MT6680 1A, 5.5V Ultra Low Dropout Linear Regulator Datasheet

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Version History

Version	Date	Description
0.1	2017-12-07	First edition
0.2	2018-02-13	Features : P5 -Update Input Voltage Range Top Marking Definition P8 -Updated marking code MT6680 Packaging P20 -Modified title Typical Application Circuit P10 -Update Circuit Pin Assignments and Descriptions : P9 -Update BIAS pin description Recommended Operating Range : P12 -Update Input Voltage Range
0.3	2018-03-15	Typical Operating Characteristics P15, P16 -Add Typical Operating Characteristics
1.0	2018-07-20	Datasheet released Ordering Information P7 -Update Ordering Information Absolute Maximum Ratings P11 -Removed CDM (Charged Device Model)
1.1	2020-10-20	Pin Assignments and Descriptions P9 -Modify EN and BIAS descriptions. Typical Application Circuit P10 -Update typical application circuit. Absolute Maximum Ratings P11 -Add Enable input voltage. Electrical Characteristics P13 -Modify electrical characteristics test conditions descriptions. Application Information P17 -Modify General Descriptions
1.2	2021-11-22	Recommended Operating Range P12 -Modify

Table of Contents

List of Figures

List of Tables

1 Overview

1.1 Features

- Input Voltage Range : 0.8V to 5.5V
- Bias Voltage Range : 3V to 5.5V
- Adjustable Output Voltage Version, Output Voltage Range : 0.5V to 3V
- Ultra Low Dropout Voltage : 60mV at 1A
- Output Voltage Accuracy
  - ± 1% Over Operating Ambient Temperature
  - ± 0.5% @ 25°C)
- Low Bias Input Current
  - Typ 35µA in Operating Mode
  - Typ 0.5µA in Disable Mode
- Output Active Discharge Function
- Enable Control
- Stable with a 10µF Output Ceramic Capacitor
- RoHS Compliant and Halogen/Pb Free

1.2 Applications

- Battery Powered Systems
- Portable Electronic Device
- Digital Set Top Boxes
- Industrial HMI, desktop POS, KIOSK, digital signage

1.3 General Descriptions

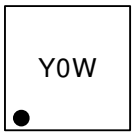
The MT6680 is a high performance positive voltage regulator with separated bias voltage (V_{BIAS}), designed for applications requiring low input voltage and ultra low dropout voltage, output current up to 1A. The feature of ultra low dropout voltage is ideal for applications where output voltage is very close to input voltage. The input voltage can be as low as 0.5V and the output voltage is adjustable by an external resistive divider. The MT6680 features very low quiescent current consumption for portable applications. The device is available in the WL-CSP-6B 0.8x1.2 (BSC) package.

1.4 Ordering Information

Table 1-1. Ordering option

Product	Package Type	Nominal Output Voltage
MT6680P/A	P: WL-CSP-6B 0.8x1.2 (BSC)	Adjustable

1.5 Top Marking Definition



Y0 : Product Code
W : Date Code

Figure 1-1. Top Marking

1.6 Pin Assignments and Descriptions

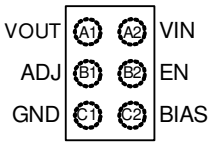


Figure 1-2. MT6680 WL-CSP-6B 0.8x1.2 (BSC) (top view)

Table 1-2. MT6680 pin descriptions

Pin No.	Pin Name	Pin Description
A1	VOUT	Regulated output voltage. A 10µF capacitor should be placed directly at this pin.
A2	VIN	Power input for the LDO.
B1	ADJ	Adjustable output voltage feedback input.
B2	EN	Chip enable (Active-High). Pulling this pin below 0.4V turns the regulator off, reducing the quiescent current to a fraction of its operating value. This pin must not be left unconnected, connect to the RC filter after BIAS if not being used. If EN is an external signal, it suggests connecting RC filter for operation. Keep VEN < V_{BIAS} +0.5V to prevent malfunction.
C1	GND	Ground. The exposed pad must be soldered to a large PCB and connected to GND for maximum power dissipation.
C2	BIAS	Supply V_{BIAS} ripple should be less than 30mV (5mV/µs) to secure safe stabilization of internal control circuitry. Apply RC filter consists of (500Ω to 1kΩ) + 1µF at the pin input. The V_{BIAS} must be higher than 3V and ensure V_{BIAS} ≥ VOUT + 1.6V for normal operation.

