



## POWER MANAGEMENT

### **DSP Switcher™ 88MG875z-x/ 88MG876-x Series**

5A Rated Output Current, Non-Isolated, Step-Down Switching Regulator Module with AnyVoltage™ Technology

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**Advance Specifications, Patent Pending**

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Doc. No. MV-S102822-00, Rev. B  
April 4, 2006



**88MG875z-x/88MG876-x**  
**5A Rated Output Current, Non-Isolated, Step-Down Switching Regulator**  
**Module with AnyVoltage™ Technology**

## Document Status

|                         |                                                                                                                                                                                                                         |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Advance Information     | This document contains design specifications for initial product development. Specifications may change without notice. Contact Marvell Field Application Engineers for more information.                               |
| Preliminary Information | This document contains preliminary data, and a revision of this document will be published at a later date. Specifications may change without notice. Contact Marvell Field Application Engineers for more information. |
| Final Information       | This document contains specifications on a product that is in final release. Specifications may change without notice. Contact Marvell Field Application Engineers for more information.                                |
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## 5A Rated Output Current, Non-Isolated, Step-Down Switching Regulator Module with AnyVoltage™ Technology

**SIP Package**



**DIP Package**



**SMT Package (TBD)**

### FEATURES/BENEFITS

- True lead-free "plug-n-play" solution
- No external components required - except a single voltage programming resistor
- Tiny SIP, DIP, and SMT packages available
- Input voltage range: 3V to 5.5V
- Programmable output voltage: 0.72V to 3.63V
- 1 MHz switching frequency
- 2% output voltage tolerance
- 95% efficiency
- 2.5V and 3.3V LDO Secondary voltage versions
- Ultra-fast transient response
- Any Voltage™ Technology provides 72 output selections and shortens design cycles
- Output voltage margining capability for easy system testing and qualification
- High reliability - lowest component count
- Works with any external capacitive load (low ESR, high ESR)
- Built-in undervoltage lockout, thermal protection, and current limit
- Control IC and passive kit components are available for high volume user



## OVERVIEW

The 88MG875z-x/88MG876-x Series<sup>1</sup> is a high-performance, non-isolated, DC-DC converter module for point-of-load (POL) applications. It functions as a synchronous step-down (buck) switching regulator in a small form factor. The module includes a proprietary Marvell® integrated regulator device. The switching frequency for the regulator is 1 MHz, and no external components are required (except one voltage programming resistor, see [Section 2.1 "Output Voltage - Any Voltage™ Technology" on page 13](#)).

Ultra-high conversion efficiency (typically 95%) allows for the use of the 88MG875z-x/88MG876-x Series without any heatsink. Additionally, the 88MG875z-x/88MG876-x Series includes an innovative single resistor method<sup>2</sup> to program the output voltage. This voltage is defined by the user with an external resistor.

The 88MG875z-x/88MG876-x Series operates from an input voltage range of 3V to 5.5V, making the device well suited for portable applications. The output voltage range is 0.72V to 3.63V, supporting future devices down to 65 nm geometries.

Other key features include an internal current limit, an undervoltage lockout, a thermal shutdown, and an ambient temperature range of -40°C to 85°C.

## APPLICATIONS

- Point-of-load power supplies
- Networking/Datacom systems
- Portable computing
- Servers
- DSP power supplies
- LAN/WAN

- 
1. The 88MG875z-x/88MG876-x series includes 88MG75z-S, 88MG875z-D, 88MG875z-T, 88MG876-S, 88MG876-D, and 88MG876-T.
  2. Patent Pending

## DEVICE FEATURE DIFFERENCES

The table below summarizes the feature differences between 88MG875z, and 88MG876

| Features             | 88MG875z                                                                                             | 88MG876                                                                                              |
|----------------------|------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| Rated Output Current | 5A                                                                                                   | 5A                                                                                                   |
| Packages             | <ul style="list-style-type: none"><li>• 12-Pin SIP</li><li>• 9-Pin DIP</li><li>• 9-Pin SMT</li></ul> | <ul style="list-style-type: none"><li>• 11-Pin SIP</li><li>• 8-Pin DIP</li><li>• 8-Pin SMT</li></ul> |
| LDO                  | LDO Voltage Option                                                                                   | No LDO                                                                                               |

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**Table 1: Product Selector Table**

| <b>Part Name</b> | <b>Description</b>                           | <b>LDO<br/>Output<br/>Voltage</b> | <b>Output<br/>Current</b> | <b>Package</b> |
|------------------|----------------------------------------------|-----------------------------------|---------------------------|----------------|
| 88MG875B-S       | SIP Module: 5A Rated Output Current with LDO | 3.3V                              | 5A                        | 12-Pin SIP     |
| 88MG875B-D       | DIP Module: 5A Rated Output Current with LDO | 3.3V                              | 5A                        | 9-Pin DIP      |
| 88MG875B-T       | SMT Module: 5A Rated Output Current with LDO | 3.3V                              | 5A                        | 9-Pin SMT      |
| 88MG875E-S       | SIP Module: 5A Rated Output Current with LDO | 2.5V                              | 5A                        | 12-Pin SIP     |
| 88MG875E-D       | DIP Module: 5A Rated Output Current with LDO | 2.5V                              | 5A                        | 9-Pin DIP      |
| 88MG875E-T       | SMT Module: 5A Rated Output Current with LDO | 2.5V                              | 5A                        | 9-Pin SMT      |
| 88MG876-S        | SIP Module: 5A Rated Output Current          | --                                | 5A                        | 11-Pin SIP     |
| 88MG876-D        | DIP Module: 5A Rated Output Current          | --                                | 5A                        | 8-Pin DIP      |
| 88MG876-T        | SMT Module: 5A Rated Output Current          | --                                | 5A                        | 8-Pin SMT      |



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## Section 1. Signal Description

### 1.1 Pin Diagram

Figure 1: 88MG875z-S Package - Component View

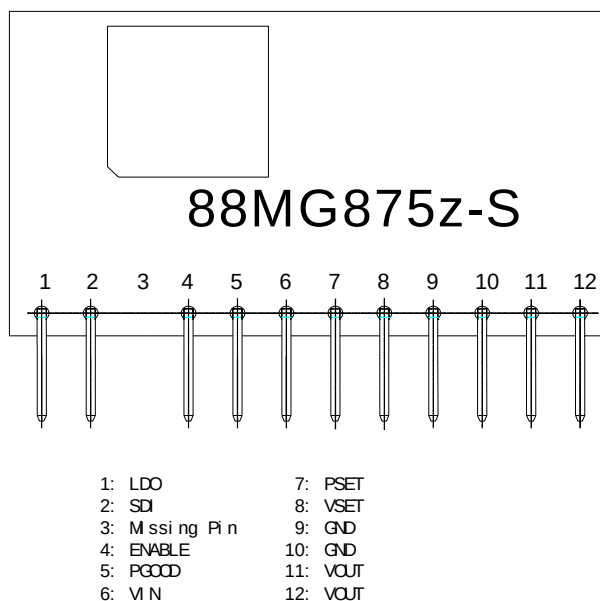
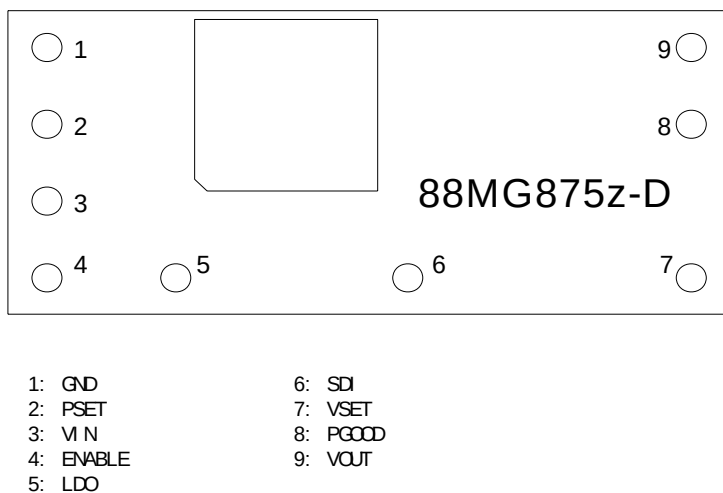
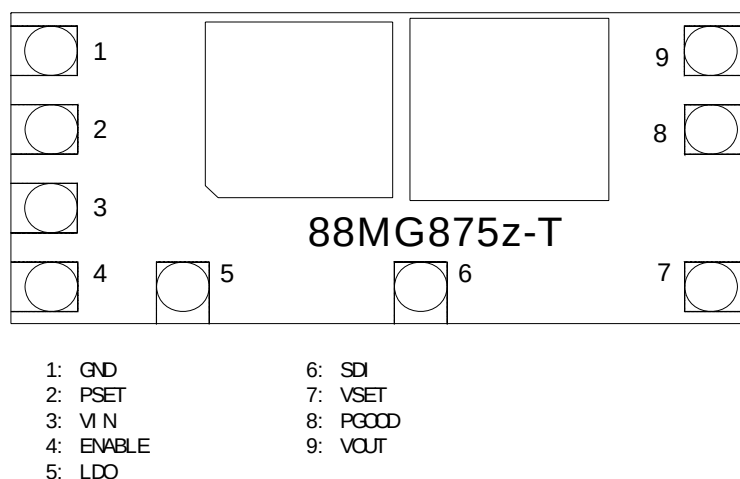


