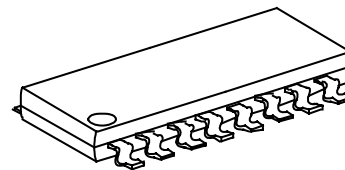
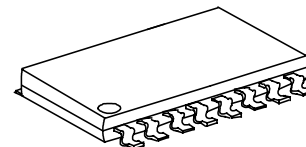


**PHASE SHIFT DUAL PWM IC
WITH SCP/OVP FUNCTION****GENERAL DESCRIPTION**

The **FP5352**, an 1-chip composed of dual channel phase shift 180° totem-pole output stage pulse-width-modulation control circuits with two independent error amplifiers for step-down converter application, the inverting input of amplifier connects to a 1.0V precision reference regulator, power down under-voltage lockout circuit (UVLO), short circuit and over voltage shutdown and auto-restart protection circuit (SCP/OVP) and dead-time control circuit (DTC), applied to offer the space and low cost in many applications of PC peripherals .

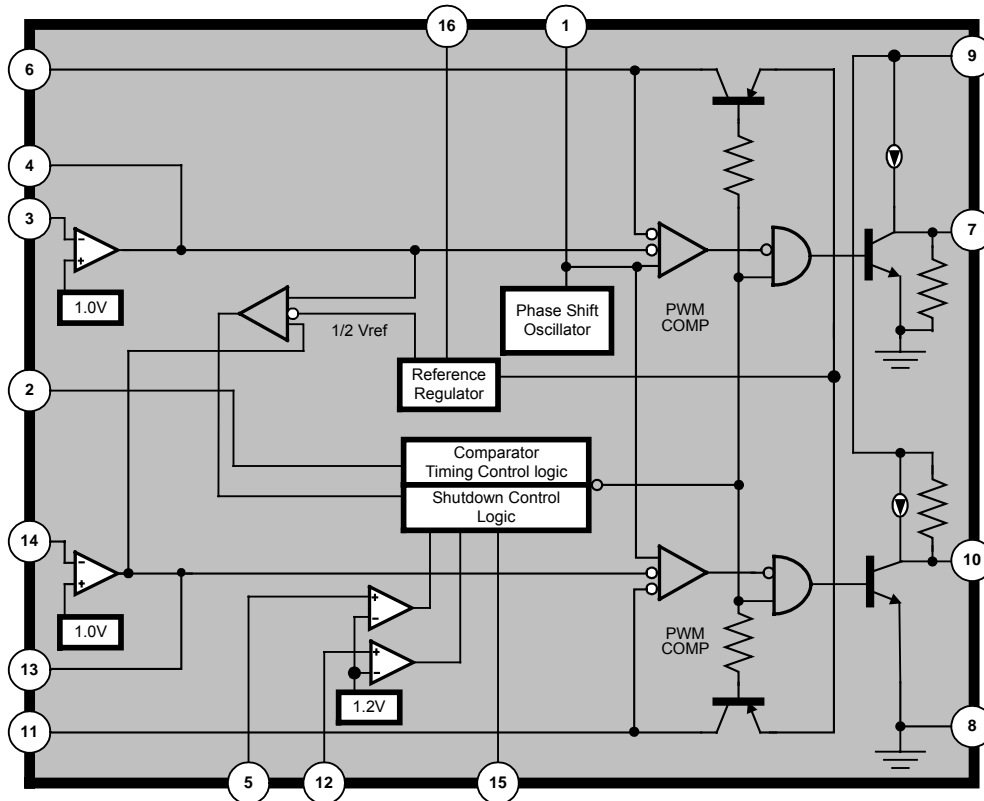
FEATURES

- Internal EA Bias Reference Voltage: 1.0V
- Reference Voltage Precision: 2%
- Totem-pole Output for MOS Driving
- Dual PWM Output Phase Shift 180°
- Wide operating voltage range: 3.6~25V
- Variable Dead-time Control (DTC)
- Power Down Under-voltage Lock-out (UVLO)
- SC/OV Protection (SCP/OVP)
- Protection Shutdown and Auto-restart
- Shutdown Mode (ON/OFF)
- Programming Oscillation Frequency
- Package: SOP16/SSOP16

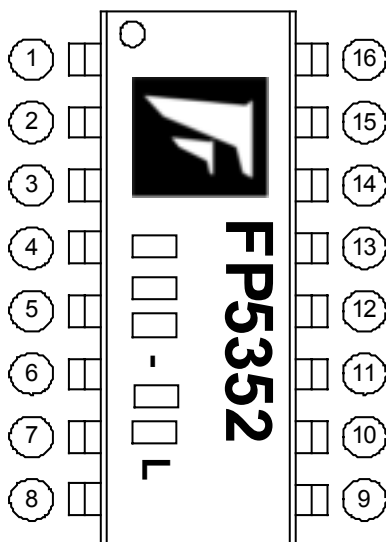
**SOP16****SSOP 16****TYPICAL APPLICATION**

