4-Channel LED Backlight Converter with SMBus Controlled

Features

- 4 channels
- 6V to 24V Input Voltage Supply
- Drive up to 68(17x4) White LEDs (3.5V/180mA each)
- Current Match (balance) +/- 1% (Typ.)
- Current Accuracy +/-1% (Typ.)
- Built internal SW MOSFET Rds(on) 0.25 ohm (typ.)
- SMBus control to program below:
  - -LED Current: 22.58mA to 180 mA
  - -Switching Frequency: 200KHz to 900KHz
  - -Dimming mode: PWM, DC and Mixed-mode
- Enable / Shutdown Function and Fault indication
- Built in UVLO Control Detection on VIN
- Built in Protection function:
  - -Built in Internal MOSFET Current Limit function about 3.3A (Typ.)
  - -String Open / Short Circuit Detection
  - -Over Voltage Protection
  - -Over Temperature Protection
- Available in TDFN 5x5-16 Packages
- Halogen and Lead Free Available (RoHS Compliant)

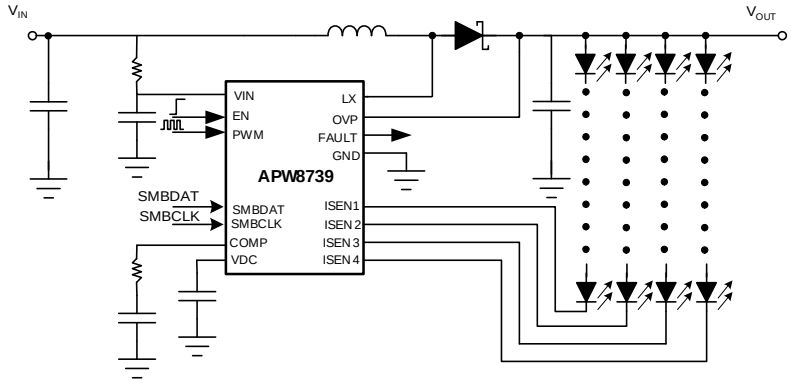
General Description

The APW8739 is a high efficiency driver for 4 channels of LEDs. It's a wide range input voltage operating from 6V to 24V. It's capable of driving typically 68 (17x4) pieces of 3.5V/180mA LEDs. It contains 4 channels of voltage controlled current sources with typical current matching of ±1%. It's built internal Rds(on) 0.25 ohm (typ.) with current mode control. The APW8739 be able to control LED current by SMBus interface. SMBus control LED current made had PWM, DC and Mixed-mode. The APW8739 has enable, shutdown function and Fault detection function. The APW8739 features extensive protection functions that include UVLO, Current limit, LED strings open and short circuit detections, Output Over-Voltage Protection (OVP) and Over Temperature Protection (OTP). The APW8739 is available in TDFN5x5-16 Packages.

Applications

- AIO Backlight

Simplified Application Circuit

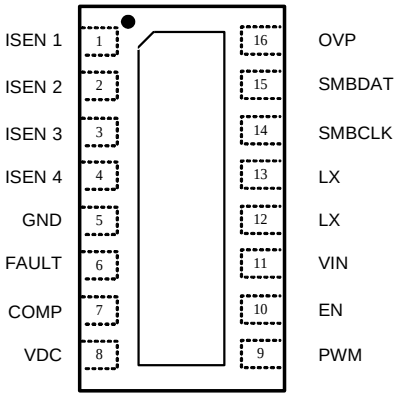


Ordering and Marking Information

APW8739 □□□-□□□ Assembly Material Handling Code Temperature Range Package Code	Package Code QB : TDFN 5x5-16 Operating Ambient Temperature Range I : -40 to 85°C Handling Code TR : Tape & Reel Assembly Material G : Halogen and Lead Free Device
APW8739: 	XXXXX - Date Code

Note: ANPEC lead-free products contain molding compounds/die attach materials and 100% matte tin plate termination finish; which are fully compliant with RoHS. 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. ANPEC defines ¡§Green¡¨ to mean lead-free (RoHS compliant) and halogen free (Br or Cl does not exceed 900ppm by weight in homogeneous material and total of Br and Cl does not exceed 1500ppm by weight).

Pin Configuration



TDFN 5x5 - 16

Top View

Absolute Maximum Ratings (Note 1)

Symbol	Parameter	Rating	Unit
V_{IN}	VIN Input Voltage (VIN to GND)	-0.3 to 40	V
V_{FAULT}	Fault Voltage to GND	-0.3 to 40	V
V_{DC}	VDC Voltage to GND	-0.3 to 6	V
V_{SMBCLK}	SMBCLK Voltage to GND	-0.3 to 26.5	V
V_{SMBDAT}	SMBDAT Voltage to GND	-0.3 to 26.5	V
$I_{ISEN1~4}$	ISEN1 – ISEN4 LED Current	200	mA
$V_{I/O}$	VEN, VPWM, VCOMP ,VFAULT to GND Voltage	-0.3 to 44	V
	VSEN1, VSEN2, VSEN3, VSEN4, VOUT to GND Voltage	-0.3 to 66	V
	VLX to GND Voltage	-0.3 to 72	V
	PGND to AGND Voltage	-0.3 to 0.3	V
T_J	Maximum Junction Temperature	150	°C
T_{STG}	Storage Temperature	-65 to 150	°C
T_{SDR}	Maximum Lead Soldering Temperature (10 Seconds)	260	°C

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Thermal Characteristics (Note 2)

Symbol	Parameter	Typical Value	Unit
θ_{JA}	Junction-to-Ambient Resistance in free air TDFN5X5 -16	28.8	°C/W
θ_{JC}	Junction-to-Case Resistance in free air TDFN5X5 -16	4.4	°C/W

Note 2: θ_{JA} and are measured with the component mounted on a high effective the thermal conductivity test board in free air. The thermal pad of TDFN5x5-16 package is soldered directly on the PCB.

Recommended Operating Conditions (Note 3)

Symbol	Parameter	Range	Unit
V_{IN}	VIN Input Voltage (VIN to GND)	6 to 24	V
V_{OUT}	Converter Output Voltage	~65	V
I_{LED}	Output LED Current per string	20~180	mA
V_{EN}	Enable Voltage	5	V
F_{SW}	Boost SW Frequency	200 ~ 900	kHz
T_A	Ambient Temperature	-40 to 85	°C
T_J	Junction Temperature	-40 to 125	°C

Note 3: Refer to the typical application circuit

Electrical Characteristics (Cont.)

Unless otherwise specified, these specifications apply over V_{IN}=12V, V_{ENA} =5V and T_A= -40 to 85 °C. Typical values are at T_A=25°C.

Symbol	Parameter	Test Conditions	APW8739			
			Min	Typ	Max	Unit
Supply Voltage And Current						
V_{IN}	Input Supply Voltage Range		6	-	24	V
I_Q	Quiescent Current		-	3.3	-	mA
I_{SHDN}	Shutdown Current	V_{IN} =6V, EN=0V	-	-	18	uA
	Enable and PWM Dimming					
	EN and PWM Logic	High Logic	2	-	-	V
		Low Logic	-	-	0.8	V
	EN and PWM Leakage Current		-	-	10	uA
	SMBDAT and SMBCLK Logic	High Logic	2	-	-	V
		Low Logic	-	-	0.8	V
SMBus Control Timing (Note 4)						
	SMBDAT and SMBCLK Leakage Current		-	0.01	1	uA
F_{SMB}	SMBus Operating Frequency		10	-	100	KHz
T_{BUF}	Bus free time between stop and start condition		4.7	-	-	us
$T_{\_HD\_STA}$	Hold time after start condition	After this period, the first clock is generated	4	-	-	us
$T_{\_SD\_STA}$	Repeated start condition setup time		4.7	-	-	us
$T_{\_SD\_STO}$	Stop condition setup time		4	-	-	us
$T_{\_HD\_DAT}$	Data hold time		300	-	-	ns
$T_{\_SU\_DAT}$	Data setup time		250	-	-	ns
$T_{\_TIMEOUT}$	Detect clock low timeout		25	-	35	ms
$T_{\_LOW}$	Clock low period		4.7	-	-	us
$T_{\_HIGH}$	Clock high period		4	-	50	us
$T_{\_LOW\_SEXT}$	Slave device cumulative clock low extend time_slave		-	-	25	ms
$T_{\_LOW\_MEXT}$	Master device cumulative clock low extend time_master		-	-	10	ms
T_{F_SMB}	Fall time of SMB DAT/CLK		-	-	300	ns
T_{R_SMB}	Rise time of SMB DAT/CLK		-	-	1000	ns
$T_{\_SMB\_POR}$	Power on reset of SMB	Time in which a device must be operation after power on reset	-	3	500	ms

Electrical Characteristics (Cont.)

Unless otherwise specified, these specifications apply over V_{IN}=12V, V_{ENA} =5V and T_A= -40 to 85 °C. Typical values are at T_A=25°C.