Figure 2: 88MG875z-D Package - Component View



**Figure 3: 88MG875z-T Packages - Component View**



**Figure 4: Connection Block Configuration Sample for 88MG875z -S**

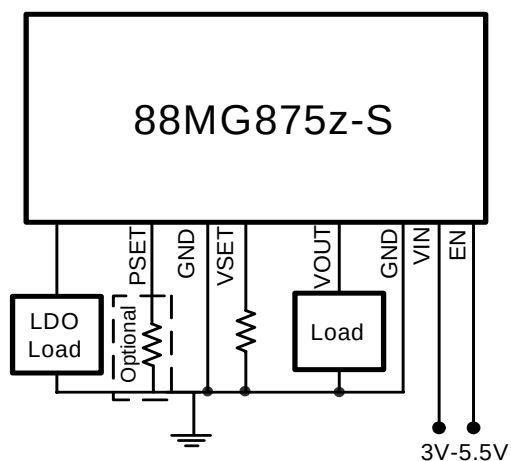


Figure 5: 88MG876-S Package - Component View

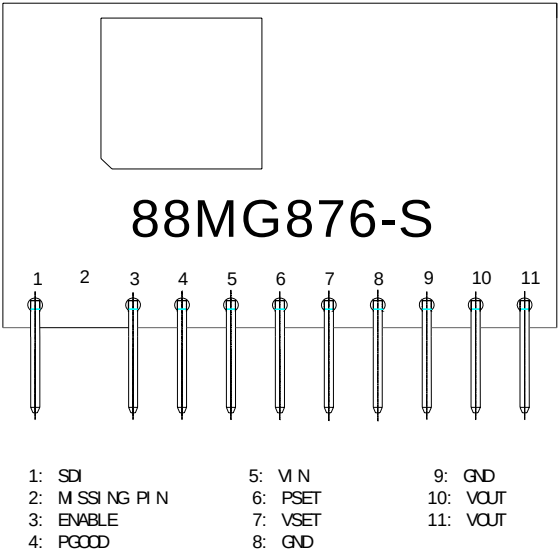
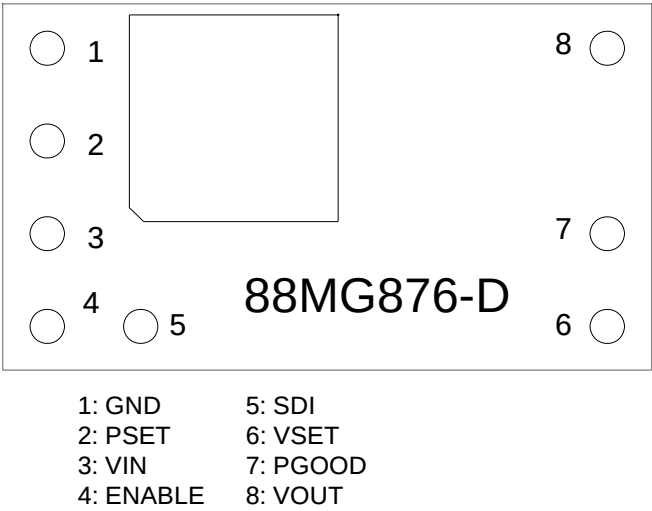
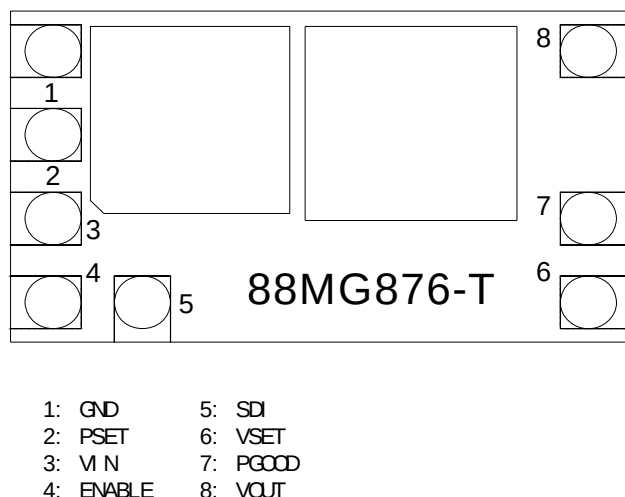


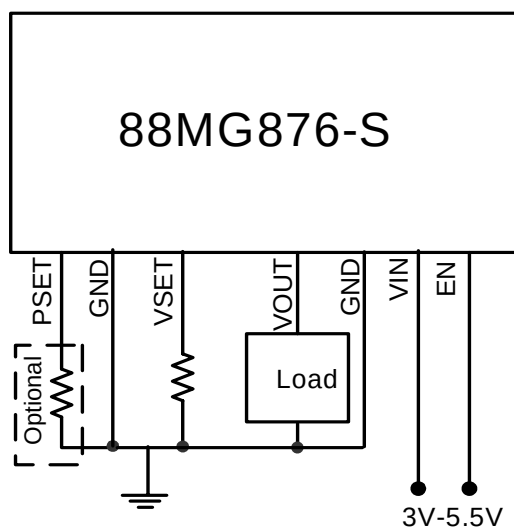
Figure 6: 88MG876-D Package - Component View



**Figure 7: 88MG876-T Package - Component View**



**Figure 8: Connection Block Configuration Sample for 88MG876-S**



## 1.2 Pin Description

| Name                 | Pin Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| LDO_OUT <sup>1</sup> | Secondary Output Voltage. Connect directly to load with a short wide PCB trace.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| PSET                 | Percent Set.<br>An external resistor is connected to the ground to trim the set voltage by the percentage value. See <a href="#">Table 3</a> in the <a href="#">Section 2.1 "Output Voltage - Any Voltage™ Technology" on page 13</a> for resistor values and percentage options.<br>The total capacitance across this pin and GND should be less than 25 pF. Shorting this pin to ground, floating this pin, or using $R_{VSET} > 619K$ or $R_{VSET} < 7.68K$ does not affect the set voltage. A resistor with tolerance of 5% or better must be used. If this pin is not used, it is recommended that the pin be tied to GND. |
| GND                  | Power ground.<br>Connect this pin to a suitable low-impedance ground plane.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| NC                   | Not connected.<br>No pin.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| VSET                 | Voltage set.<br>An external resistor is connected to ground to set the output voltage of the switching regulator. See <a href="#">Table 3</a> in the <a href="#">Section 2.1 "Output Voltage - Any Voltage™ Technology" on page 13</a> for resistor values and output voltage options.<br>The total capacitance across this pin and GND should be less than 15 pF. Shorting this pin to ground, floating this pin, or using $R_{VSET} > 619K$ or $R_{VSET} < 7.68K$ disables the switching regulator. A resistor with tolerance of 5% or better must be used.                                                                   |
| VOUT                 | Output voltage.<br>Connect directly to load with a short wide PCB trace.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| VIN                  | 3V - 5.5V Input voltage.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| EN                   | Enable<br>Logic low ( $\leq 0.8V$ ) disables the regulator. Open collector will enable the regulator due to internal pull-up resistor provided. The high signal has to be at least 20 $\mu s$ in duration to enable the regulator.                                                                                                                                                                                                                                                                                                                                                                                              |
| TDO                  | Terminal Data Output. This pin is a special function pin. Contact your Marvell® representative for information otherwise this pin should be left floating.                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| TDI                  | Terminal Data Input. This pin is a special function pin. Contact your Marvell® representative for information otherwise this pin should be left floating.                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| PGOOD                | The power good pin (PG) is an active-high, open-drain output pin. Refer to <a href="#">Section 2.7</a> for further details on the PGOOD pin.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

1. This pin is present in 88MG875z.



**88MG875z-x/88MG876-x**  
**5A Rated Output Current, Non-Isolated, Step-Down Switching Regulator**  
**Module with AnyVoltage™ Technology**

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**Table 2: Pin Number Assignment Table**

| Pin Name    | 88MG875z-S | 88MG875z-D/T | 88MG876-S | 88MG876-D/T |
|-------------|------------|--------------|-----------|-------------|
| LDO_OUT     | 1          | 5            | -         | -           |
| SDI         | 2          | 6            | 1         | 5           |
| GND         | 9, 10      | 1            | 8, 9      | 1           |
| MISSING PIN | 3          | -            | 2         | -           |
| VSET        | 8          | 7            | 7         | 6           |
| VOUT        | 11, 12     | 9            | 10, 11    | 8           |
| VIN         | 6          | 3            | 5         | 3           |
| ENABLE      | 4          | 4            | 3         | 4           |
| PGOOD       | 5          | 8            | 4         | 7           |
| PSET        | 7          | 2            | 6         | 2           |

## Section 2. Functional Description

### 2.1 Output Voltage - Any Voltage™ Technology

The output voltage of the 88MG875z-x/88MG876-x Series devices is programmed by using the look-up [Table 3](#) to select the resistor value for the VSET and PSET pins. The VSET pin sets the output voltage, and the PSET pin trims the set voltage to a percentage value.

