High Efficiency, 10A Synchronous Boost Converter

General Description

ME2187 is a high power density synchronous boost converter which integrates two low $R_{DS(ON)}$ MOSFETs to reduce conduction loss. It provides tiny and high efficiency solution for portable electronics. ME2187 has wide input voltage range from 2.7 to 12 V and can provide output voltage up to 12.6 V. It has 10 A switch current capability and is capable of delivering more than 30W power.

ME2187 uses current mode COT control to regulate output voltage. It works with PWM mode in moderate to heavy load. In light load, it can work with PFM mode and FPWM mode selected by the MODE pin to avoid problems caused by low switch frequency. The switch frequency is adjustable ranging from 200 kHz to 2.2 MHz by an external resistor. ME2187 is also capable of programming peak current limit and soft-start time. In addition, ME2187 provides UVLO, OVP and thermal shutdown protection.

Features

- Input voltage range: 2.7 ~ 12 V
- Output voltage range: 4.5 ~ 12.6 V
- Low shutdown current: 1 ~ 3 uA
- Low $R_{DS(ON)}$ MOSFETs (LSD/HSD): 13 mΩ / 16 mΩ
- Up to 90% efficiency @ V_{IN} = 3.3 V, V_{OUT} = 9 V, and I_{OUT} = 3 A
- Adjustable switch frequency: 200 kHz ~ 2.2 MHz
- Selectable mode between PFM and FPWM
- Programmable peak switch current limit
- Programmable soft-start time
- Output over-voltage protection @ 13.4 V
- Thermal shutdown @ 150 °C

Typical Applications

- Quick Charge Power Bank
- E-Cigarette
- Bluetooth Speaker
- Portable POS terminal

Package

- 16-pin ESOP16
- 20-pin DFN20L(4.5 × 3.5×0.9-0.5)
  DFN20L(4.5 × 3.5×0.75-0.5)

Typical Application Circuit

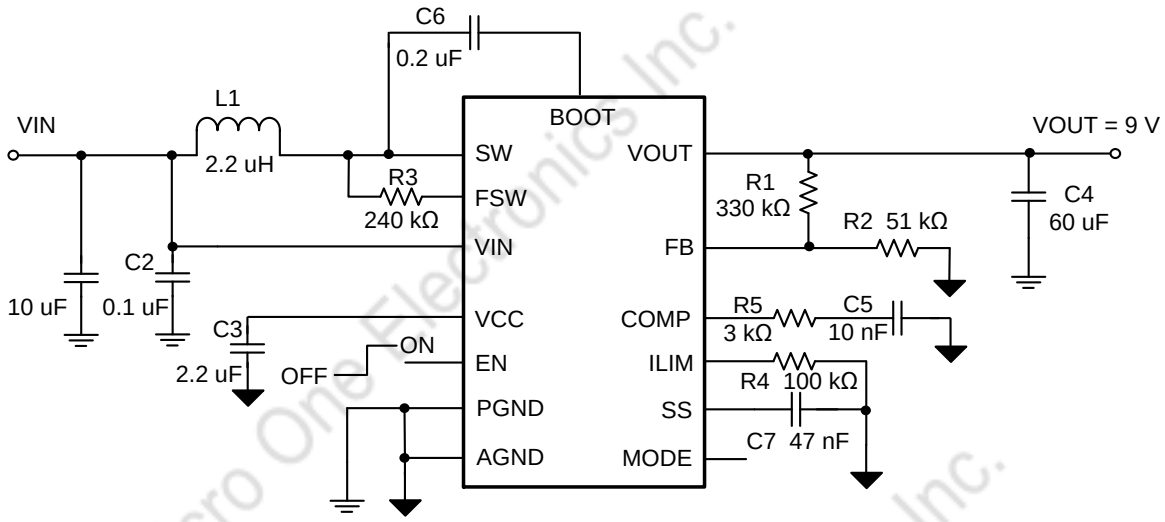
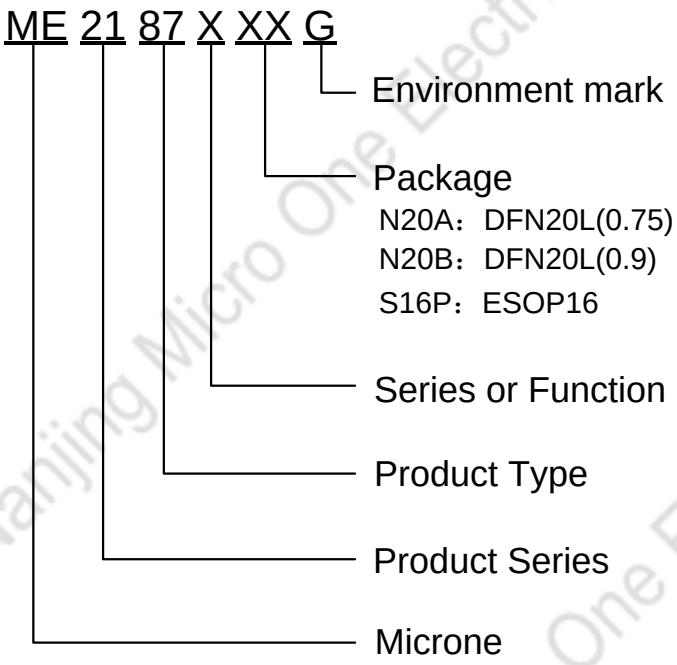


