RoHS

COMPLIANT

HALOGEN FREE



Integrated DrMOS Power Stage

DESCRIPTION

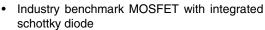
The SiC780 is an integrated power stage solution optimized for synchronous buck applications offering high current, high efficiency and high power density. Packaged in Vishay's proprietary 6 mm x 6 mm MLP package, SiC780 enables voltage regulator designs to deliver in excess of 50 A per phase current with 93 % peak efficiency.

The internal Power MOSFETs utilize Vishay's state-of-the-art TrenchFET Gen III Technology that delivers industry benchmark performance by significantly reducing switching and conduction losses.

The SiC780 incorporates an advanced MOSFET gate driver IC that features high current driving capability, adaptive dead-time control, and integrated bootstrap Schottky diode, and a thermal warning (THDN) that alerts the system of excessive junction temperature. The driver is also compatible with a wide range of PWM controllers and supports Tri-state PWM, 3.3 V(SiC780ACD)/5 V (SiC780CD) PWM Logic, and skip mode (SMOD) to improve light load efficiency.

FEATURES







- 93 % peak efficiency
- High frequency operation up to 1 MHz
- · Power MOSFETs optimized for 12 V input stage
- 3.3 V (SiC780ACD)/5 V (SiC780CD) PWM logic with Tri-state and hold-off
- SMOD logic for light load efficiency boost
- Low PWM propagation delay (< 20 ns)
- Thermal monitor flag
- Enable feature
- V_{CIN} UVLO
- Compliant with Intel DrMOS 4.0 specification
- Material categorization: For definitions of compliance please see www.vishav.com/doc?99912

APPLICATIONS

- Synchronous buck converters
- Multi-phase VRDs for CPU, GPU and memory
- DC/DC POL modules

TYPICAL APPLICATION DIAGRAMM

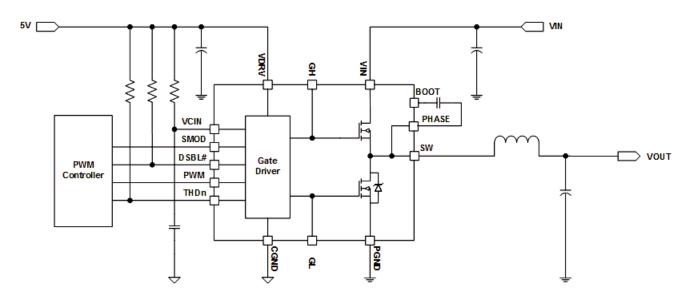


Figure 1: SiC780 Typical Application Diagram

PIN CONFIGURATION - Bottom View



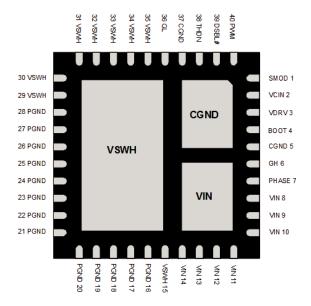
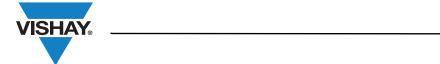


Figure 2 - SiC780 Pin Configuration

PIN DESCRIPTION					
Pin Number	Symbol	Description			
1	SMOD#	LS FET turn-off logic. Active low			
2	V _{CIN}	Supply voltage for internal logic circuitry			
3	V _{DRV}	Supply voltage for internal gate driver			
4	BOOT	High side driver bootstrap voltage			
5, 37, P1	C _{GND}	Analog ground for the driver IC			
6	GH	High side gate signal			
7	PHASE	Return path of HS Gate driver			
8 to 14, P2	V _{IN}	Power stage input voltage. Drain of high side MOSFET			
15, 29 to 35, P3	V _{SWH}	Phase node of the power stage			
16 to 28	P _{GND}	Power ground			
36	GL	Low side gate signal			
38	THDN	Thermal shutdown open drain output			
39	DSBL#	Disable pin. Active low			
40	PWM	PWM input logic			



