

## Description

The GM66500 series is 5.0A low-dropout linear voltage regulators that provide a low-voltage, high-current output with a minimum of external components.

The GM66500 series offers extremely low dropout (typically 400mV at 5.0A) and low ground current (typically 70mA at 5.0A).

The GM66500 series is ideal for PC add-in cards that need to convert from standard 3.0V to 2.5V and 2.5V to 1.8V, down to new, lower core voltages. A guaranteed maximum dropout voltage of 500mV over all operating conditions allows the GM66500 series to provide 2.5V from a supply as low as 3V. The GM66500 series also has fast transient response, for heavy switching applications. The device requires only 47 $\mu$ F of output capacitance to maintain stability and achieve fast transient response.

The GM66500 series is fully protected with overcurrent limiting, thermal shutdown, reversed-battery protection, reversed-lead insertion protection, and reversed-leakage protection.

The GM66501 series offers a TTL-logic-compatible enable pin and an error flag that indicates undervoltage and overcurrent conditions. Offered in a fixed voltages, 1.8V and 2.5V, the GM66500 series comes in the TO-220 and TO-263 packages and is an ideal upgrade to older, NPN-based linear voltage regulators.

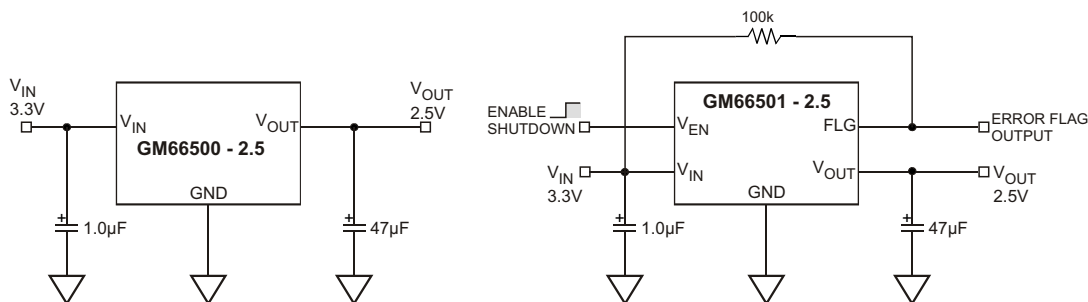
## Features

- ◆ 5.0A minimum guaranteed output current
- ◆ 400mV dropout voltage
  - Designed for 3.0V to 2.5V conversion
  - Designed for 2.5V to 1.8V conversion
- ◆ 1% initial accuracy
- ◆ Low ground current
- ◆ Current limiting and Thermal shutdown
- ◆ Reversed-battery and reversed-lead insertion protection
- ◆ Reversed-leakage protection
- ◆ Fast transient response
- ◆ TO-220 and TO-263 packages
- ◆ TTL/CMOS compatible enable pin (GM66501 only)
- ◆ Error flag output (GM66501 only)
- ◆ Ceramic capacitor stable (See Application Information)

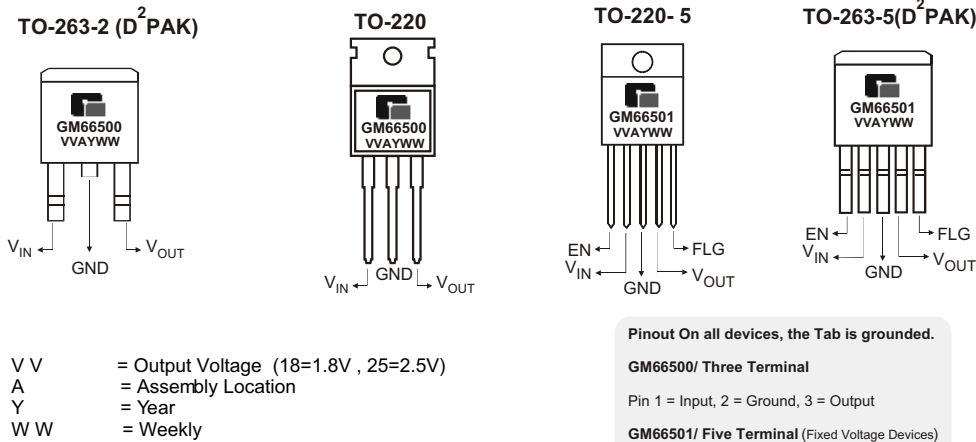
## Application

Low Voltage Digital ICs  
 LDO linear regulator for PC add-in cards  
 High-efficiency linear power supplies  
 SMPS post regulator  
 Multimedia and PC processor supplies  
 Low-voltage microcontrollers  
 Strong ARM™ processor supply

