

## Synchronous Buck PWM and Linear Controllers

### Features

- Provides Two Regulated Voltages
  - One Synchronous-Rectified Buck PWM Controller
  - One Linear Controller
- Low Reference Voltage for Further Applications
  - Both Controllers :  $0.8V \pm 2\%$  Over Temperature
- Both Controllers Drive N-Channel MOSFETs
  - PWM Controller Drives Dual N-Channel MOSFETs
  - Linear Controller Drives N-Channel MOSFET
- Built-in PWM Feedback Compensation
  - No Steady-State Error
  - Voltage-Mode PWM Control
  - Full 0~100% Duty Ratio
  - Fast Transient Response
- Adjustable Outputs by External Resistor Dividers
- Under-Voltage Monitoring on Both Controllers
- Small Converter Size
  - 600kHz Constant Switching Frequency
  - Built-In Soft-Start
  - Simple SO-8 Package
- Shutdown Control
- Lead Free Available (RoHS Compliant)

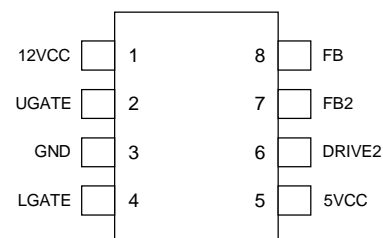
### Applications

- Motherboard
- Graphics Cards
- 12V, 5V and 3.3V Inputs DC-DC Converter

### General Description

The APW7058 integrates one synchronous-rectified Buck PWM controller and one linear controller to provide two regulated voltages for graphics cards and other embedded processor applications. The PWM controller which drives dual N-channel MOSFETs uses fixed 600kHz frequency, voltage-mode PWM control and integrates power-on-reset(POR), built-in soft-start, output under-voltage monitoring and shutdown functions into a single chip. The linear controller which drives a N-channel MOSFET bypass transistor allows users to optimize the transient response by external components. The POR circuit with hysteresis monitors both 5VCC and 12VCC supply voltages to start up/shutdown the IC at power-on/off. An internal 0.8V temperature-compensated reference is designed to meet the low output voltage requirement for further applications. The built-in soft-start function sets the soft-start interval to prevent the output voltages from overshoot as well as limiting the input currents. The under-voltage protections monitor the voltages at FB and FB2 for short-circuit protection. The under-voltage protections cycle the soft-start function until 3 times of UVP events are happened. Pulling and holding the FB2 pin above 1.28V to disable the both controllers.

### Pin Description



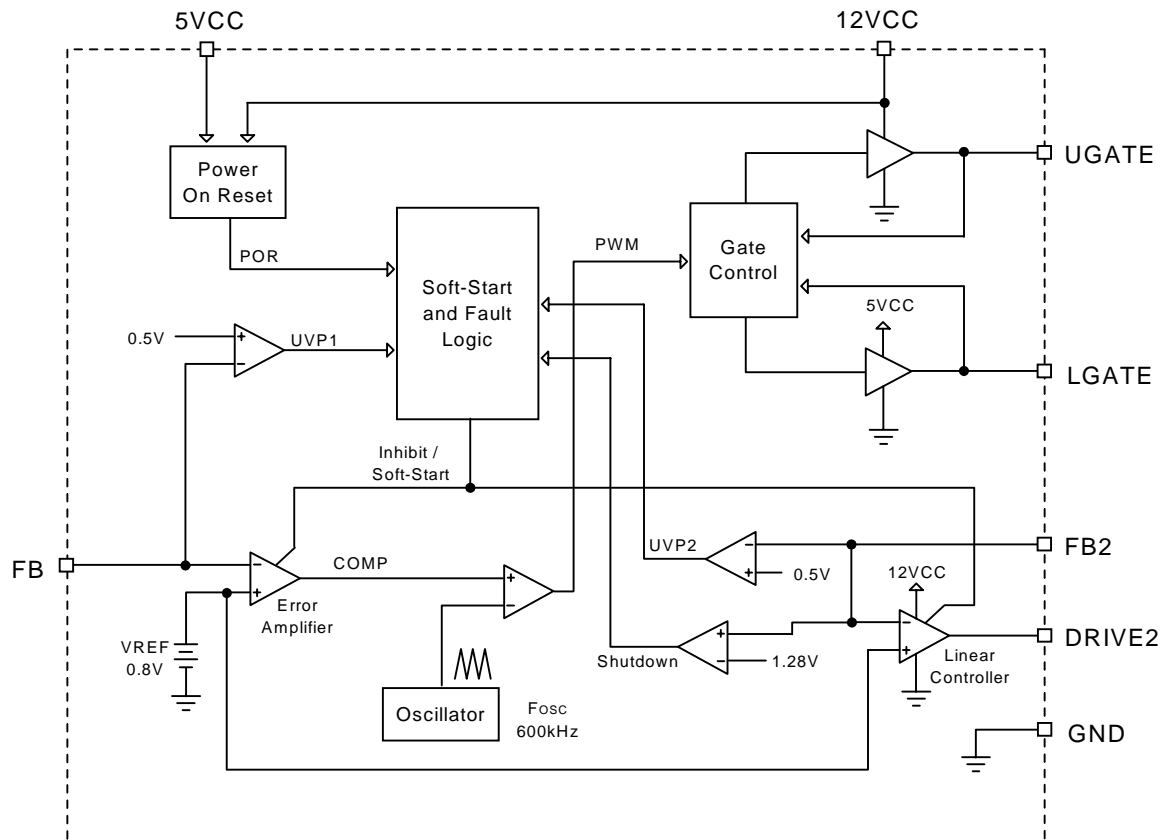
ANPEC reserves the right to make changes to improve reliability or manufacturability without notice, and advise customers to obtain the latest version of relevant information to verify before placing orders.

