GAMMA MICROELECTRONICS

# GM38C42, GM38C43, GM38C44, GM38C45

## HIGH PERFORMANCE CURRENT MODE PWM CONTROLLERS

## Description

GM38C4x is fixed frequency, high performance, and current- mode PWM controllers. Gamma's BiCMOS devices are pin compatible with standard 384x bipolar devices but with several improvements.

Undervoltage lockout circuitry allows the '42 and '44 versions to start up at 14.5V and operate down to 9V, and the '43 and '45 versions start at 8.4V with operation down to 7.6V. All versions operate up to 16V.

When compared to bipolar 384x devices operating from a 15V supply, start-up current has been reduced to 50μA typical and operating current has been reduced to 4.0 mA typical. Decreased output rise/fall times drive larger MOSFETs, and rail-to-rail output capability increases efficiency, especially at lower supply voltages. GM38C4x also features a trimmed oscillator discharge current and bandgap reference.

GM38C4x denotes 8-pin plastic DIP and SOP packages.

## Features

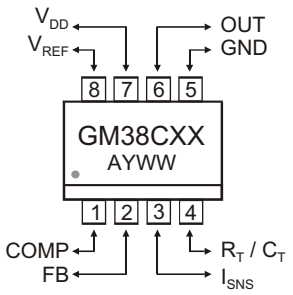
- **40ns output rise and 30ns output fall times**
- **-40° to +85°C temp. range same as standard UC284x**
- **Low-power BiCMOS Process**
- **Very low start-up current (50μA typical)**
- **Low operating current (4mA typical)**
- **CMOS outputs with rail-to-rail swing**
- **≥500kHz current-mode operation**
- **Pin-for-pin compatible with UC3842/ 3843 / 3844/ 3845(A)**
- **Trimmed oscillator discharge current**
- **UVLO with hysteresis**
- **Low cross-conduction currents**

## Application

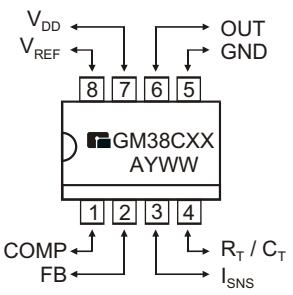
**Current-mode, off-line, switched-mode power supplies**
**Current-mode, dc-to-dc converters.**
**Step-down "buck" regulators**
**Step-up "boost" regulators**
**Flyback, isolated regulators**
**Forward converters**
**Synchronous FET converters**

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

**SOP - 8**




**DIP - 8**




A = Assembly Location
Y = Year
W W = Weekly

## ◆ ORDERING INFORMATION

| Ordering Number | Package | Shipping |
|---|---|---|
| GM38C42S8T | SOP - 8 | 100 Units/ Tube |
| GM38C42S8R | SOP - 8 | 2,500 Units/ Tape & Reel |
| GM38C42D8T | DIP-8 | 60 Units/ Tube |
| GM38C43S8T | SOP - 8 | 100 Units/ Tube |
| GM38C43S8R | SOP - 8 | 2,500 Units/ Tape & Reel |
| GM38C43D8T | DIP-8 | 60 Units/ Tube |
| GM38C44S8T | SOP - 8 | 100 Units/ Tube |
| GM38C44S8R | SOP - 8 | 2,500 Units/ Tape & Reel |
| GM38C44D8T | DIP-8 | 60 Units/ Tube |
| GM38C45S8T | SOP - 8 | 100 Units/ Tube |
| GM38C45S8R | SOP - 8 | 2,500 Units/ Tape & Reel |
| GM38C45D8T | DIP-8 | 60 Units/ Tube |

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

## ◆ ABSOLUTE MAXIMUM RATINGS

| PARAMETER | SYMBOL | VALUE | UNIT |
|---|---|---|---|
| Zener Current<br>Operation at ≥ 16V may require special precautions(Note6) | $I_{DD}$ | 30 | mA |
| Supply Voltage(Note 6) | $V_{DD}$ | 18 | V |
| Switch Supply Voltage | $V_D$ | 18 | V |
| Current Sense Voltage | $V_{ISNS}$ | - 0.3 to + 5.5 | V |
| Feedback Voltage | $V_{FB}$ | - 0.3 to + 5.5 | V |
| Output Current | $I_{OUT}$ | 0.5 | A |
| Storage Temperature | $T_A$ | - 50 to + 150 | °C |