For example, to program 2.25V output, a 165k resistor is selected for the VSET pin, and an 11k resistor is selected for the PSET pin. The 165k resistor sets the output voltage to 2.5V and the 11k resistor trims the set voltage off by 10% (or -10%). Using a resistor value greater than 619k or less than 7.68k for the VSET pin disables the switching regulator and sets the SW pin to high impedance. Using a resistor value greater than 619k or less than 7.68k for the PSET pin does not affect the set voltage.

Using a VSET resistor with value greater than 619 kohm or less than 7.68 kohm disables the step-down switching regulator and sets the SW pin to high impedance. If the VSET resistor's value is outside the 5% tolerance, the output can be either higher or lower than the set voltage.

Using a resistor value greater than 619 kohm or less than 7.68 kohm for the PSET pin does not affect the set voltage. When the PSET pin is not used, it must be connected to ground. Like the VSET resistor, the percent value can be either higher or lower if the PSET resistor's value is outside the 5% tolerance.

**Table 3: Any Voltage Programming Table for 5% Resistors**

|      |      | PSET   |       |       |       |       |       |       |       |       |
|------|------|--------|-------|-------|-------|-------|-------|-------|-------|-------|
|      |      | -10.0% | -7.5% | -5.0% | -2.5% |       | 2.5%  | 5.0%  | 7.5%  | 10.0% |
|      |      | 11k    | 18k   | 30k   | 51k   | GND   | 100k  | 160k  | 270k  | 470k  |
| VSET | 11k  | 0.720  | 0.740 | 0.760 | 0.780 | 0.800 | 0.820 | 0.840 | 0.860 | 0.880 |
|      | 18k  | 0.900  | 0.925 | 0.950 | 0.975 | 1.000 | 1.025 | 1.050 | 1.075 | 1.100 |
|      | 30k  | 1.080  | 1.110 | 1.140 | 1.170 | 1.200 | 1.230 | 1.260 | 1.290 | 1.320 |
|      | 51k  | 1.350  | 1.388 | 1.425 | 1.463 | 1.500 | 1.575 | 1.575 | 1.613 | 1.650 |
|      | 100k | 1.620  | 1.665 | 1.710 | 1.755 | 1.800 | 1.890 | 1.890 | 1.925 | 1.980 |
|      | 160k | 2.250  | 2.313 | 2.375 | 2.438 | 2.500 | 2.625 | 2.625 | 2.688 | 2.750 |
|      | 270k | 2.700  | 2.775 | 2.850 | 2.925 | 3.000 | 3.150 | 3.150 | 3.225 | 3.300 |
|      | 470k | 2.970  | 3.053 | 3.135 | 3.218 | 3.300 | 3.465 | 3.465 | 3.548 | 3.630 |

**Table 4: Any Voltage Programming Table for 1% Resistors**

|      |       | PSET   |       |       |       |           |       |       |       |       |
|------|-------|--------|-------|-------|-------|-----------|-------|-------|-------|-------|
|      |       | -10.0% | -7.5% | -5.0% | -2.5% |           | 2.5%  | 5.0%  | 7.5%  | 10.0% |
|      |       | 11k    | 18.7k | 31.6k | 53.6k | Open /GND | 97.6k | 165k  | 280k  | 475k  |
| VSET | GND   | 0.000  | 0.000 | 0.000 | 0.000 | 0.000     | 0.000 | 0.000 | 0.000 | 0.000 |
|      | 11k   | 0.720  | 0.740 | 0.760 | 0.780 | 0.800     | 0.820 | 0.840 | 0.860 | 0.880 |
|      | 18.7k | 0.900  | 0.925 | 0.950 | 0.975 | 1.000     | 1.025 | 1.050 | 1.075 | 1.100 |
|      | 31.6k | 1.080  | 1.110 | 1.140 | 1.170 | 1.200     | 1.230 | 1.260 | 1.290 | 1.320 |
|      | 53.6k | 1.350  | 1.388 | 1.425 | 1.463 | 1.500     | 1.538 | 1.575 | 1.613 | 1.650 |
|      | 97.6k | 1.620  | 1.665 | 1.710 | 1.755 | 1.800     | 1.845 | 1.890 | 1.935 | 1.980 |
|      | 165k  | 2.250  | 2.313 | 2.375 | 2.438 | 2.500     | 2.563 | 2.625 | 2.688 | 2.750 |
|      | 280k  | 2.700  | 2.775 | 2.850 | 2.925 | 3.000     | 3.075 | 3.150 | 3.225 | 3.300 |
|      | 475k  | 2.970  | 3.053 | 3.135 | 3.218 | 3.300     | 3.383 | 3.465 | 3.548 | 3.630 |
|      | Open  | 0.000  | 0.000 | 0.000 | 0.000 | 0.000     | 0.000 | 0.000 | 0.000 | 0.000 |

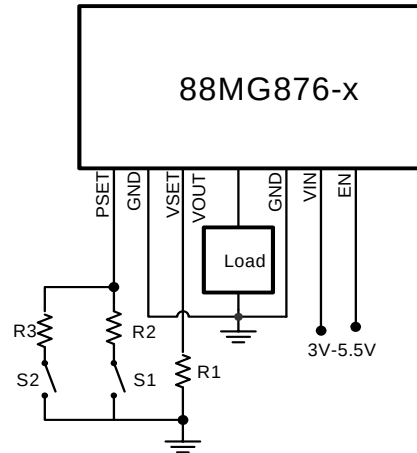
The VSET and PSET resistor are read once during start-up before the output voltage is turned on. After the output voltage is turned on, the VSET and PSET resistors are ignored. The benefit of this is that the output voltage tolerance is not dependant upon the tolerance or thermal characteristics of these resistors.

## 2.2 Output Voltage Margining

A useful application of the Marvell® Any Voltage™ technology is “output voltage margining”. Voltage margining is commonly used during system qualification to evaluate operation at “corner” conditions of voltage, temperature etc. Typically, output voltage will be offset up and down by some percentage (margin) of the nominal value. For the 88MG875z-x/88MG876-x Series, the VSET pin/resistor controls the nominal voltage of the switching regulator output while the PSET pin/resistor controls the margin voltage. As can be seen in [Table 3](#), the PSET pin allows the margin to be set as high as 10% above and as low as -10% below the nominal setpoint established by VSET. Depending on the value of the PSET resistor intermediate points of  $\pm 7.5\%$ ,  $\pm 5\%$  and  $\pm 2.5\%$  can also be accessed.

For example, if an application calls for a nominal output voltage of 1.5V then [Table 3](#) prescribes a value of R1 for the VSET resistor. This selection is shown in [Figure 9](#) connected to the VSET pin. To offset the voltage above and below the nominal value, the PSET pin can be used with resistor values again from [Table 3](#). Additionally, switches S1 and S2 can be alternately closed to select from the two resistors R3 and R2 (offset values) for PSET. If more offsets are required more switches and resistors may be used. As shown in [Figure 9](#), if S1 is closed and S2 is opened a positive 5% offset would be added to the nominal 1.5V output yielding 1.575V. Conversely, if S1 is opened and S2 closed the output would be offset to -5% from 1.5V, or 1.425V. Finally with both S1 and S2 opened the output would return to the nominal 1.5V. Thus voltage margining can be simply and reliably implemented with a minimum of components and design effort.

Figure 9: Output Voltage Margining

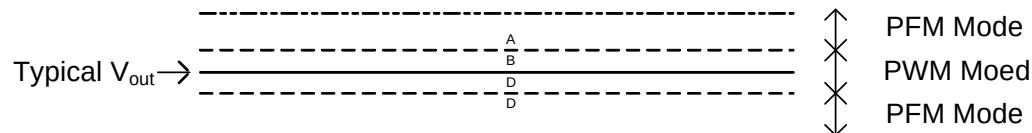


## 2.3 Regulation and Start-up

The step-down switching regulator uses Pulse Width Modulation (PWM) And Pulse Frequency Modulation (PFM) modes to regulate the output voltage using digital control. The mode of operation depends on the level of output current and the output voltage.

In steady states, the step-down switching regulator monitors the current flowing through the inductor to determine if the regulator is handling heavy or light load applications. For heavy load applications, the step-down regulator operates in the PWM mode (B and C) to minimize the ripple current for optimum efficiency and to minimize the ripple output voltage. The step-down regulator operates in the PFM and Discontinuous Conduction Mode (DCM) (A and D) to limit the switching action for optimum efficiency in light load applications. In this mode, the average output voltage is slightly higher than the average output voltage for heavy transient load applications.

Figure 10: Output Voltage Window

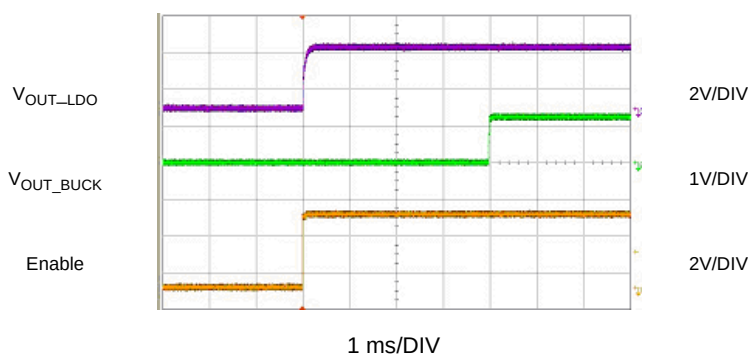


## 2.4 Digital Soft Start

During start-up, the 88MG875z-x/88MG876-x provides a soft start function. Soft start reduces surge currents from input voltage and provides a well-controlled output voltage rise characteristics. The rate of the output voltage start-up is limited by the value of the output capacitor and the internal current limit circuitry. This combination forces the output voltage to come up slowly, providing a soft-start characteristic.

