

## PWM CONTROL IC WITH SCP/DTC FUNCTION

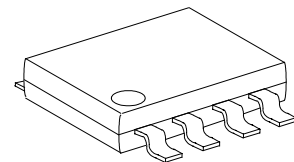
### GENERAL DESCRIPTION

The **FP5001**, a 1-chip composed of open collector transistor output pulse-width-modulation control circuits with an error amplifier and dead-time comparators (DTC), the **FP5001** contains a 1.0V precision voltage reference regulator, under-voltage lockout circuit (UVLO), short circuit protection circuit (SCP), applied to offer space and low cost in many applications such as the DC/DC converter and backlight inverter.

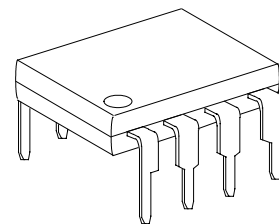
Using few external components, **FP5001**, a high performance integrated IC, is designed for a control circuit. The circuit diagram of the typical application example is as below.

### FEATURES

- Reference Voltage Precision: 2%
- Output sink current up to 100mA
- Low quiescent supply current
- Wide operating voltage range: 3.6~40V
- Variable dead-time control (DTC)
- UVLO protection function
- SCP protection function
- Oscillator Frequency: Max. 500KHz
- Package: PDIP8/ SOP8