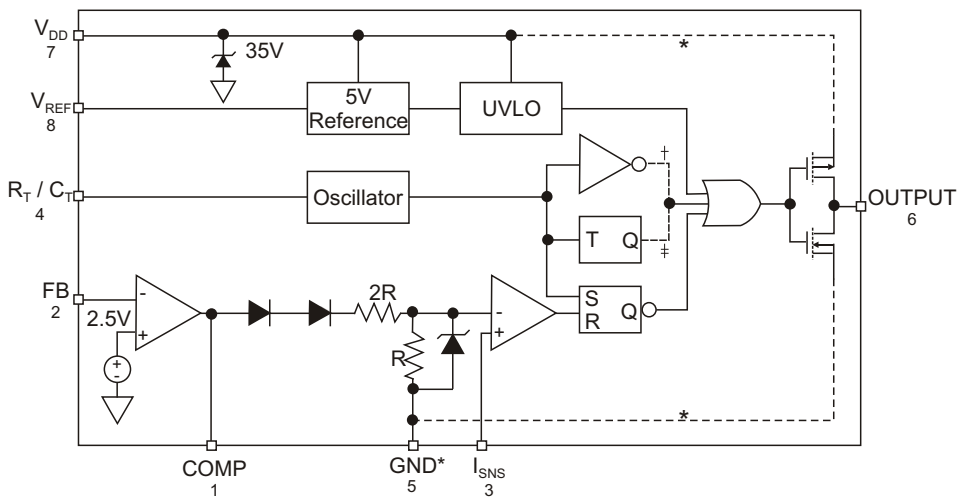
## ◆ OPERATING RATINGS

| PARAMETER | SYMBOL | VALUE | UNIT |
|---|---|---|---|
| Junction Temperature | $T_J$ | 150 | °C |

## ◆ PACKAGE PIN DESCRIPTION

| PIN LEAD | FUNCTION | FUNCTION |
|---|---|---|
| 1 | COMP | Compensation: Connect external Compensation network to modify the error amplifier output. |
| 2 | FB | Feedback (Input): Error amplifier input .Feedback is 2.5Vat desired output voltage. |
| 3 | $I_{SNS}$ | Current Sense (Input): Current sense comparator input. Connect to current sensing resistor or current transformer. |
| 4 | $R_T$ / $C_T$ | Timing Resistor / Timing Capacitor: Connect external RC network to select switching frequency. |
| 5 | GND | Ground: Combined analog and power ground. |
| 6 | OUT | Power Output: Totem - pole output. |
| 7 | $V_{DD}$ | Analog Supply (Input): Controller circuitry supply input. Return to analog ground (AGND). |
| 8 | $V_{REF}$ | 5V Reference (Output): Connect external RC network. |

## ◆ BLOCK DIAGRAM




* 8 - lead versions only

## ◆ ELECTRICAL CHARACTERISTICS

($T_A$ = -40°C to 85°C, Note 4, $V_{DD}$ = 15V, $C_T$=3.3 nF, $R_T$=10k , unless otherwise noted )