ORDERING INFORMATION						
Part Number	Package	Marking Code				
SiC780CD-T1-GE3	PowerPAK MLP66-40L	SiC780				
SiC780ACD-T1-GE3	PowerPAK MLP66-40L	SiC780A				
SiC780DB	Reference	Board				

ABSOLUTE MAXIMUM RATINGS (1)						
Electrical Parameter	Symbol	Limits	Unit			
Input Voltage	V _{IN}	- 0.3 to 22				
Control Input Voltage	V _{CIN}	- 0.3 to 7				
Drive Input Voltage	V _{DRV}	- 0.3 to 7				
Switch Node (DC)	V _{SW}	- 0.3 to 22	٧			
Switch Node (AC) (2)	V _{SW}	- 0.3 to 27	V			
Boot Voltage (DC Voltage)	V _{BS}	- 0.3 to 29				
Boot to Switching Node (DC Voltage)	V _{BS_SW}	- 0.3 to 7				
All Logic Inputs and Outputs (PWM, DSBL, SMOD and THDN)		- 0.3 to V _{CIN} + 0.3				
Max. Operating Junction Temperature	T _J	150				
Ambient Temperature	T _A	- 40 to 125	°C			
Storage Temperature		- 65 to 150				

Notes:

2. The specification values indicated "AC" is $\rm V_{SW}$ to $\rm P_{GND}$ 27 V (< 50 ns), max.

RECOMMENDED OPERATING CONDITIONS						
Parameter	Min.	Тур.	Max.	Unit		
Input Voltage (V _{IN})	4.5		18			
Drive Input Voltage (V _{DRV})	4.5	5	5.5			
Control Input Voltage (V _{CIN})	4.5	5	5.5	V		
Switching Node (LX, DC Voltage)			19			
BOOT-SW	4	4.5	5.5			

THERMAL RESISTANCE RATINGS				
Parameter	Min.	Тур.	Max.	Unit
Thermal Resistance from Junction to Case (to P3 PAD (V _{SHW})		2.5		°C/W
Thermal Resistance from Junction to PCB		5		O/ VV

^{1.} Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

SiC780, SiC780A

Vishay Siliconix



ELECTRICAL SPECIFICATIO	NS					
Parameter	Symbol	Test Conditions Unless Specified $V_{DSBL\#} = 5 \text{ V, } V_{SMOD} = 5 \text{ V,}$ $V_{IN} = 12 \text{ V, } V_{DRV} = V_{CIN} = 5 \text{ V,}$ $T_A = 25 \text{ °C}$	Min. ⁽³⁾	Тур. ⁽¹⁾	Max. ⁽³⁾	Unit
Power Supplies						
		V _{DSBL#} = 0 V, no switching		100		
V _{CIN} Control Logic Input Current	I _{VCIN}	$V_{DSBL\#} = 5 \text{ V}$, no switching		300		μΑ
		$V_{DSBL\#} = 5 \text{ V, } f_{S} = 300 \text{ kHz, } D = 0.1$		300		
Drive Input Current (Dynamic)		f _s = 300 kHz, D = 0.1		16	25	mA
Drive input Current (Dynamic)	L	f _s = 1 MHz, D = 0.1		60		ША
Drive Input Current (No Switching)	I _{VDRV}	V _{DSBL#} = 0 V, no switching		30		μΑ
Drive input ourient (No Switching)		$V_{DSBL\#} = 5 \text{ V}$, no switching		60		μΛ
Bootstrap Supply						
Bootstrap Switch Forward Voltage	V _F	V _{CIN} = 5 V, forward bias current 2 mA			0.4	V
PWM Control Input (SiC780CD)						
Rising Threshold	V _{th_pwm_r}		3.4	3.7	4.2	
Falling Threshold	V _{th_pwm_f}		0.7	0.9	1.2	
Tri-state Voltage	V _{tri}	PWM pin floating		2.3		V
Tri-state Rising Threshold	V _{th_tri_r}		0.9		1.5	
Tri-state Falling Threshold	$V_{th_tri_f}$		3	3.4	3.7	
Tri-state Rising Threshold Hysteresis	V _{hys_tri_r}			225		mV
Tri-state Falling Threshold Hysteresis	V _{hys_tri_f}			325		111 V
PWM Input Current		V _{PWM} = 5 V			500	μΑ
r www imput Guiterit	I _{PWM}	V _{PWM} = 0 V			- 500	μΑ
PWM Control Input (SiC780ACD)						
Rising Threshold	V _{th_pwm_r}		2.1	2.4	2.8	
Falling Threshold	V _{th_pwm_f}		0.7	0.9	1.2	
Tri-state Voltage	V _{tri}	PWM pin floating		1.8		V
Tri-state Rising Threshold	V _{th_tri_r}		0.9		1.5	
Tri-state Falling Threshold	V _{th_tri_f}		1.9	2.2	2.6	
Tri-state Rising Threshold Hysteresis	V _{hys_tri_r}			225		mV
Tri-state Falling Threshold Hysteresis	V _{hys_tri_f}			275		1117
PWM Input Current		V _{PWM} = 3.3 V			300	μΑ
i www.mput Ourient	I _{PWM}	V _{PWM} = 0 V			- 300	μΛ

