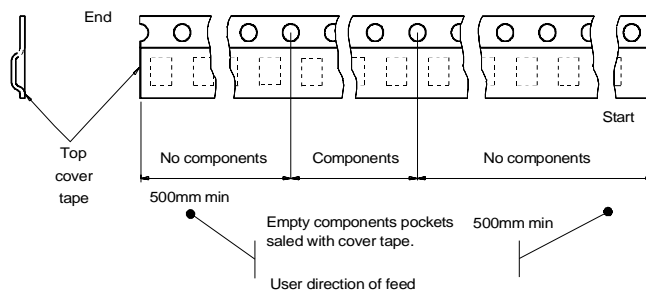
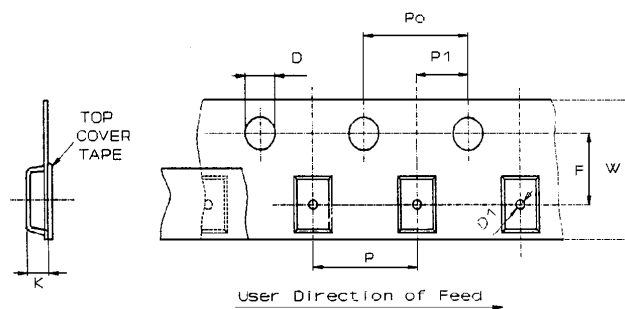
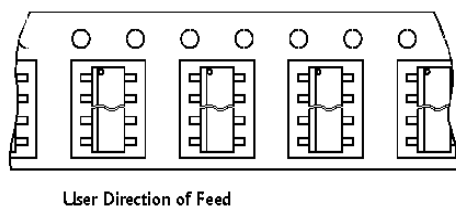
All dimensions are in mm.

#### TAPE DIMENSIONS

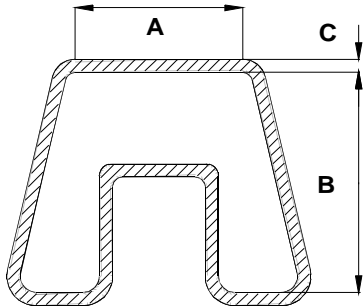
According to Electronic Industries Association (EIA) Standard 481 rev. A, Feb 1986

Tape width	W	12
Tape Hole Spacing	P0 ( $\pm 0.1$ )	4
Component Spacing	P	8
Hole Diameter	D ( $\pm 0.1/-0$ )	1.5
Hole Diameter	D1 (min)	1.5
Hole Position	F ( $\pm 0.05$ )	5.5
Compartment Depth	K (max)	4.5
Hole Spacing	P1 ( $\pm 0.1$ )	2

All dimensions are in mm.



DIP-8 TUBE SHIPMENT (no suffix)



Base Q.ty	20
Bulk Q.ty	1000
Tube length ( $\pm 0.5$ )	532
A	8.4
B	11.2
C ( $\pm 0.1$ )	0.8

All dimensions are in mm.

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