1.7 Typical Application Circuit

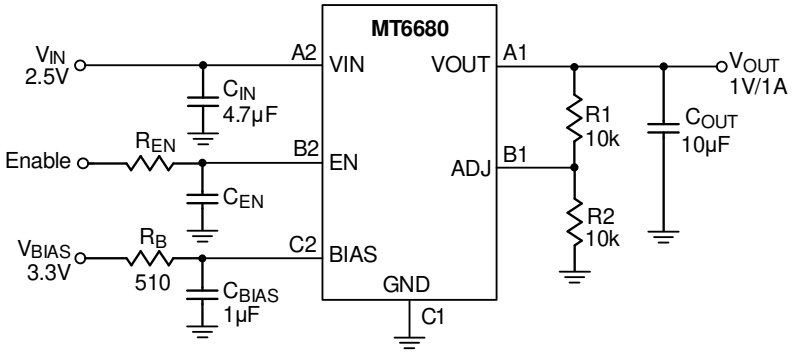


Figure 1-3. Typical application circuit

Note:

- All the input and output capacitances are the suggested values, which refer to the effective capacitances, and are subject to any de-rating effect, like a DC bias.

2 Electrical Characteristics

2.1 Absolute Maximum Ratings

(Note 1)

- Supply Input Voltage, VIN ---------- -0.3V to 6V
- Enable Input Voltage, EN ---------- -0.3V to (V_{BIAS} + 0.5V)
- All Other Pins ---------- -0.3V to 6V
- Power Dissipation, PD @ TA = 25°C
  WL-CSP-6B 0.8x1.2 (BCS) ---------- 0.67W
- Package Thermal Resistance **(Note 2)**
  WL-CSP-6B 0.8x1.2 (BCS), θJA ---------- 148°C/W
- Lead Temperature (Soldering, 10 sec.)---------- 260°C
- Junction Temperature---------- 150°C
- Storage Temperature Range --65°C to 150°C
- ESD Susceptibility **(Note 3)**
  HBM (Human Body Model) ---------- 2kV

Note 1:

- Stresses beyond those listed "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

Note 2:

- θJA is measured under natural convection (still air) at TA = 25°C with the component mounted on a high effective-thermal-conductivity four-layer test board on a JEDEC 51-7 thermal measurement standard.

Note 3:

- Devices are ESD sensitive. Handling precaution recommended.

2.2 Recommended Operating Range

(Note 1)

- Supply Input Voltage, VIN ---------- 0.8V to 5.5V
- Supply Input Voltage, BIAS ---------- 3V to 5.5V
- Junction Temperature Range ---------- -40°C to 125°C
- Ambient Temperature Range ---------- -40°C to 85°C

Note 1:

The device is not guaranteed to function outside its operating conditions.

2.3 Electrical Characteristics

V_{BIAS} = 3V, and (VOUT + 1.6V), whichever is greater, V_{IN} = V_{OUT}(Normal) + 0.3V, I_{OUT} = 1mA, V_{EN} = 1V, C_{IN} = 10µF, C_{OUT} = 10µF, C_{BIAS} = 1µF, T_A = 25°C, unless otherwise specified.

Note:

- Performance guaranteed over the indicated operating temperature range by design and/or characterization. Production tested at T_A = 25°C. Low duty cycle pulse techniques are used during the testing to maintain the junction temperature as close to ambient as possible.