- 1. Typical limits are established by characterization and are not production tested.
- 2. Guaranteed by design.
- 3. Min. and max. parameters are not 100 % production tested.





ELECTRICAL SPECIFICATIO	NS					
Parameter	Symbol	Test Conditions Unless Specified $V_{DSBL\#} = V_{SMOD} = 5 \text{ V},$ $V_{IN} = 12 \text{ V}, V_{VDRV} = V_{VCIN} = 5 \text{ V},$ $T_A = 25 \text{ °C}$	Min. ⁽³⁾	Typ. ⁽¹⁾	Max. ⁽³⁾	Unit
Timing Specifications						
Tri-State to GH/GL Rising Propagation Delay	T _{PD_R_Tri}			20		
Tri-state Hold-Off Time	T _{TSHO}			150		
GH - Turn Off Propagation Delay	T _{PD_OFF_GH}			20		
GH - Turn ON Propagation Delay (Dead Time Rising)	T _{PD_ON_GH}	No load, see fig. 4.		10		
GL - Turn Off Propagation Delay	T _{PD_OFF_GL}			20		ns
GL - Turn On Propagation Delay (Dead Time Falling)	T _{PD_ON_GL}			10		
DSBL# Hi to GH/GL Rising Propagation Delay	T _{PD_R_DSBL}			22		
DSBL# Lo to GH/GL Falling Propagation Delay	T _{PD_F_DSBL}			10		
DSBL#, SMOD INPUT			•			
DSBL# Logic Input Voltage	V	Enable	2			
DSBL# Logic input voltage	V _{DSBL}	Disenable			0.8	V
SMOD Logic Input Voltage	V _{SMOD}	High State	2			
OWOD Logic input voltage	▼SMOD	Low State			0.8	
Protection						
Under Voltage Lockout	V _{UVLO}	Rising, On Threshold		3.7	4.3	٧
Chack Foliago Lookout	VUVLO	Falling, Off Threshold	2.7	3.2		•
Under Voltage Lockout Hysteresis				550		mV
THDn Flag Set		Note 2		160		
THDn Flag Clear		11010 2		135		°C
THDn Flag Hysteresis				25		
THDn Output Low				0.02		V

^{1.} Typical limits are established by characterization and are not production tested.

^{2.} Guaranteed by design.

^{3.} Min. and max. parameters are not 100 % production tested.