During soft start, the 88MG875z-x/88MG876-x feeds a constant current to the output capacitor in several steps. [Figure 11](#) shows the inductor current waveform during startup. The current limit is ramped up in 7 steps beginning at approximately 40% of the current limit rating and ending at 100% at 25  $\mu$ s per step. The buck regulator behaves like a current source during this time as the output ramps up slowly.

**Figure 11: Start-up Using the Enable Pin**



## 2.5 Undervoltage Lockout (UVLO)

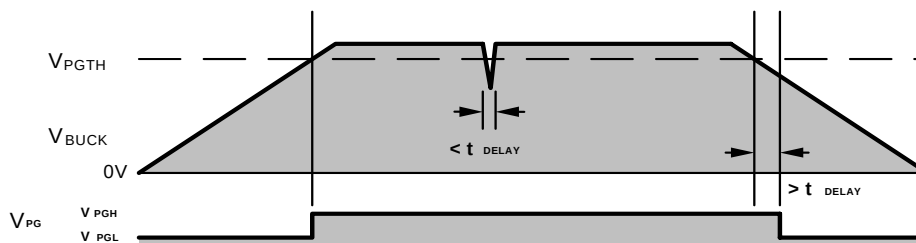
The 88MG875z-x/88MG876-x Series incorporates undervoltage-lockout circuitry to disable the step-down regulator when the input voltage is below 2.75V (typical). The step-down regulator is enabled when the input voltage is above 2.85V (typical).

## 2.6 Thermal Shutdown

If the junction temperature of the Control IC on 88MG875z-x/88MG876-x Series exceeds 150°C (typical), the thermal shutdown circuitry disables the step-down regulator. The step-down regulator is enabled when the junction temperature falls to 120°C (typical).

## 2.7 PGOOD

The power good pin (PG) is an active-high, open-drain output pin. It is asserted when the output voltage of the step-down regulator is below the threshold. When the output voltage is above the threshold, the power good pin is de-asserted. Setting the output voltage greater than 1.35V, the threshold voltage is  $0.9\% \times V_{OUT}$  (typical). Setting the output voltage less than 1.32V, the threshold voltage is  $V_{OUT} - 130\text{mV}$  (typical). A built-in  $25\mu\text{s}$  ( $t_{\text{DELAY}}$ ) delay is incorporated to prevent nuisance tripping.



## Section 3. Electrical Specifications

### 3.1 Absolute Maximum Ratings

Stresses above those listed in Absolute Maximum Ratings may cause permanent device failure. Functionality at or above those limits is not implied. Exposure to absolute maximum ratings for extended periods may affect device reliability.

| Parameter                     | Symbol         | Range                       | Units |
|-------------------------------|----------------|-----------------------------|-------|
| Input Voltage to GND          | $V_{IN}$       | -0.3 to 6.0                 | V     |
| Voltage Set to GND            | $V_{SET}$      | -0.6 to ( $V_{IN} + 0.3$ )  | V     |
| Percentage Set Voltage to GND | $V_{PSET}$     | -0.6 to ( $V_{IN} + 0.3$ )  | V     |
| Shutdown Voltage to GND       | $V_{SHDN}$     | -0.6 to ( $V_{IN} + 0.3V$ ) | V     |
| Storage Temperature Range     | $T_{STOR}$     | -65 to +150                 | °C    |
| Peak Switch Current           | $I_{PEAK}$     | 7.5                         | A     |
| Rated Output Current          | $I_{OUT}$      | 5                           | A     |
| LDO Output Current (Peak)     | $I_{OUT\_LDO}$ | 450                         | mA    |

### 3.2 Recommended Operating Conditions<sup>1</sup>

| Parameter                                | Symbol   | Range      | Units |
|------------------------------------------|----------|------------|-------|
| Input Voltage                            | $V_{IN}$ | 3 to 5.5   | V     |
| Operating Temperature Range <sup>2</sup> | $T_{OP}$ | -40 to +85 | °C    |

1. This device is not guaranteed to function outside the specified operating range.
2. This device is guaranteed to meet the specifications from 0°C to 70°C. Any specifications that pertain to the operating temperature range -40°C to +85°C are assured by design, characterization, and correlation with statistical process controls.



### 3.3 Electrical Characteristics

The following applies unless otherwise noted:  $V_{IN} = 5.0V$ .  $T_A = 25^\circ C$ . Bold values indicate  $-40^\circ C \leq T_A \leq 85^\circ C$ .

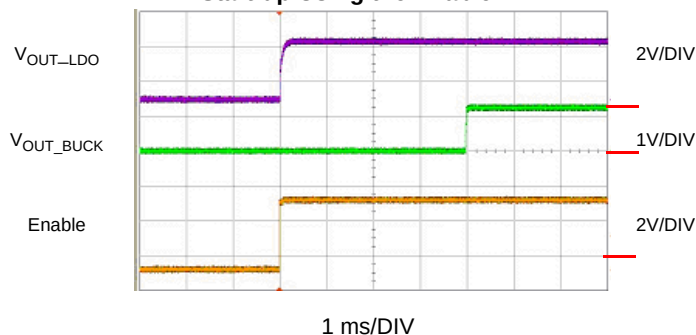
| Parameter                         | Symbol                 | Condition                                                                    | Min  | Typ  | Max  | Units    |
|-----------------------------------|------------------------|------------------------------------------------------------------------------|------|------|------|----------|
| Input Voltage Range               | V <sub>IN</sub>        |                                                                              | 3.0  |      | 5.5  | V        |
| Total Quiescent Current (No Load) | I <sub>IN</sub>        |                                                                              |      | 10   |      | mA       |
| Shutdown Supply Current           | I <sub>IN</sub>        | V <sub>SHDN</sub> = V <sub>IN</sub> = 5.5V                                   |      | 1    | 10   | μA       |
| Undervoltage Lockout              | V <sub>UVLO</sub>      | High threshold, V <sub>IN</sub> increasing                                   |      | 2.85 | 3.00 | V        |
|                                   |                        | Low threshold, V <sub>IN</sub> decreasing                                    | 2.65 | 2.75 |      | V        |
| Enable Input Voltage Logic        | V <sub>EN</sub>        | Enable regulator (5V)                                                        | 3    |      |      | V        |
|                                   |                        | Enable regulator (3.3V)                                                      | 2.4  |      |      | V        |
|                                   |                        | Disable regulator (3.3V/5V)                                                  |      |      | 0.8  | V        |
| Shutdown Input Current            | I <sub>SHDN</sub>      | V <sub>SHDN</sub> = GND or 5.5V                                              |      |      | ±1   | μA       |
| Over-Temperature Thermal Shutdown | T <sub>OTS</sub>       | T <sub>J</sub> increasing (disable regulator)                                |      | 150  |      | °C       |
|                                   |                        | T <sub>J</sub> decreasing (enable regulator)                                 |      | 120  |      | °C       |
| Switching Frequency               | f <sub>SW</sub>        |                                                                              |      | 1    |      | MHz      |
| Output Voltage Tolerance          | Δ V <sub>OUT</sub>     |                                                                              |      | 1    |      | %        |
| Line Regulation                   |                        | I <sub>OUT</sub> = 5A                                                        |      | 0.2  |      | %        |
|                                   |                        | V <sub>IN</sub> = 3.0V to 5.5V                                               |      |      |      |          |
| Load Regulation                   |                        | V <sub>OUT</sub> = 1.5V<br>I <sub>OUT</sub> = 0.5A to 5.0A                   |      | 0.5  |      | %        |
| Input Current Ripple              | I <sub>IN</sub> ripple | V <sub>OUT</sub> = 0.8V<br>I <sub>OUT</sub> = 5A                             |      | 10.5 |      | mA pk-pk |
| Input Voltage Ripple              | V <sub>IN</sub> ripple | (without external filter)                                                    |      | 50.0 |      | mV pk-pk |
| Output Voltage Noise              |                        | V <sub>IN</sub> = 5.0V<br>V <sub>OUT</sub> = 1.8V<br>I <sub>OUT</sub> = 5.0A |      | 6.0  |      | mV RMS   |
|                                   |                        |                                                                              |      | 11.0 |      | mV pk-pk |
| Electrical Material Rating        |                        |                                                                              |      |      |      |          |
| Flammability Rating               |                        | UL94V-0                                                                      |      |      |      |          |
| Material Type                     |                        | FR4-PCB                                                                      |      |      |      |          |

**Table 5: LDO Output Electrical Characteristics**

| Parameter           | Symbol | Condition                                    | Min | Typ | Max | Units |
|---------------------|--------|----------------------------------------------|-----|-----|-----|-------|
| Line Regulation LDO |        | $I_{OUT} = 800 \text{ mA}$                   |     | 0.2 |     | %     |
|                     |        | $V_{IN} = -4.0\text{V to } 5.5\text{V}$      |     |     |     |       |
| Load Regulation LDO |        | $I_{OUT} = 10 \text{ mA to } 800 \text{ mA}$ |     | 0.5 |     | %     |

