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### DESCRIPTION

The MP86961 is a monolithic Half Bridge with built-in internal power MOSFETs and gate driver. It achieves 20A continuous output current over a wide input supply range.

Integrating the Driver and MOSFETs results in high efficiency due to optimal dead time control and parasitic inductance reduction.

The MP86961 is a Monolithic IC designed to drive up to 20A per phase. Housed in a very small 5x5mm QFN Package, this device can be operated from 100kHz to 1MHz.

The IC is intended to work with 5V tri-state output controllers.

The MP86961 is ideal for notebook applications where efficiency and small size are a premium.

### FEATURES

- Wide 4.5V to 21V Operating Input Range
- 20A Output Current
- Simple Logic Interface(5.0V)
- Operate from 100kHz to 1MHz
- Accepts 3-state PWM Input
- Suitable for single-/multi-phase operation
- Available in a 5mm x 5mm QFN Package
- ROHS6 Compliant

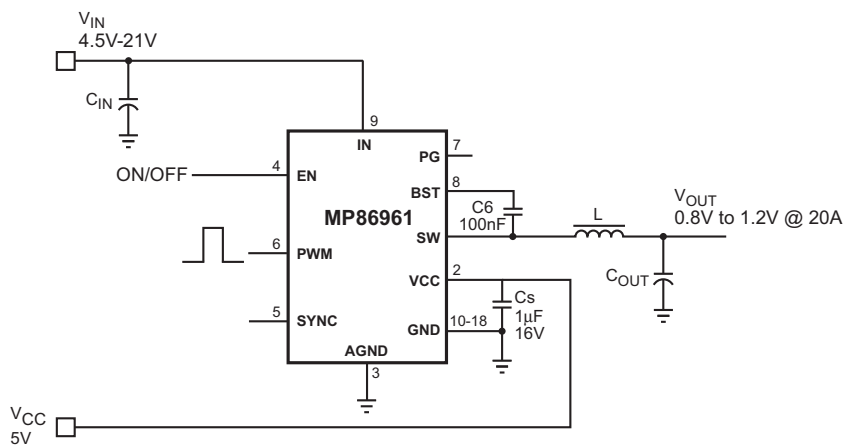
### APPLICATIONS

- Power modules
- Notebook, Core Voltage
- Graphic Card Core Regulators

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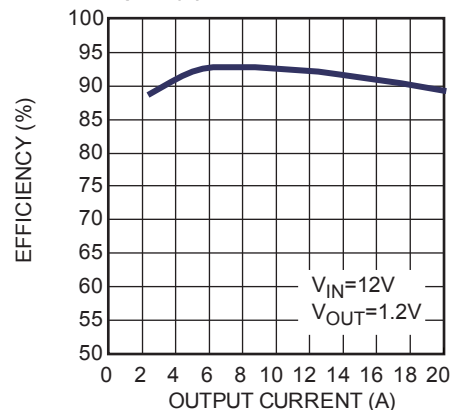
This Product is Patent Pending.

### TYPICAL APPLICATION



#### 300kHz Efficiency

$F_{SW} = 300\text{kHz}$ ,  $L = 0.44\mu\text{H}$ ,  
 $\text{DCR} = 0.32\text{m}\Omega$



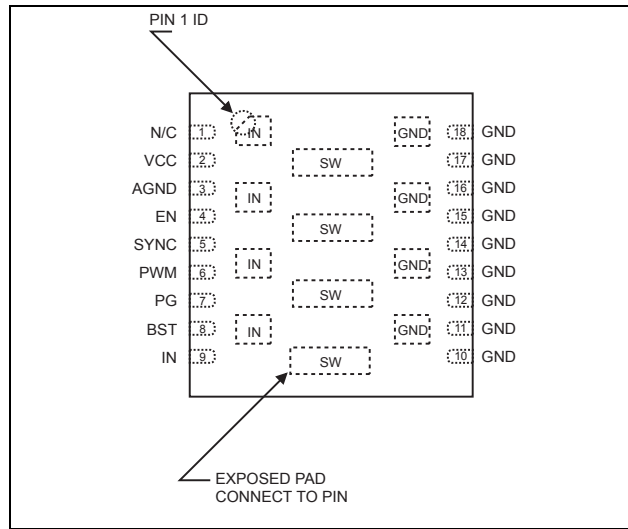
## ORDERING INFORMATION

Part Number*	Package	Top Marking	Free Air Temperature(T <sub>A</sub> )
MP86961DU	5x5 QFN	86961DU	-40°C to +85°C

\* For Tape & Reel, add suffix –Z (e.g. MP86961DU–Z);