- PC Peripherals
- Networking products
- Royer CCFL Inverter
- Portable products

FUNCTIONAL BLOCK DIAGRAM



MARK VIEW



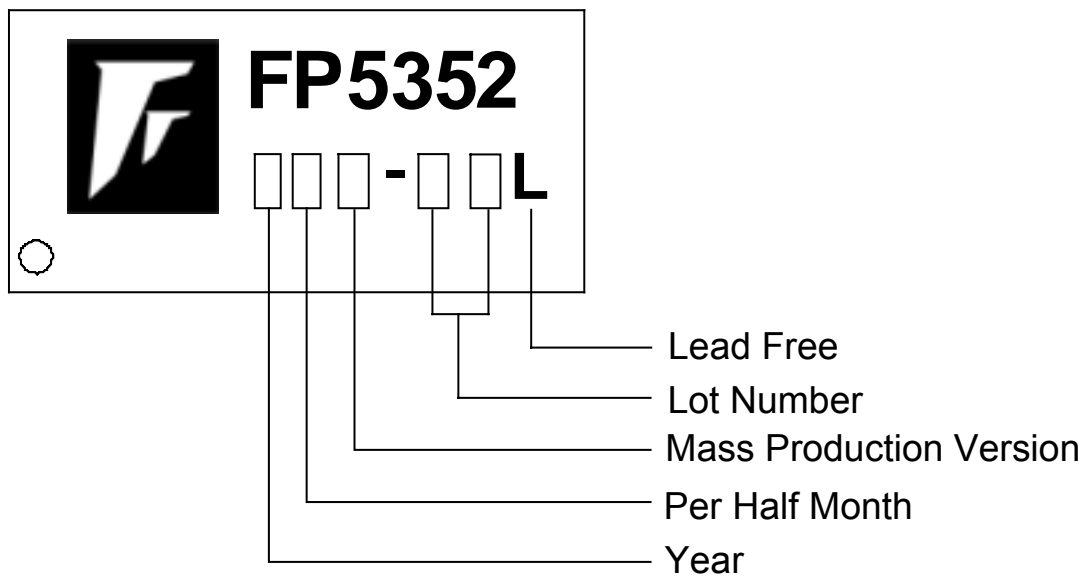
PIN DESCRIPTION

NAME	NO.	STATUS	DESCRIPTION
RT	1	I	Connect a Resistor for Oscillator
CP	2	I	Shutdown re-start control timer
FB1	3	I	Error Amplifier 1 Non-inverting Input
COMP1	4	O	Error Amplifier 1 Feedback Output
OVP1	5	I	CH1 Over-voltage Detection Input
DTC1	6	I	CH1 Dead-Time Control Input
OUT1	7	O	CH1 Totem-pole Output
GND	8	P	IC Ground/Power Ground
PVCC	9	P	IC Totem-pole Power Supply
OUT2	10	O	CH2 Totem-pole Output
DTC2	11	I	CH2 Dead-Time Control Input
OVP2	12	I	CH2 Over-voltage Detection Input
COMP2	13	O	Error Amplifier 2 Feedback Output
FB2	14	I	Error Amplifier 2 Non-inverting Input
ENB	15	I	ON/OFF Control Input
VCC	16	P	IC Power Supply

ORDER INFORMATION

Part Number	Operating Temperature	Package	Description
FP5352D-LF	-20°C ~ +85°C	SOP16	Tube
FP5352DR-LF	-20°C ~ +85°C	SOP16	Tape & Reel
FP5352R-LF	-20°C ~ +85°C	SSOP16	Tube
FP5352RR-LF	-20°C ~ +85°C	SSOP16	Tape & Reel

IC DATE CODE DISTINGUISH



FOR EXAMPLE:

January A (Front Half Month), B (Last Half Month)
 February C, D
 March E, F -----And so on

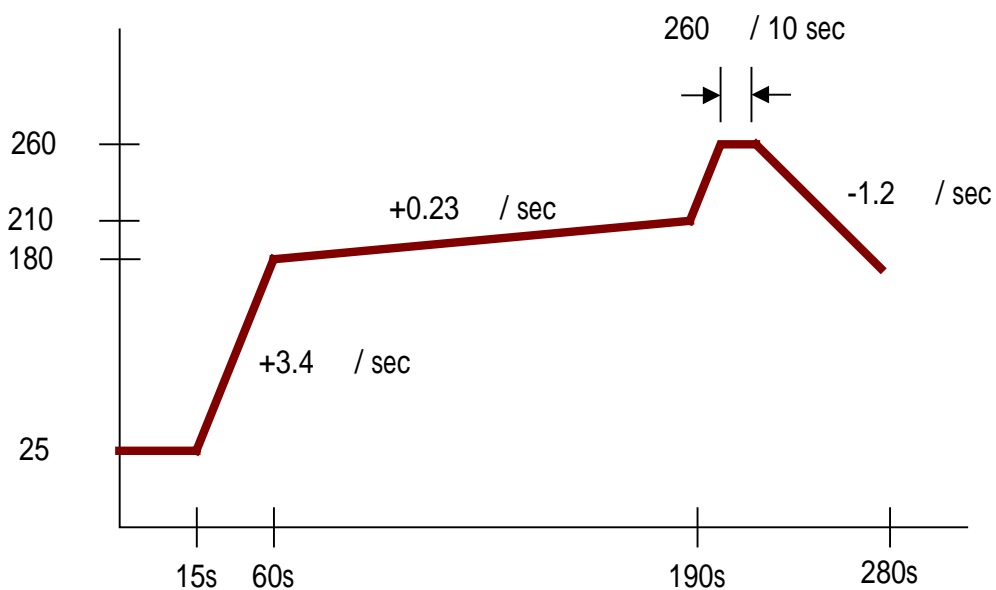
Lot Number is the last two numbers

For Example:

A3311C62
 ↳ Lot Number

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (Vcc) -----	+20V
Output Current (Io) -----	+150mA
Maximum Junction Temperature (T _j) -----	+150°C
Thermal Resistance Junction to Ambient	
SOP16 package -----	150°C /W
SSOP16 package -----	220°C /W
Power Dissipation	
SOP16 package	
Ta=25 -----	830mW
Ta=70 -----	530mW
SSOP16 package	
Ta=25 -----	570mW
Ta=70 -----	360mW
Operating Temperature Range -----	-20°C 85°C
Storage Temperature Range -----	-65°C 150°C
Lead Temperature (soldering, 10 sec) -----	+260°C



IR Reflow Curve

DC ELECTRICAL CHARACTERISTICS

Electrical characteristics over recommended operating free-air temperature range, $V_{CC}=6V$, $f=200kHz$ (unless otherwise noted)

Reference section

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Output voltage	V_{REF}	COMP connected to FB	0.98	1.0	1.2	V
Input voltage regulation	V_{REF}/V_{REF}	$V_{CC}=3.6V$ 20V		2	12.5	mV
Output voltage change with Temperature		$T_A=-20$ to 25		-0.1	± 1	%
		$T_A=25$ to 85		-0.2	± 1	

Under voltage lockout section

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Upper threshold voltage(V_{CC})	V_{UPPER}	$T_A=25$		3.2		V
Lower threshold voltage(V_{CC})	V_{LOW}			3.0		V
Hysteresis (V_{CC})	V_{HYS}		100	200		mV