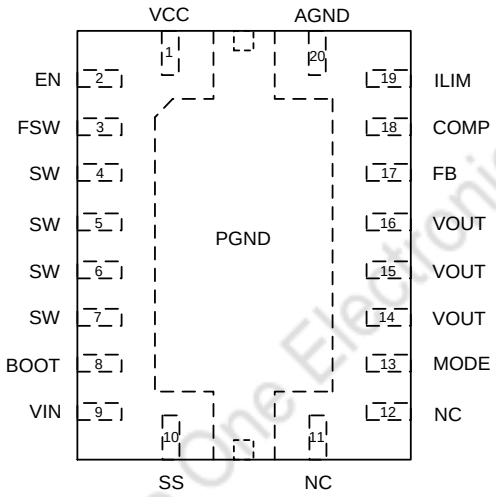
Fig 1. ME2187 typical application schematic

Selection Guide

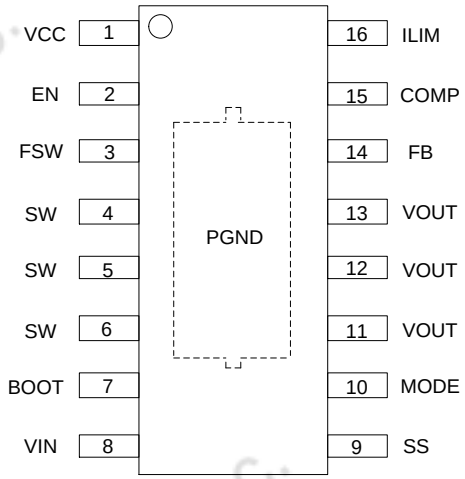


product series	product description
ME2187AS16PG	Package：ESOP16
ME2187AN20AG	Package：DFN20L(4.5 × 3.5×0.75-0.5)
ME2187AN20BG	Package：DFN20L(4.5 × 3.5×0.9-0.5)