Table 2-1. Electrical specifications

Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
Operating Input Voltage Range		V_{IN}		V_{OUT} + V_{DROP}	--	5.5	V
Operating Bias Voltage Range		V_{BIAS}		(V_{OUT} + 1. 6) ≥ 3	--	5.5	V
Under-Voltage Lockout		V_{UVLO}	V_{BIAS} rising	--	1.6	--	V
			Hysteresis	--	0.2	--	V
Reference Voltage (Adj devices only)		V_{REF}		0.49	0.5	0.51	V
Output Voltage Accuracy		V_{OUT}	(1)	-0.5	--	0.5	%
Output Voltage Accuracy (1)		V_{OUT}	1. $V_{OUT(NOM)}$ + 0.3V ≤ V_{IN} ≤ $V_{OUT(NOM)}$ + 1V 2. V_{BIAS} ≥ 3V and $V_{OUT(NOM)}$ + 1.6V ≤ V_{BIAS} ≤ 5.5V 3. 1mA ≤ I_{OUT} ≤ 1A	-1	--	1	%
V_{IN} Line Regulation		ΔV_{LINE_VIN}	$V_{OUT(NOM)}$ + 0.3V ≤ V_{IN} ≤ 5V	--	0.01	--	%/V
V_{BIAS} Line Regulation		ΔV_{BIAS_VIN}	V_{BIAS} ≥ 3V and $V_{OUT(NOM)}$ + 1.6V ≤ V_{BIAS} ≤ 5.5V	--	0.01	--	%/V
Load Regulation		ΔV_{LOAD}	I_{OUT} = 1mA to 1A	--	2	--	mV
V_{IN} Dropout Voltage		V_{DROP_VIN}	I_{OUT} = 1A	--	60	75	mV
V_{BIAS} Dropout Voltage		V_{DROP_BIAS}	I_{OUT} = 1A, V_{IN} = V_{BIAS} (2) (3)	--	1.05V	1.5V	V
Output Current Limit		I_{LIM}	V_{OUT} = 90% $V_{OUT(Normal)}$	--	2000	--	mA
ADJ Pin Operating Current		I_{ADJ}		--	0.1	0.5	µA
Bias Pin Quiescent Current		I_{BIAS}	V_{BIAS} = 3V	--	35	50	µA
Bias Pin Shutdown Current		$I_{BIAS(DIS)}$	V_{EN} ≤ 0.4 V	--	0.5	1	µA
V_{IN} Pin Shutdown Current		$I_{VIN(DIS)}$	V_{EN} ≤ 0.4 V	--	0.5	1	µA
EN Input Voltage	Logic_High	V_{IH}		0.9	--	--	V
	Logic_Low	V_{IL}		--	--	0.4	
EN Pull Down Current		I_{EN}	V_{EN} = 5.5V, V_{BIAS} = 5.5V	--	0.3	--	µA
Turn-On Time		t_{ON}	From assertion of V_{EN} to V_{OUT} = 98% $V_{OUT\ (NOM)}$. $V_{OUT(NOM)}$ = 1V	--	150	--	µs
Power Supply Rejection Ratio (4)		PSRR_V_{IN}	V_{IN} to V_{OUT}, f = 1kHz, I_{OUT} = 150mA, VIN ≥ V_{OUT} + 0.5V	--	70	--	dB
		PSRR_V_{BIAS}	V_{BIAS} to V_{OUT}, f = 1kHz, I_{OUT} = 150mA, V_{IN} ≥ V_{OUT} + 0.5V	--	70	--	dB

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Noise Voltage **(Note 5)**	eNO	V_{IN} = V_{OUT} + 0.5V, f = 10Hz to 100kHz	--	30 x V_{OUT}/ V_{REF}	--	μV_{RMS}
Thermal Shutdown Threshold	T_{SD}	Shutdown temperature	--	160	--	°C
Thermal Shutdown Hysteresis	ΔT_{SD}		--	20	--	°C
Output Discharge Pull−Down	R_{DISCH}	$V_{EN} \leq$ 0.4V, V_{OUT} = 0.5V	--	150	--	Ω

(1) Note 1 for adjustable devices tested at 0.5V; external resistor tolerance is not taken into account.

