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MPM80 Series

Data Sheet

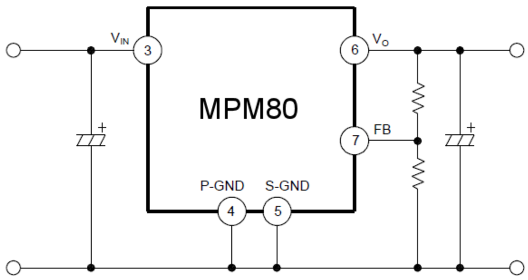
Description

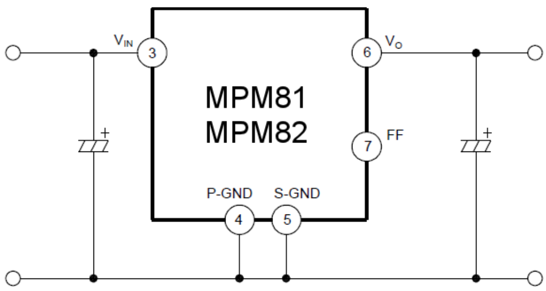
MPM series is hybrid module ICs that include a non-isolated buck converter circuit with an inductor in a full-mold package. These features achieve simple circuit using few components, and reduce design cost and PCB space.

Features

- Few external components realize reducing design and assembly cost.
  (Built-in inductor and phase compensation circuit)
- Easy to mount heatsink by full-molded package
- Two types of lead forming
  Upright angle for realizing mount area saving:
  Right angle for low profile monting
- PWM synchronous rectification
- Wide input voltage range and high efficiency
- Protection:
  Overcurrent Protection: Pulse-by-pulse
  Overvoltage Protection: Latch
  Thermal Shutdown: Auto-restart

Typical Application

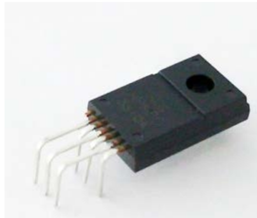




Package

TO220F-8L

(Upright angle)



(Right angle)

Not to scale.

MPM80 Series

Products	V_O (V)	Order No.	Lead Formings
MPM80	3V to 16V	MPM80	Upright angle
		MPM80-R	Right angle
MPM81	3.3V (Fixed-output)	MPM81	Upright angle
		MPM81-R	Right angle
MPM82	5.0V (Fixed-output)	MPM82	Upright angle
		MPM82-R	Right angle

Specifications

- Input voltage, V_{IN} = 8V to 30V
- Maximum output current, I_O = 2A
- Operating frequency, 630kHz

Applications

- Factory automation equipment
- Communication equipment
- Consumer equipment
- Another DC/DC power supply circuit

Contents

1. Absolute Maximum Ratings

Unless otherwise specified, T_A = 25 °C

Parameter	Symbol	Test Conditions	Rating	Units
Voltage Between VIN and GND Pins	V_{IN}	Short between P-GND and S-GND.	35	V
Voltage Between FB and GND Pins	V_{FB}	Short between P-GND and S-GND	5	V
Voltage Between VO and GND Pins	V_O	Short between P-GND and S-GND	20	V
MIC Capacity Loss	P_{LOSS}	Without a heatsink	2	W
Junction Temperature	T_j		−20 to 125	°C
Storage Temperature	T_{stg}		−20 to 125	°C
Thermal Resistance*	$\theta_{j\text{-}A}$	Without a heatsink	50	°C／W

*Between MIC junction and ambient.

2. Recommended Operating Condition

Recommended operating conditions refer to operating conditions to maintain normal circuit functions specified in the Electrical Characteristics table in this document and they must be followed in actual use.

See Typical Application for circuit connection.

Characteristic	Symbol	Min.	Max.	Unit	Conditions
Input Voltage Range	V_{IN}	8 [(1)]	30	V	
Output Voltage Range	V_O	3	16	V	MPM80 only
Output Current Range [(2)]	I_O	0	2	A	
Operating Junction Temperature [(2)]	T_{j_OP}	−40	125	°C	
Operating Temperature Range	T_A	−40	85	°C	Derating is required

[(1)] Minimum value must be either 8 V or V_O + 3 V, whichever is larger.
[(2)] Derating is required (see Section 10.1).

3. Electrical Characteristics

Unless otherwise specified, T_A = 25 °C, V_{IN} = 12 V

The Electrical Characteristics refer to characteristics value specification in the typical circuit shown in Section 6 when the IC operates under conditions in this document.

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units	Notes
Output Voltage Setting Reference Voltage	V_{FB_REF}	I_O = 1 A	0.784	0.800	0.816	V	MPM80
Setup Output Voltage	V_{O_REF}	V_{IN} = 8 V to 30 V I_O = 1 A	3.230	3.300	3.370	V	MPM81
		V_{IN} = 8 V to 30V I_O = 1 A	4.900	5.000	5.100	V	MPM82
Output Voltage Setting Reference Voltage Temperature Coefficient	$\Delta V_{FB\_REF}/\Delta T$	T_A= −20 to 85 °C	—	±0.05	—	mV/°C	MPM80
Line Regulation [1]	V_{LINE}	V_{IN} = 8 V to 30 V I_O = 1 A V_O = 5.0 V (MPM80)	−2	—	2	%	
Operating Frequency	f		567	630	693	kHz	
Load Regulation [1]	V_{LOAD}	I_O = 0 to 2 A V_O = 5.0 V (MPM80)	−3	—	3	%	
Overcurrent Protection Starting Current [2]	I_S	Drooping, Auto restart V_O = 5.0 V (MPM80)	2.4	—	4.0	A	
Supply Current	I_{IN}	I_O = 0 A V_{FB} = 1 V	—	2.5	—	mA	
Overvoltage Protection Starting Voltage [3]	V_{OVP}	V_{IN} = 8 V to 35 V	—	1.1 $\times V_{FB\_REF}$	—	V	MPM80
			—	1.1 $\times V_{O\_REF}$	—	V	MPM81 MPM82
MIC Thermal Shut-down Stating Temperature [4]	T_{j_TSD}	V_{IN} = 8 V to 35 V	135	150	—	°C	
Under Voltage Lockout (UVLO) Voltage	UVLO		6.0	7.0	7.5	V	
UVLO Release Threshold	UVLO(OFF)		5.5	6.5	7.0	V	
UVLO Hysteresis Voltage [3]	UVLO(HYS)		—	0.5	—	V	
Minimum Input-Output Difference	V_{IN}-$V_{O(MIN)}$	V_O = 12 V	3	—	—	V	
Minimum Settable Output Voltage	$V_{O(MIN)}$	V_{IN} = 30 V	—	3	—	V	MPM80
Internal Soft-Start Timer [3]	t_{SS}	V_{IN} = 12 V I_O = 1 A	—	6.4	—	ms	
Maximum ON Duty [3]	D_{MAX}		—	90	—	%	
Minimum ON Time [3]	t_{MIN}		—	160	—	ns	
Inductance Value	L		4.48	5.6	6.72	µH	

[1] In the MPM80, line regulation and load regulation do not include the setup deviation of output voltage. The output voltage setup deviation is influenced by the resistance variation of external R1 and R2. See Section 6 Typical Application Circuit for details.