Short-circuit protection control section

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
SCP standby voltage	V_{SB}	$V_{comp} < 1.5V$		0.5		V
SCP threshold voltage	V_{TH}	$V_{comp} > 1.5V$		1.0		V
SCP re-start charge current	I_{RSC}	$V_{comp} > 1.5V$		25		μA
SCP re-start / hold time	T_{RS}/T_{HOLD}	$V_{comp} > 1.5V$		1/35		-
SCP comparator 1 threshold voltage	$V_{COMP(TH)}$			1.5		V

Note1:Function Diagram figure 25

Oscillator section

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Frequency	f	$R_T=100K$		150		KHz
Frequency change with voltage	f/ V	$V_{CC}=3.6V$ to 20V		0.2		%
Frequency change with Temperature	f/ T	$T_A=-20$ to 25		-0.4	± 2	%
Voltage at RT	V_{RT}			1		V

DC ELECTRICAL CHARACTERISTICS (Cont.)

Dead-time control section

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input bias current (DTC)	I_{BIAS}				1	μA
Input threshold voltage	V_{TH}	Zero duty cycle		2.0	2.20	V
		Maximum duty cycle	1.2	1.35		

Error –amplifier section

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input voltage	V_{IN}	$V_{CC} = 3.6V$ to $20V$	0		1.5	V
Input bias current	I_{BIAS}			160	500	nA
Open-loop voltage amplification	A_{VO}		70	80		dB
Unity-gain bandwidth	BW			1.5		MHz
Positive output voltage swing	V_{POS}		$V_{ref}-0.3$			V
Negative output voltage swing	V_{NEG}				1	V
Output (sink) current	I_{SINK}	$V_{ID}=-0.1V, V_O=1.25V$	2	3		mA
Output (source) current	I_{SOURCE}	$V_{ID}=0.1V, V_O=1.25V$	-100	-140		μA

Output section

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Vout Low Voltage	V_{OL}	$I_{SINK}=20mA$		0.15	0.2	V
		$I_{SINK} = 130mA, V_{CC}=15V$		1.7	2.0	
Vout High Voltage	V_{OH}	$I_{SOURCE}=20mA$	4.0	4.5		V
		$I_{SOURCE}=130mA, V_{CC}=15V$	12.8	13.4		
Output Pull High Resistance						K
Rise Time	t_R	$T_J=25, C_L=1nF$		50	100	nS
Fall Time	t_F	$T_J=25, C_L=1nF$		50	100	nS

PWM comparator section

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input threshold voltage	V_{TH}	Zero duty cycle		2.0	2.20	V
		Maximum duty cycle	1.2	1.35		

Over Voltage Protect section

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT

Total device

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Standby supply current	$I_{STANDBY}$	Off-state				mA
Average supply current	I_{AVE}	$R_T=100K$				mA

DETAILED DESCRIPTION

Voltage reference

A 2.5V reference regulator supplies **FP5352** internal circuits and uses the resistive dividers to provide a 1.0V precision reference voltage on the non-inverting terminal of error amplifier and SCP comparator 1.0V threshold voltage.

Error amplifier

The error amplifier compares the feedback voltage from dc-dc converter output to the 1.0V reference and generates the error signal for the PWM comparator. The relation between $V_I(FB)$ and **FP5352** error amplifier pins are shown below (see Figure 19).

The converter output voltage explains such as below expression:

$$V_I(FB) = \left(1 + \frac{R1}{R2}\right) * V_{REF}$$

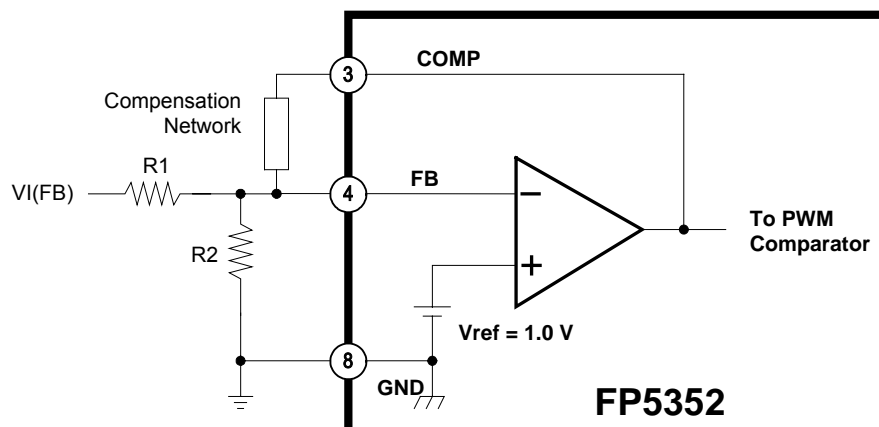


Figure 19. Error Amplifier with Converter Feedback Resistors

Note:

It is necessary to check the converter total open loop gain and phase shift from Bode plot before compensation network adjustment. Finally, let the system works stability.

Oscillator/PWM Comparator

The oscillator frequency (f_{osc}) can be decided from 20KHz to 1.5MHz by the resistor connected to R_T pin. The oscillator frequency can be determined by the follow formula or graph shown in Figure 5.

$$f = \frac{30000}{R_T} \text{ (KHz)}, \text{ and } R_T \text{ value cannot be used below } 20K\Omega$$

The internal oscillator output is a triangular waveform and its minimum voltage level is approximately 0.7 V and maximum level approximately 1.3V (see Fig 20). The PWM comparator compares the triangular waveform with the signals from output voltage of error-amplifier and the DTC voltage, then PWM comparator output controls the output stage of totem-pole transistors pair off or on whenever the triangular wave is greater than the both input signals or less.