Symbol	Parameter	Test Conditions	APW8739			
			Min	Typ	Max	Unit
Under Voltage Lockout						
V_{UVLO}	Under Voltage Lockout Threshold		-	4.3	-	V
ΔV_{UVLO}	Under Voltage Lockout Hysteresis		-	200	-	mV
Oscillator						
F_{SW_ACC}	Operation Frequency	Boost operation at PWM mode, F_{SW}=400kHz	-10	-	10	%
F_{SW}	Switching Frequency	Boost operation at PWM mode	-	400	-	kHz
F_{SW_RG}	Switching Frequency Setting Range		200	-	900	kHz
LED Current						
$I_{SEN\_LEK\_I}$	Leakage Current of ISEN	V_{SEN}=50V, I_{SEN}=0uA	-	20	-	uA
V_{SEN_MIN}	Minimum SEN Regulation Voltage	I_{SEN}=120mA	-	0.5	-	V
I_{SEN_MAX}	Maximum SEN Current		-	-	180	mA
F_{PWM}	Dimming Frequency		200	-	1000	Hz
I_{SEN_ACC}	ISEN Current Accuracy	PWM duty=100%, I_{SEN}=120mA	-3	-	+3	%
I_{SEN_MAT}	ISEN Current Matching	PWM duty=100%, I_{SEN}=120mA	-2	-	+2	%
V_{SEN_OPEN}	Light Bar Open Threshold		-	0.1	-	V
	Unused threshold		-	0.2	-	V
V_{SEN_SHORT}	Light Bar Short Threshold		-	5.6	-	V
F_{PWM_LED}	Mixed Mode Dimming Frequency	When Dimming Duty < 25%	-	26	-	KHz
	Internal Power Switch					
D_{MAX}	Max duty cycle		-	90	-	%
R_{ON}	Power Switch on Resistance	V_{DC}=5V, I_{SW_BST}=100mA	-	0.25	0.5	Ω

Electrical Characteristics (Cont.)

Unless otherwise specified, these specifications apply over V_{IN}=12V, V_{ENA} =5V and T_A= -40 to 85 °C. Typical values are at T_A=25°C.

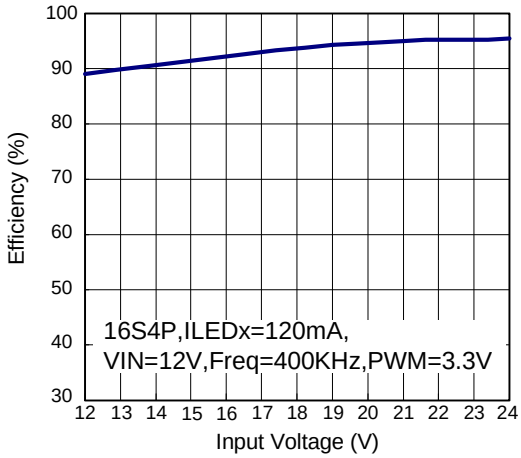
Symbol	Parameter	Test Conditions	APW8739			
			Min	Typ	Max	Unit
Output over Voltage Protection						
V_{OVP}	Over Voltage Protection	OVP Selection b=11	-	65	-	V
Power Switch Current Limit						
I_{OCP}	Switching Current Limit		2.8	3.3	-	A
Thermal Protection						
T_{OTP}	Over Temperature Protection		-	145	-	°C
	Resume Temp.		-	125	-	°C

Pin Description

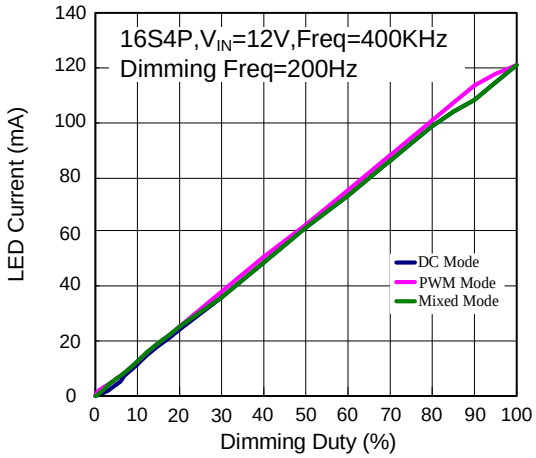
PIN	NAME	FUNCTION
TDFN 5×5 -16		
1	ISEN1	WLED Current source 1
2	ISEN1	WLED Current source 2
3	ISEN2	WLED Current source 3
4	ISEN3	WLED Current source 4
5	GND	Ground Pin
6	FAULT	LED Operation status output
7	COMP	Compensation pin for error amplifier. Connect the compensation network to GND
8	VDC	5V regulator supply for low voltage block. Connect 1uF capacitor to GND.
9	PWM	PWM brightness dimming control pin. Do not leave this pin floating.
10	EN	Enable control input pin. (active high)
11	VIN	Main power supply pin
12, 13	LX	Switching node of boost converter.
14	SMBCLK	Clock of SM Bus.
15	SMBDAT	Data of SM Bus.
16	VOUT	Over Voltage protection input pin. Based on internal resistor divider.
17	Exposed Pad	Ground.