For RoHS compliant packaging, add suffix –LF (e.g. MP86961DU–LF–Z)

## PACKAGE REFERENCE



### Absolute Maximum Ratings <sup>(1)</sup>

Supply Voltage V <sub>IN</sub> .....	27V
V <sub>SW</sub> .....	-0.3V (-3V for <20ns) to V <sub>IN</sub> + 0.3V (+3V for <20ns)
V <sub>BST</sub> .....	V <sub>SW</sub> + 6V
All Other Pins .....	-0.3V to +6V
Continuous Power Dissipation (T <sub>A</sub> = +25°C) <sup>(2)</sup> .....	3.5W
Junction Temperature .....	150°C
Lead Temperature .....	260°C
Storage Temperature .....	-65°C to +150°C

### Recommended Operating Conditions <sup>(3)</sup>

Supply Voltage V <sub>IN</sub> .....	4.5V to 21V
V <sub>CC</sub> Driver Voltage .....	4.5V to 5.5V
Operating Junct. Temp (T <sub>J</sub> ) .....	-40°C to +125°C

Thermal Resistance <sup>(4)</sup>	θ <sub>JA</sub>	θ <sub>JC</sub>
5x5 QFN .....	36	8

#### Notes:

- Exceeding these ratings may damage the device.
- The maximum allowable power dissipation is a function of the maximum junction temperature T<sub>J</sub>(MAX), the junction-to-ambient thermal resistance θ<sub>JA</sub>, and the ambient temperature T<sub>A</sub>. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P<sub>D</sub>(MAX)=(T<sub>J</sub>(MAX)-T<sub>A</sub>)/ θ<sub>JA</sub>. Exceeding the maximum allowable power dissipation will cause excessive die temperature.
- The device is not guaranteed to function outside of its operating conditions.
- Measured on approximately 4" square of 4-layer PCB.



## ELECTRICAL CHARACTERISTICS

$V_{IN} = 12V$ ,  $T_A = +25^{\circ}C$ , unless otherwise noted.

Parameters	Symbol	Condition	Min	Typ	Max	Units
$I_{CC}$ Standby	$I_{CC\_Stdby}$	$V_{CC} = 5V$ , PWM=EN=LO		230	300	$\mu A$
$I_{IN}$ (Shutdown)	$I_{IN\ (Off)}$	$V_{CC} = 0V$		1	5	$\mu A$
$I_{IN}$ Standby	$I_{IN\_Stdby}$	$V_{CC} = 5V$ , PWM=EN=LO		1		$\mu A$
Rise Time		$I_{OUT} = 20A$		5		ns
Fall Time		$I_{OUT} = 20A$		3		ns
Minimum On-Time				55		ns
Dead-Time Rising				5		ns
Dead-Time Falling				10		ns
$V_{CC}$ Under Voltage Lockout Threshold Rising				3.7	4.2	V
$V_{CC}$ Under Voltage Lockout Threshold Hysteresis				470		mV
SYNC Pull-Up Current	$I_{SYNC}$	SYNC=0V		-14		$\mu A$
SYNC Logic High Voltage			2			V
SYNC Logic Low Voltage					0.4	V
EN Input Low Voltage					0.4	V
En Input High Voltage			2			V
Power Good Rds(on)		EN=0V		20		$\Omega$
<b>PWM Input</b>						
Input Current	$I_{PWM}$	$V_{PWM}=5V$		90		$\mu A$
		$V_{PWM}=0V$		-90		$\mu A$
PWM Low to Tri-State Rising Threshold				1.7		V
PWM Tri-State to High Threshold				3.7		V
PWM High to Tri-State Rising Threshold				3.4		V
PWM Tri-State to Low Threshold				1		V
Tri-State Shutdown Holdoff Time	$t_{TSSHD}$	$V_{CC}=5V$ , Temperature= $25^{\circ}C$		80		ns
UG/LG Three-State Propagation Delay	$t_{PTS}$			20		ns
USW Turn-Off Propagation Delay	$t_{PDUL}$	$V_{CC}=5V$		30		ns
LSW Turn-Off Propagation Delay	$t_{PDLL}$	$V_{CC}=5V$		10		ns
USW Turn-On Propagation Delay	$t_{PDUH}$	$V_{CC}=5V$		20		ns
LSW Turn-On Propagation Delay	$t_{PDLH}$	$V_{CC}=5V$		45		ns

