ML7900 - FBE* SERIES

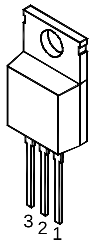
3-TERMINAL NEGATIVE VOLTAGE REGULATOR

The **ML7900 series** are 3-Terminal Negative Voltage Regulators. These negative regulators are intended as complements to the popular ML7800 series of positive voltage regulations, and they are available in the same voltage options from -5V to -24V. The ML7900 series employ internal current-limiting. safe-area protection , and thermal shutdown, making them virtually indestructible.

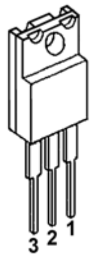
* Parts of **FBE** are satisfied with requirements of directive **2002/95/EC** on **RoHS**.

■ Package Outline

TO-220
(7900A)



1. OUT
2. IN
3. COMMON



TO-220F
(7900FA)

ABSOLUTE MAXIMUM RATINGS (Ta=25℃)

PARAMETER	SYMBOL	Maximum Rating			UNIT
Input Voltage	V_{IN}	ML7905 to ML7909		-35	V
		ML7912 to ML7920		-35	
		ML7924		-40	
Storage Temperature Range	Tstg	-40 to +125			℃
Operating Temperature Range		Operating Junction Temperature	Tj	-30 to +125	℃
		Operating Ambient Temperature	Topr	-30 to +75	
Power Dissipation	P_D	15(Tc≦45℃)			W

THERMAL RESISTANCE

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

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

Measurement is to be conducted in pulse testing.

PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
ML7905A / ML7905FA						
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	-	2.2	5.0	mA
Load Regulation	ΔVo Io	V_{IN}=-10V Io=0.005A to 1.5A	-	50	100	mV
Line Regulation	ΔVo Vin	V_{IN}=-7 to -25V Io=0.5A	-	12.5	100	mV
Ripple Rejection	RR	V_{IN}=-10V Io=0.5A e_{in}=2Vp-p f=120Hz	54	60	-	dB
Output Noise Voltage	V_{NO}	V_{IN}=-10V BW=10Hz to 100KHz Io=0.5A	-	125	-	μV
Average Temperature Cofficient of Output Voltage	ΔVo / ΔT	V_{IN}=-10V Io=5mA	-	-0.4	-	mV/℃

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APR 2005

ELECTRICAL CHARACTERISTICS

(Tj=25℃,C1=0.33 μF,Co=0.1 μF)

Measurement is to be conducted in pulse testing.

