FMLDC06503A1V8AWH Thru FMLDC06503A3V3AWH

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FMLDC06503A1V8AWH Thru FMLDC06503A3V3AWH

300mA Low Voltage Difference CMOS Voltage Regulators

Features

- Input voltage range : 2.0V ~ 6.5V.
- Fixed output voltage : designed for 1.0V to 5.0V output.
- Output voltage tolerance : ±1%.
- Output current : 300mA.
- Dropout voltage : 120mV @100mA (V_{OUT} = 3.3V).
- Power supply rejection ratio : 80dB@1KHz.
- Low output noise : 25×V_{OUT} μ V_{RMS} (10Hz ~ 100kHz).
- Lead-free parts meet RoHS requirements.

Applications

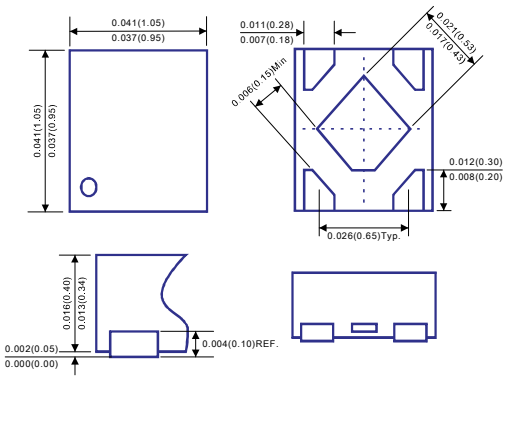
- Wearable Electronics.
- Gaming Controllers, Remote controls, Toys, Drones, Set-top Boxes.
- Wireless communication equipments.
- Always-on Power Supplies.

Mechanical data

- Epoxy:UL94-V0 rated flame retardant.
- Case : T1010P4.
- Weight : Approximated 1.5mg.

Package outline

T1010P4



Dimensions in inches and (millimeters)

Maximum ratings (T_{OPT}=25℃, unless otherwise note)

Parameter	Symbol	Ratings	Unit
Input voltage (Note 2)	V_{IN}	-0.3~8.0	V
Output current	I_{OUT}	300	mA
Power dissipation (Note 3)	P_D	0.42	W
Electrostatic discharge (Note 5)	$V_{ESD-HBM}$	2	KV
	V_{ESD-MM}	400	V
Thermal resistance, junction to ambient	$R_{\theta JA}$	222	℃/W
Thermal resistance, junction to case	$R_{\theta JC}$	114.3	℃/W
Operating junction temperature range	T_J	-40~+125	℃
Storage temperature	T_{STG}	+150	℃
Soldering temperature and time	T_{Solder}	+260	℃

Note :

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions. Exposure to absolute maximum rated conditions for extended periods may affect device reliability.

(2) All voltages are with respect to network ground terminal.

(3) Refer to Thermal Information for details.

(4) It is necessary to ensure that the operating junction temperature of the device does not exceed the rated value of the recommended operating conditions when using the device for design.

(5) ESD testing is conducted in accordance with the relevant specifications formulated by the Joint Electronic Equipment Engineering Commission (JEDEC). The human body model (HBM) electrostatic discharge test is based on the JESD22-114D test standard, using a 100pF capacitor and discharging to each pin of the device through a resistance of 1.5kΩ. The electrostatic discharge test in mechanical model (MM) is based on the JESD22-A115-A test standard and uses a 200pF capacitor to discharge directly to each pin of the device.

(6) Thermal metric is measured in still air with T_A = 25°C and installed on a 1 in^2 FR-4 board covered with 2 ounces of copper.

FMLDC06503A1V8AWH Thru FMLDC06503A3V3AWH

Electrical characteristics

(V_{IN} = V_{OUT} +1V, C_{IN} = 1.0μF, C_{OUT} = 1.0μF, T_A= 25°C, unless otherwise specified)

Parameter	Symbol	Conditions		Min	Typ	Max	Unit
Input voltage	V_{IN}			2.0		6.5	V
Output voltage (note 8)	V_{OUT}	I_{OUT}=1mA(note9)		-1		1	%
Output Current limit	$I_{OUT\ LIMIT}$				510		mA
Quiescent current	I_Q	I_{OUT}=0mA			0.8	1.5	μA
Dropout voltage (note 9)	V_{DO}	V_{OUT}=1.8 to2.5V	I_{OUT}=100mA		200		mV
		V_{OUT}=2.6 to 2.9V			140		
		V_{OUT}=5.0V			120		
Line regulation (note 10)	LNR	V_{IN} = V_{OUT} +1V to 6.5V, I_{OUT} = 10mA			0.02	0.3	%/V
Load regulation	ΔV_{LOAD}	V_{IN}= V_{OUT} +1V, I_{OUT} = 1 to 100mA			15		mV
		V_{IN}= V_{OUT} +1V, I_{OUT} = 1 to 300mA			27	55	
Output voltage temperature characteristics (note 11)	TR	V_{IN} = 5.0V, I_{OUT} =1mA, T_A= -40 to 85℃			15		ppm/℃
Standby current	I_{STBY}	V_{EN}=GND				0.2	μA
EN logic low voltage	V_{ENH}			1.2		V_{IN}	V
	V_{ENL}					0.3	V
Ripple suppression ratio	PSRR	V_{IN} = (V_{OUT} +1V)$_{DC}$ + 1V_{PPAC}, I_{OUT} = 10mA	f = 100Hz		65		dB
			f = 1kHz		80		
		V_{IN} = (V_{OUT} +1V)$_{DC}$ + 1V_{PPAC}, I_{OUT} = 100mA	f = 100kHz		60		
			f = 1kHz		70		
EN logic voltage	V_{ENH}			1.2		V_{IN}	V
	V_{ENL}					0.3	V
Auto discharge resistance	$R_{discharge}$	V_{IN}=5V, V_{OUT}=1.5V, EN=GND			500		Ω
Thermal shutdown	T_{SD}				150		℃
Thermal shutdown hysteresis	ΔT_{SD}				20		℃

Note：

(7)Typical numbers are at 25°C and represent the most likely norm.