[2] In the MPM80, if the output voltage ,V_O, is set to any value other than 5.0 V, OCP operating point may vary significantly because the internal inductor's inductance and the operating frequency are fixed.

[3] Determined by design.

[4] Thermal shutdown is auto-restart.

4. Block Diagram

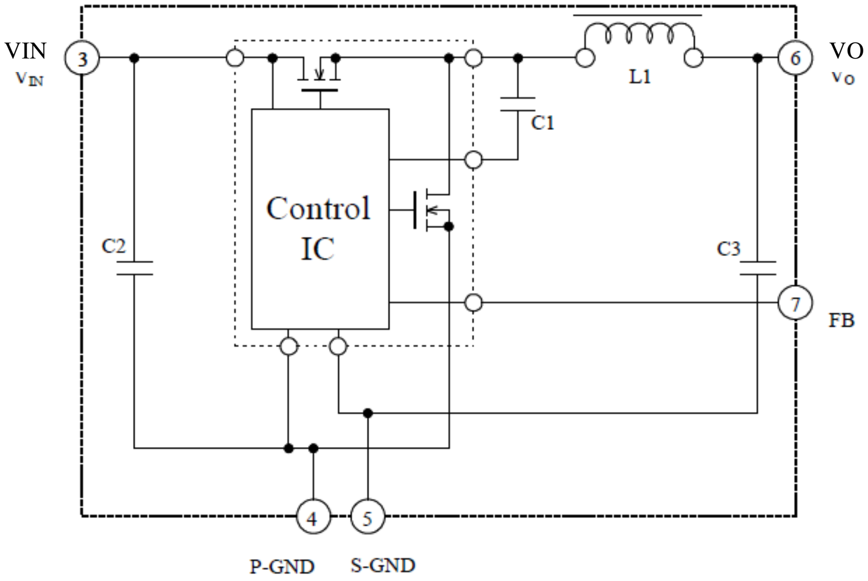


Figure 4-1. MPM80 Block Diagram

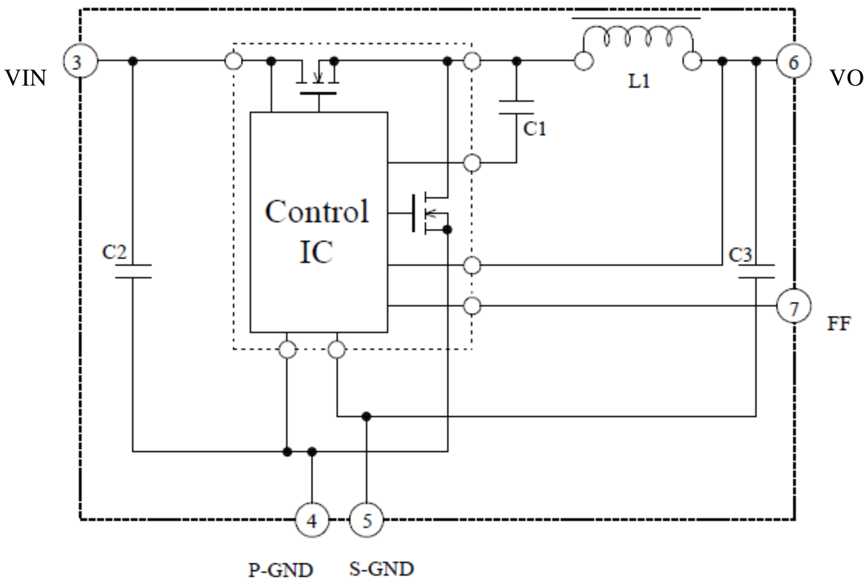
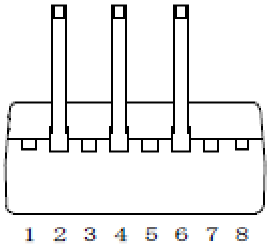


Figure 4-2. MPM81 and MPM82 Block Diagram

5. Pin Configuration Definitions

Table 5-1. MPM80



Pin	Name	Descriptions
1	—	Lead has been cut [1]
2	NC	No connection
3	VIN	Input pin for power source Connect the input smoothing capacitor C_{IN}
4	P-GND	Power ground pin
5	S-GND	Signal ground pin
6	VO	Output pin Connect the output smoothing capacitor C_{OUT}
7	FB	Output voltage feedback pin Connect the dividing resistors R1, R2 in Typical Application
8	—	Pin was pulled out [2]

Table 5-2. MPM81 and MPM82

Pin	Name	Descriptions
1	—	Lead has been cut [1]
2	NC	No connection
3	VIN	Input pin for power source Connect the input smoothing capacitor C_{IN}
4	P-GND	Power ground pin
5	S-GND	Signal ground pin
6	VO	Output pin Connect the output smoothing capacitor C_{OUT}
7	FF	Feed forward pin Phase compensation capacitor, C_P, is connceted between V_O and FF when a ceramic capacitor is used for C_{OUT}.
8	—	Pin was pulled out [2]

[1] 1 pin is not the function pin but the test pin to measure the oscillation frequency. Therefore 1mm of pin remains though it is cut off at the root of pin after test. Since the remained pin is live part, please pay attention to avoid the connection of the remained pin and the other live part pattern.(Figure 5-1)

[2] 8 pin is pulled out for this product. The burr sticks out in the 8 pin position.

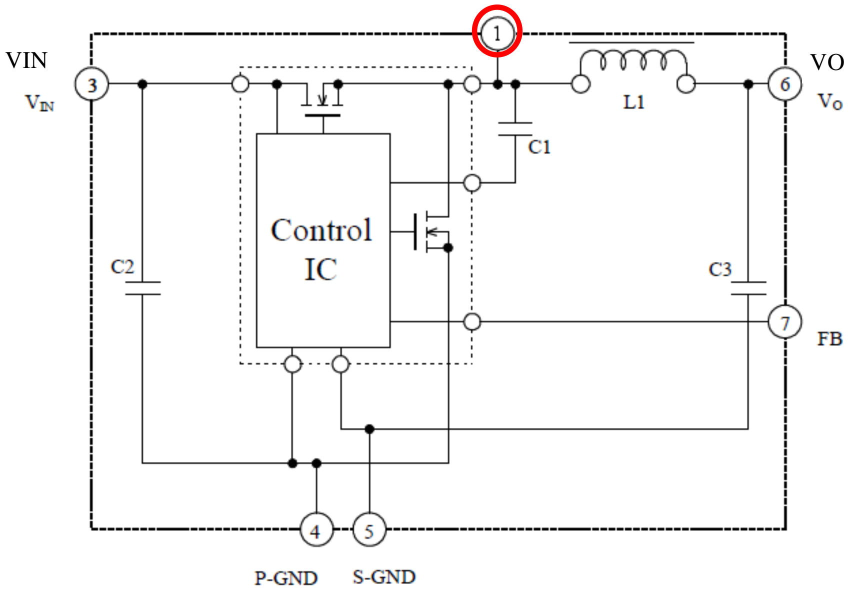


Figure 5-1. Internal Connection of 1 pin

6. Typical Application

Figure 6-1 and Figure 6-2 show the typical circuit of the MPM80, MPM81 and MPM82.
Table 6-1 shows the recommended circuit parameter.