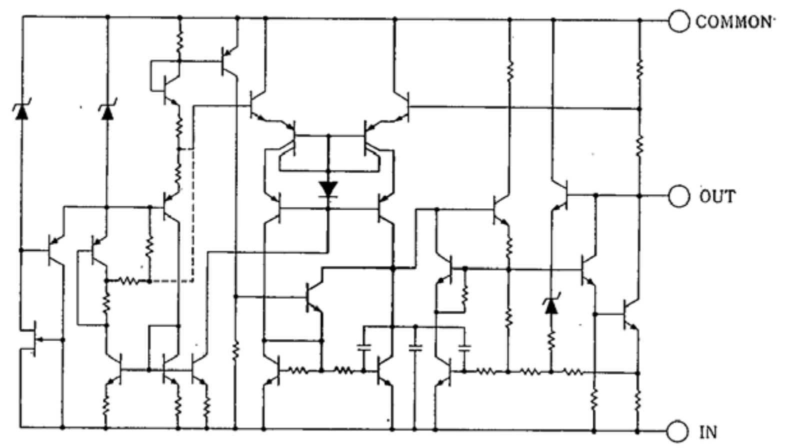
PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
ML7906A / ML7906FA						
Output Voltage	Vo	V_{IN}=-11V Io=0.5A	-5.75	-6.0	-6.25	V
Quiescent Current	I_Q	V_{IN}=-11V Io=0mA	-	2.2	5.0	mA
Load Regulation	ΔVo Io	V_{IN}=-11V Io=0.005A to 1.5A	-	50	120	mV
Line Regulation	ΔVo Vin	V_{IN}=-8 to -25V Io=0.5A	-	12.5	120	mV
Ripple Rejection	RR	V_{IN}=-11V Io=0.5A ein=2Vp-p f=120Hz	54	60	-	dB
Output Noise Voltage	V_{NO}	V_{IN}=-11V BW=10Hz to 100KHz Io=0.5A	-	150	-	μV
Average Temperature Cofficient of Output Voltage	ΔVo / ΔT	V_{IN}=-11V Io=5mA	-	-0.4	-	mV/℃
ML7908A / ML7908FA						
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	-	2.2	5.0	mA
Load Regulation	ΔVo Io	V_{IN}=-14V Io=0.005A to 1.5A	-	60	160	mV
Line Regulation	ΔVo Vin	V_{IN}=-10.5 to -25V Io=0.5A	-	12.5	160	mV
Ripple Rejection	RR	V_{IN}=-14V Io=0.5A ein=2Vp-p f=120Hz	54	60	-	dB
Output Noise Voltage	V_{NO}	V_{IN}=-14V BW=10Hz to 100KHz Io=0.5A	-	200	-	μV
Average Temperature Cofficient of Output Voltage	ΔVo / ΔT	V_{IN}=-14V Io=5mA	-	-0.7	-	mV/℃
ML7909A / ML7909FA						
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	-	2.2	5.0	mA
Load Regulation	ΔVo Io	V_{IN}=-15V Io=0.005A to 1.5A	-	60	180	mV
Line Regulation	ΔVo Vin	V_{IN}=-11.5 to -25V Io=0.5A	-	8	180	mV
Ripple Rejection	RR	V_{IN}=-15V Io=0.5A ein=2Vp-p f=120Hz	54	60	-	dB
Output Noise Voltage	V_{NO}	V_{IN}=-15V BW=10Hz to 100KHz Io=0.5A	-	250	-	μV
Average Temperature Cofficient of Output Voltage	ΔVo / ΔT	V_{IN}=-15V Io=5mA	-	-0.8	-	mV/℃
ML7912A / ML7912FA						
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	-	2.7	6.0	mA
Load Regulation	ΔVo Io	V_{IN}=-19V Io=0.005A to 1.5A	-	60	240	mV
Line Regulation	ΔVo Vin	V_{IN}=-14.5 to -30V Io=0.5A	-	5	240	mV
Ripple Rejection	RR	V_{IN}=-19V Io=0.5A ein=2Vp-p f=120Hz	54	60	-	dB
Output Noise Voltage	V_{NO}	V_{IN}=-19V BW=10Hz to 100KHz Io=0.5A	-	300	-	μV
Average Temperature Cofficient of Output Voltage	ΔVo / ΔT	V_{IN}=-19V Io=5mA	-	-0.8	-	mV/℃

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

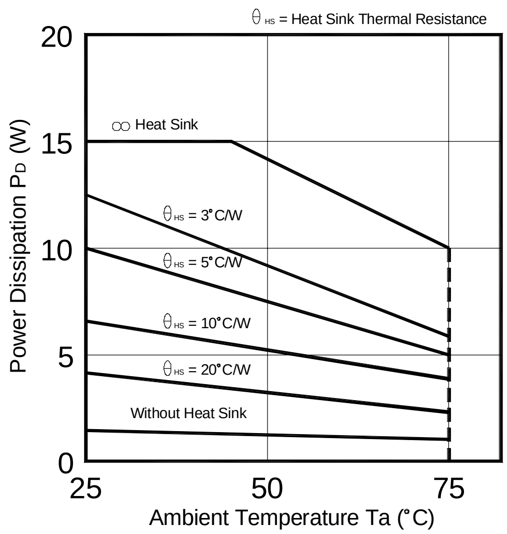
Measurement is to be conducted in pulse testing.