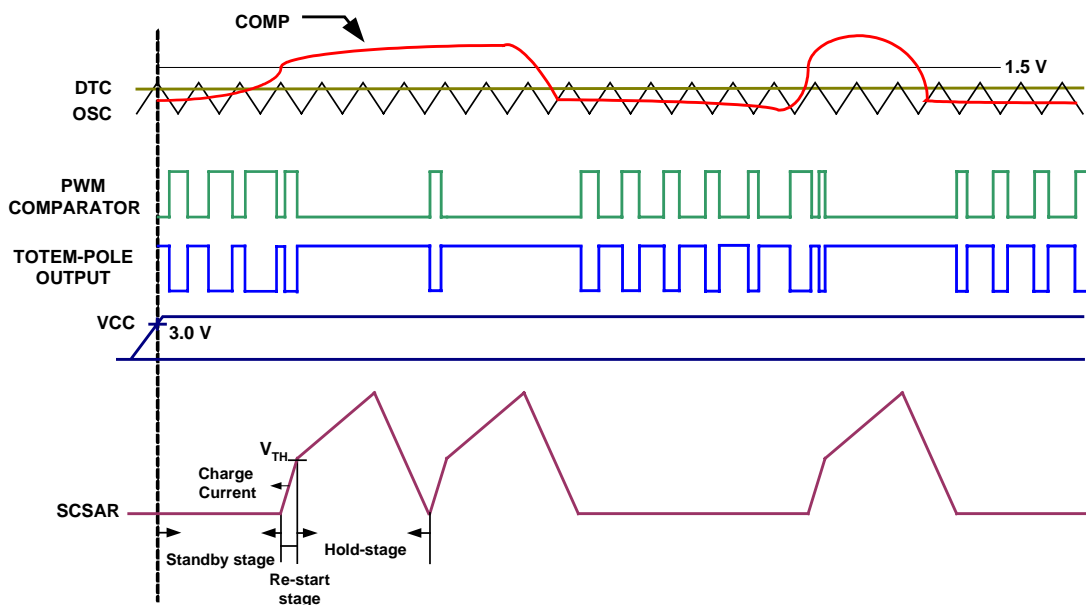


Figure 20. PWM Timing Diagram

Dead-time control (DTC)

DTC main function is a limitation of PWM duty cycle less than 100%. The source current of R_T is same as dead-time current I_{DT} at DTC pin. There is a resistor R_{DT} connecting between DTC and GND and generating a bias voltage V_{DT} that compares with the output waveform of oscillator in the PWM comparator. The PWM duty cycle begins 0% when V_{DT} sets at 0.7 V or less, and then V_{DT} sets at 1.3 V or greater and PWM duty cycle reaches 100%. Engineer can choose a resistor R_{DT} for a specific limitation of PWM duty cycle D.

According to the following formula, we can choose a RDT for a maximum duty cycle.

$$R_{DT} = (R_T + 1250) * (0.6 * D + 0.7)$$

For example:

R_T is 33K for oscillator frequency, and we assume the maximum duty cycle is 75%.

$$R_{DT} = (33K + 1250) * (0.6 * 0.75 + 0.7) = 39.38K$$

When using a resistor R_{DT} is 39.38K, the limitation of PWM duty cycle is 75%.

A capacitor (C_{DT}), connecting with the resistor R_{DT} as shown in Figure 21, is a soft-start function when power on. The soft-start time formula is shown as below:

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

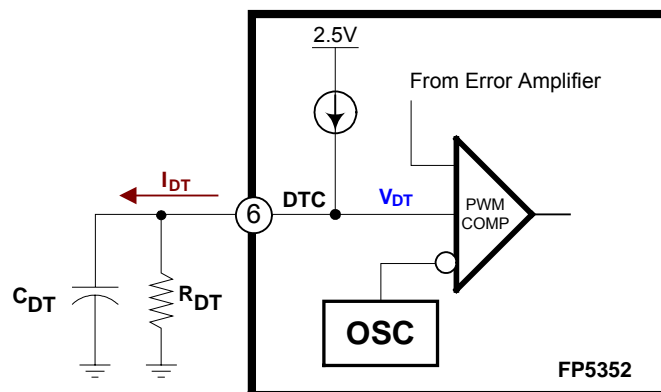


Figure 21. Soft-Start Circuit

Note:

C_{DT} is discharged by internal circuit every time when UVLO or SCP becomes active.

Under voltage lock-out (UVLO) protection

When the power supply turns off, the output of **FP5352** also turns off and resets the SCP latch whenever the supply voltage drops under the UVLO off threshold voltage. It is a simple protection function when the supply voltage can not maintain at a stable operating condition. The UVLO hysteresis voltage avoids an internal false trigger whenever power noise or spike.

Short-circuit shutdown and auto re-start protection (SCSAR)

FP5352 includes short-circuit shutdown and auto re-start protection function (see Figure 22), which turns the Power MOS off to prevent damage when the converter output is over loading or short circuit.