DETAILED OPERATIONAL DESCRIPTION

PWM Input with Tri-state Function

The PWM input receives the PWM control signal from the VR controller IC. The PWM input is designed to be compatible with standard controllers using two state logic (H and L) and advanced controllers that incorporate Tri-state logic (H, L and Tri-state) on the PWM output. For two state logic, the PWM input operates as follows. When PWM is driven above $V_{th_pwm_r}$ the low side is turned OFF and the high side is turned ON. When PWM input is driven below V_{th pwm f} the high side turns off and the Low side turns on. For Tri-state logic, the PWM input operates as above for driving the MOSFETs. However, there is an third state that is entered into as the PWM output of Tri-state compatible controller enters its high impedance state during shut-down. The high impedance state of the controller's PWM output allows the SiC780A to pull the PWM input into the Tri-state region (see the Tri-state Voltage Threshold Diagram below). If the PWM input stays in this region for the Tri-state Hold-Off Period, t_{TSHO} , both high side and low side MOSFETs are turned off. This function allows the VR phase to be disabled without negative output voltage swing caused by inductor ringing and saves a schottky diode clamp. The PWM and Tri-state regions are separated by hysteresis to prevent false triggering. The SiC780ACD incorporates PWM voltage thresholds that are compatible with 3.3 V logic, and SiC780CD is 5 V logic.

Disable (DSBL#)

In the low state, the DSBL# pin shuts down the driver IC and disables both high-side and low-side MOSFET. In this state, the standby current is minimized. If DSBL# is left unconnected an internal pull-down resistor will pull the pin down to C_{GND} and shut down the IC.

Diode Emulation Mode (SMOD) Skip

When SMOD pin is low the diode emulation mode is enabled and GL is turned off. This is a non-synchronous conversion mode that improves light load efficiency reducing switching losses. Conducted losses that occur in synchronous buck regulators when inductor current is negative can also be reduced. Circuitry in the external controller IC detects when inductor current crosses zero and drive SMOD Lo turning the low side MOSFET off. See SMOD Operation diagram for additional details. This function can be also be used for a pre-biased output voltage. If SMOD is left unconnected, an internal pull up resistor will pull the pin up to V_{CIN} (Logic High) to disable the SMOD function.

Thermal Shutdown Warning (THDN)

The THDN pin is an open drain signal that flags the presence of excessive junction temperature. Connect a maximum of 20 $k\Omega$ to pull this pin up to V_{CIN} . An internal temperature sensor detects the junction temperature. The temperature threshold is 160 °C. When this junction temperature is exceeded the THDN flag is set. When the junction temperature drops below 135 °C the device will clear the THDN signal. The SiC780 does not stop



operation when the flag is set. The decision to shutdown must be made by an external thermal control function.

Voltage Input (V_{IN})

This is the power input to the drain of the high-side Power MOSFET. This pin is connected to the high power intermediate BUS rail.

Switch Node (V_{SWH} and PHASE)

The Switch node V_{SWH} is the circuit PWM regulated output. This is the output applied to the filter circuit to deliver the regulated high output for the buck converter. The PHASE pin is internally connected to the switch node V_{SWH}. This pin is to be used exclusively as the return pin for the BOOT capacitor. A 20.2 k Ω resistor is connected between GH and PHASE to provide a discharge path for the HS MOSFET in the event that V_{CIN} goes to zero while V_{IN} is still applied.

Ground connections (C_{GND} and P_{GND})

P_{GND} (power ground) should be externally connected to C_{GND} (control signal ground). The layout of the Printed Circuit Board should be such that the inductance separating the $C_{\mbox{\footnotesize GND}}$ and $P_{\mbox{\footnotesize GND}}$ should be a minimum. Transient differences due to inductance effects between these two pins should not exceed 0.5 V.

Control and Drive Supply Voltage Input (V_{DRV},V_{CIN})

V_{CIN} is the bias supply for the gate drive control IC. V_{DRV} is the bias supply for the gate drivers. It is recommended to separate these pins through a resistor. This creates a low pass filtering effect to avoid coupling of high frequency gate drive noise into the IC.