## TYPICAL APPLICATION CIRCUITS



#### ◆ MARKING INFORMATION & PIN CONFIGURATIONS (TOP VIEW)



#### ◆ ORDERING INFORMATION

ORDERING NUMBER	OUTPUT VOLTAGE	PACKAGE	SHIPPING
<b>GM66500</b>			
GM66500-1.8TA3T	1.8V	TO-263-2	50 Units/ Tube
GM66500-1.8TA3R	1.8V	TO-263-2	800 Units/ Tape & Reel
GM66500-1.8TB3T	1.8V	TO-220	50 Units/ Tube
GM66500-2.5TA3T	2.5V	TO-263-2	50 Units/ Tube
GM66500-2.5TA3R	2.5V	TO-263-2	800 Units/ Tape & Reel
GM66500-2.5TB3T	2.5V	TO-220	50 Units/ Tube
GM66500-3.3TA3T	3.3V	TO-263-2	50 Units/ Tube
GM66500-3.3TA3R	3.3V	TO-263-2	800 Units/ Tape & Reel
GM66500-3.3TB3T	3.3V	TO-220	50 Units/ Tube
GM66500-5.0TA3T	5.0V	TO-263-2	50 Units/ Tube
GM66500-5.0TA3R	5.0V	TO-263-2	800 Units/ Tape & Reel
GM66500-5.0TB3T	5.0V	TO-220	50 Units/ Tube
<b>GM66501</b>			
GM66501-1.8TA5T	1.8V	TO-263-5	50 Units/ Tube
GM66501-1.8TA5R	1.8V	TO-263-5	800 Units/ Tape & Reel
GM66501-1.8TB5T	1.8V	TO-220-5	50 Units/ Tube
GM66501-2.5TA5T	2.5V	TO-263-5	50 Units/ Tube
GM66501-2.5TA5R	2.5V	TO-263-5	800 Units/ Tape & Reel
GM66501-2.5TB5T	2.5V	TO-220-5	50 Units/ Tube

\* For detail Ordering Number identification, please see last page.

#### ◆ PIN DESCRIPTION

PIN number GM66500	PIN Number GM66501	PIN Name	PIN Function
	1	$V_{EN}$	Enable (Input): TTL/CMOS compatible input. Logic high=enable; logic low or open=shutdown.
1	2	$V_{IN}$	Unregulated Input: +16V maximum supply.
2, TAB	3, TAB	GND	Ground: Ground pin and TAB are internally connected.
3	4	$V_{OUT}$	Regulator Output.
	5	FLG	Error Flag (Output): Open collector output. Active low indicates an output fault condition.

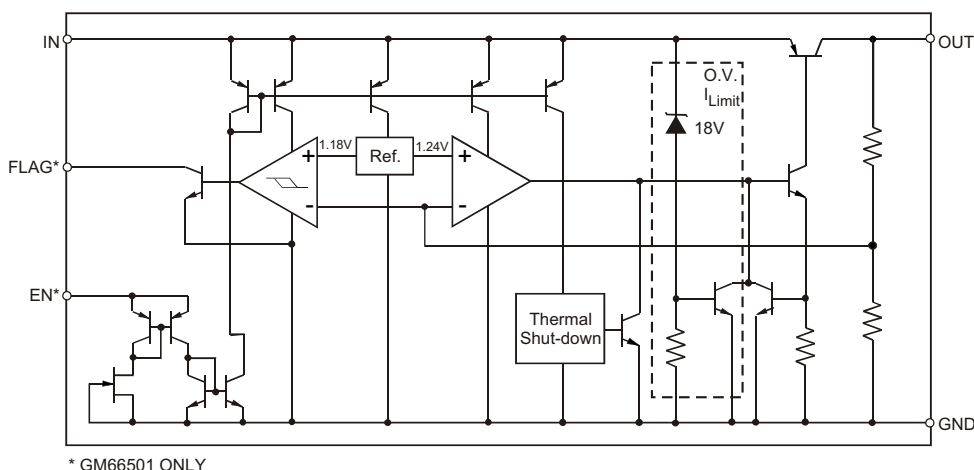
#### ◆ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Value	Unit
Power Dissipation	$P_D$	Internally limited	W
Input Supply Voltage (Note 1)	$V_{IN}$	-20 to +20	V
Lead Temperature (Soldering, 5 sec)	$T_{LEAD}$	260	°C
Storage Temperature Range	$T_{STG}$	-65 to +150	°C
EDS, Note 3			

#### ◆ OPERATING RATINGS

Parameter	Symbol	Value	Unit
Supply Voltage	$V_{IN}$	+ 2.25 to +16	V
Enable Voltage	$V_{EN}$	+16	V
Operating junction Temperature Range	$T_J$	-40 to +125	°C
Thermal Resistance (TO-263-2 ,TO-220)	$J_C$	2.0	°C/W
Maximum Power Dissipation, Note 4			