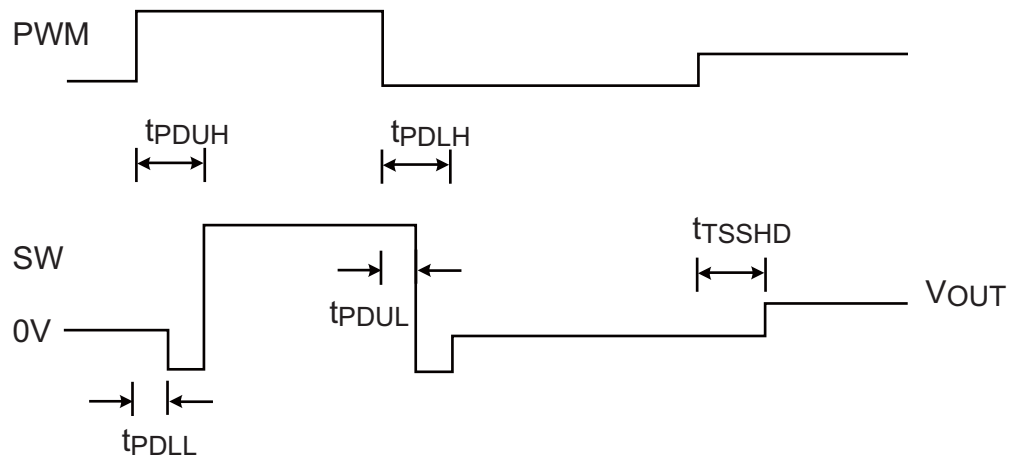


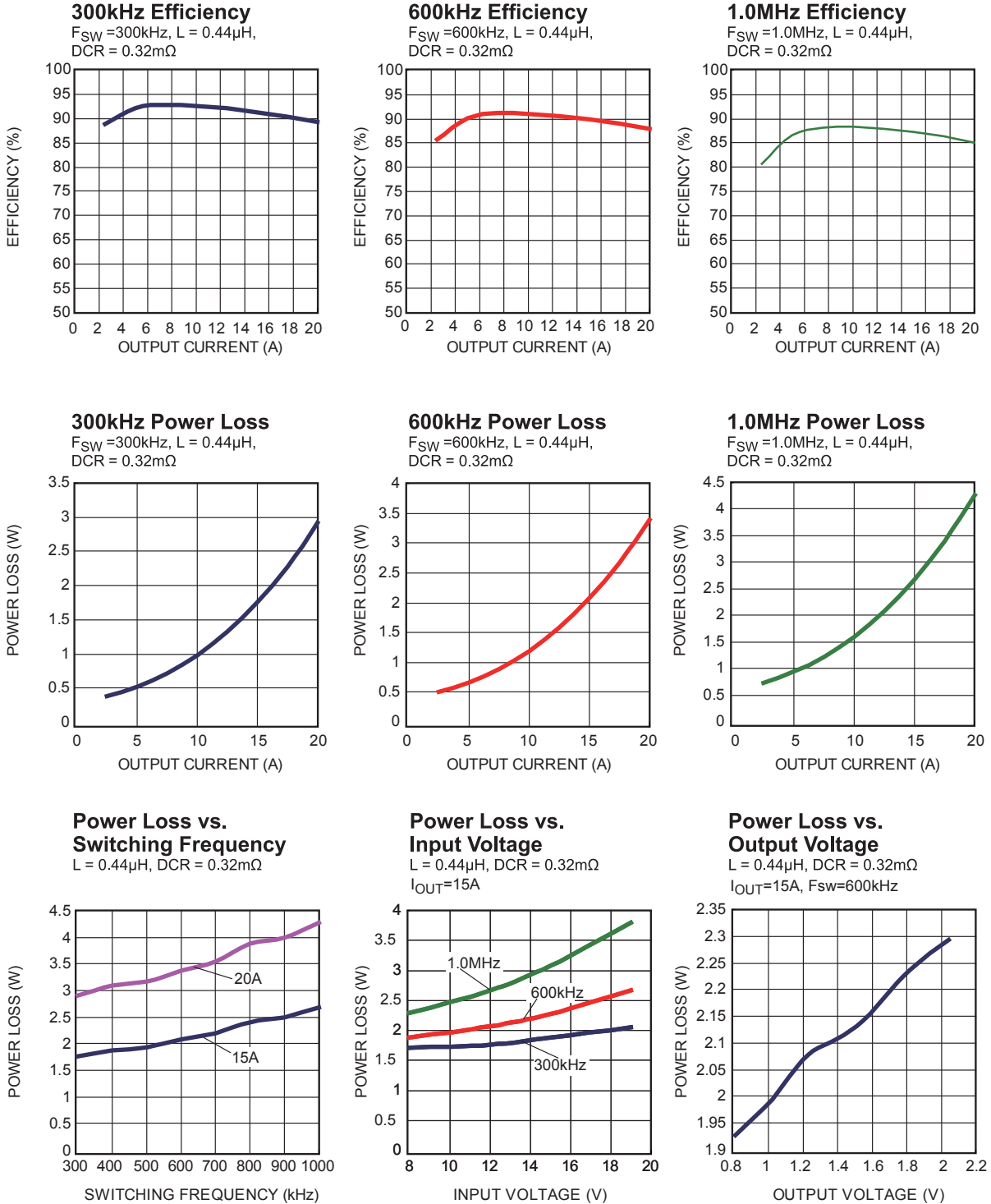
Figure 1- Timing Diagram

## PIN FUNCTIONS

Pin #	Name	Description
1	NC	Not Connected.
2	VCC	Low-Side Driver Bias Supply. Decouple with a 1 $\mu$ F ceramic capacitor.
3	AGND	Signal Ground.
4	EN	Active High On/Off Control. Pulling this Pin Low forces the SW pin to be in a high impedance state.
5	SYNC	Leaving this pin Open enables the Lower Synchronous Switch. Pulling it Low forces the Lower Switch into Diode Emulation mode.
6	PWM	Pulse Width Modulation Control. Accepts three state input. Force PWM to midstate or open to place SW into high impedance state.
7	PG	Power Good. Open drain output is low impedance to ground until internal supplies are good.