Pin Configuration



DFN20L

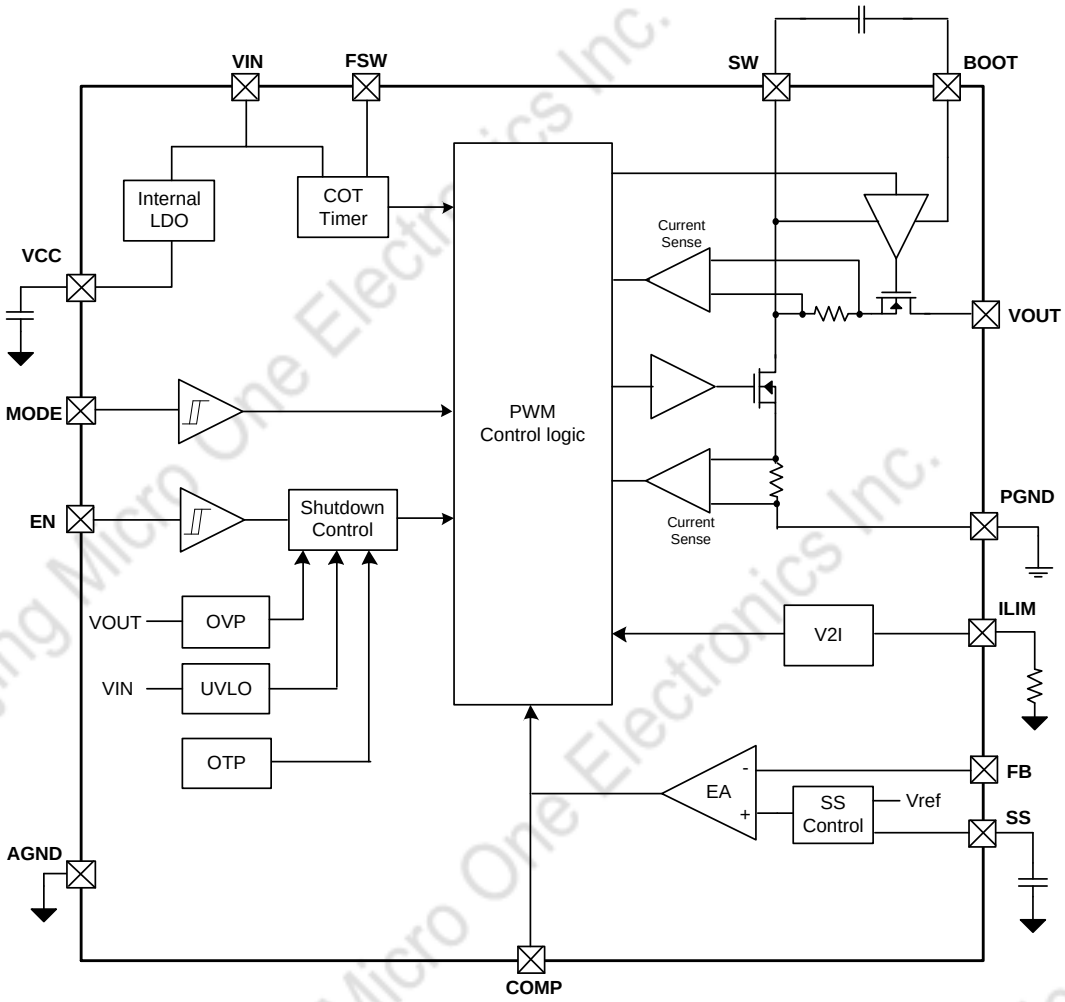


ESOP16

Pin Assignment

Pin			Description
Name	**Number DFN20L**	**Number ESOP16**	
VCC	1	1	Output of internal LDO. A ceramic capacitor of more than 1 uF is required between VCC pin and ground.
EN	2	2	Enable logic input. Logic high enables IC and logic low disables IC.
FSW	3	3	Use external resistor between FSW pin and SW pin to set switch frequency
SW	4, 5, 6, 7	4, 5, 6	Switching node of boost converter. It is connected to the drain of LSD and the source of HSD.
BOOT	8	7	Power supply for HSD gate driver. A ceramic capacitor of more than 0.2 uF is required between BOOT pin and ground.
VIN	9	8	Power supply for IC.
SS	10	9	Use external capacitor between SS pin and ground to set soft-start time.
NC	11, 12		No connection inside the IC. It's recommended to connect these two pins to ground to improve thermal performance.
MODE	13	10	Mode select pin. In light load, logic high or floating selects PFM mode and logic low selects FPWM mode.
VOUT	14, 15, 16	11,12,13	Output of boost converter.
FB	17	14	Voltage feedback. This pin is connected to the center tape of a resistor divider.
COMP	18	15	Output of internal error amplifier. Loop compensate network is required between COMP pin and ground.
ILIM	19	16	Use external resistor between ILIM pin and ground to set peak current limit.
AGND	20		Analog ground.
PGND	Thermal PAD	Thermal PAD	Power ground. It is connected to the source of LSD.

Block Diagram



Absolute Maximum Ratings (Note1)

Symbol		Description	Value	Unit
V_{PIN}	BOOT	Voltage between each pin and ground.	-0.3 ~ SW + 6.6	V
	VIN, SW, FSW, VOUT		-0.3 ~ 14	V
	EN, VCC, SS, COMP, MODE, ILIM, FB		-0.3 ~ 6.6	V
T_A		Operating ambient temperature	-40 ~ 85	ºC
T_J		Operating junction temperature	-40 ~ 150	ºC
T_{stg}		Storage temperature	-55 ~150	ºC
T_{lead}		Lead temperature	260	ºC
PD	DFN20L	Power Dissipation	2.4	W
	ESOP16		2.23	W
θ_{JA}	DFN20L	Package thermal resistance	52	ºC/W
	ESOP16		56	ºC/W

Note 1: Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device.

ESD Ratings

Model	Value	Unit
Human body mode(HBM), all pins	±2000	V
Charged device model (CDM), all pins	±500	V

Recommended Operating Conditions

Symbol	Description	Min	Typ	Max	Unit
V_{IN}	Input voltage range	2.7	-	12	V
V_{OUT}	Output voltage range	4.5	-	12.6	V
L	Inductance, effective value	0.6	2.2	10	uH
C_O	Output capacitance, effective value	10	60	1000	uF
T_A	Operating ambient temperature	-40	-	85	ºC

Electrical Characteristics

(T_A = 25 ºC, V_{IN} = 3.6 V, V_{OUT} = 9 V, L = 2.2 uH, R_{ILIM}= 100 kΩ, R_{FREQ} = 240 kΩ, unless otherwise specified)

Symbol	Description	Test Conditions	Min	Typ	Max	Unit
V_{IN}	Input Voltage range		2.7	-	12	V
V_{UVLO}	Input UVLO threshold voltage	Input voltage rising	-	-	2.7	V
V_{UVLO_HYS}	UVLO hysteresis		-	0.2	-	V
I_{SD}	Shutdown current into the VIN pin	IC disabled, no feedback resistor and load connected to VOUT pin	-	1	3	uA
I_Q	Input quiescent current in PFM mode and empty load	IC enabled, no load, MODE pin floating	-	600	1200	uA
V_{CC}	Output voltage of internal LDO	V_{IN} = 8 V, I_{VCC} = 10 mA	4	5	6	V
V_{ENH}	EN logic high threshold voltage	VCC = 5 V	-	-	1.2	V
V_{ENH}	EN logic low threshold voltage	VCC = 5 V	0.4	-	-	V
R_{EN}	EN internal pull-down resistor	VCC = 5 V	-	800	-	kΩ
V_{MODEH}	MODE logic high threshold voltage	VCC = 5 V	-	-	4.0	V
V_{MODEL}	MODE logic low threshold voltage	VCC = 5 V	1.5	-	-	V
R_{MODE}	MODE pull-up resistor	VCC = 5 V	-	800	-	kΩ
V_{OUT}	Output voltage range		4.5	-	12.6	V
V_{REF}	Feedback reference voltage		1.188	1.206	1.224	V
I_{FB}	Leakage current into FB pin	V_{FB} = 1.5 V	-	-	100	nA
I_{SS}	Soft-start charging current		-	5	-	uA
$R_{DS(ON)1}$	LSD on-resistance		-	13	17	mΩ
$R_{DS(ON)2}$	HSD on-resistance		-	16	21	mΩ
I_{LIM_PFM}	Peak switch current limit in PFM mode	R_{ILIM} = 100 kΩ, MODE pin floating	-	12.2	-	A