#### ◆ BLOCK DIAGRAM



#### ◆ ELECTRICAL CHARACTERISTICS

$T_J = 25^\circ\text{C}$ , **bold** values indicate  $-40^\circ\text{C} \leq T_J \leq +125^\circ\text{C}$ ; unless noted

Parameter	Conditions	Min	Typ	Max	Unit
Output Voltage	$I_O = 10\text{ mA}$	-1		1	%
	$10\text{mA} \leq I_{OUT} \leq 5\text{A}$ , $V_{OUT} + 1.0\text{V} \leq V_{IN} \leq 16\text{V}$	-2		2	%
Line Regulation	$I_{OUT} = 10\text{mA}$ , $V_{OUT} + 1.0\text{V} \leq V_{IN} \leq 16\text{V}$		0.06	0.5	%
Load Regulation	$V_{IN} = V_{OUT} + 1.0\text{V}$ , $10\text{mA} \leq I_{OUT} \leq 5\text{A}$		0.20	1.0	%
Output Voltage change with Temperature Coef. <b>Note 5</b>	$V_{OUT} / T$		20	100	ppm/ $^\circ\text{C}$
Dropout Voltage <b>Note 6</b>	$V_{OUT} = -2\%$ (Note 3) $I_{OUT} = 250\text{mA}$ $I_{OUT} = 2.5\text{A}$ $I_{OUT} = 5\text{A}$		125 320 400	250 575	mV
Ground Current <b>Note 7</b>	$I_{OUT} = 2.5\text{A}$ , $V_{IN} = V_{OUT} + 0.8\text{V}$ $I_{OUT} = 5\text{A}$ , $V_{IN} = V_{OUT} + 0.8\text{V}$ Characterize		15 70		mA
Ground Pin Current at Dropout $I_{GNDDO}$	$V_{IN} \leq V_{OUT(nominal)} - 0.5\text{V}$ , $I_{OUT} = 10\text{mA}$		2.1		mA
Current Limit	$V_{OUT} = 0\text{V}$ , $V_{IN} = V_{OUT} + 1.0\text{V}$ (Note 4)		7.5		A
Output Noise Voltage	$C_{OUT} = 47\mu\text{F}$ , $I_{OUT} = 100\text{mA}$ , 10Hz to 100kHz		260		$\mu\text{V}$ (rms)
<b>Enable Input (GM66501)</b>					
Enable Input Voltage	Logic Low (off)			0.8	V
	Logic high (on)	2.25			V
Enable Input Current	$V_{EN} = V_{IN}$		30	35 75	$\mu\text{A}$
	$V_{EN} = 0.8\text{V}$			2 4	$\mu\text{A}$
Shutdown Output Current	(Note 8)		10		$\mu\text{A}$
<b>Flag Output (GM66501)</b>					
Output Leakage Current	$V_{OH} = 16\text{V}$		0.01	1 2	$\mu\text{A}$
Output Low Voltage	$V_{IN} = 2.25\text{V}$ , $I_{OL} = 250\mu\text{A}$ (Note 9)		220	300 400	mV
Low Threshold	1% of $V_{OUT}$	93			%
High Threshold	1% of $V_{OUT}$			99.2	%
Hysteresis			1		%

**Note 1.** Exceeding the absolute maximum ratings may damage the device.

**Note 2.** The device is not guaranteed to function outside its operating rating.

**Note 3.** Devices are ESD sensitive. Handling precautions recommended.

**Note 4.**  $P_{D(max)} = (T_{J(max)} - T_A) \cdot J_A$ , where  $J_A$  depends upon the printed circuit layout. See "Applications Information".

**Note 5.** Output voltage temperature coefficient is  $V_{OUT(worst\ case)} + (T_{J(max)} - T_{J(min)})$  where  $T_{J(max)}$  is  $+125^\circ\text{C}$  and  $T_{J(min)}$  is  $-40^\circ\text{C}$ .

**Note 6.**  $V_{DO} = V_{IN} - V_{OUT}$  when  $V_{OUT}$  decreases to 98% of its nominal output voltage with  $V_{IN} = V_{OUT} + 1\text{V}$ . For voltages below 2.25V, dropout voltage is the input-to-output voltage differential with the minimum input voltage being 2.25V. Minimum input operating voltage is 2.25V.

