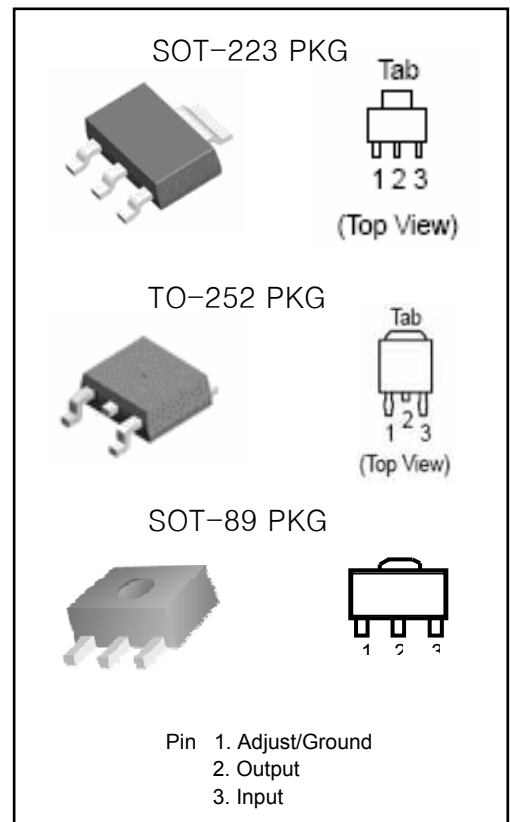


1A L.D.O. VOLTAGE REGULATOR

LM1117S/RS/F

FEATURES

- Output Current up to 1 A
- Low Dropout Voltage (1.2V at 1A Output Current)
- Three Terminal Adjustable(ADJ) or Fixed 1.2V,1.5V, 1.8V, 2.5V, 2.85V, 3.3V, 5.0V
- Line Regulaion typically at 0.1% max
- Load Regulaion typically at 0.2% max
- Internal Current and Terminal Protection
- Maximum Input Voltage – 15V
- Surface Mount Package SOT–223, TO–252, SOT–89
- 100% Thermal Limit Burn-In



APPLICATION

- Active SCSI Terminators
- Portable/Plan Top/Notebook Computers
- High Efficiency Linear Regulators
- SMPS Post Regulators
- Mother B/D Clock Supplies
- Disk Drives
- Battery Chargers

ORDERING INFORMATION

Device (Marking)	Package
LM1117S-ADJ	SOT-223
LM1117S-XX	
LM1117RS-ADJ	TO-252
LM1117RS-XX	
LM1117F-ADJ	SOT-89
LM1117F-XX	

(X.X=Output Voltage=1.2V,1.5V, 1.8V, 2.5V, '3.3V, 5.0V, Adjustable=ADJ)

DESCRIPTION

The LM1117 is a low power positive-voltage regulator designed to meet 1A output current and comply with SCSI-II specifications with a fixed output voltage of 2.85V. This device is an excellent choice for use in battery-powered applications, as active terminators for the SCSI bus, and portable computers.

The LM1117 features very low quiescent current and very low dropout voltage of 1V at a full load and lower as output current decreases. LM1117 is available as an adjustable or fixed 1.5V, 1.8V, 2.5V, 3.3V, and 5.0V output voltages.

The LM1117 is offered in a 3-pin surface mount package SOT-223, TO-252 & SOT-89. The output capacitor of 10 μ F or larger is needed for output stability of LM1117 as required by most of the other regulator circuits.

1A L.D.O. VOLTAGE REGULATOR

LM1117S/RS/F

ABSOLUTE MAXIMUM RATINGS

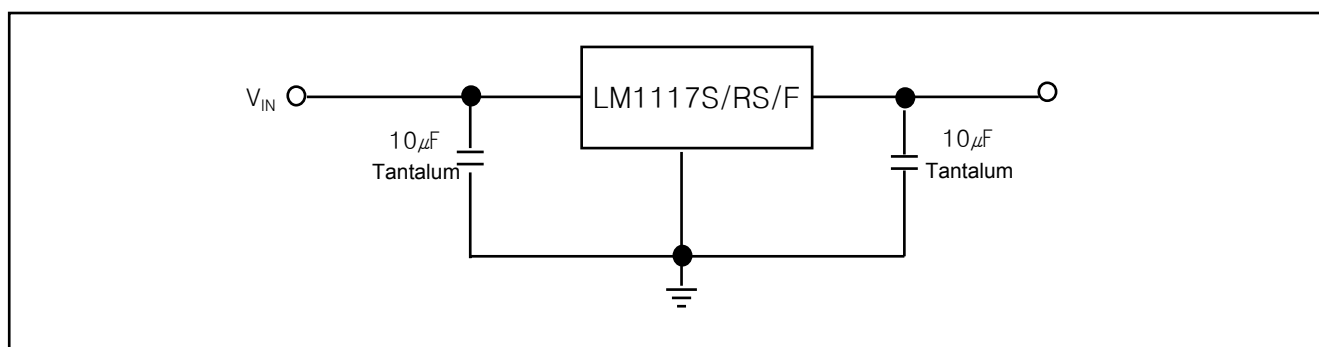
CHARACTERISTIC	SYMBOL	MIN.	MAX.	UNIT
DC Input Voltage	V_{IN}		15	V
Lead Temperature (Soldering, 5 Seconds)	T_{SOL}		260	°C
Storage Temperature Range	T_{STG}	-65	150	°C
Operating Junction Temperature Range	T_{OPR}	-40	125	°C