I_{LIM_FPWM}	Peak switch current limit in FPWM mode	R_{ILIM} = 100 kΩ, MODE pin short to ground	-	10.6	-	A
F_{SW}	Switch frequency	R_{FREQ} = 240 kΩ, MODE pin short to ground	-	550	-	kHz
t_{min_ON}	Minimum on time		-	110	200	ns
t_{min_OFF}	Minimum off time		-	100	200	ns
V_{OVP}	Output over-voltage protection threshold voltage	Output voltage rising	-	13.4	-	V
V_{OVP_HYS}	Output over-voltage protection hysteresis		-	0.3	-	V
T_{SD}	Thermal shut down threshold	Junction temperature rising	-	150	-	°C
T_{SD_HYS}	Thermal shut down hysteresis		-	20	-	°C

Typical performance characteristics

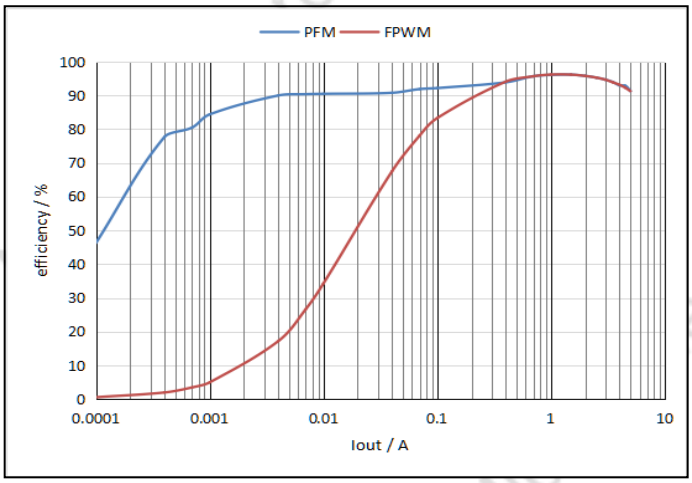


Fig 2. Efficiency vs I_{OUT} @ V_{IN}=3.6 V, V_{OUT} = 5 V

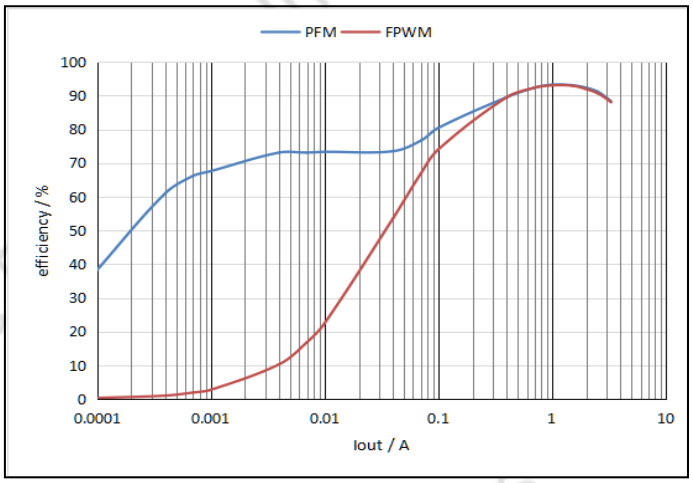


Fig 3. Efficiency vs I_{OUT} @ V_{IN}=3.6 V, V_{OUT} = 9 V

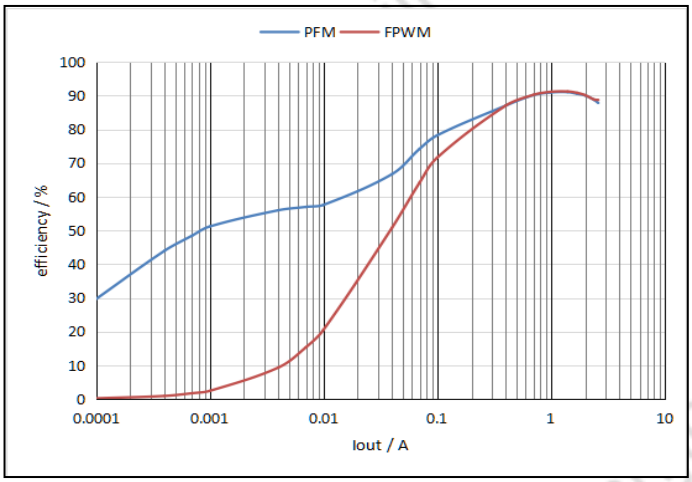


Fig 4. Efficiency vs I_{OUT} @ V_{IN}=3.6 V, V_{OUT} = 12 V

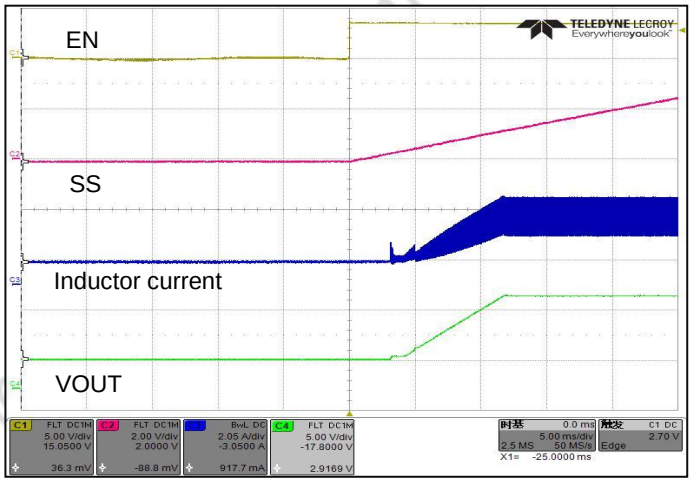


Fig 5. Start-up waveform

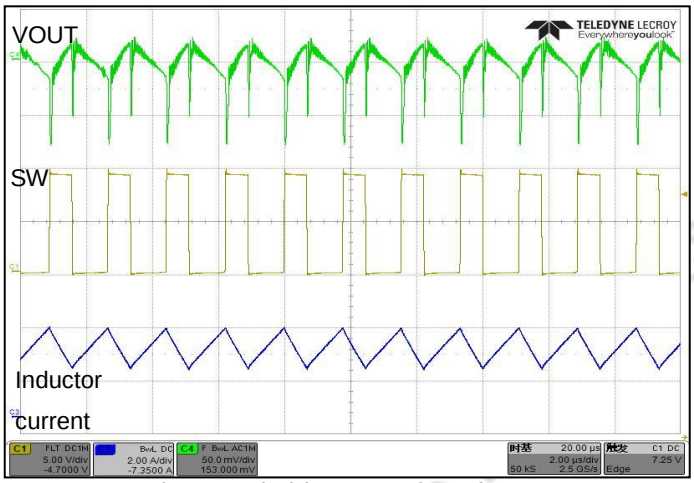


Fig 6. Switching waveform in CCM

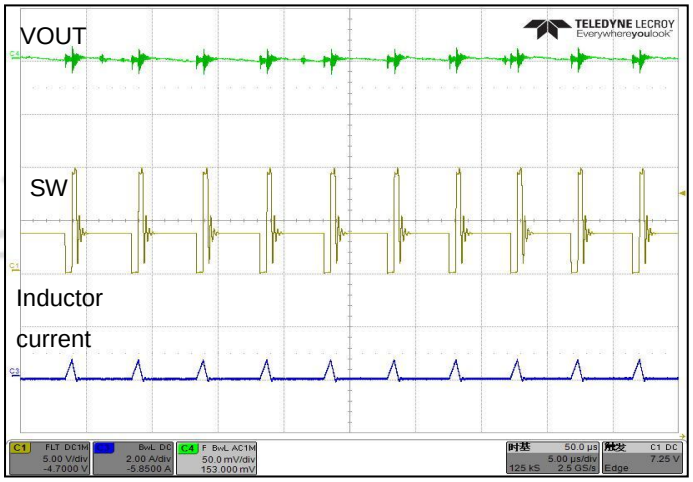


Fig 7. Switching waveform in PFM

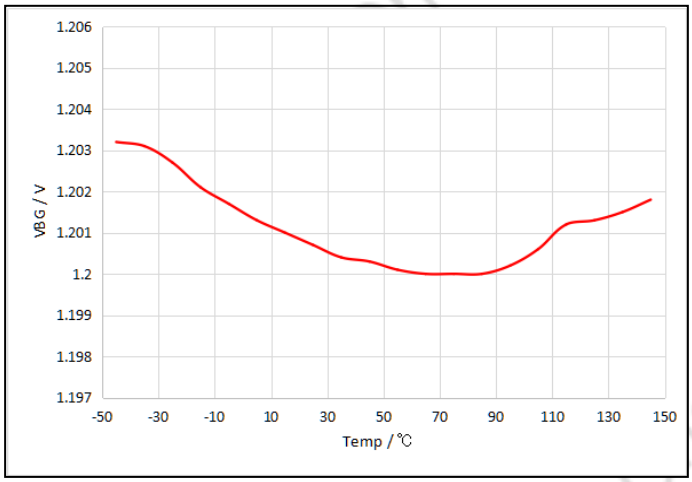


