GM66500 Series

5A ULTRA LOW DROPOUT VOLTAGE REGULATORS

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 47µF of output capacitance to maintain stability and achieve fast transient response.

The GM66500 series is fully protected with over current 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 under-voltage and over-current conditions. Offered in 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 earlier, NPN- based linear voltage regulators.

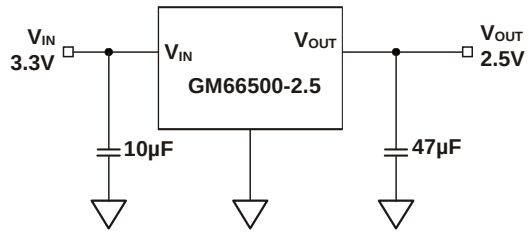
Features

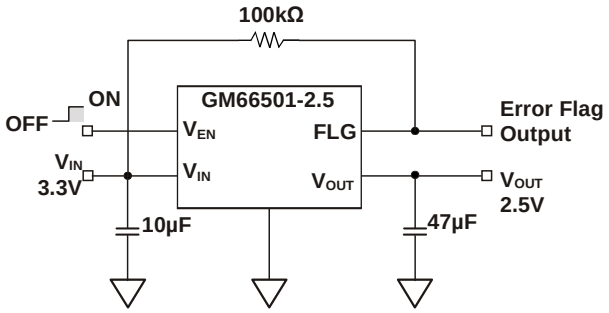
- **5A minimum guaranteed output current**
- **Ultra Low Dropout Voltage of 400mV, designed for 3.0V to 2.5V and 2.5V to 1.8V conversions**
- **1% Accurate Tolerance**
- **Fast Transient Response**
- **Reverse-battery and reverse lead insertion Protection**
- **TTL/CMOS compatible enable pin (GM66501 only)**
- **Error Flag output (GM66501 only)**

Application

- **Low Voltage Digital ICs**
- **LDO linear regulator for PC and add on cards**
- **High efficiency linear power suppliers**
- **SMPS post regulator**
- **Multimedia and PC processor suppliers**
- **Low voltage microprocessors**
- **Strong "ARM" processor supply**
- **SMPS post regulator**

Typical Application Circuits

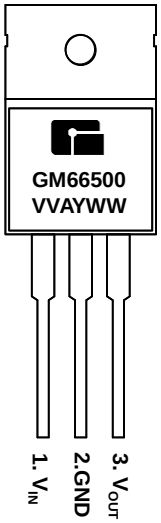




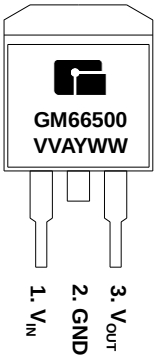
Marking Information and Pin Configurations (Top View)

GM66500 (Pb Free)

TO 220

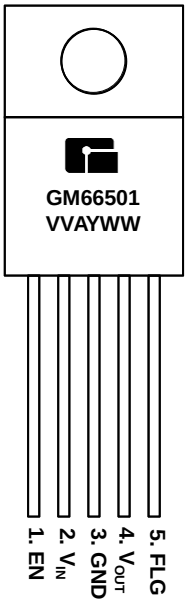


TO 263
(D^2-PAK)

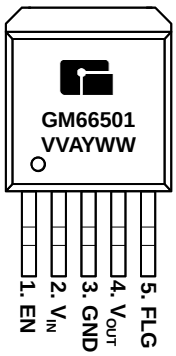


GM66501 (Pb Free)

5L-TO 220



5L-TO 263

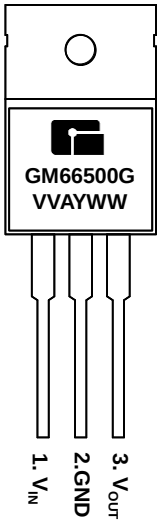


VV: Voltage suffix (15 = 1.5V, 50 = 5.0V…A = Adj)
A: Assembly / Test site code
Y: Year
WW: Week

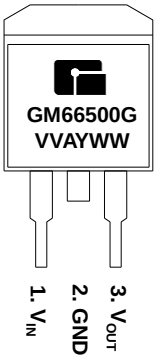
Marking Information and Pin Configurations (Top View)

GM66500 (Green Product)

TO 220

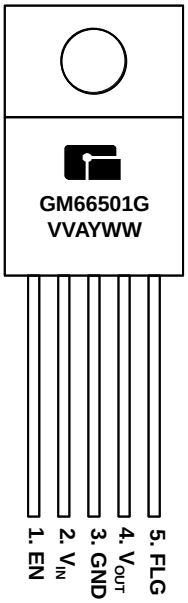


TO 263
(D^2-PAK)