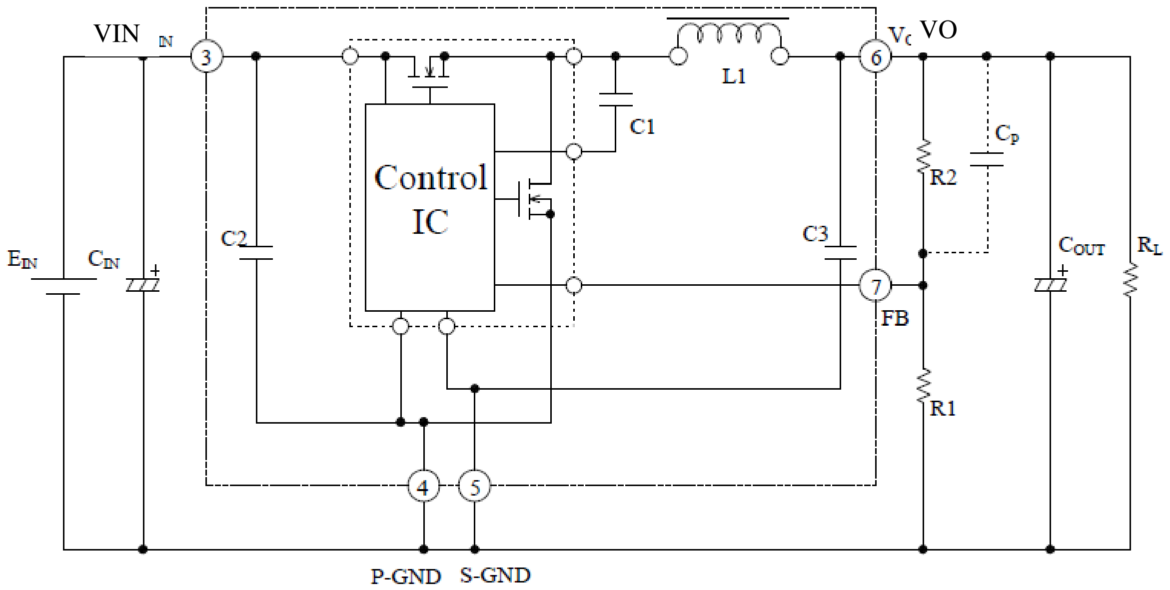


Figure 6-1. MPM80

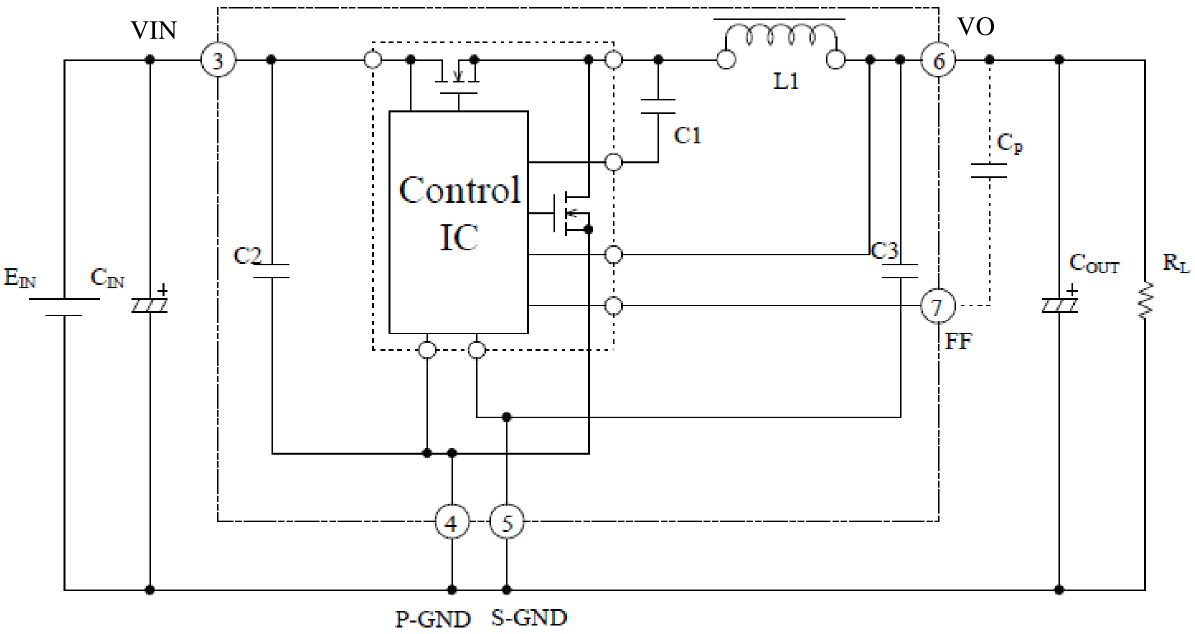


Figure 6-2. MPM81 and MPM82

Table 6-1. Reference Circuit Parameter

Symbol	Parameters	Constant Information	Notes
E_{IN}	Source of input voltage	8 V to 30 V	
C_{IN}	Input smoothing capacitor	100 µF to 1000 µF	C_{IN} is not required if the input voltage is stable. If operation is unstable, add a bypass capacitor (about 1 µF, ceramic) as near as possible to the device, between V_{IN} and GND pins.
C_{OUT}	Output smoothing capacitor	Electrolytic capacitor is 220 µF to 1000 µF. Ceramic capacitor is 47 µF to 100 µF.	A low-impedance capacitor should be used for switching power supply when using an electrolytic capacitor
R1	Output voltage setup resistor	680 Ω to 1.5 kΩ	It is required only for MPM80. It is not necessary for MPM81 and MPM82.
R2	Output voltage setup resistor		Resistance value is set according to the desired output voltage. R2 is calculated by the Equation (1). It is required only for MPM80. It is not required for MPM81 and MPM82.
C_P	Phase compensation capacitor	100 pF to 470 pF	C_P is required when using a ceramic capacitor for C_{OUT}.
R_L	Load		Load is connected to the subsequent C_{OUT}.