THERMAL DATA

PARAMETER	SYMBOL	SOT-223	TO-252	SOT-89	UNIT
Thermal Resistance Junction-Ambient	$R_{\theta JA}$	130	93	315	°C/W

TYPICAL APPLICATION

FIXED OUTPUT VOLTAGE



1A L.D.O. VOLTAGE REGULATOR

LM1117S/RS/F

ELECTRICAL CHARACTERISTICS FOR LM1117S/RS/F-ADJ(ADJUSTABLE)

(Refer to the test circuits, $T_J=25^\circ\text{C}$ $C_O=10\mu\text{F}$ unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Reference Voltage	V_{REF}	$I_O = 10\text{mA}$ to 1A, $V_{IN} - V_O = 1.5$ to 13.75V	1.238	1.25	1.262	V
Reference Voltage ($T_J=0\sim 125^\circ\text{C}$)	V_{REF}	$I_O = 10\text{mA}$ to 1A, $V_{IN} - V_O = 1.5$ to 13.75V	1.219		1.281	V
Line Regulation	ΔV_O	$I_O = 10\text{mA}$, $V_{IN} - V_O = 1.5$ to 13.75V		0.1	0.2	%
Load Regulation	ΔV_O	$I_O = 10\text{mA}$ to 1A, $V_{IN} - V_O = 2\text{V}$		0.2	0.4	%
Temperature Stability	ΔV_O			0.5		%
Long Term Stability	ΔV_O	1000 hrs, $T_J = 125^\circ\text{C}$		0.3		%
Operating Input Voltage	V_{IN}				15	V
Adjustment Pin Current	I_{ADJ}	$V_{IN} - V_O = 1.5$ to 12V $I_O = 100\text{mA}$		50	120	μA
Adjustment Pin Current Change	ΔI_{ADJ}	$V_{IN} - V_O = 1.5$ to 12V, $I_O = 10\text{mA}$ to 1A		0.5	5	μA
Minimum Load Current	$I_{O(MIN)}$	$V_{IN} - V_O = 12\text{V}$		5	10	mA
Current Limit	I_O	$V_{IN} - V_O = 5\text{V}$	1000	1250	1600	mA
Output Noise (% V_O)	ϵ_N	B = 10Hz to 10kHz, $T_J = 25^\circ\text{C}$		0.003		%
Supply Voltage Rejection	SVR	$I_O = 40\text{mA}$, $f = 120\text{Hz}$, $T_J = 25^\circ\text{C}$ $V_{IN} - V_O = 3\text{V}$, $V_{NIPPLE} = 1V_{PP}$	60	75		dB
Dropout Voltage	V_D	$I_O = 100\text{mA}$		1.0	1.1	V
		$I_O = 500\text{mA}$		1.1	1.2	V
		$I_O = 1\text{A}$		1.2	1.3	V
Thermal Regulation		$T_A = 25^\circ\text{C}$ 30ms Pulse		0.003		%/W

ELECTRICAL CHARACTERISTICS FOR LM1117S/RS/F-1.2V

(Refer to the test circuits, $T_J=25^\circ\text{C}$ $C_O=10\mu\text{F}$ unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Output Voltage	V_O	$V_{IN} = 3.2$ $I_O = 0\text{mA}$ to 1A	1.176	1.20	1.224	V
Output Voltage	V_O	$V_{IN}=2.5$ to 12V, $I_O=0\text{mA}$ to 1A ($T_J = 0\sim 125^\circ\text{C}$)	1.152		1.248	V
Line Regulation	ΔV_O	$I_O = 10\text{mA}$, $V_{IN} - V_O = 1.5$ to 13.75V		0.1	0.2	%
Load Regulation	ΔV_O	$I_O = 10\text{mA}$ to 1A, $V_{IN} - V_O = 2\text{V}$		0.2	0.4	%
Temperature Stability	ΔV_O			0.5		%
Long Term Stability	ΔV_O	1000 hrs, $T_J = 125^\circ\text{C}$		0.3		%
Operating Input Voltage	V_{IN}				15	V
Quiescent Current	I_D	$V_{IN} - V_O = 5\text{V}$		5	10	mA
Current Limit	I_O	$V_{IN} - V_O = 5\text{V}$	1000	1250	1600	mA
Output Noise (% V_O)	ϵ_N	B = 10Hz to 10kHz, $T_J = 25^\circ\text{C}$		0.003		%
Supply Voltage Rejection	SVR	$I_O = 40\text{mA}$, $f = 120\text{Hz}$, $T_J = 25^\circ\text{C}$ $V_{IN} - V_O = 3\text{V}$, $V_{NIPPLE} = 1V_{PP}$	60	75		dB
Dropout Voltage	V_D	$I_O = 100\text{mA}$		1.0	1.1	V
		$I_O = 500\text{mA}$		1.1	1.2	V
		$I_O = 1\text{A}$		1.2	1.3	V
Thermal Regulation		$T_A = 25^\circ\text{C}$ 30ms Pulse		0.003		%/W