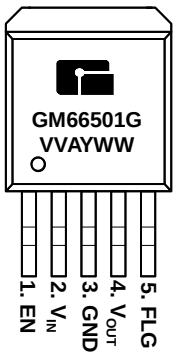


GM66501 (Green Product)

5L-TO 220



5L-TO 263



G: Green Product
VV: Voltage suffix (15 = 1.5V, 50 = 5.0V…A = Adj)
A: Assembly / Test site code
Y: Year
WW: Week

Ordering Information – Pb Free

Ordering Number	Output Voltage	Package	Shipping
GM66500			
GM66500-1.8TA3T	1.8V	TO-263	50 Units/Tube
GM66500-1.8TA3R	1.8V	TO-263	800 Units / Reel
GM66500-1.8TB3T	1.8V	TO-220	50 Units/Tube
GM66500-2.5TA3T	2.5V	TO-263	50 Units/Tube
GM66500-2.5TA3R	2.5V	TO-263	800 Units / Reel
GM66500-2.5TB3T	2.5V	TO-220	50 Units/Tube
GM66500-3.3TA3T	3.3V	TO-263	50 Units/Tube
GM66500-3.3TA3R	3.3V	TO-263	800 Units / Reel
GM66500-3.3TB3T	3.3V	TO-220	50 Units/Tube
GM66500-5.0TA3T	5.0V	TO-263	50 Units/Tube
GM66500-5.0TA3R	5.0V	TO-263	800 Units / Reel
GM66500-5.0TB3T	5.0V	TO-220	50 Units/Tube
GM66500-5.0ST3T	5.0V	SOT-223	80 Units/Tube
GM66500-5.0ST3R	5.0V	SOT-223	2,500 Units / Tape & Reel
GM66501			
GM66501-1.8TA5T	1.8V	TO-263-5	50 Units/Tube
GM66501-1.8TA5R	1.8V	TO-263-5	800 Units / 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 / Reel
GM66501-2.5TB5T	2.5V	TO-220-5	50 Units/Tube

Ordering Information – Green Product

Ordering Number	Output Voltage	Package	Shipping
GM66500			
GM66500-1.8TA3TG	1.8V	TO-263	50 Units/Tube
GM66500-1.8TA3RG	1.8V	TO-263	800 Units / Reel
GM66500-1.8TB3TG	1.8V	TO-220	50 Units/Tube
GM66500-2.5TA3TG	2.5V	TO-263	50 Units/Tube
GM66500-2.5TA3RG	2.5V	TO-263	800 Units / Reel
GM66500-2.5TB3TG	2.5V	TO-220	50 Units/Tube
GM66500-3.3TA3TG	3.3V	TO-263	50 Units/Tube
GM66500-3.3TA3RG	3.3V	TO-263	800 Units / Reel
GM66500-3.3TB3TG	3.3V	TO-220	50 Units/Tube
GM66500-5.0TA3TG	5.0V	TO-263	50 Units/Tube
GM66500-5.0TA3RG	5.0V	TO-263	800 Units / Reel
GM66500-5.0TB3TG	5.0V	TO-220	50 Units/Tube
GM66500-5.0ST3TG	5.0V	SOT-223	80 Units/Tube
GM66500-5.0ST3RG	5.0V	SOT-223	2,500 Units / Tape & Reel
GM66501			
GM66501-1.8TA5TG	1.8V	TO-263-5	50 Units/Tube
GM66501-1.8TA5RG	1.8V	TO-263-5	800 Units / Reel
GM66501-1.8TB5TG	1.8V	TO-220-5	50 Units/Tube
GM66501-2.5TA5TG	2.5V	TO-263-5	50 Units/Tube
GM66501-2.5TA5RG	2.5V	TO-263-5	800 Units / Reel
GM66501-2.5TB5TG	2.5V	TO-220-5	50 Units/Tube