$$R2 = \left(\frac{V_O}{V_{FB\_REF}} - 1\right) \times R1 \qquad (1)$$

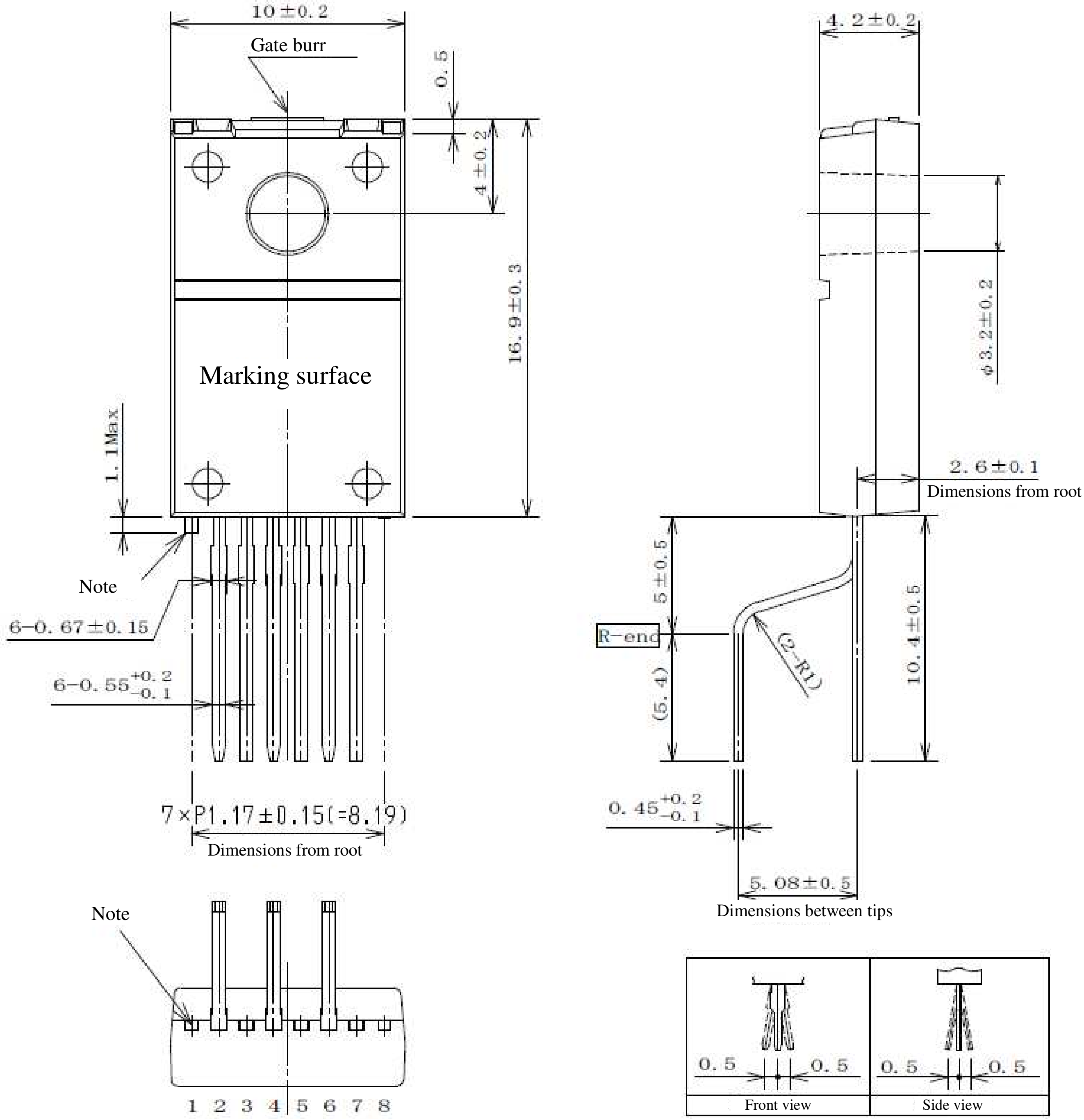
where

V_O: Target output voltage (V)

V_{FB_REF}: FB pin reference voltage (0.8V typ.)

7. External Dimensions

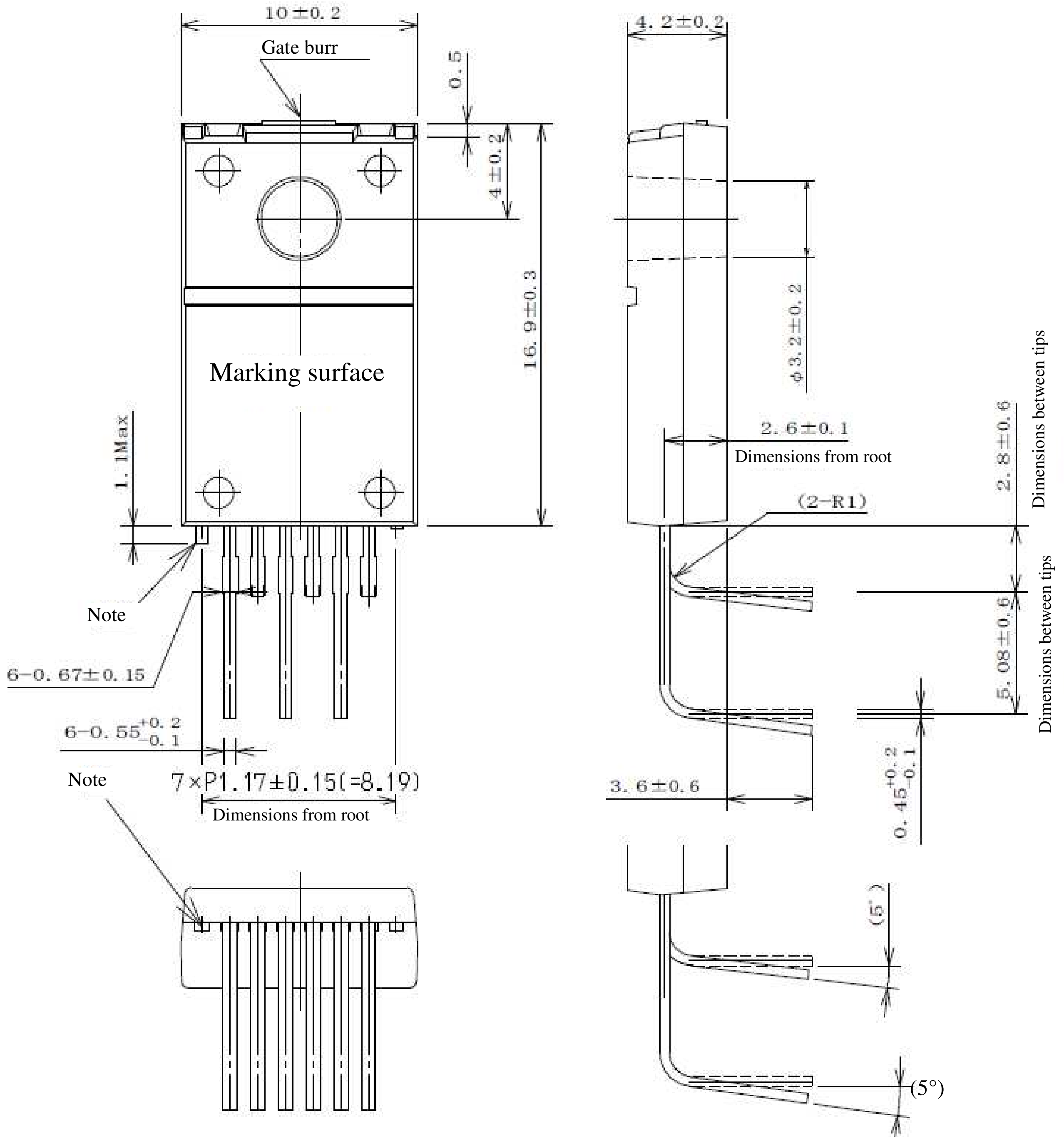
● TO220F-8L (Upright angle lead forming, MPM8x)