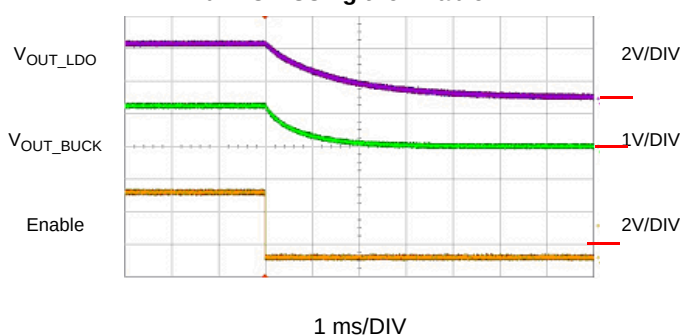
## 3.4 Startup Waveforms

Start-up Using the Enable Pin



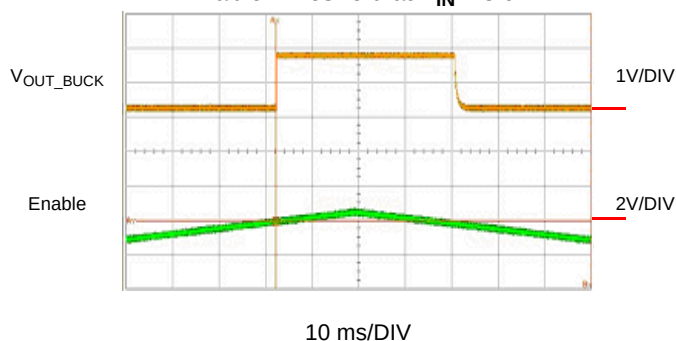
$V_{IN} = 5.0V$   
 $V_{LDO} = 3.3V$   
 $V_{BUCK} = 1.2V$   
 $I_{LOAD} = \text{No Load}$   
 $t_{DLY} \sim 4 \text{ ms}$

Turn Off Using the Enable Pin



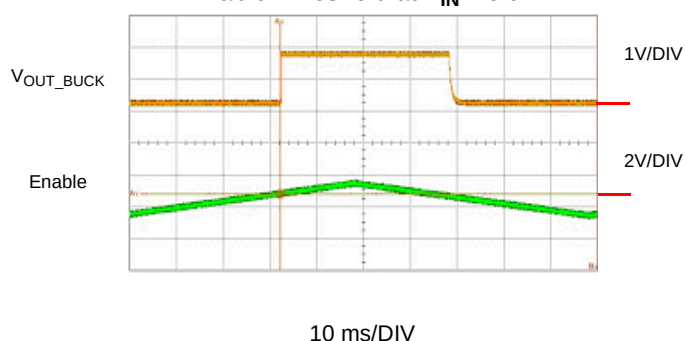
$V_{IN} = 5.0V$   
 $V_{LDO} = 3.3V$   
 $V_{BUCK} = 1.2V$   
 $I_{LOAD} = \text{No Load}$

Enable Threshold at  $V_{IN} = 3.0V$



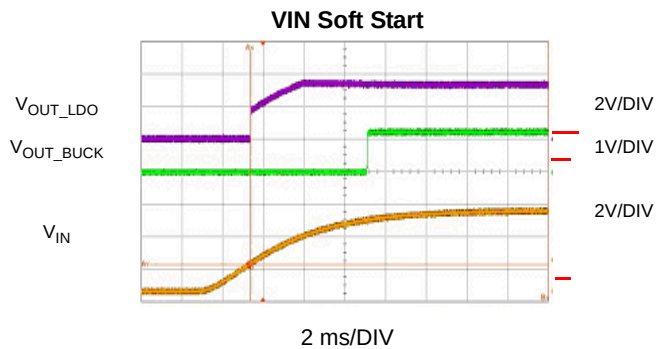
$V_{IN} = 3.0V$   
 $V_{LDO} = 3.3V$   
 $V_{BUCK} = 1.2V$   
 $I_{LOAD} = \text{No Load}$   
 $V_{TH} = 1.47V \text{ (Note)}$

Enable Threshold at  $V_{IN} = 5.0V$

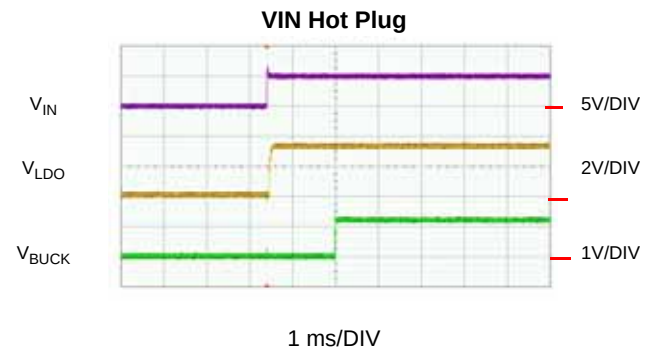


$V_{IN} = 5.0V$   
 $V_{LDO} = 3.3V$   
 $V_{BUCK} = 1.2V$   
 $I_{LOAD} = \text{No Load}$   
 $V_{TH} = 2.33V \text{ (Note)}$

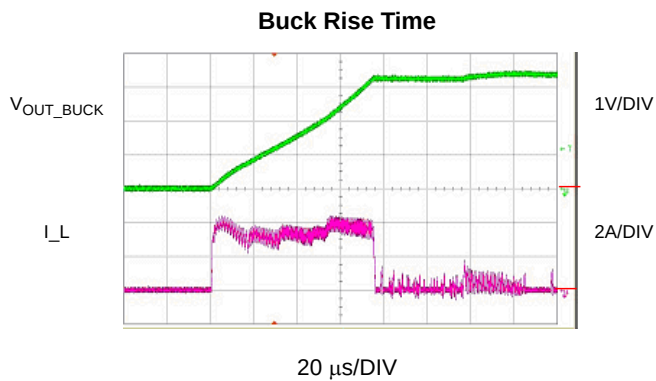
**NOTE:** There is a delay (3.5 ms typ) before the output voltage turns on. The actual threshold is before delay.



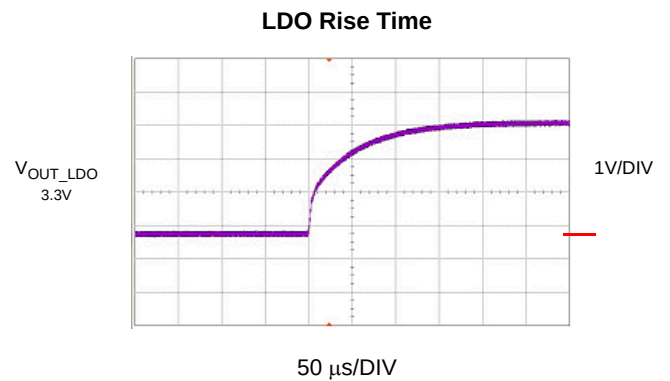
$V_{IN} = 5.0V$       LDO Start = 1.7V  
 $V_{LDO} = 3.3V$   
 $V_{BUCK} = 1.2V$   
 $I_{LOAD} = \text{No Load}$



$V_{IN} = 5.0V$        $t_{DLY} = 4 \text{ ms}$   
 $V_{LDO} = 3.3V$   
 $V_{BUCK} = 1.2V$   
 $I_{LOAD} = \text{No Load}$



$V_{IN} = 5V$        $t_{RISE} = 75 \mu s$   
 $V_{OUT} = 3.3V$   
 $I_{LOAD} = 7.5A$

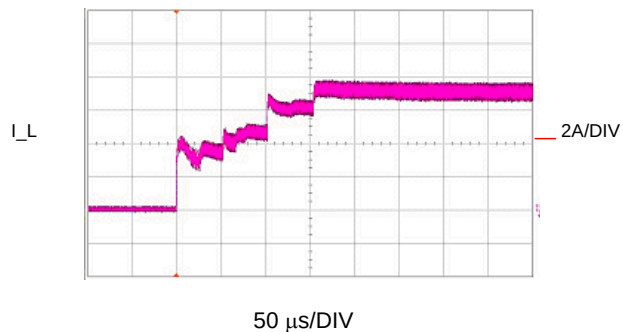


$V_{IN} = 5.0V$        $t_{RISE} = 100 \mu s$   
 $V_{LDO} = 3.3V$



**88MG875z-x/88MG876-x**  
**5A Rated Output Current, Non-Isolated, Step-Down Switching Regulator**  
**Module with AnyVoltage™ Technology**