8	BST	Bootstrap. This capacitor is needed to drive the power switch's gate above the supply voltage. It is connected between SW and BST pins to form a floating supply across the power switch driver.
9 Exposed Pad	IN	Supply Voltage. $C_{IN}$ is needed to prevent large voltage spikes from appearing at the input.
10–18 Exposed Pad	GND	Power Ground.
Exposed Pad	SW	Switch Output. These pins are fused together.

# TYPICAL PERFORMANCE CHARACTERISTICS

$V_{IN} = 12V$ ,  $V_{CC} = 5V$ ,  $V_{OUT} = 1.2V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.

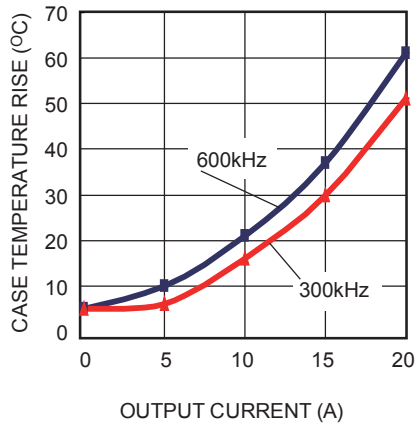


## TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

$V_{IN} = 12V$ ,  $V_{CC} = 5V$ ,  $V_{OUT} = 1.2V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.