| CHARACTERISTICS | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|
| **Reference Section** | | | | | |
| Output Voltage | $T_A$ = 25°C, $I_O$ = 1mA | 4.9 | 5.0 | 5.1 | V |
| Line Regulation | 12V ≤ $V_{DD}$ ≤ 16V, $I_O$ = 5μA, (Note 6) | | 2 | 20 | mV |
| Load Regulation | 1≤ $I_O$≤ 20mA | | 1 | 25 | mV |
| Temp. Stability | (Note 1) | | 0.2 | | mV / °C |
| Total Output Variation | Line, Load, Temp.,Note 1 | 4.82 | | 5.18 | V |
| Output Noise Voltage | 10Hz≤ f ≤10kHz, $T_A$ = 25°C, (Note 1) | | 50 | | μV |
| Long Term Stability | $T_A$ = 125°C, 1000hrs., (Note 1) | | 5 | 25 | mV |
| Output Short Circuit | | -30 | -80 | -180 | mA |
| **Oscillator Section** | | | | | |
| Initial Accuracy | $T_A$ = 25°C, (Note 5) | 49 | 52 | 55 | KHz |
| Voltage Stability | 12≤ $V_{DD}$≤ 16V, (Note 6) | | 0.2 | 1.0 | % |
| Temp. Stability | $T_{MIN}$ ≤ $T_A$ ≤ $T_{MAX}$, (Note 1) | | 0.04 | | % / °C |
| Clock Ramp<br>Reset Current | $T_A$ = 25°C, $V_{RT/CT}$ = 2V,<br>$T_{MIN}$ ≤ $T_A$ ≤ $T_{MAX}$ | 7.7<br>7.2 | 8.4<br>8.4 | 9.0<br>9.5 | mA |
| Amplitude | $V_{RT/CT}$ (Peak to Peak) | | 1.9 | | Vp-p |
| **Error Amplifier Section** | | | | | |
| Input Current | $V_{FB}$ = 5V | | -0.1 | -2 | μA |
| Input Voltage | $V_{COMP}$ = 2.5V | 2.42 | 2.5 | 2.58 | V |
| Open Loop Voltage Gain | 2V ≤ $V_O$ ≤ 4V | 65 | 90 | | dB |
| Power Supply Rejection Ratio | 12V ≤ $V_{DD}$ ≤ 16V | 60 | | | dB |
| Output Sink Current | $V_{FB}$ = 2.7V, $V_{COMP}$ = 1.1V | 2 | 14 | | mA |
| Output Source Current | $V_{FB}$ = 2.3V, $V_{COMP}$ = 5V | -0.5 | -1 | | mA |
| High Output Voltage | $V_{FB}$ = 2.3V, $R_L$ = 15k to GND | 5.0 | 6.6 | | V |
| Low Output Voltage | $V_{FB}$ = 2.7V, $R_L$ = 15k to $V_{REF}$ | | 0.1 | 1.1 | V |
| Unity Gain Bandwidth | (Note 1) | 0.7 | 1.0 | | MHz |
| **Current Sense Section** | | | | | |
| Gain | Note 2 and 3 | 2.85 | 3.0 | 3.15 | V / V |
| Maximum Threshold | $V_{COMP}$ = 5V, (Note 2) | 0.9 | 1.0 | 1.1 | V |
| PSRR | 12V ≤ $V_{DD}$ ≤ 16V, (Note 2) | | 70 | | dB |
| Input Bias Current | | | -1.0 | -2 | μA |
| Delay to Output | | | 120 | 250 | ns |

## ◆ ELECTRICAL CHARACTERISTICS

($T_A$ = -40°C to 85°C, Note 4, $V_{DD}$ = 15V, $C_T$=3.3 nF, $R_T$=11k , unless otherwise noted )

| CHARACTERISTICS | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|
| **Output Section** | | | | | |
| $R_{DS(ON)}$ High | $I_{SOURCE}$ = 200mA | | 20 | | |
| $R_{DS(ON)}$ Low | $I_{SINK}$ = 200mA | | 11 | | |
| Rise Time | $T_A$ = 25°C, $C_L$ = 1nF | | 40 | 80 | ns |
| Fall Time | $T_A$ = 25°C, $C_L$ = 1nF | | 30 | 60 | ns |
| **Undervoltage Lockout Section** | | | | | |
| Start Threshold | GM38C42, GM38C44 | 13.5 | 14.5 | 15.5 | V |
| | GM38C43, GM38C45 | 7.8 | 8.4 | 9.0 | |
| Minimum Operating Voltage | GM38C42, GM38C44 | 8 | 9 | 10 | V |
| | GM38C43, GM38C45 | 7.0 | 7.6 | 8.2 | |
| **PWM Section** | | | | | |
| Maximum Duty Cycle | GM38C42, GM38C43 | 94 | 96 | | % |
| | GM38C44, GM38C45 | 46 | 50 | | |
| Minimum Duty Cycle | | | | 0 | % |
| **Total Standby Current** | | | | | |
| Start - Up Current | $V_{DD}$ = 13V for GM38C42, GM38C44<br>$V_{DD}$ = 7.5V for GM38C43, GM38C45 | | 50 | 200 | µA |
| Operating Supply Current | $V_{FB}$ = $V_{ISNS}$ = 0V | | 4 | 6 | mA |
| Zener Voltage ($V_{DD}$) | $I_{DD}$ = 25 mA, Note 6 | 30 | 37 | | V |