Typical Operating Characteristics

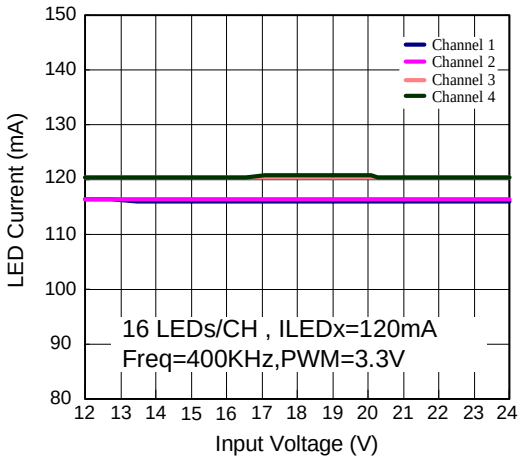
Efficiency VS Input Voltage



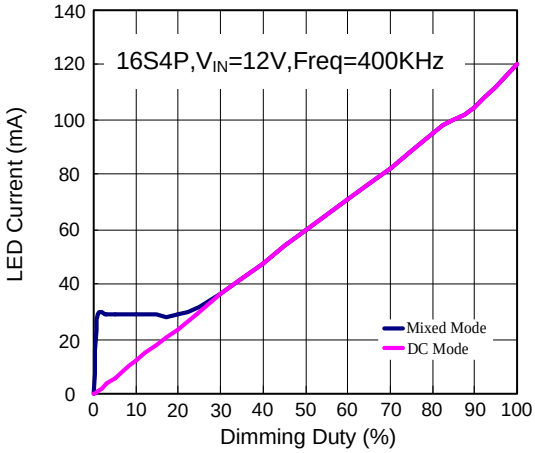
LED Current VS Dimming Duty



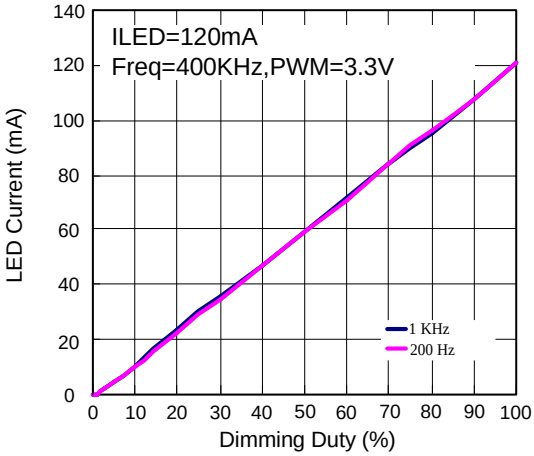
Efficiency VS Input Voltage



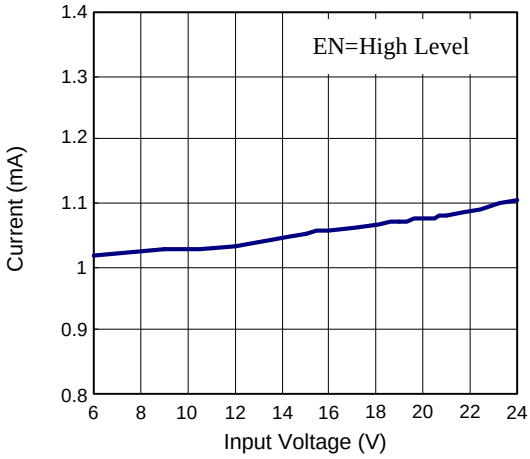
LED Current VS SMBus Duty



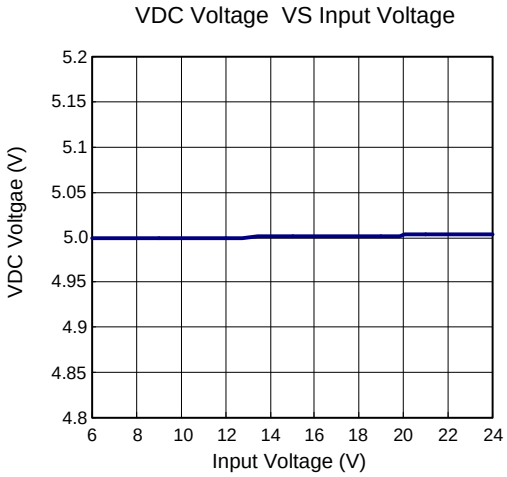
LED Current VS Dimming Freq



Quiescent Current VS Input Voltage

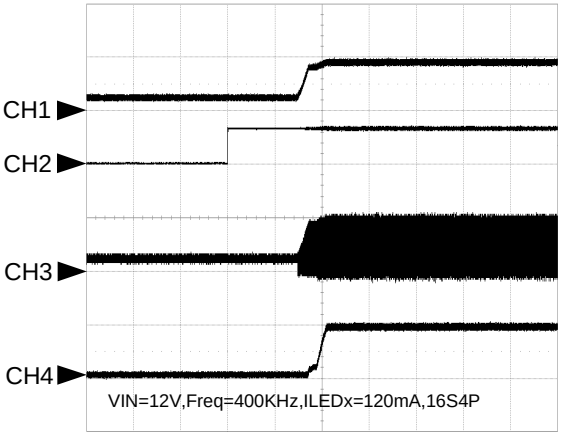


Typical Operating Characteristics



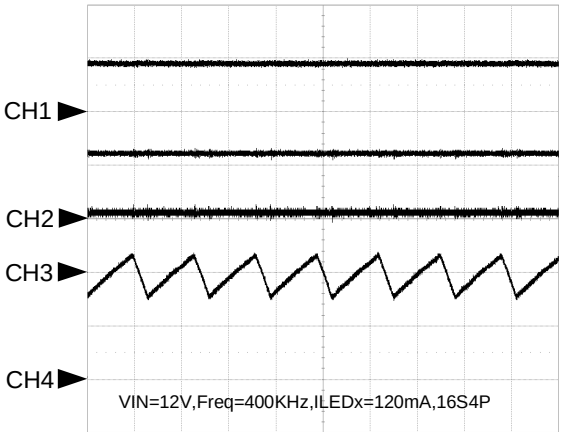
Operating Waveforms

Power on PWM – DC Mode



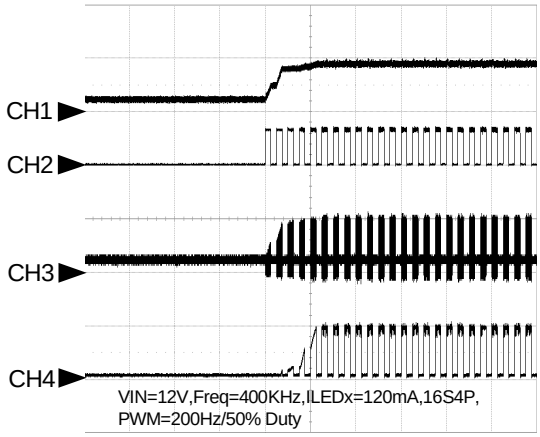
CH1:V_{OUT}-50V/div
CH2:V_{PWM}-5V/div
CH3:V_{LX}-50V/div
CH4:I_{OUT}-500mA/div
Time:20ms/div

Normal Operation



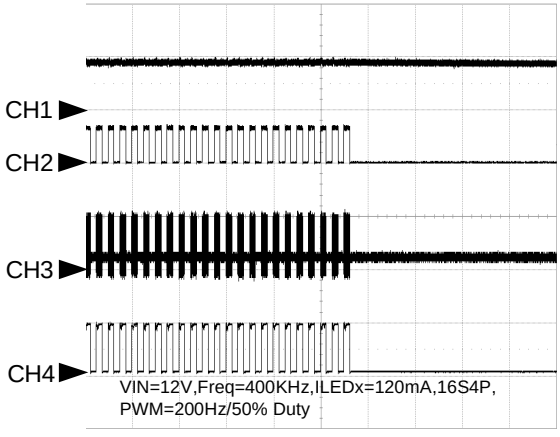
CH1:V_{OUT}-50V/div
CH2:V_{IN}-10V/div
CH3:V_{FAULT}-5V/div
CH4:I_L-1A/div
Time:2us/div

Power on PWM – PWM Mode



CH1:V_{OUT}-50V/div
CH2:V_{EN}-5V/div
CH3:V_{LX}-50V/div
CH4:I_{OUT}-500mA/div
Time:20ms/div

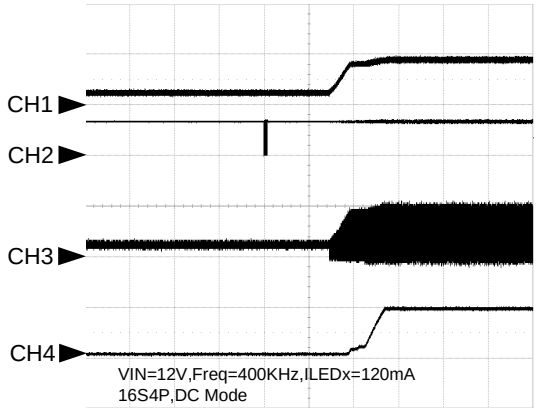
Power off PWM - PWM Mode



CH1:V_{OUT}-50V/div
CH2:V_{PWM}-5V/div
CH3:V_{LX}-50V/div
CH4:I_{OUT}-500mA/div
Time:20ms/div

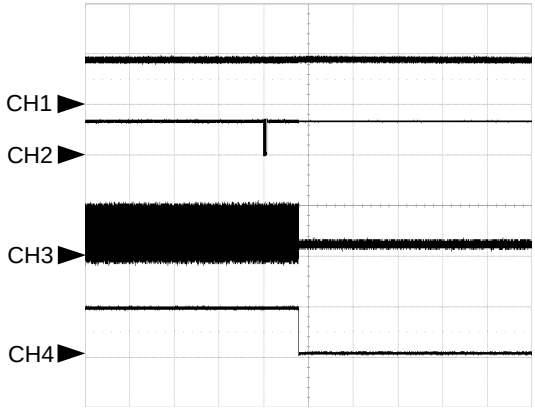
Operating Waveforms (Cont.)

Power on SMBus



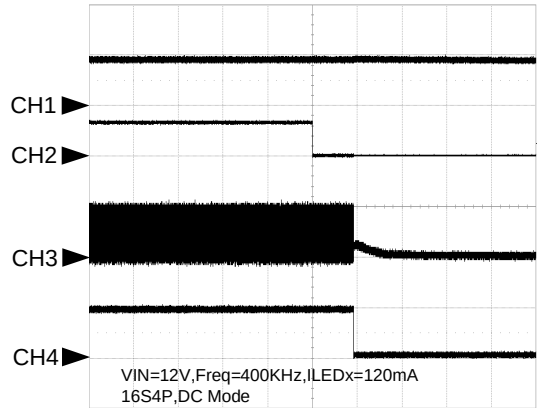
CH1:V_{OUT}-50V/div
CH2:V_{DATA}-5V/div
CH3:V_{LX}-50V/div
CH4:I_{OUT}-500mA/div
Time:20ms/div

Power off SMBus



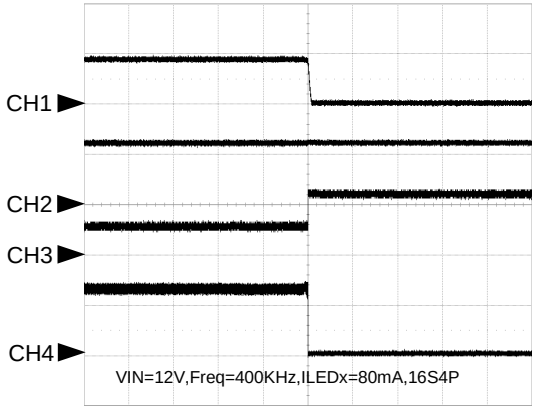
CH1:V_{OUT}-50V/div
CH2:V_{DATA}-5V/div
CH3:V_{LX}-50V/div
CH4:I_{OUT}-500mA/div
Time:20ms/div