(8)Test the difference of output voltage and input voltage when input voltage is decreased gradually till output voltage equals to 98% of V_{OUT} Normal.

(9)The line regulation is calculated by the following formula:

$$TR = \frac{\Delta V_{OUT}}{V_{OUT} \times \Delta T}$$

where, ΔV_{OUT} is the variation of the output voltage, ΔV_{IN} is the variation of the input voltage.

(10) The output voltage temperature characteristics (T_R) is calculated by the following formula:

$$LNR = \frac{\Delta V_{OUT}}{V_{OUT} \times \Delta V_{IN}}$$

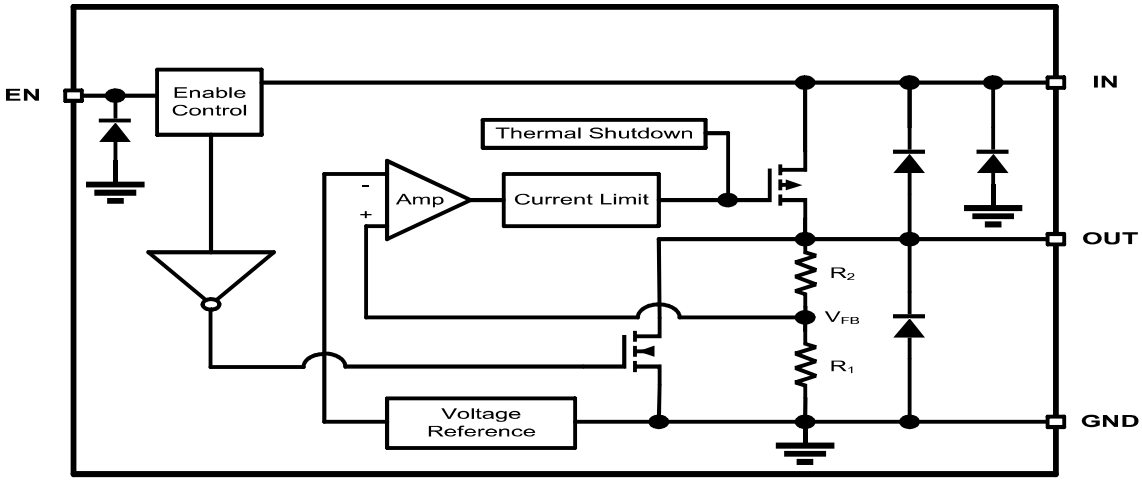
where, ΔV_{OUT} is the variation of the output voltage, ΔT is the variation of the ambient temperature.

Detailed Description

1. Description

The FMLDC06503A series is a group of linear voltage regulators with ultra-low power consumption and low voltage difference. After optimization, it has excellent transient performance. These features make the device ideal for most battery powered applications. This low dropout linear regulator provides built-in current limiting, short circuit protection and thermal shutdown protection functions.

2. Functional block diagram



The internal feedback resistors R_1 and R_2 form a voltage divider circuit to compare the V_{FB} input error amplifier with the reference voltage. The internal regulator tube (PMOS) will control its conduction degree through the grid voltage provided by the error amplifier output, which will make the output voltage V_{OUT} not affected by temperature changes or input voltage changes to a certain extent, thus maintaining the stability of the device output voltage.

3. Power Supply Input

When the input voltage is lower than the rated range of the data sheet, the device will lose the regulation function of stabilizing the output voltage, that is, it is unable to maintain the output voltage within the rated range. At this time, compared with normal operation, the quiescent current of the device may exceed the rated range, and the transient response performance may be seriously degraded.

When the input voltage is higher than the rated range of the data sheet, the device may cause irreversible damage or failure due to exceeding the maximum rated range of electrical stress.

For the rated input voltage of the device, see Recommended Operating Conditions.

4. Output Current

When the circuit design is appropriate, the FMLDC06503A series can reach the maximum load capacity of up to 300mA. According to the power dissipation of the package and the effective connection thermal resistance with the environment, selecting the appropriate package for the circuit design can make the device emit more heat energy.

5. Enable Control

The enable pin of the device (EN) is active at high level. When the voltage of the EN is greater than the EN logic high voltage ($V_{EN\,H}$), the device will be enabled and maintain the normal output. When the voltage of the EN is lower than the EN logic low voltage ($V_{EN\,L}$), the internal circuit of the device will be disabled and the output will be turned off, the device, the device will be in the standby mode until EN is turned to high level again. The V_{ENH} and V_{ENL} can be found in the Electrical Characteristics.

Normal startup waveform and startup slope rate control can be ensured when the device starts from any low voltage lower than V_{ENL}, but the discharge time of output capacitor must be taken into account. EN can not be float, if EN is not required to control the output voltage independently, connect EN to IN.

6. Dropout Voltage

Dropout voltage (V_{DO}) refers to the minimum voltage difference between input and output (V_{IN} - V_{OUT}) to make the device output voltage reach the rated range at rated current. When the dropout voltage condition required by the device is reached, the internal MOSFET will be fully turned on, at this time, the MOSFET is equivalent to a switch for regulation. The V_{DO} increases with the increase of load current. Since V_{IN} - V_{OUT} must be no less than the V_{DO}, the V_{DO} indirectly specifies the minimum input voltage of devices under different load current conditions. If the V_{IN} - V_{OUT} is less than the V_{DO}, the performance of the device may deteriorate (see Operation in Dropout Mode for details).