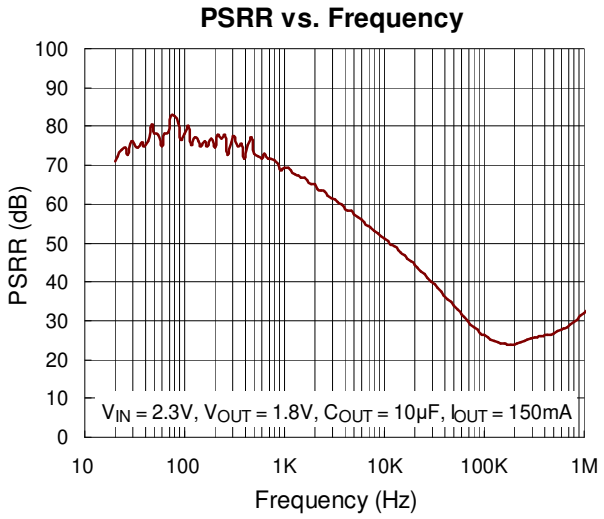
(2) Note 2 for dropout voltage is characterized when V_{OUT} falls 3% below $V_{OUT(Normal)}$.

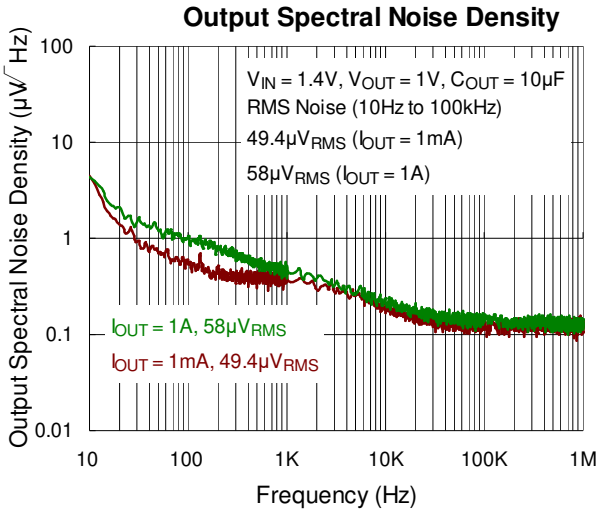
(3) Note 3 for output voltages below 0.9V, V_{BIAS} dropout voltage does not apply due to a minimum Bias operating voltage of 3V.

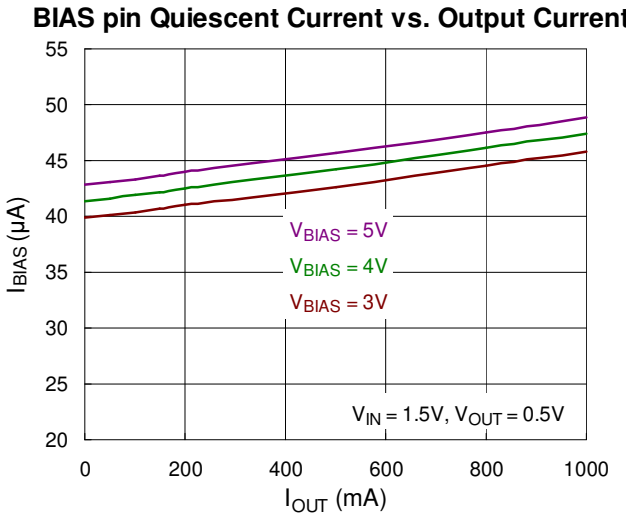
(4) Note 4 for guaranteed by design.

