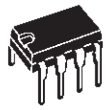
VIPer12ADIP
VIPer12AS

OFF LINE BATTERY CHARGER ADAPTER

TARGET SPECIFICATION

TYPE	$R_{DS(on)}$	I_N	V_{DSS}
VIPer12ADIP VIPer12AS	30Ω	0.36A	730V

SO8



DIP8

ORDER CODES:

DIP8	VIPer12ADIP
SO-8	VIPer12AS

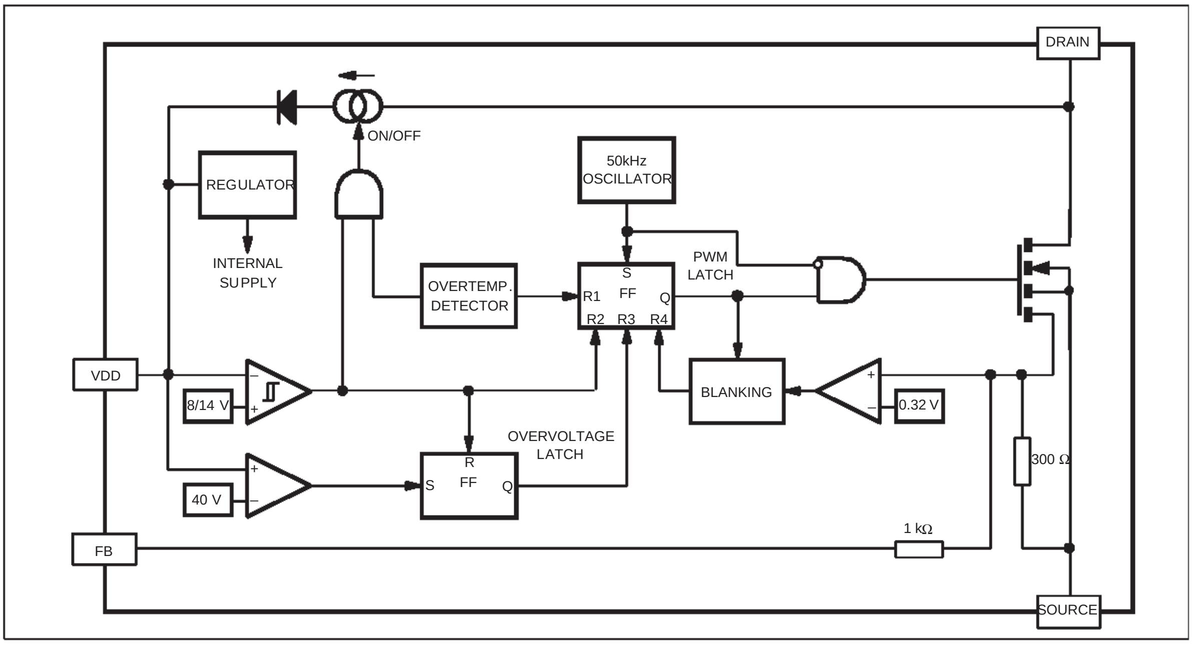
- FIXED 50 kHz SWITCHING FREQUENCY
- 8V TO 40V WIDE RANGE VDD VOLTAGE
- CURRENT MODE CONTROL
- AUXILIARY UNDERVOLTAGE LOCKOUT WITH HYSTERESIS
- HIGH VOLTAGE START UP CURRENT SOURCE
- OVERTEMPERATURE, OVERCURRENT AND OVERVOLTAGE PROTECTION

DESCRIPTION

The VIPer12A combines a dedicated current mode PWM controller with a high voltage Power MOSFET on the same silicon chip. Typical applications cover off line power supplies with a secondary power capability ranging from less than 1W to 5W in wide input voltage range and 10W in single European voltage range or with a doubler configuration. 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 configurations.
- Automatic burst mode in low load condition.
- Overvoltage protection in hiccup mode.

BLOCK DIAGRAM



THERMAL DATA

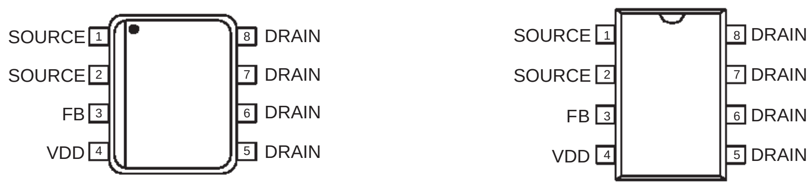
Symbol	Parameter	Value	Unit
$R_{thj\text{-}case}$	Thermal Resistance Junction-Pins (MAX) for SO8 Thermal Resistance Junction-Pins (MAX) for DIP8	15 15	°C/W °C/W
$R_{tjh\text{-}amb}$	Thermal Resistance Junction-Ambient (MAX) for SO8 (See note 1) Thermal Resistance Junction-Ambient (MAX) for DIP8 (See note 1)	65 65	°C/W °C/W

Note 1: When mounted on a standard single-sided FR4 board with 50mm of Cu (at least 35 µm thick) connected to all DRAIN pins.