1A L.D.O. VOLTAGE REGULATOR

LM1117S/RS/F

ELECTRICAL CHARACTERISTICS FOR LM1117 S/RS/F-1.5

(Refer to the test circuits, $T_J=25^\circ\text{C}$ $C_O=10\mu\text{F}$ unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Output Voltage	V_O	$V_{IN} = 3.0$ to 12V , $I_O = 0\text{mA}$ to 1A	1.485	1.5	1.515	V
Output Voltage	V_O	$V_{IN}=3.0$ to 12V , $I_O=0\text{mA}$ to 1A ($T_J = 0\sim 125^\circ\text{C}$)	1.470		1.530	V
Line Regulation	ΔV_O	$V_{IN} = 3.0$ to 12V , $I_O = 0\text{mA}$		0.1	0.2	%
Load Regulation	ΔV_O	$V_{IN} = 3.5\text{V}$, $I_O = 0$ to 1A		0.2	0.4	%
Temperature Stability	ΔV_O			0.5		%
Long Term Stability	ΔV_O	1000 hrs, $T_J = 125^\circ\text{C}$		0.3		%
Operating Input Voltage	V_{IN}	$I_O = 100\text{mA}$			12	V
Quiescent Current	I_D	$V_{IN}-V_O = 5\text{V}$		5	10	mA
Current Limit	I_O	$V_{IN}-V_O = 5\text{V}$	1000	1250	1600	mA
Output Noise Voltage	e_N	$B = 10\text{Hz}$ to 10kHz , $T_J = 25^\circ\text{C}$		100		μV
Supply Voltage Rejection	SVR	$I_O = 40\text{mA}$, $f = 120\text{Hz}$, $T_J = 25^\circ\text{C}$ $V_{IN} = 5.5\text{V}$, $V_{NIPPLE} = 1V_{PP}$	60	75		dB
Dropout Voltage	V_D	$I_O = 100\text{mA}$		1.0	1.1	V
		$I_O = 500\text{mA}$		1.1	1.2	V
		$I_O = 1\text{A}$		1.2	1.3	V
Thermal Regulation		$T_A = 25^\circ\text{C}$ 30ms Pulse		0.003		%/W

ELECTRICAL CHARACTERISTICS FOR LM1117 S/RS/F-1.8

(Refer to the test circuits, $T_J=25^\circ\text{C}$ $C_O=10\mu\text{F}$ unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Output Voltage	V_O	$V_{IN} = 3.3$ to 12V , $I_O = 0\text{mA}$ to 1A	1.782	1.8	1.818	V
Output Voltage	V_O	$V_{IN}=3.3$ to 12V , $I_O=0\text{mA}$ to 1A ($T_J = 0\sim 125^\circ\text{C}$)	1.764		1.836	V
Line Regulation	ΔV_O	$V_{IN} = 3.3$ to 12V , $I_O = 10\text{mA}$		0.1	0.2	mV
Load Regulation	ΔV_O	$V_{IN} = 3.8\text{V}$, $I_O = 0$ to 1A		0.2	0.4	mV
Temperature Stability	ΔV_O			0.5		%
Long Term Stability	ΔV_O	1000 hrs, $T_J = 125^\circ\text{C}$		0.3		%
Operating Input Voltage	V_{IN}	$I_O = 100\text{mA}$			12	V
Quiescent Current	I_D	$V_{IN}-V_O = 5\text{V}$		5	10	mA
Current Limit	I_O	$V_{IN}-V_O = 5\text{V}$	1000	1250	1600	mA
Output Noise Voltage	e_N	$B = 10\text{Hz}$ to 10kHz , $T_J = 25^\circ\text{C}$		100		μV
Supply Voltage Rejection	SVR	$I_O = 40\text{mA}$, $f = 120\text{Hz}$, $T_J = 25^\circ\text{C}$ $V_{IN} = 5.5\text{V}$, $V_{NIPPLE} = 1V_{PP}$	60	75		dB
Dropout Voltage	V_D	$I_O = 100\text{mA}$		1.0	1.1	V
		$I_O = 500\text{mA}$		1.1	1.2	V
		$I_O = 1\text{A}$		1.2	1.3	V
Thermal Regulation		$T_A = 25^\circ\text{C}$ 30ms Pulse		0.003		%/W

1A L.D.O. VOLTAGE REGULATOR

LM1117S/RS/F

ELECTRICAL CHARACTERISTICS FOR LM1117 S/RS/F-2.5

(Refer to the test circuits, $T_J=25^\circ\text{C}$ $C_O=10\mu\text{F}$ unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Output Voltage	V_O	$V_{IN} = 4.0$ to 12V , $I_O = 0\text{mA}$ to 1A	2.475	2.5	2.525	V
Output Voltage	V_O	$V_{IN}=4.0$ to 12V , $I_O=0\text{mA}$ to 1A ($T_J = 0\sim 125^\circ\text{C}$)	2.450		2.550	V
Line Regulation	ΔV_O	$V_{IN} = 4.0$ to 12V , $I_O = 10\text{mA}$		0.1	0.2	%
Load Regulation	ΔV_O	$V_{IN} = 4.5\text{V}$, $I_O = 0$ to 1A		0.2	0.4	%
Temperature Stability	ΔV_O			0.5		%
Long Term Stability	ΔV_O	1000 hrs, $T_J = 125^\circ\text{C}$		0.3		%
Operating Input Voltage	V_{IN}	$I_O = 100\text{mA}$			12	V
Quiescent Current	I_D	$V_{IN}-V_O = 5\text{V}$		5	10	mA
Current Limit	I_O	$V_{IN}-V_O = 5\text{V}$	1000	1250	1600	mA
Output Noise Voltage	e_N	$B = 10\text{Hz}$ to 10kHz , $T_J = 25^\circ\text{C}$		100		μV
Supply Voltage Rejection	SVR	$I_O = 40\text{mA}$, $f = 120\text{Hz}$, $T_J = 25^\circ\text{C}$ $V_{IN} = 5.5\text{V}$, $V_{NIPPLE} = 1\text{V}_{PP}$	60	75		dB
Dropout Voltage	V_D	$I_O = 100\text{mA}$		1.0	1.1	V
		$I_O = 500\text{mA}$		1.1	1.2	V
		$I_O = 1\text{A}$		1.2	1.3	V
Thermal Regulation		$T_A = 25^\circ\text{C}$ 30ms Pulse		0.01	0.1	%/W