**Note 7.**  $I_{GND}$  is the quiescent current.  $I_{IN} = I_{GND} + I_{OUT}$

**Note 8.**  $V_{EN} \leq 0.8\text{V}$ ,  $V_{IN} \leq 8\text{V}$ , and  $V_{OUT} = 0\text{V}$

**Note 9.** For a 2.5V device,  $V_{IN} = 2.25\text{V}$  (device is in dropout).

**Note 10.** Design with proper heat sink to dissipate heat to keep chip from thermal protection when  $V_{IN} - V_{OUT} > 0.6\text{V}$

#### ◆ TYPICAL CHARACTERISTICS

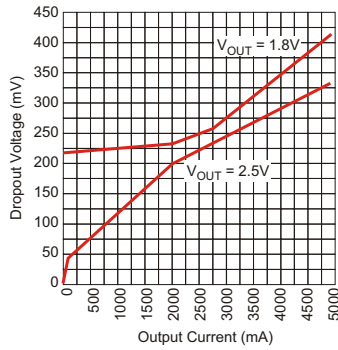


Figure 1. Dropout Voltage vs. Output Current

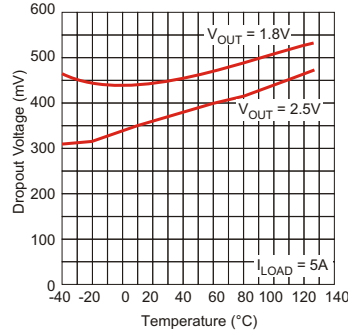


Figure 2. Dropout Voltage vs. Temperature

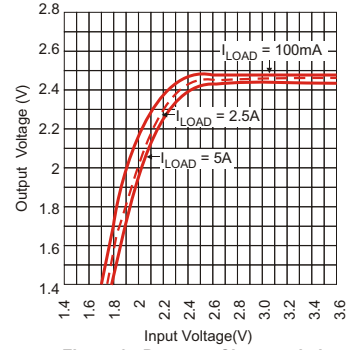


Figure 3. Dropout Characteristics

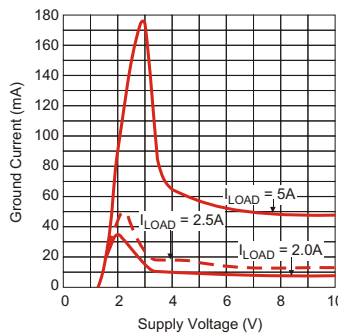


Figure 4. Ground Current vs. Supply Voltage

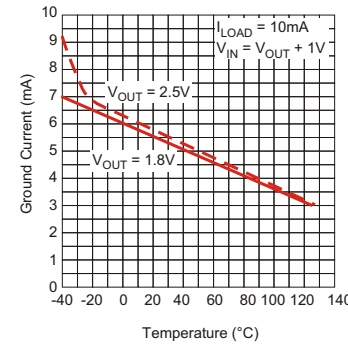


Figure 5. Ground Current vs. Temperature

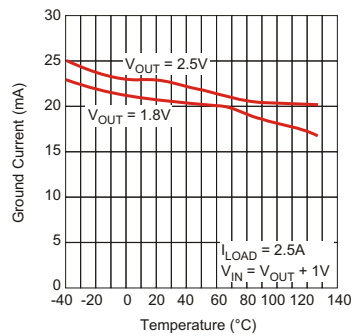


Figure 6. Ground Current vs. Temperature

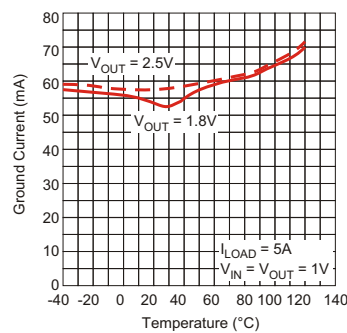


Figure 7. Ground Current vs. Temperature

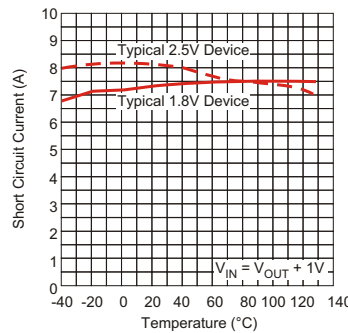


Figure 8. Short Circuit Current vs. Temperature

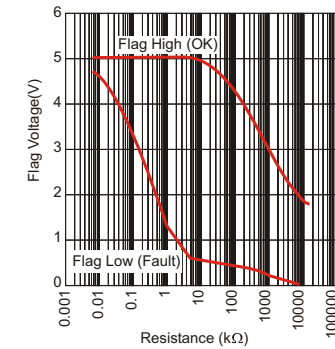


Figure 9. Error Flag Pull-up Resistor

#### ◆ APPLICATION INFORMATION

The GM66500 series is a high-performance low-dropout voltage regulator, suitable for moderate to high-current voltage regulator applications. Its 400mV dropout voltage at full load makes it especially valuable in battery-powered systems and as a high-efficiency noise filter in post-regulator applications.

Unlike older NPN-pass transistor designs, where the minimum dropout voltage is limited by the base-to-emitter voltage drop and collector-to-emitter saturation voltage, dropout performance of the PNP output of these devices is limited only by the low  $V_{CE}$  saturation Voltage.

