MICRO ELECTRONICS

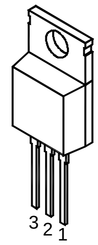
ML7800 SERIES

3-TERMINAL POSITIVE VOLTAGE REGULATOR

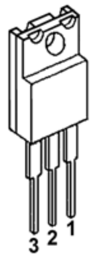
The ML7800 series are 3-Terminal Positive Voltage Regulators. These regulators employ internal current-limiting, thermal-shutdown and safe-area compensation, making them essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current (Please refer to the "thermal design" portion of application note). They are intended as fixed voltage regulations in a wide range of applications including local (on-card) regulation for elimination of distributution problems associated with single point regulation. In addition to use as fixed voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents.

■ Package Outline

TO-220



1. OUT
2. GND
3. IN



TO-220F

ABSOLUTE MAXIMUM RATINGS (Ta=25℃)

PARAMETER	SYMBOL	Maximum Rating			UNIT
Input Voltage	V_{IN}	ML7805 to ML7809		35	V
		ML7812 to ML7820		35	
		ML7824		40	
Storage Temperature Range	Tstg	-40 to +125			℃
Operating Temperature Range		Operating Junction Temperature	Tj	-30 to +150	℃
		Operating Ambient Temperature	Topr	-30 to +75	
Power Dissipation	P_D	15(Tc≦70℃)			W

THERMAL RESISTANCE

Thermal Resistance	Junction-to-Ambient Temperature	Θ ja	60	℃/W
	Junction-to-Case	Θ jc	5	

ELECTRICAL CHARACTERISTICS (Tj=25℃,C1=0.33 μF,Co=0.1 μF)

Measurement is to be conducted in pulse testing.

PARAMETER	SYMBOL	TEST CONDITIONS				MIN.	TYP.	MAX.	UNIT
ML7805A / ML7805FA									
Output Voltage	Vo	V_{IN}=10V	Io=0.5A			4.8	5.0	5.2	V
Quiescent Current	I_Q	V_{IN}=10V	Io=0mA			-	4.2	8.0	mA
Load Regulation	ΔVo Io	V_{IN}=10V	Io=0.005A to 1.5A			-	15	100	mV
Line Regulation	ΔVo Vin	V_{IN}=7 to 25V	Io=0.5A			-	3	100	mV
Ripple Rejection	RR	V_{IN}=10V	Io=0.5A	e_{in}=2Vp-p	f=120Hz	62	78	-	dB
Output Noise Voltage	V_{NO}	V_{IN}=10V	BW=10Hz to 100KHz		Io=0.5A	-	40	-	μV
Average Temperature Cofficient of Output Voltage	ΔVo / ΔT	V_{IN}=10V	Io=0.5A			-	-1.1	-	mV/℃

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REV B

ELECTRICAL CHARACTERISTICS (Tj=25℃,C1=0.33 μF,Co=0.1 μF)

Measurement is to be conducted in pulse testing.