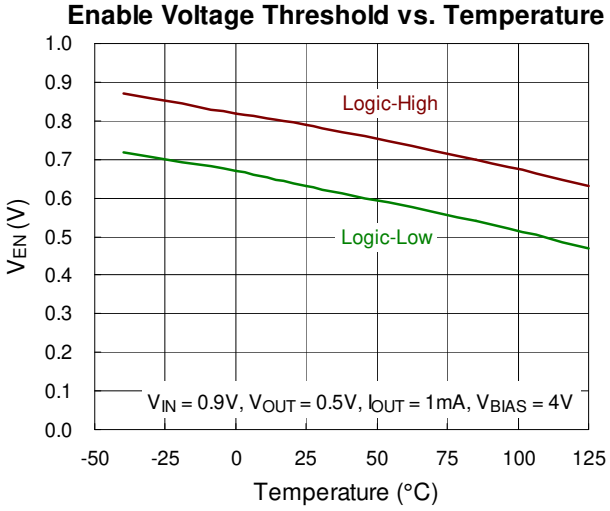
3 Typical Operating Characteristics

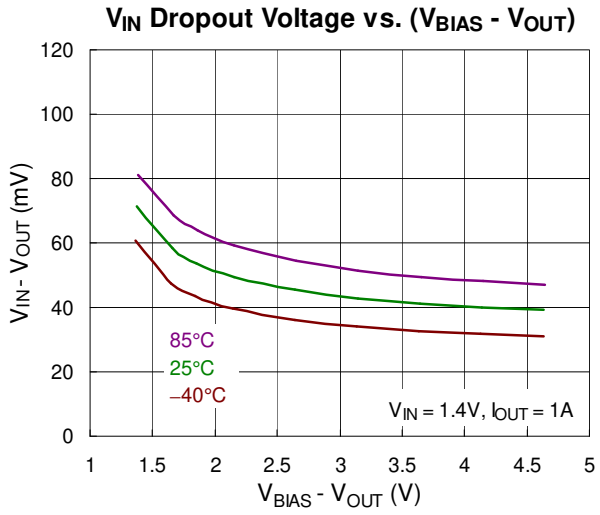
3.1 Typical Operating Characteristics

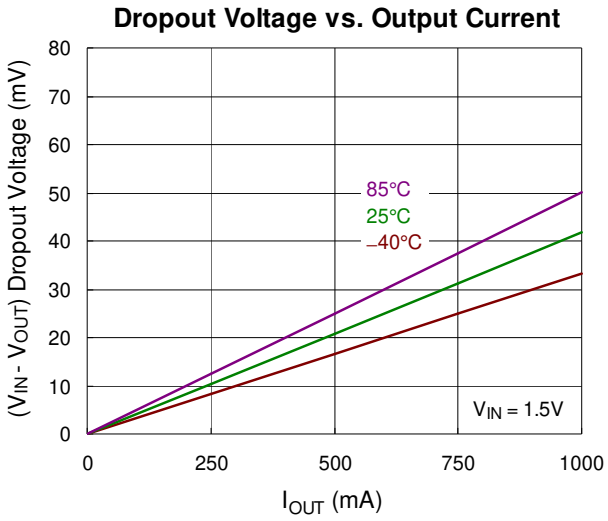


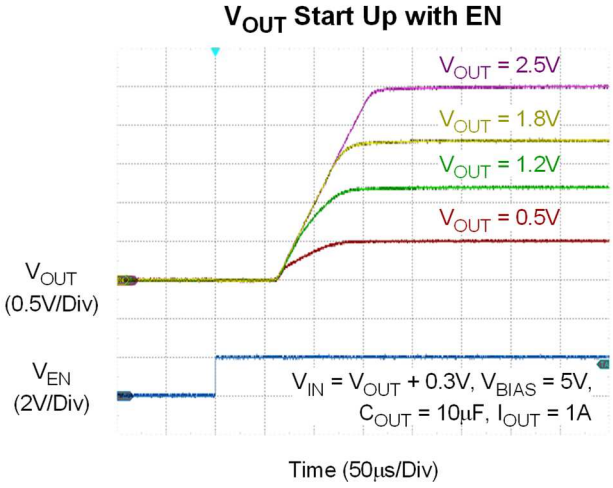


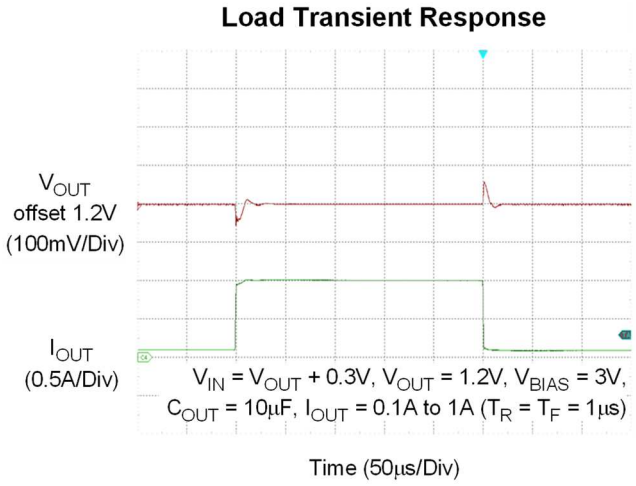












4 Application Information

4.1 General Descriptions

The MT6680 is a low voltage, low dropout linear regulator with input voltage V_{IN} from 0.8V to 5.5V, V_{BIAS} from 3V to 5.5V and adjusted output voltage from 0.5V to (V_{IN} - V_{DROP}). Keep V_{EN} < V_{BIAS} + 0.5V to prevent malfunction.

4.2 Output Voltage Setting

For the MT6680, the voltage on the ADJ pin sets the output voltage and is determined by the values of R1 and R2. The values of R1 and R2 can be calculated for any voltage using the formula given in equation :

$$V_{OUT} = 0.5V \times \left(\frac{R1 + R2}{R2} \right)$$

Using lower values for R1 and R2 is recommended to reduce the noise injected from the ADJ pin. Note that R1 is connected from V_{OUT} pin to ADJ pin, and R2 is connected from ADJ to GND.

4.3 Dropout Voltage

There are two power supply inputs V_{IN} and V_{BIAS} and only one output V_{OUT} for the MT6680, the dropout voltage with these two different input also have different definition. V_{IN} dropout voltage is the voltage difference between V_{IN} and V_{OUT} when V_{OUT} starts to decrease while reduce V_{IN} level (for this condition, V_{BIAS} needs high enough as specific value published in Electrical Characteristics table). V_{BIAS} dropout voltage is the voltage difference between V_{BIAS} and V_{OUT} while V_{IN} and BIAS pins are connected together and V_{OUT} starts to decrease.