The GM66500 series regulator is fully protected from damage due to fault conditions. Current limiting is provided. This limiting is linear, output current during overload conditions is constant. Thermal shutdown disables the device when the die temperature exceeds the maximum safe operating temperature. Transient protection allows device (and load) survival even when the input voltage spikes above and below nominal. The output structure of these regulators allows voltages in excess of the desired output voltage to be applied without reverse current flow.

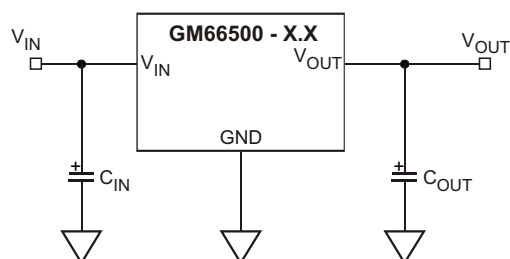


Figure 10. Capacitor Requirements

#### Thermal Design

Linear regulators are simple to use. The most complicated design parameters to consider are thermal characteristics.

Thermal design requires four application-specific parameters:

- Maximum ambient temperature ( $T_A$ )
- Output Current ( $I_{OUT}$ )
- Output Voltage ( $V_{OUT}$ )
- Input Voltage ( $V_{IN}$ )
- Ground Current ( $I_{GND}$ )

Calculate the power dissipation of the regulator from these numbers and the device parameters from this datasheet, where the ground current is taken from data sheet

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

The heat sink thermal resistance is determined by:

$$\theta_{JA} = \frac{T_{J(MAX)} - T_A}{P_D} - (\theta_{JC} + \theta_{CS})$$

where  $T_{J(max)} \leq 125^\circ\text{C}$  and  $\theta_{CS}$  is between  $0^\circ\text{C}$  and  $2^\circ\text{C/W}$ .

The heat sink may be significantly reduced in applications where the minimum input voltage is known and is large compared with the dropout voltage. Use a series input resistor to drop excessive voltage, and distribute the heat between this resistor and the regulator. The low dropout properties of Super eta PNP regulators allow significant reductions in regulator power dissipation and the associated heat sink without compromising performance. When this technique is employed, a capacitor of at least 1.0 $\mu\text{F}$  is needed directly between the input and regulator ground.

#### Output Capacitor

The GM66500 series requires an output capacitor to maintain stability and improve transient response. Proper capacitor selection is important to ensure proper operation. The GM66500 series output capacitor selection is dependent upon the ESR (equivalent series resistance) of the output capacitor to maintain stability. When the output capacitor is 47 $\mu\text{F}$  or greater, the output capacitor should have less than 1  $\Omega$  of ESR. This will improve transient response as well as promote stability. Ultra-low-ESR capacitors, such as ceramic chip capacitors may promote instability. These very low ESR levels may cause an oscillation and/or underdamped transient response. When larger capacitors are used, the ESR requirement approaches zero. A 100 $\mu\text{F}$  ceramic capacitor can be used on the output while maintaining stability. A low-ESR 47 $\mu\text{F}$  solid tantalum capacitor works extremely well and provides good transient response and stability over temperature.

Aluminum electrolytics can also be used, as long as the ESR of the capacitor is  $\leq 1 \Omega$ .

The value of the output capacitor can be increased without limit. Higher capacitance values help to improve transient response, ripple rejection, and reduce output noise.

**Input Capacitor**

An input capacitor of 1 $\mu$ F or greater is recommended when the device is more than 4 inches away from the bulk as supply capacitance, or when the supply is a battery. Small surface mount ceramic chip capacitors can be used for the bypassing. Larger values will help to improve ripple rejection by bypassing the input to the regulator, further improving the integrity of the output voltage.

**Transient Response and 3.3V to 2.5V and 2.5V to 1.8V Conversions**

The GM66500 series has excellent transient response to variations in input voltage and load current. The device has been designed to respond quickly to load current variations and input voltage variations. Large output capacitors are not required to obtain this performance. A standard 47 $\mu$ F output capacitor, preferably tantalum, is all that is required. Larger values improve performance even further.

By virtue of its low-dropout voltage, this device does not saturate into dropout as readily as similar NPN-based designs. When converting from 3.3V to 2.5V or 2.5V to 1.8V, the NPN-based regulators are already operating in dropout, with typical dropout requirements of 1.2V or greater. To convert down to 2.5V without operating in dropout, NPN-based regulators require an input voltage of 3.7V at the very least.

The GM66500 series regulator will provides excellent performance with an input as low as 3.0V or 2.5V respectively. This gives the PNP-based regulators a distinct advantage over older, NPN-based linear regulators. A typical NPN regulator does not have the headroom to do this conversion.

**Minimum Load Current**

The GM66500 series regulator is specified between finite loads. If the output current is too small, leakage currents dominate and the output voltage rises. A 10mA minimum load current is necessary for proper regulation.