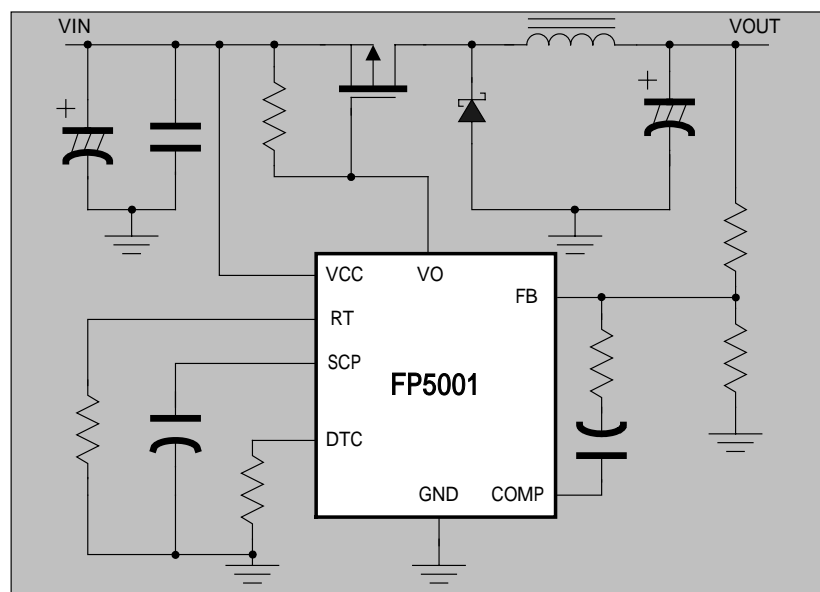


SOP8

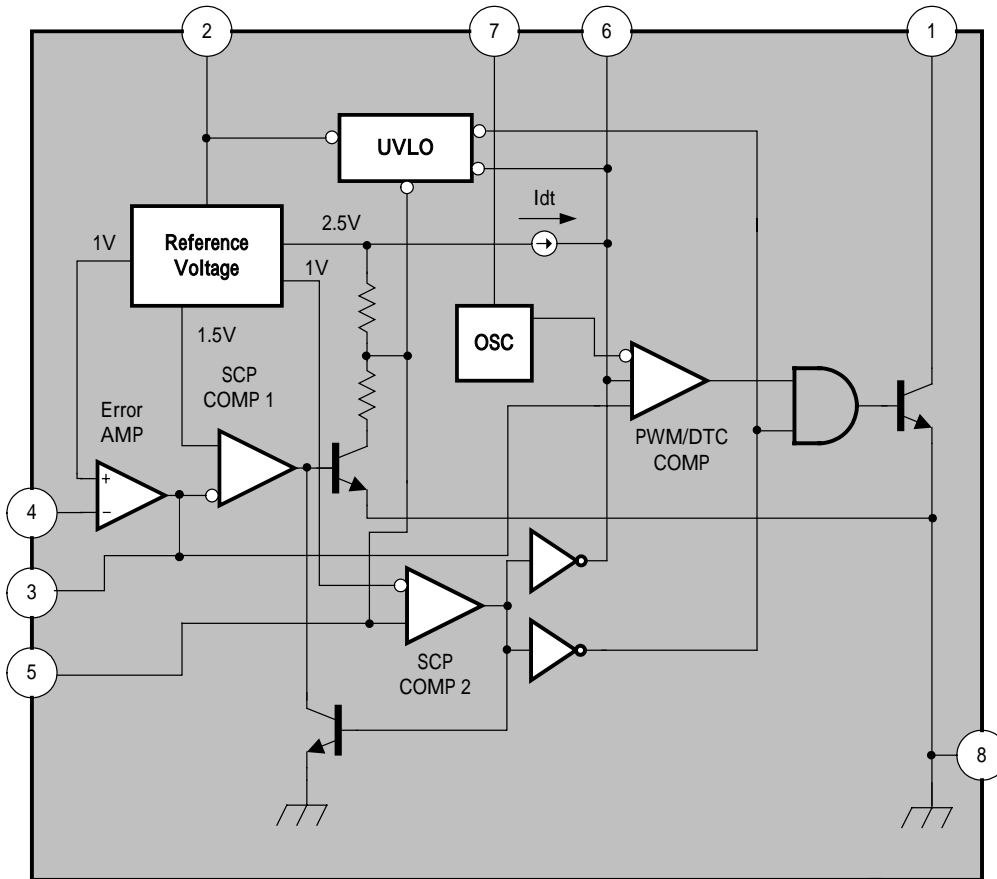


PDIP8

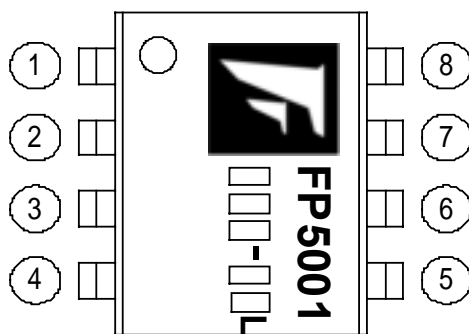
### TYPICAL APPLICATION CIRCUIT



### FUNCTIONAL BLOCK DIAGRAM



### MARK VIEW



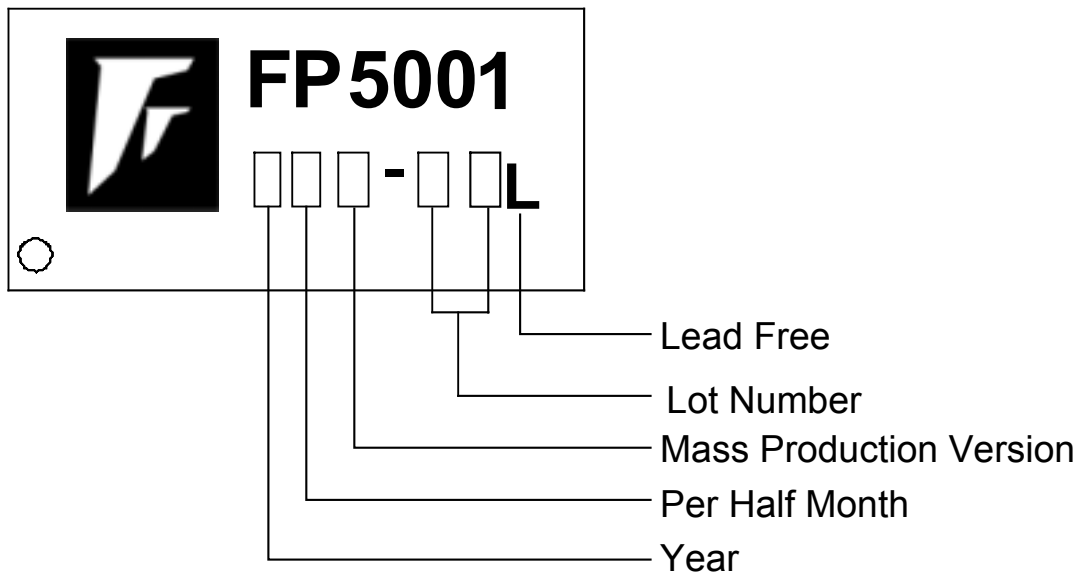
### PIN DESCRIPTION

NAME	NO.	STATUS	DESCRIPTION
OUT	1	O	Open Collector Transistor Output
VCC	2	P	IC Power Supply
COMP	3	O	Error Amplifier Feedback Output
FB	4	I	Error Amplifier Inverting Input
SCP	5	I	Short Circuit Protection Input
DTC	6	I	Dead-Time Control Input
RT	7	I	A resistance of Oscillator
GND	8	P	IC Ground

## ORDER INFORMATION

Part Number	Operating Temperature	Package	Description
FP5001D-LF	-20 85	SOP8	Tube
FP5001DR-LF	-20 85	SOP8	Tape & Reel
FP5001P-LF	-20°C 85°C	PDIP8	Tube

## IC DATE CODE DISTINGUISH



### FOR EXAMPLE:

January A (Front Half Month), B (Last Half Month)

February C, D

March E, F -----And so on.

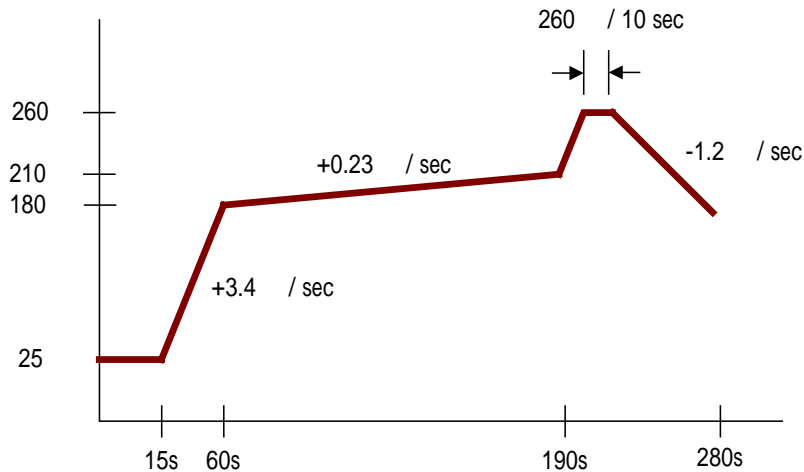
Lot Number is the last two numbers

### For Example:

A3311C62L  
 ↳ Lot Number

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage ( $V_{cc}$ )	-----	+40V
Differential Input Voltage ( $V_{id}$ )	-----	+20V
Collector Output Voltage ( $V_o$ )	-----	+40V
Collector Output Current ( $I_o$ )	-----	+150mA
Maximum Junction Temperature ( $T_j$ )	-----	+150
Thermal Resistance Junction to Ambient (SOP package)	-----	175 /W
(PDIP package)	-----	100 /W
Power Dissipation (SOP8 package)		
$T_a=25$	-----	650mW
$T_a=70$	-----	550mW
Operating Temperature Range	-----	-20    85
Storage Temperature Range	-----	-65    150
SOP8 Lead Temperature (soldering, 10 sec)	-----	+260
PDIP8 Lead Temperature (soldering, 20 sec)	-----	+260



## DC ELECTRICAL CHARACTERISTICS

Electrical characteristics over recommended operating temperature range ,  $V_{CC} = 6V$  ,  $f_{osc} = 70KHz$  ( unless otherwise noted )

### Reference

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Output voltage	$V_{REF}$	COMP connected to FB	0.98	1	1.02	V
Input regulation	$V_{REF}$	$V_{CC} = 3.6 V$ to 40 V		2	12.5	mV
Output voltage change with temperature	$V_{REF} / V_{REF}$	$T_A = -20$ to 25	-10	-1	15	mV/V
		$T_A = 25$ to 85	-10	-2	10	

†All typical values are at  $T_A = 25$  .

### Under voltage lockout

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Upper threshold voltage	$V_{upper}$	$T_A = 25$		3		V
Lower threshold voltage	$V_{low}$	$T_A = 25$		2.8		V
Hysteresis	$V_{hys}$	$T_A = 25$	100	200		mV
Reset threshold voltage	$V_{reset}$	$T_A = 25$	2.1	2.55		V

†All typical values are at  $T_A = 25$  .

### Short-circuit protection

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
SCP threshold voltage	$V_{TH}$	$T_A = 25$	0.95	1.00	1.05	V
SCP voltage , latched	$V_{LATCH}$	No pullup		2.4		V
SCP voltage , UVLO operation	$V_{OPR}$		140	185	230	mV
SCP voltage , UVLO standby	$V_{STANDBY}$	No pullup		60	120	mV
Input source current	$I_{SOURCE}$	$T_A = 25$	-10	-15	-20	$\mu A$
SCP comparator 1 threshold voltage	$V_{COMP(TH)}$			1.5		V

†All typical values are at  $T_A = 25$  .