**Soft Start Current Limit**



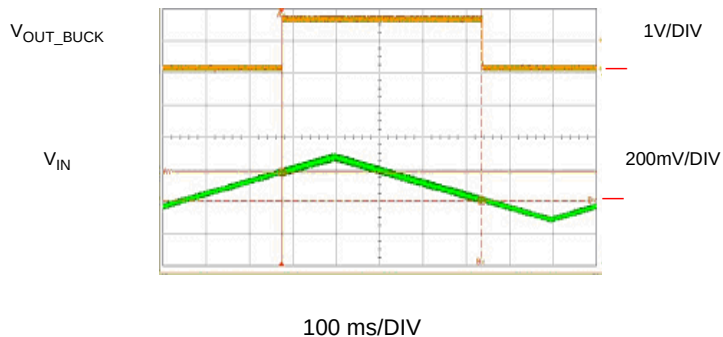
$V_{IN} = 5.0V$

$I_{LIMIT} = 7.5A$

$V_{LDO} = 3.3V$

$V_{BUCK} = 1.2V$

**UVLO Threshold**



$V_{LDO} = 3.3V$

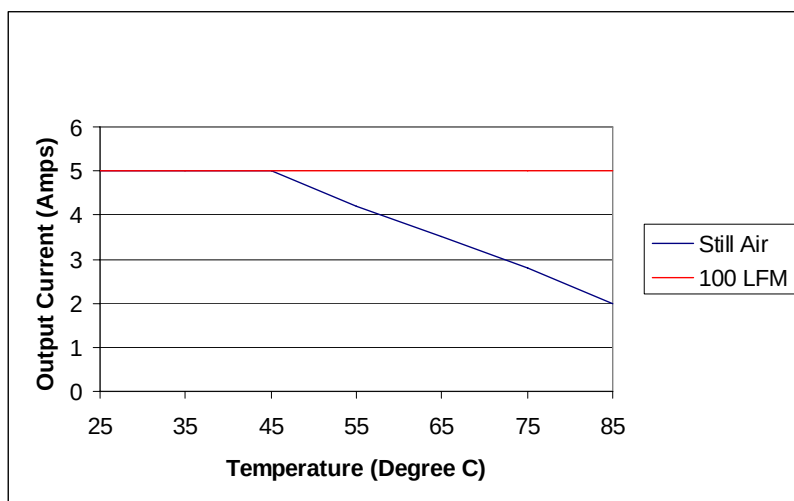
$V_{HTH} = 2.966V$

$V_{BUCK} = 1.2V$

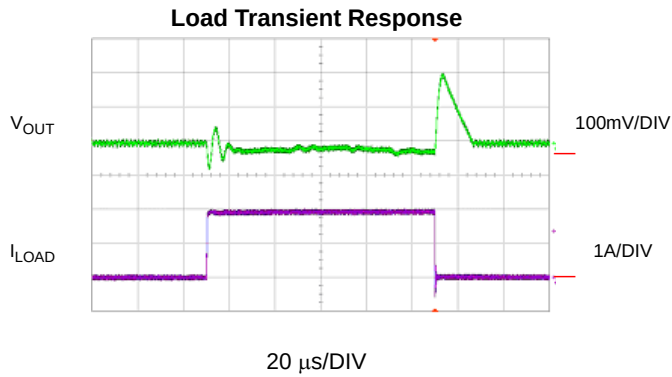
$V_{LTH} = 2.792V$

$I_{LOAD} = \text{No Load}$

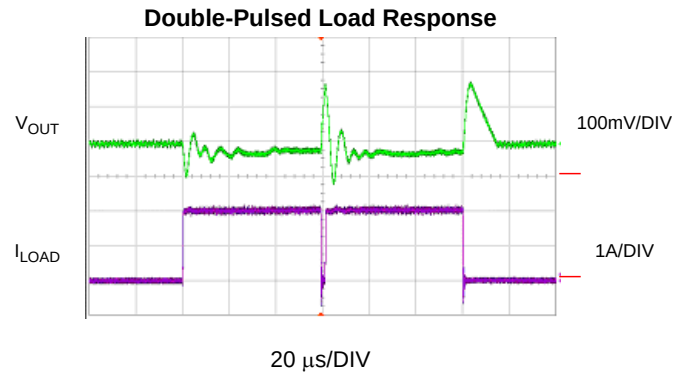
**Temperature Derating**



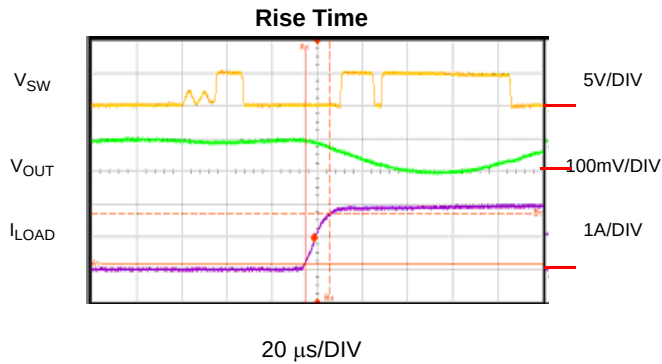
### 3.5 Load Transient Response Waveforms



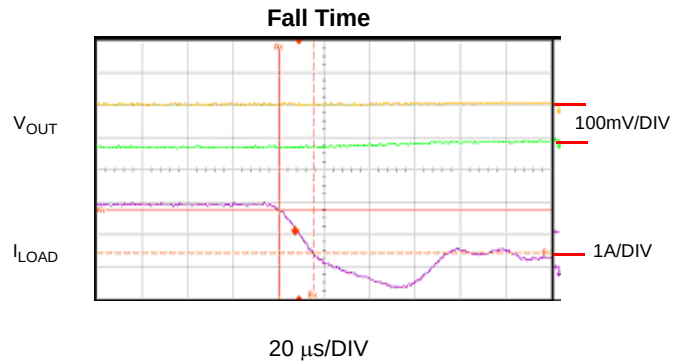
$V_{IN} = 5.0V$   $I_{LOAD} = 0.5A$  to  $5A$   
 $V_{BUCK} = 1.0V$   $t_{RISE} = 11 A/\mu s$   
 $t_{FALL} = 176 A/\mu s$



$V_{IN} = 5.0V$   $I_{LOAD} = 0.5A$  to  $5A$   
 $V_{OUT} = 1.0V$   $t_{RISE} = 11 A/\mu s$   
 $t_{FALL} = 176 A/\mu s$



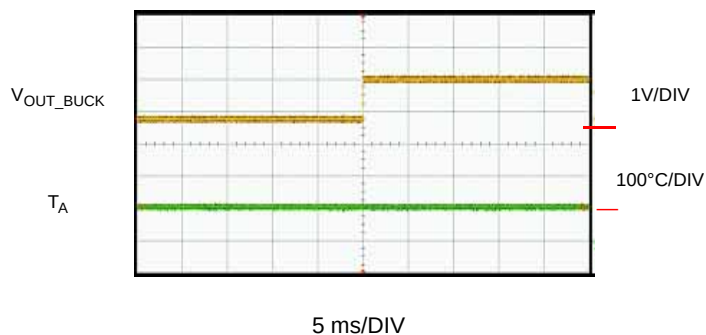
$V_{IN} = 5.0V$   $I_{LOAD} = 0.5A$  to  $5A$   
 $V_{BUCK} = 1.0V$   $t_{RISE} = 11 A/\mu s$   
 $t_{FALL} = 176 A/\mu s$



$V_{IN} = 5.0V$   $I_{LOAD} = 0.5A$  to  $5A$   
 $V_{BUCK} = 1.0V$   $t_{RISE} = 11 A/\mu s$   
 $t_{FALL} = 176 A/\mu s$

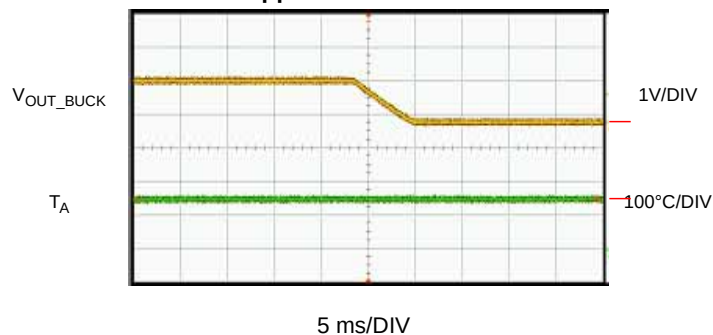
## 3.6 Thermal Shutdown

**G75 Lower Thermal Shutdown**



$V_{IN} = 5.0V$        $I_{LOAD} = 5.0A$   
 $V_{BUCK} = 1.2V$        $L_{TH} = 107.65\text{ }^{\circ}C$

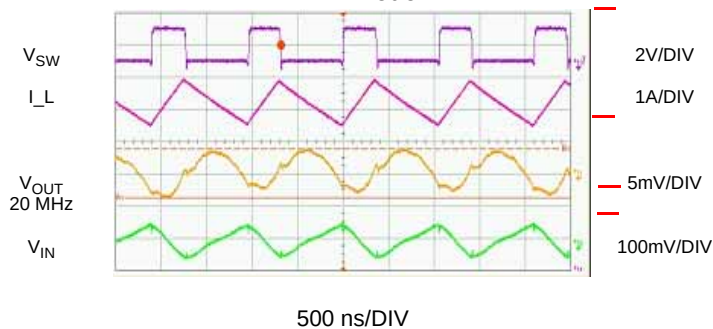
**G75 Upper Thermal Shutdown**



$V_{IN} = 5.0V$        $I_{LOAD} = 5.0A$   
 $V_{BUCK} = 1.2V$        $U_{TH} = 150.68\text{ }^{\circ}C$