## Ordering and Marking Information

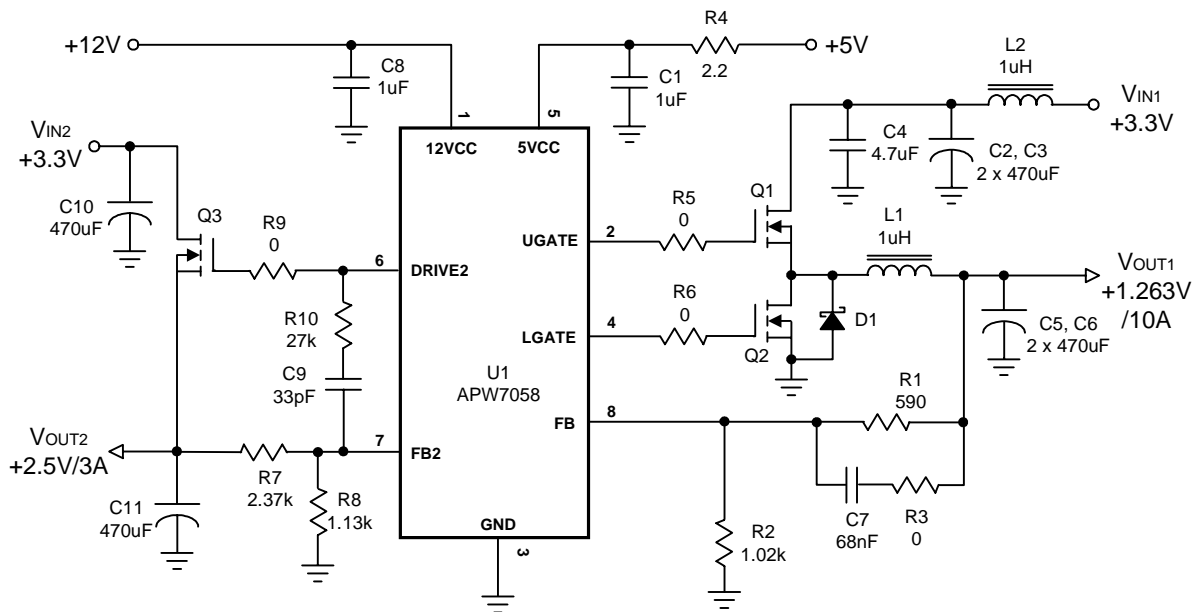
<p>APW 7058 □□-□□□</p> <ul style="list-style-type: none"> <li>□□□ : Lead Free Code</li> <li>□□ : Handling Code</li> <li>□ : Temp. Range</li> <li>□ : Package Code</li> </ul>	<p>Package Code K : SOP - 8</p> <p>Operating Junction Temp. Range C : 0 to 70°C</p> <p>Handling Code TU : Tube TR : Tape &amp; Reel</p> <p>Lead Free Code L : Lead Free Device    Blank : Original Device</p>
<p>APW7058 K : <span style="border: 1px solid black; padding: 2px;">APW7058 XXXXX</span></p>	<p>XXXXX - Date Code</p>

Notes : ANPEC lead-free products contain molding compounds/die attach materials and 100% matte in plate termination finish; which are fully compliant with RoHS and compatible with both SnPb and lead-free soldering operations. ANPEC lead-free products meet or exceed the lead-free requirements of IPC/JEDEC J STD-020C for MSL classification at lead-free peak reflow temperature.