PARAMETER	SYMBOL	TEST CONDITIONS				MIN.	TYP.	MAX.	UNIT
ML7915A / ML7915FA									
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			-	2.7	6.0	mA
Load Regulation	ΔVo Io	V_{IN}=-23V	Io=0.005A to 1.5A			-	60	300	mV
Line Regulation	ΔVo Vin	V_{IN}=-17.5 to -30V		Io=0.5A		-	5	300	mV
Ripple Rejection	RR	V_{IN}=-23V	Io=0.5A	ein=2Vp-p	f=120Hz	54	60	-	dB
Output Noise Voltage	V_{NO}	V_{IN}=-23V	BW=10Hz to 100KHz		Io=0.5A	-	375	-	μV
Average Temperature Cofficient of Output Voltage	ΔVo / ΔT	V_{IN}=-23V	Io=5mA			-	-1	-	mV/℃
ML7918A / ML7918FA									
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			-	2.7	6.0	mA
Load Regulation	ΔVo Io	V_{IN}=-27V	Io=0.005A to 1.5A			-	60	360	mV
Line Regulation	ΔVo Vin	V_{IN}=-21 to -33V		Io=0.5A		-	5	360	mV
Ripple Rejection	RR	V_{IN}=-27V	Io=0.5A	ein=2Vp-p	f=120Hz	54	60	-	dB
Output Noise Voltage	V_{NO}	V_{IN}=-27V	BW=10Hz to 100KHz		Io=0.5A	-	450	-	μV
Average Temperature Cofficient of Output Voltage	ΔVo / ΔT	V_{IN}=-27V	Io=5mA			-	-1	-	mV/℃
ML7924A / ML7924FA									
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			-	2.7	6.0	mA
Load Regulation	ΔVo Io	V_{IN}=-33V	Io=0.005A to 1.5A			-	85	480	mV
Line Regulation	ΔVo Vin	V_{IN}=-28 to -38V		Io=0.5A		-	5	480	mV
Ripple Rejection	RR	V_{IN}=-33V	Io=0.5A	ein=2Vp-p	f=120Hz	54	60	-	dB
Output Noise Voltage	V_{NO}	V_{IN}=-33V	BW=10Hz to 100KHz		Io=0.5A	-	600	-	μV
Average Temperature Cofficient of Output Voltage	ΔVo / ΔT	V_{IN}=-33V	Io=5mA			-	-1	-	mV/℃

■ **Equivalent Circuit**

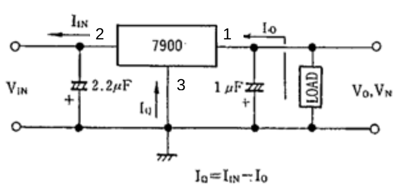


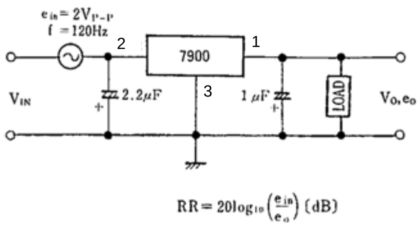
■ **Power Dissipation vs. Ambient Temperature**



■ **Test Circuit**

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

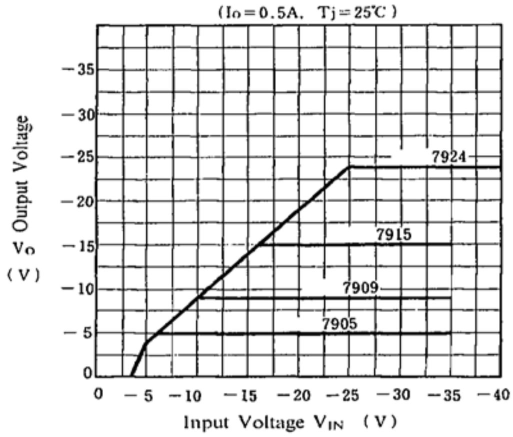




■ Typical Characteristics

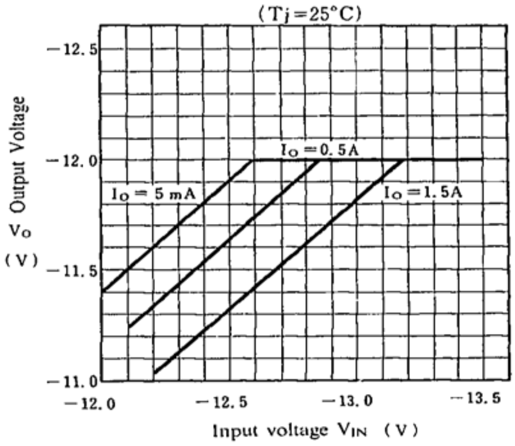
7900 Output Characteristics

(Io=0.5A, Tj=25℃)