Fig 8. Reference voltage vs temperature

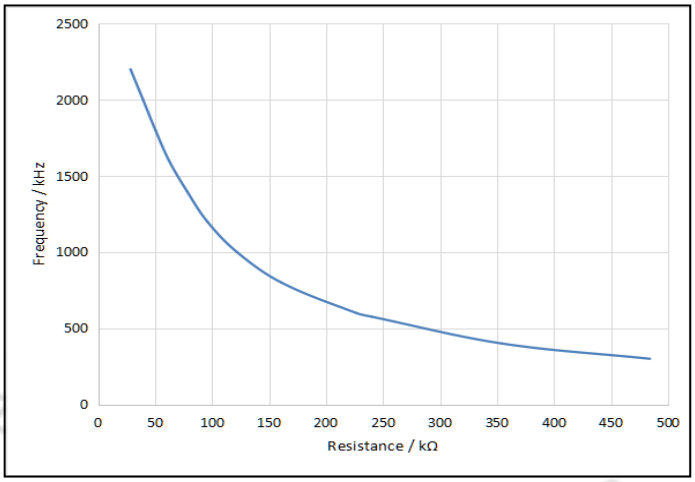


Fig 9. Switching frequency vs setting resistance

Operation Description

ME2187 is a synchronous boost converter which integrates two very low $R_{DS(ON)}$ power switches to improve efficiency. It adopts current mode COT control topology to regulate output voltage. In moderate to heavy load, during every switching period, low-side MOSFET is turned on until switch current ramps up to a certain peak current determined by error amplifier. During dead time, inductor current flows through body diode of high-side MOSFET. After dead time, the high-side MOSFET is turned on and will be turned off after adaptive constant off time is reached. In light load, operating mode can be selected by MODE pin. When MODE pin is floating or logic high, ME2187 works in PFM mode and extends off time of switching period to reduce delivered energy. When MODE pin is short to ground, ME2187 works in FPWM mode. In FPWM mode, the power efficiency is low but the fixed switching frequency can avoid audible noise and other problems caused by low switching frequency.