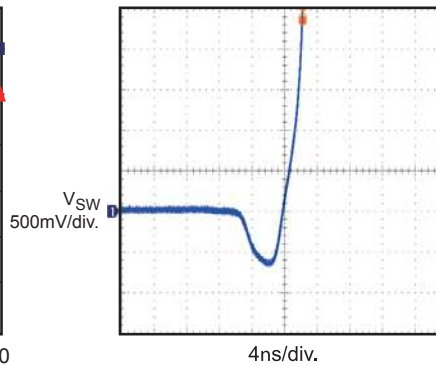
**Temperature Rise vs. Output Current**

No airflow



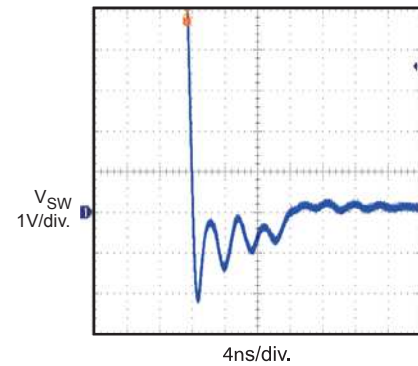
**SW Rising Edge Dead Time**

$I_{OUT} = 15A$



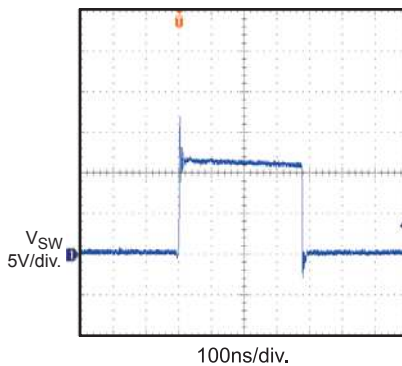
**SW Falling Edge Dead Time**

$I_{OUT} = 15A$



**Output Waveform**

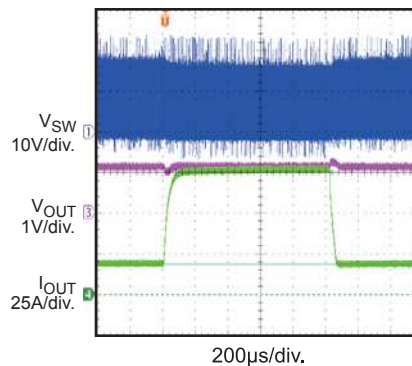
$I_{OUT} = 20A$



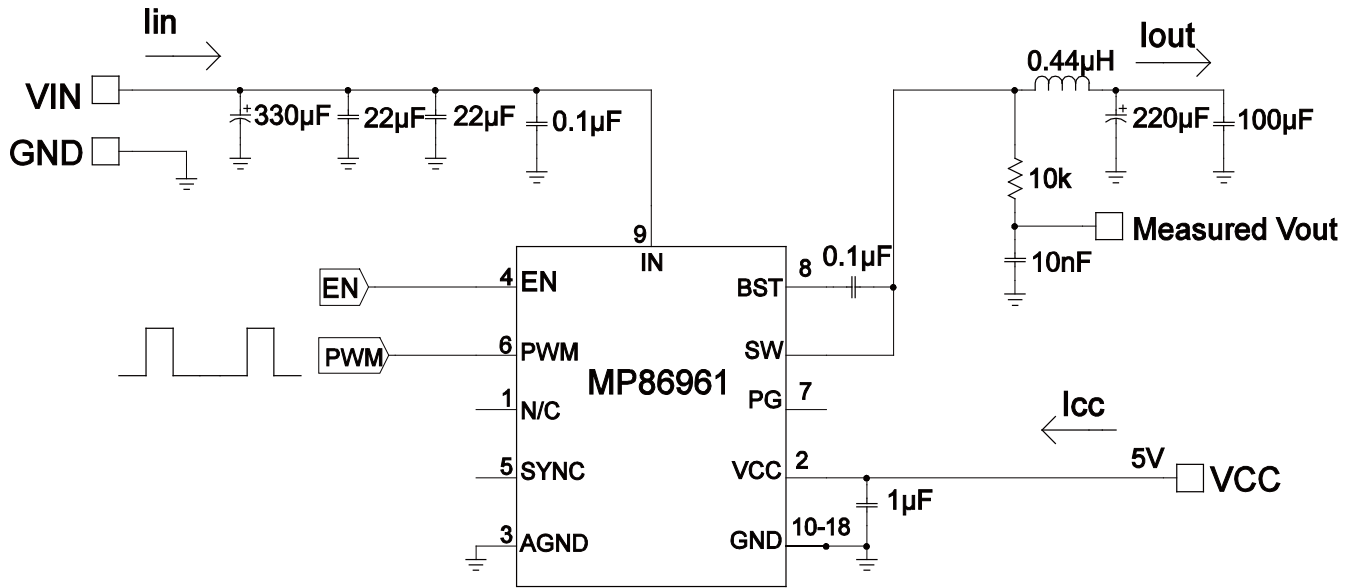
**SOA Waveform**

$V_{IN} = 19V$ ,  $V_{OUT} = 1.2V$

$I_{OUT} = 20A$  to  $80A$ ,  $F_{SW} = 600kHz$



## EFFICIENCY MEASUREMENT SETUP





## BLOCK DIAGRAM

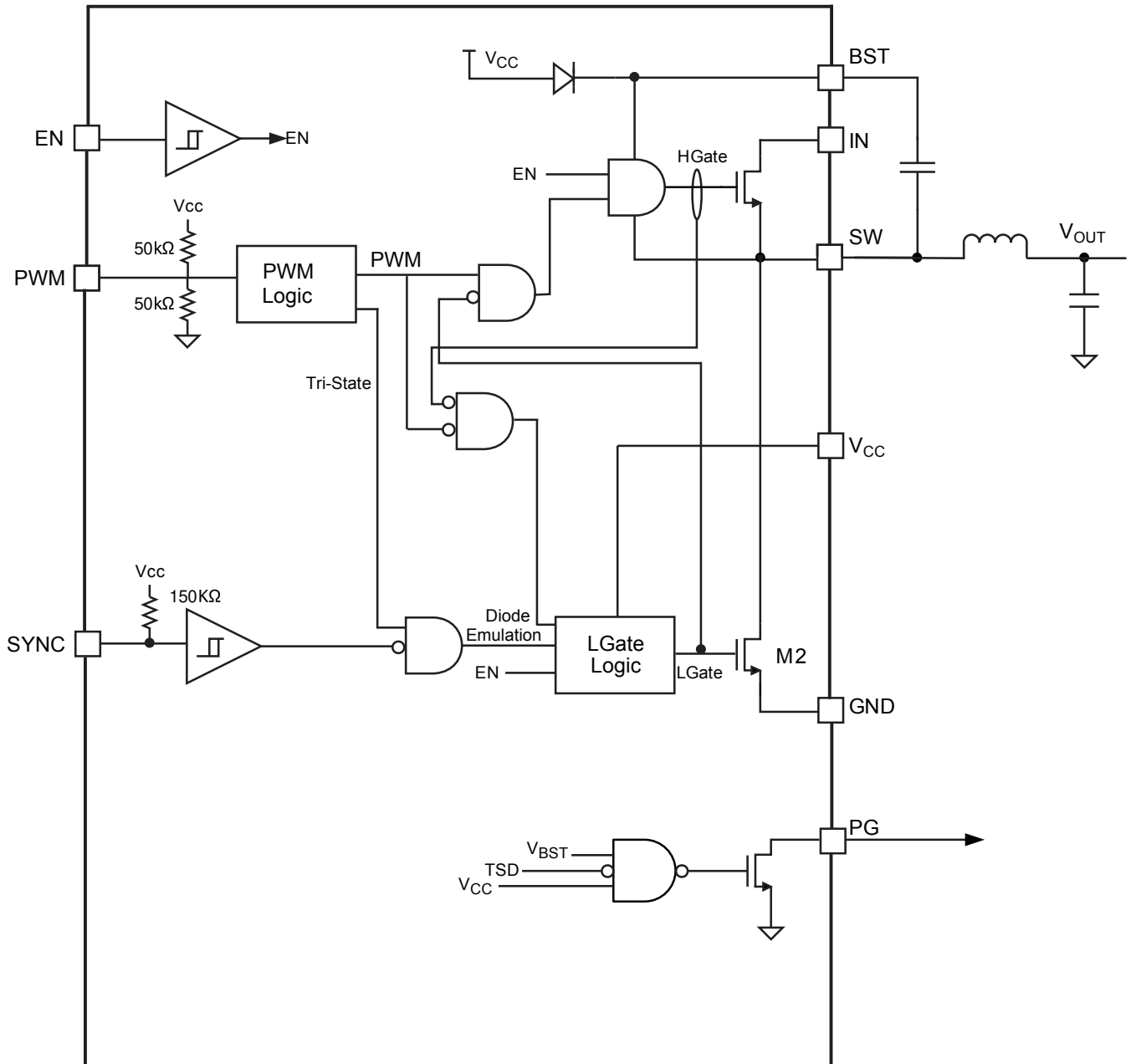


Figure 2—Functional Block Diagram

## OPERATION

The MP86961 is a 20A Monolithic Half Bridge driver with MOSFETs ideally suited for single-/multi-phase Buck regulators.

Once the EN,  $V_{IN}$ ,  $V_{CC}$  and  $V_{BST}$  signals are sufficiently high, operation begins. BST voltage has a typical rising UVLO of 2.2V and a falling UVLO of 2.0V. When BST is below the UVLO voltage, the device will be off.