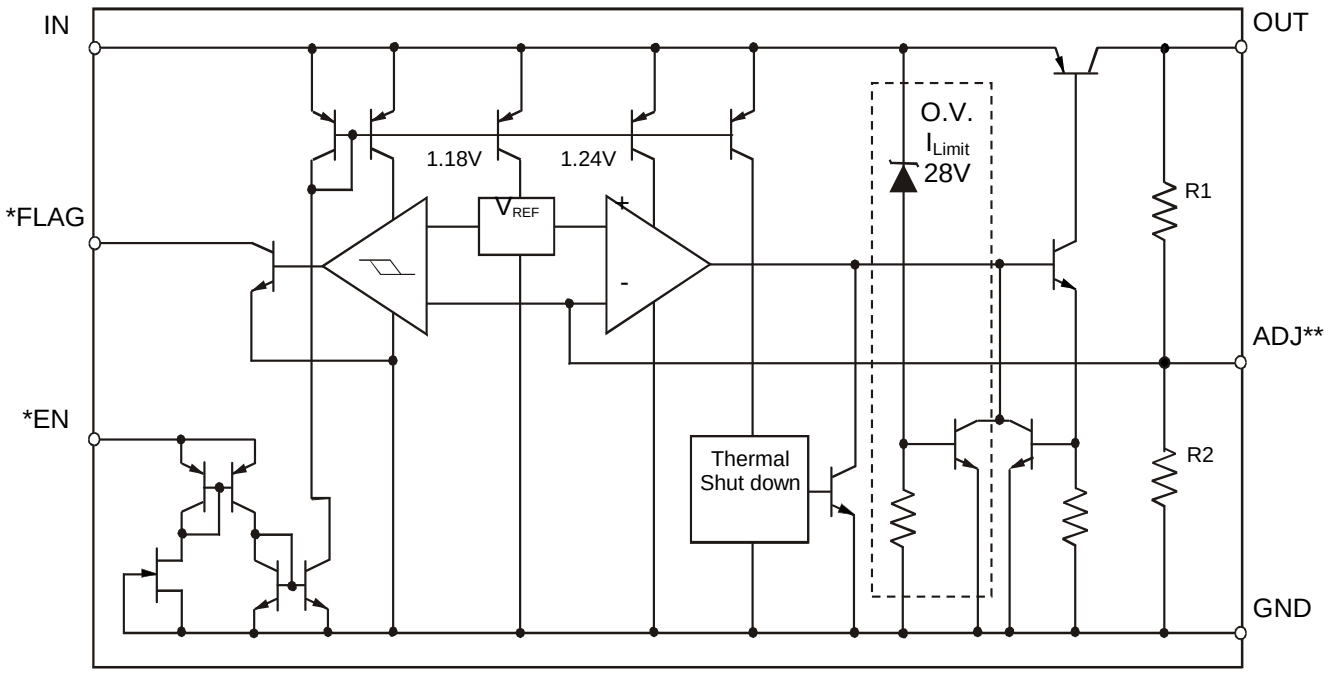
Absolute Maximum Ratings (Note 1)

Parameter	Symbol	Value	Unit
Power Dissipation	P_D	Internally Limited	W
Input Power Supply Voltage	V_{IN}	-20 to +20	V
Storage Temperature Range	T_{STG}	- 65 to 150	℃
Lead Temperature (Soldering, 5 sec)		+ 260	℃
ESD (Note 3)			

Operating Ratings (Note 2)

Parameter	Symbol	Value	Unit
Maximum Operating Input Voltage	V_{IN}	+2.25 to +16	V
Enable Voltage	VEN	+16	V
Operating Junction Temperature	T_J	-40 to +125	°C
Thermal Resistance (TO263, TO220)	θ_{JC}	2.0	°C/W

Block Diagram



* GM66501 only

Electrical Characteristics:

(Unless otherwise specified: T_J = 25°C, Bold values are guaranteed across the full operating temperature range.)

Parameter	Condition		Symbol	Min	Typ	Max	Unit
Output Voltage	I_O = 10mA		V_{OUT}	-1		1	%
	10mA ≤ I_O ≤ 5A, V_{OUT} + 1V ≤ V_{IN} ≤ 16V			**-2**		**2**	
Line Regulation	I_O = 10mA, V_{OUT} + 1V ≤ V_{IN} ≤ 16V		ΔV_{OI}		0.06	0.5	%
Load Regulation	V_{IN} = V_{OUT} + 1V, 10mA ≤ I_O ≤ 5A		ΔV_{OL}		0.2	1.0	%
Output Voltage Change with Temperature Coefficient (Note 5)	(Note 5)		$\Delta V_{OUT}/\Delta T$		20	100	ppm/℃
Dropout Voltage (Note 6)	ΔV_{OUT} = -2%	I_O = 250mA	V_{DO}		125	**250**	mV
		I_O = 2.5A			320		
		I_O = 5.0A			400	**575**	
Ground Current (Note 7)	I_O = 2.5A, V_{IN} = V_{OUT} +1.0V		I_{GND}		15		mA
	I_O = 5.0A, V_{IN} = V_{OUT} +1.0V				70		
Ground Pin Current at Dropout	V_{IN} = 0.5V less than specified V_{OUT}, I_O = 10mA		I_{GNDDO}		2.1		mA
Current Limit	V_{OUT} = 0V, V_{IN} = V_{OUT} +1.0V (Note 4)		I_{CL}		7.5		A
Output Noise Voltage	C_{OUT} = 47μF , 10Hz to 100kHz, I_L = 100mA		e_n		260		μV_{RMS}
Enable Input (GM66501)							
Enable Input Voltage	Logic Low (OFF)					**0.8**	V
	Logic High (ON)			**2.25**			
Enable Input Current	V_{EN} = V_{IN}		I_{ENH}		30	35	μA
						75	
	V_{EN} = 0.8V		I_{ENL}			**2**	
						4	
Shutdown Output Current	(Note 8)				10		μA
Flag Output (GM66501)							
Output Leakage Current	V_{OH} =16V				0.01	1	μA
						2	
Output Low Voltage	V_{IN} = 2.25V, I_{OL} = 250μA				220	300	mV
						400	
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: Device are ESD sensitive. Handling precautions recommended.