Power off EN



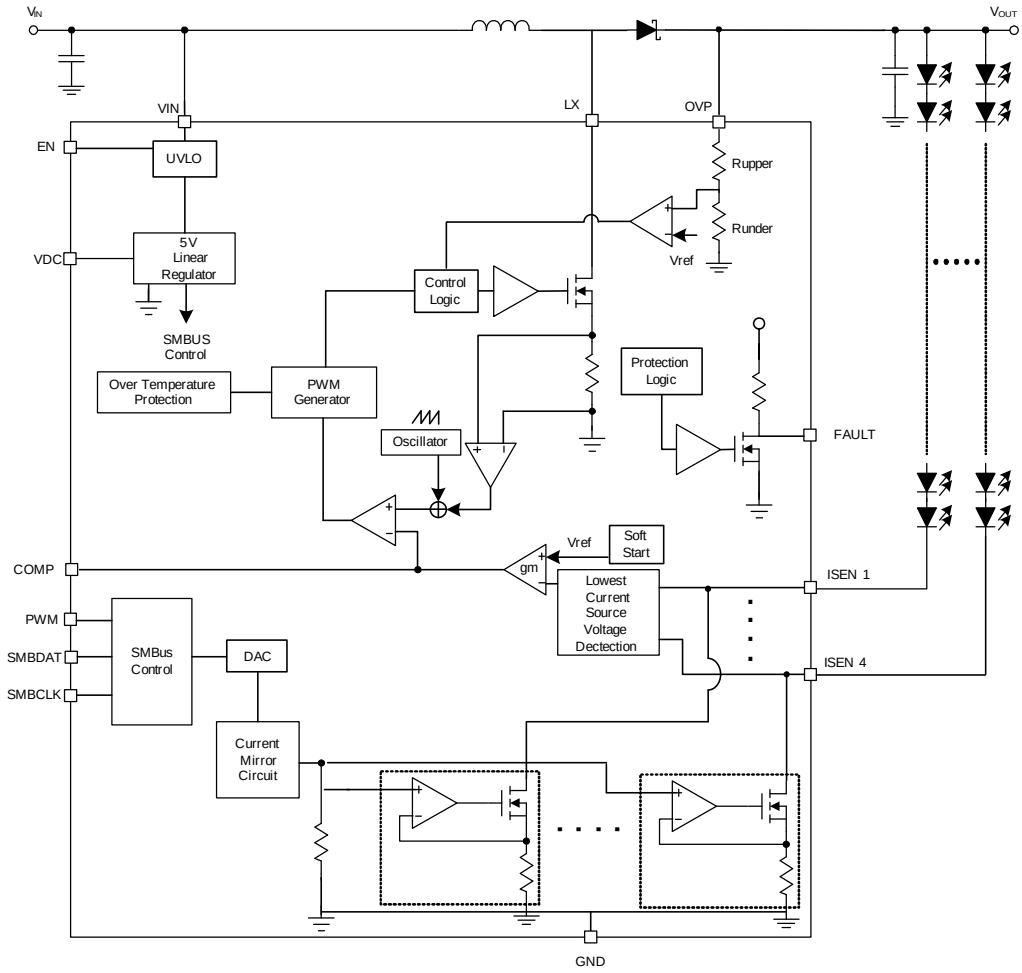
CH1:V_{OUT}-50V/div
CH2:V_{EN}-5V/div
CH3:V_{LX}-50V/div
CH4:I_{OUT}-500mA/div
Time:20ms/div

OCP



CH1:V_{OUT}-50V/div
CH2:V_{IN}-10V/div
CH3:V_{FAULT}-10V/div
CH4:I_{LX}-2A/div
Time:10ms/div

Block Diagram



Typical Application Circuits

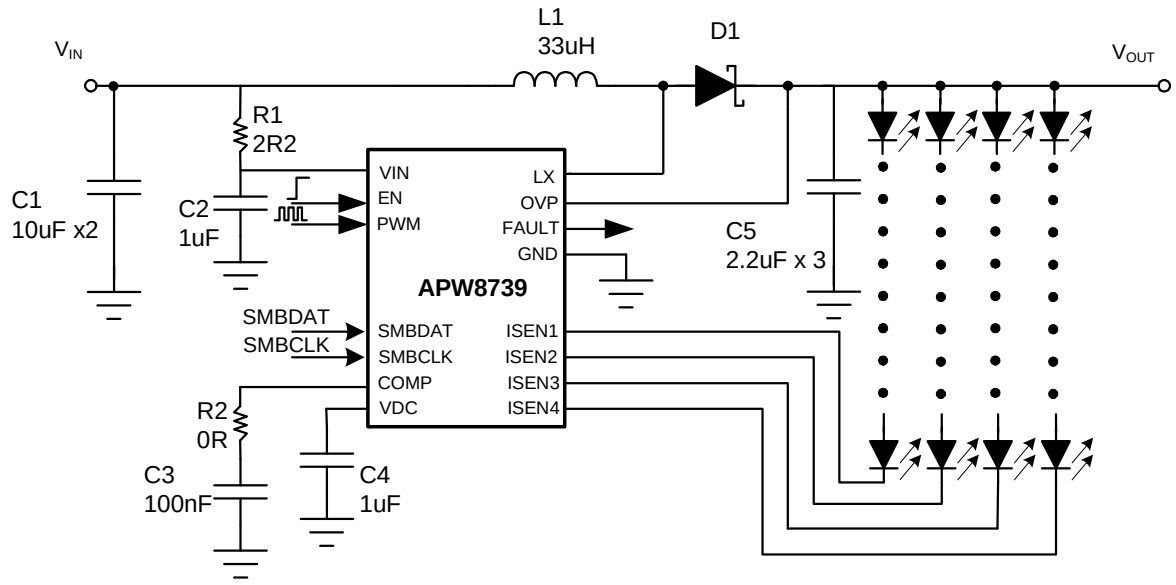


Figure 1: Typical Application

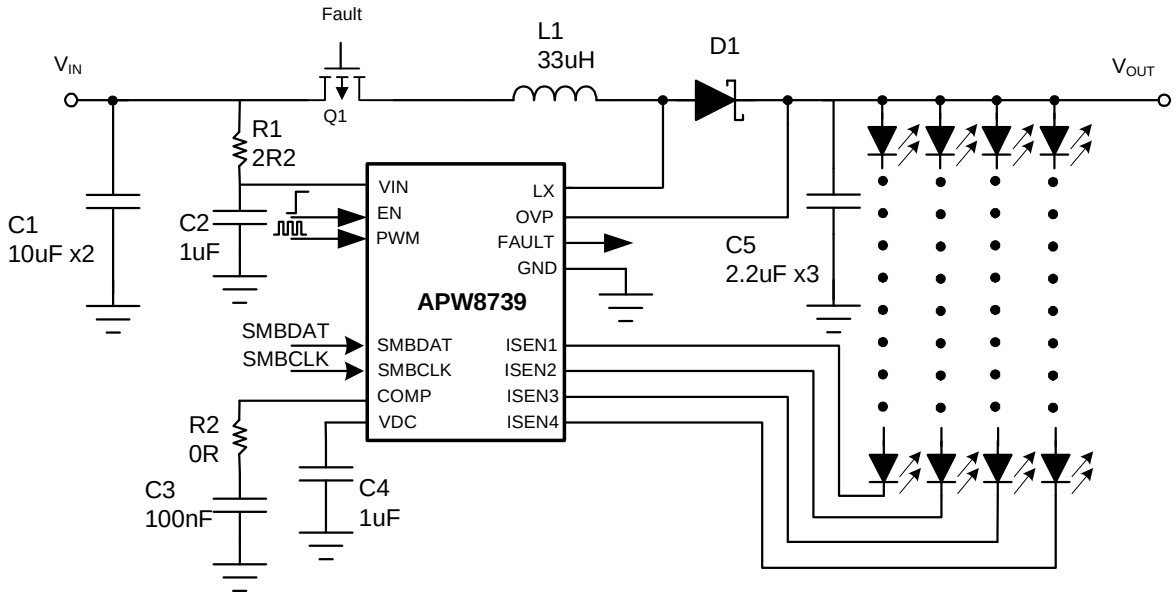


Figure 2: External P-Mosfet Isolation Application

Function Description

The APW8739 is a high efficiency driver for 4 channels of LEDs. It contains an adjustable-frequency current-mode PWM step-up converter, a 5V linear regulator, dimming control circuit. The APW8739 contains 4 channels of voltage controlled current sources with typical currents matching of ±2%, which compensate for the non-uniformity effect of forward voltages variance in the LED stacks. To minimize the voltage headroom and power loss in the typical multi-strings operation, the APW8739 features a dynamic headroom control that monitors the highest LED forward voltage string and uses its feedback signal for output regulation.

Enable and PWM

Driving EN to the ground places the APW8739 in shutdown mode. When in shutdown, the internal gate driver turns off. The PWM can be used for PWM input for dimming. If the dimming function is not used, connect PWM and EN together. The EN and PWM pins cannot be floating, thus a pull-low resistance may needs to be added.

Current Source

The APW8739 integrated 4 matched current sources to maintain uniform LED brightness for LCD backlight application. The maximum LED current is set by register address 02h. LED current adjust range is from 22.58mA to 180mA.

Dimming Controls

The APW8739 allows 3 ways for controlling the output current. DC Mode Dimming: The LED current magnitude is set by maximum current and PWM duty relationship.

$$I_{LED}=I_{MAX} \times \text{PWM Duty}$$

PWM Mode Dimming: Using PWM signal to control LED current, and the LED current frequency is synchronized the PWM frequency. As shown in figure 3.

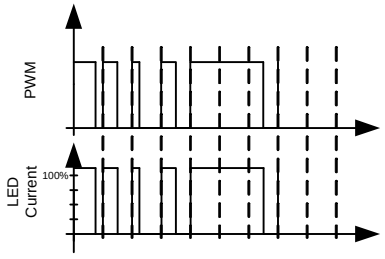


Figure 3: PWM Mode Dimming

Mixed Mode Dimming: The output current dimming was delay 2 cycles.

(i) When 25% < PWM duty < 100% condition, LED output current as DC Mode dimming.

(ii) PWM duty < 25% condition, LED output current magnitude will change to PWM duty decided.

In addition, the using PWM dimming controlled want to low duty dimming control. suggestion the minimum current is must more than 2mA.

LED Current Brightness Selection

The APW8739 allows user to input the duty directly, instead of using signal of PWM pin for calculation. If users would like to input the duty for the DC/ mix mode dimming, configure register as below table 1.

Table 1: LED Brightness Register

Address	Bit	Name	Description
00h	[2]	LED Brightness Selection	Note 5
04h	[7:0]	LED Brightness Control	0%(0x00h) to 100%(0xFFh)

Note 5:

Bit [2]=0 :Dimming control is by PWM pin.