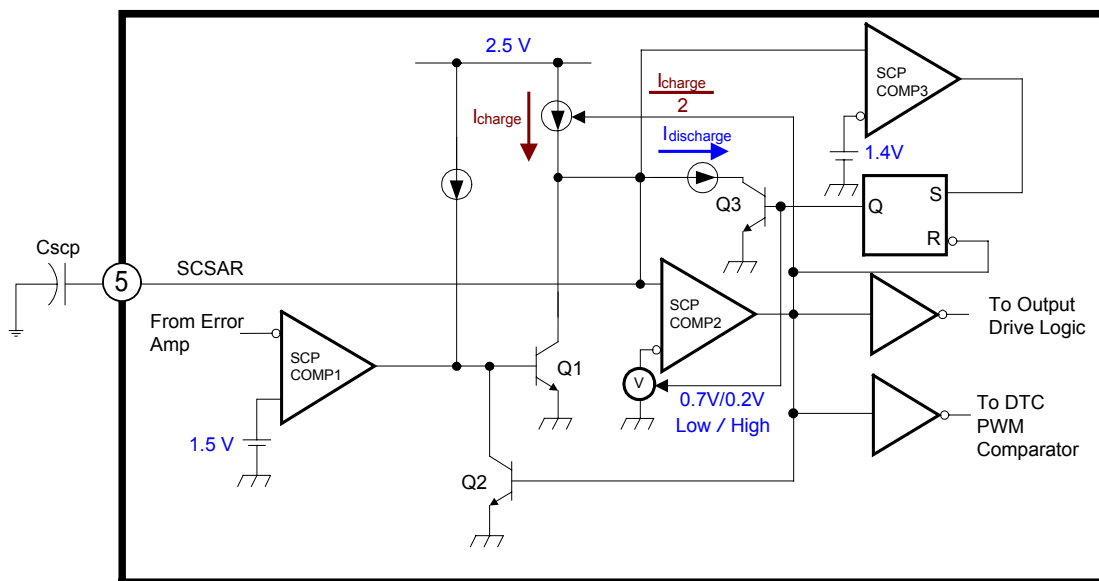


Figure 22. SCSAR Protection Circuit

Generally, error amplifier output voltage is lower than 1.5V, and SCP comparator 1 output keeps a high state and Q1 is turn-on, C_{SCP} cannot be charged. When short circuit occurs, the COMP pin of error-amplifier would rise more than 1.5V, SCP comparator 1 output changes to low state and C_{SCP} is charged by I_{CHARGE} current. The SC function of **FP5352** is release because short circuit is removed before Q2 active and SCP comparator 2 is latch. When C_{SCP} is charged until a 0.7V threshold voltage and SCP comparator 2 output changes to high state and Q2 is turn-on to keep Q1 off in latch mode. Meanwhile, the source current of C_{SCP} would change half of original current for the first shutdown phase, **FP5352** output is turn-off and DTC pin is pull-low. When C_{SCP} voltage is greater than 1.4V of SCP comparator 3, the output of S-R Latch would turn on Q3 and change SCP comparator 2 from 0.7V to 0.2V, when SCP comparator 3 is active, C_{SCP} is discharged until SCP comparator 2 is release the latch state,

output of **FP5352** is active and DTC pin is working in soft-start state or limitation of duty cycle.

C_{SCP} discharging time from 1.4V to 0.2V is the second shutdown phase which finishes and **FP5352** would be release shutdown state and re-start the normal operation. Figure 23 is a relation description about SCSAR pin and the other pins of **FP5352**.

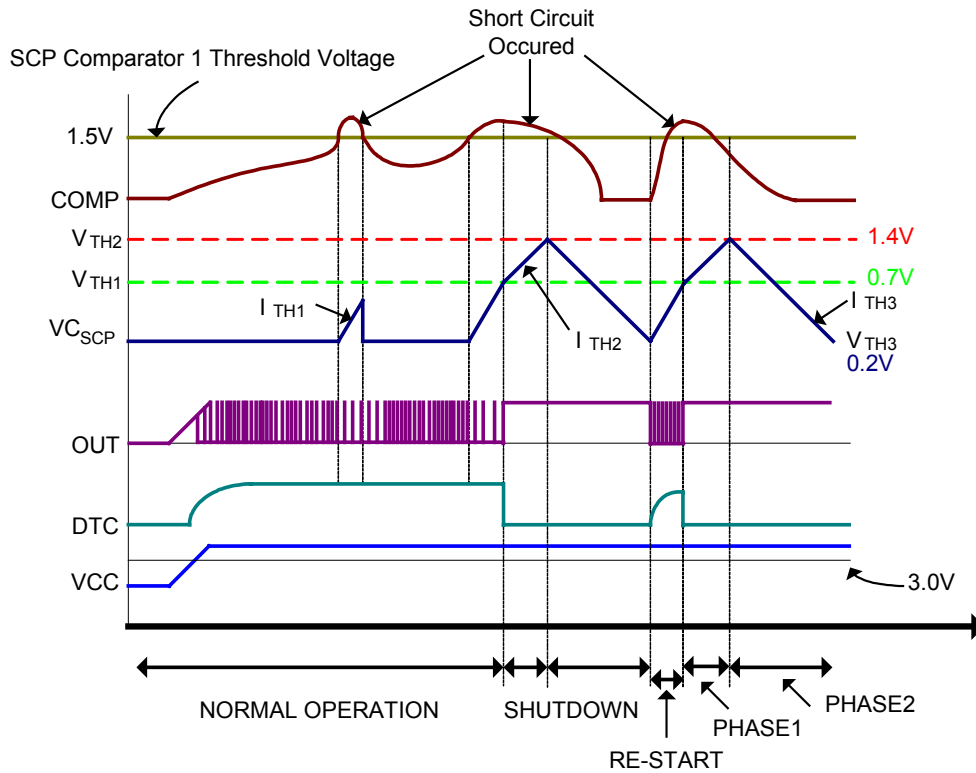


Figure 23. Shutdown and Re-start waveform

The formulas are shown below for shutdown and re-start time calculation:

AUTO RE-START time equation:

$$t_{RE-START} = \frac{V_{TH1} * C_{SCP}}{I_{TH1}}$$

SHUTDOWN time equation:

$$t_{SHUTDOWN} = t_{PHASE1} + t_{PHASE2} = \frac{(V_{TH2} - V_{TH1}) * C_{SCP}}{I_{TH2}} + \frac{(V_{TH2} - V_{TH3}) * C_{SCP}}{I_{TH3}}$$

Output transistors

The output of the **FP5352** is a totem-pole transistor pair, which supplies source and sink current capacity for driving the external MOSFET directly, a basic drive method is shown as figure 24.

When PWM operation frequency is different, the both of on and off time of MOSFET also are different.

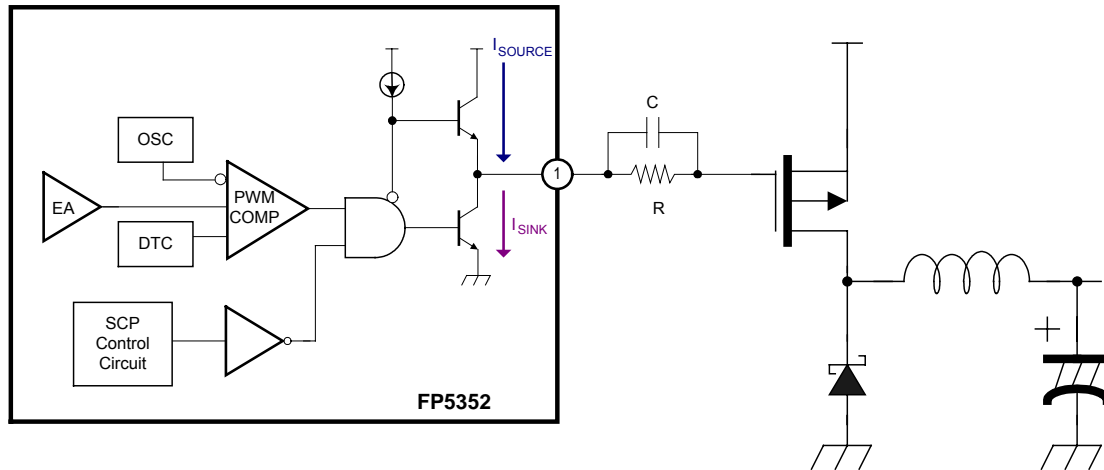


Figure 24. MOSFET Output Driving Circuit

Note:

It is very important to choose a suitable MOSFET for high frequency operation. The larger capacitor between gate and source of MOSFET has more switching loss under the same condition as high frequency operation, supply voltage and driving current.