ABSOLUTE MAXIMUM RATING

Symbol	Parameter	Value	Unit
V_{DS}	Continuous Drain Source Voltage (T_j = 25 ... 125°C)	-0.3 ... 730	V
I_D	Continuous Drain Current	Internally limited	A
V_{DD}	Supply Voltage	0 ... 44	V
I_{FB}	Feedback Current	3	mA
V_{ESD}	Electrostatic Discharge (R =1.5kΩ; C=100pF)	1.5	kV
T_j	Junction Operating Temperature	Internally limited	°C
T_c	Case Operating Temperature	-40 to 150	°C
T_{stg}	Storage Temperature	-55 to 150	°C

CONNECTION DIAGRAM

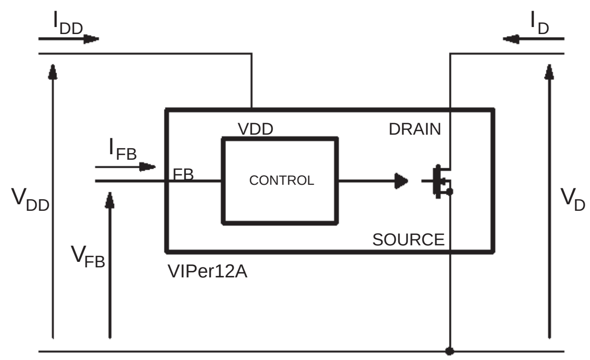


SO8 DIP8

PIN FUNCTIONS

Pin Name	Pin Function
V_{DD}	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, a hysteresis comparator monitors the V_{DD} voltage and provides two thresholds: - V_{DDon}: Voltage value (typically 14V) at which the device starts switching and turns off the start up current source. - V_{DDoff}: 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_{DD} capacitor.
FB	Feedback input. The useful voltage range extends from 0V to 1V, and defines the peak drain MOSFET current. The maximum one, which also corresponds to the current limitation, is obtained for an FB pin left open.

CURRENT AND VOLTAGE CONVENTIONS



ELECTRICAL CHARACTERISTICS (T_j=25°C; V_{DD}=16V, unless otherwise specified)

POWER SECTION

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
BV_{DSS}	Drain-Source Voltage	I_D=1mA; V_{FB}=2V	730			V
I_{DSS}	Off State Drain Current	V_{DS}=500V; V_{FB}=2V; T_j=125°C			0.5	mA
R_{DSon}	Static Drain-Source On State Resistance	I_D=0.2A I_D=0.2A; T_j=100°C		27	30 54	Ω
t_f	Fall Time	I_D=0.1A; V_{IN}=300V(See fig.1) (See note 1)		300		ns
t_r	Rise Time	I_D=0.2A; V_{IN}=300V(See fig.1) (See note 1)		50		ns
C_{oss}	Drain Capacitance	V_{DS}=25V		40		pF

Note 1: On clamped inductive load

SUPPLY SECTION

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
I_{DDch}	Start Up Charging Current	V_{DS}=100V (See fig. 2)		-0.5		mA
I_{DDoff}	Start Up Charging Current in Thermal Shutdown	V_{DD}=5V; V_{DS}=100V $T_j > T_{SD} - T_{HYST}$	0			mA
I_{DD0}	Operating Supply Current Not Switching	I_{FB}=1.5mA		3	5	mA
I_{DD1}	Operating Supply Current Switching	I_{FB}=0.5mA		3.5		mA
D_{RST}	Restart Duty Cycle	(See fig. 3)		16		%
V_{DDoff}	V_{DD} Undervoltage Shutdown Threshold	(See fig. 2 & 3)		8	9	V
V_{DDon}	V_{DD} Start Up Threshold	(See fig. 2 & 3)		14	16	V
V_{DDhyst}	V_{DD} Threshold Hysteresis	(See fig. 2)	5	6		V
V_{DDovp}	V_{DD} Overvoltage Threshold		36	40	44	V

OSCILLATOR SECTION

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
F_{OSC}	Oscillator Frequency Total Variation	V_{DD}=$V_{DD(off)}$ ... 36V; T_j=0 ... 100°C	45	50	55	kHz

PWM COMPARATOR SECTION

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
G_{ID}	I_{FB} to I_D Current Gain	(See fig. 4)		380		
I_{Dlim}	Peak Current Limitation	I_{FB}=0mA (See fig. 4)	0.36	0.4	0.44	A
I_{FBsd}	I_{FB} Shutdown Current	(See fig. 4)		0.83		mA
R_{FB}	FB Pin Input Impedance	I_D=0mA (See fig. 4)		1.3		kΩ
t_d	Current Sense Delay to Turn-Off	I_D=0.2A		200		ns
t_b	Blanking Time			500		ns
t_{ONmin}	Minimum On Time			700		ns