### Oscillator

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Frequency	f	$R_t = 100K$		70		KHz
Standard deviation of frequency	f			15		KHz
Frequency change with voltage	f/ V	$V_{CC} = 3.6V$ to 40V		1		KHz
Frequency change with temperature	f/ T	$T_A = -20$ to 25	-4	-0.4	4	KHz
		$T_A = 25$ to 85	-4	-0.2	4	KHz
Voltage at RT	$V_{RT}$			1		V

†All typical values are at  $T_A = 25$  .

**DC ELECTRICAL CHARACTERISTICS (Cont.)**

Electrical characteristics over recommended operating temperature range ,  $V_{CC} = 6V$  ,  $f_{osc} = 70KHz$  ( unless otherwise noted ) ( continued )

**Dead-time control**

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Output ( source ) current	$I_{SOURCE}$	$V_{(DT)} = 1.5V$	$0.9 \times I_{RT}^{\ddagger}$		$1.2 \times I_{RT}$	$\mu A$
Input threshold voltage	$V_{TH}$	Duty cycle = 0%	0.5	0.7		V
		Duty cycle = 100%		1.3	1.5	

†All typical values are at  $T_A = 25$  .

‡Output source current at RT

**Error amplifier**

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input voltage	$V_{IN}$	$V_{CC} = 3.6V$ to 40V	0		1.5	V
Input bias current	$V_{BIAS}$			-160	-500	nA
Output voltage swing	Positive	$V_{POS}$	1.5	2.3		V
	Negative	$V_{NEG}$		0.3	0.4	V
Open-loop voltage amplification	$A_{VO}$			80		dB
Unity-gain bandwidth	$BW_U$			1.5		MHz
Output ( sink ) current	$I_{SINK}$	$V_{(FB)} = 1.2V$ , $COMP = 1V$	600	1100		$\mu A$
Output ( source ) current	$I_{SOURCE}$	$V_{(FB)} = 0.8V$ , $COMP = 1V$	-45	-70		$\mu A$

†All typical values are at  $T_A = 25$  .

**Output**

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Output saturation voltage	$V_{SAT}$	$I_O = 10mA$		0.8	1.2	V
Off-state current	$I_{OFF}$	$V_O = 40V$ , $V_{CC} = 0$			10	$\mu A$
		$V_O = 40V$			10	
Short-circuit output current	$I_{SC}$	$V_O = 6V$		40		mA

†All typical values are at  $T_A = 25$  .

**Total device**

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Standby supply current	Off state $I_{STANDBY}$			1	1.5	mA
Average supply current	$I_{AVE}$	$R_t = 100k$		1.2	1.5	mA

†All typical values are at  $T_A = 25$  .

## DETAILED DESCRIPTION

### Voltage reference

A 2.5-V regulator operating from VCC is used to power the internal circuitry of the **FP5001**.

A resistive divider provides 1-V reference for the error amplifier and SCP circuits.

### Error amplifier

The error amplifier compares a sample of the dc-to-dc converter output voltage to the 1V reference and generates an error signal for the PWM comparator. The dc-to-dc converter output voltage is set by selecting the error-amplifier gain (see Figure 1), using the following expression:

$$V_o = (1 + R1/R2) \times (1 \text{ V})$$

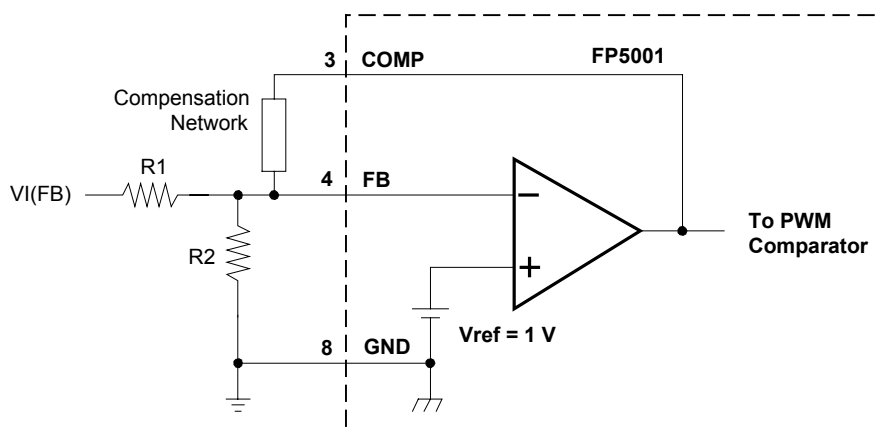


Figure 1. Error-Amplifier Gain Setting

The error-amplifier output is brought out as COMP for use in compensating the dc-to-dc converter control loop for stability. Because the amplifier can only source 45 uA, the total dc load resistance should be 100 k or more.

### Oscillator/PWM

The oscillator frequency ( $f_{osc}$ ) can be set between 20 kHz and 500 kHz by connecting a resistor between RT and GND. Acceptable resistor values range from 15 kΩ to 250 kΩ. The oscillator frequency can be determined by using the graph shown in Figure 5.

The oscillator output is a triangular wave with a minimum value of approximately 0.7 V and a maximum value of approximately 1.3 V. The PWM comparator compares the error-amplifier output voltage and the DTC input voltage to the triangular wave and turns the output transistor off whenever the triangular wave is greater than the lesser of the two inputs.

**Dead-time control (DTC)**

DTC provides a means of limiting the output-switch duty cycle to a value less than 100%, which is critical for boost and flyback converters. A current source generates a reference current ( $I_{DT}$ ) at DTC that is nominally equal to the current at the oscillator timing terminal, RT. Connecting a resistor between DTC and GND generates a dead-time reference voltage ( $V_{DT}$ ), which the PWM/DTC comparator compares to the oscillator triangle wave as described in the previous section. Nominally, the maximum duty cycle is 0% when  $V_{DT}$  is 0.7 V or less and 100% when  $V_{DT}$  is 1.3 V or greater. Because the triangle wave amplitude is a function of frequency and the source impedance of RT is relatively high (1250  $\Omega$ ), choosing  $R_{DT}$  for a specific maximum duty cycle, D, is accomplished using the following equation and the voltage limits for the frequency in question as found in Figure 11 ( $V_{osc,max}$  and  $V_{osc,min}$  are the maximum and minimum oscillator levels):

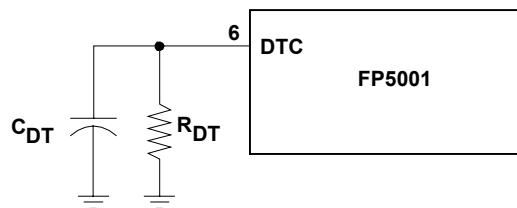
$$R_{DT} = (R_t + 1250) [ D (V_{osc,max} - V_{osc,min}) + V_{osc,min} ]$$

Where

$R_{DT}$  and  $R_t$  are in ohms, D in decimal

Soft start can be implemented by paralleling the DTC resistor with a capacitor ( $C_{DT}$ ) as shown in Figure 2. During soft start, the voltage at DTC is derived by the following equation:

$$V_{DT} \approx I_{DT} R_{DT} \left( 1 - e^{-t/R_{DT} C_{DT}} \right)$$



**Figure 2. Soft-Start Circuit**

If the dc-to-dc converter must be in regulation within a specified period of time, the time constant,  $R_{DT}C_{DT}$ , should be  $t_0/3$  to  $t_0/5$ . The FP5001 remains off until  $V_{DT} \approx 0.7$  V, the minimum ramp value.  $C_{DT}$  is discharged every time UVLO or SCP becomes active.