## Block Diagram



## Typical Application



- Q1, Q2 : APM2014N UC
- D1 : 3A Schottky Diode
- Q3 : APM2055N UC
- C2, C3, C5, C6, C10, C11 : 470 $\mu$ F/6.3V, ESR=30m $\Omega$

## Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
5V <sub>CC</sub>	5VCC Supply Voltage (5VCC to GND)	-0.3 ~ 7	V
12V <sub>CC</sub>	12VCC Supply Voltage (12VCC to GND)	-0.3 ~ 15	V
	UAGTE, DRIVE2 to GND	-0.3 ~ 12V <sub>CC</sub>	V
	LGATE, FB, FB2 to GND	-0.3 ~ 5V <sub>CC</sub>	V
	Maximum Junction Temperature	150	$^{\circ}$ C
T <sub>STG</sub>	Storage Temperature	-65 ~ 150	$^{\circ}$ C
T <sub>SDR</sub>	Maximum Soldering Temperature, 10 Seconds	300	$^{\circ}$ C
V <sub>ESD</sub>	Minimum ESD Rating (Human body model)	$\pm$ 2	KV

## Thermal Characteristics

Symbol	Parameter	Value	Unit
$\theta_{JA}$	Junction-to-Ambient Resistance in free air (SOP-8)	160	$^{\circ}$ C/W

## Recommended Operating Conditions (Note)

Symbol	Parameter	Range	Unit
5V <sub>CC</sub>	5VCC Supply Voltage	5 ± 5%	V
12V <sub>CC</sub>	12VCC Supply Voltage	12 ± 10%	V
V <sub>OUT1</sub>	Output Voltage of the Buck converter	0.8 ~ 3.3	V
V <sub>IN1</sub>	Input Voltage of the Buck converter	3.3/5 ± 5%	V
V <sub>OUT2</sub>	Output Voltage of the Linear Regulator	0.8 ~ 3.3	V
V <sub>IN2</sub>	Input Voltage of the Linear Regulator	3.3/5 ± 5%	V
T <sub>A</sub>	Ambient Temperature	0 ~ 70	°C
T <sub>J</sub>	Junction Temperature	0 ~ 125	°C

Note : Refer to the typical application circuit

## Electrical Characteristics

Unless otherwise specified, these specifications apply over 5V<sub>CC</sub>=5V, 12V<sub>CC</sub>=12V and T<sub>A</sub>= 0~70 °C. Typical values are at T<sub>A</sub>=25°C.

Symbol	Parameter	Test Conditions	APW7058			Unit
			Min	Typ	Max	
<b>SUPPLY CURRENT</b>						
I <sub>CC</sub>	5VCC Supply Current	LGATE Open, FB2=DRIVE2		2.5		mA
	12VCC Supply Current	UGATE Open		2.5		mA
<b>POWER-ON RESET</b>						
	Rising 5VCC Threshold	12V <sub>CC</sub> =12V	4.0	4.2	4.5	V
	Falling 5VCC Threshold	12V <sub>CC</sub> =12V	3.5	3.7	3.9	V
	Rising 12VCC Threshold	5V <sub>CC</sub> =5V	9.6	10.3	10.8	V
	Falling 12VCC Threshold	5V <sub>CC</sub> =5V	9.3	9.7	10.2	V
<b>OSCILLATOR</b>						
F <sub>OSC</sub>	Free Running Frequency		550	600	650	kHz
	Ramp Upper Threshold			2.85		V
	Ramp Lower Threshold			0.95		V
ΔV <sub>OSC</sub>	Ramp Amplitude			1.9		V <sub>P-P</sub>
<b>REFERENCE VOLTAGE</b>						
V <sub>REF</sub>	Reference Voltage			0.8		V
	System Accuracy	Over Line, Load and Temperature	-2		+2	%

## Electrical Characteristics (Cont.)

Unless otherwise specified, these specifications apply over  $5V_{CC}=5V$ ,  $12V_{CC}=12V$  and  $T_A=0-70^\circ C$ . Typical values are at  $T_A=25^\circ C$ .

Symbol	Parameter	Test Conditions	APW7058			Unit
			Min	Typ	Max	
<b>BUILT-IN PWM FEEDBACK COMPENSATION</b>						
	DC Gain			75		dB
$F_P$	First Pole Frequency			10		Hz
$F_z$	First Zero Frequency			1		kHz
	UGATE Duty Range		0		100	%
	FB Input Current				0.1	$\mu A$
<b>PWM CONTROLLER GATE DRIVERS</b>						
	UGATE Source	$V_{UGATE}=1V$		0.6		A
	UGATE Sink	$V_{UGATE}=1V$		7.3		$\Omega$
	LGATE Source	$V_{LGATE}=1V$		0.6		A
	LGATE Sink	$V_{LGATE}=1V$		1.8		$\Omega$
$T_D$	Dead Time			50		nS
<b>LINEAR CONTROLLER</b>						
	DC Gain			78		dB
	Gain Bandwidth Product	$C_L=0.5nF$		1.6		MHz
		$C_L=1nF$		1		
	FB Input Current				0.1	$\mu A$
	DRIVE2 Source Current	$V_{FB2}=V_{REF}-20mV$ , $V_{DRIVE2}=7V$		9.8		mA
	DRIVE2 Sink Current	$V_{FB2}=V_{REF}+20mV$ , $V_{DRIVE2}=3V$		2.6		mA
	DRIVE2 Output High Voltage	DRIVE2 Open		11.7		V
	DRIVE2 Output Low Voltage	DRIVE2 Open		0.01		V
<b>UNDER-VOLTAGE PROTECTION</b>						
$UV_{FB}$	FB/FB2 Under-Voltage Level	FB or FB2 Falling		0.5		V
	FB/FB2 Under-Voltage Hysteresis			15		mV
<b>SOFT-START AND SHUTDOWN</b>						
$T_{SS}$	Soft-Start Interval			2		mS
	FB2 Shutdown Threshold	FB2 Rising		1.28		V
	FB2 Shutdown Hysteresis			30		mV

## Functional Pin Description

### 12VCC (Pin 1)

Connect this pin to 12V supply voltage. It provides bias voltage for the high-side MOSFET driver and the linear controller. The voltage at this pin is monitored for Power-On-Reset purposes.