4.4 C_{IN} and C_{OUT} Selection

The MT6680 is designed specifically to work with low ESR ceramic output capacitor for space saving and performance consideration. Using a ceramic capacitor with effective capacitance range from 4.7µF to 22µF on the MT6680 output ensures stability. The input capacitor must be located at a distance of no more than 0.5 inch from the input pin of the chip. However, a capacitor with larger value and lower ESR (Equivalent Series Resistance) is recommended since it will provide better PSRR and line transient response. Any good quality ceramic capacitor can be used, C_{IN} = 4.7µF and C_{BIAS} = 0.1µF or greater are recommended.

4.5 Chip Enable Operation

The MT6680 goes into sleep mode when the EN pin is in a logic low condition. In this condition, the pass transistor, error amplifier, and band gap are all turned off reducing the supply current to only 1µA (max.).

Consideration should be taken in the power on sequence, it is mandatory to ensure V_{BIAS} > V_{OUT} + 1.6V before both V_{EN} > V_{IH} and V_{IN} > V_{OUT} + 0.1V. The BIAS pin supplies voltage for the LDO control circuit, and powering up V_{BIAS} first will ensure turn on time (tON) and output voltage accuracy (V_{OUT}) to follow datasheet spec.

Figure 4-1 also shows the use of an RC-delay circuit that hold off V_{EN} until V_{BIAS} has ramped up to target value. This technique can also be used to drive EN from V_{IN}. An external control signal can also be used to enable the device after V_{IN} and V_{BIAS} are present.