PARAMETER	SYMBOL	TEST CONDITIONS				MIN.	TYP.	MAX.	UNIT
ML7806A / ML7806FA									
Output Voltage	Vo	V_{IN}=11V	Io=0.5A			5.75	6.0	6.25	V
Quiescent Current	I_Q	V_{IN}=11V	Io=0mA			-	4.3	8.0	mA
Load Regulation	ΔVo Io	V_{IN}=11V	Io=0.005A to 1.5A			-	15	120	mV
Line Regulation	ΔVo Vin	V_{IN}=8 to 25V		Io=0.5A		-	5	120	mV
Ripple Rejection	RR	V_{IN}=11V	Io=0.5A	e_{in}=2Vp-p	f=120Hz	59	75	-	dB
Output Noise Voltage	V_{NO}	V_{IN}=11V	BW=10Hz to 100KHz		Io=0.5A	-	45	-	μV
Average Temperature Cofficient of Output Voltage	ΔVo / ΔT	V_{IN}=11V	Io=5mA			-	-0.8	-	mV/℃
ML7808A / ML7808FA									
Output Voltage	Vo	V_{IN}=14V	Io=0.5A			7.7	8.0	8.3	V
Quiescent Current	I_Q	V_{IN}=14V	Io=0mA			-	4.3	8.0	mA
Load Regulation	ΔVo Io	V_{IN}=14V	Io=0.005A to 1.5A			-	15	160	mV
Line Regulation	ΔVo Vin	V_{IN}=10.5 to 25V		Io=0.5A		-	6	160	mV
Ripple Rejection	RR	V_{IN}=14V	Io=0.5A	e_{in}=2Vp-p	f=120Hz	55	72	-	dB
Output Noise Voltage	V_{NO}	V_{IN}=14V	BW=10Hz to 100KHz		Io=0.5A	-	52	-	μV
Average Temperature Cofficient of Output Voltage	ΔVo / ΔT	V_{IN}=14V	Io=5mA			-	-0.8	-	mV/℃
ML7809A / ML7809FA									
Output Voltage	Vo	V_{IN}=15V	Io=0.5A			8.65	9.0	9.35	V
Quiescent Current	I_Q	V_{IN}=15V	Io=0mA			-	4.3	8.0	mA
Load Regulation	ΔVo Io	V_{IN}=15V	Io=0.005A to 1.5A			-	15	180	mV
Line Regulation	ΔVo Vin	V_{IN}=11.5 to 25V		Io=0.5A		-	7	180	mV
Ripple Rejection	RR	V_{IN}=15V	Io=0.5A	e_{in}=2Vp-p	f=120Hz	55	70	-	dB
Output Noise Voltage	V_{NO}	V_{IN}=15V	BW=10Hz to 100KHz		Io=0.5A	-	60	-	μV
Average Temperature Cofficient of Output Voltage	ΔVo / ΔT	V_{IN}=15V	Io=5mA			-	-1	-	mV/℃
ML7812A / ML7812FA									
Output Voltage	Vo	V_{IN}=19V	Io=0.5A			11.5	12.0	12.5	V
Quiescent Current	I_Q	V_{IN}=19V	Io=0mA			-	4.3	8.0	mA
Load Regulation	ΔVo Io	V_{IN}=19V	Io=0.005A to 1.5A			-	25	240	mV
Line Regulation	ΔVo Vin	V_{IN}=14.5 to 30V		Io=0.5A		-	10	240	mV
Ripple Rejection	RR	V_{IN}=19V	Io=0.5A	e_{in}=2Vp-p	f=120Hz	55	71	-	dB
Output Noise Voltage	V_{NO}	V_{IN}=19V	BW=10Hz to 100KHz		Io=0.5A	-	75	-	μV
Average Temperature Cofficient of Output Voltage	ΔVo / ΔT	V_{IN}=19V	Io=5mA			-	-1	-	mV/℃

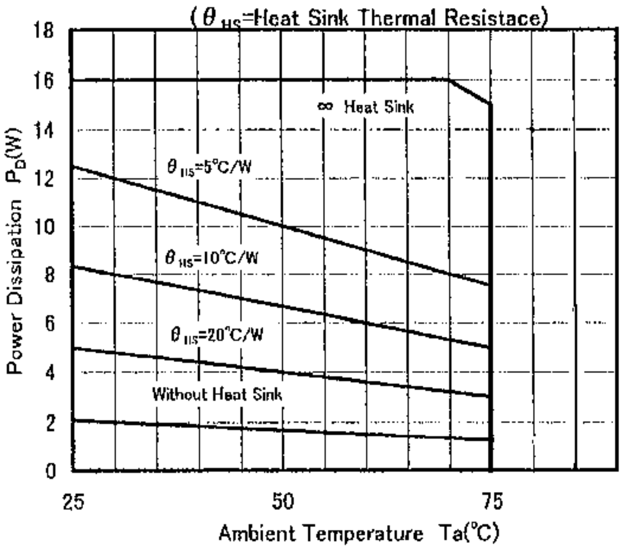
ELECTRICAL CHARACTERISTICS (Tj=25℃,C1=0.33 μF,Co=0.1 μF)

Measurement is to be conducted in pulse testing.