OVERTEMPERATURE SECTION

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

Figure 1: Rise and Fall Time

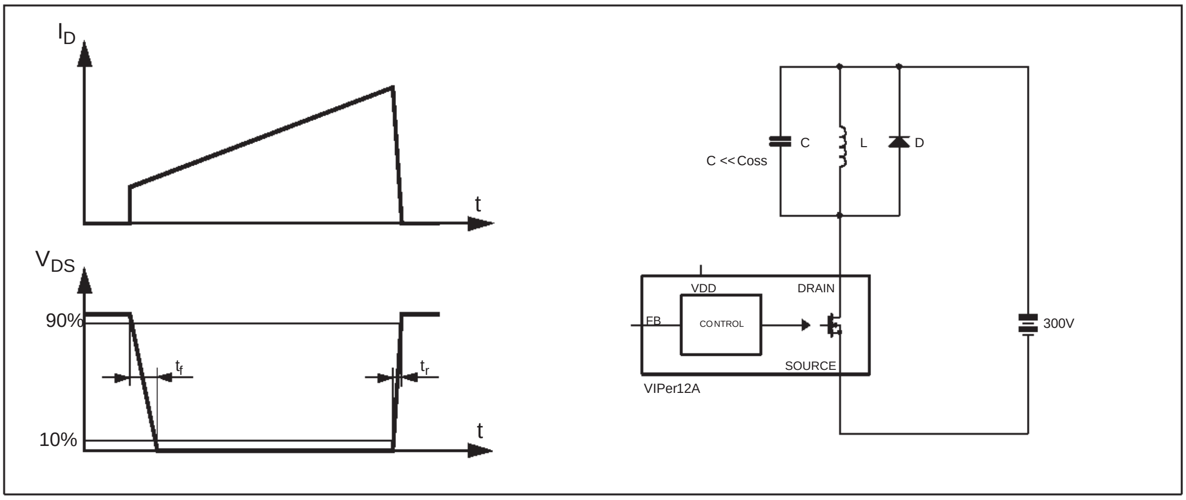


Figure 2: Start Up Current

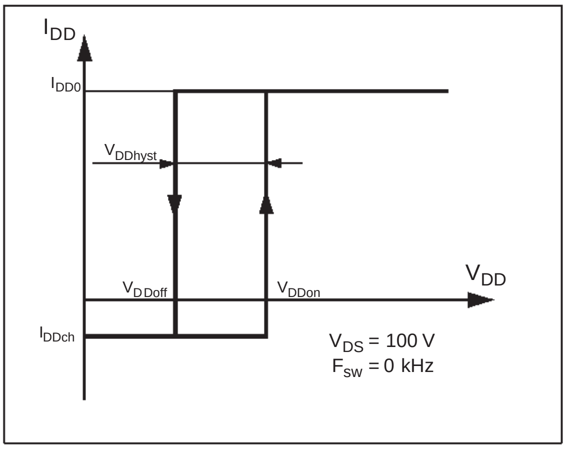


Figure 3: Restart Duty Cycle

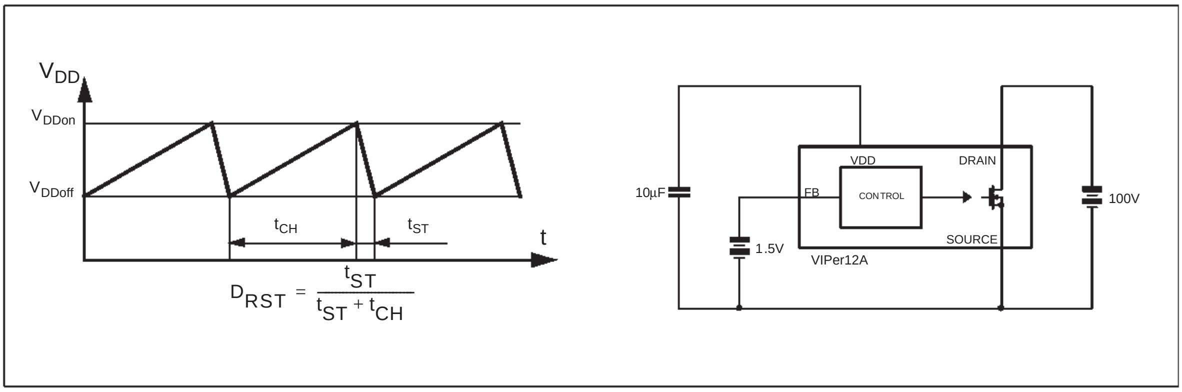


Figure 4: Peak Drain Current vs Feedback Current

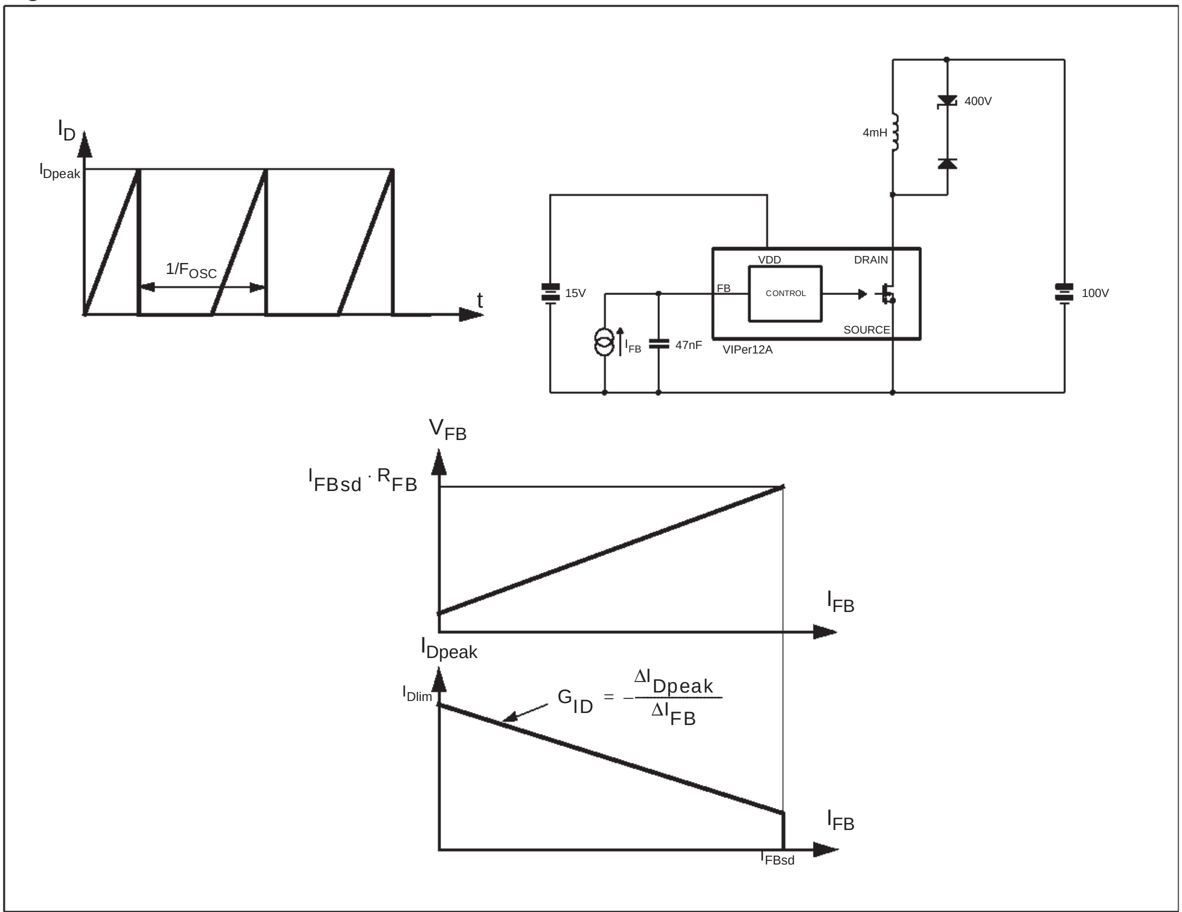


Figure 5: Thermal Shutdown

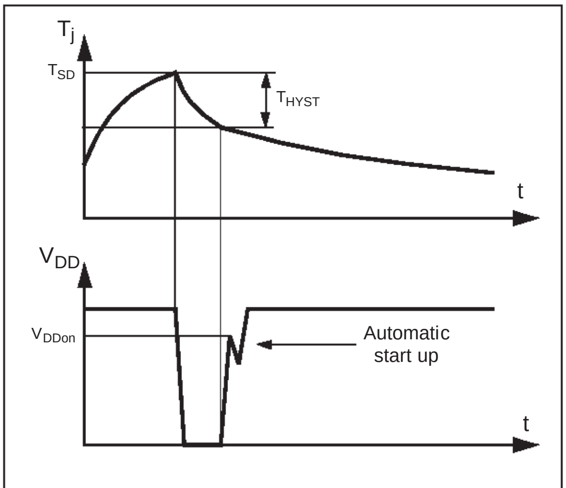
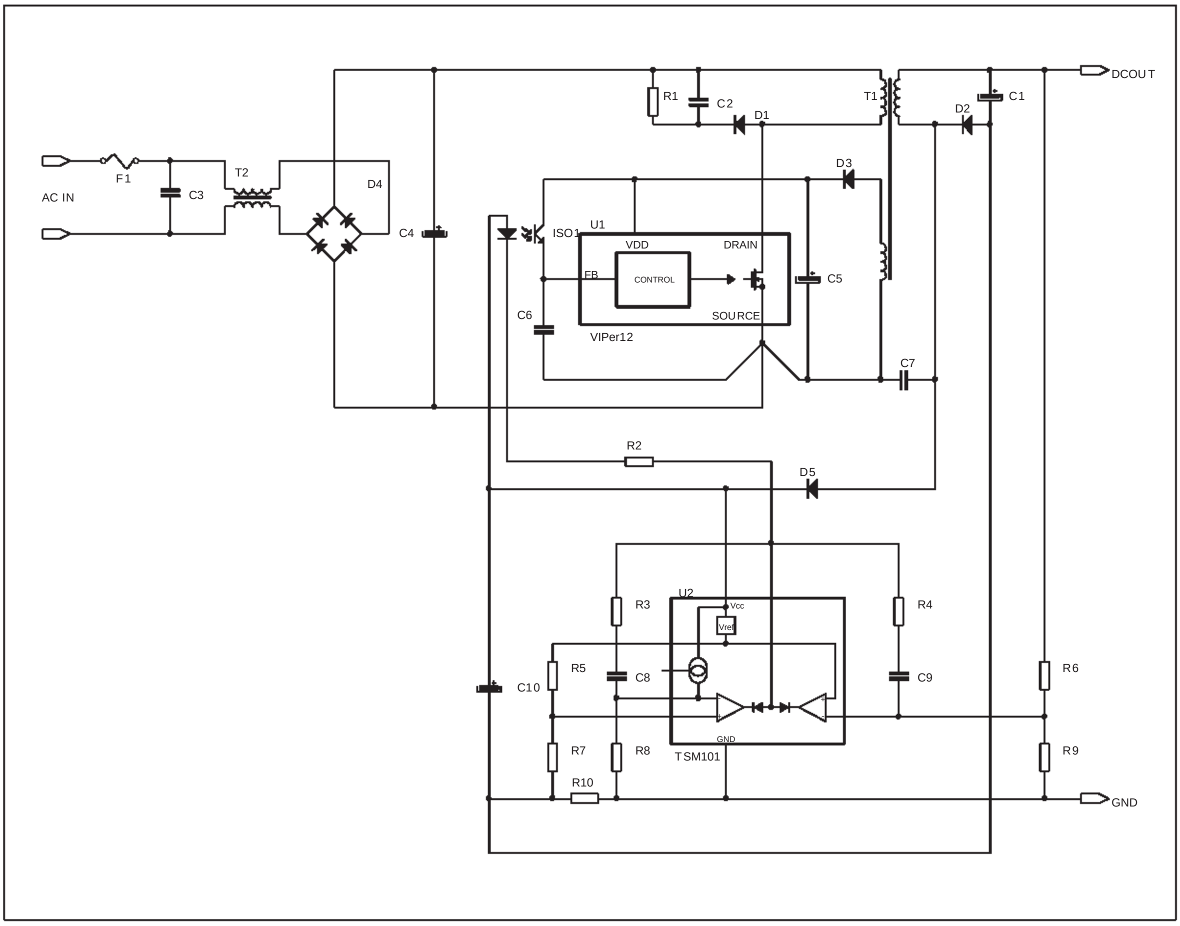


Figure 6: Rectangular U-I output characteristics for battery charger



Rectangular U-I output characteristic

A complete regulation scheme can achieve combined and accurate output characteristics. Figure 6 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 useful V_{DD} pin voltage range extends from 8 V to 40 V. This feature