APPLICATION NOTE

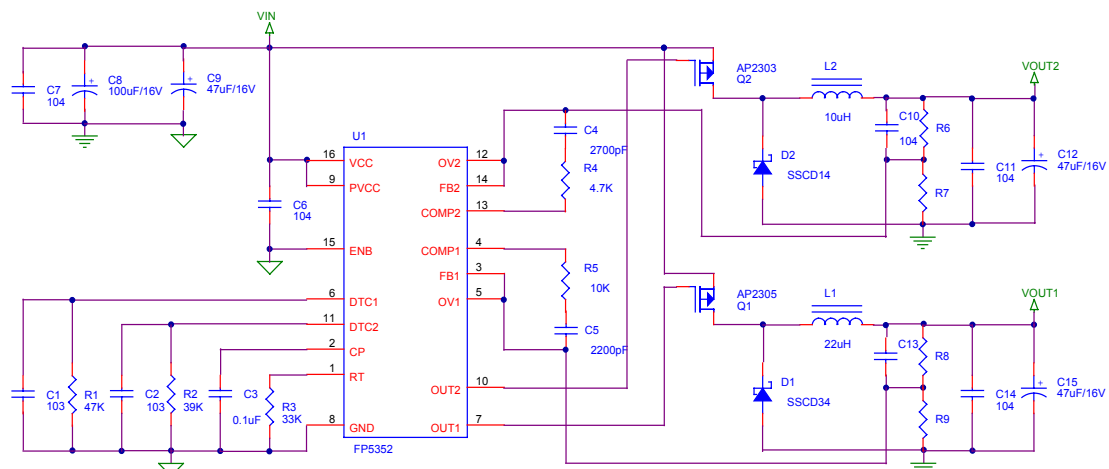


Figure 1 FP5352 2-channel Buck Regulators Application Circuits

Note

The R1-C1 and R2-C2 are dead-time limit and soft-start timing control.

The C3 is OC/OV/SC shutdown and re-start timing capacitor.

The R3 is adjustable for oscillation frequency.

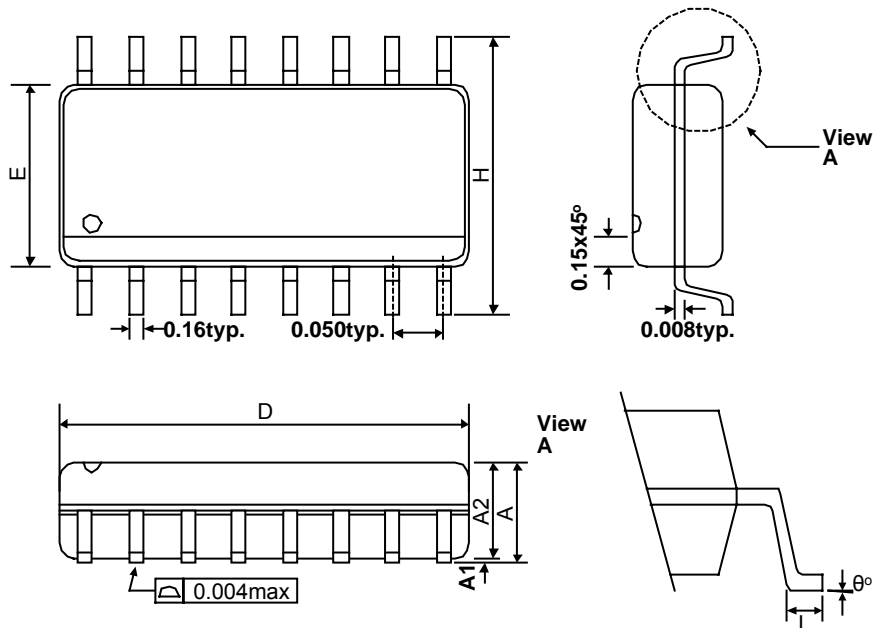
The R4-C4 and R5-C5 are type 3 compensation circuits for error amplifier1/2.

The R6-R7 and R8-R9 with 1.0V reference are used for VOUT1/2 voltage.

The OV set point is higher than R6-R7/R8-R9 resistor ratio with 1.2V.