**Undervoltage-lockout (UVLO) protection**

The undervoltage-lockout circuit turns the output transistor off and resets the SCP latch whenever the supply voltage drops too low (approximately 3 V at 25°C) for proper operation. A hysteresis voltage of 200 mV eliminates false triggering on noise and chattering.



### Short-circuit protection (SCP)

The **FP5001** includes short-circuit protection (see Figure 3), which turns the power switch off to prevent damage when the converter output is shorted. When activated, the SCP prevents the switch from being turned on until the internal latching circuit is reset. The circuit is reset by reducing the input voltage until UVLO becomes active or until the SCP terminal is pulled to ground externally.

When a short circuit occurs, the error-amplifier output at COMP rises to increase the power-switch duty cycle in an attempt to maintain the output voltage. SCP comparator 1 starts an RC timing circuit when COMP exceeds 1.5V. If the short is removed and the error-amplifier output drops below 1.5V before time out, normal converter operation continues. If the fault is still present at the end of the time-out period, the timer sets the latching circuit and turns off the **FP5001** output transistor.

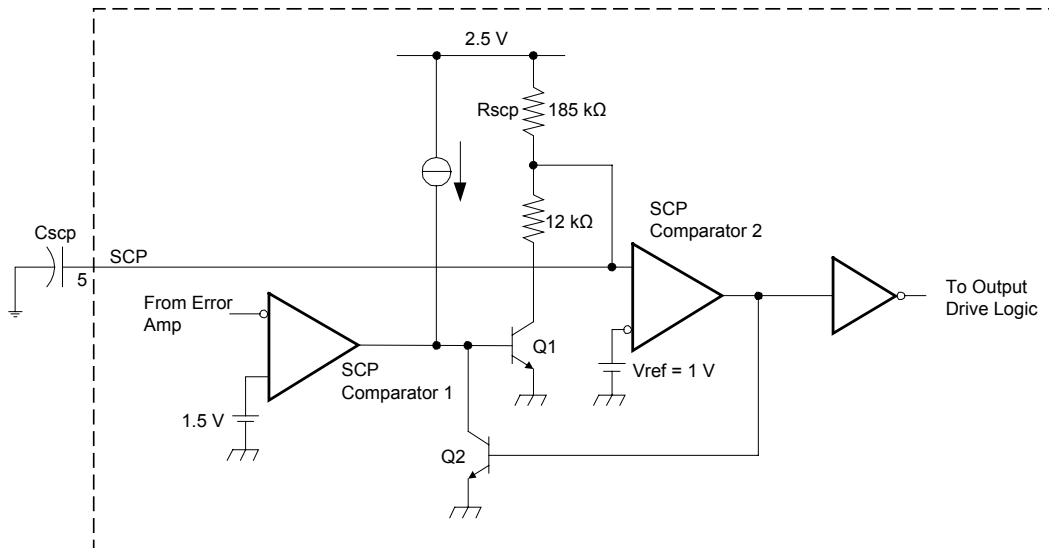


Figure 3. SCP Circuit

The timer operates by charging an external capacitor ( $C_{SCP}$ ), connected between the SCP terminal and ground, towards 2.5V through a 185-kΩ resistor ( $R_{SCP}$ ). The circuit begins charging from an initial voltage of approximately 185 mV and times out when the capacitor voltage reaches 1V. The output of SCP comparator 2 then goes high, turns on Q2, and latches the timer circuit. The expression for setting the SCP time period is derived from the following equation:

$$V_{SCP} = (2.5 - 0.185)(1 - e^{-t/\tau}) + 0.185$$

Where

$$\tau = R_{SCP}C_{SCP}$$

The end of the time-out period,  $t_{SCP}$ , occurs when  $V_{SCP} = 1$  V. Solving for  $C_{SCP}$  yields:

$$C_{SCP} = 12.46 \times t_{SCP} \quad \text{Where } t \text{ is in seconds, } C \text{ in } \mu\text{F.}$$

$t_{SCP}$  must be much longer (generally 10 to 15 times) than the converter start-up period or the converter will not start.

### Output transistor

The output of the **FP5001** is an open-collector transistor with a maximum collector current rating of 100mA and a voltage rating of 40V. The output is turned on under the following conditions: the oscillator triangle wave is lower than both the DTC voltage and the error-amplifier output voltage, the UVLO circuit is inactive, and the short-circuit protection circuit is inactive.