Bit [2]=1 :Dimming control is using register address 04h.

PS: There is no 2 cycles delay when using this register setting to 1.

Dimming Mode Configuration Register

The APW8739 provides control configuration for the users. Its configure registers as below table 2.

Table 2: Dimming Mode Configure Register

Address	Bit	Name	Description
00h	[1:0]	Dimming mode selection	b00: PWM Mode b01: DC Mode b10: Mixed Mode

PS: If the dimming mode command is set b11, the dimming mode is still mixed mode.

Function Description

5V Low Dropout Regulator

A 5V linear regulator is integrating to supply internal circuit and driver. The VDC pin was requires a bypass capacitor of 1uF or more for the regulation. VDC pin had 30mA sourcing capability.

Inrush Current Control and Soft-start

The APW8739 integrates independent inrush current control and soft-start functions. When receiving the STOP bit signal, the APW8739 will start to check PWM duty and then enter soft-start. It's several tens of milliseconds processing soft start and limit less than 2A.

Short Circuit Protection (SCP)

The APW8739 integrates the LED strings short circuit protection (SCP) circuit. Such circuit monitors the voltage on each channel. When any channels exceed short-circuit threshold (5.6V typical), the device disable current channels. All the other good channels work normally. The APW8739 short circuit protection setting by register address 03h.when bit [2] is setting 1 then the function is disabling. On the contrary, the bit [2] is setting to 0, the short strings LED mode will be choose Reset mode or Latch mode. The reset mode is mean LED strings from short condition change to normal then LED current will be recovery to normal state. User is setting latch mode once LED strings short condition is occurs, the particular channel will be off. The short circuit protection register setting is below table 3.

Table 3: Short Circuit Protection Setting Register

Address	Bit	Name	Description
03h	[1]	Short Strings LED mode	0: Reset Mode 1: Latch Mode
	[2]	Short strings LED Enable	0: Enable 1:Disable

Open Circuit Protection (OCP)

The output voltage of APW8739 is regulated according to the minimum current source voltage on all the strings in use. If one or more strings are open, the respective ISEN are pulled to GND (0.1V typical). If any ISEN is below target current, the corresponding current source is disabled. The unaffected LED strings still operate normally. If all strings are open, the APW8739 boost the output voltage of converter high to the OVP threshold and then the device is latched.

Over-Temperature Protection (OTP)

The over-temperature circuit limits the junction temperature of the APW8739. When the junction temperature exceeds 145°C, a thermal sensor turns off the power MOSFET, allowing the devices to cool. The thermal sensor allows the converters to start a soft-start process and to regulate the output voltage again after the junction temperature cools by 20°C. The OTP is designed with a 20°C hysteresis to lower the average Junction Temperature (T_J) during continuous thermal overload conditions, increasing the lifetime of the device.

Under-Voltage Lockout

The Under-Voltage Lockout (UVLO) circuit compares the input voltage with the UVLO threshold (4.3V, typical) to ensure the input voltage is high enough for reliable operation. The 0.2V (typical) hysteresis prevents supply transients from causing a restart.

Over-Current Fault

The address 00h bit [4] is setting OCP function. When that bit set to 1, the device internal counter is start to check OCP process. If OCP continues to occur 128 times, the fault pin will be pulling high. On the contrary, the OCP status is always continues to occur. The over current fault setting is below table 4.

Table 4: Over Current Fault Setting Register

Address	Bit	Name	Description
00h	[4]	OCP Fault	0: Disable 1: Enable

Function Description

Switch Frequency

The APW8739 switch frequency is adjust by register of the address 01h bit [3:0].The switch frequency setting range is from 200KHz to 900KHz (bit [3:0] is setting 02h to 09h).The switch frequency setting is below table 5.

Table 5: Switch Frequency Setting Register

Address	Bit	Name	Description
01h	[3:0]	Switch Frequency	Note 6

Note 6:
(1): Bit [3:0] =00h ~ 02h: Switch frequency is setting=200 KHz
(2): Bit [3:0] =04h: Switch frequency is setting=400 KHz
(3): Bit [3:0] =09h ~ 0Fh: Switch frequency is setting=900 KHz

The adjust switch frequency resolution is around 100 KHz.

Current Limit

The APW8739 had current limit protection. The current limit is setting by register of the address 01h bit [4].The current limit setting is below table 6. The APW8739 is monitoring the inductor current of peak current to prevent over load. When current limit is occurs then current peak is clamp to setting value.

Table 6: Current Limit Setting Register

Address	Bit	Name	Description
01h	[4]	Current Limit	0: 2.2A 1: 3.3A

Over-Voltage Protection (OVP)

The APW8739 had over voltage protection. The OVP value is setting by register of the address 01h bit [6:5], the OVP is can be selection which table 7 below. When the load is open, the converter unceasingly boosts the output voltage high. Therefore, the device is latched in OVP protection is occurs.

Table 7: Over Voltage Protection Setting Register

Address	Bit	Name	Description
01h	[6:5]	Over Voltage	b00: 35V b01: 50V b10: 60V b11: 65V

LED Current Setting

The APW8739 had adjusted LED current function. It's setting by register of the address 02h bit [7:0].The LED current setting is below table 8.

Table 8: LED Current setting Register

Address	Bit	Name	Description
02h	[7:0]	LED current setting	Note 7

Note 7:
(1): Bit [7:0] =00h: LED current setting=0mA
(2): Bit [7:0] =01h ~ 20h: LED current setting=22.58mA
(3): Bit [7:0] =FFh: LED current setting=180mA

The adjust LED current resolution is around 0.706mA.

LED Current Setting

The APW8739 had adjusted LED current function. It's setting by register of the address 02h bit [7:0].The LED current setting is below table 8.

Fault Protection

The APW8739 fault protection function can protect in abnormal state. The fault pin will output a voltage level as same with VIN, which forcing the P-MOSFET to be turned off in P-MOSFET application circuit and to prevent the short current to damage IC or components. The fault pin output voltage be able to clamp to VIN minus 6V make sure the P-MOSFET can be fully turn on at normal operation condition. In addition, the fault function can be choose disable or enable, it's written register address 03h bit [7]. If written to 1 the fault function is enable, on the contrary, the fault function is disable. When fault function is happened, the register address 03h bit[0] will be 0 change to 1.If the fault function want to cleared, User could setting register address 03h bit[3] written to 1.Finally, The fault protection setting show as below table 9.
When the Fault pin will be turns high condition has schottky diode shorted, output voltage shorted to ground and OCP fault setting is enable.

Function Description

Table 9: Fault Protection setting Register

Address	Bit	Name	Default Value	Description	R/W
03h	[0]	Monitor fault condition	---	Detect fault condition happen or not (Read only).	R
	[3]	Fault flag could be cleared by SMBus	Original State (0)	0:Keep the original state 1:Clear fault flag	R/W
	[7]	Fault function enable	Enable (1)	0:Disable 1:Enable	R/W

SMBus Dimming

The APW8739 had an SMBus Dimming function setting by register address 04h bit[7:0].The dimming control range is from 0% to 100%,the dimming control current resolution to every step is around 0.392%. The SMBus dimming control setting function register as below table 10.

Table 10: SMBus Dimming Control setting Register

Address	Bit	Name	Default Value	Description	Resolution	R/W
04h	[7:0]	SMBus Dimming Control	0%	0x00:0% 0xFF :100%	0.392%	R/W

LED Current Written Check

The APW8739 had LED current check function. The function is providing users to check LED current greater than zero. The LED current is zero than the bit will be changed to 1. The LED current check function register as below table 11. In additional, the register address 06h bit[6:4] is able to read vendor code ID.

Table 11: LED Current check setting Register

Address	Bit	Name	Default Value	Description	R/W
06h	[7]	LED Current Check	LED Current=0 (1)	0: LED Current Setting>0 1: LED Current Setting=0	R
06h	[6:4]	Vendor ID	Vendor ID (b110)	Vendor ID	R

Function Description

Table 12: Register Map

Slave Address : b0110001							
Address	Bit	Name	Default Value	Description	Resolution	Range	R/W
00h	[1:0]	Dimming Mode Selection	PWM Mode(b01)	b00:PWM Mode b01:DC Mode b10:Mixed Mode	--	--	R/W
	[2]	LED Brightness Selection	PWM Pin(b0)	b0: depend on the status of PWM pin b1: depend on address:04h data (note 8)	--	--	R/W
	[4]	OCP Fault	Disable(0)	b0: Disable b1: Enable	--	--	
	[7]	OVP Reset	Disable(0)	b0: Disable b1: Enable	--	--	R/W
01h	[3:0]	Boost Switching Frequency	400kHz (0x04h)	0x04h:400kHz Between the code 0x00h and 0x02h are equal to 200kHz. Between the code 0x09h and 0x0fh are equal to 900kHz.	~100kHz (0x02h to 0x09h)	200kHz(0x02h) to 900kHz(0x09h)	R/W
	[4]	Switching Current Limitation Selection	3.3A(b1)	Boost Switch Current Limitation. b0:0.6667x3.3A b1:3.3A	--	--	R/W
	[6:5]	Over Voltage Protection Selection	65V (b11)	Boost Output Over Voltage Protection. b11:65V b10:60V b01:50V b00:35V	--	35V(b00) to 65V (b11)	R/W
02h	[7:0]	LED Current Setting	0mA (0x00h)	Control the Max Current 0xFFh:180mA 0x20h:22.58mA 0x00h:0mA Between the code 0x01h and 0x20h are equal to 22.58mA	~0.706mA(0xFFh to 0x20h)	180mA(0xFFh) to 22.58mA(0x20h)	R/W
03h	[0]	Fault Flag	--	Monitor Fault Condition. 0: not detected fault 1: detected fault (Note 9)	--	--	R
	[1]	Short LED Protection Latch Selection	Reset Mode (0)	0: Reset Mode 1: Latch Mode	--	--	R/W
	[2]	Short LED Protection	Enable (0)	0: Enable 1: Disable	--	--	R/W
	[3]	Fault Flag Clear	Original State (0)	Fault Flag Could is Cleared By SMBus. 0: keep the original state 1: clear fault flag	--	--	R/W