7. Auto-discharge Function

The device with enable control has an auto-discharge circuit. When the enable control is turned off, the device will be disabled. An internally integrated pull-down MOSFET (see Functional Block Diagram) will connect a resistor RDischarge to the ground to release the charge in the output capacitor, thus closing the entire device circuit. The value of RDischarge can be found in the Electrical Characteristics. The discharge time of the output capacitor after the device is disabled is determined by the output capacitance COUT and load resistance RL in parallel with the RDischarge. The time constant τ can be calculated by the following formula:

$$\tau = C \times R_{Discharge} \quad (R_L = 0)$$

$$\tau = C \times \left(\frac{R_L \times R_{Discharge}}{R_L + R_{Discharge}} \right) \quad (R_L \neq 0)$$

The output voltage after discharging through pull-down MOSFET can be calculated by the following formula:

$$V = V_{OUT} \times e^{-\frac{t}{\tau}}$$

$$t = \tau \times \ln\left(\frac{V}{V_{OUT}}\right)$$

8. Built-in Current Limit & Short Circuit Protection

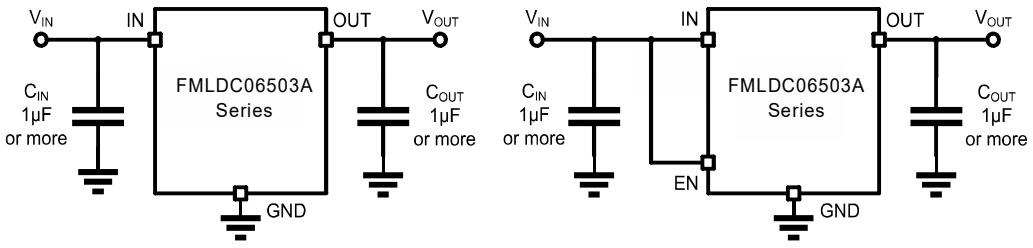
.The FMLDC06503A series has an internal current limiting circuit, which can protect the device by limiting the load current value in case of instantaneous high load current. When the current limiting is triggered, the output voltage is not regulated. If the out pin of the regulator is short circuited, the internal current limiting circuit also will be triggered. When the load current of the device is large, the device will generate more heat due to the increase of power consumption, which may cause the device to turn off its output due to the internal thermal shutdown protection before the current limit is triggered.

In order to ensure the normal operation of current limit, the inductance of input and load shall be minimized. Continuous operation under current limit is not recommended.

Enable Control The enable pin of the device EN is active at high level. When the voltage of the EN is greater than the EN logic high voltage $V_{EN\,H,}$ the device will be enabled and maintain the normal output. When the voltage of the EN is lower than the EN logic low voltage $V_{EN\,L}$, the internal circuit of the device will be disabled and the output will be turned off, the device will be in the standby mode until EN is turned to high level again. The $V_{EN\,H}$ and $V_{EN\,L}$ can be found in the Electrical Characteristics. Normal startup waveform and startup slope rate control can be ensured when the device starts from any low voltage lower than $V_{EN\,L}$, but the discharge time of output capacitor must be taken into account. EN can be float, when the EN is floating, it will be pulled down to ground internally. If EN is not required to control the output voltage independently, it's recommend to connect EN to IN.

Application and Implementation

1. Typical Application Circuit



2. Application Information

2.1. Selection of Bypass Capacitances

Output Capacitors C_{OUT}: Recommended 1μF output ceramic capacitor to keep the device output stable, and the capacitor position should be as close to the device pin as possible. For FMLDC06503A series, the device needs an output capacitor to achieve loop stability. As with any regulator, a larger output capacitance reduces the peaks during a load transient but slows down the response time of the device. The proper capacitor can help to obtain better dynamic performance.

2.2. Transient Response

Transient response refers to the change of system output from initial state to stable state under the action of typical signal input. For LDO, the designer should pay attention to the possible impact of linear transient response and load transient response on the system: linear transient response refers to the transient response of output to change when the input voltage changes, while load transient response refers to the transient response of output to change when the output current changes. The specific phenomenon is that the output voltage of the device will have a short spike, especially when the input voltage or output current changes greatly in a short time. This change is not only related to the performance of the chip itself, but also related to the change of output current, change rate and output capacitance:

1. When the output current increases, the output voltage of the device will decrease to a certain extent, and the larger output current will provide a higher current discharge path for the output capacitor, which will affect the peak value generated by the transient spike and reduce the peak value;
2. The output current or input voltage changes relatively slowly, and the output change of the device is relatively small, affecting the spike caused by the change;
3. The use of large input and output capacitors can reduce the spike caused by transient response to a certain extent to improve the transient performance, but large output capacitors can also affect the response time of devices.

For the selection of bypass capacitance value, refer to the Section of Bypass Capacitances selection.

2.3. Operation in Dropout Mode

The FMLDC06503A series is internally integrated with a P-MOSFET to achieve low dropout voltage. The voltage difference between the input and the output (V_{IN} - V_{OUT}) of the device must not be lower than the corresponding dropout voltage (V_{DO}) to ensure that the output voltage tolerance is within the rated range of the data sheet. The dropout voltage will increase with the increase of load current. When the V_{IN} - V_{OUT} is less than the V_{DO}, the P-MOSFET inside the device is in a linear state, the resistance from the input pin to the output pin is equal to the resistance from the drain to the source of the P-MOSFET, and the device functions like a resistor. When operating in this state, the response time of the error amplifier inside the device will be limited, which will seriously degrade the transient performance of the device, when the external circuit has a transient change, the deviation of the output voltage will become larger than the normal operating state. In addition, the PSRR and noise performance of the device will be worse than that under normal operating conditions.