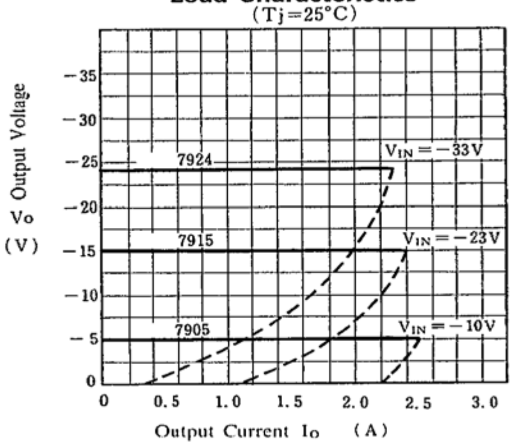
7912 Output Voltage vs. Low Input Voltage

(Tj=25°C)



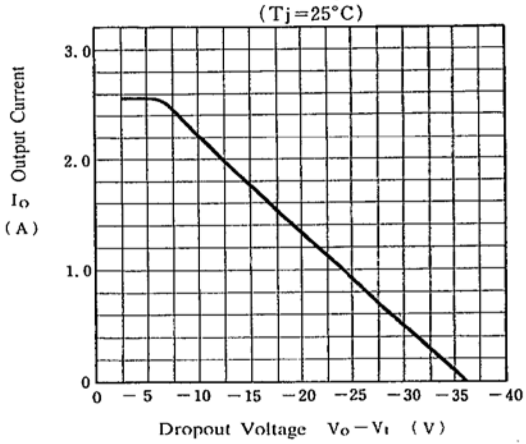
7905/15/24 Load Characteristics

(Tj=25°C)

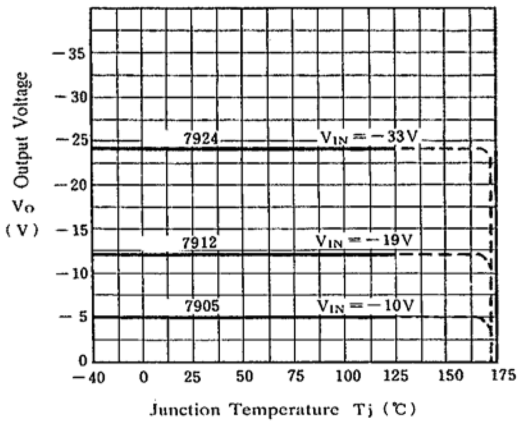


7900 Series Short Circuit Output Current

(Tj=25°C)