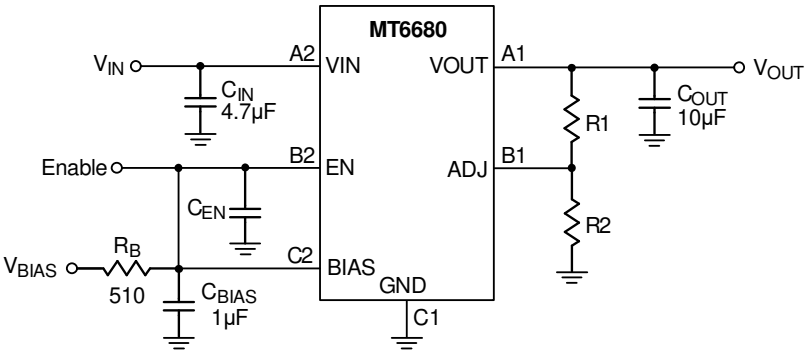


Figure 4-1. Soft-start delay using an RC circuit to enable the device

4.6 Current Limit

The MT6680 continuously monitors the output current to protect the pass transistor against abnormal operations. When an overload or short circuit is encountered, the current limit circuitry controls the pass transistor's gate voltage to limit the output within the predefined range.

4.7 Thermal Considerations

The junction temperature should never exceed the absolute maximum junction temperature $T_{J(MAX)}$, listed under Absolute Maximum Ratings, to avoid permanent damage to the device. The maximum allowable power dissipation depends on the thermal resistance of the IC package, the PCB layout, the rate of surrounding airflow, and the difference between the junction and ambient temperatures. The maximum power dissipation can be calculated using the following formula :

$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$

Where $T_{J(MAX)}$ is the maximum junction temperature, T_A is the ambient temperature, and θ_{JA} is the junction-to-ambient thermal resistance.

For continuous operation, the maximum operating junction temperature indicated under Recommended Operating Conditions is 125°C. The junction-to-ambient thermal resistance, θ_{JA}, is highly package dependent. For a WL-CSP-6B 0.8x1.2 (BSC) package, the thermal resistance, θ_{JA}, is 148°C/W on a standard JEDEC 51-7 high effective-thermal-conductivity four-layer test board. The maximum power dissipation at T_A = 25°C can be calculated as below :

$P_{D(MAX)}$ = (125°C – 25°C) / (148°C /W) = 0.67W for a WL-CSP-6B 0.8x1.2 (BSC) package.

The maximum power dissipation depends on the operating ambient temperature for the fixed $T_{J(MAX)}$ and the thermal resistance, θ_{JA}. The derating curves in Figure 4-2 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