Notes:

1) Unit: mm
2) The arrows “Note” show the pin has been cut. Since the remained pin is live part, please pay attention to avoid the connection of the remained pin and the other live part pattarn.
3) ”Gate burr” shows the position the gate burr with the hight of 0.3mm (max.) is generated.
4) Bare lead frame: Pb-free (RoHS compliant)
5) Screw tightening torque: 6 kgf·cm to 8 kgf·cm

● TO-220F-8L (Right angle lead forming, MPM8x-R)

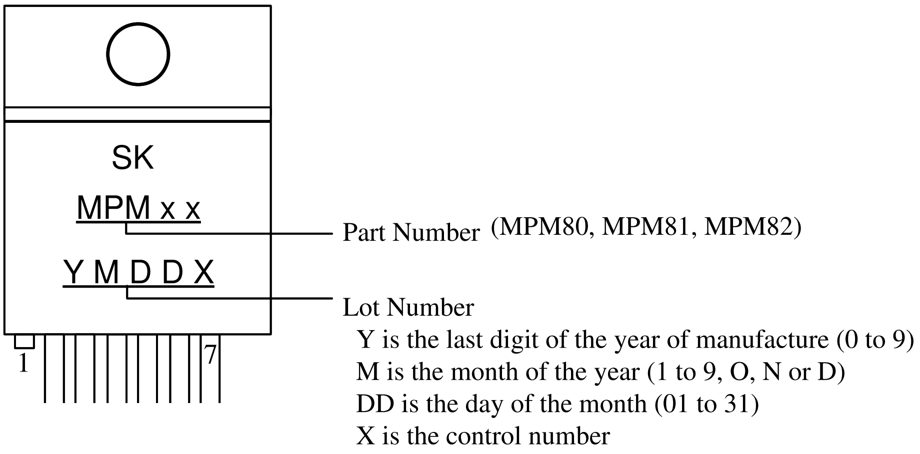


* This figure shows the exaggeration of the lead condition.
It may differ from the actual bending shape.

Notes:

1) Unit: mm
2) The arrows “Note” show the pin has been cut. Since the remained pin is live part, please pay attention to avoid the connection of the remained pin and the other live part pattarn.
3) ”Gate burr” shows the position the gate burr with the hight of 0.3mm (max.) is generated.
4) Bare lead frame: Pb-free (RoHS compliant)
5) Screw tightening torque: 6 kgf·cm to 8 kgf·cm

8. Marking Diagram



9. Operational Description

MPM80 series is the simple switching regulator module with incorporated inductor. This product can be used just by inserting a capacitor for input/output like conventional three pin regulator IC.

9.1 Startup and Stop

The module starts operation when the applied voltage exceeds the UVLO release voltage (6.5 V typ.). The output voltage of VO pin, V_O , becomes the setting value when VIN pin voltage increases to the minimum difference of input/output (3 V min.) or more.

It stops operation similarly when the VIN pin voltage decreases to the UVLO voltage (7 V typ.).

Since the module does not have ON/OFF function by external signal, V_O turns ON/OFF according to the ON/OFF of power supply.

The module has soft start function. V_O rises if the VIN pin voltage increases to the UVLO release voltage or more. The soft start function is activated for 6.4 ms (typ.). The soft start time is fixed in the module and cannot be adjusted externally.

9.2 Overcurrent Protection

The module has drooping type overcurrent protection.

The peak current is detected by pulse-by-pulse while the high-side MOSFET in the incorporated IC chip is on status. When the peak current exceeds the set value, the output voltage of VO pin, V_O, is decreased by forcibly shortening the on time of MOSFET. Furthermore, when V_O decreases, the switching frequency decreases in order to reduce power dissipation in the range of low V_O.

V_O is automatically recovers when the factors of overcurrent are removed.

9.3 Overvoltage Protection

The overvoltage protection of the module is the protection for the output voltage. This protection is not for the input overvoltage. If the applied voltage of VO pin or FB pin (in MPM80) becomes 1.1 times in set value for some reason, the switching operation stops in latch status.

The IC turns to normal operation when the factors of overvoltage are removed and the IC is restarted.

9.4 Thermal Shutdown

Thermal shutdown circuit detects junction temperature of internal MIC. When the temperature exceeds the MIC shutdown start temperature (150 °C typ.), MOSFET switching operation is stopped. It automatically restarts when the junction temperature decreases to MIC shutdown start temperature by stopping switching operation.

The thermal shutdown of the module is the protection circuit for IC against heat generation such as transient short circuit. The operation comprising reliability of the situation where a heat generation continues such as a short circuit for long period is not guaranteed.

10. Design Notes

10.1 Derating Curve

Figure10-1 shows the derating curve of MPM82. For MPM80 series, it is necessary to reduce the rate according to the actual ambient temperature, T_A.

The module must be used within the range of the curve in Figure10-1. The heatsink may be required in order to use the module within the absolute maximum ratings that the junction temperature, T_j, is 125 °C or lower.

The junction temperature, $T_{,j}$ is calculated from the Equation (2).

$$T_j = P_{LOSS} \times \theta_{j-H} \quad (2)$$

Where,
P_{LOSS}: Internal loss (W)
$\theta_{j\text{-}H}$: Thermal resistance between junction and heatsink (°C/W)

Internal loss, P_{LOSS}, is expressed by the Equation (3).

$$P_{LOSS} = (I_{IN} \times V_{IN}) - (I_O \times V_O)\ , \quad (3)$$

where,
I_{IN} is input current (A),
V_{IN} is input voltage (V),
I_O is output current (A) and
V_O is output voltage (V).

Thermal resistance between junction and heatsink $\theta_{j\text{-}H}$ is expressed by the Equation (4).

$$\theta_{j-H} = \theta_{j-c} + \theta_H \ , \quad (4)$$

where,
$\theta_{j\text{-}c}$ is thermal resistance between junction and case 8 °C/W and
θ_H is thermal resistance of heatsink (°C/W).