ELECTRICAL CHARACTERISTICS FOR LM1117 S/RS/F-2.85

(Refer to the test circuits, $T_J=25^\circ\text{C}$ $C_O=10\mu\text{F}$ unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Output Voltage	V_O	$V_{IN} = 4.4$ to 12V , $I_O = 0\text{mA}$ to 1A	2.821	2.85	2.878	V
Output Voltage	V_O	$V_{IN}=4.4$ to 12V , $I_O=0\text{mA}$ to 1A ($T_J = 0\sim 125^\circ\text{C}$)	2.793		2.907	V
Line Regulation	ΔV_O	$V_{IN} = 4.4$ to 12V , $I_O = 10\text{mA}$		0.1	0.2	%
Load Regulation	ΔV_O	$V_{IN} = 4.85\text{V}$, $I_O = 0$ to 1A		0.2	0.4	%
Temperature Stability	ΔV_O			0.5		%
Long Term Stability	ΔV_O	1000 hrs, $T_J = 125^\circ\text{C}$		0.3		%
Operating Input Voltage	V_{IN}	$I_O = 100\text{mA}$			12	V
Quiescent Current	I_D	$V_{IN}-V_O = 5\text{V}$		5	10	mA
Current Limit	I_O	$V_{IN}-V_O = 5\text{V}$	1000	1250	1600	mA
Output Noise Voltage	e_N	$B = 10\text{Hz}$ to 10kHz , $T_J = 25^\circ\text{C}$		100		μV
Supply Voltage Rejection	SVR	$I_O = 40\text{mA}$, $f = 120\text{Hz}$, $T_J = 25^\circ\text{C}$ $V_{IN} = 5.85\text{V}$, $V_{NIPPLE} = 1\text{V}_{PP}$	60	75		dB
Dropout Voltage	V_D	$I_O = 100\text{mA}$		1.0	1.1	V
		$I_O = 500\text{mA}$		1.1	1.2	V
		$I_O = 1\text{A}$		1.2	1.3	V
Thermal Regulation		$T_A = 25^\circ\text{C}$ 30ms Pulse		0.003		%/W

1A L.D.O. VOLTAGE REGULATOR

LM1117S/RS/F

ELECTRICAL CHARACTERISTICS FOR LM1117 S/RS/F-3.3

(Refer to the test circuits, $T_J=25^\circ\text{C}$ $C_O=10\mu\text{F}$ unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Output Voltage	V_O	$V_{IN} = 4.8$ to 12V , $I_O = 0\text{mA}$ to 1A	3.267	3.3	3.333	V
Output Voltage	V_O	$V_{IN}=4.8$ to 12V , $I_O=0\text{mA}$ to 1A ($T_J = 0\sim 125^\circ\text{C}$)	3.234		3.366	V
Line Regulation	ΔV_O	$V_{IN} = 4.8$ to 12V , $I_O = 10\text{mA}$		0.1	0.2	%
Load Regulation	ΔV_O	$V_{IN} = 5.3\text{V}$, $I_O = 0$ to 1A		0.2	0.4	%
Temperature Stability	ΔV_O			0.5		%
Long Term Stability	ΔV_O	1000 hrs, $T_J = 125^\circ\text{C}$		0.3		%
Operating Input Voltage	V_{IN}	$I_O = 100\text{mA}$			12	V
Quiescent Current	I_D	$V_{IN} - V_O = 5\text{V}$		5	10	mA
Current Limit	I_O	$V_{IN} - V_O = 5\text{V}$	1000	1250	1600	mA
Output Noise Voltage	e_N	$B = 10\text{Hz}$ to 10kHz , $T_J = 25^\circ\text{C}$		100		μV
Supply Voltage Rejection	SVR	$I_O = 40\text{mA}$, $f = 120\text{Hz}$, $T_J = 25^\circ\text{C}$ $V_{IN} = 6.3\text{V}$, $V_{NIPPLE} = 1\text{V}_{PP}$	60	75		dB
Dropout Voltage	V_D	$I_O = 100\text{mA}$		1.0	1.1	V
		$I_O = 500\text{mA}$		1.1	1.2	V
		$I_O = 1\text{A}$		1.2	1.3	V
Thermal Regulation		$T_A = 25^\circ\text{C}$ 30ms Pulse		0.003		%/W