offers a great flexibility in design to achieve various behaviors. In figure 6 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 7 presents the internal current mode structure.

The Power MOSFET delivers a sense current I_s which is proportional to the main current Id. R2 receives this current and the current coming from the FB pin. The voltage across R2 is then compared to a fixed reference voltage of about 0.32 V. The MOSFET is switched off when the following equation is reached:

$$R_2 \cdot (I_S + I_{FB}) = 0.32V$$

By extracting I_S:

$$I_S = \frac{0.32V}{R_2} - I_{FB}$$

By using the current sense ratio of the MOSFET G_{ID} :

$$I_D = G_{ID} \cdot I_S = G_{ID} \cdot \left(\frac{0.32V}{R_2} - I_{FB}\right)$$

When I_{FB} is zero (optocoupler in off state), the device operates at its full current capacity which corresponds to the drain current limitation I_{Dlim}. This value can be expressed as:

$$I_{Dlim} = G_{ID} \cdot \frac{0.32V}{R_2}$$

By expressing again I_D as a function of I_{Dlim} and I_{FB}, it comes:

$$I_D = I_{Dlim} - G_{ID} \cdot I_{FB}$$

This formula is valid as long as I_{FB} satisfies :

$$I_{FB} < \frac{I_{Dlim}}{G_{ID}}$$

The internal design of the VIPer12 is done in such a way that the device stops switching when I_{FB} exceeds a threshold given by I_{FBsd}. This value is about 85% of the above expression, and is represented on figure 4. It is therefore possible to address a real 0% duty cycle, which is especially important when the converter is lightly loaded. Actually, it will enter a burst mode operation by missing switching cycles, as soon as the drain current is about 15% of I_{Dlim}, that is to say 60 mA.