Bootstrap Circuit (BOOT)

The internal bootstrap switch and an external bootstrap capacitor form a charge pump that supplies voltage to the BOOT pin. An integrated bootstrap diode is incorporated so that only an external capacitor is necessary to complete the bootstrap circuit. Connect a boot strap capacitor with one leg tied to BOOT pin and the other tied to PHASE pin. Shoot-Through Protection and Adaptive Dead Time

Shoot-Through Protection and Adaptive Dead Time

The SiC780A has an internal adaptive logic to avoid shoot through and optimize dead time. The shoot through protection ensures that both high-side and low-side MOSFET are not turned on the same time. The adaptive dead time control operates as follows. The HS and LS gate voltages are monitored to prevent the one turning on until the other's gate voltage is sufficiently low (1 V), that and built in delays ensure the one Power MOS is completely off, before the other can be turned on. This feature helps to adjust dead time as gate transitions change with respect to output current and temperature.



Under Voltage Lockout (UVLO)

During the start up cycle, the UVLO disables the gate drive holding high-side and low-side MOSFET gate low until the input voltage rail has reached a point at which the logic circuitry can be safely activated. The SiC780A also incorporates logic to clamp the gate drive signals to zero when the UVLO falling edge triggers the shutdown of the device. As an added precaution, a 20.2 $k\Omega$ resistor is connected between GH and PHASE to provide a discharge path for the HS MOSFET.

FUNCTIONAL BLOCK DIAGRAM

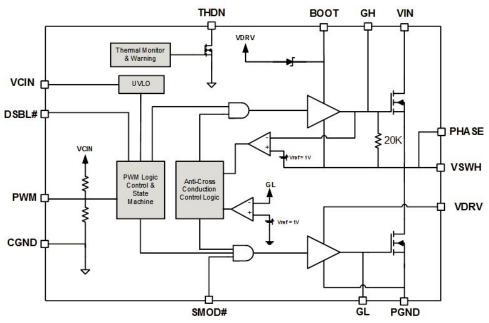


Figure 3: SiC780 Functional Block Diagram

DEVICE TRUTH T	DEVICE TRUTH TABLE							
DSBL#	SMOD	PWM	GH	GL				
Open	X	X	L	L				
L	X	X	L	L				
Н	L	L	L	L				
Н	L	Н	Н	L				
Н	Н	Н	Н	L				
Н	Н	L	L	Н				
Н	L	Tri-state	L	L				
Н	Н	Tri-state	L	L				

PWM TIMING DIAGRAM

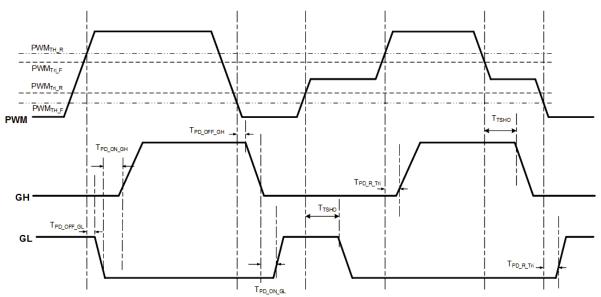


Figure 4: Definition of PWM Logic and Tri-state

SMOD OPERATION DIAGRAM

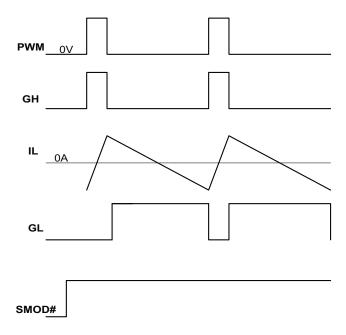


Figure 5: CCM Operation with SMOD# = HIGH





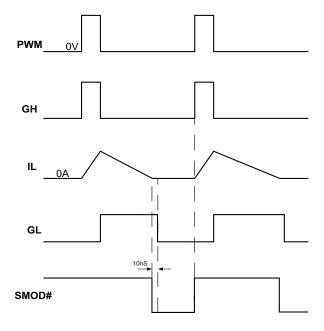
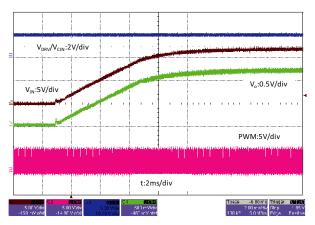
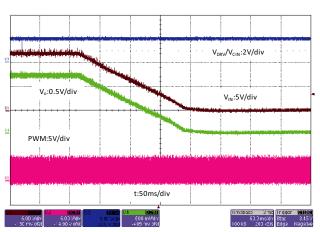