2.4.Recommended Continuous Operating Areas

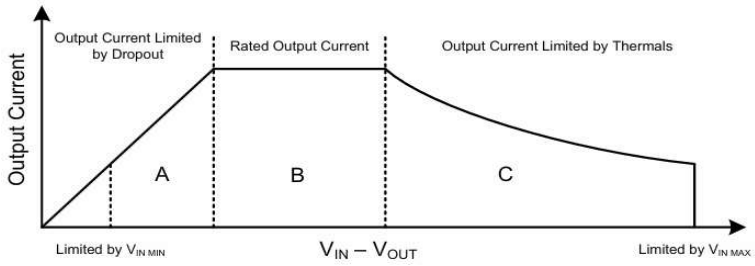
As an LDO, the working area of FMLDC06503A series is limited by dropout voltage, output current, junction temperature and input voltage under continuous working condition. The recommended areas for continuous operation are shown in Figure 9-1:

A. The LDO input and output voltage difference V_{IN} - V_{OUT} must meet the dropout voltage V_{DO} conditions. See Dropout Voltage for more details.

B. Rated output current range I_{rated}.

C. The actual junction temperature T_J of LDO shall not exceed the rated junction temperature. The product of voltage difference and current at both ends of LDO is power consumption, which determines the actual working junction temperature of LDO, so the curve is not linear.

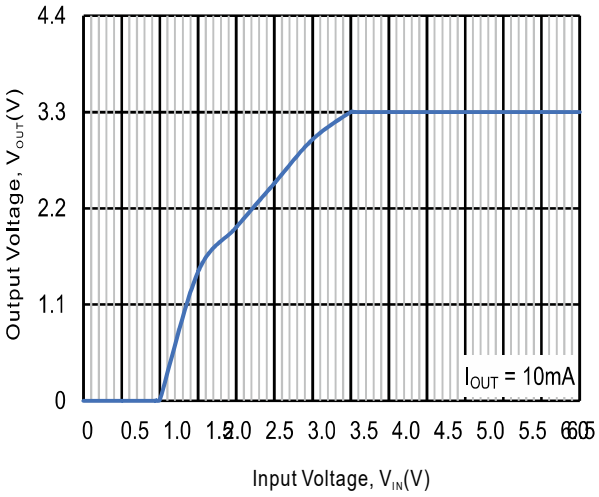
In addition, the working area of FMLDC06503A series is limited by the rated $V_{IN\ MIN}$ and $V_{IN\ MAX}$.



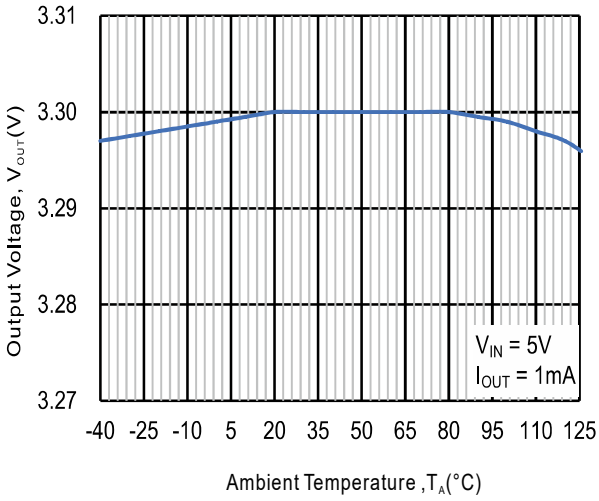
FMLDC06503A1V8AWH Thru FMLDC06503A3V3AWH

Rating and characteristic curves (V_{OUT} = 3.3V, C_{IN} = 1.0μF, C_{OUT} = 1.0μF, T_A = 25°C, unless otherwise specified)