**Note 1:** These parameters, although guaranteed, are not 100% tested in production.
**Note 2:** Parameter measured at trip point of latch with $V_{EA}$ = 0.
**Note 3:** Gain defined as:

$$A = \frac{V_{PIN1}}{V_{TH}(I_{SNS})} ; 0 \leq V_{TH}(I_{SNS}) \leq 0.8V$$

**Note 4:** Adjust $V_{DD}$ above the start threshold before setting at 15V.
**Note 5:** Output frequency equals oscillator frequency for the GM38C42 and GM38C43. Output frequency for the GM38C44, and GM38C45 equals one half the oscillator frequency.
**Note 6:** On 8-pin version, 18V is maximum input on pin 7, as this is also the supply pin for the output stage.

## ◆ TYPICAL PERFORMANCE CHARACTERISTICS

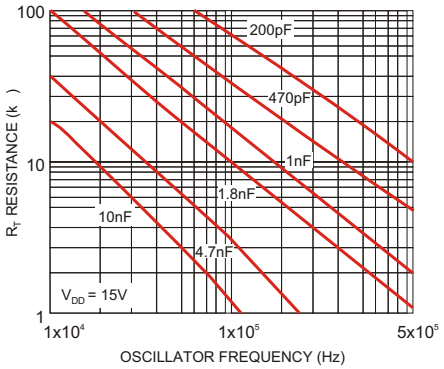



**Figure 1. Oscillator Frequency Configuration**

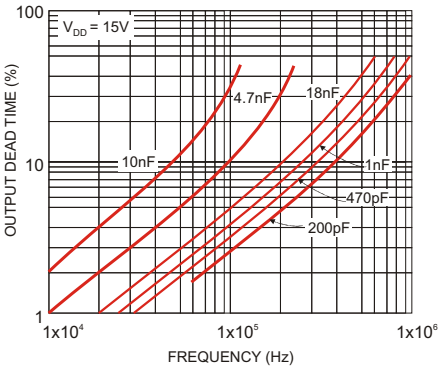



**Figure 2. GM38C42, GM38C43 Output Dead Time vs. Oscillator Frequency**

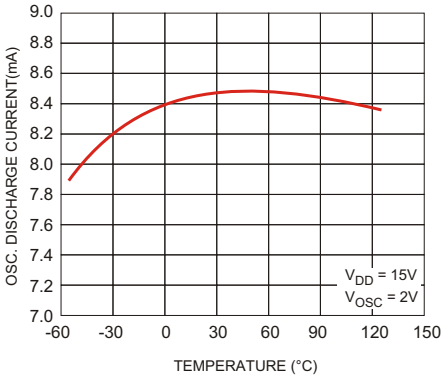



**Figure 3. Oscillator Discharge Current vs. Temperature**

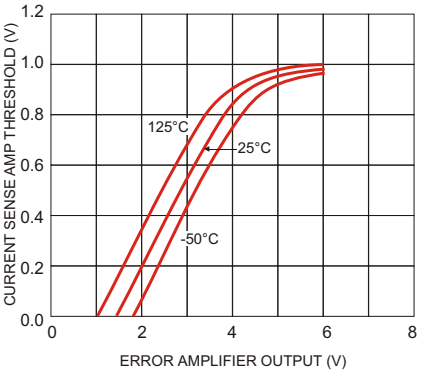



**Figure 4. Current Sense Amplifier vs. Error Amplifier Output**

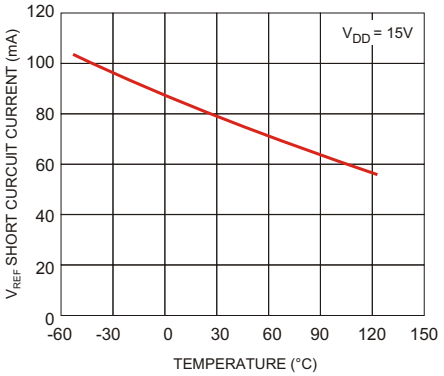



**Figure 5. Short - Circuit Reference Current vs. Temperature**

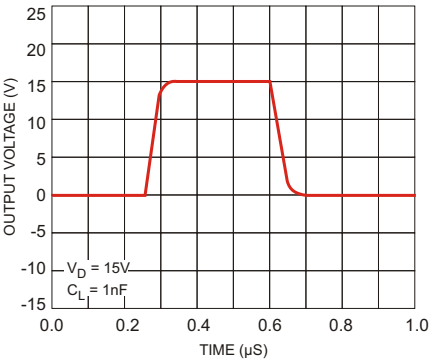



**Figure 6. GM38C4X Output Waveform**

## ◆ Application Information

Familiarity with 384x converter designs is assumed.
GM38C4x has been designed to be compatible with 384xA series controllers.

**GM38C4x Advantages**
**Start-up Current**
Start-up current has been reduced to an ultra-low 50μA(typical) permitting higher-valued, lower-wattage, and start-up resistors (power controller during power supply start-up). The reduced resistor wattage reduces cost and printed circuit space.

**Operating Current**
Operating current has been reduced to 4mA compared to 11mA for a typical bipolar controller. The controller runs cooler and the $V_{DD}$ hold-up capacitance required during start-up may be reduced.

**Output Driver**
Complementary internal P-and N-channel MOSFETs produce rail-to-rail output voltages for better performance driving external power MOSFETs. The driver transistor's low on resistance and high peak current capability can drive gate capacitances of greater than 1000pF. The value of output capacitance which can be driven is determined only by the rise/fall time requirements. Within the restrictions of output capacity and controller power dissipation, maximum switching frequency can approach 500kHz.