MP86961 can work with most PWM controllers. The device accepts PWM signal from 100kHz up to 1MHz. There is an internal resistor divider to put PWM voltage to tri-state region if the PWM pin is open.

Internally, SYNC is tied to  $V_{CC}$  through a resistor. By default, the device will operate in synchronous mode. To enter Diode Emulation mode, drive SYNC pin LOW.

### Startup and Shutdown Sequence

MP86961 can work with any startup or shutdown sequencing combination of  $V_{IN}$ ,  $V_{CC}$  and EN. If PWM signal is present, the MP86961 will start working whenever  $V_{IN}$ ,  $V_{CC}$  and EN are ready. On the other hand, if any of these signals is not ready, the MP86961 will stop working. However, it is recommended to turn on and turn off the device through the EN pin.

### PCB Layout Guideline

PCB layout is very important to achieve stable operation. Please follow these guidelines to achieve optimal performance.

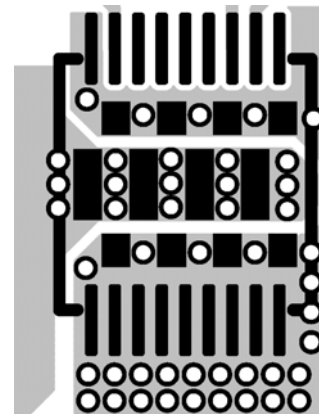
1) Keep the path of switching current short and minimize the loop area formed by input capacitor. Keep the connection between SW pin and input power ground as short and wide as possible.