### UGATE (Pin 2)

Connect this pin to the gate of the high-side MOSFET. This pin provides gate drive for the MOSFET.

### GND (Pin 3)

Signal and power ground for the IC. Putting vias to ground planet directly and close to GND pins minimizes noises.

### LGATE (Pin 4)

Connect this pin to the gate of the low-side MOSFET. This pin provides gate drive for the MOSFET.

### 5VCC (Pin 5)

Connect this pin to a 5V supply voltage via a RC filter (2.2Ω and 1μF are recommended). This pin provides the bias for the control circuitry and the low-side MOSFET driver. The voltage at this pin is monitored for Power-On-Reset purposes.

### DRIVE2 (Pin 6)

Connect this pin to the gate of an external N-Channel MOSFET transistor. This pin provides the gate voltage for the linear regulator pass transistor. It also provides a means of compensating the linear controller for applications where the user needs to optimize the regulator transient response.

### FB2 (Pin 7)

Connect this pin to the output ( $V_{OUT2}$ ) of the linear regulator via a proper sized resistor divider. The voltage at this pin is regulated to 0.8V and the  $V_{OUT2}$  is determined using the following formula :

$$V_{OUT2}=0.8V \times \left(1+\frac{R7}{R8}\right)$$

where R7 is the resistor connected from  $V_{OUT2}$  to FB2, and R8 is the resistor connected from FB2 to GND. This pin is also monitored for under-voltage events. Pulling and holding FB2 above 1.28V shuts down both regulators. Releasing FB2 initiates soft-start on both regulators.

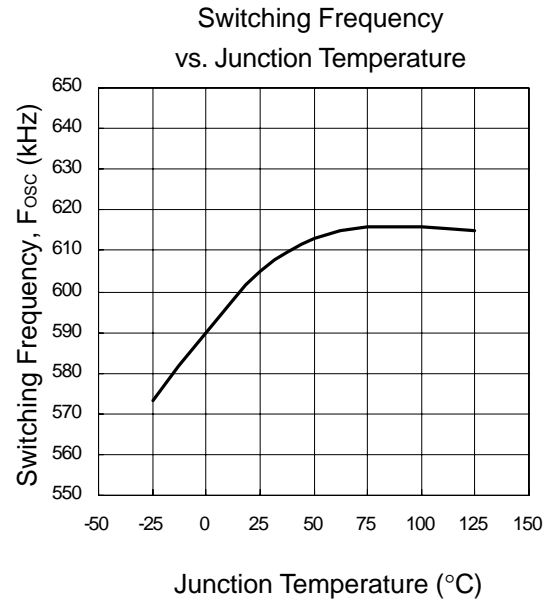
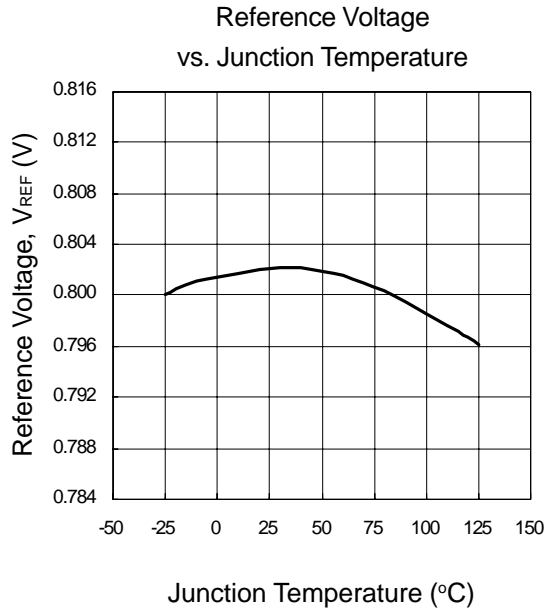
### FB (Pin 8)

This pin is the inverting input of the internal error amplifier. Connect this pin to the output ( $V_{OUT1}$ ) of the Buck converter via a proper sized resistor divider to provide feedback loop of the Buck converter. The  $V_{OUT1}$  is determined using the following formula :

$$V_{OUT1}=0.8V \times \left(1+\frac{R1}{R2}\right)$$

where R1 is the resistor connected from  $V_{OUT1}$  to FB, and R2 is the resistor connected from FB to GND. This pin is also monitored for under-voltage events.