**Design Precautions**
When operating near 20V, circuit transients can easily exceed 20V absolute maximum rating and permanently damaging the controller's CMOS construction. To reduce transients, use a 0.1μF low-ESR capacitor to next to the controller's supply $V_{DD}$ (or $V_D$ for '-1' versions)and ground connections.
Film type capacitors, such as Wima MKS2, are recommended.

When designing high -frequency converters, avoid capacitive and inductive coupling of the switching waveform into high impedance circuitry such as the error amplifier, oscillator, and current sense amplifier. Avoid long printed-circuit traces and component leads. Locate oscillator and compensation circuitry neat the IC. Use high frequency decoupling capacitors on $V_{ERF}$, and if necessary, on $V_{DD}$. Return high di/dt currents directly to their source and use large ground planes.

**Buck Converter**
Refer to Figure 7. When at lest 26V is applied to the input, C5 is charged through R2 until the voltage $V_{DD}$ is greater than 14.5V(the undervoltage lockout value of the GM38C42), output switching begins when Q1is turned on by the gate drive transformer T1 and charging the output filter capacitor C3 through L1. D5 supplies a regulated +12V to $V_{DD}$ once the circuit is running.

Current sense transformer CT1 provides current feedback to ISNS for current-mode operation and cycle-by-cycle current limiting. This is more efficient than a high- power sense resistor and provides the required ground-referenced level shift.

When Q1 turns off, current flow continues from ground through D1 and L1 until Q1 is turned on again.

The 100V Schottky diode D1 reduces the forward voltage drop in the main current path, resulting in higher efficiency than could be accomplished by using an ultra-fast recovery diode. R1 and C2 suppress parasitic oscillations from D1.

Using a high-value inductance for L1 and a low-ESR capacitor for C3 permits small capacitance with minimum output ripple. This inductance value also improves circuit efficiency by reducing the flux swing in L1.
Magnetic components are carefully chosen for minimal loss at 500kHz.