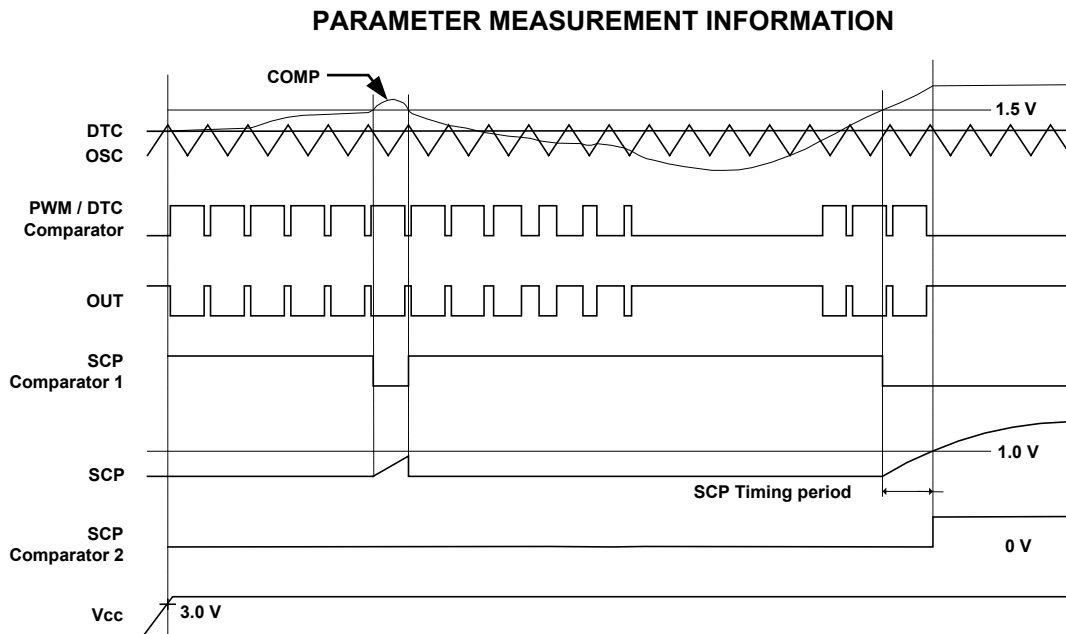
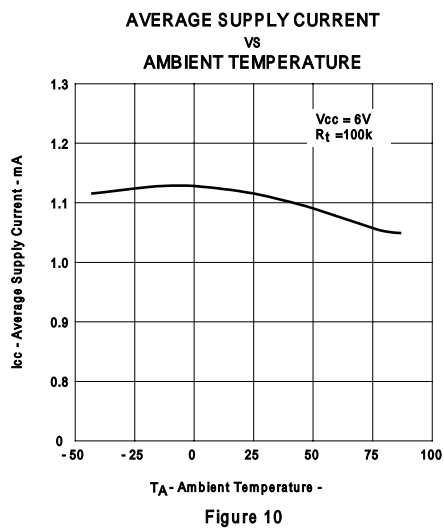
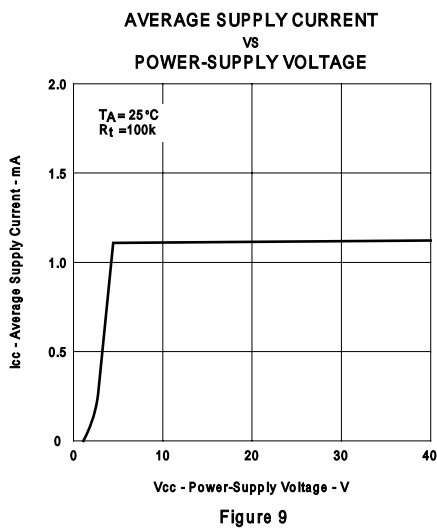
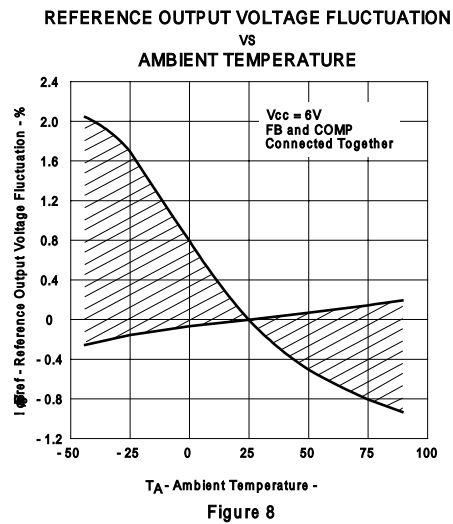
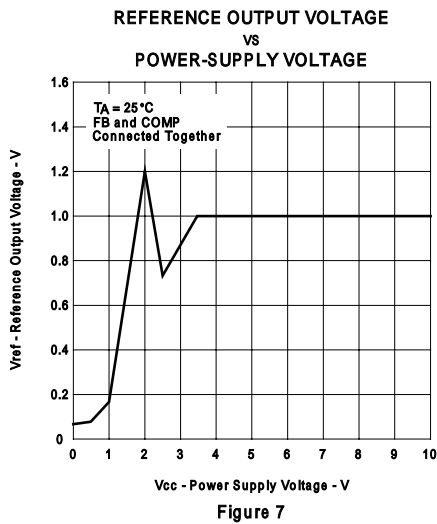
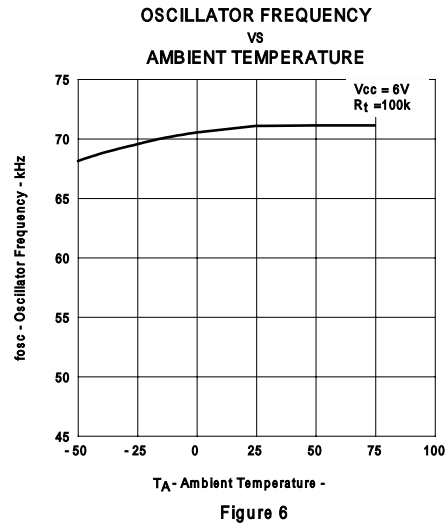
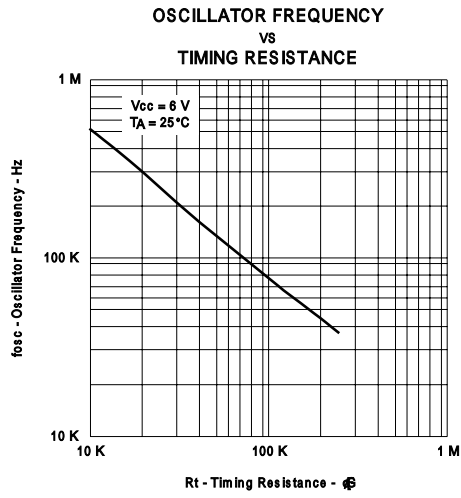