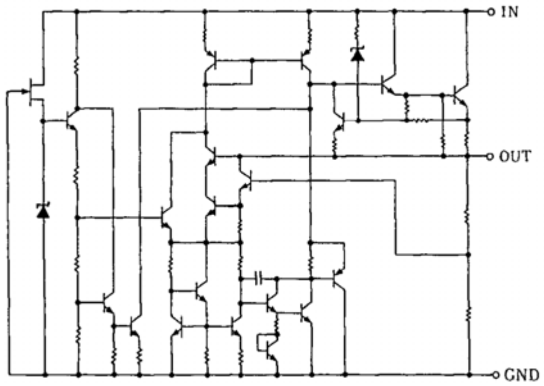
PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
ML7815A / ML7815FA						
Output Voltage	Vo	V_{IN}=23V Io=0.5A	14.4	15.0	15.6	V
Quiescent Current	I_Q	V_{IN}=23V Io=0mA	-	4.3	8.0	mA
Load Regulation	ΔVo Io	V_{IN}=23V Io=0.005A to 1.5A	-	35	300	mV
Line Regulation	ΔVo Vin	V_{IN}=17.5 to 30V Io=0.5A	-	12	300	mV
Ripple Rejection	RR	V_{IN}=23V Io=0.5A ein=2Vp-p f=120Hz	54	70	-	dB
Output Noise Voltage	V_{NO}	V_{IN}=23V BW=10Hz to 100KHz Io=0.5A	-	90	-	μV
Average Temperature Cofficient of Output Voltage	ΔVo / ΔT	V_{IN}=23V Io=5mA	-	-1	-	mV/℃
ML7818A / ML7818FA						
Output Voltage	Vo	V_{IN}=27V Io=0.5A	17.3	18.0	18.7	V
Quiescent Current	I_Q	V_{IN}=27V Io=0mA	-	4.5	8.0	mA
Load Regulation	ΔVo Io	V_{IN}=27V Io=0.005A to 1.5A	-	55	360	mV
Line Regulation	ΔVo Vin	V_{IN}=21 to 33V Io=0.5A	-	15	360	mV
Ripple Rejection	RR	V_{IN}=27V Io=0.5A ein=2Vp-p f=120Hz	53	69	-	dB
Output Noise Voltage	V_{NO}	V_{IN}=27V BW=10Hz to 100KHz Io=0.5A	-	110	-	μV
Average Temperature Cofficient of Output Voltage	ΔVo / ΔT	V_{IN}=27V Io=5mA	-	-1	-	mV/℃
ML7820A / ML7820FA						
Output Voltage	Vo	V_{IN}=29V Io=0.5A	19.2	20.0	20.8	V
Quiescent Current	I_Q	V_{IN}=29V Io=0mA	-	4.5	8.0	mA
Load Regulation	ΔVo Io	V_{IN}=29V Io=0.005A to 1.5A	-	61	400	mV
Line Regulation	ΔVo Vin	V_{IN}=23 to 35V Io=0.5A	-	16	400	mV
Ripple Rejection	RR	V_{IN}=29V Io=0.5A ein=2Vp-p f=120Hz	51	66	-	dB
Output Noise Voltage	V_{NO}	V_{IN}=29V BW=10Hz to 100KHz Io=0.5A	-	150	-	μV
Average Temperature Cofficient of Output Voltage	ΔVo / ΔT	V_{IN}=29V Io=5mA	-	-2.0	-	mV/℃
ML7824A / ML7824FA						
Output Voltage	Vo	V_{IN}=33V Io=0.5A	23.0	24.0	25.0	V
Quiescent Current	I_Q	V_{IN}=33V Io=0mA	-	4.6	8.0	mA
Load Regulation	ΔVo Io	V_{IN}=33V Io=0.005A to 1.5A	-	65	480	mV
Line Regulation	ΔVo Vin	V_{IN}=28 to 38V Io=0.5A	-	18	480	mV
Ripple Rejection	RR	V_{IN}=33V Io=0.5A ein=2Vp-p f=120Hz	50	66	-	dB
Output Noise Voltage	V_{NO}	V_{IN}=33V BW=10Hz to 100KHz Io=0.5A	-	170	-	μV
Average Temperature Cofficient of Output Voltage	ΔVo / ΔT	V_{IN}=33V Io=5mA	-	-2.4	-	mV/℃