ELECTRICAL CHARACTERISTICS FOR LM1117 S/RS/F-5.0

(Refer to the test circuits, $T_J=25^\circ\text{C}$ $C_O=10\mu\text{F}$ unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Output Voltage	V_O	$V_{IN} = 6.5$ to 15V , $I_O = 0\text{mA}$ to 1A	4.950	5.0	5.050	V
Output Voltage	V_O	$V_{IN}=6.5$ to 15V , $I_O=0\text{mA}$ to 1A ($T_J = 0\sim 125^\circ\text{C}$)	4.900		5.100	V
Line Regulation	ΔV_O	$V_{IN} = 6.5$ to 15V , $I_O = 10\text{mA}$		0.1	0.2	%
Load Regulation	ΔV_O	$V_{IN} = 7.0\text{V}$, $I_O = 0$ to 1A		0.2	0.4	%
Temperature Stability	ΔV_O			0.5		%
Long Term Stability	ΔV_O	1000 hrs, $T_J = 125^\circ\text{C}$		0.3		%
Operating Input Voltage	V_{IN}	$I_O = 100\text{mA}$			15	V
Quiescent Current	I_D	$V_{IN} - V_O = 5\text{V}$		5	10	mA
Current Limit	I_O	$V_{IN} - V_O = 5\text{V}$	1000	1250	1600	mA
Output Noise Voltage	e_N	$B = 10\text{Hz}$ to 10kHz , $T_J = 25^\circ\text{C}$		100		μV
Supply Voltage Rejection	SVR	$I_O = 40\text{mA}$, $f = 120\text{Hz}$, $T_J = 25^\circ\text{C}$ $V_{IN} = 6.3\text{V}$, $V_{NIPPLE} = 1\text{V}_{PP}$	60	75		dB
Dropout Voltage	V_D	$I_O = 100\text{mA}$		1.0	1.1	V
		$I_O = 500\text{mA}$		1.1	1.2	V
		$I_O = 1\text{A}$		1.2	1.3	V
Thermal Regulation		$T_A = 25^\circ\text{C}$ 30ms Pulse		0.003		%/W

APPLICATION CIRCUITS

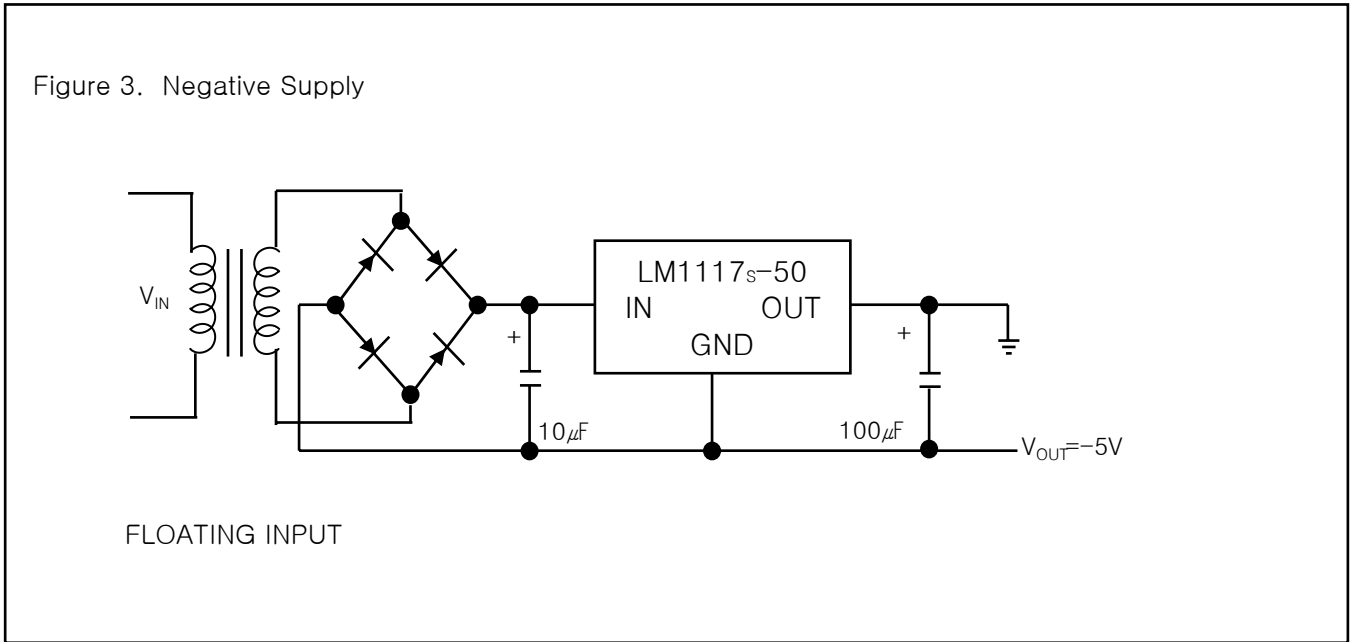
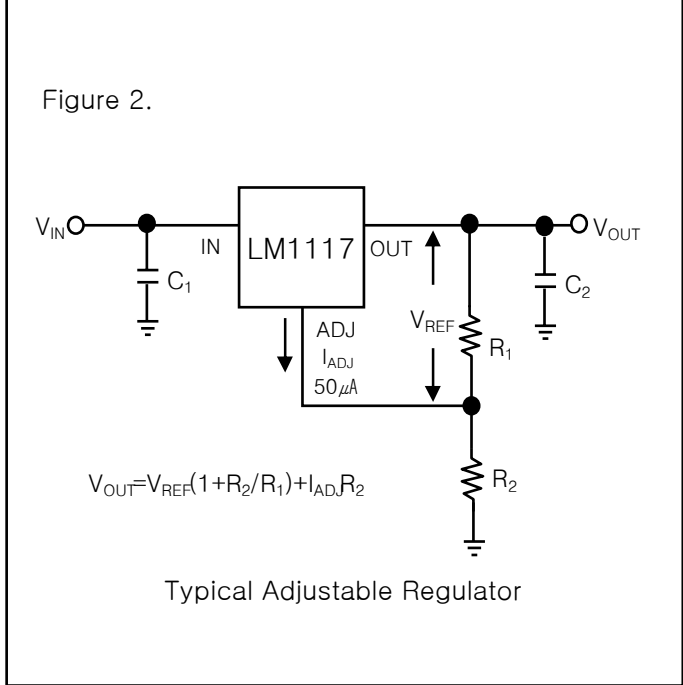
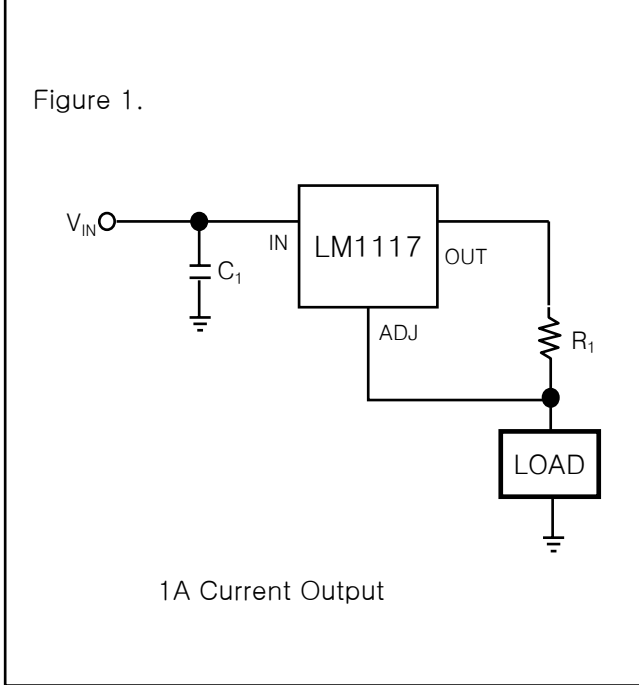