It is then possible to build the total DC transfer function between I_D and I_{FB} as shown on figure 8. 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 not able to control it in a linear way any more. This drain current depends on the

Figure 7: Internal Current Control Structure

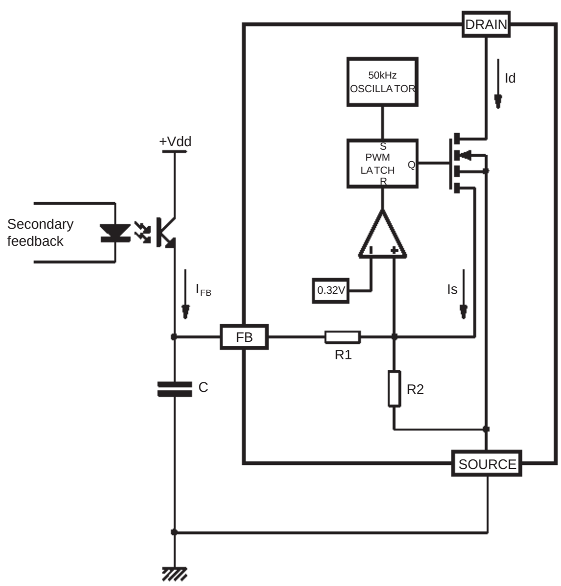
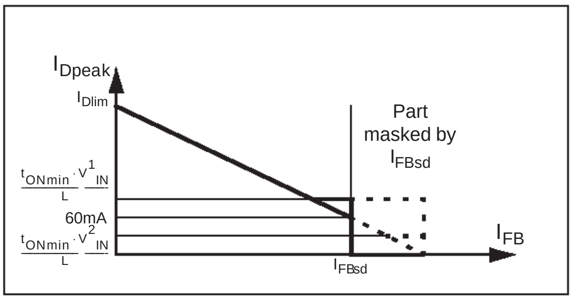


Figure 8: I_{FB} Transfer Function



primary inductance value of the transformer and the input voltage. Two cases may occur, depending on the value of this current versus the fixed 60 mA, as described above.

In the above results, the resistance R1 never appears in the computation. This is normal, because the optocoupler forces a current into the FB pin and this current is completely transmitted to the summing node of the fast current mode comparator. But together with the capacitor C, this resistance builds a noise canceller filter avoiding any spurious voltage to jam the current mode section.

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 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 9. 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 9: Start Up Sequence

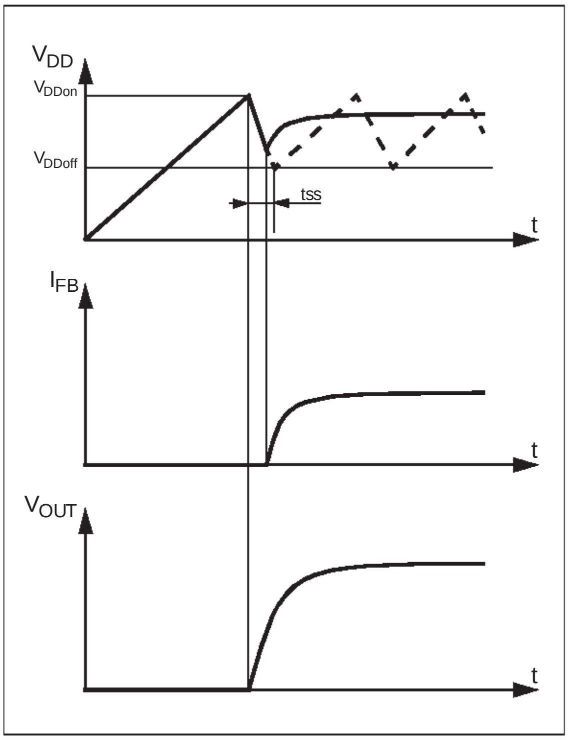
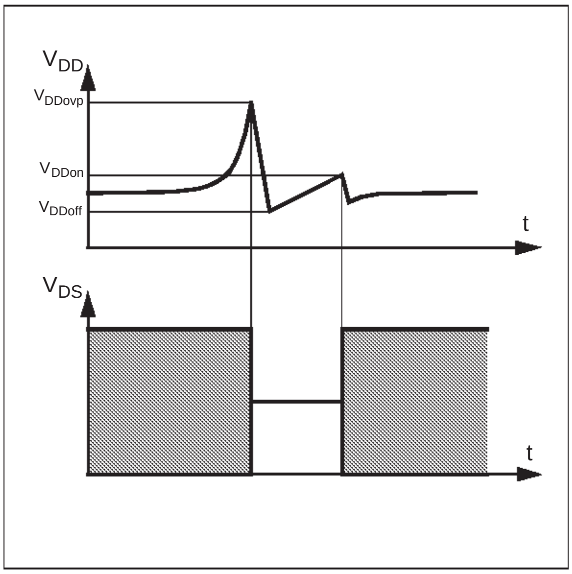