2) Always place some input bypass ceramic capacitors next to the device and on the same layer as the device. Do not put all of the input bypass capacitors on the back side of the device. Use as many vias and input voltage planes as possible to reduce the switching spike. BST capacitor and  $V_{CC}$  capacitor should also be as close to the device as possible.

3) The recommended external BST cap is 100nF. Do not use a capacitance value lower than 100nF. Place a 1.0Ω resistor between the BST capacitor and BST pin for optimized performance.

4) Do not place via on the pad or on the pin footprint. Doing so may cause soldering issue during the assembling process. Use Figure 3 as a via placement reference.

5) Connect IN, SW and GND to large copper area and use vias to cool the chip to improve thermal performance and long-term reliability. See Figure 4 as an example.



**Figure 3—Via Placement Guideline**

Do not put via on the device's pad footprint or pin footprint to avoid assembly issue. Use as many vias as possible to cool down the device.

6) Place the  $V_{CC}$  decouple capacitor close to the IC. Connect AGND and PGND at the point of  $V_{CC}$  capacitor's ground connection.

### Recommended SMT Setting

Stencil thickness: 0.12mm

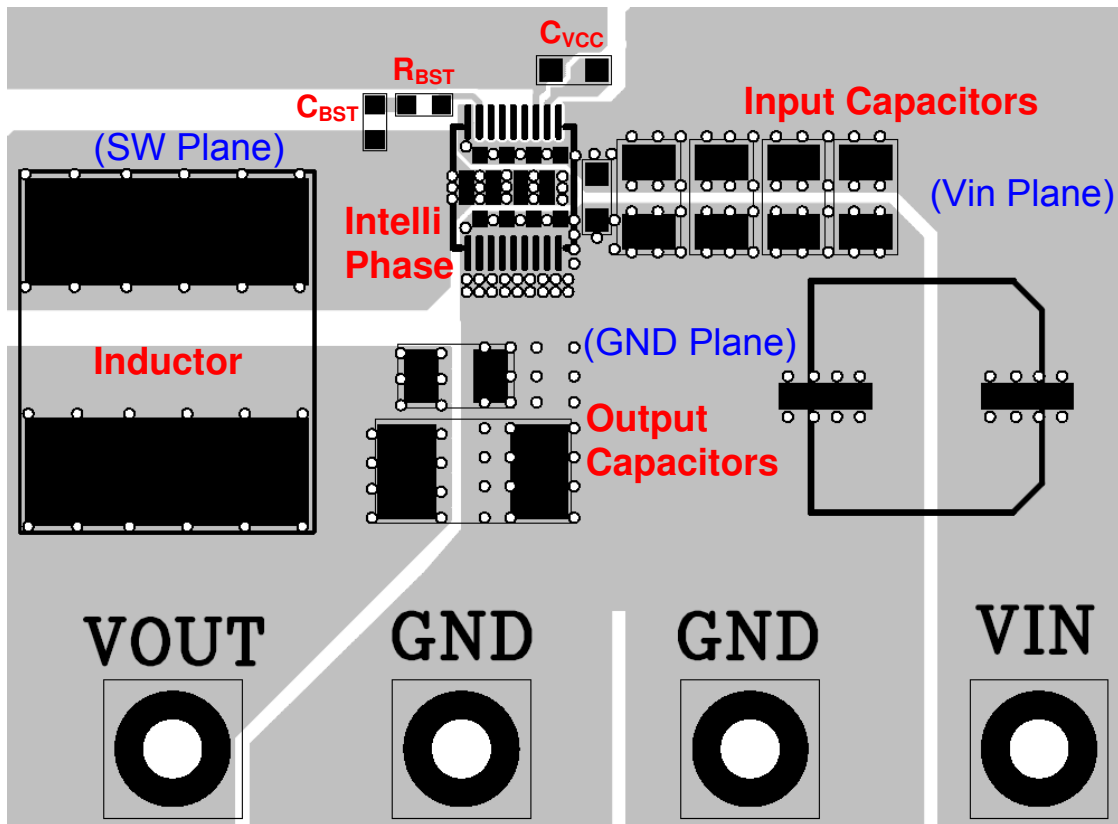
EP Pad Opening: (Stencil opening : Real PCB Size)

Length: 0.85:1

Width: 1:1

Note: The EP pad for Intelli-Phase are IN, SW and GND pad on the bottom.