Figure 4. Active Terminator for SCSI-2 BUS

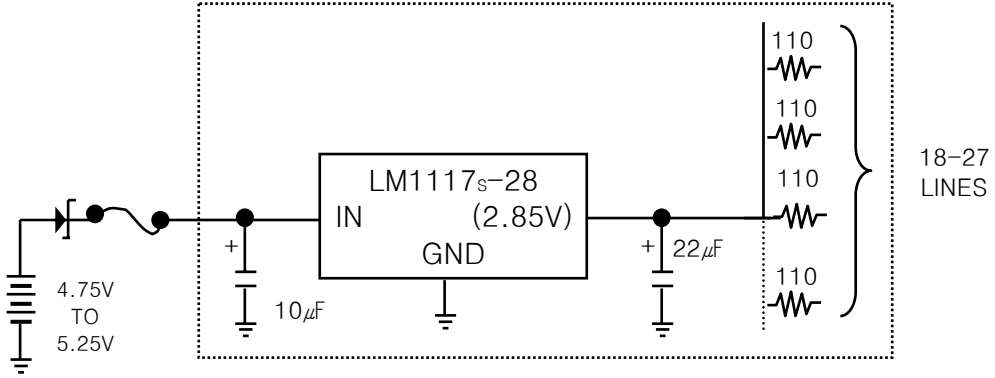
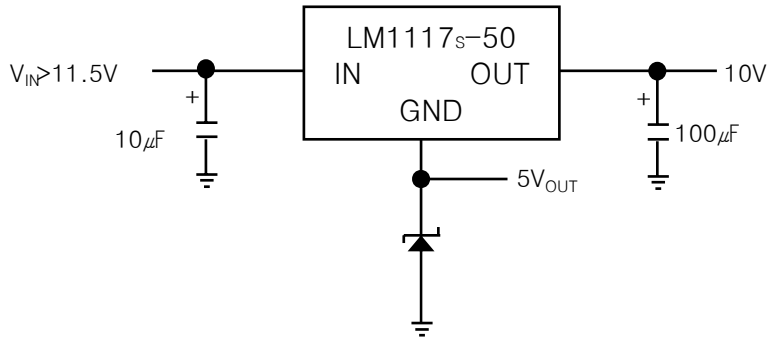
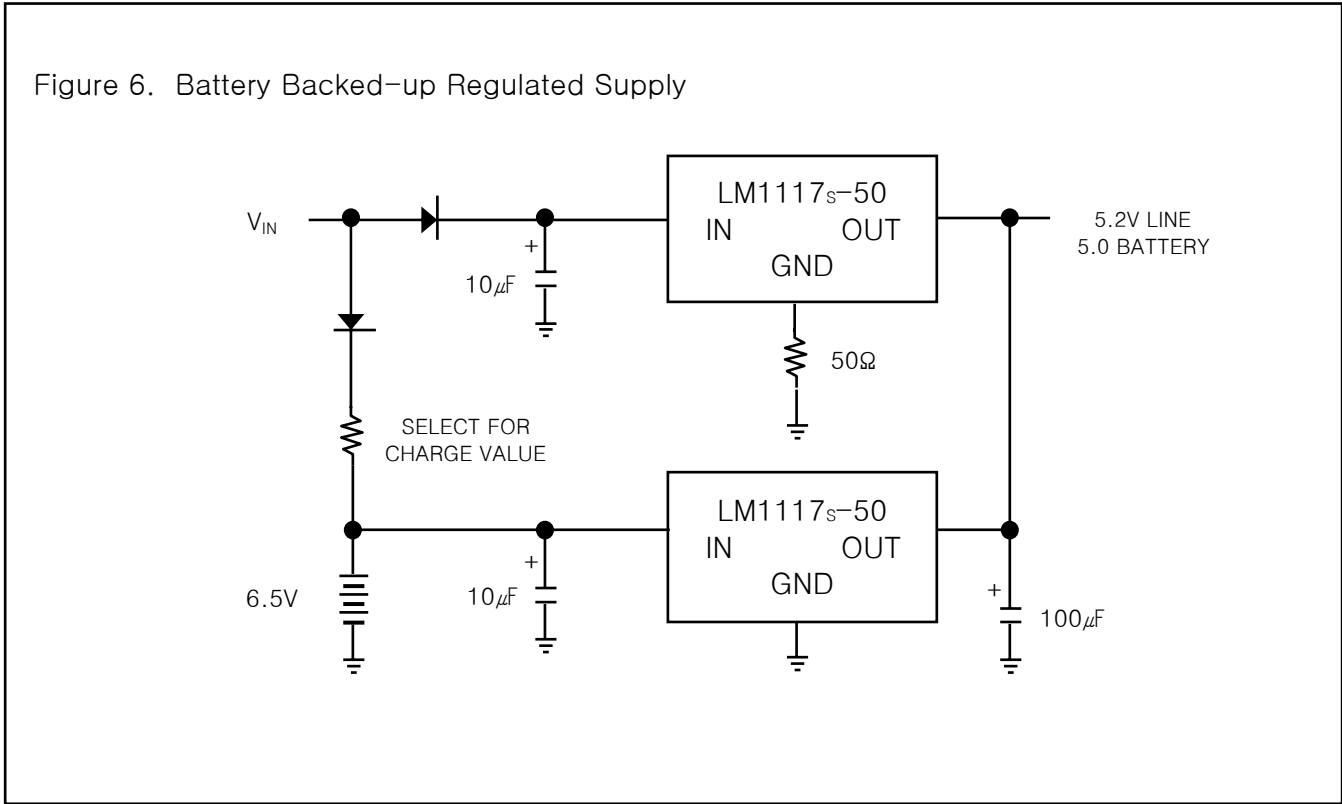