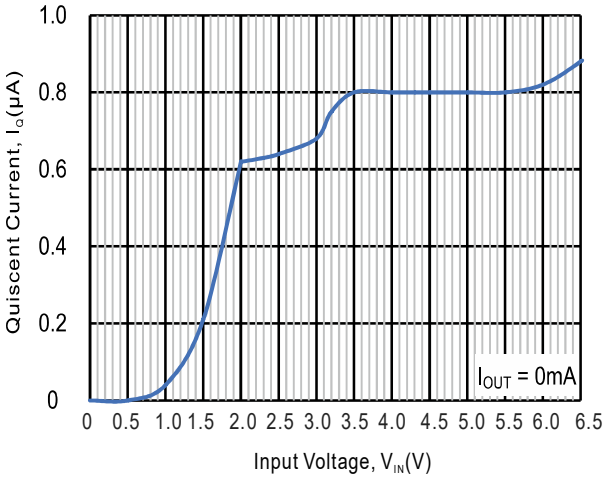
Line Regulation



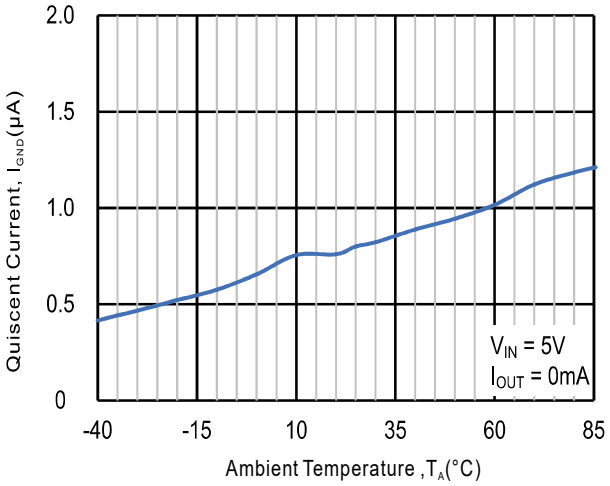
Temperature Characteristics



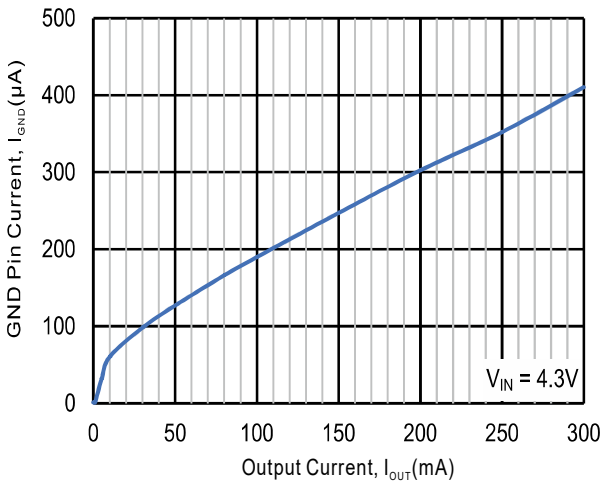
Quiscent Current



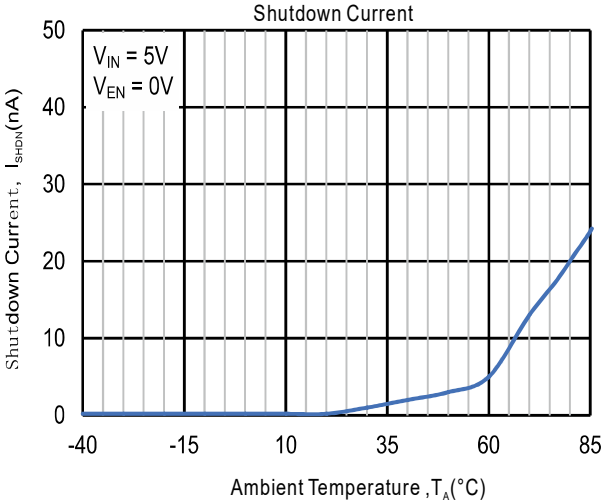
Quiscent Current



GND Pin Current



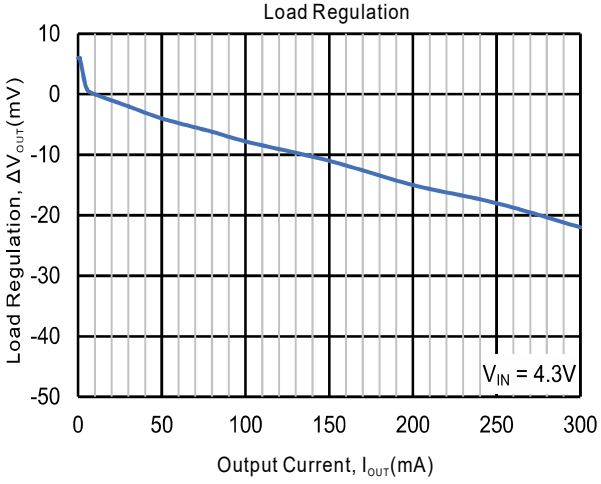
Shutdown Current



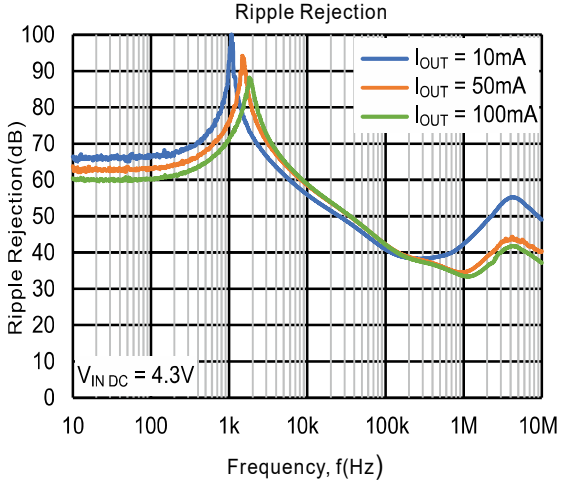
FMLDC06503A1V8AWH Thru FMLDC06503A3V3AWH

Rating and characteristic curves (V_{OUT} = 3.3V, C_{IN} = 1.0μF, C_{OUT} = 1.0μF, T_A = 25°C, unless otherwise specified)