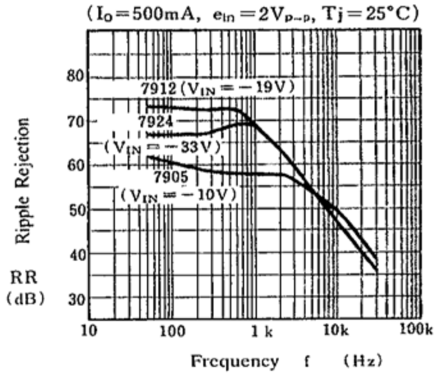


7905/12/24 Output Voltage vs. Junction Temperature

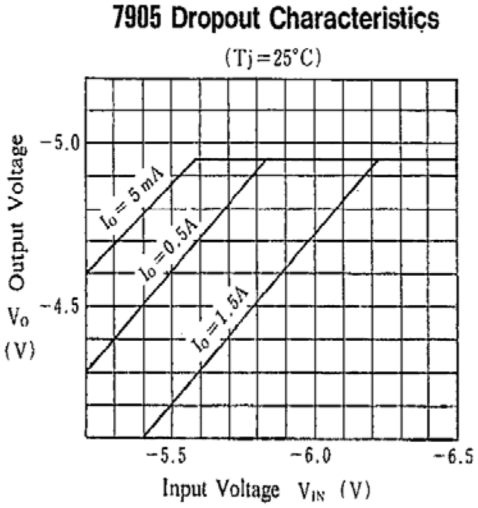


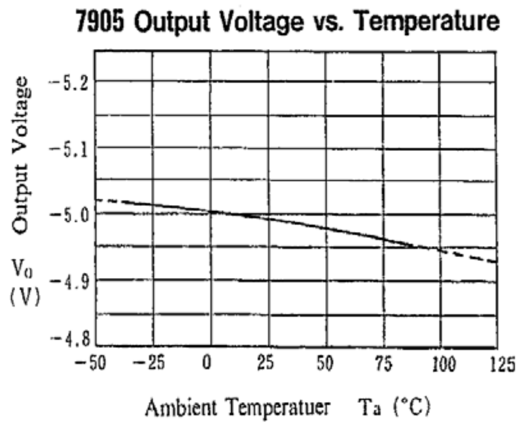
7905/15/24 Ripple Rejection vs. Frequency

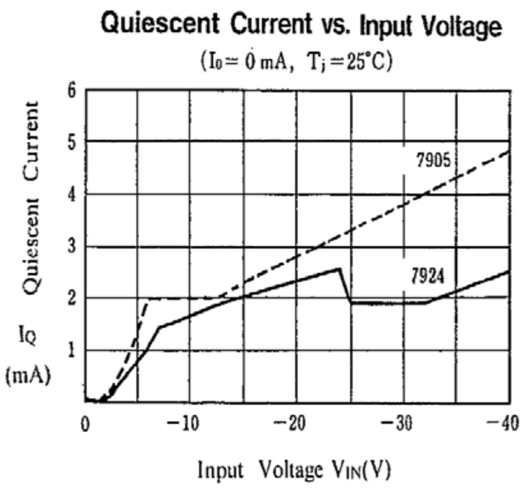
(Io=500mA, ein=2Vp-p, Tj=25°C)



■ **Typical Characteristics**



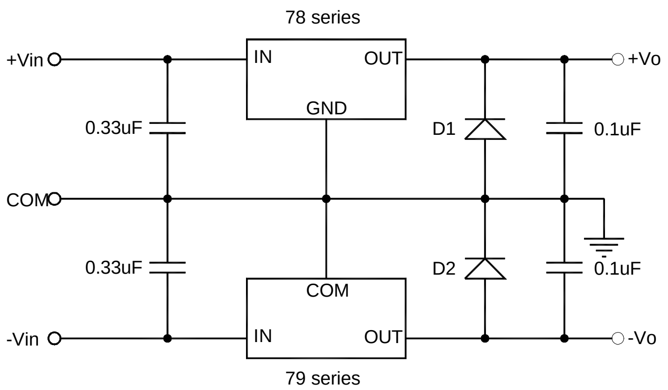




1. Application Circuit

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

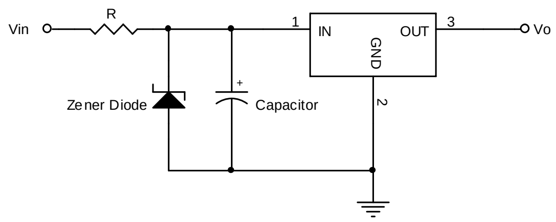
Positive/Negative Voltage Supply

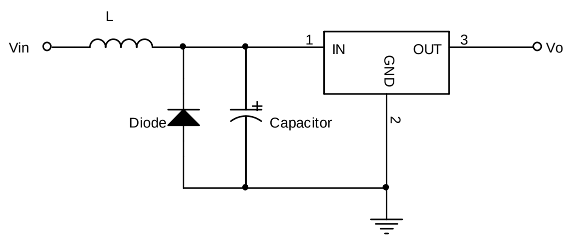


Note : In the above positive and negative power supply application, D1 and D2 should be connected. If D1 and D2 are not connected, either of positive or negative power supply circuit may not turns on.