Figure 10: Overvoltage Sequence

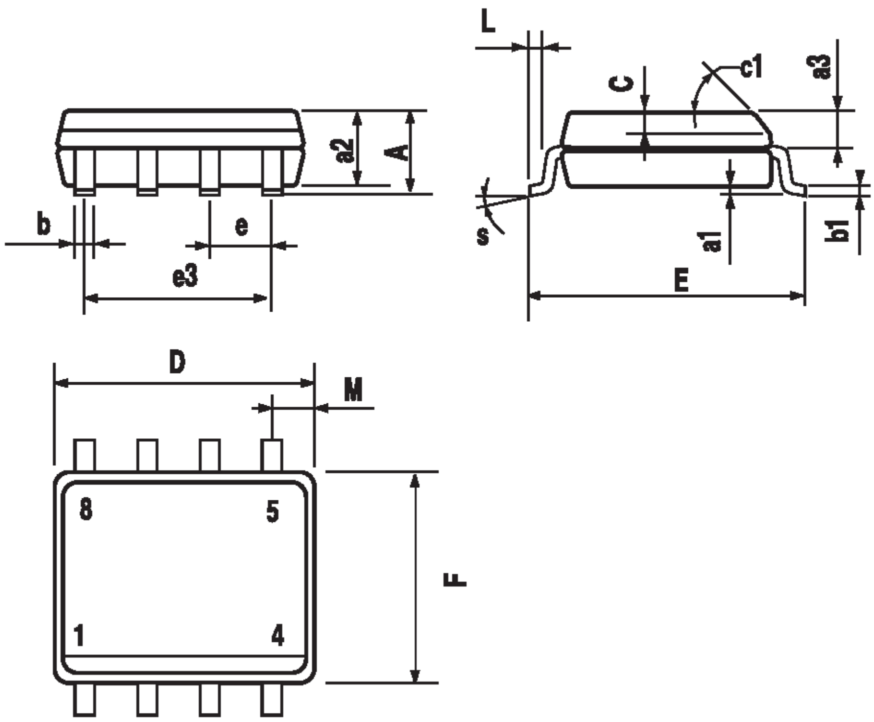


Overvoltage threshold

An overvoltage detector on the V_{DD} pin allows the VIPer12 to reset itself when V_{DD} exceeds V_{DDovp}. This is illustrated in figure 10, 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.