Figure 5. Voltage Regulator With Reference





* NOTES : IF ANYTHING WILL BE CHANGED FOR THIS SPECIFICATION,
TAEJIN TECHNOLOGY MUST INFORM PCC BEFORE THE CHANGE

Typical Performance Characteristics

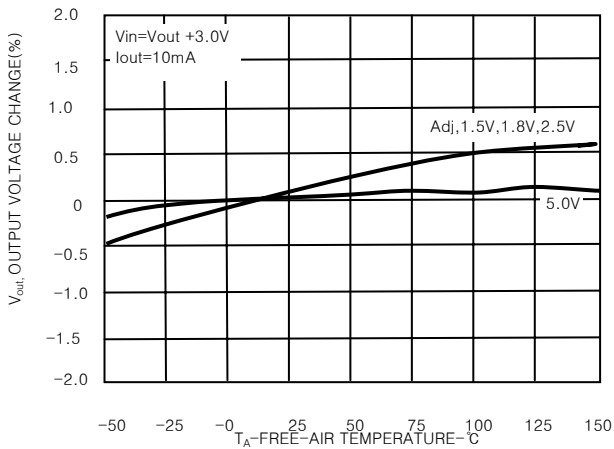


FIG 1. OUTPUT VOLTAGE CHANGE vs TEMPERATURE (°C)