**Error Flag**

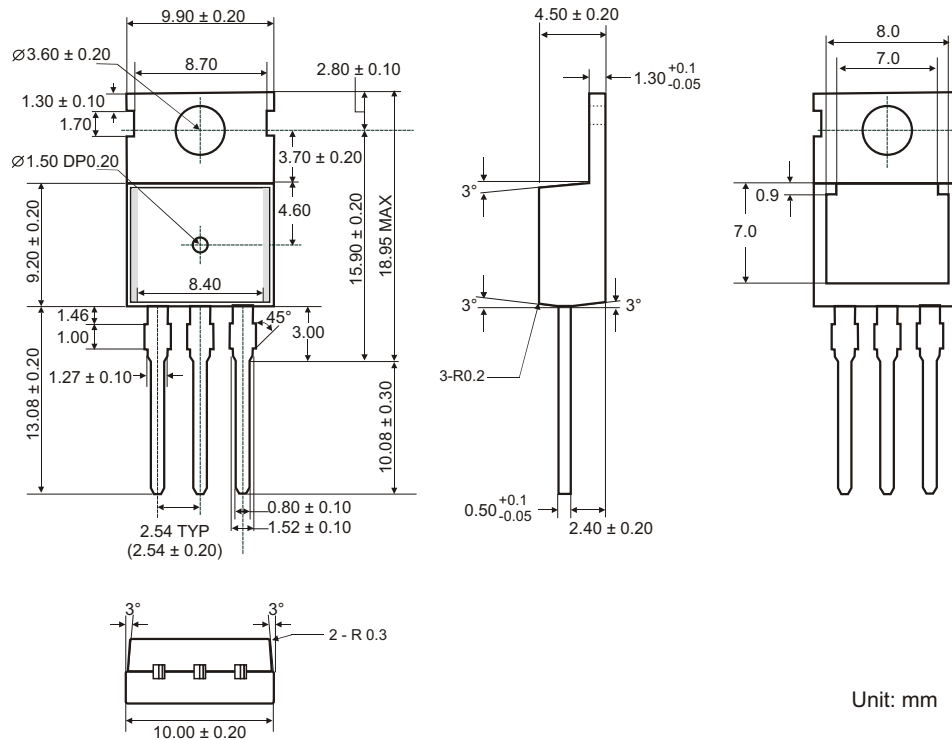
The GM66500 series version features an error flag circuit which monitors the output voltage and signals an error condition when the voltage 5% below the nominal output voltage.

The error flag is an open-collector output that can sink 10mA during a fault condition. Low output voltage can be caused by a number of problems, including an overcurrent fault (device in current limit) or low input voltage. The flag is inoperative during overtemperature shutdown. When the error flag is not used, it is best to leave it open. The flag pin can be tied directly to pin 4, the output pin.

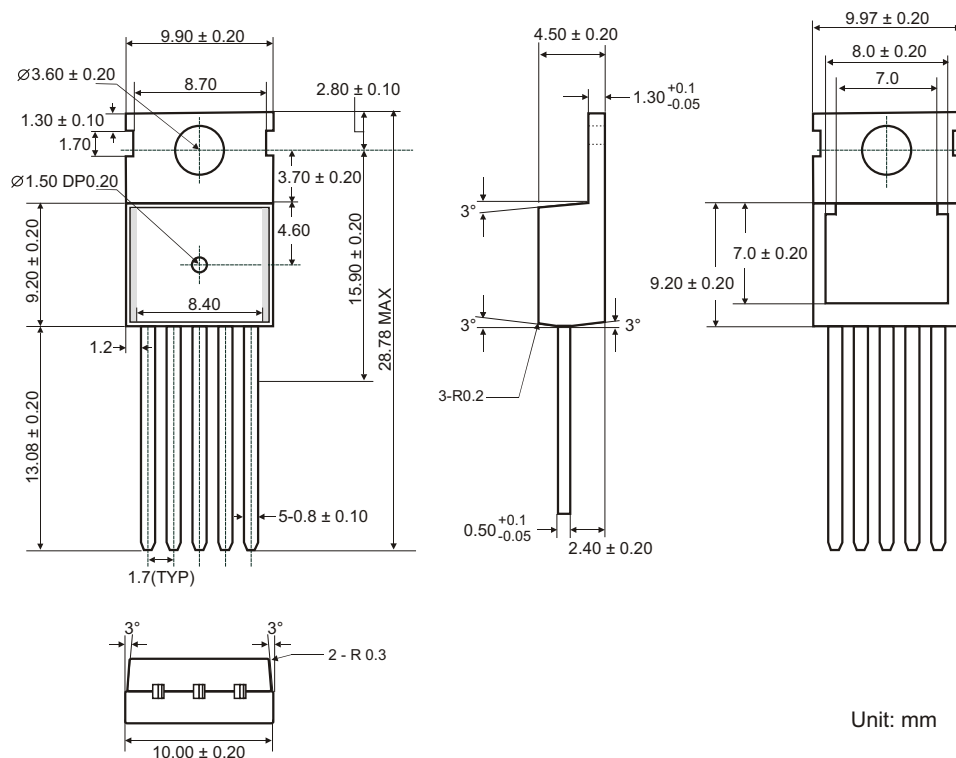
**Enable Input**

The GM66500 series version features an enable input for on/off control of the device. Its shutdown state draws "zero" current. The enable input is TTL/CMOS compatible for simple logic interface, but can be connected to up to 20V. When enabled, it draws approximately 15 $\mu$ A.