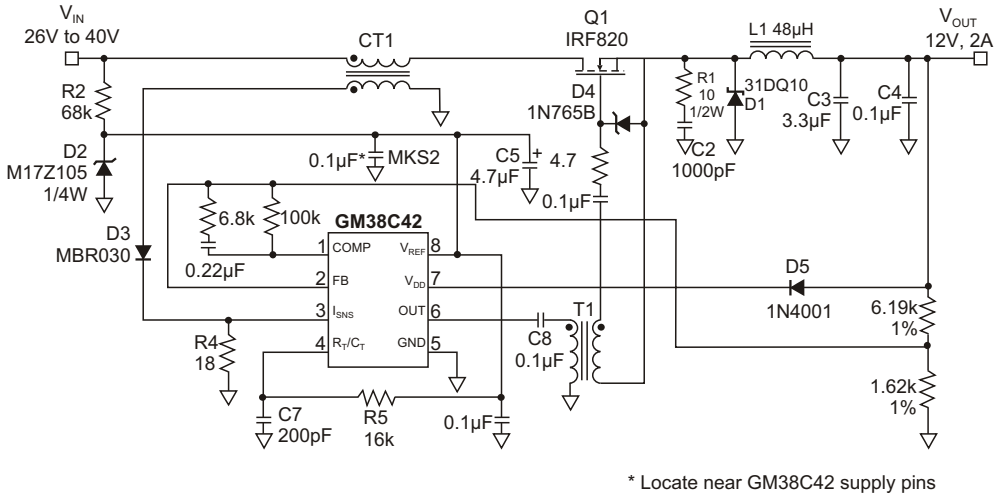
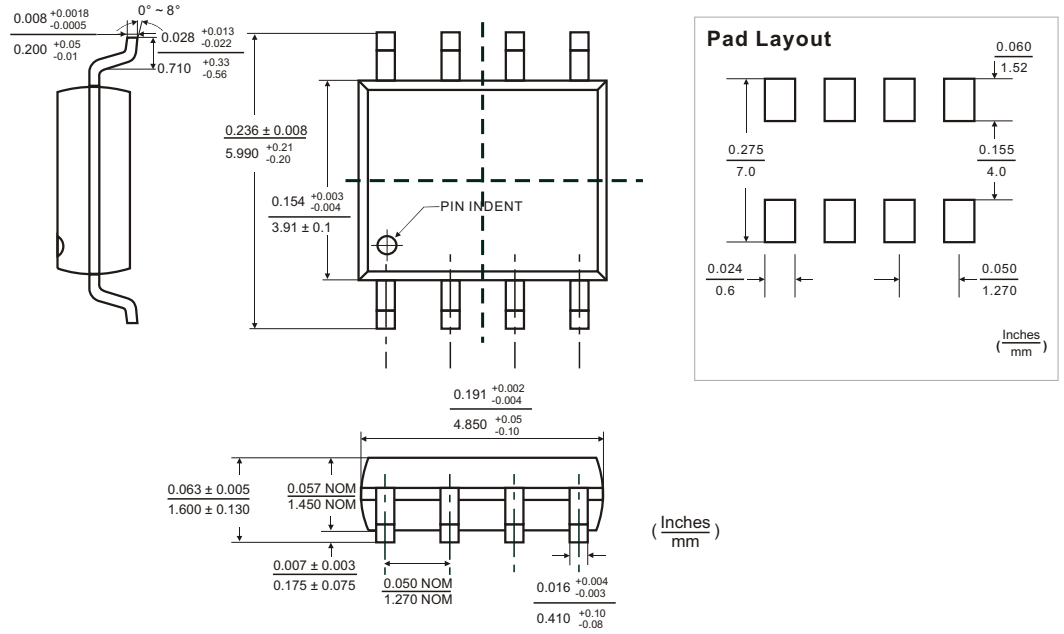