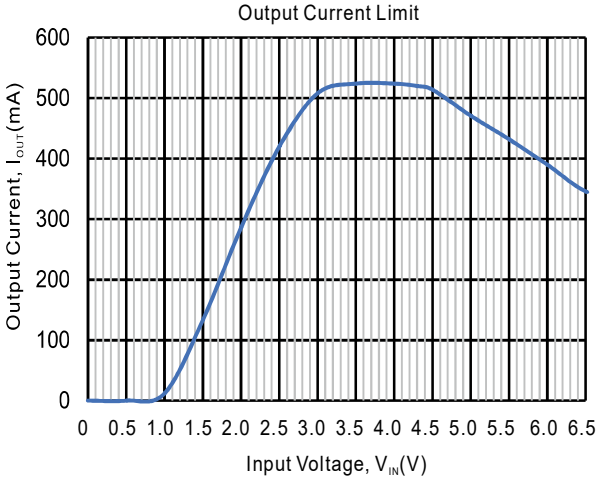
Load Regulation



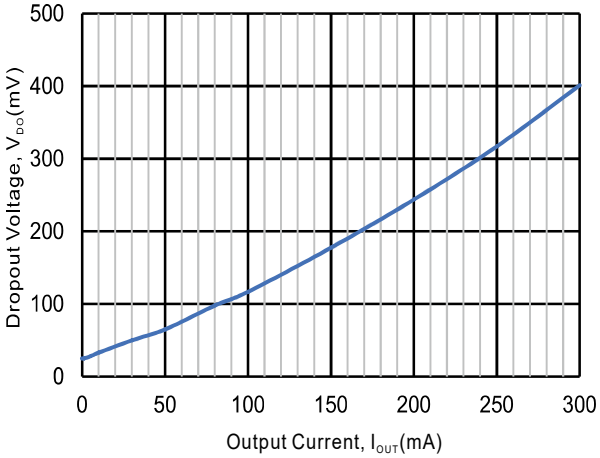
Ripple Rejection



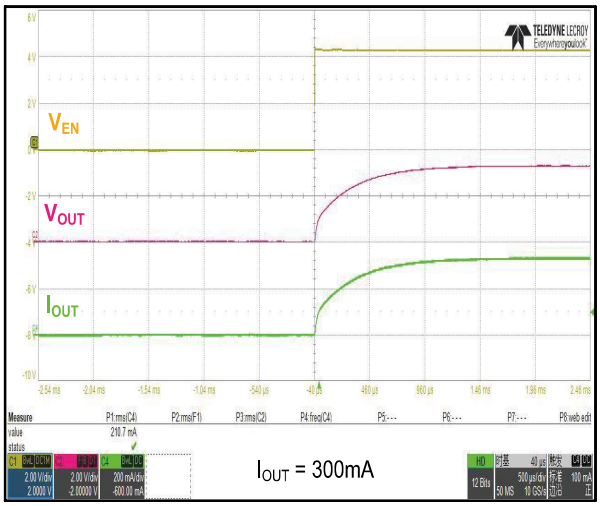
Output Current Limit

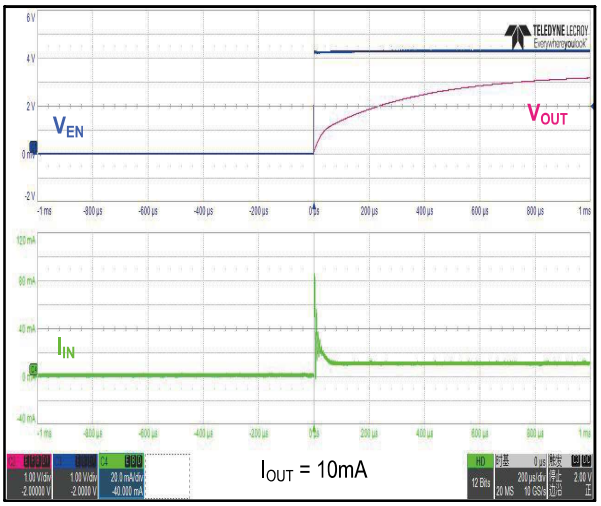


Dropout Voltage



EN High(V_{IN}=4.3V, VEN=0~4.3V)