REV B

■ Power Dissipation vs. Ambient Temperature

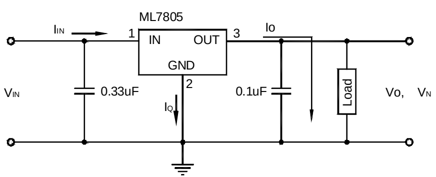


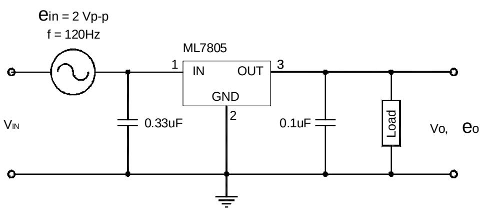
■ Equivalent Circuit



■ Test Circuit

1. Output Voltage, Line Regulation, Load Regulation, Quiescent Current, Average Temperature Coefficient of Output Voltage, Output Noise Voltage.
2. Ripple Rejection



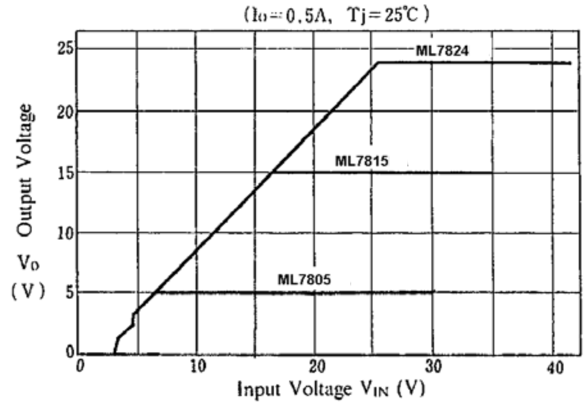


REV B

■ Typical Characteristics

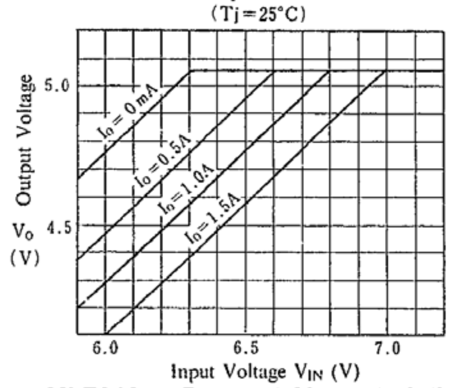
ML7805 / 15 / 24 Output Characteristics

(I_O = 0.5A, Tj = 25℃)



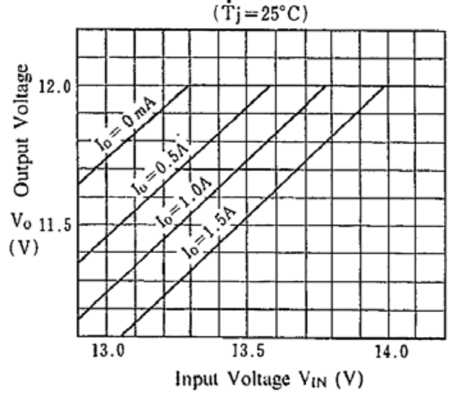
ML7805 Dropout Characteristics

(Tj = 25°C)