PACKAGE OUTLINE

SOP-16L



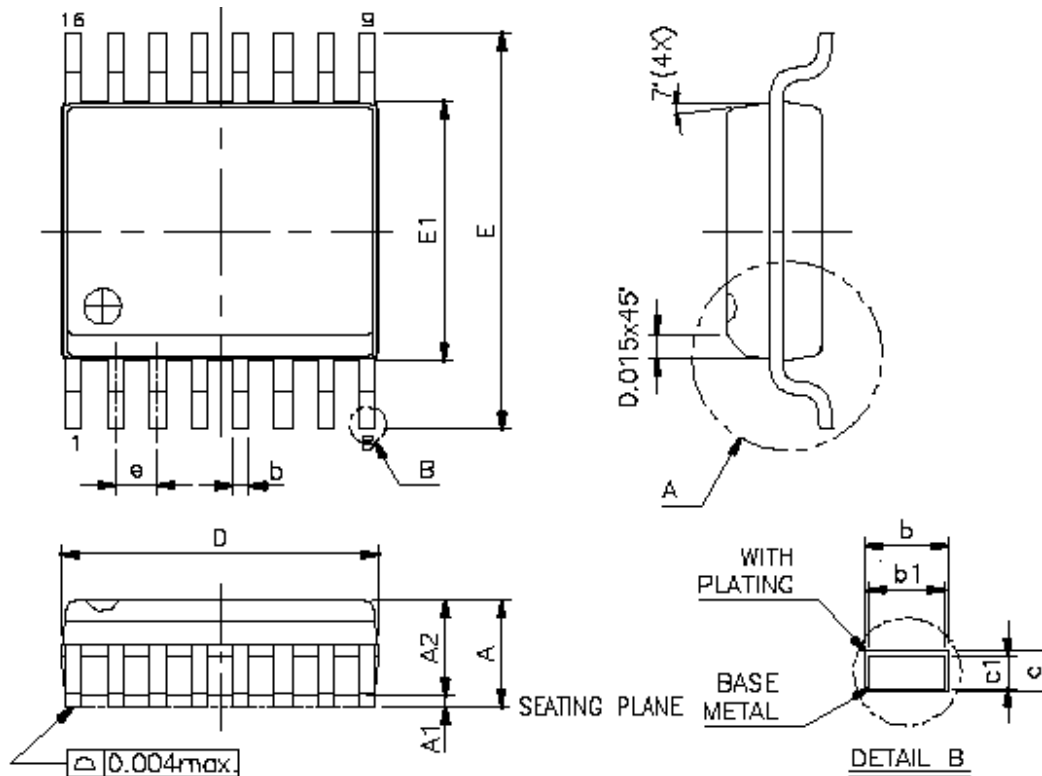
SYMBOLS	MIN	MAX
A	0.053	0.069
A1	0.004	0.010
D	0.386	0.394
E	0.150	0.157
H	0.228	0.244
L	0.016	0.050
°	0	8

UNIT:INCH

NOTE:

- 1.JEDEC OUTLINE:MS-012 AC
- 2.DIMENSIONS "D" DOES NOT INCLUDE MOLD FLASH,PROTRUSIONS OR GATE BURRS.MOLD FLASH,PROTRUSIONS AND GATE BURRS SHALL NOT EXCEED .15mm (.006in) PER SIDE
- 3.DIMENSIONS "E" DOES NOT INCLUDE INTER-LEAD FLASH,OR PROTRUSIONS.
- 4.INTER-LEAD FLASH AND PROTRUSIONS SHALL NOT EXCEED .25mm (.010in) PER SIDE.

SSOP-16L



SYMBOLS	MIN.	MAX.
A	0.053	0.069
A1	0.004	0.010
A2	-	0.059
b	0.008	0.012
b1	0.008	0.011
c	0.007	0.010
c1	0.007	0.009
D	0.189	0.197
E	0.228	0.244
E1	0.150	0.157
L	0.016	0.050
e	0.025 Basic	
\circ	0	8

UNIT:INCH

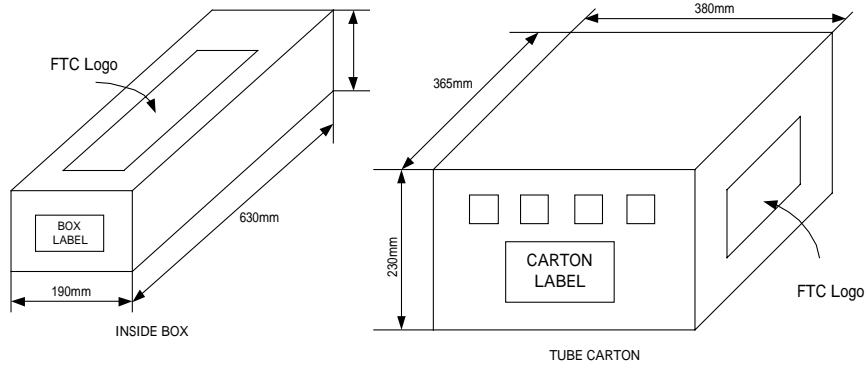
NOTES:

1. JEDEC OUTLINE: MO-137 AB
2. "D", DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .15mm(006in).
3. "E", DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS. MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .25mm(010in) PER SIDE.
4. DATUM PLANE COINCIDENT WITH THE BOTTOM OF LEAD, WHERE LEAD EXITS BODY.

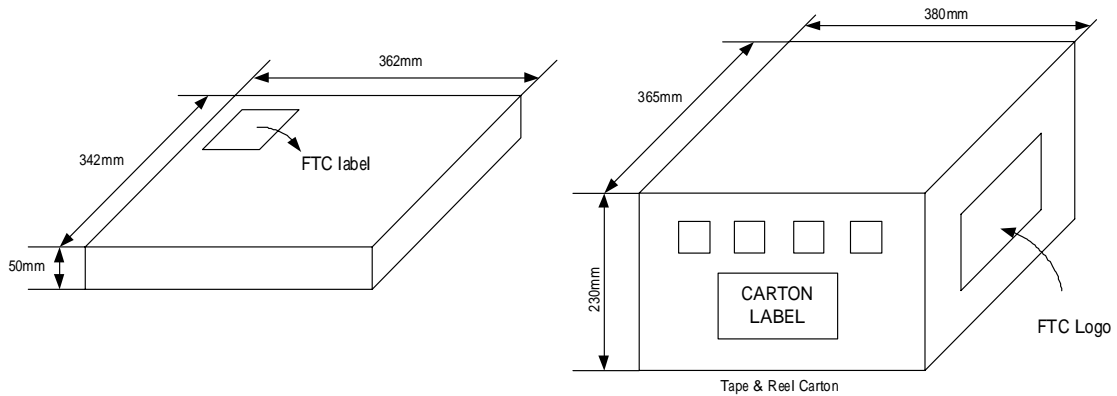
PACKING SPECIFICATIONS

BOX DIMENSION

TUBE INSIDE BOX AND CARTON



TAPE AND REEL INSIDE BOX AND CARTON



PACKING QUANTITY SPECIFICATIONS

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

LABEL SPECIFICATIONS

TAPPING & REEL

Feeling Technology Corp.	
Product	FP5352DR-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>	