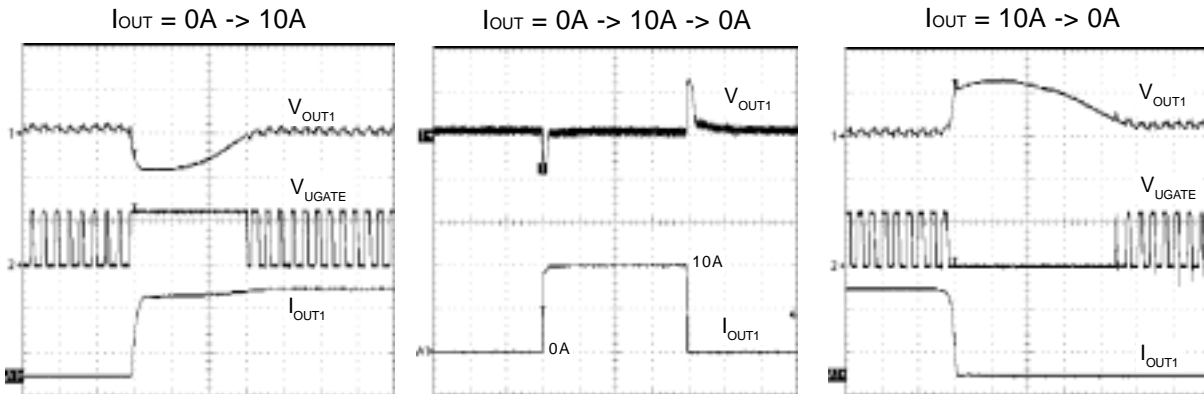
## Typical Characteristics



Operating Waveforms (Refer to the typical application circuit)

1.  $V_{OUT1}$  Load Transient Response :  $I_{OUT} = 0A \rightarrow 10A \rightarrow 0A$

-  $I_{OUT1}$  slew rate =  $\pm 10A/\mu S$



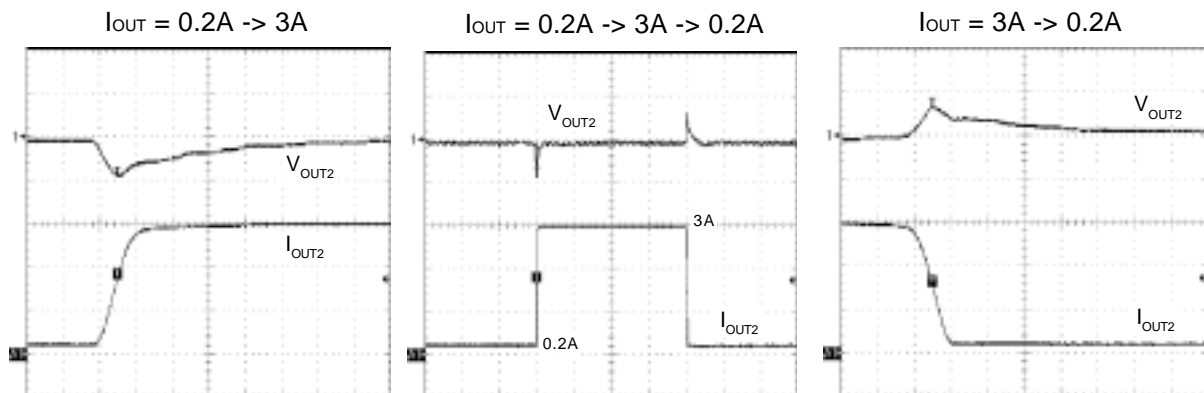
Ch1 :  $V_{OUT1}$ , 100mV/Div, DC,  
Offset = 1.25V  
Ch2 :  $V_{UGATE}$ , 10V/Div, DC  
Ax1 :  $I_{OUT1}$ , 5A/Div  
Time : 5 $\mu S$ /Div  
BW = 20MHz

Ch1 :  $V_{OUT1}$ , 100mV/Div, DC,  
Offset = 1.25V  
Ax1 :  $I_{OUT1}$ , 5A/Div  
Time : 100 $\mu S$ /Div  
BW = 20MHz

Ch1 :  $V_{OUT1}$ , 100mV/Div, DC,  
Offset = 1.25V  
Ch2 :  $V_{UGATE}$ , 10V/Div, DC  
Ax1 :  $I_{OUT1}$ , 5A/Div  
Time : 5 $\mu S$ /Div  
BW = 20MHz

2.  $V_{OUT2}$  Load Transient Response :  $I_{OUT} = 0.2A \rightarrow 3A \rightarrow 0.2A$

-  $I_{OUT2}$  slew rate =  $\pm 3A/\mu S$



Ch1 :  $V_{OUT2}$ , 50mV/Div, DC,  
Offset = 2.50V  
Ax1 :  $I_{OUT2}$ , 1A/Div  
Time : 1 $\mu S$ /Div  
BW = 20MHz

Ch1 :  $V_{OUT2}$ , 50mV/Div, DC,  
Offset = 2.50V  
Ax1 :  $I_{OUT2}$ , 1A/Div  
Time : 50 $\mu S$ /Div  
BW = 20MHz