Function Description

Table 12: Register Map

Slave Address : b0110001							
Address	Bit	Name	Default Value	Description	Resolution	Range	R/W
	[7]	Fault Function enable	Enable (1)	Fault Function Enable. 0:Disable 1:Enable	--	--	R/W
04h	[7:0]	LED Brightness Control	0%(0x00h)	0x00h: 0% 0xFFh: 100%	0.392%	0%(0x00h) to 100%(0xFFh)	R/W
06h	[6:4]	Vendor ID	Vendor ID (b110)	Vendor ID	--	--	R
06h	[7]	LED Current Check	LED Current (0/1)	0:LED Current Setting > 0 1:LED Current Setting = 0	--	--	R

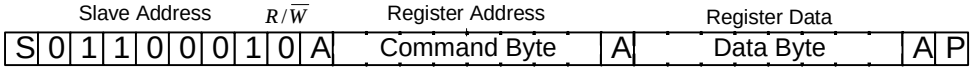
Note 8: When dimming mode is set as direct PWM, brightness must be controlled by PWM pin only.

Note 9: There are 2 fault conditions which activate the flag. One is the switching pin shorted to ground; another is the shorted schottky diode.

SMBus Write Timing Sequence

Write 1 byte

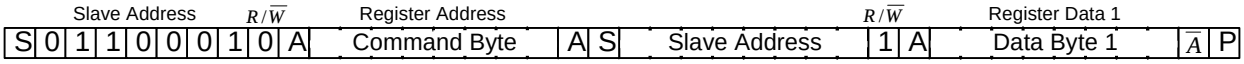
(Command byte is sent after the address and detemines which register receives the data that follows the command byte.)



SMBus Read Timing Sequence

Read 1 byte

(Command byte is sent after the address and detemines which register is accessed. After a start, the Device address is sent again and LSB is set to logic 1. Data defined by command byte then is sent by APW8739.)