## 3.7 Switching Waveforms

**PWM mode**

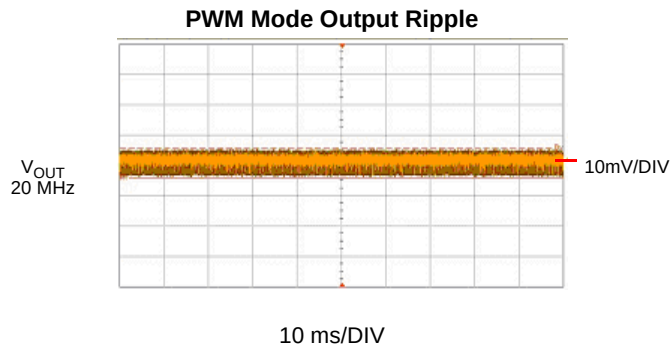


$V_{IN} = 5.0V$        $V_{IN(PK-PK)} = 110\text{ mV}$   
 $V_{BUCK} = 1.5V$        $I_{IND(PK-PK)} = 1.5A$   
 $I_{OUT} = 5A$        $I_{IND(PK)} = 5.87A$   
 $V_{OUT(PK-PK)} = 7.62\text{ mV}$       Freq = 950 KHz

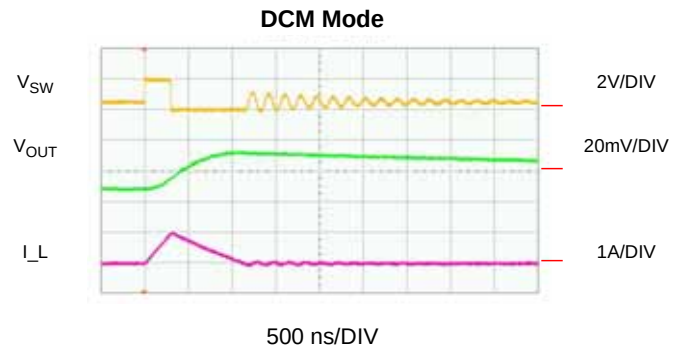
**DCM Mode**



$V_{IN} = 5.0V$        $I_{IND(PK)} = 1.33A$   
 $V_{BUCK} = 1.5V$       Freq = 105 KHz  
 $I_{OUT} = 50\text{ mA}$   
 $V_{OUT(PK-PK)} = 3.\text{ mV}$



$V_{IN} = 5.0V$        $V_{OUT(PK-PK)} = 9.79.mV$   
 $V_{LDO} = 3.3V$   
 $V_{BUCK} = 1.5V$   
 $I_{LOAD} = 5.0A$



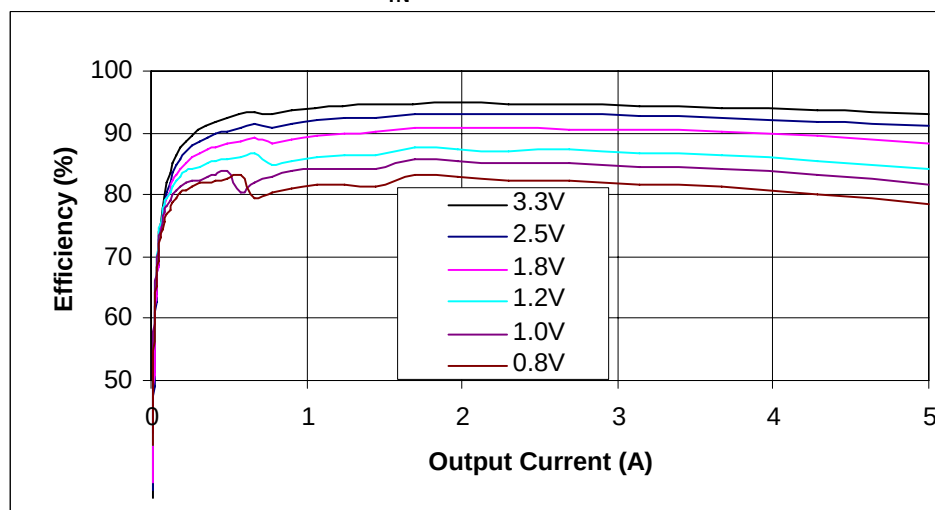
$V_{IN} = 5.0V$       Freq Ringing = 5.09 MHz  
 $V_{LDO} = 3.3V$   
 $V_{BUCK} = 1.5V$   
 $I_{LOAD} = 50 mV$

**NOTE:** For repeatability of measuring output ripple ( $V_{OUT(P-P)}$ ), the test procedure is to set the scope bandwidth to 20 MHz and use a coax cable with very short leads terminated into  $50\Omega$ . The coax leads must be routed as far as possible from the switching node.

## 3.8 Efficiency

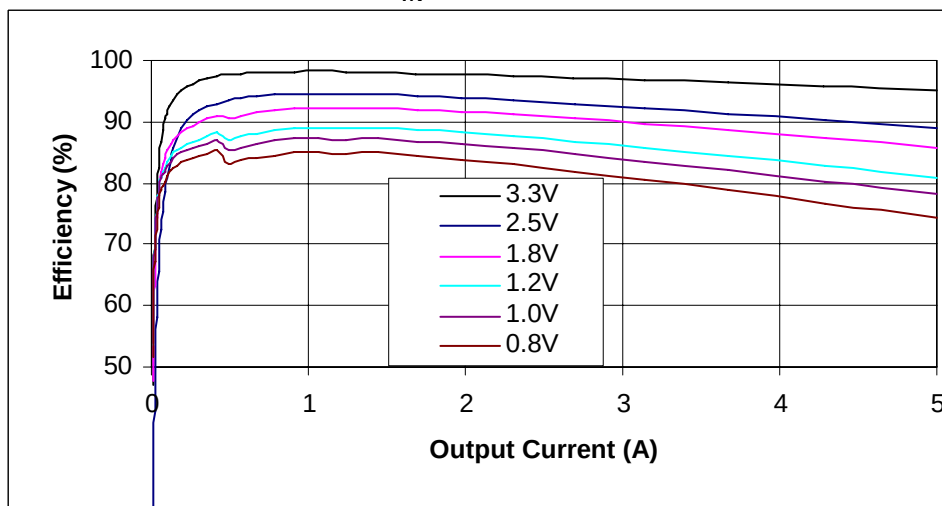
EFFICIENCY VS. OUTPUT CURRENT

$V_{IN} = 5.0V @ 25^{\circ}C$



EFFICIENCY VS. OUTPUT CURRENT

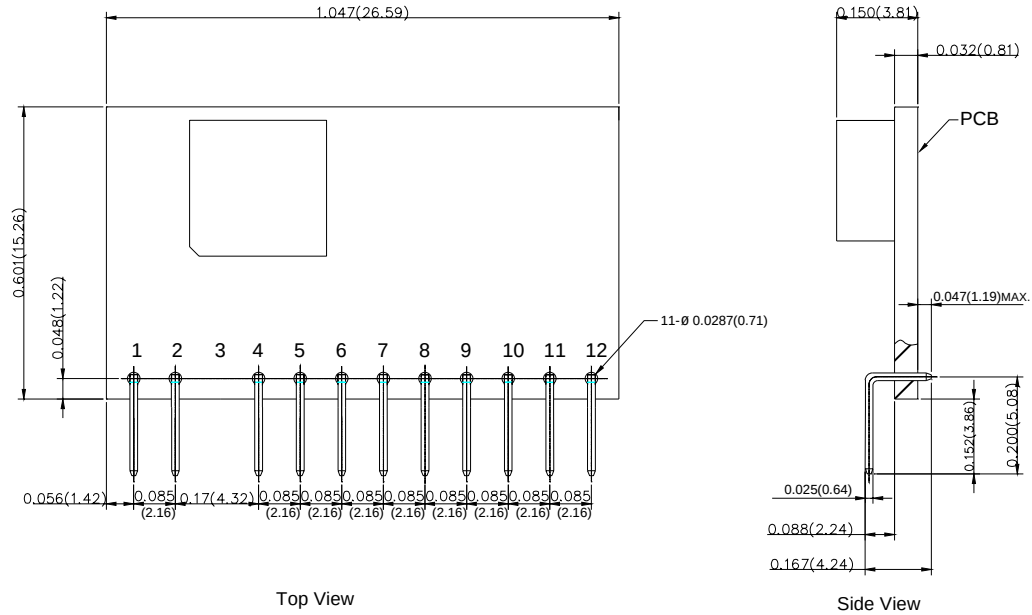
$V_{IN} = 3.3V @ 25^{\circ}C$

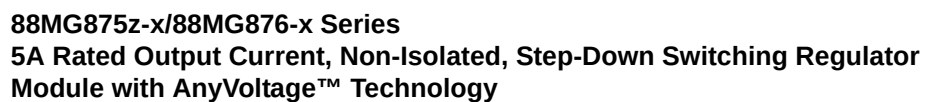


## Section 4. Mechanical Drawings

### 4.1 Mechanical Drawings for 88MG875z-x

Figure 12: 88MG875z-S Mechanical Dimensions (SIP Package)