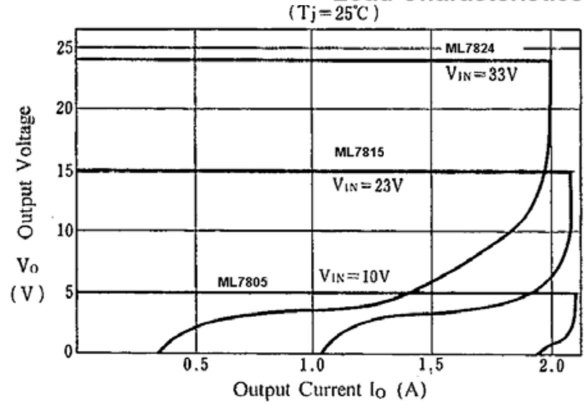
ML7812 Dropout Characteristics

(Tj = 25°C)



ML7805 / 15 / 24 Load Characteristics

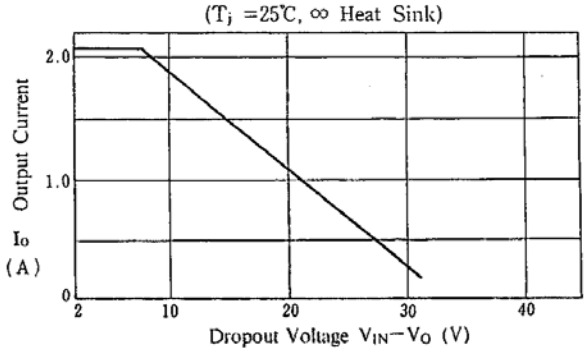
(Tj = 25℃)



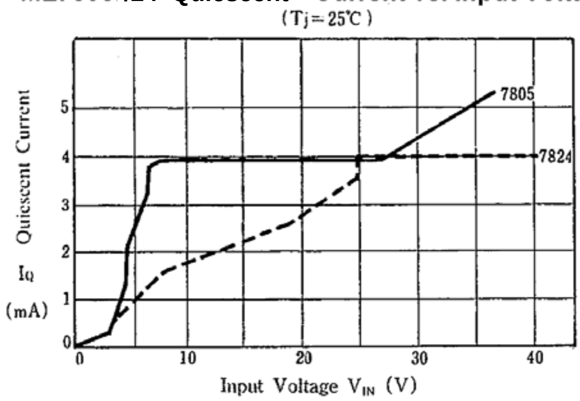
REV B

■ Typical Characteristics

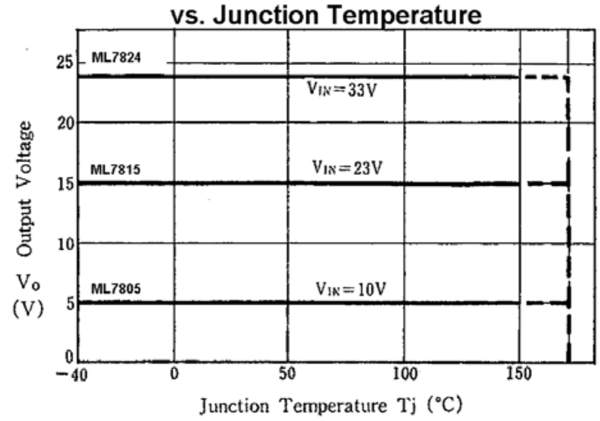
ML7800 Series Short Circuit Output Current



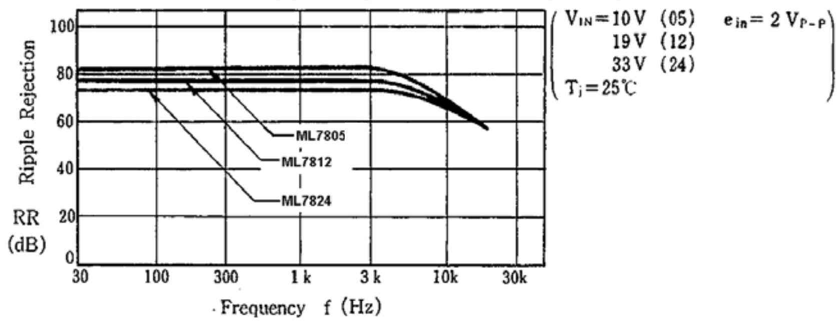
ML7805 /24 Quiescent Current vs. Input Voltage