Figure 6: DCM Operation with SMOD# = Active Toggle

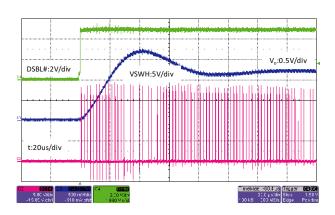
ELECTRICAL CHARACTERISTICS



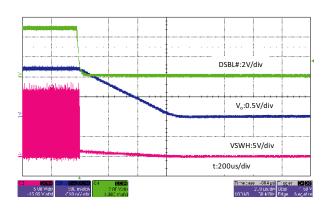
Startup with VIN Ramping Up $V_{IN} = 12 \text{ V}, V_{OUT} = 1.2 \text{ V}, F_{SW} = 500 \text{ kHz}, I_{OUT} = 0 \text{ A}$



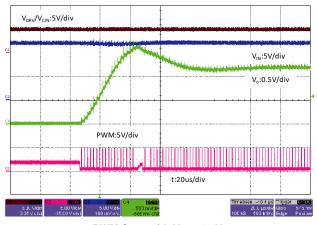
Power Off with V_{IN} Ramping Down $V_{IN} = 12 \text{ V}, V_{OUT} = 1.2 \text{ V}, F_{SW} = 500 \text{ kHz}, I_{OUT} = 1.2 \text{ A}$



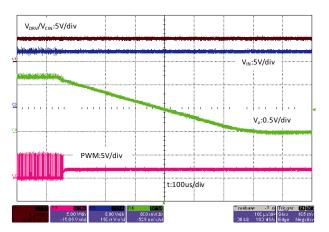
Enable with $V_{IN} = 12 V$, V_{OUT} = 1.2 V, F_{SW} = 500 kHz, I_{OUT} = 1.2 A



Disable with $V_{IN} = 12 V$, $V_{OUT} = 1.2 \text{ V}, F_{SW} = 500 \text{ kHz}, I_{OUT} = 1.2 \text{ A}$

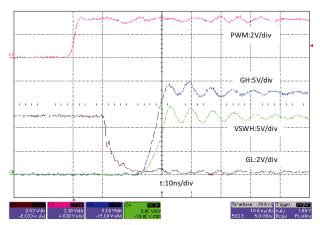


PWM Start with $V_{IN} = 12 V$, V_{OUT} = 1.2 V, F_{SW} = 500 kHz, I_{OUT} = 1.2 A

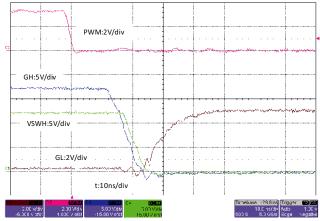


PWM Turn-off with $V_{IN} = 12 V$, V_{OUT} = 1.2 V, F_{SW} = 500 kHz, I_{OUT} = 1.2 A

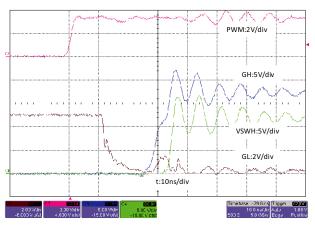
ELECTRICAL CHARACTERISTICS



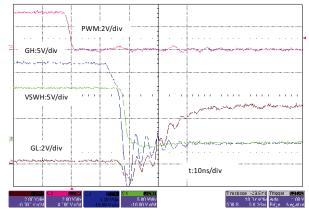
Switching Waveform at PWM Rising Edge V_{IN} = 12 V, V_{OUT} = 1.2 V, F_{SW} = 500 kHz, I_{OUT} = 0 A



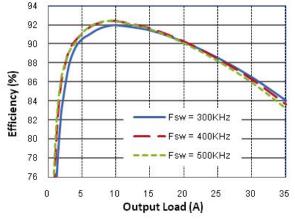
Switching Waveform at PWM Falling Edge V_{IN} = 12 V, V_{OUT} = 1.2 V, F_{SW} = 500 kHz, I_{OUT} = 0 A