Figure 4. PWM Timing Diagram

## TYPICAL CHARACTERISTICS



## TYPICAL CHARACTERISTICS (Cont.)

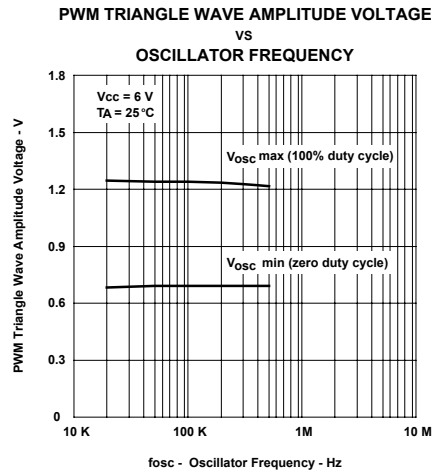


Figure 11

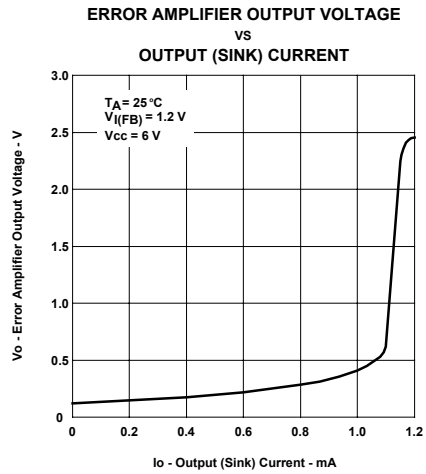


Figure 12

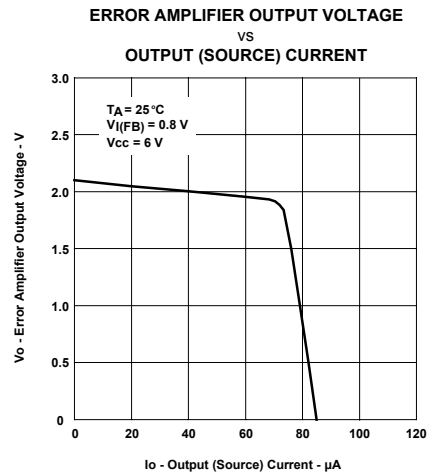


Figure 13

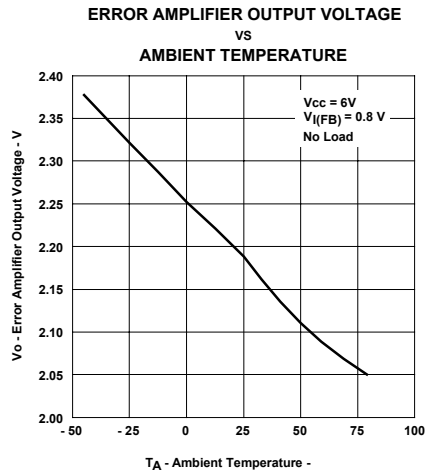


Figure 14

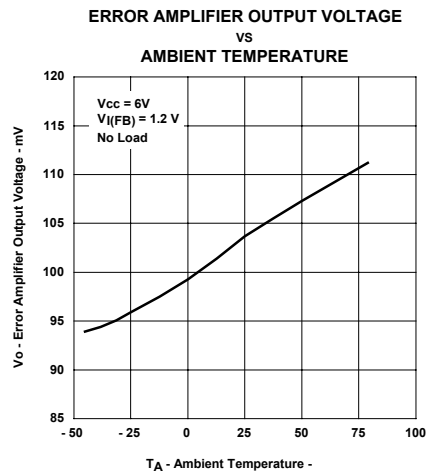


Figure 15

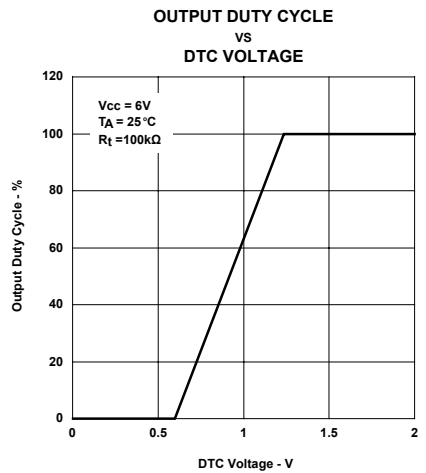


Figure 16

## TYPICAL CHARACTERISTICS (Cont.)

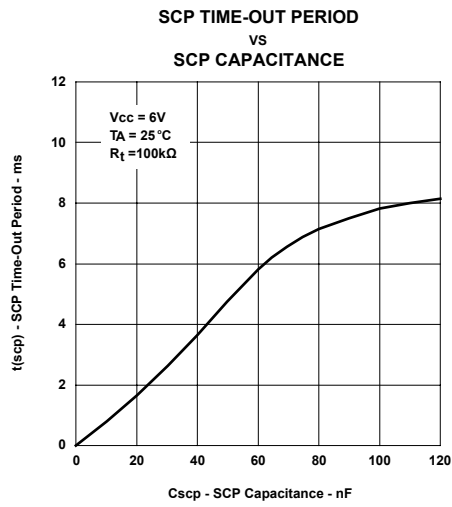


Figure 17

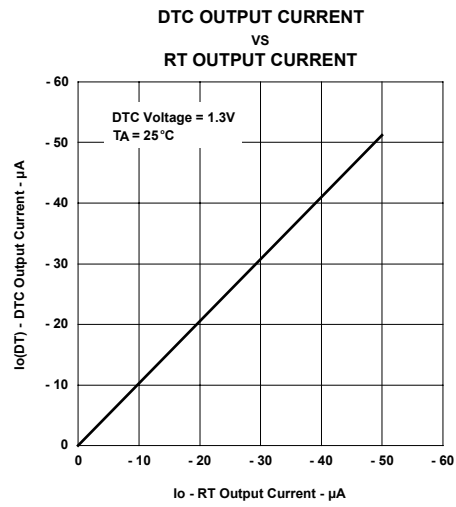


Figure 18

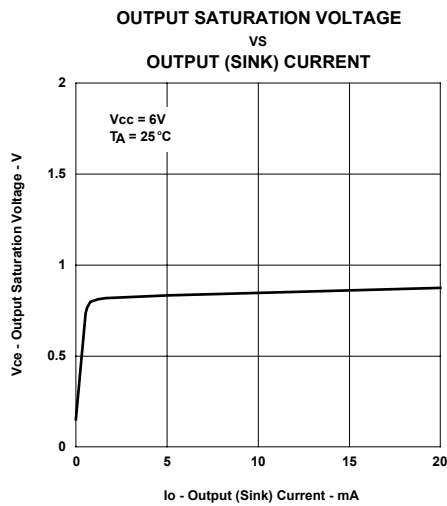
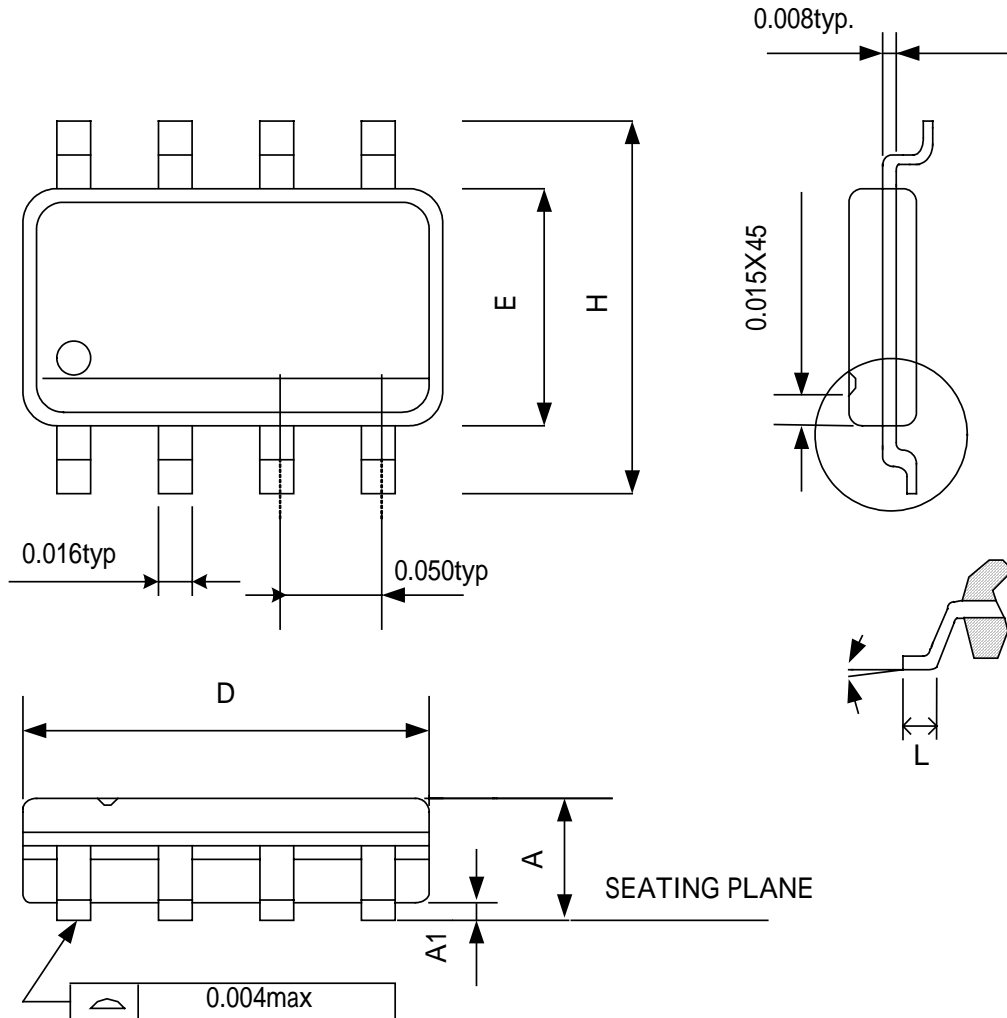