Timing Diagram

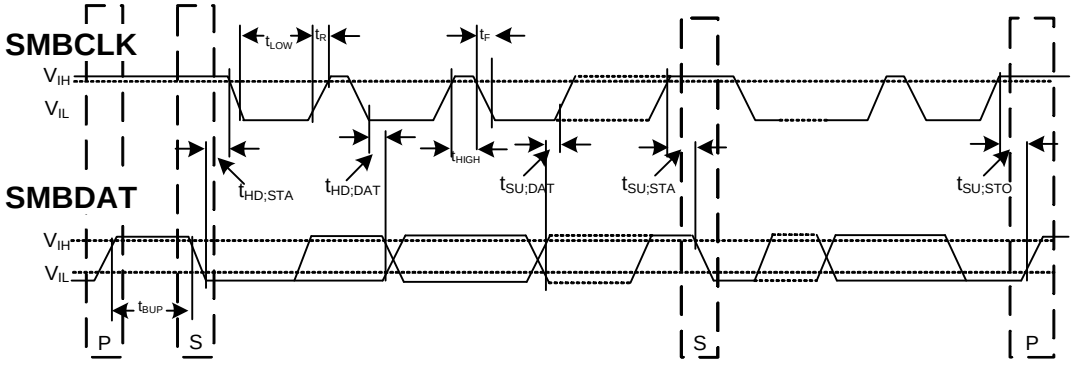


Figure 4: SMBus Common AC Specification

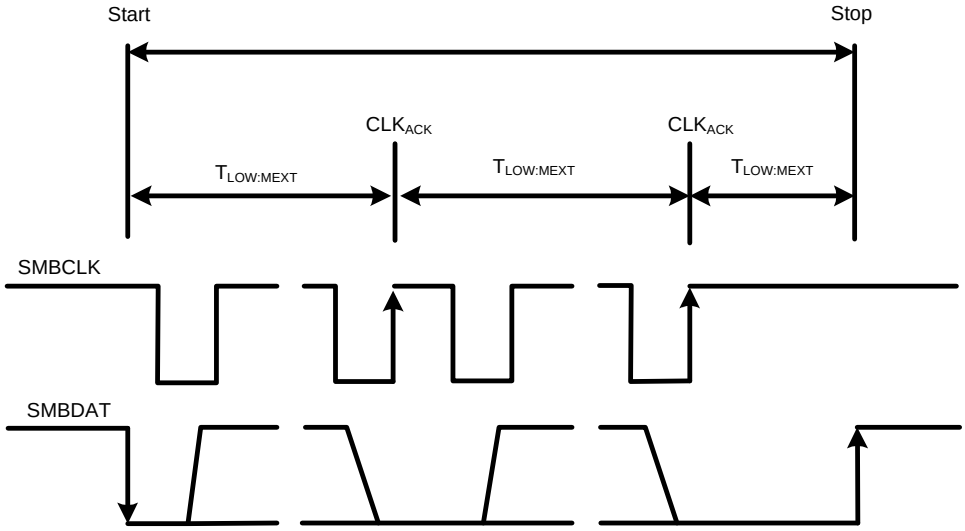


Figure 5: Timing Diagram of SMBus Timeout

Timing Diagram

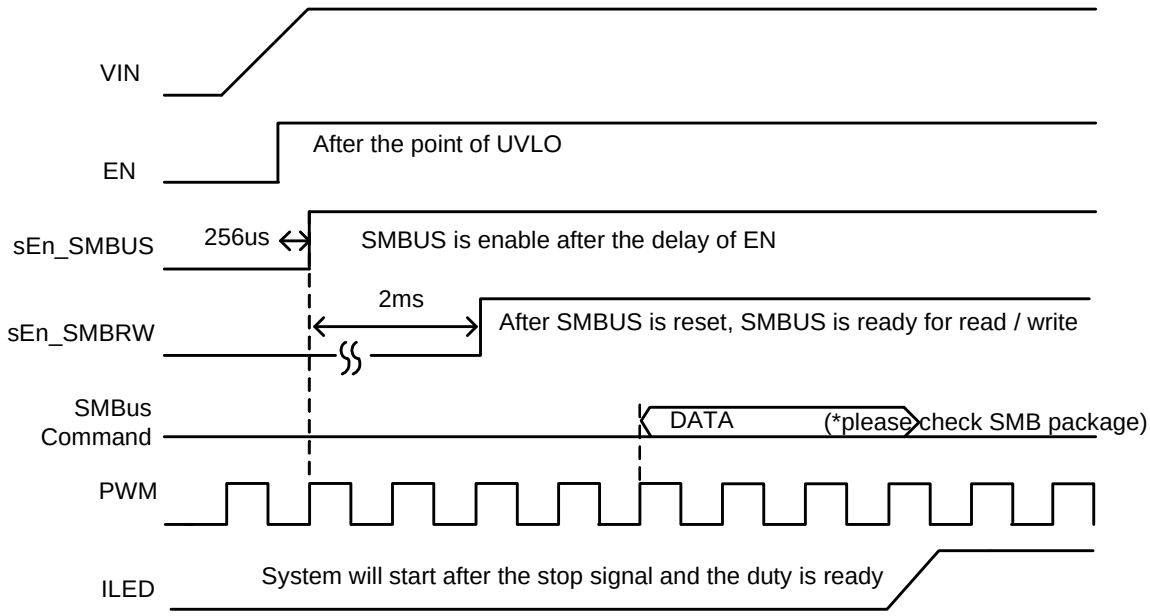


Figure 6: Power On Sequence

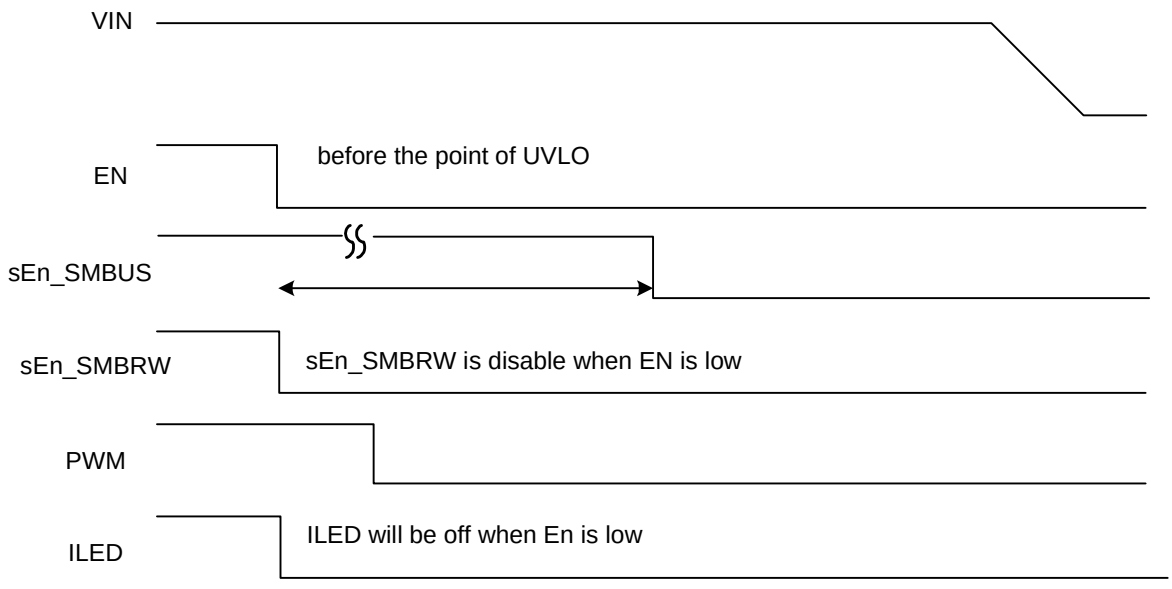


Figure 7: Power Off Sequence

Application Information

Supply Voltage Capacitor Selection

The APW8739 equips a built-in LDO linear regulator to provide the internal logic of IC power. The output of LDO is the pin out of VDC. The VDC pin is recommended to connect at least a 1uF bypass capacitor. The bypass capacitor should be X5R or X7R type to assure the bypass capacitance remains stable in over voltage or over temperature.

Input Capacitor Selection

The ceramic capacitors are recommended for input capacitor applications. Low ESR will effectively reduce the input voltage ripple caused by switching operation. Two 10uF capacitors are sufficient for most applications. Nevertheless, this value can be decreased for lower output current requirement. Another consideration is the voltage rating of the input capacitor must be greater than the maximum input voltage.

Diode Selection

Schottky diodes are recommended for most applications because of their fast recovery time and low forward voltage. Power dissipation, reverse voltage rating, and pulsating peak current are important parameters for consideration when making a Schottky diode selection. Make sure that the diode's peak current rating exceeds IPEAK an reverse voltage rating exceeds the maximum output voltage.

Inductor Selection

The value of the inductance, L, can be approximated by the following equation, where the transition is form discontinuous conduction mode (DCM) to continuous conduction mode (CCM):

The duty cycle, D, can be calculated as the following equation:

$$D = \frac{V_{OUT} - V_{IN}}{V_{OUT}}$$

Where VOUT is the maximum output voltage, VIN is the minimum input voltage, FSW is the operating frequency and IOUT is the sum of current from all LED strings. The boost converter operates in DCM over the entire input voltage range when the inductor value is less than this value, L. with an inductance greater than L, the converter operates in CCM at the minimum input voltage and may be discontinuous at higher voltages.

The inductor must be selected with a saturated current rating that is greater than the peak current and the peak current must be below the current limit threshold (3.3A typ) as provided by the following equation:

$$I_{PEAK} = \frac{V_{OUT} \times I_{OUT}}{\eta \times V_{IN}} + \frac{V_{IN} \times D \times T_{SW}}{2 \times L}$$

Where η is the efficiency of the power converter. Moreover, the slope of inductor current also is considered as the following question.

$$L > \frac{V_{OUT} - V_{IN}}{1.68 \times 10^{6}}$$

Please pay attention for it , the inductance minimum value does not smaller than the criteria.

Output Capacitor Selection

Output ripple voltage is an important index for estimating the performance. This portion consists of two parts, one is the ESR voltage of output capacitor, and another part is formed by charging and discharging process of output capacitor. Refer to figure , evaluate Δ_{VOUT1} by ideal energy equalization. According to the definition of Q_1, the Q value can be calculated as the following equation:

$$Q = \frac{1}{2} \times \left[\left(I_{IN} + \frac{1}{2} \Delta I_L - I_{OUT} \right) + \left(I_{IN} - \frac{1}{2} \Delta I_L - I_{OUT} \right) \right] \times \frac{V_{IN}}{V_{OUT}} \times \frac{1}{F_{SW}} = C_{OUT} \times \Delta V_{OUT1}$$

Application Information

Where F_{SW} is the switching frequency, and ΔI_L is the inductor ripple. Mover C_{OUT} to the left side to estimate the value of ΔV_{OUT1} as the following equation:

$$\Delta V_{OUT1} = \frac{D \times I_{OUT}}{\eta \times C_{OUT} \times F_{SW}}$$

Then, take the ESR into consideration, the ESR voltage can be determined as the following equation:

$$\Delta V_{ESR} = \left(\frac{I_{OUT}}{1-D} + \frac{V_{IN} \times D \times T_{SW}}{2L} \right) \times R_{ESR}$$

Finally, the total output ripple ΔV_{OUT} is combined from the ΔV_{OUT1} and ΔV_{ESR}. In the general application, the output capacitor is recommended to use a 47uF electrolytic capacitor.

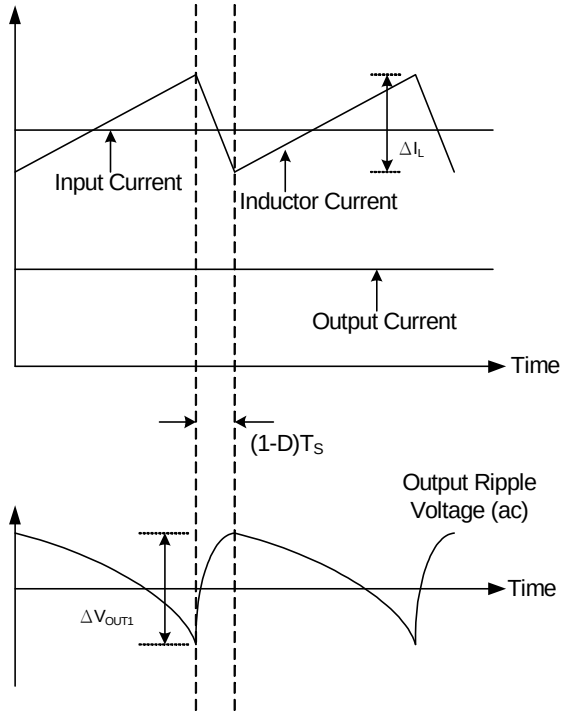
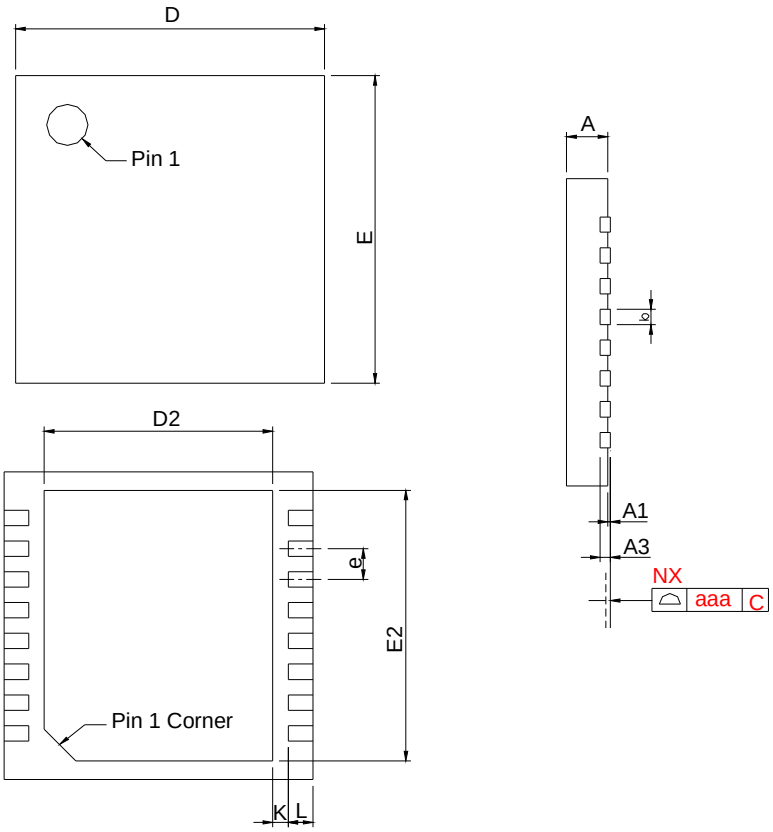