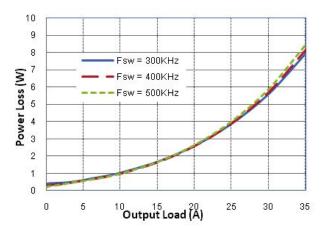
Switching Waveform at PWM Rising Edge V_{IN} = 12 V, V_{OUT} = 1.2 V, F_{SW} = 500 kHz, I_{OUT} = 30 A



Switching Waveform at PWM Falling Edge V_{IN} = 12 V, V_{OUT} = 1.2 V, F_{SW} = 500 kHz, I_{OUT} = 30 A



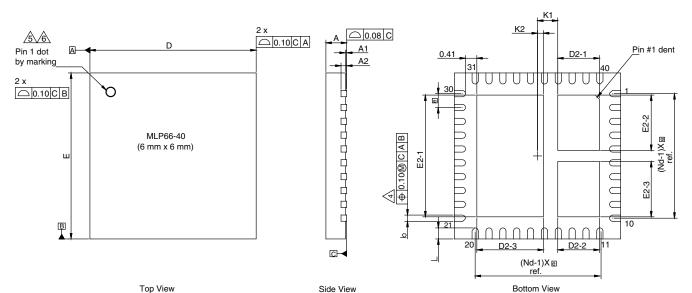
Typical Efficiency $m V_{IN}$ = 12 V, $m V_{OUT}$ = 1.2 V, $m V_{DRV}$ = $m V_{CIN}$; NO AIR FLOW, O/P Inductance = 0.33 μH



Typical Power Loss V_{IN} = 12 V, V_{OUT} = 1.2 V, V_{DRV} = V_{CIN} ; NO AIR FLOW, O/P Inductance = 0.33 µH

PACKAGE DIMENSIONS





	TOP VIEW		Side view		Dottom view	
DIM		MILLIMETERS			INCHES	
DIIVI	Min.	Nom.	Max.	Min.	Nom.	Max.
A ⁽⁸⁾	0.70	0.75	0.80	0.027	0.029	0.031
A1	0	-	0.05	0	-	0.002
A2		0.20 ref.			0.008 ref.	
b ⁽⁴⁾	0.20	0.25	0.30	0.078	0.098	0.011
D		6.00 BSC			0.236 BSC	
е		0.50 BSC			0.019 BSC	
Е		6.00 BSC			0.236 BSC	
L	0.35	0.40	0.45	0.013	0.015	0.017
N ⁽³⁾		40		40		
Nd ⁽³⁾		10			10	
Ne ⁽³⁾		10			10	
D2-1	1.45	1.50	1.55	0.057	0.059	0.061
D2-2	1.45	1.50	1.55	0.057	0.059	0.061
D2-3	2.35	2.40	2.45	0.095	0.094	0.096
E2-1	4.35	4.40	4.45	0.171	0.173	0.175
E2-2	1.95	2.00	2.05	0.076	0.078	0.080
E2-3	1.95	2.00	2.05	0.076	0.078	0.080
K1		0.73 BSC			0.028 BSC	
K2		0.21 BSC			0.008 BSC	

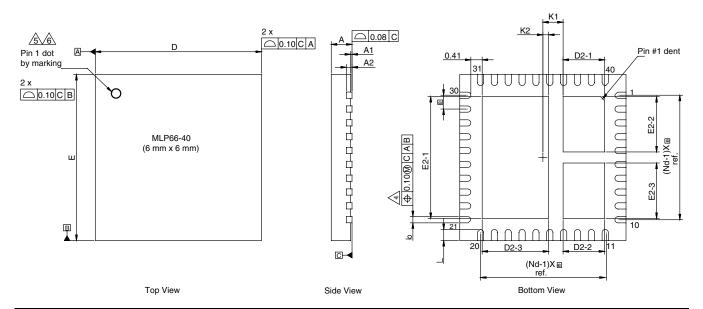
Notes:

- 1. Use millimeters as the primary measurement.
- 2. Dimensioning and tolerances conform to ASME Y14.5M-1994.
- 3. N is the number of terminals.
 - Nd is the number of terminals in X-direction and Ne is the number of terminals in Y-direction.
- 4. Dimension b applies to plated terminal and is measured between 0.20 mm and 0.25 mm from terminal tip.
- The pin #1 identifier must be existed on the top surface of the package by using indentation mark or other feature of package body.
- Exact shape and size of this feature is optional.
- Package warpage max. 0.08 mm.
- Applied only for terminals.