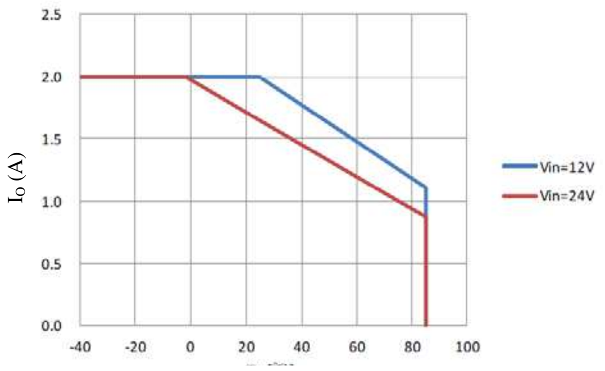


Figure10-1. MPM80 Series Derating Curve

10.2 External Components

Each component should meet the conditions of use.
The symbol of using in following description is shown in Figure 6-1 and Figure 6-2.

10.2.1 Input Smoothing Capacitor C_{IN}

The input capacitor, C_{IN}, is the bypass capacitor of input circuit. C_{IN} supplies short current pulses to the regulator, and compensates the input voltage drop. C_{IN} should be connected close to the module. If the rectifying capacitor of secondary rectifier circuit such as flyback converter is input side of the module and is not close to the module, C_{IN} must be connected close to the module.

Not only the lifetime reduction of capacitor, but also the abnormal oscillation may be caused if C_{IN} is used under the following conditions:.

Over the breakdown voltage of C_{IN}.
Over the allowable ripple current of C_{IN}.
Without derating for the breakdown voltage and allowable ripple current.

The sufficient margin to the ripple current is required for C_{IN}. The ripple current, I_{CIN}, is calculated by Equation (5).

It should be noted that C2 shown in Block Diagram of Section 4 is small capacitor for filter, and is included in the module. It is not for input smoothing capacitor.

$$I_{CIN} \approx 1.2 \times \frac{V_{OUT}}{E_{IN}} \times I_O \ , \quad (5)$$

where,
I_{CIN} is effective value of the ripple current that flows across C_{IN} (Arms),
V_{OUT} is output voltage (V),
E_{IN} is power source voltage for V_{IN} pin (V) and
I_O is output current (A).

10.2.2 Output Smoothing Capacitor C_{OUT}

C_{OUT} is the smoothing capacitor of output.
The sufficient margin to the breakdown voltage and ripple current is required for C_{OUT} like the input smoothing capacitor.

The output current is equal to the ripple current ΔI_L of inductor, L1, incorporated in the module, and charges and discharges for C_{OUT}. The ripple current of C_{OUT}, I_{COUT}, is calculated from the Equation (6) to (8).

$$t_{ON} = \frac{V_{OUT}}{E_{IN}} \times \frac{1}{f} \quad (6)$$

$$\Delta I_L = \frac{(E_{IN} - V_{OUT})}{L} \times t_{ON} \quad (7)$$

$$I_{COUT} = \frac{\Delta I_L}{2\sqrt{3}} \quad (8)$$

where,
I_{COUT} is effective value of ripple current that flows across C_{OUT} (Arms),
t_{ON} is effective value of on time of internal MOSFET (s),
V_{OUT} is output voltage (V),
E_{IN} is power source voltage for VIN pin VIN (V),
f is operating frequency of 630 kHz (typ.),
ΔI_L is the ripple current of internal inductor, and
I_L is internal inductance value of 5.6 μH (typ.).

It should be noted that C3 shown in Block Diagram of Section 4is small capacitor for filter, and is included in the module.. It is not for output smoothing capacitor.

10.2.3 Output Voltage Setup Resistor (for MPM80)

The carbon film resistor or the metal oxide film resistor should be used for R1 and R2 shown in Figure 6-1. If the wirewound resistor is used in the application, the malfunction might be caused by the inductance of wirewound resistor.

10.3 PCB Layout

1) C_{IN} and C_{OUT} should be placed as close to the module as possible.

2) R2 and R3 should be placed as close to the module as possible. If the layout connected to FB pin is long, the malfucntion may be caused due to interference such as switching noise. The pattern between R2 and R3, and between R2 and FB pin should be short as possible. (The pattern between output voltage line and R3 shoud be long if the output line and FB pin are distant.)

3) R1 should be connected to S-GND from FB pin.

4) The switching current flows through P-GND from C_{OUT}, and the voltage drop is caused by the common impedance of the GND loop and the switching current. If the GND of output detection resistor, R1, is connected to this pattarn, the load regulation may be deteriorated.

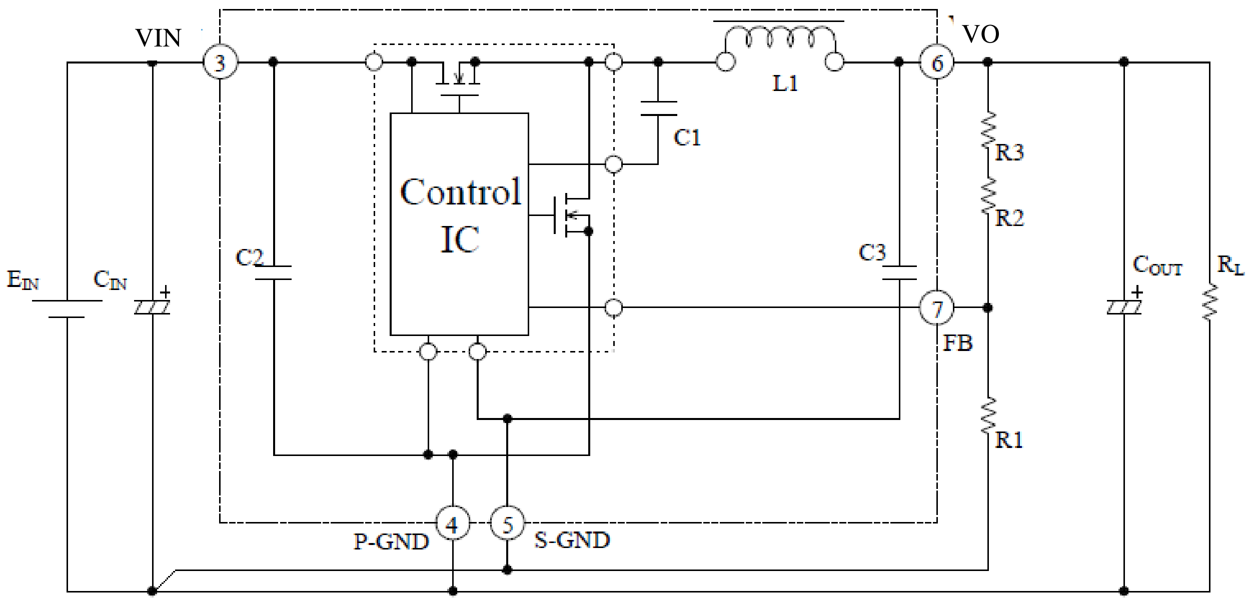


Figure 10-2. MPM80 Typical Application

11. Pattern Layout

Figure11-1 shows the PCB pattern layout as a reference, and Figure11-2 shows a circuit diagram.