ML7805 /15 /24 Output Voltage vs. Junction Temperature



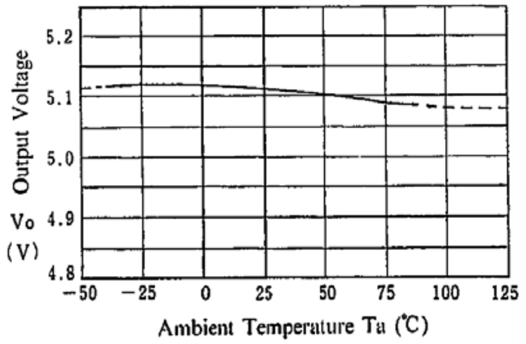
ML7805 /15 /24 Ripple Rejection vs. Frequency



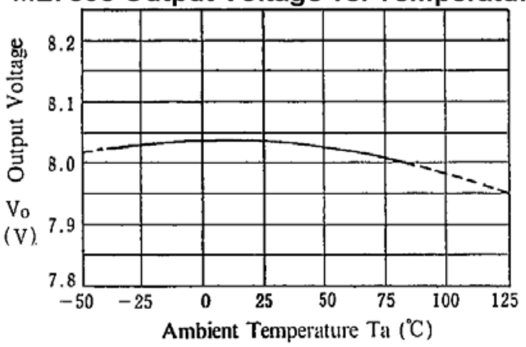
REV B

■ **Typical Characteristics**

ML7805 Output Voltage vs. Temperature



ML7808 Output Voltage vs. Temperature

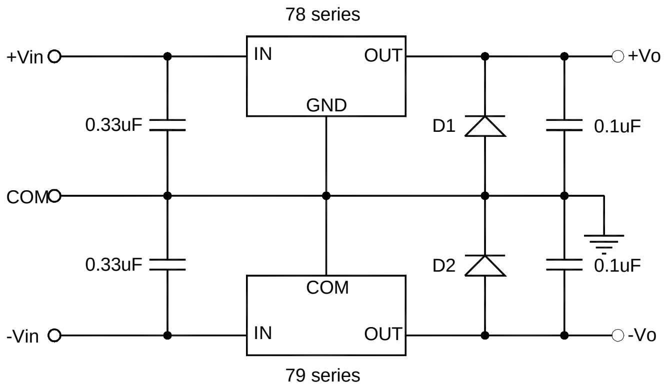


REV B

1. Application Circuit

In the following explain only the positive regulator unless otherwise specified. However they can apply to the negative voltage regulator by easy change.

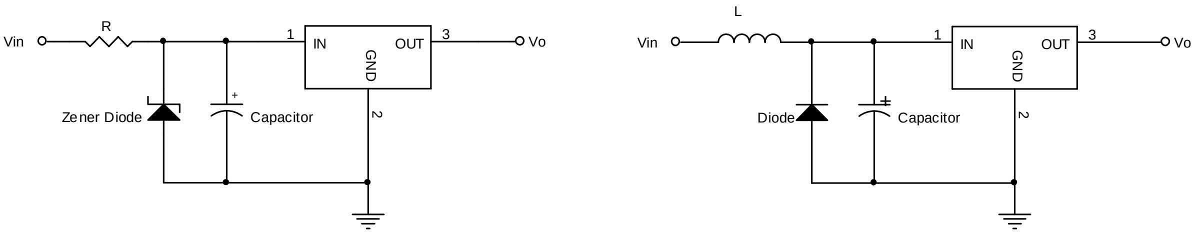
Positive/Negative Voltage Supply



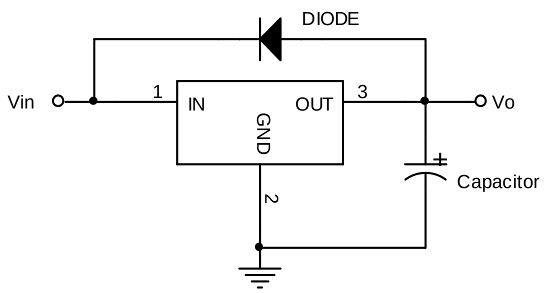
Note : In the above positive and negative power supply application, D1 and D2 should be connected. If D1 and D2 are not connected, either of positive or negative power supply circuit may not turns on.