Vishay Siliconix maintains worldwide manufacturing capability. Products may be manufactured at one of several qualified locations. Reliability data for Silicon Technology and Package Reliability represent a composite of all qualified locations. For related documents such as package/tape drawings, part marking, and reliability data, see www.vishay.com/ppg?63788



PowerPAK® MLP66-40 CASE OUTLINE



DIM.		MILLIMETERS			INCHES		
Dilvi.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	
A (8)	0.70	0.75	0.80	0.027	0.029	0.031	
A1	0.00	-	0.05	0.000	-	0.002	
A2		0.20 ref.			0.008 ref.		
b ⁽⁴⁾	0.20	0.25	0.30	0.078	0.098	0.011	
D		6.00 BSC			0.236 BSC		
е		0.50 BSC			0.019 BSC		
Е	6.00 BSC				0.236 BSC		
L	0.35	0.40	0.45	0.013	0.015	0.017	
N (3)		40			40		
Nd ⁽³⁾		10		10			
Ne ⁽³⁾		10		10			
D2-1	1.45	1.50	1.55	0.057	0.059	0.061	
D2-2	1.45	1.50	1.55	0.057	0.059	0.061	
D2-3	2.35	2.40	2.45	0.095	0.094	0.096	
E2-1	4.35	4.40	4.45	0.171	0.173	0.175	
E2-2	1.95	2.00	2.05	0.076	0.078	0.080	
E2-3	1.95	2.00	2.05	0.076	0.078	0.080	
K1	0.73 BSC			0.028 BSC			
K2		0.21 BSC			0.008 BSC		

ECN: T09-0195-Rev. A, 04-May-09

DWG: 5986

Notes

- 1. Use millimeters as the primary measurement
- 2. Dimensioning and tolerances conform to ASME Y14.5M. 1994
- 3. N is the number of terminals. Nd is the number of terminals in Y-direction and Ne is the number of terminals in Y-direction
- Dimension b applies to plated terminal and is measured between 0.20 mm and 0.25 mm from terminal tip
- The pin #1 identifier must be existed on the top surface of the package by using indentation mark or other feature of package body
- Exact shape and size of this feature is optional
- 7. Package warpage max. 0.08 mm
- Applied only for terminals

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ИНН 7805602321 КПП 780501001 P/C 40702810122510004610 ФАКБ "АБСОЛЮТ БАНК" (ЗАО) в г.Санкт-Петербурге К/С 3010181090000000703 БИК 044030703

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- Специальные условия для постоянных клиентов.
- Подбор аналогов.
- Поставку компонентов в любых объемах, удовлетворяющих вашим потребностям.
- Приемлемые сроки поставки, возможна ускоренная поставка.
- Доставку товара в любую точку России и стран СНГ.
- Комплексную поставку.
- Работу по проектам и поставку образцов.
- Формирование склада под заказчика.
- Сертификаты соответствия на поставляемую продукцию (по желанию клиента).
- Тестирование поставляемой продукции.
- Поставку компонентов, требующих военную и космическую приемку.
- Входной контроль качества.
- Наличие сертификата ISO.

В составе нашей компании организован Конструкторский отдел, призванный помогать разработчикам, и инженерам.

Конструкторский отдел помогает осуществить:

- Регистрацию проекта у производителя компонентов.
- Техническую поддержку проекта.
- Защиту от снятия компонента с производства.
- Оценку стоимости проекта по компонентам.
- Изготовление тестовой платы монтаж и пусконаладочные работы.



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