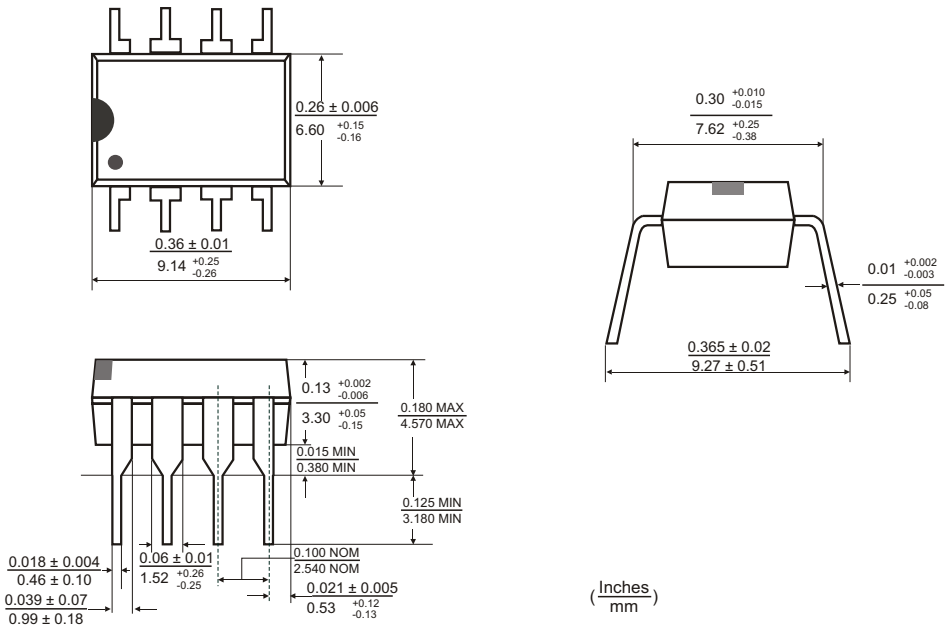

**Figure 7. 500kHz, 25W, Buck Converter**

| Test | Conditions | Results |
|---|---|---|
| Line Regulation | $V_{IN}$= 26V to 80V, $I_O$= 2A | 0.5% |
| Load Regulation | $V_{IN}$= 48V, $I_O$= 0.2A to 2A | 0.6% |
| Efficiency | $V_{IN}$= 48V, $I_O$= 2A | 90% |
| Output Ripple | $V_{IN}$= 48V, $I_O$= 2A (20MHz BW) | 100mV |

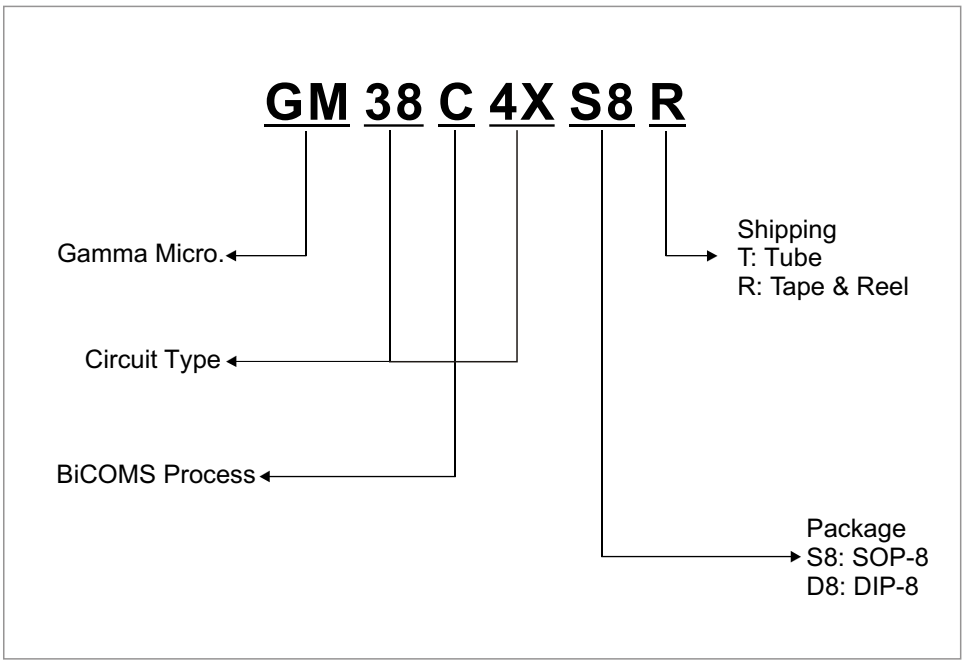
## ◆ SOP-8 PACKAGE OUTLINE DIMENSIONS




## ◆ DIP-8 PACKAGE OUTLINE DIMENSIONS



## ◆ ORDERING NUMBER



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