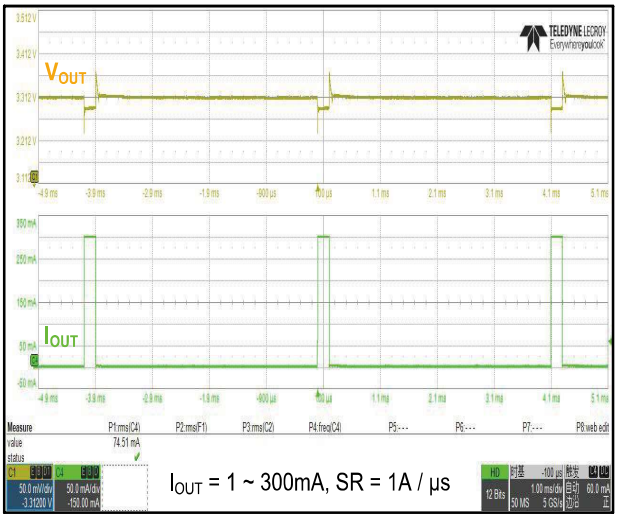


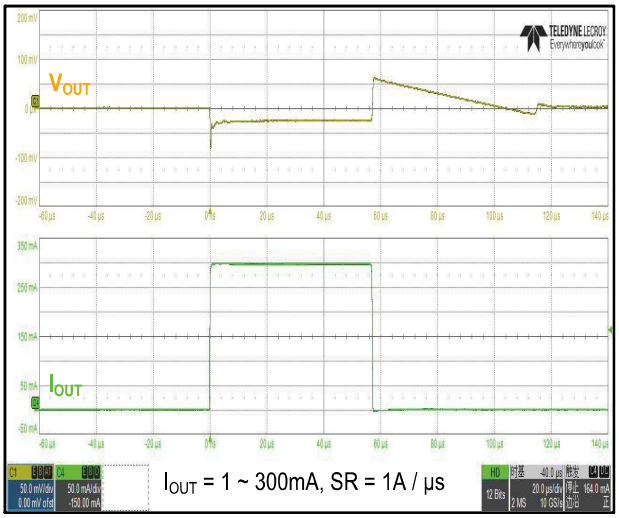


FMLDC06503A1V8AWH Thru FMLDC06503A3V3AWH

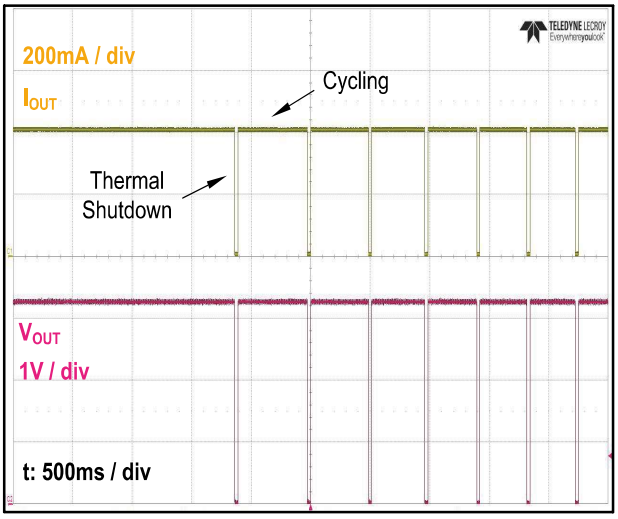
Rating and characteristic curves (V_{OUT} = 3.3V, C_{IN} = 1.0μF, C_{OUT} = 1.0μF, T_A = 25°C, unless otherwise specified)

Load Transient(V_{IN}=4.3V, V_{EN}=V_{IN})



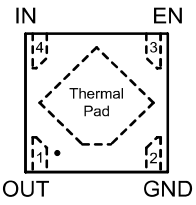
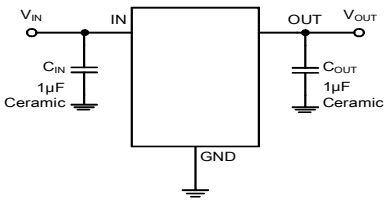


Thermal Shutdown(V_{IN}=5.5V, I_{OUT}=400mA)



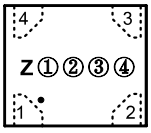
FMLDC06503A1V8AWH Thru FMLDC06503A3V3AWH

Pinning information

Pin	Simplified outline	Symbol
Pin 1 OUT Pin 2 GND Pin 3 EN Pin4 IN		

1. GND : Regulator ground.
2. OUT : Output of the regulator. An output capacitor is required for stability and help device obtain the best transient response. Use the capacitor with the recommended value and place it as close as possible to the output.
3. IN : Input to the device. Use the recommended value of the input capacitor and place it as close to the input of the device as possible to reduce the impedance of the input supply.
4. EN: Enable pin. Driving this pin to logic high enables the device; driving this pin to logic low disables the device. Don't float this pin. If enable functionality is not required, this pin must be connected to IN.
5. Thermal Pad: Connect the thermal pad to a large-area ground plane. The thermal pad is internally connected to GND.

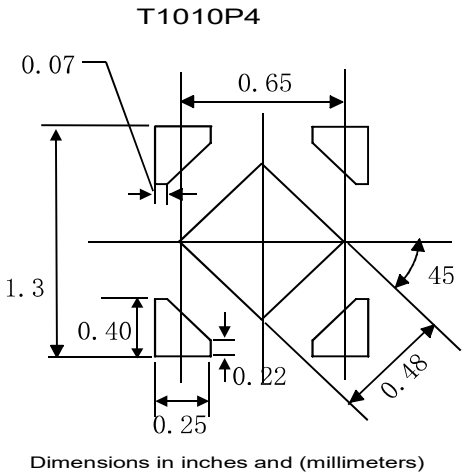
Marking



	Marking code	Description
①	D	FMLDC06503A1V8AWH
	F	FMLDC06503A2V8AWH
	G	FMLDC06503A3V0AWH
	H	FMLDC06503A3V3AWH
②③	XX	Code, indicates weekly record information of wafer lot code
④	X	Code, special pin arrangement sequence. (blank): Normal

X : Represents any character.