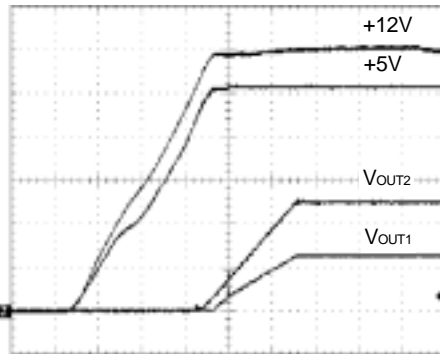
Ch1 :  $V_{OUT2}$ , 50mV/Div, DC,  
Offset = 2.50V  
Ax1 :  $I_{OUT2}$ , 1A/Div  
Time : 1 $\mu S$ /Div  
BW = 20MHz



## Operating Waveforms (Cont.)

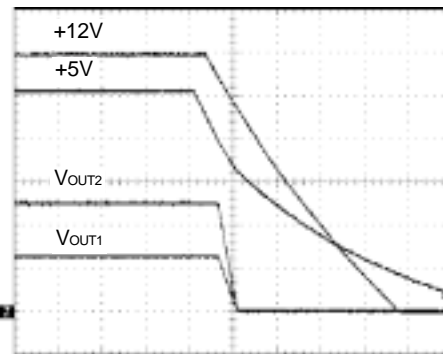
### 3. Powering ON / OFF

Soft-start at Powering ON



Ch1 : +5V, 1V/Div, DC  
 Ch2 : +12V, 2V/Div, DC  
 Ch3 : V<sub>OUT1</sub>, 1V/Div, DC  
 Ch4 : V<sub>OUT2</sub>, 1V/Div, DC  
 Time : 1mS/Div  
 BW = 20MHz

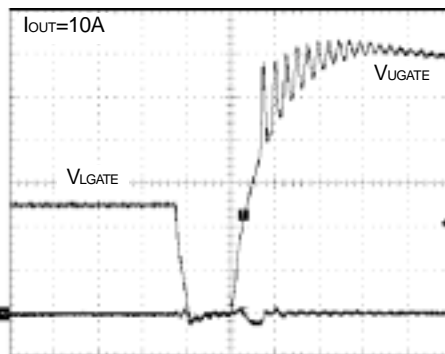
Powering OFF



Ch1 : +5V, 1V/Div, DC  
 Ch2 : +12V, 2V/Div, DC  
 Ch3 : V<sub>OUT1</sub>, 1V/Div, DC  
 Ch4 : V<sub>OUT2</sub>, 1V/Div, DC  
 Time : 5mS/Div  
 BW = 20MHz

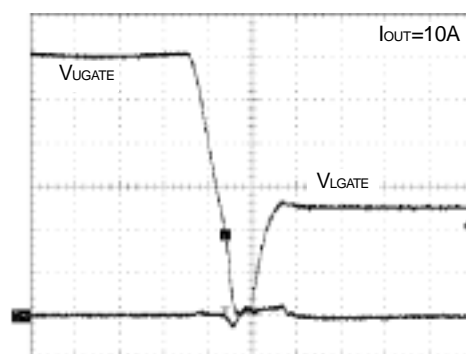
### 4. UGATE and LGATE

UGATE Rising



Ch1 : V<sub>UGATE</sub>, 2V/Div, DC  
 Ch2 : V<sub>LGATE</sub>, 2V/Div, DC  
 Time : 50nS/Div  
 BW = 500MHz