Application Information

ME2187 is capable of providing 12.6 V output voltage. It integrates two internal 10A power switches and can deliver more than 30 W power. In light load, user can select PFM mode or FPWM mode by MODE pin. ME2187 also

supports programmable soft-start time, switching frequency and peak current limit.

Setting soft-start time

When EN pin is pulled up, soft-start capacitor C_{SS} between SS pin and ground is charged by a constant current of 5 uA. The lower of voltage on C_{SS} and internal feedback V_{REF} (1.206 V) is selected as reference input of error amplifier. FB pin voltage slowly ramps up with SS pin voltage. Soft-start phase is completed after SS pin voltage exceeds V_{REF}. When EN pin is pulled down, voltage on C_{SS} is discharged to ground. Soft-start time t_{SS} can be calculated by the following equation.

$$t_{SS} = \frac{V_{REF} \times C_{SS}}{I_{SS}}$$

Setting output voltage

The output voltage can be programmed by external resistor divider (R1 and R2 in typical application schematic) connected to VOUT pin. For reducing quiescent current in empty load, it is recommended to use large resistance between 10 kΩ and 1 MΩ for R1 and R2. The resistance of R1 can be calculated by following equation.

$$R_1 = \frac{(V_{OUT} - V_{REF}) \times R_2}{V_{REF}}$$

Setting switching frequency

The switching frequency can be programmed by external resistor R_{FREQ} between FSW pin and SW pin. The RFREQ required for desired frequency can be calculated using following equation.

$$R_{FREQ} = \frac{4 \times (\frac{1}{f_{SW}} - t_{min\_OFF} \times \frac{V_{OUT}}{V_{IN}})}{C_{FREQ}}$$

Where V_{IN} is input voltage, V_{OUT} is output voltage, f_{SW} is switching frequency, C_{FREQ} is 25 pF, t_{min_OFF} is 100 ns

Setting peak current limit

The peak switch current limit can be set by external resistor R_{ILIM}. Please be advised that I_{LIM} in FPWM mode is 1.6A lower than that in PFM. To guarantee normal operation of boost converter, peak switch current limit should be higher than maximum inductor peak current. Peak current limit in PFM mode can be calculated using following equation.

$$I_{LIM} = \frac{1220000}{R_{ILIM}}$$

External component

1）High-side MOSFET driver is powered using external bootstrap capacitor. A ceramic capacitor of 200 nF

should be connected between SW pin and BOOT pin.

2） The effective capacitance is decreased with DC bias. So it is necessary to leave margin to guarantee adequate effective capacitance especially for C_I and C_O.

3） When the inductor current approaches its saturation current, its inductance can decrease 30% from the value at 0-A current. The saturation current of used inductor should be higher than the maximum peak inductor current.

Board Layout Considerations

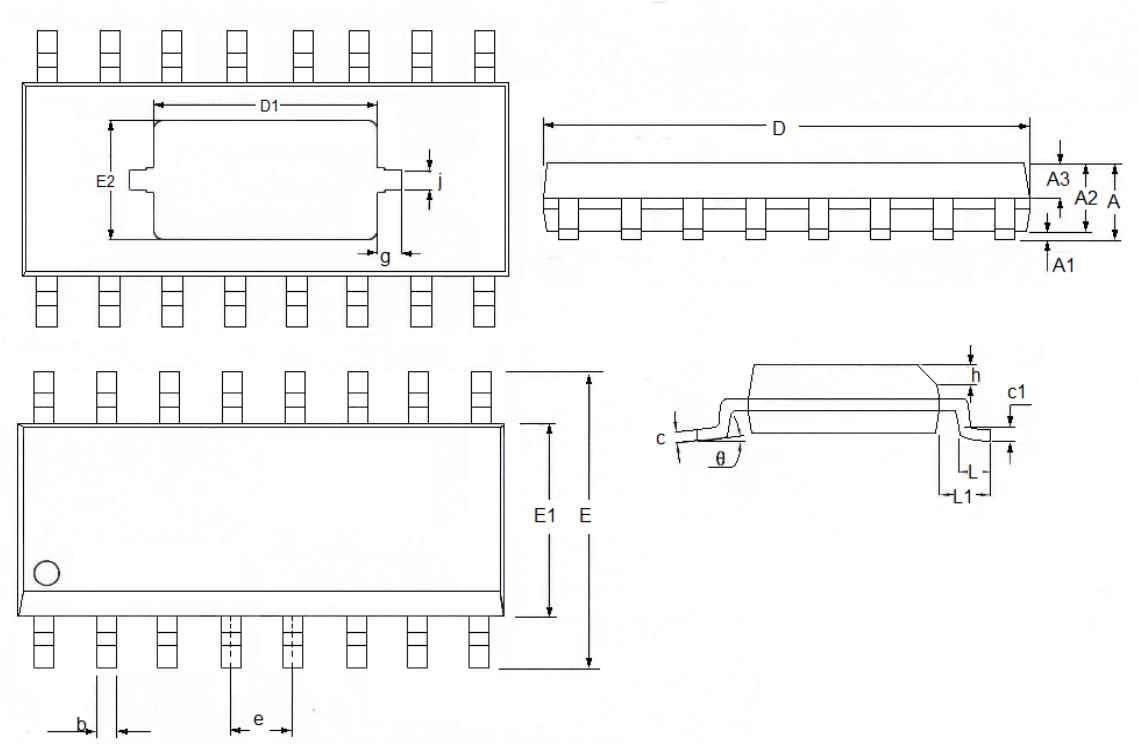
1） Boost converter implemented by ME2187 is sensitive to PCB layout. For reducing non-ideality, external component such as inductor, input capacitor, output capacitor, compensation network and resistor divider should be placed as nearly as possible to the chip.