Note 4: $P_{D(MAX)} = (T_{J(MAX)} – T_A) + \theta_{JA}$, where θ_{JA} depends upon the printed circuit layout.

Note 5: Output voltage temperature coefficient is $V_{OUT(worst\ case)}$, + $(T_{J(MAX)} – T_{J(MIN)})$ where $T_{J(MAX)}$ is +125°C and $T_{J(MIN)}$ is -40°C.

Note 6: $V_{DO} = V_{IN} – V_{OUT}$ when V_{OUT} decreases to 98% of its nominal output voltage with $V_{IN} = V_{OUT} + 1V$. 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: $V_{EN} \leq 0.8V$ and $V_{IN} \leq 8V$, $V_{OUT}=0$

Note 9: Design with proper heat sink to dissipate heat to keep chip from thermal protection when $V_{IN} – V_{OUT} > 0.6V$

Application Information

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

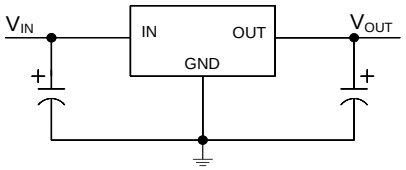


Figure 1.Linear regulators require only two capacitors for operation.

Thermal Design

Linear regulators are simple to use. The most complicated design parameters to consider are thermal characteristics. Thermal design requires the following application-specific parameters:

- Maximum ambient temperature, T_A
- Output Current, I_{OUT}
- Output Voltage, V_{OUT}
- Input Voltage, V_{IN}

First, we calculate the power dissipation of the regulator from these numbers and the device parameters from this datasheet.

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

Then the heat sink thermal resistance is determined with this formula:

$$\theta_{SA} = \frac{T_{JMAX} - T_A}{P_D} - (\theta_{JC}+\theta_{CS}),$$ where $T_{J(MAX)} \leq 125°C$ and θ_{CS} is between 0 and 20°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 Beta 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 1.0µF is needed directly between the input and regulator ground.

Application Information (continued)

Input 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 47µF or greater, the output capacitor should have less than 1 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 under damped transient response. When larger capacitors are used, the ESR requirement approaches zero. A 100µF ceramic capacitor can be used on the output while maintaining stability. A low ESR 47µF 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 ≤1Ω. 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 1µF 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 47µF 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.

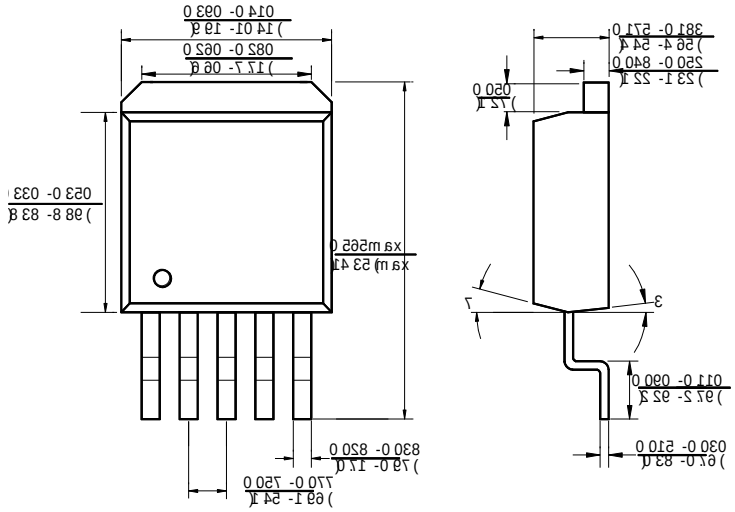
Error Flag

GM66501 versions feature an Error Flag, which looks at the output voltage and signals an error condition when this voltage drops 5% below its 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 over current fault (device in current limit) or low input voltage. The flag is inoperative during over temperature 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.