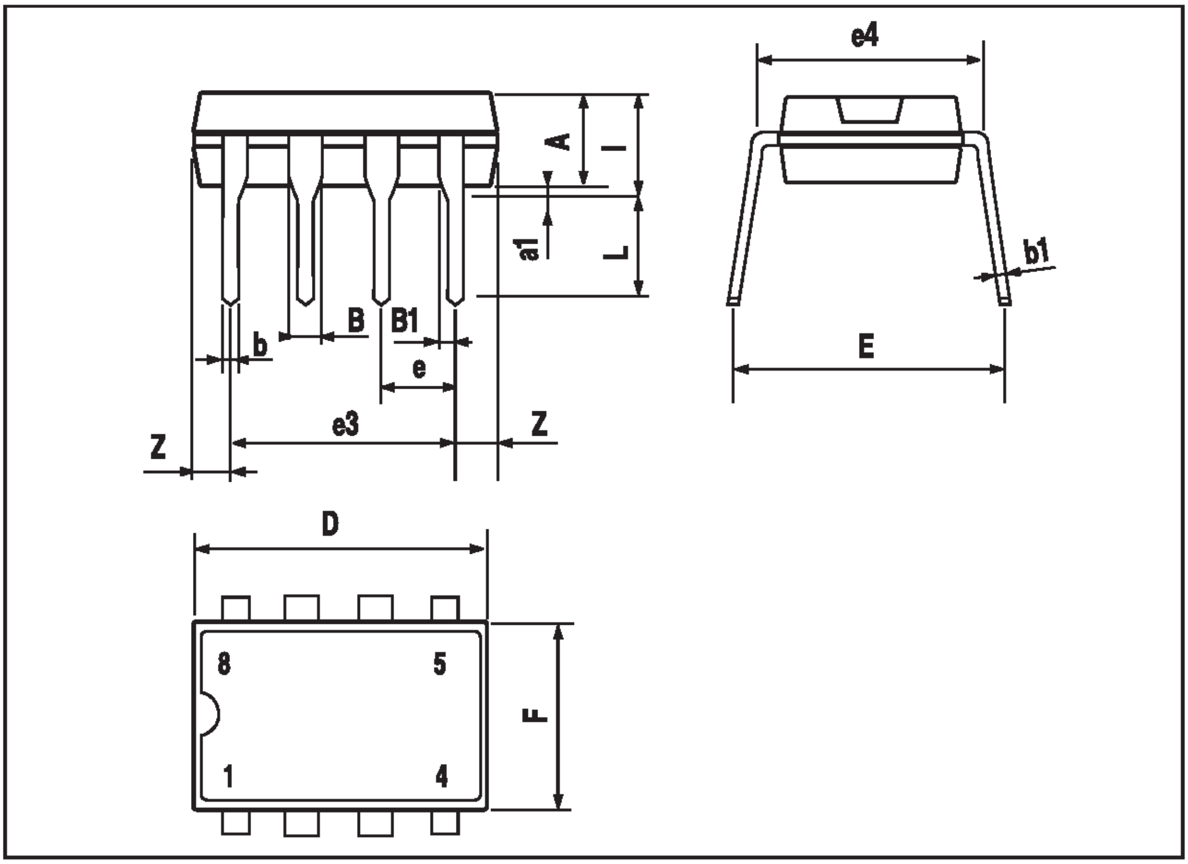
SO-8 MECHANICAL DATA

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

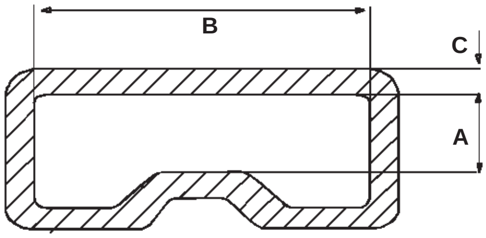


Plastic DIP-8 MECHANICAL DATA

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A		3.3			0.130	
a1	0.7			0.028		
B	1.39		1.65	0.055		0.065
B1	0.91		1.04	0.036		0.041
b		0.5			0.020	
b1	0.38		0.5	0.015		0.020
D			9.8			0.386
E		8.8			0.346	
e		2.54			0.100	
e3		7.62			0.300	
e4		7.62			0.300	
F			7.1			0.280
I			4.8			0.189
L		3.3			0.130	
Z	0.44		1.6	0.017		0.063



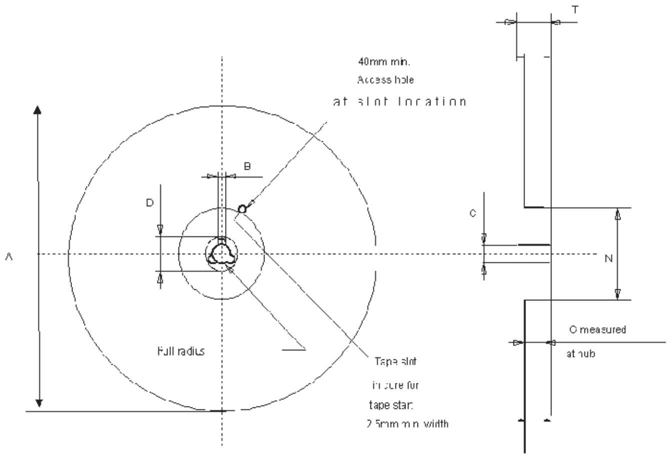
SO-8 TUBE SHIPMENT (no suffix)



Base Q.ty	100
Bulk Q.ty	2000
Tube length (± 0.5)	532
A	3.2
B	6
C (± 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 (± 0.2)	13
F	20.2
G (+ 2 / -0)	12.4
N (min)	60
T (max)	18.4

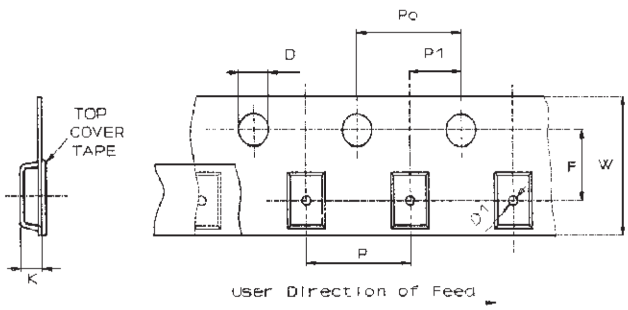
All dimensions are in mm.

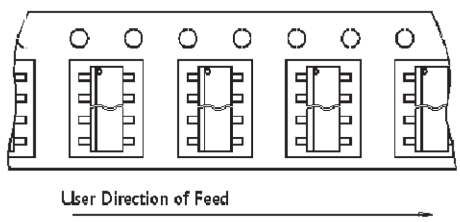
TAPE DIMENSIONS

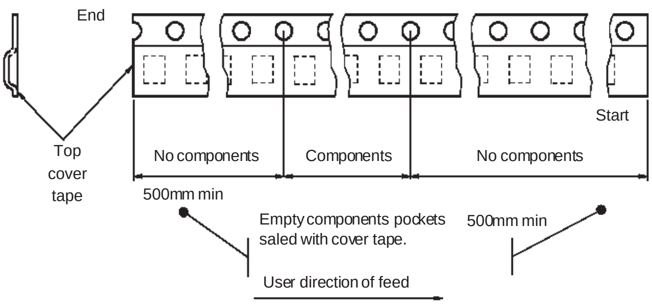
According to Electronic Industries Association (EIA) Standard 481 rev. A, Feb 1986

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

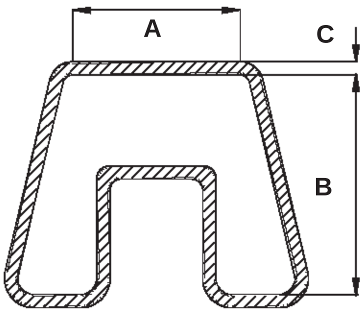
All dimensions are in mm.







DIP-8 TUBE SHIPMENT (no suffix)



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

All dimensions are in mm.