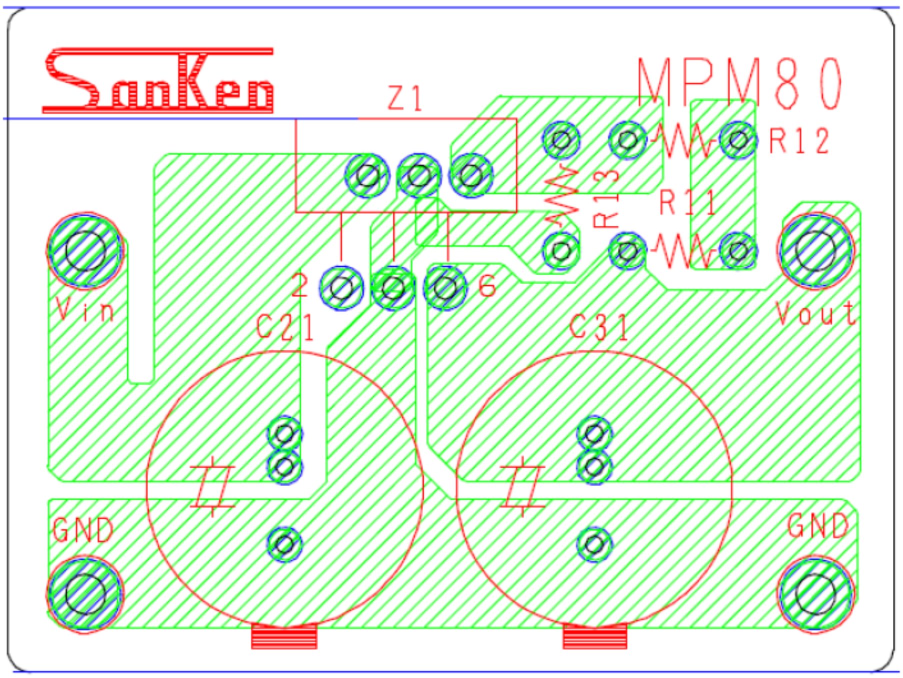


Figure 11-1. Pattern Layout

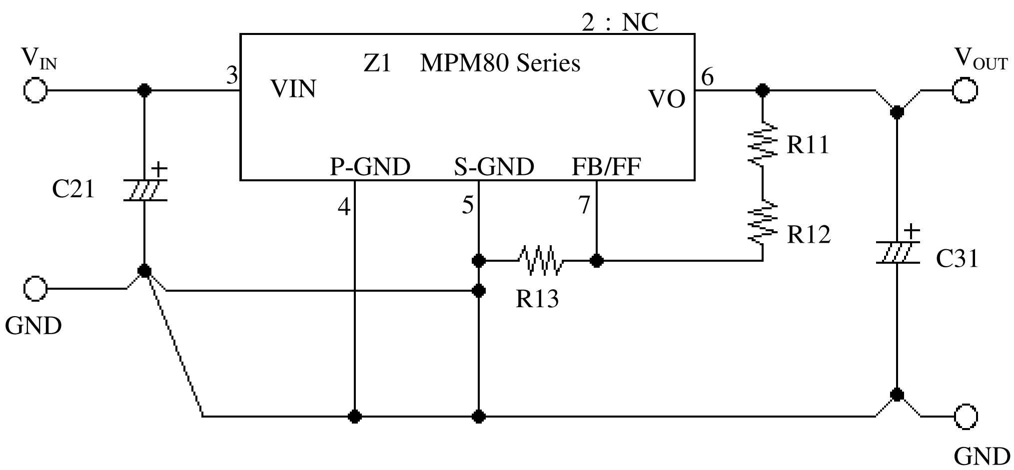


Figure 11-2. Circuit Diagram of Pattern Layout

12. Electrical Characteristics

12.1 MPM80

Test conditions: $T_A = 25$ °C, $V_O = 5$ V

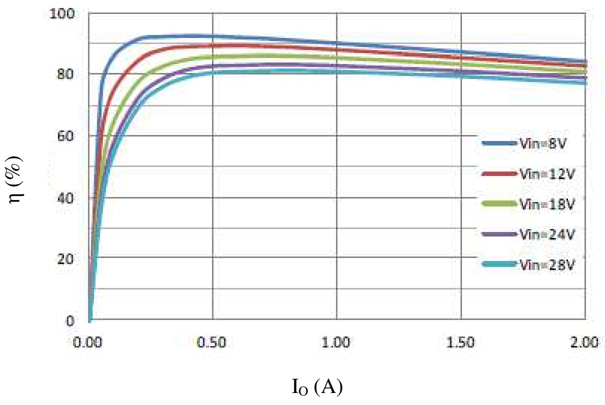


Figure 12-1. Efficiency Characteristics

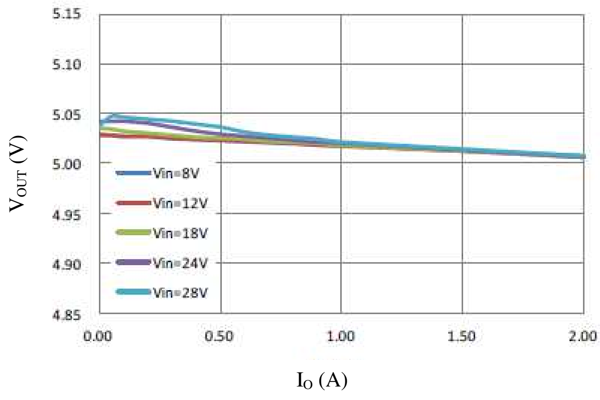


Figure 12-2. Load Regulation

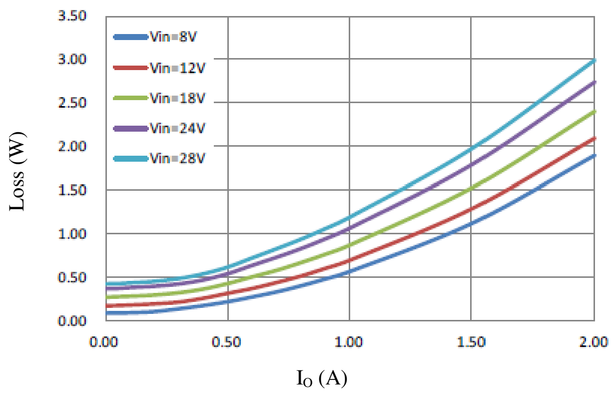


Figure 12-3. Internal Loss

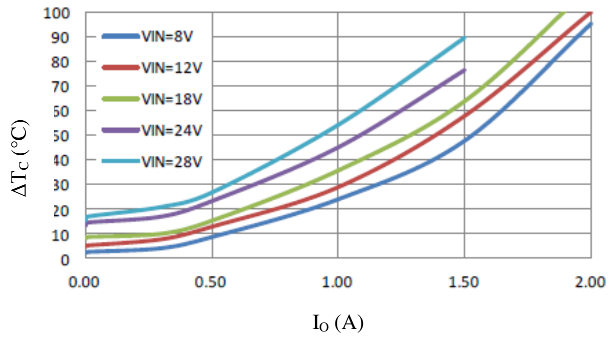


Figure 12-4. I_O vs. T_C

12.2 MPM81

Test conditions: $T_A = 25$ °C

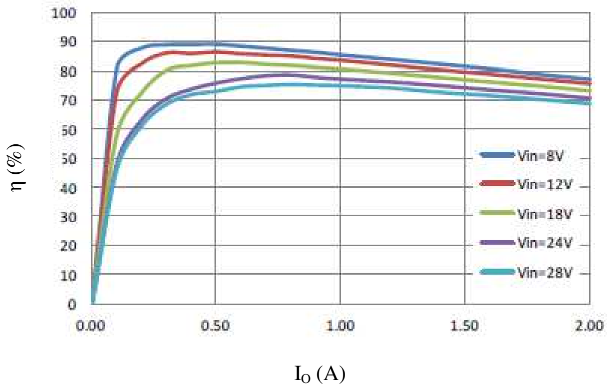