Figure 19

## PACKAGE OUTLINE

### SOP 8

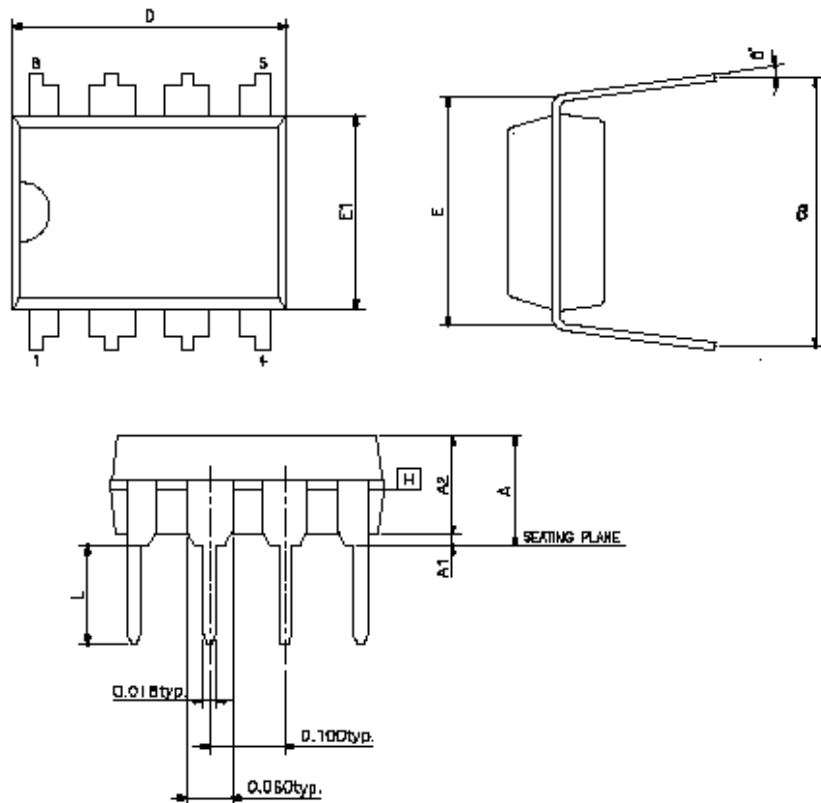


SYMBOLS	MIN	MAX
A	0.053	0.069
A1	0.004	0.010
D	0.189	0.196
E	0.150	0.157
H	0.228	0.244
L	0.016	0.050
°	0	8

#### NOTE:

1. JEDEC OUTLINE:MS-012 AA
2. DIMENSIONS "D" DOES NOT INCLUDE MOLD FLASH,PROTRUSIONS OR GATE BURRS.MOLD FLASH,PROTRUSIONS AND GATE BURRS SHALL NOT EXCEED .15mm (.06in) PER SIDE
3. DIMENSIONS "E" DOES NOT INCLUDE INTER-LEAD FLASH,OR PROTRUSIONS. INTER-LEAD FLASH AND PROTRUSIONS SHALL NOT EXCEED .25mm (.0.10in) PER SIDE.

PDIP 8



SYMBOLS	MIN	NOR	MAX
A	-	-	0.210
A1	0.015	-	-
A2	0.125	0.130	0.135
D	0.355	0.365	0.400
E	0.300BSC		
E1	0.245	0.250	0.255
L	0.115	0.130	0.150
e	0.335	0.355	0.375
°	0	7	15

Note:

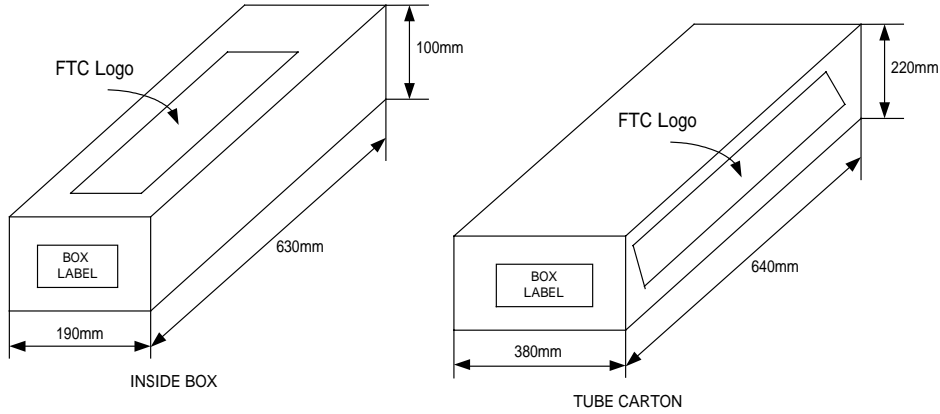
0. JEDEC OUTLINE:MS-001 BA

1. "D" "E1" DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCH
2. eB IS MEASURED AT THE LEAD TIPS WITH THE LEADS UNCONSTRAINED
3. POINTED OR ROUNDED LEAD TIPS ARE PREFERRED TO EASE INSERTION
4. DISTANCE BETWEEN LEADS INCLUDING DAM BAR PROTRUSIONS TO BE .005 INCH MINIMUM
5. DATUM PLANE H COINCIDENT WITH THE BOTTOM OF LEAD, WHERE LEAD EXITS BODY.