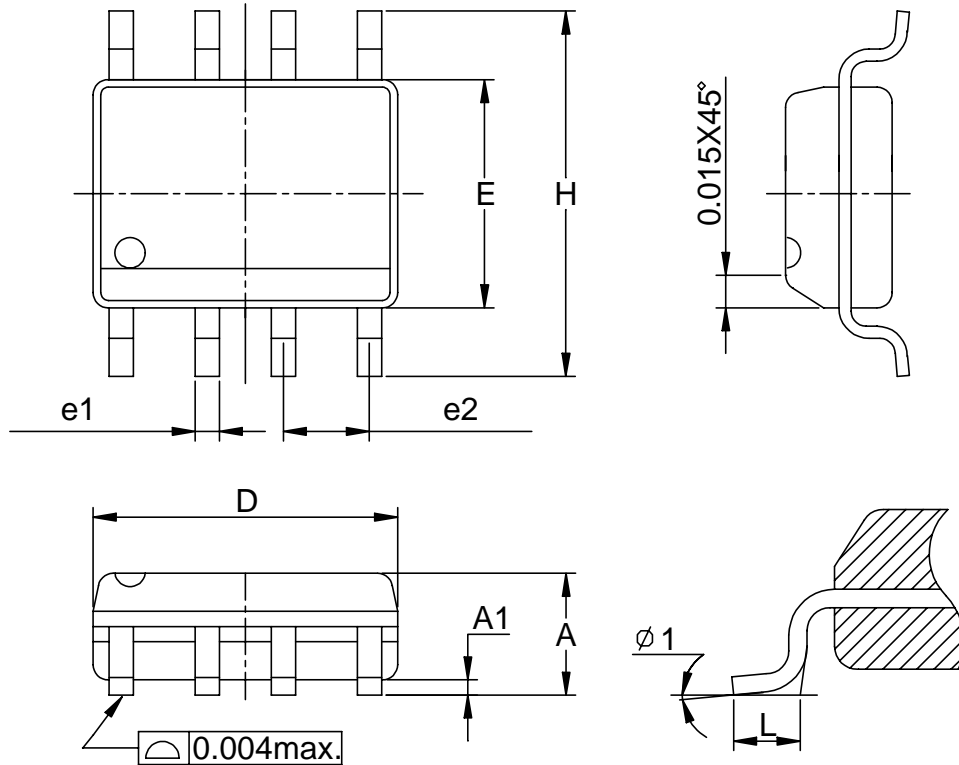
UGATE Falling



Ch1 : V<sub>UGATE</sub>, 2V/Div, DC  
 Ch2 : V<sub>LGATE</sub>, 2V/Div, DC  
 Time : 50nS/Div  
 BW = 500MHz

## Packaging Information

SOP-8 pin ( Reference JEDEC Registration MS-012)

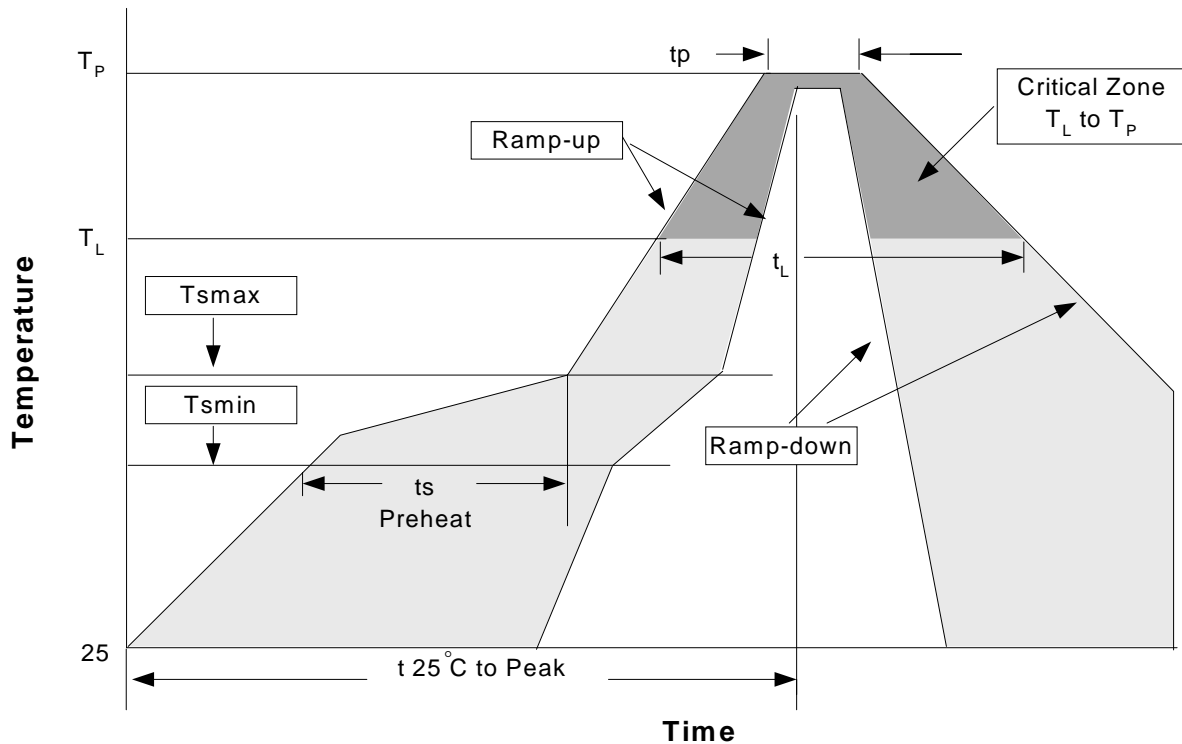


Dim	Millimeters		Inches	
	Min.	Max.	Min.	Max.
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
D	4.80	5.00	0.189	0.197
E	3.80	4.00	0.150	0.157
H	5.80	6.20	0.228	0.244
L	0.40	1.27	0.016	0.050
e1	0.33	0.51	0.013	0.020
e2	1.27BSC		0.50BSC	
φ 1	8°		8°	

## Physical Specifications

Terminal Material	Solder-Plated Copper (Solder Material : 90/10 or 63/37 SnPb), 100%Sn
Lead Solderability	Meets EIA Specification RSI86-91, ANSI/J-STD-002 Category 3.
Packaging	2500 devices per reel