2） For reducing EMI caused by high frequency switching, the trace connected to SW pin should be as short as possible. It is recommended to use ground plane to shield signal from interplane coupling.

3） To improve thermal dissipation and power efficiency, it is recommended to connect the thermal pad of package to ground plane. More thermal vias and thick PCB copper are desirable.

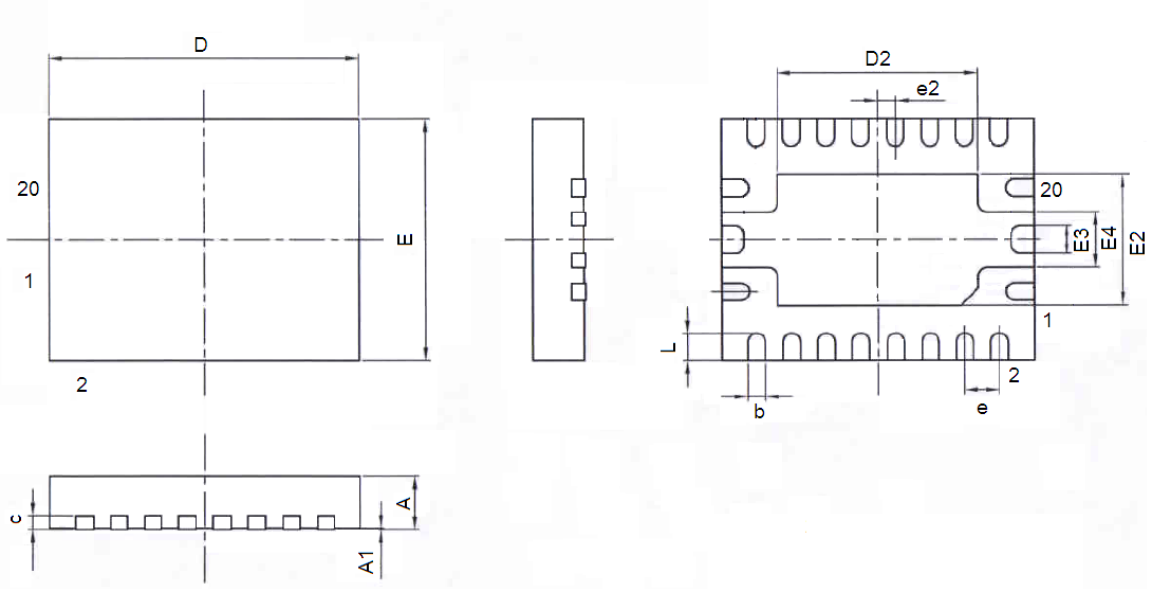
Packaging Information

- **Package Type: ESOP16**



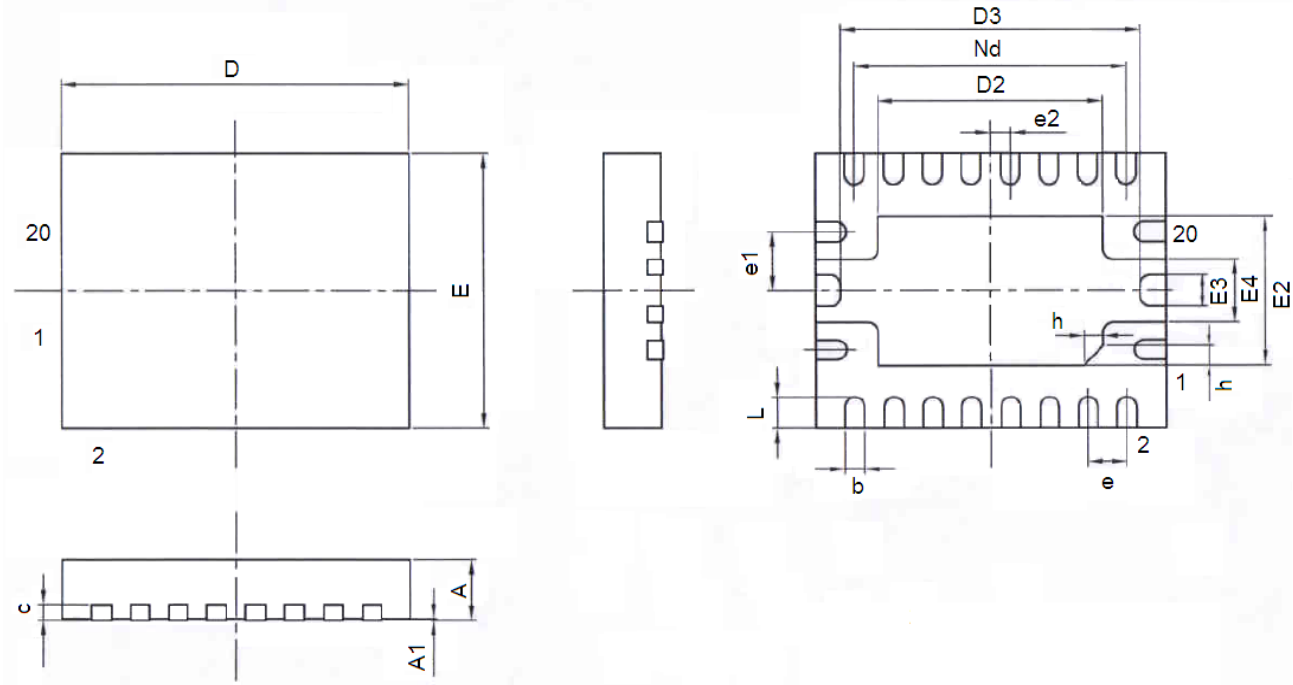
DIM	Millimeters		Inches	
	Min	Max	Min	Max
A	1.35	1.75	0.0531	0.0689
A1	0.05	0.2	0.0020	0.0079
A2	1.3	1.6	0.0512	0.0630
A3	0.6	0.71	0.0236	0.0280
b	0.356	0.47	0.0140	0.0185
c	0.2	0.24	0.0079	0.0094
D	9.8	10.2	0.3858	0.4016
E	5.8	6.24	0.2283	0.2457
E1	3.8	4	0.1496	0.1575
e	1.27BSC		0.0500	
h	0.25	0.5	0.0098	0.0197
L	0.4	0.8	0.0157	0.0315
L1	1.05BSC		0.0413	
θ	0	8°	0	8°
c1	0.25		0.0098	
D1(95*180)	4.57REF		0.1799REF	
E2(95*180)	2.41REF		0.0949REF	
g	0.51REF		0.02REF	
j	0.4REF		0.0157REF	

- **Package Type: DFN20L(4.5 × 3.5×0.75-0.5)**



DIM	Millimeters		Inches	
	Min	Max	Min	Max
A	0.7	0.8	0.0275	0.0315
A1		0.05		0.0020
b	0.2	0.3	0.0079	0.0118
c	0.203		0.0080	
D	4.5		0.1772	
D2	2.95	3.15	0.1161	0.1240
e	0.5(BSC)		0.0197(TYP)	
e2	0.25(BSC)		0.0098(BSC)	
E	3.5		0.1378	
E2	1.95	2.15	0.0768	0.0846
E3	0.25	0.45	0.0098	0.0177
E4	0.65	0.85	0.0256	0.0335
L	0.3	0.5	0.0118	0.0197

- **Package Type: DFN20L(4.5 × 3.5×0.9-0.5)**



DIM	Millimeters		Inches	
	Min	Max	Min	Max
A	0.85	0.95	0.0335	0.0374
A1		0.05		0.0020
b	0.18	0.3	0.0071	0.0118
c	0.18	0.25	0.0071	0.0098
D	4.4	4.6	0.1732	0.1811
D2	3.1	3.3	0.1220	0.1299
D3	3.85(REF)		0.1516REF	
e	0.5(BSC)		0.0197(TYP)	
e1	0.75(BSC)		0.0295(BSC)	