2. Note in Application Circuit

(1) If the higher voltage (above the rated value) or lower voltage (GND-0.5V) is supplied to the input terminals, the IC may be destroyed. To avoid such a case, a zener diode or other parts of the surge supressor should be connected as shown below.



(2) If the higher voltage than the input terminal is supplied to the output terminal, the IC may be destroyed. To avoid input terminal short to the GND or the stored voltage in the capacitor back to the output terminal, by the large value capacitor connecting to the output terminal application, the SBD should be required as shown below;



* In case of negative voltage regulator, reverse the SBD and capacitor direction.

3. Thermal Design

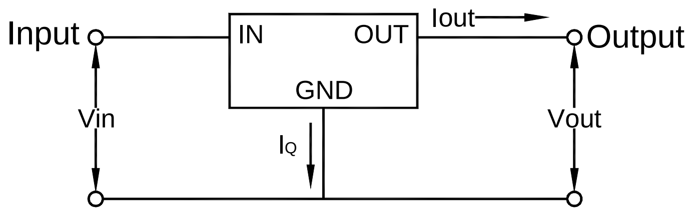
(1) Heat Producting

There are two kinds of heat producting (P_{LOSS-1}, P_{LOSS-2}) in three terminal regulator and the sum of them is total heat producting of IC (P_{LOSS}).

(1-1) P_{LOSS-1} : heat producting by own operation

Input voltage (Vin) and quiescent current (I_Q) produce the heat mentioned below equation.

P_{LOSS-1} = Vin X I_Q



(1-2) P_{LOSS-2} : heat producing by output current and the input-output differential voltage.

Internal power transistor produces the hest mentioned following equation.

P_{LOSS-2} = (Vin-Vout) x Iout (W)

Therefore, the total heat producing PLOSS is :

P_{LOSS} = P_{LOSS-1} + P_{LOSS-2}

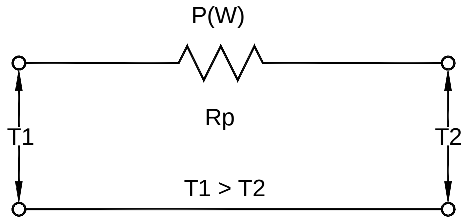
= Vin X I_Q + (Vin-Vout) X Iout (W)

(2) Thermal Resistance

(2-1) Definition of Thermal Resistance : θ

Thermal resistance (θ) is a degree of heat radiation mentioned following equation.

= (T1 - T2)/P (℃ /W)	Heat Producing Quantity	: P (W)
	Ambient Temperature or case temperature	:T2 (℃)
	Heat Source Temperature	:T1 (℃)



(2-2) Thermal resistance of TO-220

There are two kinds of thermal resistance of TO-220. One is " θ jc" for the application with the heat sink, the other is " θ ja" for the application without the heat sink.

θ jc : thermal resistance between IC chip (junction point) and the package back side contacting with the heat sink.

θ ja : thermal resistance between IC chip (junction point) and ambience.

REV B

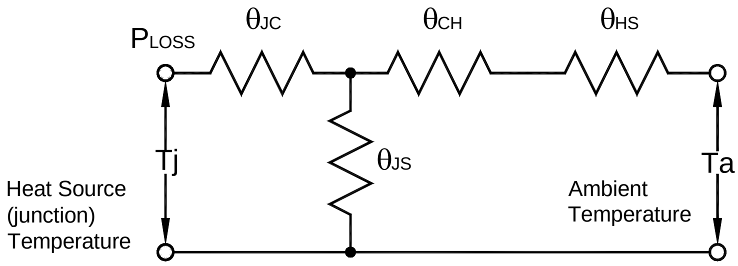
(3) Heat Radiation Balance

The heat produced in the IC is radiated to ambience through the package and the heat sink.