CARTON

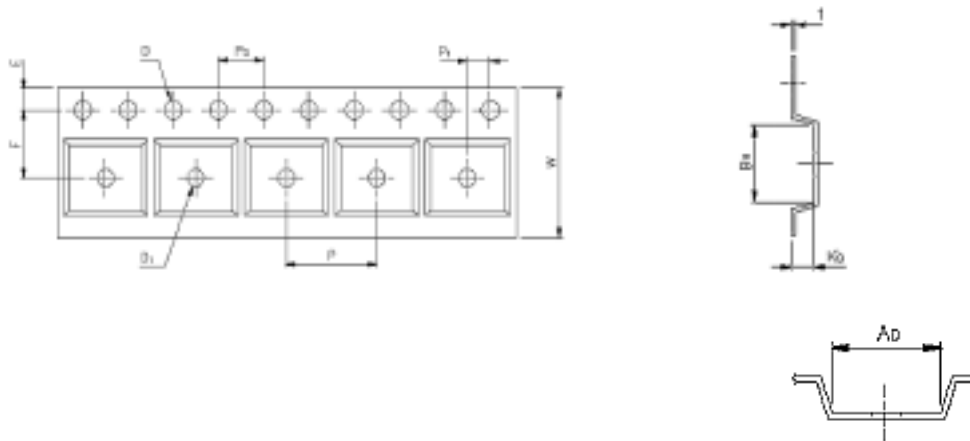
Feeling Technology Corp.	
Product Type: FP5352DR-LF	
Lot No: A3311C62	
Date Code: 4Xx-XXL	
Package Type: SOP-16L	
Marking Type: Laser	無鉛 Lead Free
Total Q'ty: 10,000	

SOP16

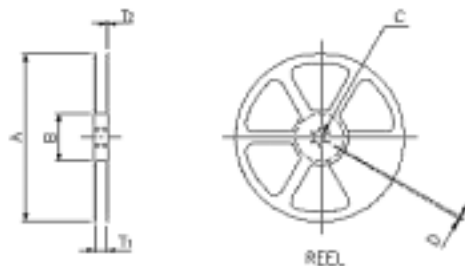
CARRIER TAPE DIMENSIONS

APPLICATION	P ₀	P ₁	A ₀	B ₀	K ₀	t
SOP16	4.0±0.1	2.0±0.1	6.5±0.1	10.3±0.1	2.1±0.1	0.30±0.05

APPLICATION	W	P	E	F	D	D ₁
SOP16	16.0±0.3	8.0±0.1	1.75±0.1	7.5±0.1	1.55 ^{+0.1}	1.5 ^{+0.25}



REEL DIMENSIONS



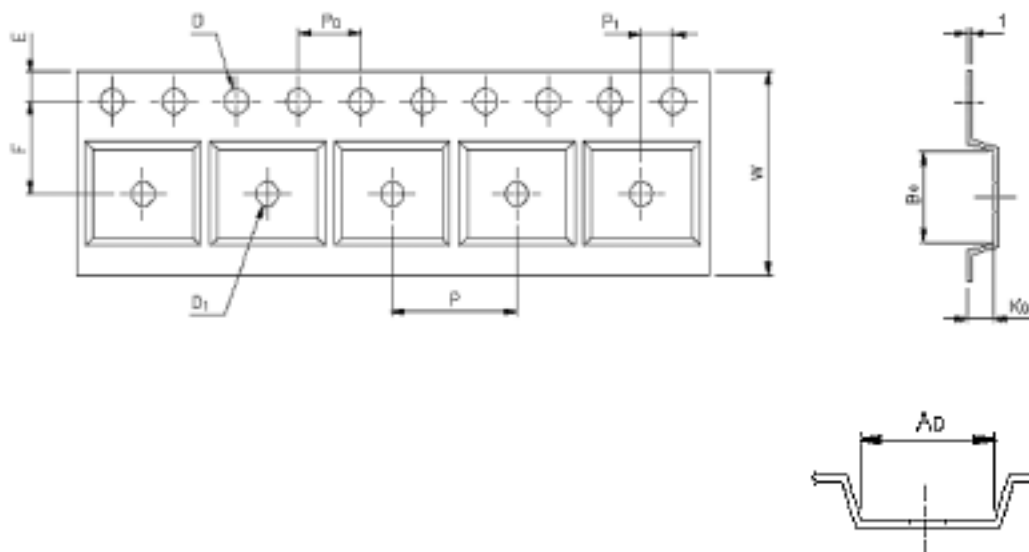
APPLICATION	MATERIAL	A	B	C	D	T1	T2
SOP16	PLASTIC REEL	330±3	100±2.0	13.0±0.5	2.0±0.5	16.4 ^{+0.3} -0.2	2.5±0.5

SSOP16

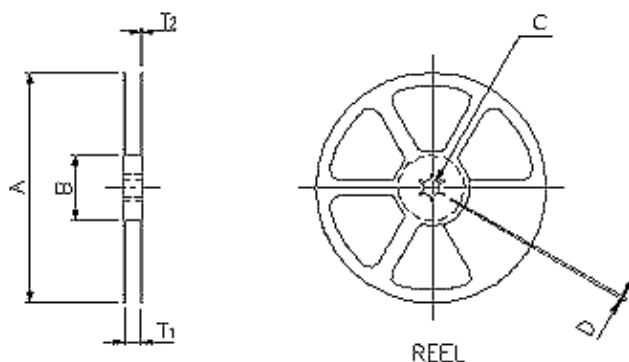
CARRIER TAPE DIMENSIONS

APPLICATION	W	P	E	F	D	D ₁
SSOP16	12.0±0.3	8.0±0.1	1.75±0.1	5.5±0.05	1.5 ^{+0.1}	1.5 ^{+0.25}

APPLICATION	P ₀	P ₁	A ₀	B ₀	K ₀	t
SSOP16	4.0±0.1	2.0±0.05	6.5±0.1	10.3±0.1	2.1±0.1	0.30±0.05



REEL DIMENSIONS



APPLICATION	MATERIAL	A	B	C	D	T ₁	T ₂
SSOP16	PLASTIC REEL	330	62	12.75 ^{+0.15}	2.0±0.15	12.4	16.8