### Reflow Condition (IR/Convection or VPR Reflow)



### Classification Reflow Profiles

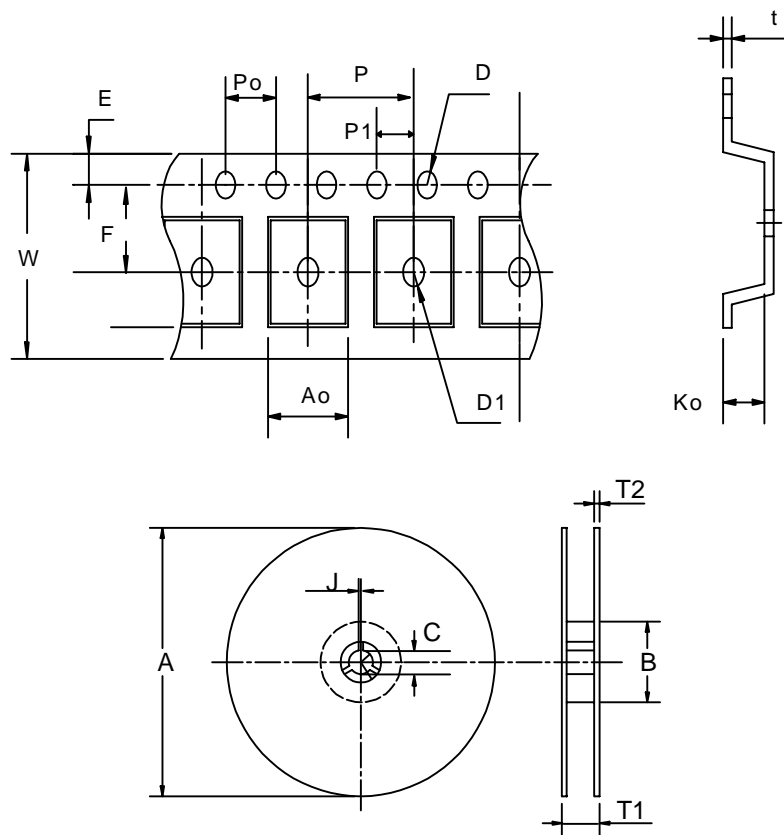
Profile Feature	Sn-Pb Eutectic Assembly		Pb-Free Assembly	
	Large Body	Small Body	Large Body	Small Body
Average ramp-up rate (T <sub>L</sub> to T <sub>P</sub> )	3°C/second max.		3°C/second max.	
Preheat				
- Temperature Min (T <sub>smin</sub> )	100°C		150°C	
- Temperature Mix (T <sub>smax</sub> )	150°C		200°C	
- Time (min to max)(t <sub>s</sub> )	60-120 seconds		60-180 seconds	
T <sub>smax</sub> to T <sub>L</sub>				
- Ramp-up Rate			3°C/second max	
T <sub>smax</sub> to T <sub>L</sub>				
- Temperature(T <sub>L</sub> )	183°C		217°C	
- Time (t <sub>L</sub> )	60-150 seconds		60-150 seconds	
Peak Temperature(T <sub>p</sub> )	225 +0/-5°C	240 +0/-5°C	245 +0/-5°C	250 +0/-5°C
Time within 5°C of actual Peak Temperature(t <sub>p</sub> )	10-30 seconds	10-30 seconds	10-30 seconds	20-40 seconds
Ramp-down Rate	6°C/second max.		6°C/second max.	
Time 25°C to Peak Temperature	6 minutes max.		8 minutes max.	

Note: All temperatures refer to topside of the package. Measured on the body surface.

## Reliability test program

Test item	Method	Description
SOLDERABILITY	MIL-STD-883D-2003	245°C , 5 SEC
HOLT	MIL-STD-883D-1005.7	1000 Hrs Bias @ 125 °C
PCT	JESD-22-B, A102	168 Hrs, 100 % RH , 121°C
TST	MIL-STD-883D-1011.9	-65°C ~ 150°C, 200 Cycles
ESD	MIL-STD-883D-3015.7	VHBM > 2KV, VMM > 200V
Latch-Up	JESD 78	10ms , $I_{tr}$ > 100mA

## Carrier Tape & Reel Dimension



<b>Application</b>	A	B	C	J	T1	T2	W	P	E
<b>SOP-8</b>	330±1	62 ± 1.5	12.75 + 0.15	2 + 0.5	12.4 +0.2	2± 0.2	12 + 0.3 - 0.1	8± 0.1	1.75± 0.1
<b>Application</b>	F	D	D1	Po	P1	Ao	Bo	Ko	t
<b>SOP-8</b>	5.5 ± 0.1	1.55±0.1	1.55+ 0.25	4.0 ± 0.1	2.0 ± 0.1	6.4 ± 0.1	5.2± 0.1	2.1± 0.1	0.3±0.013

(mm)

## Cover Tape Dimensions

Application	Carrier Width	Cover Tape Width	Devices Per Reel
SOP- 8	12	9.3	2500

## Customer Service

### **Anpec Electronics Corp.**

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