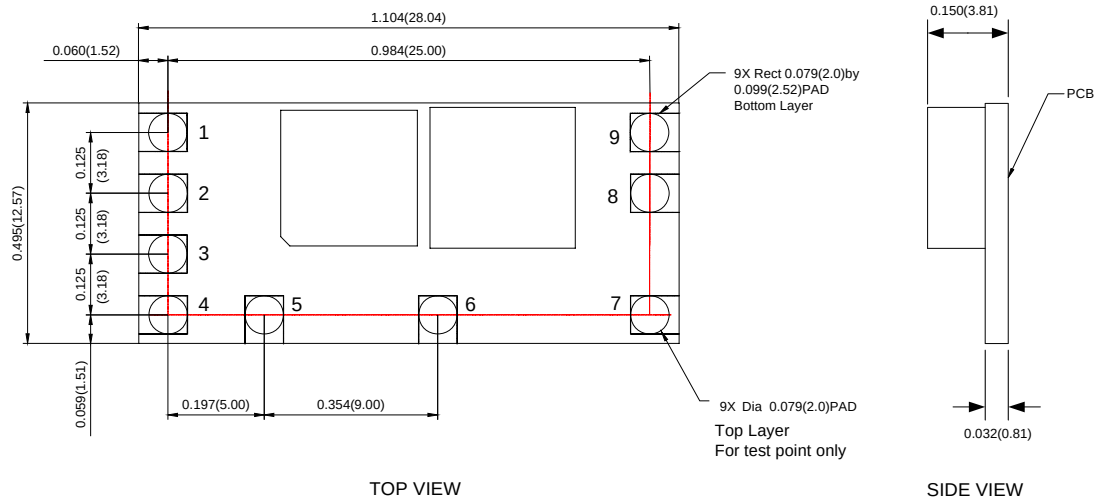
**Top View**

The top view shows a rectangular PCB with overall dimensions of 1.104 (28.04) in width and 0.485 (12.57) in height. It features 9 mounting holes arranged in a grid. The hole positions are defined by dimensions: 0.06 (1.52) from the left edge to the first column of holes, 0.197 (5.00) between the first and second columns, 3.54 (9.00) between the second and third columns, and 0.433 (11.00) between the third and fourth columns. The hole diameter is 9-Ø0.046 (1.17). The distance from the bottom edge to the first row of holes is 0.059 (1.51), and the vertical spacing between the four rows of holes is 0.125 (3.18). A central rectangular cutout is present.

**Side View**

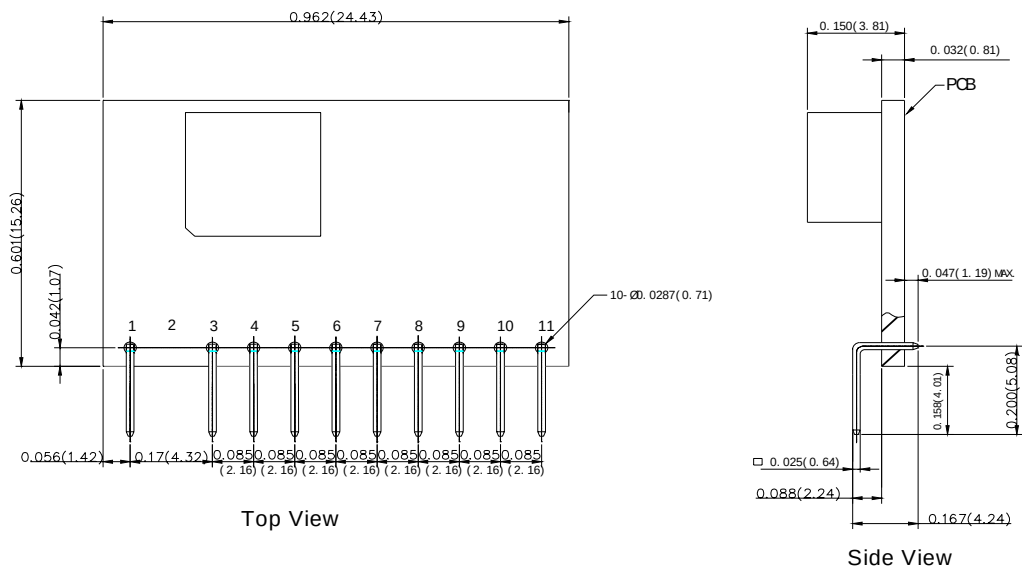
The side view shows the profile of the PCB. The total thickness is 0.215 (5.46). The mounting holes have a diameter of Ø0.040 (1.02). The distance from the front edge to the first hole is 0.0320 (0.81), and the distance between the first and second holes is 0.140 (3.56). The distance from the second hole to the back edge is 0.205 (5.21). The PCB is labeled with "POB" and "PI N(9X) ROUND".

Figure 14: 88MG875z-T Mechanical Dimensions (SMT Package)



## 4.2 Mechanical Drawings for 88MG876-x

**Figure 15: 88MG876-S Mechanical Dimensions (SIP Package)**







## Section 5. Ordering Information

### 5.1 Ordering Part Numbers and Package Markings

Figure 18 shows the typical ordering part numbering scheme for the MDS-G76 part. Markings for the other variants are similar. For complete ordering information, contact your Marvell FAE or sales representative.

Figure 18: 88MG875z Sample Ordering Part Number

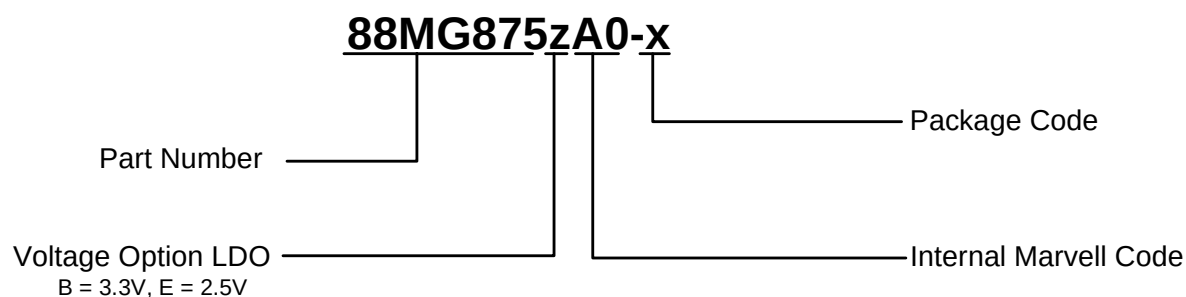
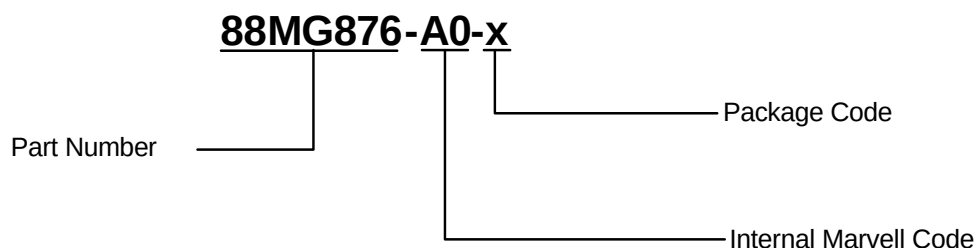


Figure 19: 88MG876 Sample Ordering Part Number



The standard ordering part number for the respective solution is shown in [Table 6](#).

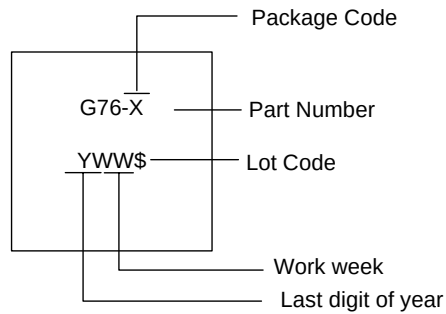
**Table 6: Ordering Part Numbers**

| Part Number | Switcher Output Voltage | LDO Output Voltage | Rated Output Current | Ambient Temperature Range <sup>1</sup> | Package    |
|-------------|-------------------------|--------------------|----------------------|----------------------------------------|------------|
| 88MG875B-S  | Programmable            | 3.3V               | 5A                   | -40°C to 85°C                          | 12-pin SIP |
| 88MG875B-D  | Programmable            | 3.3V               | 5A                   | -40°C to 85°C                          | 9-pin DIP  |
| 88MG875B-T  | Programmable            | 3.3V               | 5A                   | -40°C to 85°C                          | 9-pin SMT  |
| 88MG875E-S  | Programmable            | 2.5V               | 5A                   | -40°C to 85°C                          | 12-pin SIP |
| 88MG875E-D  | Programmable            | 2.5V               | 5A                   | -40°C to 85°C                          | 9-pin DIP  |
| 88MG875E-T  | Programmable            | 2.5V               | 5A                   | -40°C to 85°C                          | 9-pin SMT  |
| 88MG876-S   | Programmable            | --                 | 5A                   | -40°C to 85°C                          | 11-pin SIP |
| 88MG876-D   | Programmable            | --                 | 5A                   | -40°C to 85°C                          | 8-pin DIP  |
| 88MG876-T   | Programmable            | --                 | 5A                   | -40°C to 85°C                          | 8-pin SMT  |

1. Any specifications that pertain to the operating temperature range -40°C to 85°C are assured by design, characterization, and correlation with statistical process controls.

[Figure 20](#) shows a typical package marking and pin 1 location for the 88MG876 part. Markings for the other variants are similar.

**Figure 20: 88MG876 Package Marking**





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