e2	0.25(BSC)		0.0098(BSC)	
Nd	3.5(BSC)		0.1378(BSC)	
E	3.4	3.6	0.1339	0.1417
E2	2.1	2.3	0.0827	0.0906
E3	0.35(BSC)		0.0138(BSC)	
E4	0.75(BSC)		0.0295(BSC)	
L	0.35	0.45	0.0138	0.0177
h	0.2	0.3	0.0079	0.0118

- The contents of this document will be updated with the product's improvement without prior notice. Please consult our sales staff before using this document to ensure that you are using the latest version.
- The application circuit examples described in this document are only used to indicate the representative use of the product and do not guarantee the design of mass production.
- Please use this product within the limits stated in this document. We will not be responsible for any damage caused by improper use.
- The products described in this document are not allowed to be used in equipment or devices that affect the human body without the written permission of our company, including but not limited to: health equipment, medical equipment, disaster prevention equipment, fuel control equipment, automobile equipment, aviation equipment and vehicle equipment.
- Although our company has always been committed to improving product quality and reliability, semiconductor products have a certain probability of malfunction or wrong work. To prevent personal injury or property damage caused by such accidents, please pay full attention to safety design, for example: Alternate design, fire protection design, and prevention of wrong action design.
- When exporting this product or this document overseas, you should abide by applicable import and export control laws.
- Copying or reprinting part or all of this document in any form without the permission of our company is strictly prohibited.