The quantity of the heat radiation depends on the heat source temperature, ambient temperature and the thermal resistance of the package.

(3-1) TO-220 with heat sink

Heat radiation balance model of the TO-220 with heat sink is shown as below.

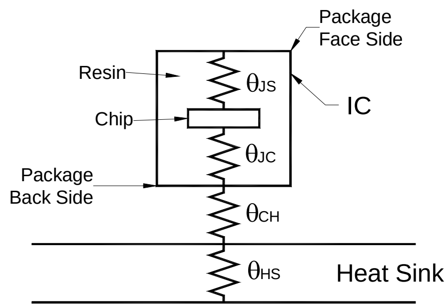


Where θ jc : thermal resistance between IC chip (junction point) and the package backside connecting to the heatsink.

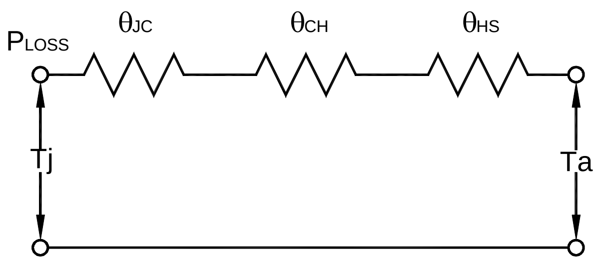
θ js : thermal resistance between IC chip (junction point) and the package surface.

θ CH : thermal resistance between package backside and the heat sink including the condidtion of insulator, silicon grease and tighten torque.

θ HS : thermal resistance of the heat sink



If the js is large enough compare with other thermal resistance, the js can be neglected and the heat radiation model can be mentioned as below.



The relation between temperature and heat radiation quantity is shown below.

$Tj = P_{LOSS} \times (\theta_{jc} + \theta_{CH} + \theta_{HS}) + Ta$ (℃)

REV B

(4) Thermal Design

The heat radiation balance model of the TO-220 with the heat sink is shown as follows.

Heat radiation balance

$T_j = P_{LOSS} \times (\theta_{jc} + \theta_{CH} + \theta_{HS}) + T_a$ (℃) (4-1)

$P_{LOSS} = V_{in} \times I_Q + (V_{in} - V_{out}) \times I_{out}$ (W) (4-2)

Substituting "Eq.(4-2) into "Eq.(4-1)" obtains

$T_j = [V_{in} \times I_Q + (V_{in} - V_{out}) \times I_{out}] \times (\theta_{jc} + \theta_{CH} + \theta_{HS}) + T_a$ (℃) (4-3)

In Eq.(4-3)

Vin, Iout, θ_{CH}, θ_{HS}, Ta depand on using condition.

Tj, I_Q,Vout, θ_{jc} depend on IC depend on IC specification.

When θ_{CH}, I_Q and Tj are assumed the following values,

Eq.(4-3) becomes Eq.(4-4).

θ_{CH}=0.3 to 0.4 (℃/W) Insert the mica paper (0.1t) and thermal conduction silicon grease between the IC and heat sink and tighten them with the bolt by 4Kg*cm-min.

I_Q = 5 to 6mA (max.)

Tj = 125℃ (max.)

$T_{j(max)} = 125 = [5 \times V_{in} + (V_{in} - V_{out}) \times I_{out}] \times (5 + 0.3 + \theta_{HS}) + T_a$ (℃) (4-4)

When fix the Vout, Tj depends on the Vin, Iout, θ_{HS} and Ta.

It means;

Lower Vin and / or Iout are required to linit the temperature rise.

Smaller θ_{HS} is required for the effective heat reduce (i.e. using the large heat sink).

In the thermal design, when fix the Vin, Iout and Ta, selectthe heat sink which θ_{HS} is smaller that the result of Eq.(4-4).

For more detail, please refer the heat resistance value mentioned in the specification of the heat sink supplier.