Solder type: #3

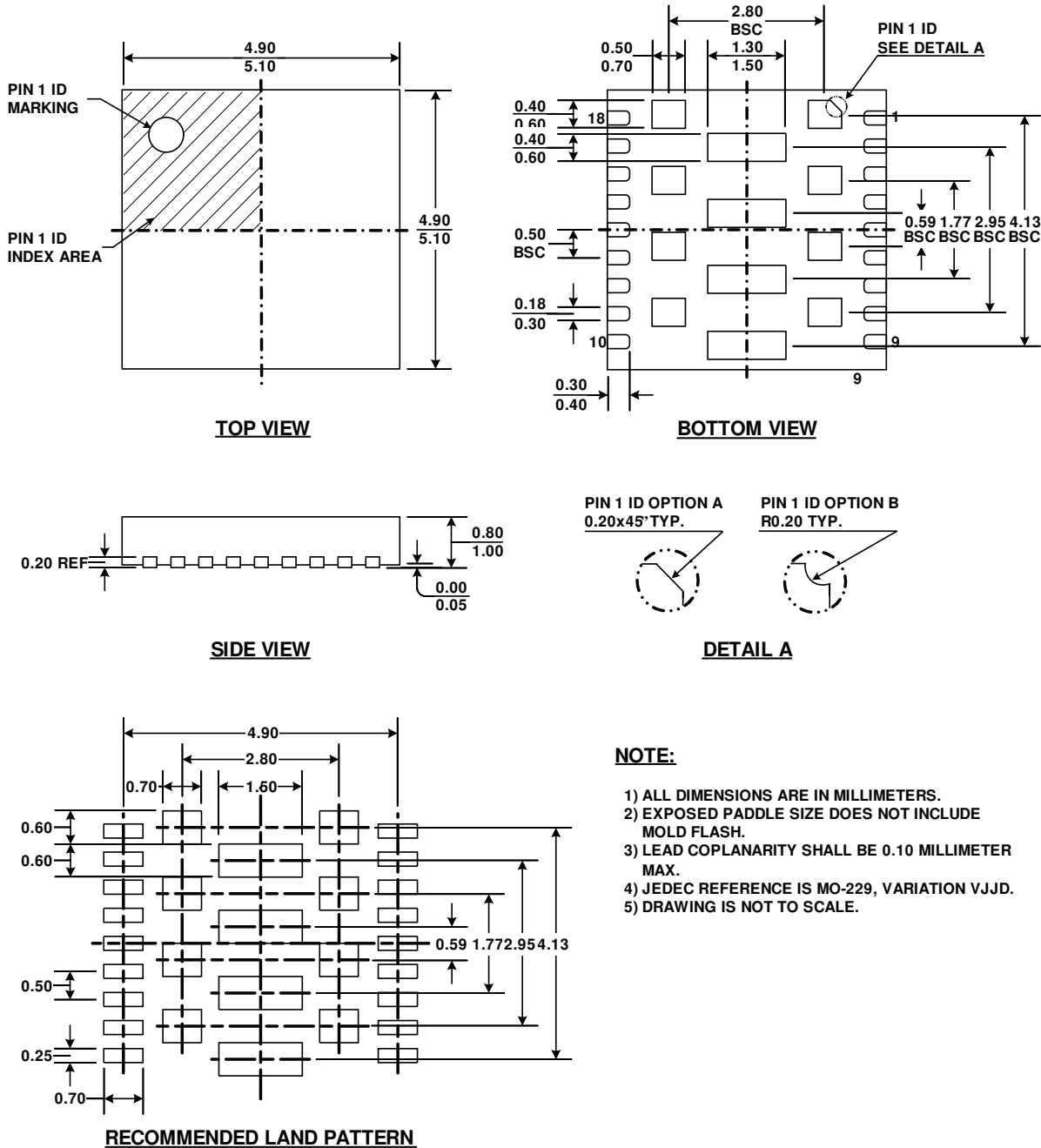


**Figure 4—Copper Area Guideline**

Use large copper area, many vias and many IN, SW and GND inner layer planes to achieve optimal thermal performance.

# PACKAGE INFORMATION

## FCTQFN18L (EXPOSED PAD)



### NOTE:

- 1) ALL DIMENSIONS ARE IN MILLIMETERS.
- 2) EXPOSED PADDLE SIZE DOES NOT INCLUDE MOLD FLASH.
- 3) LEAD COPLANARITY SHALL BE 0.10 MILLIMETER MAX.
- 4) JEDEC REFERENCE IS MO-229, VARIATION VJJD.
- 5) DRAWING IS NOT TO SCALE.

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