Figure 12-5. Efficiency Characteristics

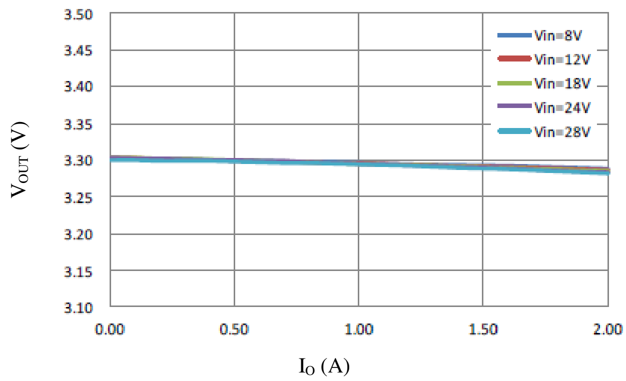


Figure 12-6. Load Regulation

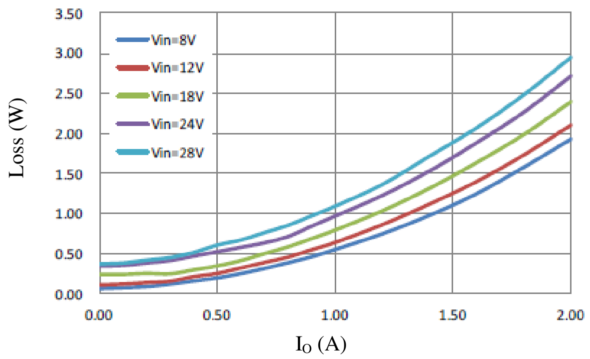


Figure 12-7. Internal Loss

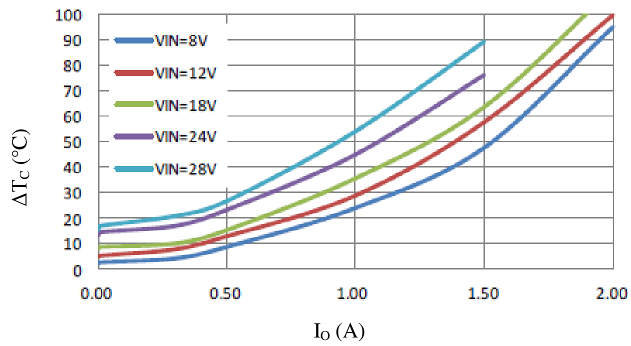


Figure 12-8. I_O vs. T_C

12.3 MPM82

Test conditions: $T_A = 25$ °C

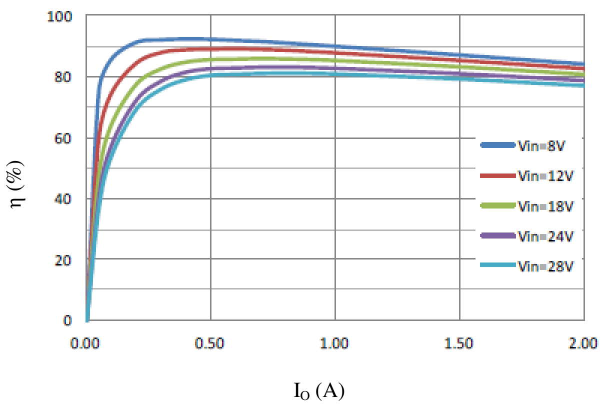


Figure 12-9. Efficiency Characteristics

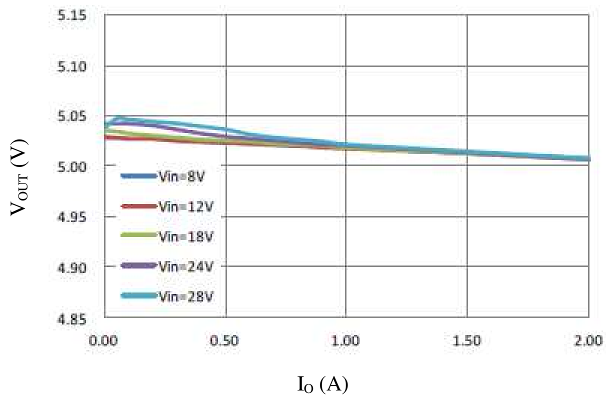


Figure 12-10. Load Regulation

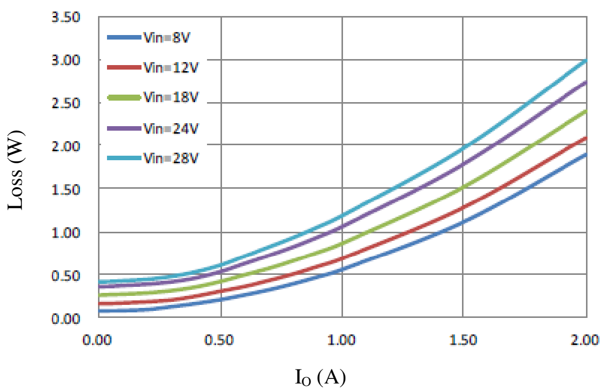


Figure 12-11. Internal Loss

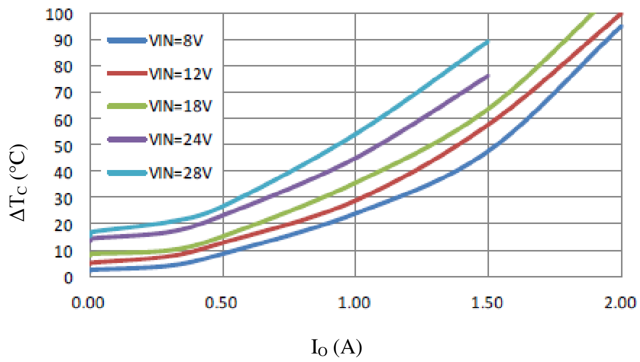


Figure 12-12. I_O vs. T_C

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