◆ TO-220 PACKAGE OUTLINE DIMENSIONS

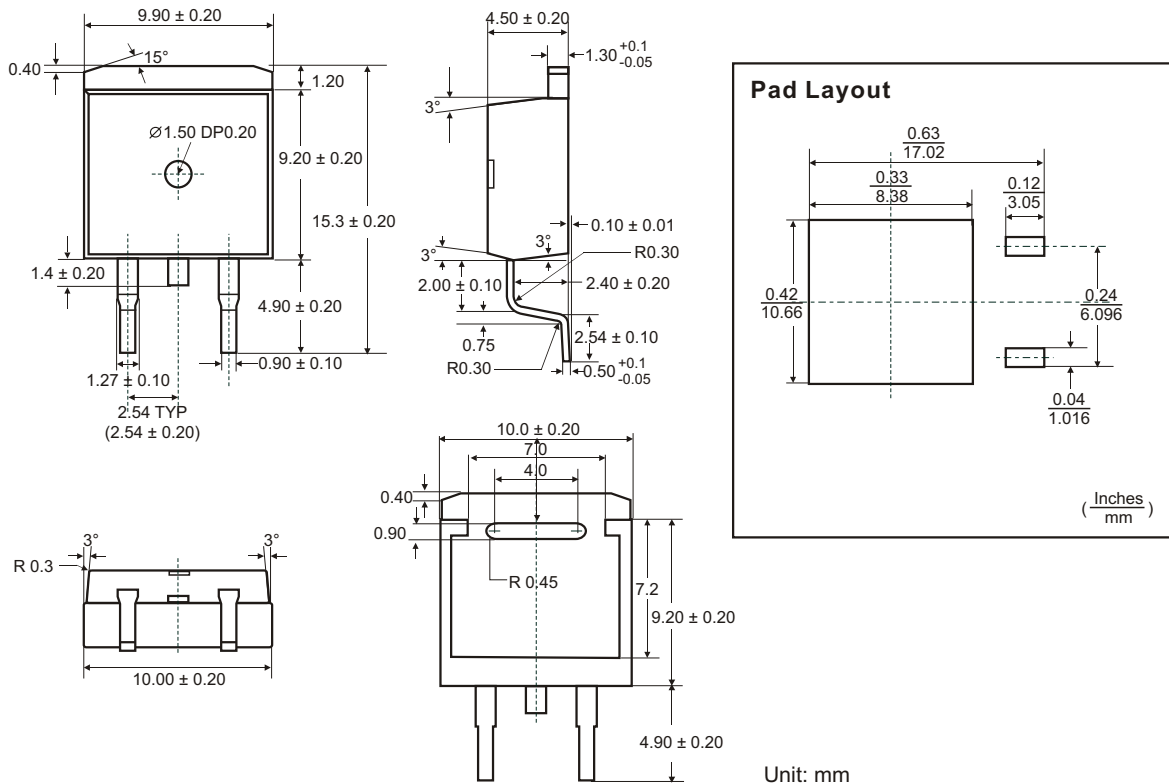


◆ TO-220-5 PACKAGE OUTLINE DIMENSIONS

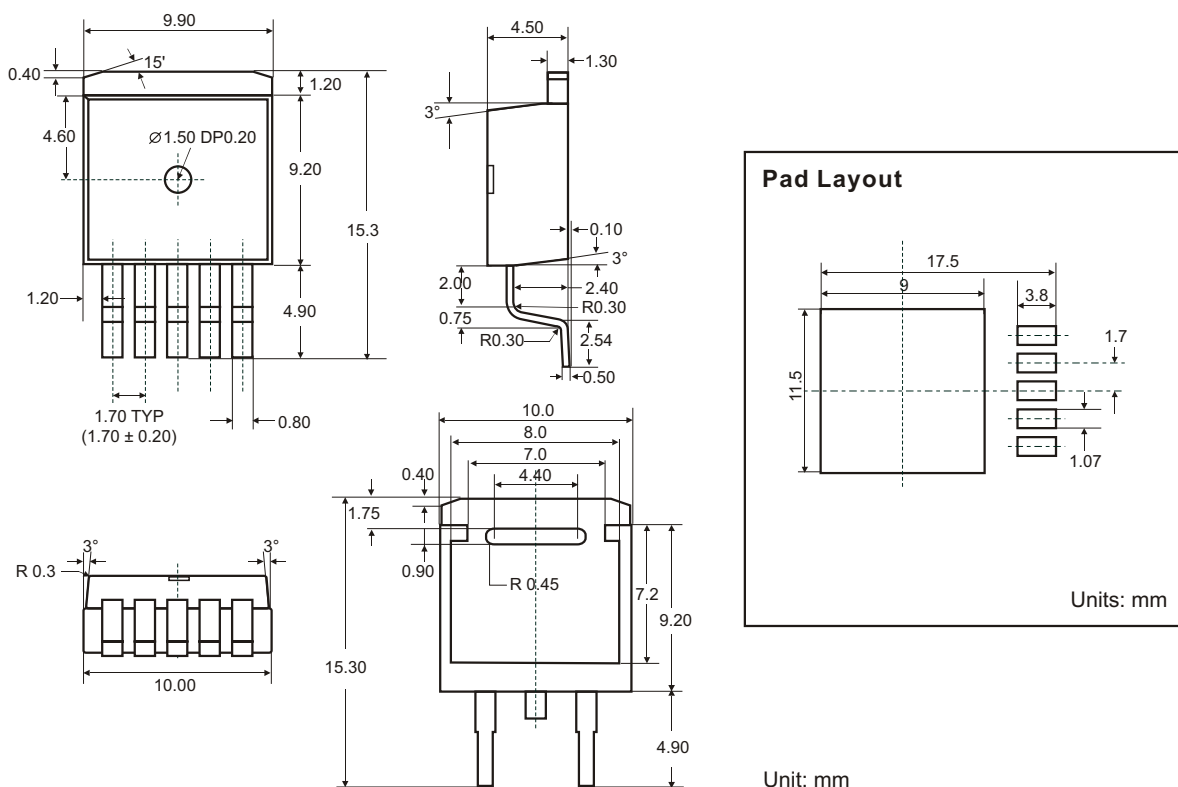




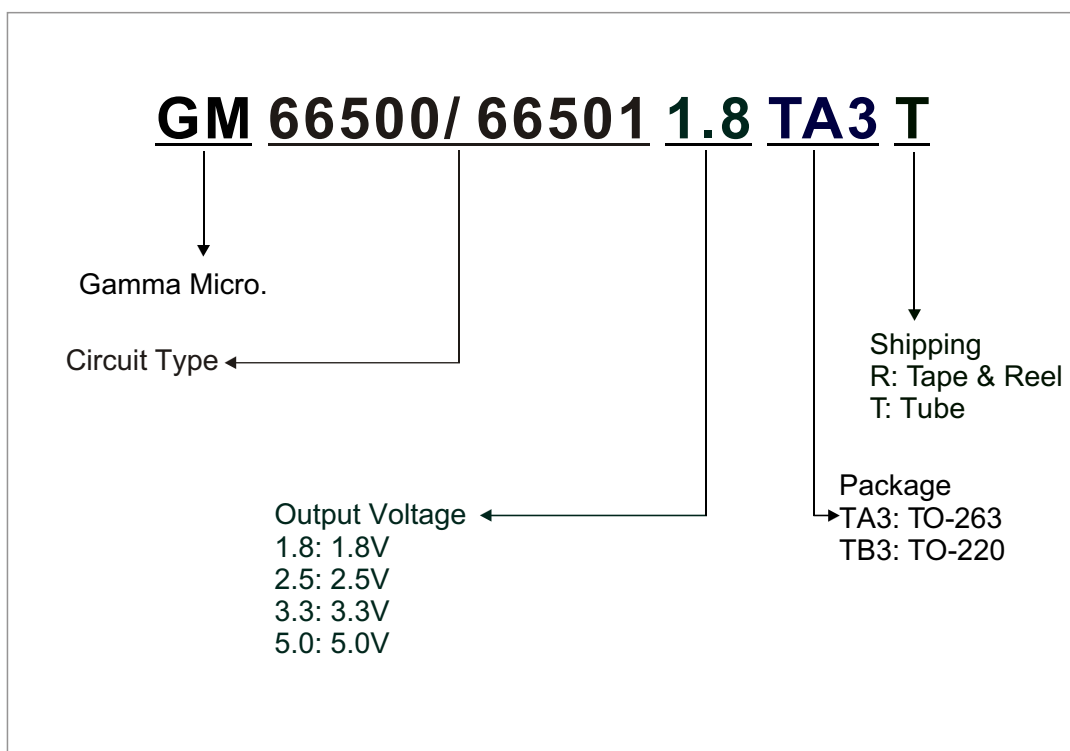
#### ◆ TO-263-2 PACKAGE OUTLINE DIMENSIONS





#### ◆ TO-263-5 PACKAGE OUTLINE DIMENSIONS



## ◆ ORDERING NUMBER



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