Figure 7: The Output Ripple Voltage without the Contribution of ESR

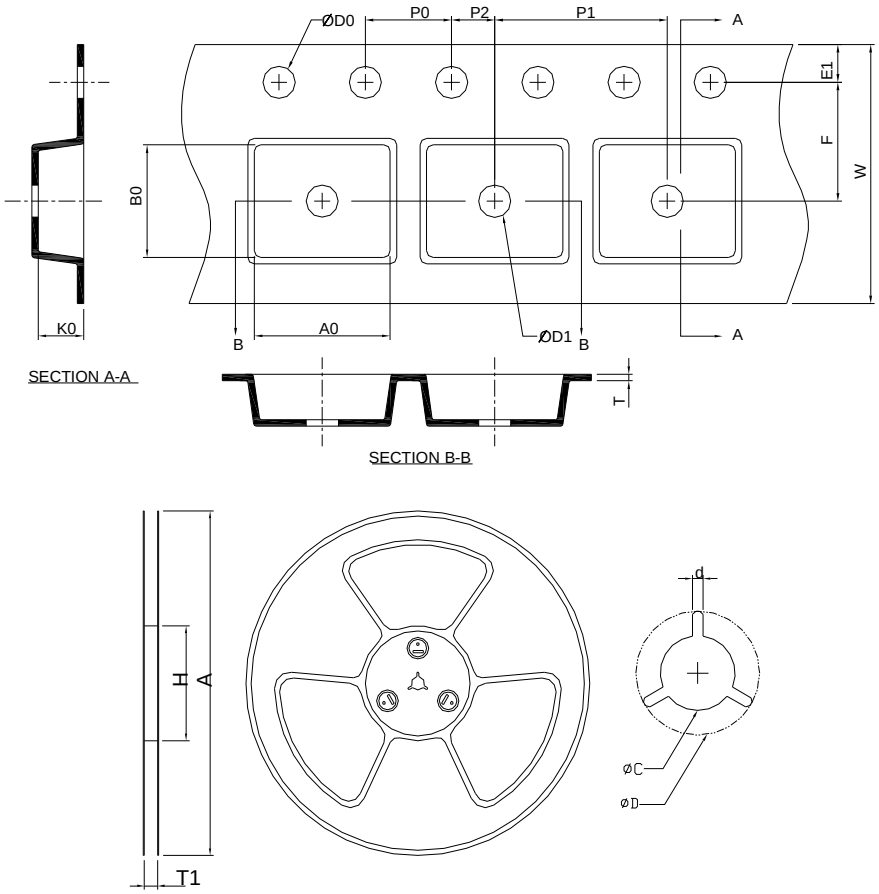
Package Information

TDFN5x5-16



SYMBOL	TDFN5*5-16			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.70	0.80	0.028	0.031
A1	0.00	0.05	0.000	0.002
A3	0.20 REF		0.008 REF	
b	0.20	0.30	0.008	0.012
D	4.90	5.10	0.193	0.201
D2	3.60	3.80	0.142	0.150
E	4.90	5.10	0.193	0.201
E2	4.30	4.50	0.169	0.177
e	0.50 BSC		0.020 BSC	
L	0.35	0.45	0.014	0.018
K	0.20		0.008	
aaa	0.08		0.003	

Carrier Tape & Reel Dimensions



Application	A	H	T1	C	d	D	W	E1	F
TDFN5x5	330.0±2.00	50 MIN.	12.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	12.0±0.30	1.75±0.10	5.5±0.10
	P0	**P1**	**P2**	**D0**	**D1**	**T**	**A0**	**B0**	**K0**
	4.0±0.10	8.0±0.10	2.0±0.10	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	5.35±0.20	5.35±0.20	1.00±0.20

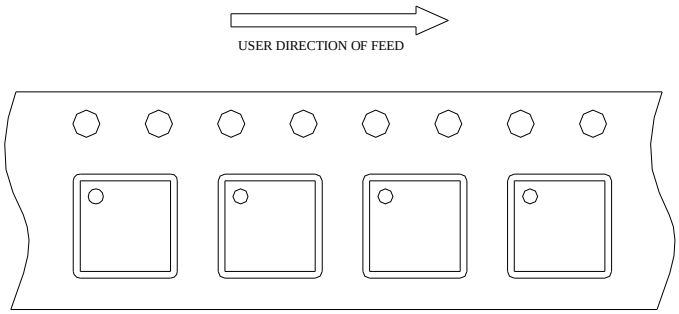
(mm)

Devices Per Unit

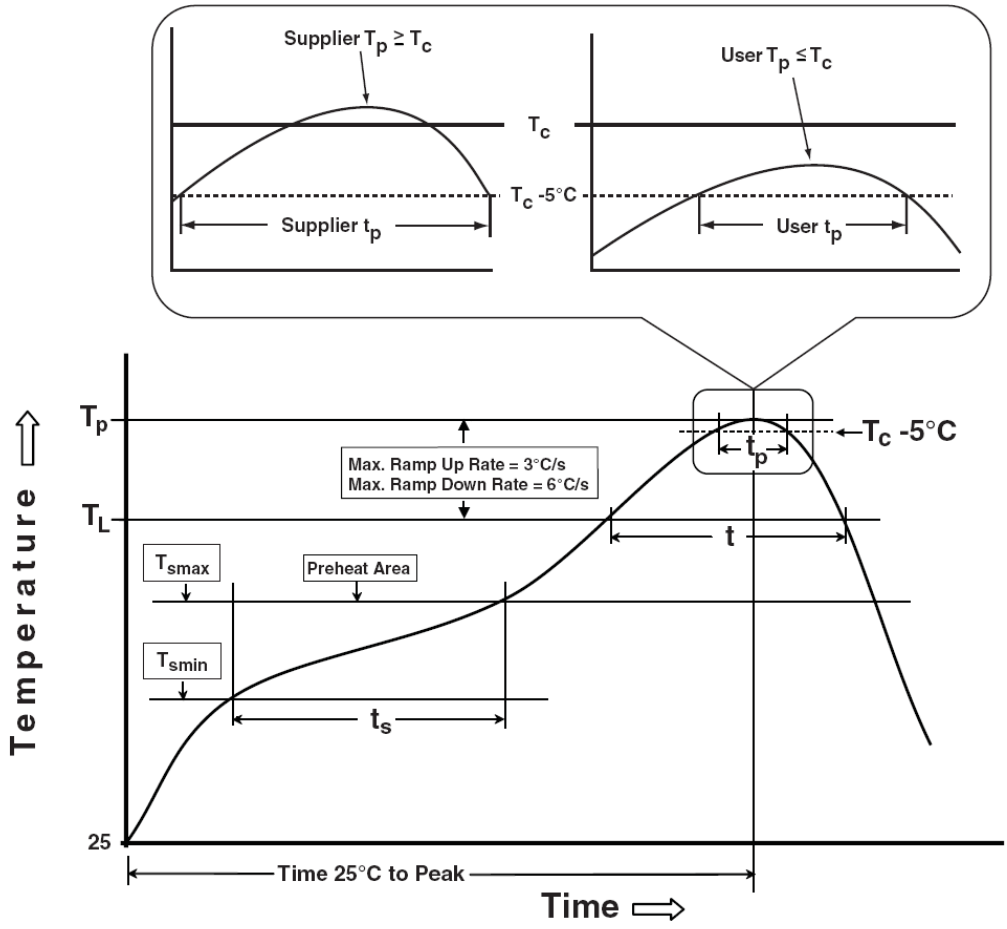
Package Type	Unit	Quantity
TDFN5x5-16	Tape & Reel	2500

Taping Direction Information

TDFN5x5-16



Classification Profile



Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Preheat & Soak Temperature min (T_{smin}) Temperature max (T_{smax}) Time (T_{smin} to T_{smax}) (t_s)	100 °C 150 °C 60-120 seconds	150 °C 200 °C 60-120 seconds
Average ramp-up rate (T_{smax} to T_P)	3 °C/second max.	3°C/second max.
Liquidous temperature (T_L) Time at liquidous (t_L)	183 °C 60-150 seconds	217 °C 60-150 seconds
Peak package body Temperature (T_p)*	See Classification Temp in table 1	See Classification Temp in table 2
Time (t_P)** within 5°C of the specified classification temperature (T_c)	20** seconds	30** seconds
Average ramp-down rate (T_p to T_{smax})	6 °C/second max.	6 °C/second max.
Time 25°C to peak temperature	6 minutes max.	8 minutes max.
* Tolerance for peak profile Temperature (T_p) is defined as a supplier minimum and a user maximum. ** Tolerance for time at peak profile temperature (t_p) is defined as a supplier minimum and a user maximum.		

Table 1. SnPb Eutectic Process – Classification Temperatures (Tc)

Package Thickness	Volume mm^3 <350	Volume mm^3 ³350
<2.5 mm	235 °C	220 °C
≥2.5 mm	220 °C	220 °C

Table 2. Pb-free Process – Classification Temperatures (Tc)

Package Thickness	Volume mm^3 <350	Volume mm^3 350-2000	Volume mm^3 >2000
<1.6 mm	260 °C	260 °C	260 °C
1.6 mm – 2.5 mm	260 °C	250 °C	245 °C
≥2.5 mm	250 °C	245 °C	245 °C

Reliability Test Program

Test item	Method	Description
SOLDERABILITY	JESD-22, B102	5 Sec, 245°C
HOLT	JESD-22, A108	1000 Hrs, Bias @ Tj=125°C
PCT	JESD-22, A102	168 Hrs, 100%RH, 2atm, 121°C
TCT	JESD-22, A104	500 Cycles, -65°C~150°C
HBM	MIL-STD-883-3015.7	VHBM≧2KV
MM	JESD-22, A115	VMM≧200V
Latch-Up	JESD 78	10ms, 1_{tr}≧100mA

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