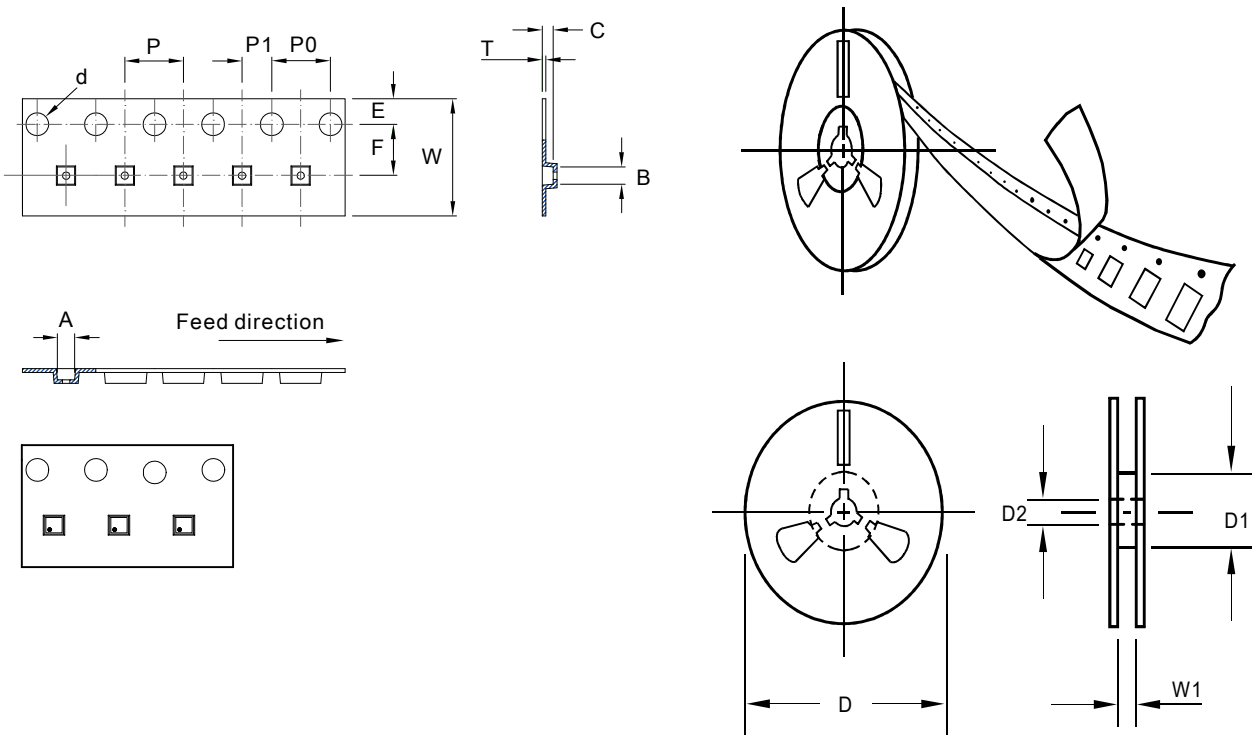
Suggested solder pad layout



Dimensions in inches and (millimeters)

FMLDC06503A1V8AWH Thru FMLDC06503A3V3AWH

Packing information



Unit : mm

Item	Symbol	Tolerance	T1010P4
Carrier width	A	±0.1	1.12
Carrier length	B	±0.1	1.13
Carrier depth	C	±0.1	0.5
Sprocket hole	d	±0.1	1.55
7" Reel outside diameter	D	±1.0	178.00
7" Reel inner diameter	D1	±0.5	54.5
Feed hole diameter	D2	±0.3	13.50
Sprocket hole position	E	±0.1	1.75
Punch hole position	F	±0.1	3.50
Punch hole pitch	P	±0.1	4.00
Sprocket hole pitch	P0	±0.1	4.00
Embossment center	P1	±0.1	2.00
Over all tape thinkness	T	±0.1	0.20
Tape width	W	±0.2	8.00
Reel width	W1	±0.2	9.60

Note : Devices are packed in accordance with EIA standard RS-481-A and specifications listed above.

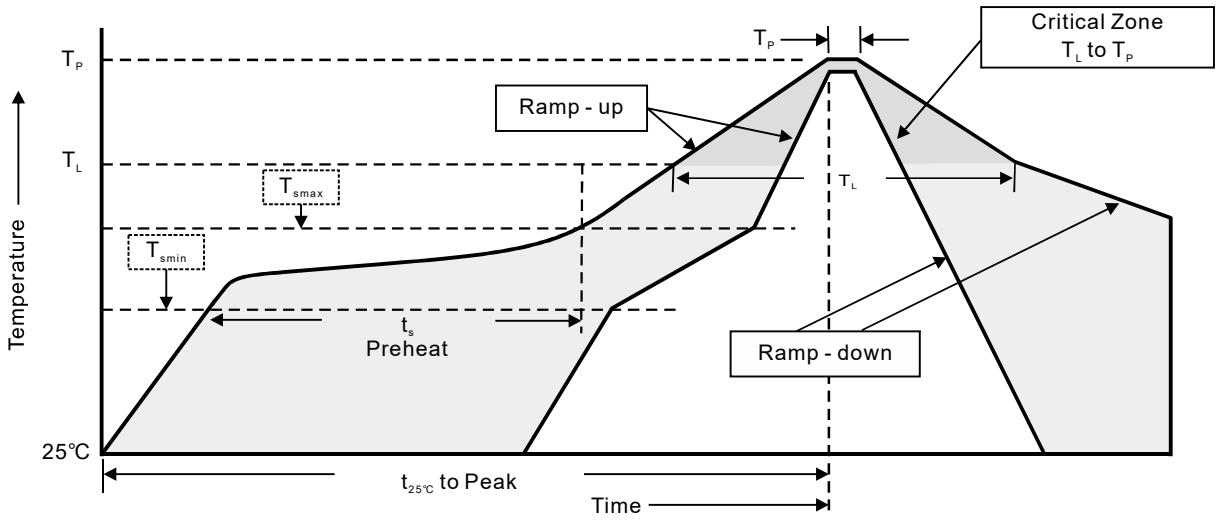
FMLDC06503A1V8AWH Thru FMLDC06503A3V3AWH

Reel packing

Package	Units (pcs)			Dimension (Unit : mm³)		
	Reel	Inner Box	Outer Box	Reel DIA,	Inner Box	Outer Box
T1010P4	3,000	100,000	400,000	178 (7")	210 x 208 x 205	440 x 440 x 230

Suggested thermal profiles for soldering processes

1. Storage environment : Temperature = 5℃ ~ 40℃, Humidity = 55%, ±25%.
2. Reflow soldering of surface - Mount devices.



3.Reflow soldering

Profile feature	Soldering condition
Average ramp-up rate (T_L to T_P)	< 3 ℃/sec
Preheat - Temperature Min (T_{smin}) - Temperature Max (T_{smax}) - Time (Min to Max) (t_s)	 150℃ 200℃ 60 ~ 120 sec
T_{smax} to T_L - Ramp-up rate	 < 3 ℃ / sec
Time maintained above : - Temperature (T_L) - Time (T_L)	 217℃ 60 ~ 260 sec
Peak temperature (T_P)	255 ℃ -0 / +5℃
Time with 5℃ of actual peak temperature (T_P)	10 ~ 30 sec
Ramp-down rate	< 6℃ / sec
Time 25℃ to peak temperature	< 6 minutes