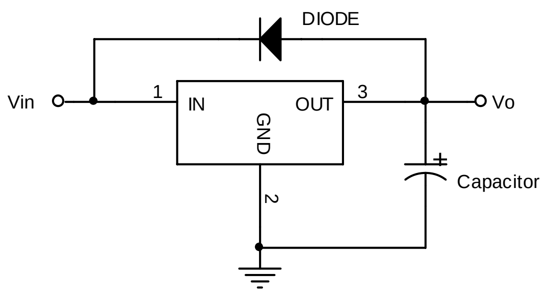
2. Note in Application Circuit

(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

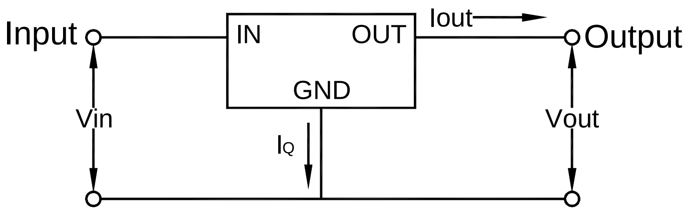
(1) Heat Producting

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}

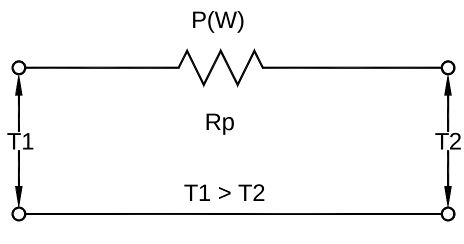
= Vin X I_Q + (Vin-Vout) X Iout (W)

(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.

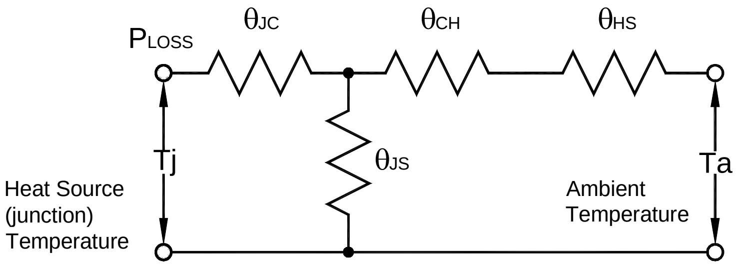
(3) Heat Radiation Balance

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.

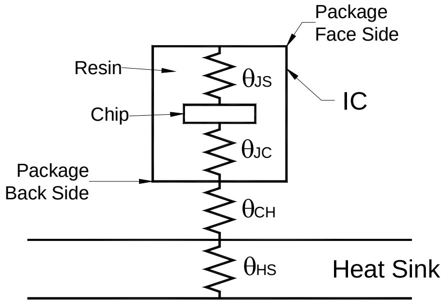


Where θ jc : thermal resistance between IC chip (junction point) and the package backside connecting to the heatsink.

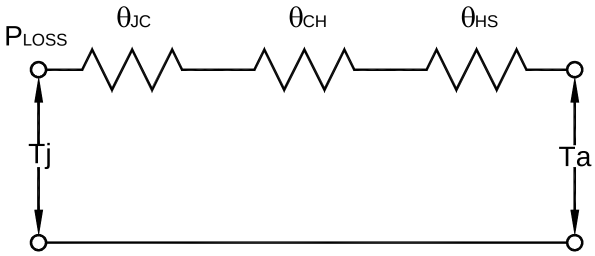
θ js : thermal resistance between IC chip (junction point) and the package surface.

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.

$Tj=P_{LOSS}$ X (θ jc+ θ_{CH} + θ_{HS}) + Ta (℃)

(4) Thermal Design

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

Heat radiation balance

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

$P_{LOSS} = Vin \times I_Q + (Vin-Vout) \times Iout$ (W) (4-2)

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

$Tj = [Vin \times I_Q + (Vin-Vout) \times Iout] \times (\theta_{jc} + \theta_{CH} + \theta_{HS}) + Ta$ (℃) (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.)

$Tj(max) = 125 = [5 \times Vin + (Vin-Vout) \times Iout] \times (5+0.3+ \theta_{HS}) + Ta$ (℃) (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.