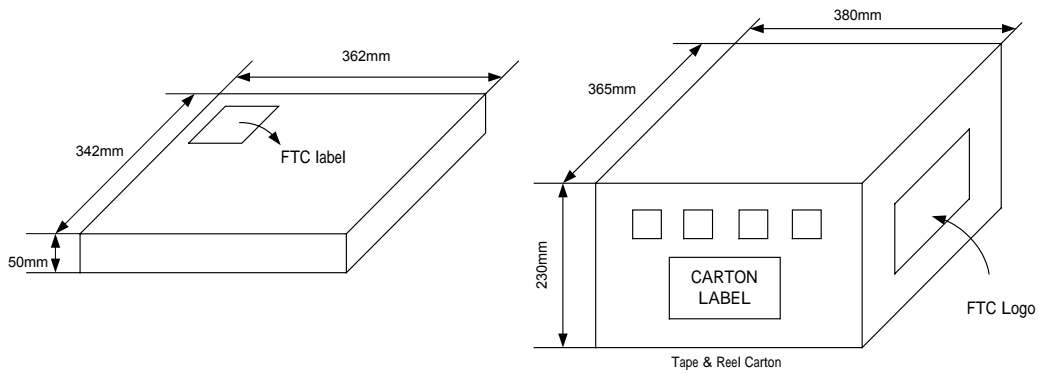
**PACKING SPECIFICATIONS**

**BOX DIMENSION**

**TUBE INSIDE BOX AND CARTON**



**TAPE & REEL INSIDE BOX AND CARTON**



**PACKING QUANTITY SPECIFICATIONS**

100 EA / TUBE	2500 EA / REEL
100 TUBES / INSIDE BOX	4 INSIDE BOXES / CARTON
4 INSIDE BOXES / CARTON	

**LABEL SPECIFICATIONS**

**TAPPING & REEL**

Feeling Technology Corp. Product FP5001DR-LF Lot No A3311C62 D/C 4Xx-XXL Q'ty	<div style="border: 1px solid black; padding: 2px; display: inline-block;">                     無鉛                      Lead Free                 </div>
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CARTON

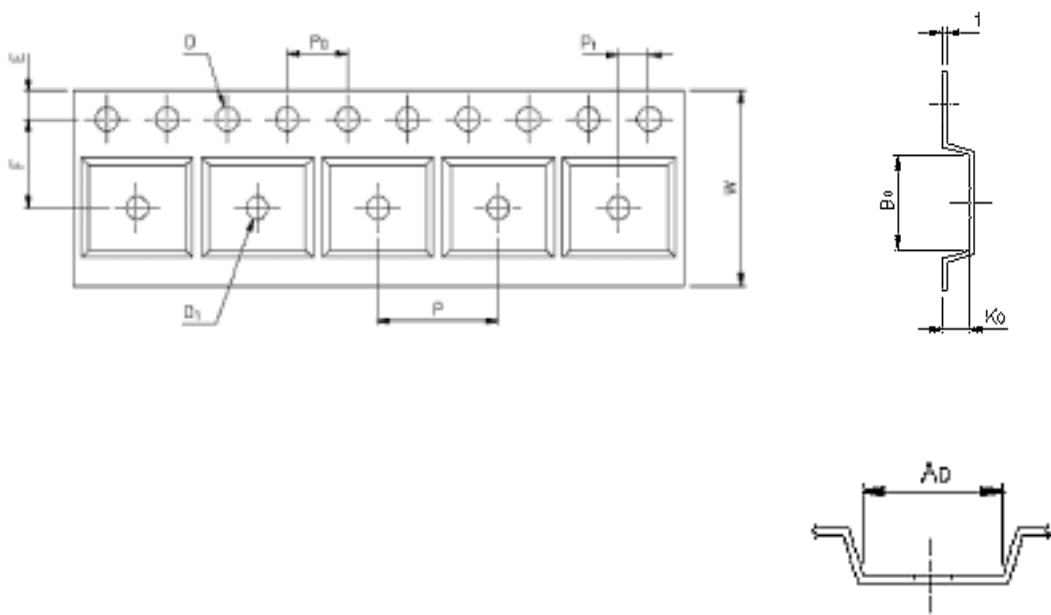
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 Lot No: A3311C62  
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 Package Type: SOP-8L  
 Marking Type: Laser  
 Total Q'ty: 10,000

無鉛  
Lead Free

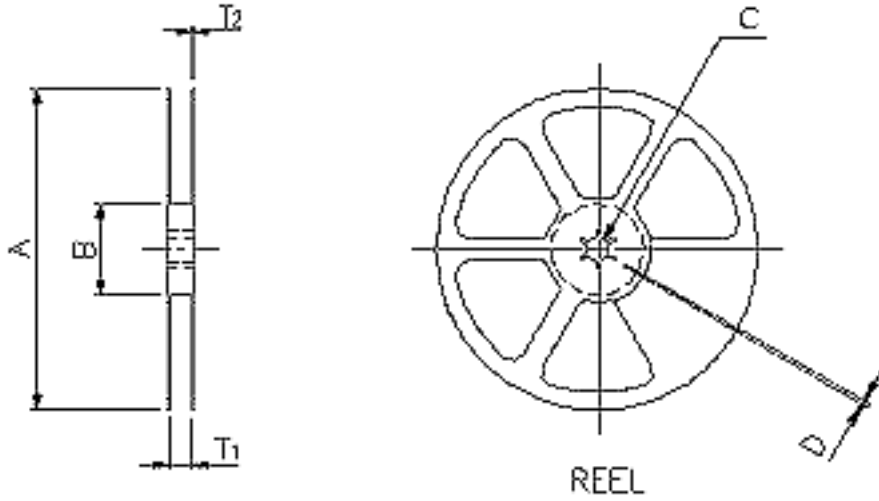
### CARRIER TAPE DIMENSIONS

APPLICATION	W	P	E	F	D	D <sub>1</sub>
SOP8	12.0 <sup>+0.3</sup> / <sub>-0.1</sub>	8.0±0.1	1.75±0.1	5.5±0.1	1.55±0.1	1.5 <sup>+0.25</sup>

APPLICATION	P <sub>0</sub>	P <sub>1</sub>	A <sub>0</sub>	B <sub>0</sub>	K <sub>0</sub>	t
SOP8	4.0±0.1	2.0±0.1	6.4±0.1	5.20±0.1	2.1±0.10	0.30±0.013



### REEL DIMENSIONS



APPLICATION	MATERIAL	A	B	C	D	T <sub>1</sub>	T <sub>2</sub>
SOP8	PLASTIC REEL (WHILE)	330±0.1	62±1.5	12.75+0.15	2+0.6	12.4+0.2	2.0+0.2