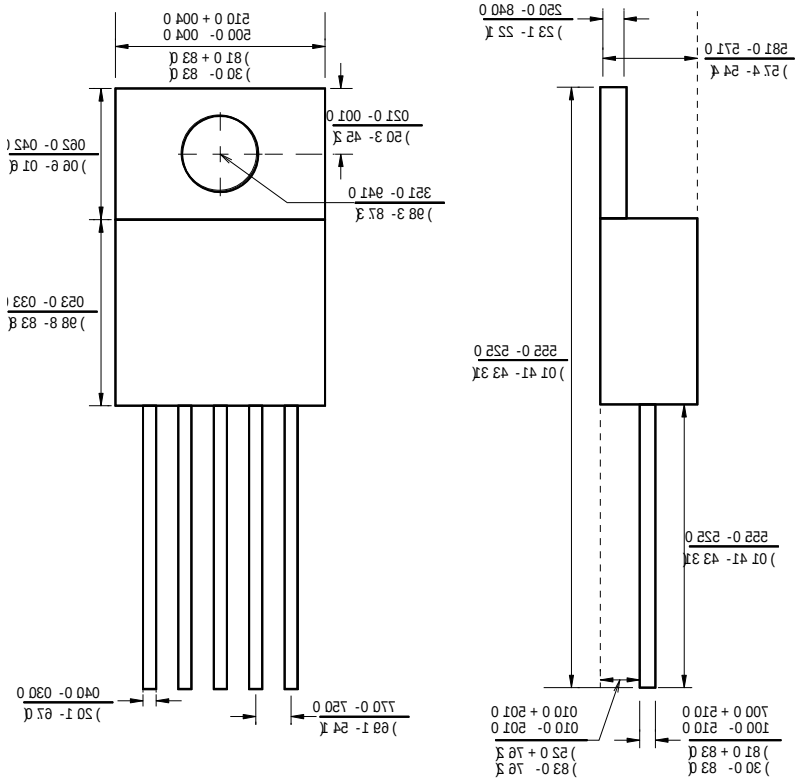
Enable Input

The GM66501 series version features an enable input for ON/OFF control of the device. It's 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 15µA.

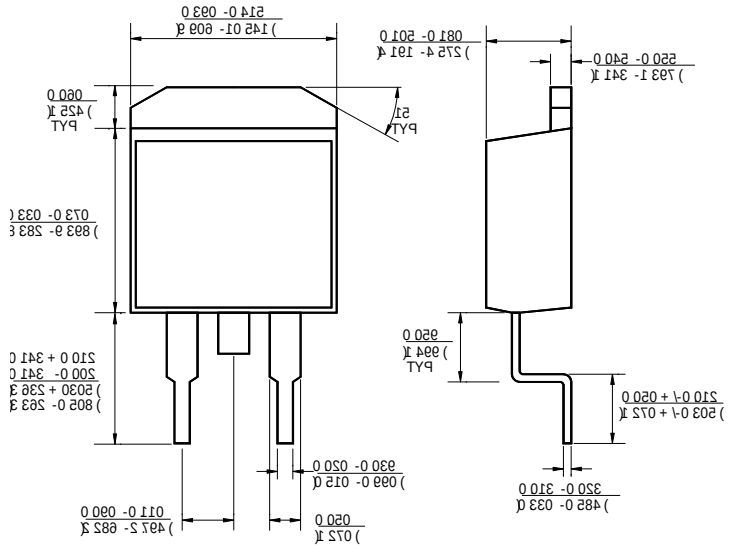
Package Outline Dimensions – TO-263-5



Package Outline Dimensions – TO-220-5



Package Outline Dimensions – TO263



Ordering Number

GM	66500	-1.5	TA3	R	G
APM Gamma Micro	Circuit Type	Output Voltage 1.5 = 1.5V 1.8 = 1.8V 2.5 = 2.5V 3.0 = 3.0V 3.3 = 3.3V 5.0 = 5.0V	Package Type TA3: TO263 TB3: TO220	Shipping Type R:Taping& Reel T: Tube	Blank: Pb free G:Green

GM	66501	-1.5	TA5	R	G
APM Gamma Micro	Circuit Type	Output Voltage 1.5 = 1.5V 1.8 = 1.8V 2.5 = 2.5V 3.0 = 3.0V 3.3 = 3.3V 5.0 = 5.0V	Package Type TA5: TO263-5 TB5: TO220-5	Shipping Type R:Taping& Reel T:Tube	Blank: Pb free G:Green