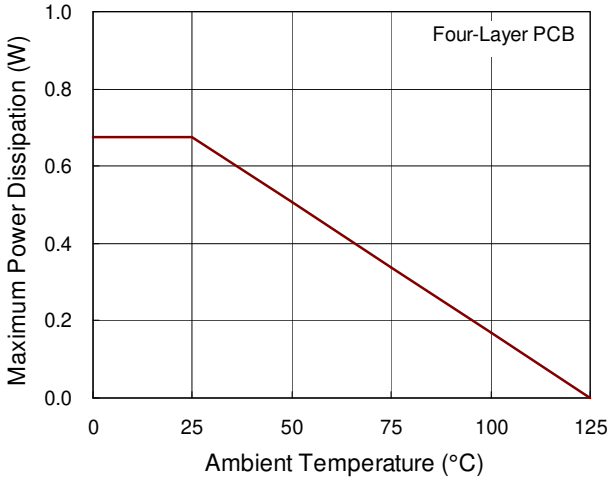


Figure 4-2. Derating curve of maximum power dissipation

5 Functional Descriptions

5.1 General Descriptions

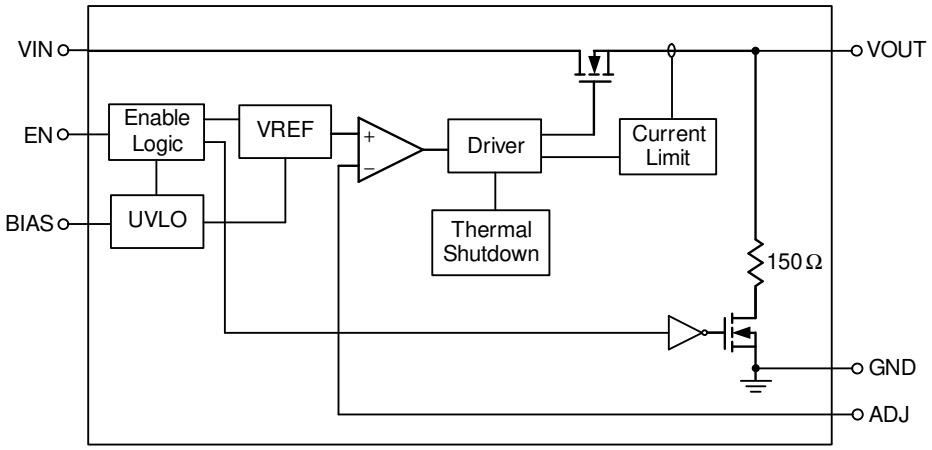


Figure 5-1. MT6680 functional block diagram

6 Operation

6.1 General Descriptions

The MT6680 uses N-MOSFET pass transistor for output voltage regulation from V_{IN} voltage. The separated bias voltage (V_{BIAS}) power the low current internal control circuit for applications requiring low input voltage and ultra low dropout voltage.

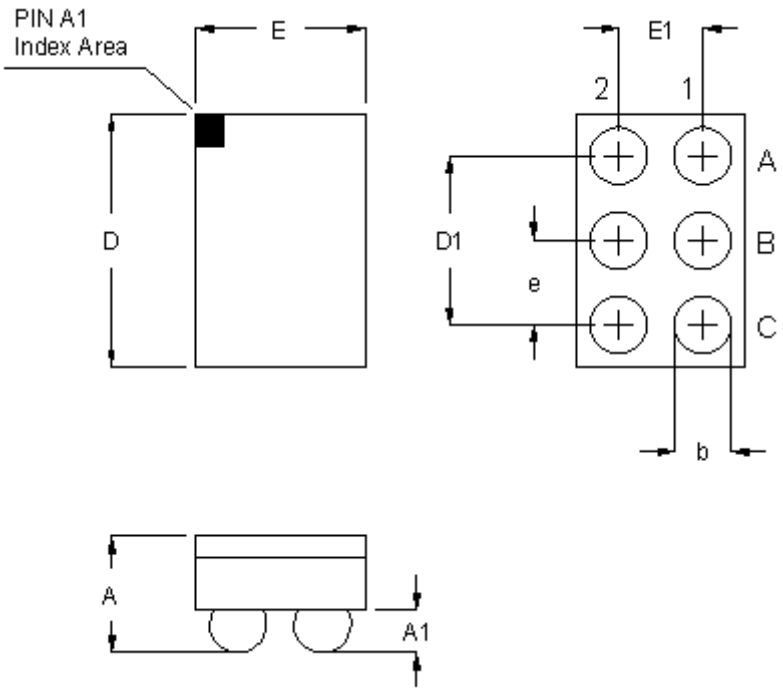
In steady-state operation, the feedback voltage is regulated to the reference voltage by the internal regulator. When the feedback voltage signal is less than the reference, the output current passes through the power MOSFET will be increased. The extra amount of the current is sent to the output until the voltage level of ADJ pin returns to the reference. On the other hand, if the feedback voltage is higher than the reference, the power MOSFET current is decreased. The excess charge at the output can be released by the loading current.

6.2 Over-Temperature Protection (OTP)

The MT6680 has an over-temperature protection. When the device triggers the OTP, the device shuts down until the temperature back to normal state.

7 MT6680 Packaging

7.1 Outline Dimensions



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.500	0.600	0.020	0.024
A1	0.170	0.230	0.007	0.009
b	0.240	0.300	0.009	0.012
D	1.160	1.240	0.046	0.049
D1	0.800		0.031	
E	0.760	0.840	0.030	0.033
E1	0.400		0.016	
e	0.400		0.016	

6B WL-CSP 0.8x1.2 (BSC)

Figure 7-1. MT6680 Package dimension

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