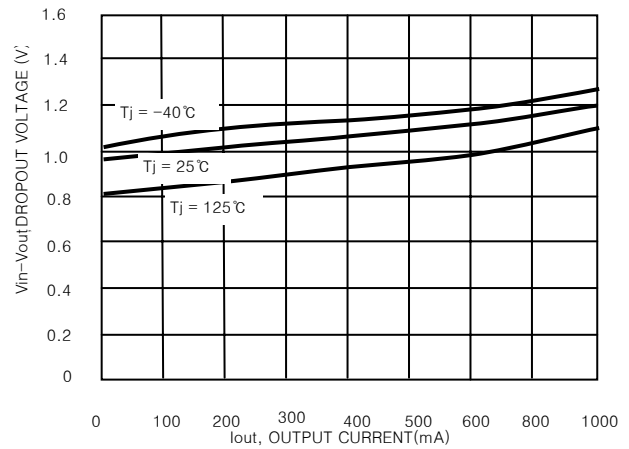


FIG 2. DROPOUT VOLTAGE vs OUTPUT CURRENT

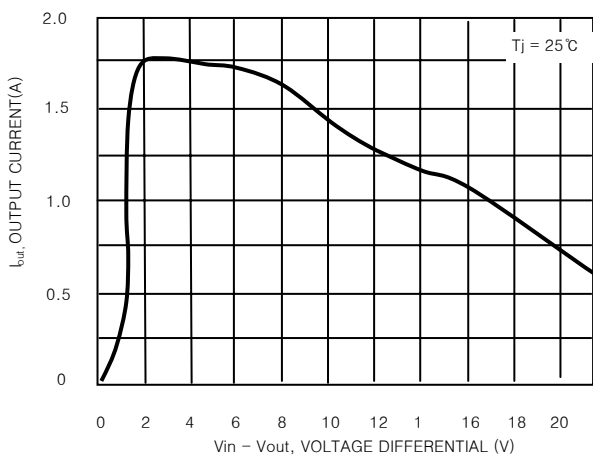


FIG 3. OUTPUT SHORT CIRCUIT CURRENT vs DIFFERENTIAL VOLTAGE

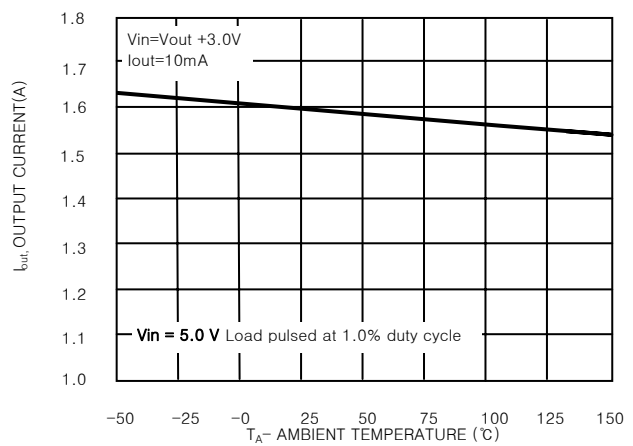


FIG 4. OUTPUT SHORT CIRCUIT CURRENT vs TEMPERATURE

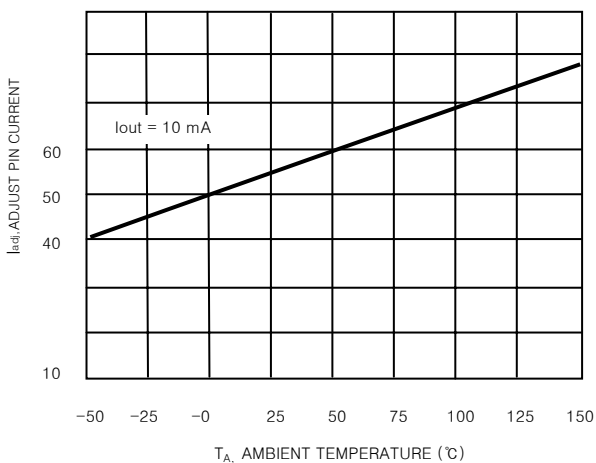


FIG 5. ADJ PIN CURRENT vs TEMPERATURE (°C)

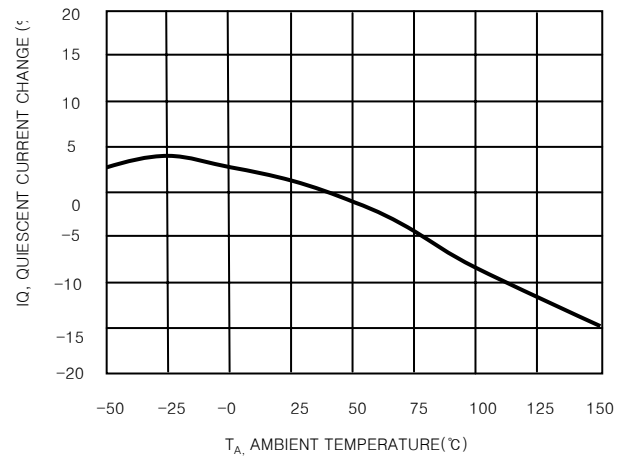


FIG 6. QUIESCENT CURRENT CHANGE vs TEMPERATURE (°C)

Maximum Output Current Capability

The LM1117 can deliver a continuous current of 1A over the full operating junction temperature range. However, the current is limited by the restriction of power dissipation which differs from packages. A heat sink may be required depending on the maximum power dissipation and maximum ambient temperature of application. With respect to the applied package, the maximum output current of 1A may be still undeliverable due to the restriction of the power dissipation of LM1117. Under all possible conditions, the junction temperature must be within the range specified under operating conditions. The temperatures over the device are given by:

$$T_C = T_A + P_D \times \theta_{CA}$$

$$T_J = T_C + P_D \times \theta_{JC}$$

$$T_J = T_A + P_D \times \theta_{JA}$$

T_J is the junction temperature, T_C is the case temperature, T_A is the ambient temperature, P_D is the total power dissipation of the device, θ_{CA} is the thermal resistance of case-to-ambient, θ_{JC} is the thermal resistance of junction-to-case, and θ_{JA} is the thermal resistance of junction to ambient. The total power dissipation of the device is given by

$$P_D = P_{IN} - P_{OUT} = (V_{IN} \times I_{IN}) - (V_{OUT} \times I_{OUT}) \\ = (V_{IN} \times (I_{OUT} + I_{GND})) - (V_{OUT} \times I_{OUT}) = (V_{IN} - V_{OUT}) \times I_{OUT} + V_{IN} \times I_{GND}$$

where I_{GND} is the operating ground current of the device which is specified at the Electrical Characteristics. The maximum allowable temperature rise (T_{Rmax}) depends on the maximum ambient temperature (T_{Amax}) of the application and the maximum allowable junction temperature (T_{Jmax}):

$$T_{Rmax} = T_{Jmax} - T_{Amax}$$

The maximum allowable value for junction-to-ambient thermal resistance, θ_{JA} , can be calculated using the formula:

$$\theta_{JA} = T_{Rmax} / P_D$$

LM1117 is available in SOT223, TO252 packages. The thermal resistance depends on amount of copper area or heat sink and on air flow. If the maximum allowable value of θ_{JA} calculated above is over 130°C/W for SO-223 package, over 93°C/W for TO252 package, no heat sink is needed since the package can dissipate enough heat to satisfy these requirements. If the value for allowable θ_{JA} falls near or below these limits, a heat sink or proper area of copper plane is required. In summary, the absolute maximum ratings of thermal resistances are as follows:

Absolute Maximum Ratings of Thermal Resistance

Characteristic	Symbol	Max. Rating	Unit
Thermal Resistance Junction-To-Ambient / SOT223	$\theta_{JA-SOT223}$	130	°C/W
Thermal Resistance Junction-To-Ambient / TO252	$\theta_{JA-TO252}$	93	°C/W
Thermal Resistance Junction-To-Ambient / SOT89	$\theta_{JA-SOT89}$	315	°C/W

No heat sink / No air flow / No adjacent heat source / 0.066 inch² copper area